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Bibliography on Vesicular Arbuscular Mycorrhizae

(1970-1982)

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Introduction

This bibliography on vesicular-arbuscular mycorrhizal associations was motivated by the lack of a single, comprehensive bibliographic source in a rapidly growing research area. The potential benefits of VA associations on food and tree crops offers an exciting challenge to agricultural researchers. Yet, precisely because it is a growing field, keeping abreast of new developments is increasingly difficult. It is hoped that this bibliography will be a tool to assist in that effort.

The bibliography contains 1235 references with abstracts and summaries of articles that appeared in the literature from 1970 to 1982. The author's personal collection forms the basis of the compilation. Various indexes, for example Biological Abstracts, Soil and Fertilizer Abstracts, Herbage Abstracts, and Field Crops Abstracts, were also consulted.

The bibliography is divided into ten sections based on subject content. Within each section the abstracts are arranged by year of publication, with the most recent publications listed first. At the end, an author index is included. Maria del Rosario Henao, of CIAT's Data Services Unit, collaborated in its production.

There may be still other publications—unknown or unavailable. The author will greatly appreciate receiving a reprint of any paper that is not included in this bibliography.

In most cases, the full text of the articles listed in this bibliography are available in photocopy from CIAT's library. Those references that have an asterisk (*) are NOT available.

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0001 ABBOTT, L.K.; ROBSON, A.D. The role of vesicular-arbuscular mycorrhizal fungi in agriculture and the selection of fungi for inoculation. Aust. J. Agric. Res. 33, 389-408. 1982.
Vesicular arbuscular (VA) mycorrhizas are roots infected with particular soil fungi which form symbiotic associations. It is often assumed that VA mycorrhizal fungi could be used to increase the efficiency of phosphate fertilizers in agriculture. Our principal concern is the question: 'Can the symbiosis be exploited on a large scale?'.
VA mycorrhizas increase nutrient uptake, and hence plant growth, by shortening the distance that nutrients must diffuse through soil to the root. Mycorrhizal roots do not appear to have a lower threshold concentration of nutrients for absorption from solution than do non-mycorrhizal roots. Most soils contain VA mycorrhizas. Hence, for plant growth to respond to inoculation with VA mycorrhizal fungi, agricultural soils must have either a low incidence of indigenous VA mycorrhizal fungi or alternatively, species which are less effective than the inoculant fungi in their ability to stimulate nutrient uptake by plants. The distribution of species of VA mycorrhizal fungi varies with climatic and edaphic environment, as well as with land use. However, the factors which control their distribution are poorly understood. Differences among VA mycorrhizal fungi in their ability to increase nutrient uptake appear to be due to differences in their ability to form mycorrhizas rapidly and extensively. The importance of other differences among the fungi, such as in the absorption of nutrients from solution or in the distribution and amount of esternal mycelium, has yet to be clearly demonstrated.
Inoculant VA mycorrhizal fungi must be capable of persisting in soils at a high inoculum potential, as well as being able to increase nutrient uptake. Until now, little attention has been paid to characteristics which enable the fungi to persist after inoculation.
We are critical of many of the methods employed in experiments aimed at selecting 'efficient' VA mycorrhizal fungi. For practical purposes, selection can only achieved by means of comparisons performed in untreated field soils, with phosphorus supply limiting plant growth.
Because the form of inoculum can affect the relative abilities of VA mycorrhizal fungi to infect and improve plant growth, appropriate inocula are needed for each agricultural situation. The survival of many species of fungi in various types of inocula requires further study so that procedures can be developed for introducing particular fungi into agricultural soils.
This review emphasizes many gaps in our knowledge. For example, we need more information on how and to what extent species or strains of VA mycorrhizal fungi differ in their ability to increase plant growth We know even less about their beneficial effects in years following that of field inoculation. The ecology of indigenous VA mycorrhizal fungi in field soils has also been largely neglected. These and other deficiencies preclude any immediate recommendations for large-scale inoculation with selected VA mycorrhizal fungi.

* **0002** FRANCE, ACADÉMIE D'AGRICULTURE DE FRANCE [Mycorrhiza.] Les mycorhizes. *Comptes Rendus des Séances de l'Académie d'Agriculture de France* (1982) 68 (5) 341-397 [Fr, 127 ref. Special Issue]

* **0003** HUGUENIN, B. [Mycorrhizas. IV. Mycorrhizas and the tropical world.] Les mycorhizes. IV. Les mycorhizes et le monde tropical. *Comptes Rendus des Séances de l'Académie d'Agriculture de France* (1982) 68 (5) 390-397 [Fr, 8 ref., 1 tab.] Office de la Recherche Scientifique et Technique Outre-Mer, Paris, France.
The physiological and ecological importance of some mycorrhizal interactions is discussed on the basis of results obtained in New Caledonia and Senegal.

* **0004** LYNCH, J.M. Microbe plant interactions. the rhizospere. In: Burns, R.G.; Slater, J.H. eds. Expt. Microbial Ecology. Blackwell Scientific Publications (Oxford) pp. 395-411. 1982.

* **0005** MENGEL, K.; KIRKBY, E.A. Principles of plant nutrition. Bern, Switzerland, International Potash Institute, 1982. pp.293-408.

* **0006** MILLER, O.K. 1982. Mycorrhizae, mycorrhizal fungi and fungal biomass in subalpine tundra at Eagle Summit Alaska. Holarctic Ecology, 5:125-134 (1982).

* **0007** POWELL, C.L. Microbe plant interactions- mycorrhizae. In: Burns, R.G.; SLATER, J.H. eds. Experimental microbial ecology Blackwell Scientific Publications (Oxford) pp. 431-446. 1982.

0008 RICHARDS, P.W. The enviroment In: Jordan, C.F. Ed. Tropical ecology. Stroudsburg, Penn, Hutchinson Ross, pp.246-254 1982.

* **0009** SCHENCK, N.C. Potential to increase production of edible bean on low phosphatic tropical soils. In: First Rep. on Trop. Agric. Res. under Pl-89-808 Section 406. pp. 19. 1982.

* **0010** STRULLU, D.-G. [Mycorrhizas. I. Mycorrhizal association.] Les mycorhizes. I. L'association mycorhizienne. *Comptes Rendus des Séances de l'Académie d'Agriculture de France* (1982) 68 (5) 344-360 [Fr, 62 ref., 2 fig.] Lab. Pl. Biol., Univ. Angers, France.
Topics discussed in this review include: partners in the symbiosis (plants, fungi); organization of mycorrhizal complexes (ecto- and endomycorrhizas); and relations between the partners (infrastructure of the interface and functioning of mycorrhizal symbiosis).

* **0011** TACON, F. LE [Mycorrhizas. II. Prospects offered by the use of mycorrhizas in forestry.] Les mycorhizes. II. Perspectives offertes par l'utilisation des mycorhizes en sylviculture. *Comptes Rendus des Séances de l'Académie d'Agriculture de France* (1982) 68 (5) 361-379 [Fr, 28 ref., 1 fig., 2 tab.] INRA, CNRF, Champenoux, Seichamps, France.
Topics discussed in this review include the role of mycorrhizas in the behaviour of forest trees, ecology of symbiotic forest fungi, mycorrhization in forest nurseries (inoculation techniques), behaviour of seedlings inoculated in the nursery after planting, and selection of symbiotic fungi.

* **0012** UK, ROTHAMSTED. Experimental Station Report for 1981, Part. I Harpenden (1982) Vesicular-arbuscular mycorrhiza pp. 209-212.

