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Community Structure and Soil Properties of Chinese Cork Oak(*Quercus variabilis*) Forests in Limestone Area

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石灰岩 地域 굴참나무群集의 構造와 土壤의 物理·化學的 性質

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ABSTRACT

Floristic composition and soil properties were analyzed in Chinese cork oak(*Quercus variabilis*) communities in the limestone area, Tanyang, Ch'ungbuk Province in Korea. The tree layer was composed of *Quercus dentata*, *Platycarya strobilacea*, *Fraxinus rhynchophylla* and others as wel as *Quercus variabilis*. The shrub layer was dominated by *Ulmus davidiana* for. *suberosa*, shrubby *Q. variabilis*, *Euonymus alatus* and *Rhus chinensis*. Among these, *U. davidiana* for. *suberosa* was known to have a restricted distribution to calcareous area, and 9 species in the shrub layer including *E. alatus*, *Indigofera kirilowii* and *Rhamnus davurica* belonged to the calcicole. The herb layer was dominated by *Carex lanceolata* and *Spodiopogon cotulifer*. Ten species including *C. lanceolata*, *Clematis mandshurica*, *Isachne globosa*, *Lithospermum arvense* and *Scabiosa mansenensis* belonged to the calcicole. Soil texture was classified to clay loam in both top and subsoil.

Water content and organic matter were consistently higher in top soil than in subsoil. Soil pH ranged 7.8~8.4.Total N concentration in top soil ranged from 0.2 to 0.4mg/g, which was higher than that in subsoil. Available P and exchangeable K concentration were also significantly higher in top soil than in subsoil. However, exchangeable Ca concentration was similar between the top and the subsoil. Unlike the other nutrients, exchangeable Mg concentration in top soil was lower than that in subsoil. Organic matter, N, P and K content in this Chinese cork oak stand showed as much as the other noncalcareous sites. Soil properties in this study area seemed to have been influenced by casts forming activities of earthworms.

INTRODUCTION

Calcareous soils are distinguished primarily by the fact that they contain much greater amounts of calcium and bicarbonate ions than those in noncalcareous soils(Larcher,

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1975). They show a neutral and slightly alkaline soil reaction(Kim *et al.*, 1990). High pH and high calcium content cause formation of insoluble Ca-phosphate, and thus phosphate availability is lowered(Kinzel, 1983). High bicarbonate inhibits iron ion uptake and subsequent translocation into the shoot, which cause lime-induced chlorosis(Woolhouse, 1966 ; Chang and Mok, 1981). Calcareous soils also differ from others in that they are more permeable to water and thus drier than other soils. Therefore, the structure and function of the communities in the limestone area may be quite different from those in noncalcareous area due to the physico-chemical properties of the calcareous soils.

In Korea, calcareous soils are distributed at Yŏngwol in Kangwon Province, and Chech'on and Tanyang in Ch'ungbuk Province. The purpose of this study is to examine

