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# Vesicular-Arbuscular Mycorrhizae in Some Plants (IV)

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# 몇 가지 植物 中의 Vesicular-Arbuscular Mycorrhizae에 關하여(IV)

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**ABSTRACT: Of the 103 species (41 families) sampled from two limestone sites in Korea, 98 species (95.1%) contained VA mycorrhizae. No mycorrhizal structures were observed in the other 5 species. The nonmycorrhizal species were members of the following 4 families: Equisetaceae, Davalliaceae, Amaranthaceae and Ericaceae. Of the 124 species (51 families) sampled from two different nonlimestone sites, 99 species (79.8%) were found to contain VA mycorrhizae and no mycorrhizal structures were observed in the other 25 species. The nonmycorrhizal species were members of the following 16 families: *Equisetaceae, Pteridacaea, Davalliaceae, Cyperaceae, Commelinaceae, Polygonaceae, Chenopodiaceae, Phytolaceaceae, Amaranthaceae, Aizoaceae, Portulacaceae, Caryophyllaceae, Fumariaceae, Cruciferae, Ericaceae and Rubiaceae.***

**KEYWORDS: VA mycorrhizae, Mycorrhizal structure, Limestone area**

The significance of mycorrhizae in association with higher plants has been reviewed by a number of investigators (Trappe, 1977, 1980; Aldon, 1978; Gerdemann, 1975; Smith, 1980). Since the majority of the world's plants are mycorrhizal, it is normally easier to list the plants that do not form mycorrhizae than the plants that do form mycorrhizal relationships. Vesicular-arbuscular (VA) mycorrhiza is the most commonly occurring form of mycorrhizae (Gerdemann, 1975). The mycobionts are chlamydosporic and azygosporic species of Endogonaceae; about 120 species are now recognized, but many more will be undoubtedly discovered (Schenck and Perez, 1988).

Species of more than 200 families and 1,000 genera of vascular plants from the tropics to the tundra have been examined for presence of mycorrhizae (Maeda, 1954; Gerdemann, 1968). Of these, only 14 families are regularly nonmycorrhizal. The *Pteridophyta, Cupressaceae, Taxodiaceae,* and most taxa of monocotyledons and dicotyledons characteristically have VA infections. Although the division of plant families into mycorrhizal and nonmycorrhizal groups was useful as a general rule, Gerdemann (1975) noted that the number of exceptions would likely increase as more species were examined. In our previous studies, nonmycorrhizal species found on some sites were members of *Amaranthaceae, Compositae, Convolvulaceae, Cruciferae, Equisetaceae, Euphorbiaceae, Gramineae, Labiatae, Liliaceae, Maluaceae Pedalidaceae, Polygonaceae, Portulacaceae,* and *Solanaceae* of herbaceous plants and *Pinaceae, Ericaceae, Ebenaceae,* and *Solanaceae* of arboreous plants (Kim and Lee, 1984a; 1984b; Kim and Ku, 1986).

This study was undertaken to test the hypothesis that the number of mycorrhizal plant species would increase as more species were examined. The other objective of the study was to determine the mycorrhizal status of colonizing