* **0013** YOST, R.S., FOX, R.L.; MURDOCH, C.L. ; HABTE, M. Alleviating phosphorus stress in crops: Quantifying the mycorrhizal effects. In: First report on Trop. Agric. Res. under Pl-89-808, Section 406, pp. 52-54 1982.

* **0014** BERINGER, J. E. Mycorrhizas and nitrogen-fixing symbioses. *Reference Book, Ministry of Agriculture, Fisheries and Food, UK* (1981) No.341, 62-69 [En, 18 ref.] Rothamsted Exp. Sta., Harpenden, Herts AL5 2JQ, UK.
The significance of rhizobium-legume and other N-fixing associations and of mycorrhizas in UK agriculture is discussed.

* **0015** DAVIES, F. T., JR. How to make the most of mycorrhizal fungi. *American Nurseryman* (1981) 153 (11) 9,38,40,42,44 [En, 5 ref., 4 fig.] Texas A & M Univ., College Station, USA.
Use of selected mycorrhizal fungi can improve plant

growth in the nursery production area and increase survival rates after planting, with lower energy requirements and production costs. Mycorrhizal types, inoculum and technological problems are discussed.

0016 EZETA, F.N.; CARVALHO, P.C.L. DE 1981. Micorrizas, uma simbiose indispensável para o crescimento da mandioca. (Mycorrhizae, an assential symbiosis for cassava development). Cruz das Almas-BA, Brasil, Empresa Brasileira de Pesquisa Agropecuária. Centro Nacional de Pesquisa de Mandioca e Fruticultura. Pesquisa em andamento no.5. 2p. Port.
The ability of cassava to grow and produce on low-fertility soils is briefly described. This characteristic has been attributed by investigators in physiology and nutrition to the efficient mycorrhizae in cassava which allow P and other nutrients to be extracted from very poor soils. Current research seeks to determine soil conditions that favor mycorrhiza formation and fungi species of greater affinity to form mycorrhiza in cassava.

0017 FURLAN, V.; FORTIN, J. A. **First international directory of mycorrhizae researchers. Quebec, Canada;** Université Laval. (1981) viii + 104 pp. [En, Price $6] Fac. For., Univ. Laval, Ste-Foy, Quebec GIK 7P4, Canada.
Researchers are listed by country, major and minor research interests and by name.

0018 HALL, I.R.; ABBOT, L.K. Photographic slide collection illustrating feature of the endogonaceae. 3rd Revision November 1981.

* 0019 HAYMAN, D.S. **Mycorrhiza and its significance in horticulture.** *Plantsman* (1981) 2 (4) 214-224 [En, 4 ref., 3 fig.] Rothamsted Exp. Sta., Harpenden, Herts., UK.
The main types of mycorrhiza are described with especial reference to vesicular-arbuscular mycorrhiza and their effect on the phosphate nutrition of the host and other host functions. The use of mycorrhizal inoculum to improve plant growth is described and several examples given where it has been successful in the field and glasshouse. Practical methods for handling and isolating mycorrhizal fungi are briefly described.

0020 Soils and plant nutrition. Host specificity. In *Cassava program, annual report 1980* Cali, Colombia;CIAT (1981) 69 [En]
In pot experiments to investigate host specificity, maize, bean [*Phaseolus vulgaris*], *Vigna unguiculata*, rice, *Andropogon gayanus, Stylosanthes guianensis* and cassava cv. CM 91-3 plants were grown without or with inoculation with cassava roots infected with mycorrhiza and with P added at 0, 100 or 200 kg/ha. DM production in rice was not affected by inoculation, but was greater with no P and markedly greater with 100 kg P/ha with than without inoculation in all other spp. Inoculation had no effect on DM production of *A. gayanus* or maize when 500 kg P/ha was added. Cassava was the sp. most dependant, taken over all P rates, on mycorrhiza, followed by *S. guianensis*, but their dependance was reversed without added P; with 100 kg P/ha *S. guianensis, A. gayanus* and *V. unguiculata* were more dependant on mycorrhiza than was cassava. Cassava when infected with mycorrhiza was more tolerant of low soil P than were all the other spp.

* 0021 JALALI, B. L.; THAREJA, M. L. **Progress report on the ICAR project on studies on the plant growth responses to vesicular-arbuscular mycorrhiza 1979-80.** Hissar, India; Haryana Agricultural University. (19817) 42 pp. [En, 22 tab.]
Results of studies on the effects of *Glomus* sp. on chickpea [*Cicer arietinum*], wheat and pearl millet [*Pennisetum typhoides*] grown in the infertile soils of Haryana, India are presented.

0022 LOPES, E. S.; SIQUEIRA, J. O. **Vesicular-arbuscular mycorrhizas — their potential in phosphate nutrition in tropical regions.** In *The soil/root system in relation to Brazilian agriculture [edited by Russell, r.S.; Igue, K.; Mehta, Y.R.]* Londrina, Brazil; Fundação Instituto Agronômico do Paraná (1981) 225-242 [En, pt, 65 ref.] Instituto Agronômico de Campinas, SP, Brazil.
Factors influencing the association of vesicular-arbuscular mycorrhizas with plant roots, specificity with regard to effectivity and the effectivenss of inoculation of *Glomus* spp. in sterilized and unsterilized soils, and under tropical agriculture are discussed.

* 0023 MOSSE, B.; HAYMAN, D.S. Mycorrhiza. In: Satchell, J.E. ed. Production ecology of an english oak wood. Springerverlag, Berlin. 1981.

0024 MOSSE, B. Vesicular-arbuscular mycorrhiza research for tropical agriculture. Hawaii Inst. Trop. Agric. and Human Resources. Univ. of Hawaii, Res. Bull. 194. 82p. 1981.
This report discusses some technical aspects of work with mycorrhiza, including methods of establishing pot cultures of different endophyte species, methods of inoculation and types of inoculum, and methods of evaluating soil infectivity and degree of mycorrhizal infection. Practical suggestions for the advancement of mycorrhizal research in tropical soils are also discussed. Roots of most plants form vesicular-arbuscular (VA) mycorrhizal associations with a group of phycomycetous soil fungi belonging to the Endogonaceae. The fungi cannot be cultured on synthetic media. Spores of these fungi in the soil can be multiplied in association with a host plant. Infection is confined to the primary cortex and is both inter and intracellular; the intracellular haustorial structures (arbuscules) are short-lived. VA mycorrhiza may have particular significance for tropical agriculture because P, even more than N, is often the nutrient most limiting growth in tropical soils.

0025 PIROZYNSKI, K. A. **Interactions between fungi and plants through the ages.** *Canadian Journal of Botany* (1981) 59 (10) 1824-1827 [En, fr, 11 ref.] Paleobiology Division, National Museums of Canada, Ottawa Ont., Canada K1A 0M8.
Most modern vascular plants form either endo- or ecto-mycorrhizal symbioses with fungi. Each condition has probably arisen in different groups of plants, at different times during their evolution, and with different consequences: the origin of vascular plants, the evolution of arborescent and herbaceous habits, and the differences in composition of forests are speculatively linked with mycotrophism.

0026 SPRENT, J.C. Nitrogen fixation In: Paleg, L.G. Aspinall, D. Eds. The physiology and biochemistry of drought resistance in plants New York, Academic Press, 1981 . pp. 131-143.