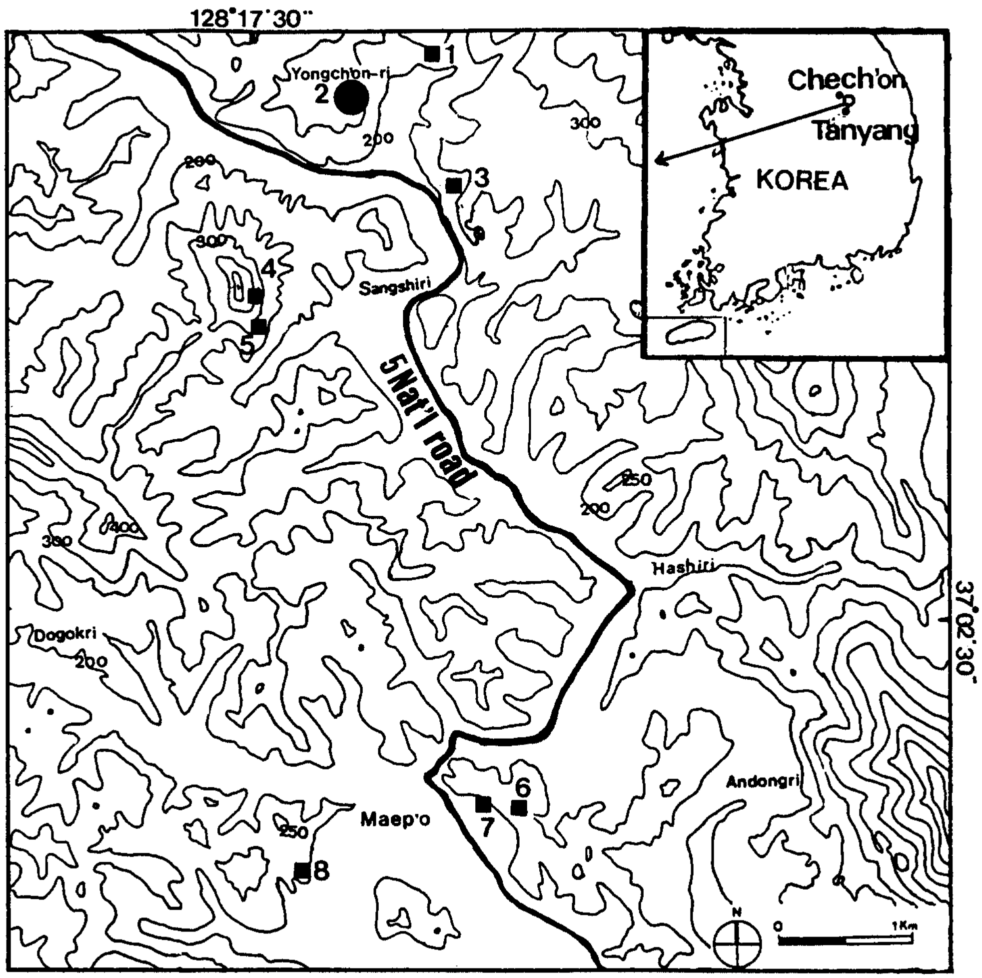

Fig. 1. Geographical and topographical map of the study area. Squares nearby numerals indicate community sampling sites and dark circle indicates soil sampling site.

the structure and soil properties of Chinese cork oak forests in the limestone area as a part of the long-term project for the study of structure and function of typical ecosystems in Korea.

MATERIALS AND METHODS

This study was conducted in Chinese cork oak forests in limestone area at Maep'o, Tanyang in Ch'ungbuk Province(128°18′E, 37°3′N). Eight sites of Chinese cork oak stands within the study area were chosen for the analysis of community structure. One of these, which is at Yongchŏn-ri, was selected for the determination of physico-chemical properties of soil(Fig. 1). This Yongchŏn-ri stand is on east-facing slope with inclination of 65°. All the methods and procedures for the vegetation analysis, soil sampling, and physico-chemical analysis of soil were described in detail by Kim *et al.* (1990).

RESULTS AND DISCUSSION

Vegetation analysis

Thirteen kinds of species were identified in the tree layer of the Chinese cork oak forests in this limestone area. Of these, *Quercus dentata*, *Platycarya strobilacea* and *Fraxinus rhynchophylla*, as well as *Q. variabilis*, had higher importance value than others(Table 1). Among these tree species, *Ulmus davidiana* for. *suberosa* was known to have a restricted distribution in the limestone area(Lee and Oh, 1970). However, Kim and Kwak(1990) classi-

Table 1. Importance values of tree layer in the *Quercus variabilis* community at Maep'o limestone areas

Species		Relative density	Relative basal area	Importance value
Tree layer(13 species)				
Quercus variabilis	(굴참나무)	66.3	85.5	75.9
Quercus dentata	(떡갈나무)	11.5	3.1	7.3
Platycarya strobilacea	(굴피나무)	5.4	2.8	4.1
Fraxinus rhynchophylla	(물푸레나무)	4.1	3.1	3.6
Thuja orientalis	(측백나무)	2.9	3.4	3.1
Ulmus davidiana for. *suberosa*	(혹느릅나무)	4.9	0.4	2.7
Juniperus rigida	(노간주나무)	1.2	0.5	0.9
Rhus chinensis	(붉나무)	1.2	0.2	0.7
Sophora japonica	(회화나무)	0.8	0.6	0.7
Zelkova serrata	(느티나무)	0.4	0.4	0.4
Prunus sargentii	(산벚나무)	0.4	0.1	0.3
Quercus aliena	(갈참나무)	0.4	0.1	0.2
Celtis sinensis	(팽나무)	0.4	0.1	0.2

fied this species as a calcifuge based on the ratio of soluble and insoluble calcium content. The average tree height was 12.5m, and tree density was 3,080 trees/ha. The mean DBH was 9.4cm, and basal area was 16.2m^2/ha. The richness, diversity indices and evenness of the tree layer in the Chinese cork oak forest were higher than those in red pine forest at the nearby limestone region(Kim and Kwak, 1990 ; Kwak *et al.*, unpublished).