**Table I.** Vesicular-arbuscular mycorrhizal status of the plants collected from four sites.

| Plant species | Mycorrhizal status | | | |
|---|---|---|---|---|
| | Limestone area | | Nonlimestone area | |
| | Meapo | Youngwol | Pakdal | Kyeryong |
| Equisetaceae | | | | |
| *Equisetum arvense* | − | | − | − |
| Pteridaceae | | | | |
| *Pteridium aquilinum* var. *latiusculum* | | | − | − |
| Davalliaceae | | | | |
| *Davallia mariesii* | − | − | − | |
| Taxaceae | | | | |
| *Cephalotaxus koreana* | | | | + |
| Cupressaceae | | | | |
| *Thuja orientalis* | + | | | |
| *Juniperus rigida* | + | | | |
| Gramineae | | | | |
| *Cleistogenes hackelii* | + | | | |
| *Calamagrostis arundinacea* | | | | + |
| *Arthraxon hispidus* | | | | + |
| *Imperata cylindrica* var. *koenigii* | | | | + |
| *Paspalum thunbergii* | | + + | | |
| *Phyllostachy nigra* var. *henonis* | | | | + |
| *Pseudosasa japonica* | | | | + |
| *Setaria vividis* | + | + | | |
| *Setaria italica* | + | | | |
| *Zea mays* | + | | | |
| *Zoysia japonica* | | | | + |
| Cyperaceae | | | | |
| *Carex humilis* | | | | − |
| *Cares cilato-marginata* | | | | − |
| *Cares siderosticta* | + | | | |
| *Cyperus amuricus* | | | − | |
| *Cyperus difformis* | | | | − |
| *Kyllinga brevifolia* | + | | + | |
| Araceae | | | | |
| *Arisaema rubustum* | | | | + + |
| Commelinaceae | | | | |
| *Aneilema keisak* | | | | − |
| *Commelina communis* | + | | + | + |
| Liliaceae | | | | |
| *Allium thunbergii* | + + | | | |
| *Asparagus oligodonos* | | + | | |
| *Asparagus schoberioides* | + | | | + |
| *Convallaria keiskei* | + + | | | + |
| *Disperum smilacinum* | | | + | + |

**Table I.** (Continued)

| Plant species | Mycorrhizal status | | | |
|---|---|---|---|---|
| | Limestone area | | Nonlimestone area | |
| | Meapo | Youngwol | Pakdal | Kyeryong |
| *Hemerocallis liliosaphodelus* | | | + | |
| *Hemerocallis fulva* | | | | + + |
| *Hosta capitata* | | | | + |
| *Hosta clausa* var. *normalis* | | | + | |
| *Hosta minor* | | | | + |
| *Lilium tsingtauense* | | | | + |
| *Liriope spicata* | | | | + |
| *Liriope platyphylla* | | | | + |
| *Pisporum sessile* | | | | + |
| *Polygonatum involucratum* | + + | | | |
| *Seilla scilloides* | | | | + |
| *Smilacina japonica* | | | | + |
| *Smilax riparia* var. *ussuriensis* | | | + | |
| *Veratum meackii* var. *japonicum* | | | + | |
| Orchidaceae | | | | |
| *Liparis kumokiri* | | | + | |
| Ulmaceae | | | | |
| *Zelkova serrata* | | | | + |
| Urticaceae | | | | |
| *Boehmeria tricuspis* | | | | + |
| Polygonales | | | | |
| *Aconogonum polymerphum* | | + | + | + |
| *Persicaria conspicua* | | | | + |
| *Persicaria filiforme* | | | | + |
| *Persicaria nodosa* | + | | | + |
| *Persicaria perfoliata* | | | | + |
| *Persicaria senticosa* | | + | − | − |
| *Persicaria thunbergii* | + | | − | − |
| *Rumex crispus* | | + | | − |
| Chenopodiaceae | | | | |
| *Chenopodium album* var. *centrorubrum* | + | | | |
| *Chenopodium ficifolium* | | | − | |
| *Kochia scoparia* | | | + | + |
| Phytolaceaceae | | | | |
| *Phytolacca esculenta* | | | | − |
| Amaranthaceae | | | | |
| *Achyranthes japonica* | − | | | − |
| *Amaranthus lividus* | | − | | − |
| *Amaranthus mangostanus* | | | + | − |
| Aizoaceae | | | | |

