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Physiological and Ecological Studies of the Vegetation on Ore Deposits

2. Incidence of Lime-chlorosis in the Vegetation of Korea

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金屬鑛體上에 나타나는 植物에 관한 生理生態學的 硏究

2. 石灰岩地帶의 白化現象

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ABSTRACT

During the period of 1975~77, a survey and an investigation were carried out to estimate the frequency of lime-chlorosis in the natural vegetation in Korea and the relationships between plants and calcareous soils.

The symptoms of lime-chlorosis were observed in flowering plants in the calcareous areas of Weonju(Ⅰ, Ⅱ), Yeongweol(Ⅰ, Ⅱ), Jecheon, Danyang and Samcheok. Although the species found to be lime-chlorotic on at least one occasion numbered 60, the total quantity of lime-chlorotic foliage observed was small. Severe lime-chlorosis of *Capsicum annuum* in agricultural fields was found out at Danyang. However, some of the species which were of widespread occurrence in affected areas showed no lime-chlorosis.

The comparison of the inorganic components in calcareous soils and in lime-chlorotic and normal leaves showed that the essential mineral nutrients substantially less soluble in water in alkaline than in acid conditions and calcifuges planted on calcareous soils often show visual signs resembling those of P or Fe deficiency.

INTRODUCTION

Lime-chlorosis is a well-known feature of vegetation on calcareous soils throught the world. The symptoms closely resemble those caused by iron-deficiency and are characteristic of the younger, actively growing leaves. During the onset of chlorosis the interveinal areas of the leaf are yellow while the cells adjacent to the veins remain green (Grime & Hutchinson, 1967).

In the United States of America, Spain, France and Israel, lime-chlorosis in citrus, apples and graps are a serious economic problem. These plants are particularly susceptible and in severe cases, may suffer a serious reduction in yield. In Britain, however, the condition is of little economic consequence (Delap 1964). Despite its low incidence in farmland, lime-chlorosis is a feature of the vegetation of calcareous localities such as Weonju, Yeongweol, Jecheon and Danyang areas in Korea.

It is of interest to know how lime-chlorosis occur in the vegetation of Korea and what effect, if any, these have determining the flora over calcareous soils. This paper is an account of survey of lime-chlorosis in Korea carried out during the period 1975~77.

MATERIALS AND METHODS

1. Survey methods

A care was taken to distinguish chlorosis from symptoms of fungal, virus and insect attack. Records were included only where chlorosis was pronounced and occurred with the greatest severity in the youngest foliage. Areas contaminated by heavy metals or by herbicides were avoided(Grime and Hutchinson, 1967). In 1975~77, observations were restricted to the calcareous areas in Korea and lists of chlorotic species were obtained. The position of the sites at which lists of chlorotic species were collected are shown in Fig. 1.

2. Chemical compositions of limestones

Chemical compositions of Indiana, Crinoidal, Dolomitic, Lithographic and Argillaceous limestones were given in Table 1. The range of the contents of CaO is 38.35~54.54%. As shown in Table 1, chalk contains 52.48% of CaO.

3. Chemical analyses and soils

The contents of chlorophyll and carotenoid in the normal and chlorotic fresh leaves of plants in the calcareous areas were determined by spectrophotometry.

Plant samples were collected from each sites. The materials were rinsed in distilled water. Leaves and stems were separated from the plants and oven-dried at 105°C. These materials were ashed in a mixture of nitric and perchloric acids. The

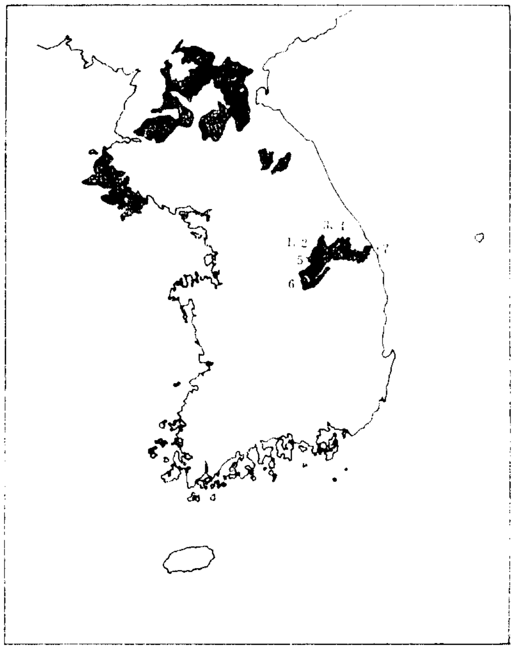


Fig. 1. The calcareous areas in Korea are shown in black on the map, taken from a solid' geological map of Korea. The areas which were visited during the lime-chlorosis survey of 1975~77 are numbered from 1 to 7. These areas represent: 1, Weonju Ⅰ; 2, Weonju Ⅱ; 3, Yeongweol Ⅰ; 4, Yeongweol Ⅱ; 5, Jecheon; 6, Danyang; 7, Samcheok.