The number of species in the shrub layer was 40. Among these, *U. davidiana* for. *suberosa*, Shrubby *Q. variabilis*, and *Euonymus alatus* had higher importance value than other species(Table 2). *E. alatus*, *Indigofefra kirilowii*, *Securinega suffruticosa*, *Viburnum carlesii*, *Lespedeza cyrtobotrya*, *Rhamnus davurica*, *Buxus microphylla* var. *coreana*, *Pyrus ussuriensis* and *Nellia uyekii* were classified as calcicole plants by Kim and Kwak(1990). Shrub density was 18, 800 individuals/ha, mean height was 2.5m, and mean crown diameter was 50.6cm. The herb layer which consisted of 91 kinds of species was dominated by *Carex lanceolata*(Table 3). The mean coverage of herb layer was 61.4%. Among these, *C. lanceolata*, *Clematis mandshurica*, *Isachne globosa*, *Patrinia rupestris*, *Thalictrum filamentosum*, *Galium trifidum*, *Lithosper-*

Table 2. Importance values of shrub layer in the *Quercus variabilis* community at Maep'o limestone areas

Species		Relative density	Canopy area(%)	Importance value
Shrub layer(40 species)				
Ulmus davidiana for. *suberosa*	(혹느릅나무)	11.5	16.7	14.1
Quercus variabilis	(굴참나무)	11.8	11.2	11.5
*Euonymus alatus**	(화살나무)	10.7	11.8	11.2
Rhus chinensis	(붉나무)	7.2	3.9	5.6
Quercus dentata	(떡갈나무)	5.4	5.0	5.2
*Indigofefra kirilowii**	(땅비싸리)	5.6	3.6	4.6
Sophora japonica	(회화나무)	2.7	6.4	4.5
*Securinega suffruticosa**	(광대싸리)	4.3	4.0	4.1
Spiraea chinensis	(당조팝나무)	5.9	1.5	3.7
Celastrus orbiculatus	(노박덩굴)	5.1	1.9	3.5
*Viburnum carlesii**	(분꽃나무)	0.3	1.2	0.7
Robinia pseudo-acacia	(아까시나무)	0.5	0.7	0.6
Morus bombycis	(가새뽕나무)	1.3	2.7	2.0
Prunus sargentii	(산벚나무)	1.3.	5.4	3.4
*Lespedeza cyrtobotrya**	(참싸리)	2.9	2.4	2.7
*Rhamnus davurica**	(갈매나무)	3.7	2.7	3.2
Buxus microphylla var. *coreana**	(회양목)	1.9	2.1	2.0
*Pyrus ussuriensis**	(산돌배)	0.5	1.3	0.9
*Nellia uyekii**	(나도국수나무)	4.0	3.7	3.8
Fraxinus rhynchophylla	(물푸레나무)	1.6	1.1	1.3
Prunus japonica var. *nakaii*	(이스라지)	2.1	1.1	1.6

*Calciole

Table 3. Cover values of herb layer in the *Quercus variabilis* community at Maep'o limestone areas

Species		Relative cover
Herb layer(91 species)		
*Carex lanceolata**	(그늘사초)	32.3
Spodiopogon cotulifer	(기름새)	7.5
Isodon inflexus	(산박하)	2.4
Cocculus trilobus	(댕댕이덩굴)	2.2
Pueraria thunbergiana	(칡)	1.9
*Clematis mandshurica**	(으아리)	1.9
Smilax sieboldii	(청가시덩굴)	1.9
Sophora flavescens	(고삼)	1.8
*Isachne globosa**	(기장대풀)	1.6
Viola variegata	(알록제비꽃)	1.6
Atractylodes japonica	(삽주)	1.6
Dioscorea batatas	(마)	1.5
*Patrinia rupestris**	(돌마타리)	1.4
Rubia cordifolia var. *pratensis*	(갈퀴꼭두선이)	1.4
Cynanchum wilfordii	(큰조롱)	1.4
*Thalictrum filamentosum**	(산꿩의다리)	1.4
*Galium trifidum**	(가는네잎갈퀴)	1.2
Miscanthus sinensis	(참억새)	1.1
*Lithospermum arvense**	(개지치)	1.1
Dictamnus dasycarpus	(백선)	0.9
*Euphorbia pekinensis**	(대극)	0.9
Themeda triandra var. *japonica**	(솔새)	0.9
Cynanchum panicularum	(산해박)	0.9
Eupatorium chinensis var. *simplicifolium*	(등골나물)	0.8
Leibnitzia anandria	(솜나물)	0.8
Lactuca raddeana	(산씀바귀)	0.8
Rhapontica uniflora	(뻐꾹채)	0.7
*Scabiosa mansenensis**	(솔체꽃)	0.7
Rubia akane	(꼭두선이)	0.7
Youngia sonchifolia	(고들빼기)	0.6