0027 TRAPPE, J. M. **Mycorrhizae and productivity of arid and semiarid rangelands.** In *Advances in Food-Producing Systems for Arid and Semiarid Lands, Part A [Manassah, J.T.; Briskey, E.J. (Editors)]* London, UK; Academic Press (1981) 581-599 [En, 85 ref.] Dep. of Bot. and Pl. Path., Oregon State Univ., Corvallis, OR 97331, USA.
The role of mycorrhizae in rangeland ecosystems is reviewed. A list of plants in which mycorrhizal associations have been found is presented and includes 32 grasses and 29 legumes.

0028 AZCON-G DE AGUILAR, C. BAREA, J.M. 1980. Micorrizas. Investigación y Ciencia. . Vol.47 8-16.

0029 BOWEN, G.D. Mycorrhizal roles in tropical plants and ecosystems. *In:* Tropical Mycorrhiza Research (Ed. by P. Mikola) Oxford Univ. Press Oxford, England. pp.165-190 (1980).

* 0030 BROWN, S.; STERNE, R. **Mycorrhizal fungi - beneficial infection.** *Arkansas Farm Research* (1980) 29 (6) 7 [En, 2 fig.] Univ. Arkansas Agric. Exp. Sta., Fayetteville, USA.
A brief account of the role of vesicular-arbuscular mycorrhizae in cotton production.

0031 SAFIR, G. R. **Vesicular-arbuscular mycorrhizae and crop productivity. 231-252 [En, approx. 100 ref.] In:** In: . CARLSON, P. S. (EDITOR) **The biology of crop productivity.** London, UK; Academic Press, Inc (London)

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Ltd. (1980) 471 pp. ISBN 0-12-159850-0 [En, Price £33.00]
Contributions on nitrogen fixation, nitrogen metabolism, drought tolerance and mycorrhizae are noted in the four following records.

0032 HAYMAN, D. S. Mycorrhiza and crop production. *Nature, UK* (1980) 287 (5782) 847-848 [En, 5 ref.] Rothamsted Experimental Station, Harpenden, UK.
An account and discussion of the nature of vesicular-arbuscular mycorrhizal fungi, their relationship and value to plants, and research on harnessing their advantages. Study should be focused on field situations where mycorrhizal benefits seem most probable, for example on wide expanses of tropical ferrolateritic soils which are deficient in and/or fix phosphate, and soils fumigated to remove plant pathogens (e.g. Californian peach and citrus nurseries).

***0033** IYER, J. G.; COREY, R. B.; WILDE, S. A. Mycorrhizae: facts and fallacies. *Journal of Arboriculture* (1980) 6 (8) 213-220 [En, 32 ref., 10 fig.] Univ. Wisconsin, Madison, USA.
The ephemeral nature of mycorrhizal short roots influenced in their development by radiation, soil drainage and eradicants is described. The need to investigate environmental conditions (including nutrient supply and absence of toxins from the soil) before inoculating soil, seed, or stock with mycorrhizal fungi is noted, with special reference to *Pinus* spp.

0034 JANOS, D.P. Mycorrhizae influence tropical succession. Tropical Succession: 56-95.1980. Most vascular plants depend to some extent on vesicular-arbuscular (V-A) mycorrhizae for mineral uptake, although a few species do not. Some mycotrophic plants cannot grow without mycorrhizae; others grow better without mycorrhizae in fertile soil, but benefit from mycorrhizae in poor soils. Thus, the mycorrhizal fungus content and the fertility of soil influence the ocurrence of plant species. Because V-A mycorrhizal fungi depend on mycotrophic plants for carbon, and because they produce few spores which may survive only a short time in the lowland humid tropics, plant community composition in turn affects the mycorrhizal fungus content of soil. This influences the further course of plant succession by affecting which species of plants can subsequently occur in the community.
Poor soils may favor alternate stable communities If mycorrhizal fungi are present, obligately mycotrophic species are the bext competitores and should dominate communities. They support an aboundance of mycorrhizal fungi, ensuring the continued superiority of obligate mycotrophs. If mycorrhizal fungi are absent, non-mycorrhizal species will comprise the community. Even if mycorrhizal fungi are subsequently introduced, these plants will not support them, favoring persistence of the non-mycorrhizal species. On fertile soils, facultative mycotrophs are most common. They will support infection if mycorrhizal fungi are available when the soils age and fertility declines, paving the way for their replacement by obligate mycotrophs. If mycorrhizal fungi are unavailable, facultatively mycotrophic species will be replaced by non-mycorrhizal plants. Non-micorrhizal plants may also derive competitive advantage where mycorrhizal fungi are present, from not needing to await ifection to start growing. Thus, pioneer species are often non-mycorrhizal. Seral species tend to be facultative mycotrophs, and most lowland tropical forest trees tend to be obligately mycotrophic. Ectomycorrhizal individuals are likely to occur in abundance in nutrient-starved or disturbed habitats, although ectomycorrhizal species are rare in the lowland tropics. Ectomycorrhizal associates may influence tropical succession by lowering populations of V-A mycorrhizal fungi.

0035 JEHNE, W. Endomycorrhizas and the productivity of tropical pastures: the potential for improvement and its practical realization. *Tropical Grasslands* (1980) 14 (3) 202-209 [En, 158 ref.] Div. of Trop. Crops and Pastures, St. Lucia, Qld., Australia 4067.
The potential of managing mycorrhizal symbiosis is examined as part of an alternative strategy in the P nutrition of pastures, energy and biomass crops in minimal input agriculture. The ability of endomycorrhizas to stimulate the nutrient uptake and growth of plants is reviewed. Increased tolerance of endomycorrhizal plants to environmental stress, disease and extreme soil conditions, their role in soil development and their relevance to the productivity and stability of tropical pastures is discussed. The feasibility and limitations of inoculating endomycorrhizas into soil is examined in relation to endomycorrhizas which naturally occur in most soils. Field studies have confirmed sustained responses in pasture growth due to endomycorrhizal inoculation, but inoculation alone may not be effective unless soil conditions are also conducive to effective symbiosis.

0036 HONGOS asociados en micorriza benefi cian el sistema radicular. Agricultura de las Americas 29(6):28-29. 1980.

0037 MARX, D.H. Role of mycorrhizae in forestation of surface mines. Proc. Trees for Reclamation, sponsored by Interstate Mining Compact Commission, and USDA Forest Service, Lexington, Kentucky October 27-28, 1980. pp. 109-116.
A brief introduction to ecto and endomycorrhizae and their importance to plants is presented. Recent findings confirm the significance of ectomycorrhizae, particularly those formed by Pisolithus tinotorius in nurseries, to survival and growth of pine seedlings on stripmined lands. Commercial inoculum of this fungus may be available in 1981. Recent research shows that edomycorrhizal fungi affect growth of grasses and certain hardwood trees on coal spoils.

0038 MEXAL, J. G. Aspects of mycorrhizal inoculation in relation to reforestation. *New Zealand Journal of Forestry Science* (1980) 10 (1) 208-217 [En, 33 ref., 3 fig., 2 tab.] Weyerhaeuser Company, Southern For. Res. Cent., Hot Springs, Arkansas, USA.
Included in this discussion are the type of inoculation and response of the host to inoculation. The direct impact of a mycorrhizal inoculation programme depends on the symbionts selected and site characteristics. Inoculation generally improves survival and growth following planting out. This advantage may be a function of the larger seedling size resulting from inoculation rather than from transplanting fungal inoculum to the forested site. Current problems and the future direction of any inoculation programme are outlined.

0039 MIKOLA, P., ed. Tropical mycorrhiza research. Oxford, England. Oxford Univ. Press. 1980. 270p.

0040 MOSSE, B.; HAYMAN, D.S. Mycorrhiza in agricultural plants. *In*: Tropical Mycorrhiza Research (Ed. by P. Mikola) Oxford Univ. Press Oxford, England. pp.213-230 (1980).