Table 1. Chemical compositions of Indiana, Crinoidal, Dolomitic, Lithographic, and Argillaceous limestones, and chalk (%)*

Compositions	Indiana limestone	Crinoidal limestone	Dolomitic limestone	Lithographic limestone	Argillaceous limestone	Chalk
SiO_2	0.07	7.41	2.55	1.15	13.80	2.38
TiO_2	—	0.14	0.02	—	—	—
Al_2O_3	0.68	1.55	0.23	0.45	7.00	1.57
Fe_2O_3	0.08	0.70	0.02	—	4.55	0.56
FeO	—	1.20	0.18	0.26	—	—
MnO	—	0.15	0.04	—	0.29	—
MgO	0.59	2.70	7.07	0.56	1.32	0.59
CaO	54.54	45.44	45.65	53.80	38.35	52.48
Na_2O	0.16	0.15	0.01	0.07	2.61	—
K_2O	—	0.25	0.03	0.07	0.86	—
H_2O+	—	0.38	0.05	0.69	—	—
H_2O-	—	0.30	0.18	0.23	—	—
P_2O_5	—	0.16	0.04	—	0.25	—
CO_2	42.90	39.27	43.60	42.69	31.31	41.85
SO_3	0.06	0.02	0.03	—	—	—
S	0.25	0.25	0.30	—	—	—
Organic matter	—	0.09	0.04	—	—	—

* By Huang(1962)

analyses of P, of K and Na, and of Ca, Mg and Fe were carried out by spectrophotometry, flame photometry, and atomic absorption spectrophotometry, respectively. The nitrogen contents of the materials were determined by the micro-Kjeldahl method.

Soils were sampled in duplicate from areas, about $1m^2$, which seemed uniform and typical for the sites. The soil samples were taken A_1 horizon from 4 places within the square. A superficial layer of stones or plants and roots were removed before sampling. All analyses were carried out in duplicate on an air-dried fraction of the samples and on a fraction that had passed through a standard 2mm sieve.

Soil pH was determined in a 1 : 2.5 soil/distilled water mixture. Total nitrogen in soils was determined by the micro-Kjeldahl method. Exchangeable cation and hydrogen were analysed by the methods of Brown(1943). Available P was determined colorimetrically by using ammonium molybdate and stannous chloride. Exchangeable K, Na, Ca, Mg, and Fe were extracted by 1 N ammonium acetate solution of pH 7.0 and determined by flame photometry and atomic absorption spectrophotometry, respectively. Organic matter in soil samples was determined by loss on ignition in heating oven-dry soils in a muffle furnace at 550°~600° for not less than 6 hours.

RESULTS AND DISCUSSION

1. A feature of vegetation

Lime-chlorosis was clearly of widespread occurrence in calcareous areas of Korea during the period from May to September. The symptoms were characteristic of the younger leaves and the proportion of leaves affected was small, although locally chlorosis was severe. Chlorotic leaves were most noticeable during the spring flush of growth and early autumn, but were transient later in summer, being most apparent during the early part of the growing season.

Between 1975 and 1977, records of chlorosis were collected from 7 calcareous areas. Symptoms were observed in 60 species(Table 2). Striking differencn in chlorosis-susceptibility were apparent among species. Some showedno sign of chlorosis even when growing in close proximity to severely affected plants of other species.