*Calicicole

mum arvense, *Euphobia pekinensis*, *Themeda triandra* var. *japonica* and *Scabiosa mansenensis* were classified as calcicoles by Kim and Kwak(1990). The number of species and mean coverage of the herb layer in the Chinese cork oak forests were less than those in the red pine forests at the nearby limestone area(Kim *et al.*, 1990 ; Kim and Kwak, 1990).

Soil properties

The soil texture was classified to clay loam in both the top and the subsoil(top soil :

sand 20～35%, silt 25～30%, clay 35～40% ; subsoil : sand 30～35%, silt 20～30%, clay 30～35%) (Foth, 1985). Kim *et al.* (1990) reported that the soil texture of red pine stand at the nearby limestone region was loam soil in top and sand soil in subsoil. Soil color in this Chinese cork oak stand(reddish brown) was quite different from that of the red pine stand(blackish color). Water content of top soil(30～50%) was consistently higher than subsoil(36～36%)(Fig. 2A). The main reasons for this difference may be due to the higher clay and organic matter contents in top soil than subsoil. Soil water content in this Chinese cork oak stand was much higher than that in red pine stand at the nearby limestone region(Kim *et al.*, 1990), and another Chinese cork oak stand(Koh and Yim, 1987). This must be due to the difference in soil texture among the stands. Soil organic matter was consistently higher in the top soil than the subsoil(Fig. 2B).

After fairly constant value from October to February, it began to increase and showed a peak in May in both of the top and subsoil, and then decreased. Soil organic matter in this Chinese cork oak stand was somewhat lower than that of the red pine stand(Kim *et al.*, 1990). The amount of litter produced in the former(683g/m^2. yr) was greater than the latter(472g/m^2. yr)(Mun and Kim, unpublished). However, we could observe that considerable amount of litter produced in the Chinese cork oak stand was translocated downhill by wind. This is because the Chinese cork oak stand was on more steeper slope (about 65°) than the red pine stand(about 45°, Kim *et al.*, 1990). Another reason for the lower soil organic matter content in the Chinese cork oak stand compared to the red pine stand may be due to the lower coverage of herb layer in the former(Kim *et al.*, 1990). Organic matter content in this Chinese cork oak stand was higher than the results in the

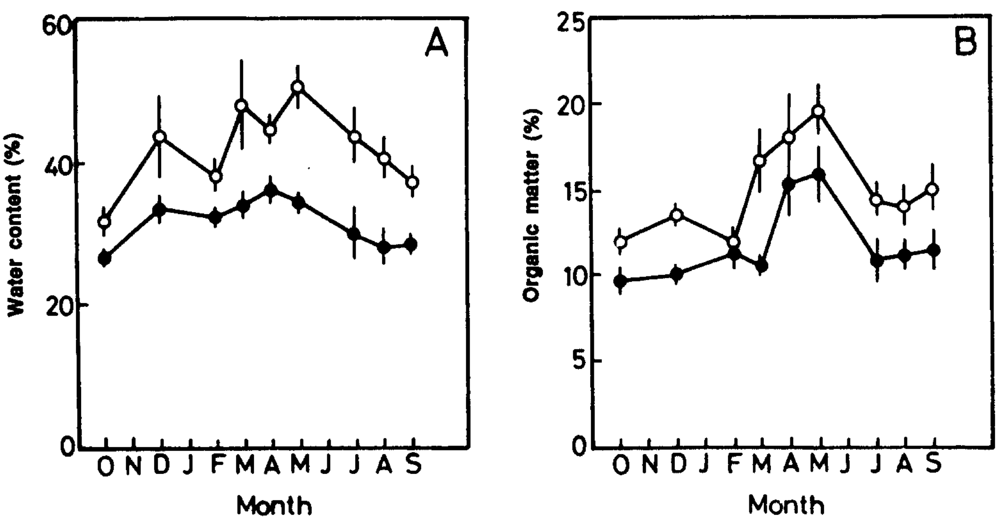

Fig. 2. Seasonal soil water(A) and organic matter(B) in the study area. Open circle and closed circles indicate top soil(0～10cm) and subsoil(10～20cm), respectively.