0041 MYSTERIOUS Mycorrhiza. Centerpoint. (AVRDC) 1980. 5,6. Fall 1980

***0042** NUHAMARA, T.S. Mycorrhiza: problems and prospects in Indonesia. BIOTROP Newsletter (Indonesia) no.34-35, p.4-5. 1980.
Mycorrhizae are a symbiotic association between the roots of higher plants (high symbiont) and a specific root-inhabiting fungus (low symbiont). In Indonesia mycorrhizae have always been associated with forestry, and are usually related to Pinus merkusii. Based on their structure and mode of infection, mycorrhizae can be classified into ecto, ectendo and endo-mycorrhizae. Most of the agricultural crops are associated with endo-mycorrhizae, while most of the forest trees are linked with ecto-mycorrhizae. A brief description is given of the problems and prospects of mycorrhizal

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similar but less marked. *G. margarita* in sterilized soil infected lettuce considerably less than other crops.

0043 OCAMPO, J. A. [VA mycorrhizae. I. General aspects.] Micorrizas VA. I. Características generales. *Anales de Edafología y Agrobiología* (1980) 39 (1/2) 351-365 [Es, en, Review, 86 ref.] Departamento de Microbiología, Estación Experimental del Zaidín, Granada, Spain.

The morphology of mycorrhizal hyphae, arbuscules and vesicles, the life cycle of the host/endophyte association, the taxonomy of the fungus and the occurrence of mycorrhizae within the plant kingdom are reviewed.

*0044 RAJ, D. J. B. Role of vesicular-arbuscular mycorrhiza in crop production. *Tobacco Research* (1980) 6 (1) 10-12 [En] Dep. of Agric. Microbiol., Univ. of Agric. Sci., GKVK Campus, Bangalore 560 065, Karnataka, India.

0045 RHODES L.H. The use of mycorrhizae in crop production systems. Outlook on Agriculture (UK) 10(6):275-281. 1980.

The role and function of mycorrhiza in plant production is reviewed. Attention is paid to types of mycorrhizae, especially the vesicular-arbuscular (VA) types, nutrient uptake by VA forms, mycorrhizal dependency of plants; association with root pathogens, and interaction with fertilizer use. Factors detrimental to VA mycorrhizae are discussed. The selection and production of mycorrhizal inocula are briefly reported.

0046 SHAMSUDDIN, M.N. Prospects of mycorrhizal inoculation of tin-tailings of Malaysia. *In*: Tropical Mycorrhiza Research (Ed. by P. Mikola) Oxford Univ. Press Oxford, England. pp.242-244 (1980)

0047 ST JOHN, T. V. Root size, root hairs and mycorrhizal infection: a re-examination of Baylis's hypothesis with tropical trees. *New Phytologist* (1980) 84 (3) 483-487 [En, 6 ref., 1 tab.] Instituto Nacional de Pesquisas da Amazônia, Manaus, Brazil.

A series of 89 Brazilian forest spp., for which root characteristics and vesicular arbuscular mycorrhizal condition were known, was used to test an aspect of the magnolioid root hypothesis. A non-parametric statistical test showed a significant association between magnolioid roots and heavy mycorrhizal infection, while spp. with graminioid-like intermediate roots tended to be uninfected.

*0048 TZEAN, S.-S.; HUANG, Y.-S. [Endomycorrhizal fungi – the beneficial partner of plants.] *NTU Phytopathologist & Entomologist* (1980) No.7, 27-30 [Ch, 6 ref.] Inst. of Bot., Academia Sinica, Taipei, Taiwan.

The endomycorrhizal fungi and their relationship with plants is briefly discussed with illustrations of the mycorrhiza in maize and their effect on growth.

*0049 ABBOT, L. K.; ROBSON, A. D.; PARKER, C. A. Double symbiosis in legumes — the role of mycorrhizas. 176-181 [En, 18 ref.]
In: BROUGHTON, W. J.; JOHN, C. K.; RAJARAO, J. C.; LIM, B. (EDITORS) Soil microbiology and plant nutrition. Kuala Lumpur, Malaya; University of Malaya Press. (1979) 640pp. [En]

*0050 COOPER, K. M. Mycorrhizas: their influence – past, present and future. *Royal New Zealand Institute of Horticulture Annual Journal* (1979) No. 7, 113-126 [En, 31 ref., 3 fig., 2 pl.] DSIR, Auckland, New Zealand.

A brief review. Members of the Orchidaceae and Ericaceae, onions, citrus and other mycorrhizal plants are mentioned.

*0051 FILIP, Z. [Mutual relationships between soil micro-organisms and plants - a review.] Wechselbeziehungen zwischen Mikroorganismen und Pflanzen-eine Übersicht. *Zeitschrift für Pflanzenernährung und Bodenkunde* (1979) 142 (4) 547-554 [De, en, Review, 33 ref.] Institut für landwirtschaftliche Mikrobiologie der Justus-Liebig-Universität Giessen, Senckenbergstr. 3, 6300 Giessen, German Federal Republic.

The topics considered are: the rhizosphere: mycorrhizae; N-fixing micro-organisms; plant pathogens.

*0052 ITALY, BOTANICAL SOCIETY OF ITALY Abstracts of papers presented at the Third Annual Meeting of the Section of Cytology of the Botanical Society of Italy, Trieste, June 1978. *Caryologia* (1979) 32 (1) 119-132 [En]

Abstracts of sixteen papers are presented, the following two of which deal with mycorrhizae:

Light and electron microscope features of the vesicular-arbuscular mycorrhiza in *Vitis* roots.

Preliminary data on the cytological organization of *Calluna vulgaris* mycorrhiza.

*0053 MAHONEY, M. P.; NEMEC, S. Researching the super soils to improve plant nutrition. *Citrus & Vegetable Magazine* (1979) 43 (4) 8, 21 [En] USDA, Orlando, Florida, USA.

A brief outline of the role of mycorrhizae in plant nutrition, including improved root systems and enhanced water and P uptake. Citrus seedlings inoculated with *Glomus etunicatus* in a greenhouse and transplanted to the field grew 1.9-fold taller than non-inoculated plants in methyl bromide-treated sites. Sour orange and Cleopatra mandarin rootstocks were more responsive than Carrizo citrange and Cleopatra mandarin.

0054 MOAWAD, M. [Use of vesicular-arbuscular mycorrhiza in tropical agriculture.] Nutzung der vesikulär-arbuskulären Mykorrhiza im tropischen Pflanzenbau. *Angewandte Botanik* (1979) 53 (1/2) 99-109 [De, en, 24 ref., 8 fig., 1 tab.] Inst. für Tropischen und Subtropischen Pflanzenbau, Univ. Göttingen, German Federal Republic.

The ability of the mycorrhiza to make phosphorus from insoluble phosphates available to plants offers a possible way to overcome the problem of phosphorus nutrition in acid soils in the humid tropics. The factors influencing efficacy of the mycorrhiza, soil temp. and pH, water regime, light intensity, host specificity, and measures for practical economic application of these symbiotic fungi are discussed.

0055 MOORE, P. D. Mycorrhizal associations. *Nature, UK* (1979) 282 (5741) 780 [En] Department of Plant Sciences, King's College, London, UK.

Grimes' hypothesis that mycorrhizal associations, particularly of an ectotrophic type, are to be expected amongst plant species adapted to nutrient stresses is discussed.