**Table I.** (Continued)

| Plant species | Mycorrhizal status | | | |
|---|---|---|---|---|
| | Limestone area | | Nonlimestone area | |
| | Meapo | Youngwol | Pakdal | Kyeryong |
| *Mollugo pentaphylla* | | | | − |
| Portulacaceae | | | | |
| *Portulaca oleracea* | | + | | − |
| Caryophyllaceae | | | | |
| *Dianthus sinensis* | | | + | − |
| *Sagina japonica* | | | | + |
| *Stellaria aquatica* | | | | − |
| *Stellaria filicaulis* | + + | | | |
| Ranunculaceae | | | | |
| *Aconitum longecassidatum* | | | | + + |
| *Clematis mandshurica* | + | | | |
| *Hepatica asiatica* | | | | + + |
| *Thalictrum aquilegifolum* | | | + | |
| *Thalictrum punctatum* | + | | | |
| Lardizabalaceae | | | | |
| *Akebia quinata* | | | | + |
| Menispermaceae | | | | |
| *Cocculus trilohus* | + | | + | |
| *Menispermum dauricum* | | | | + |
| Lauraceae | | | | |
| *Lindera obtusiloba* | | | + + | |
| Fumariaceae | | | | |
| *Corydalis ochotensis* | | | | − |
| Cruciferae | | | | |
| *Arabis nipponica* | | | | + |
| *Berteroella maximowiczii* | + | | | |
| *Capsella bursa-pasteris* | | | | − |
| *Cardamine leucantha* | | | | + |
| *Rorippa indica* | | | | − |
| Saxifragaceae | | | | |
| *Hydrangea serrata foriacuminata* | | | | + |
| Rosaceae | | | | |
| *Agrimonia pilosa* | + | + | | + + |
| *Duchesnea chrysantha* | | | | + |
| *Fragaria ananssa* | | | + | |
| *Potentilla chinensis* | + | + | + + | |
| *Potentilla fragarioides* var. *major* | + | | | |
| *Potentilla freyniana* | | | + | |
| *Sanguisorba officinalis* | + + | | + | + + |
| *Spiraea chinensis* | + | | | |
| *Spiraea prunifolia* var. *simpliciflore* | | + | | |

**Table I.** (Continued)

| Plant species | Mycorrhizal status | | | |
|---|---|---|---|---|
| | Limestone area | | Nonlimestone area | |
| | Meapo | Youngwol | Pakdal | Kyeryong |
| Leguminosae | | | | |
| *Amphicarpacea edgavorthii* var. *thisperma* | | ++ | | + |
| *Cassra nomame* | | | + | |
| *Desmodium oxyphyllum* | | + | | + |
| *Glycine max* | ++ | | + | |
| *Indigofera kirilowii* | + | | | + |
| *Kummerowia stipulacea* | + | + | | |
| *Kummerowia striata* | + | | | |
| *Lespedeza cuneata* | + | | | + |
| *Lespedeza cyrtobotrya* | + | | | |
| *Lespedeza maximowiczii* | | + | | |
| *Lespedeza tomentosa* | + | + | | |
| *Lespedeza virgata* | + | + | | |
| *Pueraria thunbergiana* | + | + | + | ++ |
| *Robinia pseudoacacia* | + | | + | |
| *Sophora flavescens* | + | + | | |
| *Trifolium respens* | | | | + |
| Geraniaceae | | | | |
| *Geranium nepalense* subsp. *thunbergii* | | | | + |
| Rutaceae | | | | |
| *Zanthozylum schinifolium* | | | | ++ |
| Euphorbiaceae | | | | |
| *Euphorbia humifusa* | + | | | |
| *Securinega suffruticosa* | + | | | + |
| Buxaceae | | | | |
| *Buxus microphylla* var. *koreana* | | | + | |
| Anacardiaceae | | | | |
| *Rhus javanica* | + | + | + | + |
| Ceastraceae | | | | |
| *Euonymus alatus* | + | + | | + |
| Staphyleaceae | | | | |
| *Staphylea bumalda* | | | | + |
| Rhamnaceae | | | | |
| *Zizyphus jujuba* | + | ++ | | |
| Malvaceae | | | | |
| *Hibiscus trionum* | + | | | |
| Voilaceae | | | | |
| *Voila mandshurica* | + | | | ++ |
| *Voila variegata* | + | | + | |
| Thymeleaceae | | | | |
| *Diarthron linifolium* | + | | | |