Q. accutissima stand(Mun *et al.*, 1977), and another Chinese cork oak stand(Koh and Yim, 1987).

Soil pH ranged from 7.8 to 8.4(Fig. 3A), which was higher than the results of the red pine forest in Yŏngwol limestone area(pH range, 7.0~7.4 ; Choung and Kim, 1987), the Chinese cork oak stand in noncalcareous soil(pH range, 4.4~5.8 ; Koh and Yim, 1987), and the *Q. accutissima* stand(pH range, 4.3~4.5) which was originated from granite(Mun *et al.*, 1977), but similar with that in the red pine stand at the same limestone area(Kim *et al.*, 1990). With the onset of the growing season it decreased from 8.4 in December to 7.9 in February and 7.8 in April, and then increased above 8.0 in May. Soil pH did not differ significantly between the top soil and the subsoil. Total nitrogen concentration in top soil ranged from 0.2 to 0.4mg/g, which was higher than that of subsoil(Fig. 3B). This may be due to the high soil organic matter in the top soil. In top soil, it peaked in December with a value of 0.4mg/g, and decreased to 0.24mg/g in July. Seasonal nitrogen in subsoil was similar with top soil. Total N concentration of soil in this Chinese cork oak stand was higher than in the red pine stand(Kim *et al.*, 1990) and another Chinese cork oak stand(Koh and Yim, 1987), and was lower than in the *Q. mongolica* stand(Kwak, 1986) and *Q. accutissima* stand(Mun *et al.*, 1977).

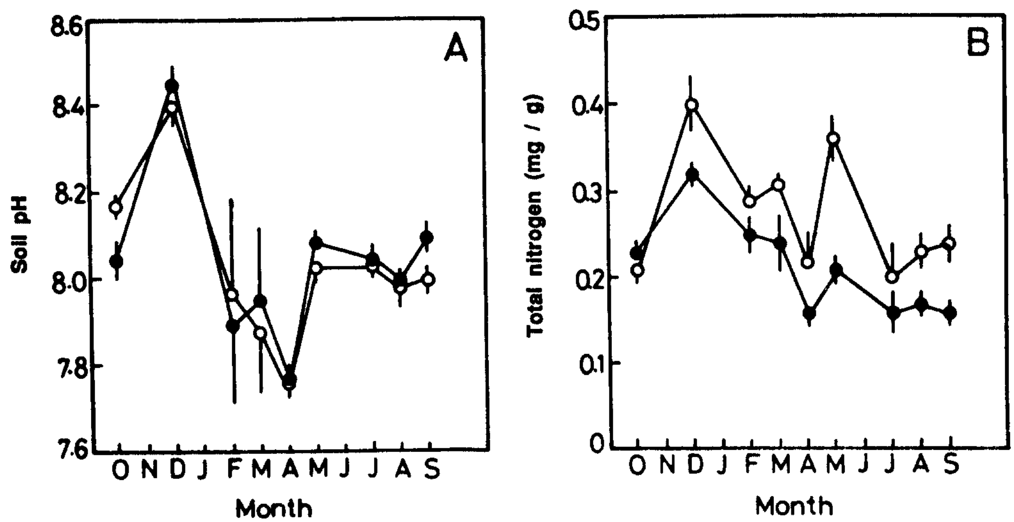

Fig. 3. Seasonal soil pH(A) and total nitrogen(B) in the study area. Legends are the same as Fig. 2.