0056 MORANDI, D.; GIANINAZZI, S.; GIANINAZZI-PEARSON, V. Interet de l'endomycorhization dans la reprise et la croissance du Frasmboisier issu de multiplication vegetative in vitro. Interest of using endomycorrhizae for the establishment and growth of axenically propagated rasberry plants after transplanting. Ann. Amelior. Plantes 1979. 29(6) 623-630.

Vegetative propagation in axenic culture is more and more widely used to rapidly produce high quality, healthylplants. However, such plants risk to be highly susceptible to different stresses occurring during their transplant into the soil. Since VA endomycorrhizas play a vital role in plant nutrition and survival, their infuence on the establishment and growth of axenically porpagated raspberry plants after transplanting was studied. In all experiments, and independent of the culture conditions (growth room, galsshouse). growth of raspberry plants was better when they were inoculated with a mycorrhizal fungusat the moment of transplant from the culture tubes into soil; mycorrhizal infection levels were high (80-90 p. 100 roots infected) and the mycorrhizal raspberries were more vigourous (Fig.1) and more uniform in size than nonmycorrhizal controls. Shoot dry weight production of the variety "Bois Blanc" transplanted into an acid soil was increased by 71p. 100 when inoculated with Glomus tenuis; for the variety "Nagymarosi", cultivated in a neutral soil, shoot dry weight increases were 53 p. 100 and 130 p. 100 after inoculationwith G. mosseae and G. fasciculatus respectively. Increased NK fertilisation improved this mycorrhizal effect and growth stimulations, as compared to nonmycorrhizal controls, were + 209 p. 100 for a first crop and + 174 p.100 for a second crop (regrowth after cutting first crop) of the

variety "Nagymarosi" infected by G. fasciculatus. These results clearly demostrate the potential interest of using endomycorrhizae to improve the establisment and growth of axenically propagated raspberries after transplanting.

0057 Mycorrhizae in horticultural crops (1972-1978). *Commonwealth Agricultural Bureaux Annotated Bibliography, Plant Series* (1979) No. C 16/79, 18 pp. [En]

The bibliography contains 109 abstracts selected from Horticultural Abstracts vols. *43-49*(5).

0058 REDHEAD, J.F. Soil mycorrhiza in relation to soil fertility and productivity. ICRAF, 1979. Nairobi. pp. 175-204. Soil Research in Agroforestry . 1979.

All tropical trees that have so far been studied grow in association with mycorrhizal fungi and all important tropical food crops are mycorrhizal Further studies are needed in savanna types of vegetation. The vesicular-arbuscular mycorrhizal association formed by species of Endogonaceae is universal.

Apart from the important genus Pinus and some species in the families Myrtaceae (some Eucalyptus spp.). Caesalpiniaceae and Dipterocarpaceae, records of ectotropical mycorrhizal associations are infrequent for tropical plants. The mycorrhizal association is essential for the growth of some genera under field conditions, e.g. Citrus and Pinus, but information is lacking for most other important genera. There is a need to study natural mycorrhizal associations and, through experiment, match the fungi and higher plants most suited to each other under particular ecological environments. Agroforestry research should consider the tripartite relationship soil/plant/fungus rather than only the soil/plant relationship. Selected fungal inocula should be multiplied and tested in crop plants under tropical conditions, both in the nursery and the field. Research is also needed to monitor the effect of soil sterilants and fungicides on the mycorrhizal relationship. Facilities and staff training in these areas should be strengthened so that more emphasis can be given to this work in tropical environments.

0059 RUEHLE, J. L.; MARX, D. H. **Fiber, food, fuel, and fungal symbionts.** *Science, USA* (1979) 206 (4417) 419-422 [En] Inst. for Mycorrhizal Res. and Dev., Forest Serv., USDA, Athens, GA 30602, USA.

Aspects of ectomycorrhizae, endomycorrhizae and the relationship between fungal symbiont and host (including crop spp.) are reviewed and discussed. Imperatives for mycorrhizal research in forestry and agriculture are outlined.

0060 SILVESTER-BRADLEY, R. Monitoring soils in agroforestry: soil biology and biochemistry. (Control de suelos agroforestales biología del suelo y bioquímica). In Mongi, H.O.; Husley, P.A. eds. Soils research in agroforesty, Nairobi, Kenya, 1979. Proceedings. Nairobi, International Council for Research in Agroforestry. Serie ICRAF-OOLE, 1979, pp.381-411. [En]

The necessity of studying only certain aspects of soil biology biochemistry, and of restricting the choice of techniques for their study are discussed. Aspects of soil biology and biochemistry are selected on the basis of their known importance to plant production in the tropics and the availability of suitable methods to study them. Methods for the study of nitrogen fixation associated with legume and grass roots, other nitrogen-fixing systems, endomycorrhizae, ectomycorrhizae, phosphate solubilizing bacteria, root distribution, root exudation, denitrification nitrification, soil respiration, decomposition, microbial biomass, and the soil fauna are described briefly and discussed. The importance of designing long field experiments with the study of soil biological properties in mind, is emphasized, and some possible experiments and sampling programmes suggested. Examples are drawn from Amazonia. Pathogenic organisms are not included.

Se discute la necesidad de estudiar sólo ciertos aspectos de la biología y bioquímica del suelo y de restringir la selección de técnicas para su estudio. Se seleccionan aspectos de la biología y bioquímica de suelos con base en su importancia para la producción vegetal en los trópicos y la disponibilidad de métodos apropiados para su estudio Se describen brevemente y se analizan los métodos para el estudio de la fijac . de N asociada con las raíces de leguminosas y gramíneas, otros sistemas de fijación de N. endomicorrizas, ectomicorrizas, bacterias que solubilizan fosfato, distribución de las raíces, exudación radical desnitrificación, nitrificación, respiración del suelo, descomposición, biomasa microbiana y fauna del suelo. Se enfatiza la importancia de diseñar experimentos de campo prolongados considerando el estudio de las propiedades biológicas del suelo, y se sugieren algunos expt. posibles y programas de muestreo. Los ejemplos provienen de la Amazonía. No se incluyen los organismos patogénicos.

0061 Soil microbiology department. VA mycorrhiza. 233-239 [En]

In: UK, ROTHAMSTED EXPERIMENTAL STATION **Report for 1978. Part 1.** Harpenden, Herts, UK. (1979) 358pp. [En, ref. at ends of sections, Price £5.00 (Parts 1 and 2)] Rothamsted Exp. Sta., Harpenden, Herts AL5 2JQ, UK.

Work is reported on the development of VA mycorrhiza in plants fed with nutrient sol. in sand and nutrient film culture, factors affecting the spread of endophytes, the effect of pesticides on VAM, mycorrhizal development in host and non-host plants grown together or in succession, and field inoculation trials. Spp. studied included maize, white clover, *Trifolium dubium*, red fescue, perennial ryegrass and lucerne.

***0062** VENKATARAMANAN, M. N.; SATYANARAYANA, G. **Mycorrhiza – a general consideration.** *Two and a Bud* (1979) 26 (2) 64-66 [En, 17 ref., 1 fig.] Tea Res. Ass., Tocklai, Jorhat, India.

This brief review includes a note on the limited information available on mycorrhizal associations of tea.

0063 ANDREW, C.S.; JONES, R.K. The phosphorus nutrition of tropical forage legumes. *In* Andrew, C.S. and Kamprath, E.J., eds. Workshop on Mineral Nutrition of Legumes in Tropical and Subtropical Soils, Brisbane, Australia, 1978. Proceedings. Melbourne, Australia, Commonwealth Scientific and Industrial Research Organization, 1978. pp.295-311. No. 12417.