Table2. A comparison of the incidence of lime-chlorosis in calcareous areas of Korea: 1, Weonju Ⅰ; 2, Weonju Ⅱ; 3, Yeongweol Ⅰ; 4, Yeongweol Ⅱ; 5, Jechcon; 6, Danyang; 7, Samcheok;

Species	Site						
	1	2	3	4	5	6	7
Artemisia annua	−	+	−	−	−	+	+
Artemisia asiatica	+		−	−	−	−	+
Artemisia feddi	+	−	−	−	−	−	−
Artemisia japonica	+	−	−	−	−	−	−
Arundinella hirta	−	−	−	−	−	−	+
Benzoin obtusilobum	−	−	−	−	−	−	+
Bidens biternata	−	−	−	−	−	−	+
Callicarpa japonica	−	−	−	−	−	−	+
Carpinus laxiflora	−	−	−	−	−	−	+
Castanea crenata	−	−	−	−	−	−	+
Chrysanthemum zawadskii ssp acutilobum	−	−	−	−	+	−	−
Chrysanthemum indicum	+	−	−	−	−	−	−
Clematis apiifolia	−	−	−	−	−	−	+
Cocculus triobus	−	−	+	−	+	−	−
Commelina communis	−	−	−	−	−	−	+
Duretia tricuspis	−	−	−	−	−	−	+
Equiselum arvense	+	+	−	−	−	−	−
Fagara mantchurica	−	−	−	+	−	−	−
Fragaria neglecta	−	−	−	+	−	−	−
Fraxinus rhynchophylla	+	−	−	−	−	−	−
Galium aerum	+	−	−	−	−	−	−
Geranium sibiricum	−	−	−	+	−	−	−
Humulus japonicus	−	−	−	−	−	−	+
Imperata cylindrica	−	−	−	−	−	−	+
Indigofera kirilowi	−		−	−	−	−	+
Isodon inflexus	+	−	−	−	−	−	−
Juglans mandsurica	−	−	−	−	−	−	+
Leibnitzia ananbria	+	−	−	−	−	−	−
Lespedeza bicolor	+	+	+	+	−	+	−
Lespedeza crytobotrya	−	−	−	−	−	−	+
Lespedeza maximowiczii	−	−	−	−	−	+	+

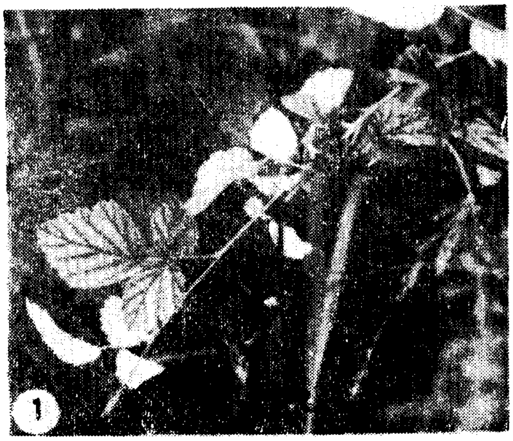
Species	Site 1	2	3	4	5	6	7
Ligustrum ibota var. *angustifolium*	−	−	−	−	−	−	+
Mentha sacharinensis	−	−	−	−	−	−	+
Miscanthus sinensis var. *purpurascens*	−	−	−	−	−		+
Polygonum longisetum	−	−	−	−	−	−	+
Polygonum perfoliatum	−	−	−	−	−	−	+
Phaseolus nipponensis	+	−	−	−	−	+	−
Porphyroscias decursiva	−	−	−	+		−	−
Potentilla flagayiodes	+	−	−	−	−	−	−
Pueraria thunbergiana	+	+	+	−	+	+	
Pursatilla darurica	−	−	+	−	+	−	
Quercus aliena	−	−	−	+	−	+	−
Quercus dentata	−	−	+	−		−	
Quercus mogolica		−	−	−	−		+
Rhus japonica	+	−	−	−		−	−
Rhus verniciflua	+	−	−	−	−	−	−
Ribes fasciculatum	−	−	−	−	−	+	+
Rubus crataegifolius	−	−	−	−	−	−	+
Rubus idacus	−	+	+	+	−	−	−
Rubus parvifolius	−	−	−	−	+	+	−
Salix gracilityla	+	−	−	−	−	+	−
Sanguisorba carnea	+	−	−	+	−	−	−
Saussurea pseudogracilis	+	−	−	−	−	−	−
Securinega subfruticosa	−	−	−	+	−	+	+
Smilax sieboldii	−	−	−	+	−	−	−
Spiraea prunifolia var. *simpliciflora*	+	−	−	+	−	+	+
Spodicpogon cotulifer	+	−	−	−	−	−	−
Stephanandra incisa	−	−	−	−	−	−	+
Thalitrum aquilegifolium	+	−	+	−	+	−	
Weigela florida	−	−	−	−	−		+