Available P concentration in top soil was consistently higher than that of subsoil(Fig. 4A). This may be due to the cast forming activities of earthworm(Syers and Springett, 1984 ; Bhadauria and Ramakrishnan, 1989 ; Mun and Kim, 1991). The amount of casts produced in this Chinese cork oak stand was estimated as 5.6t/ha(560g/m^2) in July. Mun and Kim(1991) reported that the nutrient concentration of earthworm casts was significant-

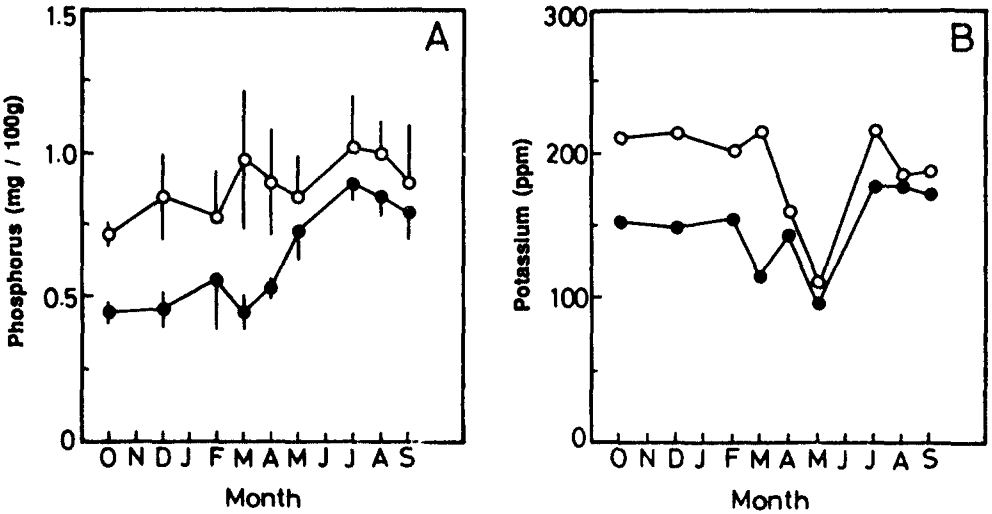

Fig. 4. Seasonal available phosphorus(A) and exchangeable potassium(B) in the study area. Legends are the same as Fig. 2.

ly higher than that in the top soil.

P concentration in this Chinese cork oak stand was somewhat lower than that in the red pine stand(Kim *et al.*, 1990), and significantly lower than that in *Q. accutissima* stand(Mun *et al.*, 1977). However, it was significantly higher than that in the *Q. mongolica* stand (Kwak, 1986). Seasonal pattern of available P was different from that of nitrogen. It increased steadly during the growing season. Exchangeable K concentration in top soil ranged 130 to 220ppm, and was higher than subsoil(Fig. 4B). Seasonal exchangeable K was very similar between the top soil and subsoil. In top soil, exchangeable K maintained similar concentrations from October to March with 215ppm. However, it decreased to 130ppm in May, and then increased again. Kim *et al.* (1990) reported that exchangeable K in the red pine stand at the same limestone area increased to maximum in May. Exchangeable K concentration in this study area was higher than that reported by Kim *et al.* (1990), and about 2 times higher than that in the *Q. mongolica* stand(Kwak, 1986). But, it was similar with the result in the *Q. accutissima* stand(Mun *et al.*, 1977).

Because the parent material could influence more directly to the subsoil than top soil, it was expected that the concentration of exchangeable Ca in the former should be greater than that in the latter. However, the concentration and seasonal changes of exchangeable Ca in subsoil was similar with the top soil(Fig. 5A). This may be due to the addition of calcium to the top soil *via* litter decomposition and casts forming activity of earthworm (Mun and Kim, 1991 ; Kim *et al.*, 1990). From October to February, exchangeable Ca maintained similar concentration about 2.3mg/g. After slight increase in March(about 2.9mg/g), they sharply decreased to 1.3mg/g for top soil and 1.1mg/g for subsoil in May,