This review of the P nutrition of tropical forage legumes is based on the factors involved in, (a) the absorption of P (size, distribution, fineness and efficiency of root systems), (b) utilization of P (translocation, growth rate, response, efficiency of P utilization), (c) interaction with other nutrients and elements, and water, and (d) efficiency of utilization of various forms of P fertilizer. Comparative species data are used where available, and discussion follows on possible reasons for differences between and within species. Symbiosis of legume - *Rhizobium* and legume - mycorrhiza are discussed in relation to soil-plant P relationships.

0064 BROADENED Knowledge; mycorrhizae help crops tape phosphorus from infertile soils CST Newsletter 2(4):20-21 1978.

0065 COMMONWEALTH BUREAU OF SOILS **Mycorrhizas and plant nutrition, 1928-1963. (A reprinting of material originally published in Annotated Bibliographies Nos. 75 and 653).** *Annotated Bibliography, Commonwealth Bureau of Soils* (1978) S653R, 30 pp. [En, 172 ref., Price £5.00 UK (£6.00 Overseas)].

0066 COMMONWEALTH BUREAU OF SOILS Mycorrhizae: soil and plant relationships. *Annotated Bibliography, Commonwealth Bureau of Soils* (1978) No.SA2003, 43pp. [En, 99 ref., Price £4.00 UK, £4.80 overseas] Rothamsted Exp. Sta., Harpenden, Herts AL5 2JQ, UK.

This contains copies of relevant abstracts from *Soils and Fertilizers* and covers 1973-7; abstracts are arranged under the headings: general; trees and shrubs; non-woody plants.

0067 COMMONWEALTH BUREAU OF SOILS Mycorrhizae: effects on plant nutrition and growth. *Annotated Bibliography, Commonwealth Bureau of Soils* (1978) No.SA2002, 24pp. [En, 58 ref., Price £3.50 UK, £4.20 overseas] Rothamsted Exp. Sta., Harpenden, Herts AL5 2JQ, UK.

This contains copies of relevant abstracts from *Soils and Fertilizers* and covers 1973-7.

*0068 GRASSLANDS DIVISION, DSIR Research Report 1978. Wellington, New Zealand, DSIR. (1978) 80pp. [En, many ref.] DSIR, Palmerston North, New Zealand.

This report is the 1st of its type produced by the Grasslands Division to celebrate 50 yr of research by the Department of Scientific and Industrial Research in New Zealand. Of the sections reported the following 8 are noted.

Lincoln Regional Station. 54-60 [En]

Work at this station in South Island is split into 7 sections. Lowland research on the Canterbury Plains includes lucerne and grass/clover pasture evaluation for irrigated and non-irrigated dryland sites, seed production of grasses and legumes, N fixation in ryegrass/white clover with irrigation or on dryland sites and leaf protein extraction. High country research in the Mackenzie Basin includes the management of existing tussock grassland and its improvement by oversowing as related to soil and climate, the influence of native vegetation on oversown seed, plant introduction and cv. testing, improvement by fertilizers and grazing, the mineral nutrition and winter feeding of sheep, growth potential under irrigation, bee pollination of red clover cv. Grassland Pawera, endomycorrhizas and legume seed coating with *Rhizobia*.

0069 DOMMERGUES, Y. R.; KRUPA, S. V. [EDITORS] Developments in agricultural and managed-forest ecology. 4. Interactions between non-pathogenic soil microorganisms and plants. Amsterdam, Netherlands; Elsevier Scientific Publishing Company. (1978) 475pp. ISBN 0-444-41638-2 [En, ref. at ends of chapters, Price f195.00] CNRS/ORSTOM, Dakar, Senegal.

In: This book covers all aspects of plant interactions with non-pathogenic soil microorganisms and has chapters entitled: the plant/microorganism system, growth and structure of roots, physiology of roots, nutrient uptake, root exudates and exudation, energy flow in the plant/microorganism system, the rhizosphere, ecology of the legume root nodule bacteria, physiology of legume symbiosis, root nodule symbiosis in non-leguminous N-fixing plants, mycorrhizae, and the impact on soil management and plant growth. Each chapter is contributed by scientists from different fields of research throughout the world.

0070 HAYMAN, D.S. Endomycorrhizae In: Dommergues, Y.R.; Krupa, S.V. eds. Interactions between non-pathogenic soil microorganisms and plants. Elsevier, Comp. Oxford, 1978. pp.401-442

0071 HAYMAN, D. S. Mycorrhizae. B. Endomycorrhizae. *Developments in Agricultural and Managed-Forest Ecology* (1978) No.4, 401-442 [En, Review, 7pp. of ref.] Rothamsted Experimental Station, Harpenden, Herts. AL5 2JQ, UK.

0072 PARKINSON, D. The restoration of soil productivity. 213-228 [En, 37 ref.] Dep. of Biol., Calgary Univ., Calgary, Alberta, Canada T2N 1N4.

In: HOLDGATE, M. W.; WOODMAN, M. J. (EDITORS) The breakdown and restoration of ecosystems. New York, USA; Plenum Press. (1978) 496pp. ISBN 0-306-32803-8 [En, ref. at ends of chapters] Inst. of Terrestrial Ecol., Cambridge CB2 1LA, UK.

The effects of natural soil devastation (flooding, fire) and man-made devastation (oil spillage, coal mining) on root-microbe interactions (including mycorrhizal and *Rhizobium* interactions) are discussed.

0073 MEDVE, R.J. Mycorrhiza: A common form of mutualism. American Biology Teacher 40:414-418. 1978.

0074 MUNNS, D.N.; MOSSE, B. Mineral nutrition of legume crops. In: Summerfield, R.J.; Bunting, A.H., eds. International Legume Conference, Kew, England, 1973. Advances in legume science, Proceedings. Kew, England, Royal Botanical Gardens, 1978. v.1. pp.115-125.

Se revisan algunos aspectos de la nutrición mineral de las leguminosas, particularmente en relación con la fijación simbiótica de N por los nódulos de las raíces y la asociación simbiótica con la micorriza vesículo-arbuscular. Se consideran los efectos residuales de la rizosfera en la absorción de nutrimentos, así como los requerimientos particulares y la tolerancia de algunas especies de leguminosas y de *Rhizobium* cultivado aisladamente o en asociación con las planta hospedante. Se discuten los principios básicos del funcionamiento de los sistemas micorrizales con referencia especial a los efectos de la mejor absorción de P en la fijación de N.

*0075 POWEL, C.L. The importance of mycorrhizal fungi in New Zealand farming. In *Proceedings of the 28th Lincoln College Farmers' Conference, 8-10 May, 1978.* (undated) 34-46 [En] Ruakura Agric. Res. Centre, Hamilton, New Zealand.

The importance of mycorrhizal fungi in New Zealand is reviewed with reference to their effect on plant growth. It is concluded that they are the main P absorbing system for legumes in soil and are also important for grasses. In glasshouse trials at Ruakura efficient fungi were successfully inoculated into field soils resulting in large persistent increases in plant growth and P uptake. Ryegrass seedlings were also successfully inoculated with *Gigaspora margarita* or indigenous mycorrhizal fungi which increased recovery of residual and fertilizer P. Field trials are being carried out on oversowing clover and ryegrass seed heavily coated with mycorrhizal inoculum. Future research suggestions are given.