**Table I.** (Continued)

| Plant species | Mycorrhizal status | | | |
|---|---|---|---|---|
| | Limestone area | | Nonlimestone area | |
| | Meapo | Youngwol | Pakdal | Kyeryong |
| Onagraceae | | | | |
| *Oenothera odorata* | + | | + | |
| Umbelliferae | | | | |
| *Angelica gigas* | | | | + |
| *Angelica decursiva* | | | | + + |
| *Peucedanum terebinthaceum* | | + + | | |
| Ericaceae | | | | |
| *Rhododendron mucronulatum* | − | | − | |
| Primulaceae | | | | |
| *Lysimuchia barystachys* | | + | | + |
| *Lysimachia mauritiana* | + + | | | + |
| *Naumburgia thysiflora* | | | + | |
| Styracaceae | | | | |
| *Styrax obassia* | | | + | |
| Oleaceae | | | | |
| *Ligustrum obtusilfolium* | | | | + + |
| Gentianaceae | | | | |
| *Swertia japonica* | + | | | |
| Asclepiadaceae | | | | |
| *Cynanchum atratum* | + | | | |
| *Metaplexis japonica* | + | + | | |
| Conoolvulaceae | | | | |
| *Calystegia japonica* | + | | | |
| Verbenaceae | | | | |
| *Caryopteris divaricata* | | | | + + |
| *Callicarpa japonica* | | | | + + |
| Labiatae | | | | |
| *Agastache rugose* | + | | | |
| *Clinopodium chinense* var. *parviflorum* | | | | + |
| *Isodon inflexus* | + | | | |
| *Leonurus sibiricus* | + | | | |
| *Mosla dianthera* | | | | + + |
| *Rabdosia japonica* | + | + | | |
| *Teucrium viscidum* var. *miquelianus* | | | | + + |
| Solanaceae | | | | |
| *Capsicum annuum* | | | | + |
| Scrophulariaceae | | | | |
| *Melampyrum roseum* var. *ovalifolium* | | | + | + |
| Pedalidaceae | | | | |
| *Sesamum indicum* | + | | | |

**Table I.** (Continued)

| Plant species | Mycorrhizal status | | | |
|---|---|---|---|---|
| | Limestone area | | Nonlimestone area | |
| | Meapo | Youngwol | Pakdal | Kyeryong |
| Plantaginaceae | | | | |
| *Plantago asiatica* | | + | + | |
| Rubiaceae | | | | |
| *Rubia akane* | + | + | | – |
| *Rubia cordifolia* var. *pratensis* | + | | + | + |
| Valerianaceae | | | | |
| *Patrinia rupestris* | + | | | |
| *Patrinia scabiosaefolia* | + + | + | + | + |
| *Patrinia villosa* | + + | | | |
| Cucurbitales | | | | |
| *Cucumis sativus* | | + | | |
| Dipsacaceae | | | | |
| *Scabiosa mansenensis* | | + + | | |
| Campanulaceae | | | | |
| *Platycodon grandiflorum* | + + | + + | | + |
| Compositae | | | | |
| *Artemisia capillaris* | | + | | + |
| *Artemisia japonica* | | + | | |
| *Artemisia montaua* | | + + | | |
| *Artemisia princops* var. *orientalis* | | + | | + |
| *Artemisia stolonifera* | | + + | + + | |
| *Aster ciliosus* | | | + + | |
| *Aster scaher* | | + + | + + | + |
| *Chrysanthemum zawadskii* | + | + + | | |
| *Cirsium japonicum* var. *ussuriensis* | | + | | |
| *Cosmos bipinnatus* | | + | | |
| *Erigeron annus* | + | + + | + + | + |
| *Filifolum sibiricum* | | + | | |
| *Inual salicina* var. *asiatica* | | + + | | |
| *Kalimeris yomena* | | + | | |
| *Leidniteia unandria* | + | | | |
| *Picris hieracioides* var. *japonica* | | | + | |
| *Rudbeckia bicolor* | | + | | |
| *Saussurea pulcholla* | | + | | |
| *Solidago virgauea* var. *asiatica* | | | + | |
| *Synenilesis palmata* | | | + + | + |
| *Synurus excelsus* | | + | | |
| *Xanthium strumarium* | + | + | | |
| *Yongia denticulata* | + + | | | |
| *Yongia sonchifolia* | + + | + | | + |

species in the soil of the limestone area.