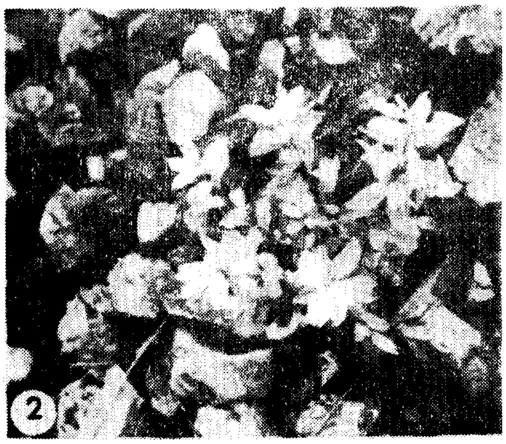
Chlorotic individuals of 21, 5, 7, 11, 6, 11 and 29 species of flowering plants were observed in the calcareous areas of Weonju I, Weonju II, Yeongweol I, Yeongweol II, Jecheon, Danyang and Samcheok during the survey, respectively. The results during this survey suggests that, with more extensive sampling elsewhere in Korea, the list of affected species could have been considerably. Among the species of common occurrence at 5 areas surveyed, *Lespedeza bicolor* and *Pueraria thunbergiana* were invariably included in the lists of chlorotic plants. Forty-two species were recorded as chlorotic on only one occasion. Phots 1 to 5 show examples of differences in the chlorosis-susceptibility of species growing in close proximity. Chlorosis was commonly observed in tree, shrub and herbaceous species, and often distributed asymmetrically in the canopy of a plant so that only one side or only certain branches were affected.

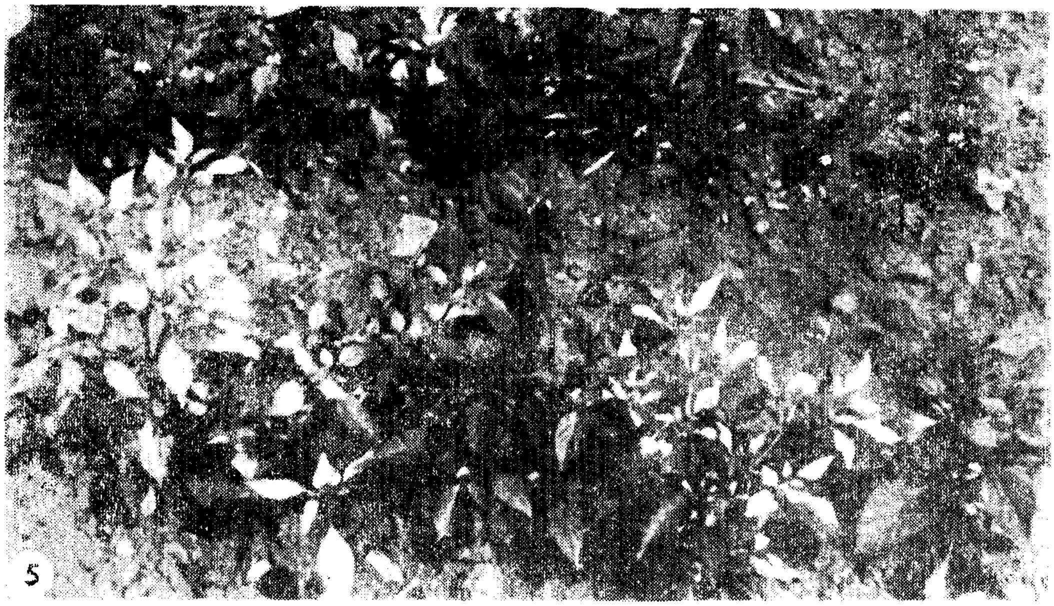
According to Davison(1964), and Grime and Hutchinson(1967), lime-chlorosis was clearly a seasonal phenomenon in that maximum intensities occurred during the May to June flush of growth and tended to disappear during the summer. These observations were consistent with the results obtained by this investigation. This survey revealed difference between species in the degree to which they were affected by chlorosis. Some of these differences may be ascribed to differences in root morphology. The asymmetrical distribution of chlorosis frequently observed in the canopy of individual plants suggests that some soil profiles are heterogeneous with regard to chlorosis potential and that differences in root distribution may be of critical importance(Grime and Hutchinson, 1967).