*0076 SANDERS, F. E.; HAYMAN, D. S. The agricultural importance of vesicular-arbuscular mycorrhiza. In *Advances in Agriculture. Proceedings of Section M Agriculture. 139th Annual Meeting of the British Association for the Advancement of Science, University of Aston, Birmingham, UK, 1977 (Hayes, W.A., Editor).* (1978) 123-139 [En, 49 ref.] Department of Plant Sciences, University of Leeds, Leeds, UK.

The physiology of the VA mycorrhizal association and agricultural factors affecting mycorrhizal population are discussed. The potential of VA mycorrhiza for improving soil phosphate utilization has been shown experimentally for several crops. Much more experimental and ecological work is necessary before this potential can be harnessed on a field scale.

*0077 USA, UNIVERSITY OF KENTUCKY, AGRICULTURAL EXPERIMENT STATION 90th Annual report for the year ending December 31, 1977. Lexington, Kentucky. (1978) 179 pp. [En, 12 pl.]

[Trees and shrubs.]

Growth and cold hardiness of container-grown nursery crops; mycorrhizal fungi for reforestation after surface-mining; effect of electromagnetic field treatment on seed germination; propagation of *Acalypha* sp. and *Aesculus rubra* by tissue culture.

0078 ROVIRA, A. D. Microbiology of pasture soils and some effects of microorganisms on pasture plants. 95-110 [En, 92 ref.] Div. of Soils, CSIRO, Glen Osmond, S.A., Australia 5064.

In: WILSON, J. R. (EDITOR) Plant relations in pastures. Melbourne, Australia; CSIRO. (1978) 439pp. ISBN 0-643-00264-2 [En, ref. at ends of chapters, Price $A25.00] Div. of Trop. Crops and Pastures, CSIRO, Brisbane, Qld., Australia 4067.

Aspects of non-symbiotic N_2 fixation, endotrophic mycorrhiza, root pathogens and allelopathy and their effects upon pasture production are discussed.

*0079 BARROW, N. J. (Div. Land Resour. Manage., CSIRO, Priv. Bag, P.O., Wembley, West. Aust. 6014, Aust.) Phosphorus uptake and utilization by tree seedlings. AUST J BOT 25(6): 571-584. 1977[recd. 1978].—Seedlings of 5 native forest species and of *Pinus radiata* D. Don were grown in pots in a forest soil at a range of levels of added phosphate for up to 20 wk. At intervals of 3 wk, roots were examined for root hairs and mycorrhizas and the weights

of plant parts and their P contents were measured. Components of growth and response were calculated from 3-dimensional surfaces which had level of phosphate and time as the independent variables. Except for *Banksia grandis* Willd., the species responded to phosphate but the time at which the response appeared was affected by seed reserves of P. Thus response appeared much earlier for the small-seeded *Eucalyptus diversicolor* F. Muell. and *Acacia pulchella* R. Br. than for the large-seeded *E. calophylla* R. Br. and *E. marginata* Donn. ex Sm. The absence of a response by *Banksia* seemed to arise because of a large seed reserve of P, a low relative growth rate and a very low concentration of P in the leaves for maximum photosynthesis. The rates of uptake of P per unit weight of roots were generally low but increased at a time coincident with the development of mycorrhizas. Relative growth rates and the net assimilation rates were also low and reached maximum values at low concentrations of P in the leaf. The outcome was that the level of applied phosphate needed for good early growth did not differ greatly from that of *Trifolium subterraneum* L.

0080 COOKE, R. Endomycorrhizas. In: The biology of symbiotic fungi. Cooke, R. ed. John Wolly & Sons. London pp.203-225. 1977.

0081 Introducing the VA mycorrhiza - CSIRO, Canberra, Australia - *Rural Research (Austr ilia)* no. 94, p. 25-28; Mar 1977 [En] fig, photos (some coloured), 3 ref.

Soil Biology *mycorrhiza*, Plant Nutrition *phosphorus*, AUSTL

In Australia, investigations revealed that many strains of VA-mycorrhiza fungi ("internal mycorrhizas") can infect a wide range of different plants. Since some of them excel in providing nutrients to their host, it might become possible to grow high-yielding crops, e.g. grain legumes, on P-defective soils with lower rates of P-fertilizer. But as is the case with Rhizobium bacteria, excellent strains may be poor competitors. This and other problems related to research on and the effective functioning of these fungi are discussed to some length.

0082 MEDVE, R.J.; HOFFMAN, F.M.; GAITHER, T.W. 1977. The effects of mycorrhizal-forming amendments on the revegetation of bituminous stripmines spoils. Bulletin of the Torrey Botanical Club, 104:218-225 (1977).

***0083** MENGE, J.A.; LEMBRIGHT, H.; JOHNSON, E. L.V. 1977. Utilization of mycorrhizal fungi in citrus myseries. Proc. Int. Soc. Citriculture 1: 129-132.

***0084** MENGE, J. A.; LEMBRIGHT, H.; JOHNSON, E. L. V. **[Utilization of mycorrhizal fungi in citrus nurseries.]** 129-132 [32 ref., 1 fig.] California University, Riverside, CA 92521. USA.

In: INTERNATIONAL SOCIETY OF CITRICULTURE **Proceedings of the International Society of Citriculture. 1977.** Volume I. PO Box 1088, Lake Alfred, Florida, USA. (1977) 323 pp. [En]

Stunting and nutrient deficiency symptoms in citrus have been associated with lack of mycorrhizal fungi in fumigated soils. The possibilities are examined of various methods of production of mycorrhizal inoculum and inoculation of citrus on a commercial scale.

***0085** MEYER, F. H. **[E. Geobotany. 4. Symbiosis: mycorrhiza.]** 4. Symbiosen: Mykorrhiza. *Progress in Botany* (1977) 39, 283-293 [De, 3pp. of ref.] Institut für Landschaftspflege und Naturschutz, Technische Universität Hannover, 3000 Hannover, German Federal Republic.

Endo- and ectomycorrhizal symbiosis is reviewed with particular reference to symbiotic partners, structure, physiology and effect on host plants, including grasses, forage legumes, potato, tobacco, and *Phaseolus* spp.

0086 MOSSE, B. The role of mycorrhiza in legume nutrition on marginal soils. Rothamsted Experimental Station, Harpenden, Herfordshire. UK. Miscellaneous Publication College of Tropical Agriculture Hawaii (USA) Legume-Rhizobium workshop no. 145; p.275-292. 1977.

Leguminosae, Plant Nutrition *mycorrhiza*, Fertilizer & Manure Responses *legumes*

This paper reviews the research done on the effect of endophytic vesicular-arbuscular (VA) mycorrhiza on the uptake of phosphorus and other elements by the host plant, and its growth and nodulation. Up to now VA endophytes remain obligate symbionts with living plant roots. No ways of culturing VA endophytes to produce sufficient inoculum have yet been found. Maintaining the increased number of known endophytes requires much time and space. It is thought that a world bank providing information and starter inoculum would greatly assist the conduct of field experiments to obtain data on which the potential of endophyte inoculation for increased crop production and better fertilizer exploitation could be assessed.

***0087** RIFAI, M. A. **Introduction to tropical mycorrhiza-forming fungi.** *BioIndonesia* (1977) No., 15-19 [En, in, 9 ref., 1 tab.] Natn. Biol. Inst., Bogor, Indonesia.

The lack of information on tropical mycorrhizal associations is emphasized and the fungal flora of S.E. Asia is briefly described in relation to altitudinal zones and host spp.

***0088** ROISTACHER, C.N. et al. Utilization of mycorrhizal fungi in citrus nurseries. Proc. Intern. Soc. Citriculture Vol.1:129-132 1977.