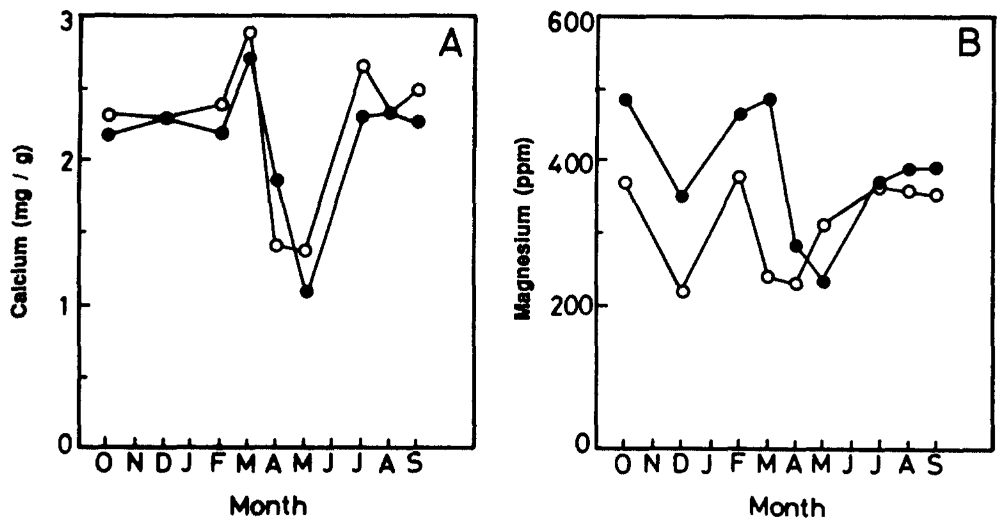

Fig. 5. Seasonal exchangeable calcium(A) and magnesium(B) in the study area. Legends are the same as Fig. 2.

and then increased to 2.7mg/g in July. Exchangeable Ca concentration in this Chinese cork oak stand was similar with the result by Kim *et al.* (1990). The concentration of exchangeable Mg in top soil was lower than that in the subsoil(Fig. 5B). There was no significant seasonal pattern in exchangeable Mg concentration in soil.

Calcareous soils are generally considered unsuitable for plant growth because of damage by heavy metal ions such as iron, manganese and aluminum(Kinzel, 1983). And also they are usually more permeable to water and drier than other soils(Larcher, 1975). In our study, however, soil water content of the Chinese cork oak stand in this limestone area was much higher than those in non-calcareous stands(Koh and Yim, 1987 ; Kwak, 1986 ; Mun *et al.*, 1977). Kim *et al.* (1990) also reported that soil water content in the red pine stand at the nearby limestone area was higher than those in the noncalcareous ones. According to our observation, soil water content in this limestone area seemed to have a high positive correlation with soil depth, soil texture and soil organic matter, and vegetation cover. The abundant earthworm population may also influence to the soil water content(Kim *et al.*, 1990 ; Mun and Kim, 1991) .

Soil in this Chinese cork oak stand showed as much organic matter, N, P and K concentration as other noncalcareous sites(Koh and Yim, 1987 ; Kwak, 1986 ; Mun *et al.*, 1977). However, much of this limestone area have shrubby stunted vegetation. The soil depth of these area which hold stunted vegetation are very shallow. Therefore, the possible reasons for the stunted vegetation landscape in the Tanyang limestone area may be due to the limitation of water and nutrients, restriction of root system resulting from shallow soil depth.

摘 要

충북 단양지역의 석회암지대에 형성된 굴참나무 군집의 구조와 토양의 물리, 화학적 성질을 밝혔다. 교목층에는 굴참나무, 떡갈나무, 굴피나무 등 13종류가, 관목층에는 혹느릅나무, 관목상 굴참나무, 화살나무, 붉나무 등 40종류가, 그리고 초본층에는 그늘사초, 기름새, 산박하 등 91종류가 출현하였다. 이들 중 화살나무, 분꽃나무, 회양목 4등을 포함한 관목 8종류, 그리고 으아리, 기장대풀, 돌마타리, 개지치, 솔체꽃 등 초본식물 10종류는 호석회식물로 밝혀졌다.

토양은 식양토이었고 토양 pH는 7.8~8.4범위로 나타났다. 조사 지소의 토양 수분함량과 유기물 함량은 비석회암지역의 굴참나무림이나 신갈나무림보다 많았고, 전질소의 함량은 0.2~0.4mg/g으로 비석회암지역의 굴참나무림, 신갈나무림, 상수리나무림과 큰 차이가 없었다.

유효인과 치환성 칼륨의 함량은 상층토가 하층토에 비해 높았으나 치환성 칼슘은 상층토와 하층토의 함량이 유사하였다. 치환성 마그네슘 함량은 상층토에 비하여 하층토에서 높았다. 본 조사지역 토양의 물리, 화학적 성질은 지렁이의 활동에 의하여 영향을 받는 것으로 해석되었다.

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