## Materials and Methods

The surveyed sites consisted of rockwall, bare rock, bushy plants and limestone area which were located near a cement manufacturing plant; Meapo, Chungbuk (37'05'N, 128'19'E), and Youngwol, Kangwon (37'11'N, 128'19'E). Non-limestone area was also sampled for comparisons; Mt. Kyeryong, Chungnam (36'21'N, 127'13'E), and Pakdaljae, Chungbuk (37'09'N, 128'04'E).

Root and soil samples were collected from the root zone, 0-20 cm deep, under three plants of each species at each occurrence. The soil was arid and usually alkaline.

To assess mycorrhizal fungal colonization, 10 fine root segments, 1 cm in length, were excised from the lateral root specimens, washed, cleaned, and differentially stained with 0.05% trypan blue in lactophenol following the procedure of Phillips and Haymen (1970). The segments were mounted in clear lactophenol and examined for vesicles, arbuscules, and hyphae. A root segment was considered colonized when hyphae and/or one or more of these structures were observed. Mycorrhizal infection was scored according to the percentage of root length containing vesicles, arbuscules, and/or interal hyphae as either − (no infection), + (>50%), + + (<50%), based on a sampling of at least 10 cm of root.

## Results and Discussion

A list of the plant species sampled and their mycorrhizal status is given in Table I. Of the 182 species sampled, 157 species (86.3%) were found to contain VA mycorrhizae. No mycorrhizal structures were observed in the other 25 species. Nonmycorrhizal species are members of the following 16 families: *Equsisetaceae, Pteridaceae, Davalliaceae, Cyperaceae, Commelinaceae, Polygonaceae, Chenopodiaceae, Phytolaceaceae, Amaranthaceae, Aizoaceae, Portulacaceae, Caryophyllaceae, Fumariaceae, Crudiferae, Ericaceae and Rubiaceae.* But the degree of mycorrhizal infection varied greatly between plant species. For some species, mycorrhizal status was not consistent. *Cyperaceae, Commelinaceae, Polygonales, Chenopodiaceae, Caryophyllaceae, Cruciferae, and Ruabiaceae* were infected at two limestone locations. Trappe (1981) and our studies (Kim and Lee, 1984a; Kim and Ku, 1986) suggested that some species of nonmycorrhiza families might become mycorrhizal under some curcumstances. 99 (79.8%) of the 124 species examined in the nonlimestone area (Table I) showed infection in at least one of the sites selected, but 98 (95.1%) of the 103 species were found to contain VA mycorrhizae.

Lambert *et al.* (1980) have reported that mycorrhizal efficiency, the net benefit to the host plant of infection by mycorrhizal fungi, was a function of a particular set of soil and environmental conditions. Our data strongly uphold previous observations (Kim and Lee, 1984a; 1984b; Kim and Ku, 1986) that nonmycorrhizal species were taxonomically related. That is, the certain families possess some characteristic, morphologic or physiologic, which inhibits the formation of mycorrhizal associations. But a limestone weedy growth habit was not strongly linked to the nonmycorrhizal state. Soil texture and permeability (Trappe, 1981), water availability (Pendleton, 1981), and soil pH (Kucey and Diab, 1984) seemed extremely important on these limestone sites in determining the number and proportion of mycorrhizal colonizers.


## 摘 要

石灰岩지대의 두 地點에서 採集한 103種(41科)의 식물뿌리 標本 중에서 98種(95.1%)에서 VA mycorrhiza가 발견되었다. 그 밖의 5種에서는 菌根구조를 발견하지 못했다. 그 種들은 다음과 같은 科에 속하는 것들이다: *Equisetaceae, Davalliaceae, Amaranthaceae, Ericaceae.* 이것과 비교하기 위하여 石灰岩지역이 아닌 두 地點에서 採集한 124種(51科)의 標本 중에서 99種이 VA mycorrhiza였다. 25種은 Nonmycorrhiza였으며 그들은 다음과 같은 16科에 속하는 것이었다: *Equisetaceae, Pteridaceae, Davalliaceae,*

*Cyperaceae, Commelinaceae, Polygonales, Chenopodiaceae, Phytolaceaceae, Amaranthaceae, Aizoaceae, Portulacaceae, Caryophyllaceae, Fumariaceae, Cruciferae, Ericaceae, and Rubiaceae.*

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