On theoretical grounds it seems possible that lime-chlorosis may play some part in the exclusion of calcifuges(Grime and Hutchinson 1967). In addition to effects arising from a reduction in chlorophyll content, chlorosis is coincident with root stunting(Hutchinson 1967 a) and with an increase in the susceptibility of the foliage to desiccation(Grime 1659; Hutchinson 1967 b). Therefore, an effect of lime-chlorosis may be to render calcifuges susceptible to desiccation. Droughts are of frequent occurrence on shallow calcareous soils.

Some of the species which were of wide spread occurrence in affected areas showed no sign of chlorosis. In this investigation, ***Pinus densiflora***, ***Viola albida***, ***Viola pachyrhiza***, ***Viola variegata*** var. ***chinensis***, ***Featuca ovina***, ***Koeleria gracilis*** and *Scabiosa mansenensis* did not show chlorosis in the calcareous areas of Korea. Anderson(1965) reported that *Festuca ovina* was the most abundant sepcies corresponding to mean percentage cover value of







Phot. 1. Lime-chlorosis in *Rubus parvifolius* from vegetation on calcareous soils in Jecheon.
Phot. 2. Lime-chlorosis in *Securinega subfruticosa* on limestones in Samcheok.
Phot. 3. Lime-chlorosis in *Ribes fasciculatum* from vegetation on calcareous soils in Danyang.
Phot. 4. Lime-chlorosis in *Spiraea pruniforia* var. *simpliciflora* on calcareous soils in Yeongweol Ⅱ.
Phot. 5. Lime-chlorosis in *Capsicum annuum* on agriculural field soils in Danyang.

63.23% in Monk's Dale. *Festuca ovina* and *Koeleria gracilis* were reported as species frequently growing in close association with chlorotic plants on screes and shallow rendzinas of Derbyshire limestone without sign of chlorosis(Grime & Hutchinson 1967). It suggests that no sign of chlorosis on the calcareous soils is a feature of the growth responses of calcicole plants.

2. Relationships between plants and calcareous soils

Results presented in Table 3 show the difference among the mean values of the various factors of calcareous soils in Korea. The pH of calcareous soils was frequently around neutral, though it approaches mild acidity in some instances. As shown in Table 3, water contents, organic matter contents, exchangeable H, exchangeable cation, available P, exchangeable K and exchangeable Na have no signinificant differences between calcareous soils-and granite soils in Mt. Kwangnung forests. However, exchangeable Ca and Mg contents, and Ca/Mg ratios were higher than those in granite soils.

The lime-chlorosis was often occured asymmetrically in the canopy of a herb, a shrub or a tree so that only one side or only certain branches were affected. *Capsicum annuum*, *Securinega subfruticosa* and *Quercus mongolica* were subject to severe lime-chlorosis of younger leaves. The comparison of the chlorophyll, carotenoid and inorganic components in the normal and lime-chlorotic leaves was given by Table 4. The contents of chlorophyll a and b in the lime-chlorotic leaves were about half in the normal. Carotenoid contents of lime-chlorotic leaves were lower than those of normal. The contents of N, P and Fe in lime-chlorotic leaves were lower than those in normal leaves but Ca and K were higher. The data from this experiment did not indicate any difference in sensitivity to Mg and Na deficiency on calcareous soils. It was analysed by Ivimey-cook(1965) that pH and Ca/Mg ratios in limestone of the Burren region of Co Clare were from 6.4 to 8.1 and from 1 to 17, respectively. Pigott(1979) reported that beneath the oaks in four sites above Coombs Dale analytical details were set out from 6 to 27 of Ca/Mg ratios. Those results

Table 3. Analytical information for soils in six calcareous areas and two areas of Mt. Kwanak and Kwangnung forests

Areas	Water contents %	Organic matter %	pH	Exchangeable H meq/100g	Exchangeable cation meq/100g	Total N %	Available P ppm	Exchangeable cations(meq/100g) Na	K	Ca	Mg	Ca/Mg	Exchangeable Fe ppm
Weonju I	32.31	6.09	6.21	10.34	7.70	1.09	1.02	0.16	0.18	4.63	0.20	23.15	0.45
Weonju II	27.15	4.72	7.22	3.39	9.60	0.14	1.68	0.17	0.17	5.12	0.26	19.69	0.37
Yeongweol I	18.71	3.52	6.78	3.96	10.78	0.16	0.82	0.12	0.19	1.40	0.16	8.75	0.86
Yeongweol II	24.36	2.47	6.92	4.42	8.53	0.20	1.97	0.09	0.16	1.02	0.09	11.33	0.92
Jecheon	21.19	3.63	7.26	6.60	22.85	0.20	6.67	0.17	0.29	8.41	0.36	23.36	0.25
Danyang	29.61	7.23	6.90	4.48	12.98	0.41	1.99	0.13	0.18	4.26	0.21	20.29	0.41
Mt. Kwanak	36.02	2.31	5.10	7.60	6.38	0.29	0.76	0.17	0.10	0.18	0.05	3.60	2.41
Kwangnung	22.50	6.23	6.80	4.57	8.95	0.97	0.95	0.10	0.21	0.51	0.13	3.92	1.93

Tbale 4. The comparison of the contents of chlorophyll, carotenoid and inorganic components in the normal and lime-chlorotic leaves of a herb, a shrub and a tree in the calcareous soils

Species	Normal Chlorosis	Chlorophyll a mg/10g fresh W.	Chlorophyll b mg/10g fresh W.	Carotenoid mg/10g flesh W.	N %	P ppm	K %	Ca ppm	Mg ppm	Na ppm	Fe ppm
Capsicum	Normal	7.79	5.79	0.68	5.39	1453	1.18	800	507	746	8
annuum	Chlorosis	3.61	2.63	0.44	4.98	506	1.74	1975	516	769	3
Securinega	Normal	8.40	5.10	1.06	4.05	1210	1.44	1475	200	943	12
subfruticosa	Chlorosis	4.02	2.34	0.76	3.83	456	1.63	2400	180	879	4
Quercus	Normal	9.33	6.40	1.62	3.51	169	1.79	375	141	786	7
mongolica	Chlorosis	5.05	3.44	1.32	3.48	91	2.07	952	136	1100	2

are in accordance with the data of Table 3.

Grime(1965) reported that addition of phosphate in presence of iron produced further increases in yield of two species of *Lathyrus*. Grime(1959) also pointed out that addition of chelated iron relieved the lime-chlorosis in *Hypericum pulchrum* and produced an increase in growth. Waters & Pigott(1971) reported that phosphate and chelated iron added in combination showed a strong positive interaction in promoting growth and flowering in *Hypericum humifusum* on one of the calcareous soils. According to Jeffrey & Pigott(1973), addition of calcium dihydrogen phosphate caused a large increase in the amounts of *Festuca ovina*. *F. rubra* and *Agrostis stolonifera* in a flushed site on sugar-limestone in Teedale in the northern Pennines and application of ammonium nitrate had little effect on the vegetation. This pattern of response is similar to that obtained by this investigation. The experiments described in this paper show that the essential mineral nutrients are usually substantially less soluble in water in alkaline than in acid conditions and calcifuges planted on calcareous soils often show visual symptoms resembling those of phosphate or iron deficiency.

Kim & Chang(1967) showed that foliar nitrogen and phosphorus of *Castenca crenata* displayed an inverse correlation with soil calcium level and so the level of soil calcium indirectly governs the height growth. As shown in Phot. 5. *Capsicum annuum* on the calcareous soils of agricultural fields in Danyang showed severe chlorosis of leaves. In severe cases, blanching of the laminae is followed by the death of shoot apices and by the appearance of brown patches in the marginal regions of the leaves. Crops which are affected may suffer a serious reduction in yield(Stewart & Leonard 1952).

要　約

本硏究는 1975~77年에 이르기까지 韓國의 石灰岩地帶의 植被에서 나타나는 植物의 白化現象을 조사하였으며 石灰質土壤과 植物과의 관계를 연구하였다.

원주 Ⅰ, Ⅱ지역, 영월 Ⅰ, Ⅱ지역, 제천, 단양 및 삼척의 石灰質 土壤에서 발달하고 있는 植被에서 60種의 植物이 白化現象을 나타내었으나 가지나 잎에서 部分的으로 일어나는 것이 보통이였다. 農作物인 고추도 백화현상이 심하게 일어나고 있었다. 그러나 김의털을 비롯한 數種의 植物은 전조사지역에 걸쳐 전혀 백화현상이 나타나지 않았다.

石灰質土壤, 白化葉 및 正常葉에 含有되어 있는 重要無機養分의 分析結果를 比較硏究한 結果, 석회질토양액의 알카리성때문에 P와 Fe의 不溶으로 야기되는 염석회식물들의 결핍증상으로 이들 石灰岩地帶에서 나타나는 식물의 백화현상을 생각할 수 있다.

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