***0089** WAITE AGRICULTURAL RESEARCH INSTITUTE **Department of Agricultural Biochemistry.** 41-55 [En, 35 ref.] Adelaide Univ., Glen Osmond, S.A., Australia 5064.

In: WAITE AGRICULTURAL RESEARCH INSTITUTE **Biennial report of the Waite Agricultural Research Institute, South Australia, 1976-1977.** Adelaide, South Australia. (undated) 184pp. [En, ref. at ends of chapters] Adelaide Univ., Glen Osmond, S.A., Australia 5064.

Work in the Department of Agricultural Biochemistry includes research on the interaction of N and P assimilation in symbiosis between legumes, *Rhizobium* and mycorrhiza, the effect of atrazine on growth and N assimilation in maize, inactivation of nitrate reductase in maize, peptidases in maize roots, aliphatic hydroxylation in *Sorghum bicolor* and enzyme inhibitors and toxins in grasses.

0090 ISLAM, R. Progress report on mycorrhiza research at IITA. Internal Report, Internat. Ist. Trop. Agric; Ibadan, Nigeria 25pp. 1976.

0091 GIANINAZZI-PEARSON, V. **[Endotrophic mycorrhizas: present knowledge and possibilities of their application in plant production.]** Les mycorhizes endotrophes: état actuel des connaissances et possibilités d'application dans la pratique culturale. *Annales de Phytopathologie* (1976) 8 (3) 249-256 [Fr, en, 38 ref., 1 pl.] Station de Physiopathologie végétale, Dijon, INRA, France.

A review dealing with the role of ericaceous and vesicular-arbuscular endotrophic mycorrhizas in the mineral nutrition and growth of plants, and the prospects for their practical use (e.g. with rhododendrons).

0092 MYCORRHIZA and phosphorus nutrition In: International Institute of Tropical Agriculture. Annual Report. pp.80-81. 1976.

0093 BAYLIS, G.T.S. The magnolioid mycorrhiza and mycotrophy in root systems derived from it. *In:* Endomycorrhizas (Ed. by F.E. Sanders, B. Mosse, and P.B. Tinker) Academic Press London. pp.373-389 (1975).

***0094** BOULLARD, B. **[Fundamental roles played by mycorrhizae in the relationship between soils and vegetation.]** *Revue d'Écologie et de Biologie du Sol* (1975) 12 (1) 227-238 [Fr] Biologie Végétale, Université de Rouen, 76130 Mont-Saint-Agan, France.

A review with forty-one references.

0095 GERDEMANN, J. W. **Vesicular-arbuscular mycorrhizae.** In *The Development and Function of Roots. Third Cabot Symposium, Petersham, Massachusetts, USA, April 1974 (Torrey, J.G.; Clarkson, D.T., Editors).* London, UK; Academic Press. (1975) 575-591 [En, 83 ref.] Department of Plant Pathology, University of Illinois, Urbana, USA.

Vesicular-arbuscular (VA) mycorrhizae occur on more plant species and are more widely distributed geographically than any other type of mycorrhiza. They occur on most

cultivated crops, native grasses, herbs and shrubs as well as the majority of forest and shade tree species. They are formed by certain species of Endogonaceae and can increase growth of the host plant although there is little change in external root morphology. Increased uptake of phosphorus and certain other nutrients and increased resistance to feeder root diseases may result from their presence. No evidence of nitrogen fixation has been recorded.

0096 HARLEY, J. L. Problems of mycotrophy. 1-24 [En, 48 ref.] Dep. of Forestry, Oxford Univ., Oxford, UK. *In:* Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds. 22-25 July 1974. London, Academic Press. pp. 1 - 24. 1975.

The need for further study of the problems of C nutrition of symbiotic systems is emphasized. The problem of the effects of each symbiont on the selective permeability of the membranes of the other and of the movement of nutrients within the symbiotic system is regarded as a central and essential problem.

0097 JANOS, D.P. Effects of vesicular-arbuscular mycorrhizae on lowland tropical rainforest trees. *In:* Endomycorrhizas (Ed. by F.E. Sanders, B. Mosse, and P.B. Tinker) Academic Press London. pp.437-446 (1975).

0098 MARX, D.H. Mycorrhizae and establisment of trees on strip-mined land. Ohio Journal of Science 1975. 75(6):288-297.
Pilot studies showed that pines tailored with Pisolithus tinctorius prior to planting survived and grew significantly better than trees with other fungal symbionts. The performance of grasses and other herbaceous plants used in revegetation of strip-mined lands may also be improved by use of specific endomycorrhizal fungi.

0099 MENGE, J.A. ; GERDEMANN, J.W.; LEMBRIGHT, H.W. Mycorrhizal fungi and citrus. Citrus Industry 61:16-18. 1975.

0100 NICHOLSON, T. H. **Evolution of vesicular-arbuscular mycorrhizas.** 25-34 [En, 33 ref.] Dep. of Biol. Sci., Dundee Univ., Dundee DD1 4HN. UK.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp. 25 - 34. 1975.
The role of VA mycorrhizas in P nutrition is discussed.

*0101 PROTSENKO, M. A. **[A micro-organism in the hyphae of a mycorrhiza-forming fungus.]** *Mikrobiologiya* (1975) 64 (6) 1121-1124 [Ru, en] Institut Brokhimii AN SSSR Im. A.N. Bakha.

Electron microscopy revealed a micro-organism with a cell wall and with a cytoplasm consisting of fine threads in the endotrophic mycorrhiza of pea plants. The micro-organism occurred in the hyphae, arbuscles and intra-root vesicles. The membrane surrounding the micro-organism was in direct contact with the cytoplasm of the fungus.

*0102 RAMBELLI, A. [Problems of mycorrhizal symbiosis.] la problematica della simbiosi micorrizica. Giornale Botanico Italiano (1975) 109(3)99-107. Inst. Bot. Garden, Univ. Rome, Italy.

The principal morphological characters of ectotrophic and endotrophic mycorrhizas in broad leaved trees, conifers and the gramineae are discussed.

0103 SANDERS, F. E.; MOSSE, B.; TINKER, P. B. (EDITORS) **Endomycorrhizas. Proceedings, Symposium, University of Leeds, July 1974 UK.** London, UK; New York, San Francisco, USA; Academic Press. (1975) 626pp. [En] University of Leeds, UK.

After an introductory paper on the problems of mycotrophy, papers by different authors discuss: the evolution, classification and culture of endophytes; the general, carbohydrate and phosphorus physiology of mycorrhizae; the fine structure of mycorrhizae; the effects of mycorrhizae on plant growth; the ecology of mycorrhizae; the biological interactions of mycorrhizae.

*0104 TINKER, P. B. H. **Effects of vesicular-arbuscular mycorrhizas on higher plants.** *Symposia of the Society for Experimental Biology* (1975) No.29, 325-350 [En, Review, 71 refs.] Department of Plant Sciences, University of Leeds, LS2 9JT, UK.

0105 TINKER, P. B. H.; SANDERS, F. E. Rhizosphere microorganisms and plant nutrition. *Soil Science* (1975) 119 (5) 353-368 [En] Department of Plant Sciences, Leeds University, UK.

The distribution of microorganisms on and around roots, and their effects on higher plants, are discussed. Bacterial effects on plant nutrition are uncertain, and direct effects seem likely to be small. Mycorrhizal fungi can improve plant nutrition greatly, usually by increasing phosphate supply, and the mechanisms are now fairly well understood.

*0106 BAKSHI, B.K. Mycorrhiza and its role in forestry. Dehra Dun, India; Forest Research Institute and Colleges. 1974. 89p.
A brief introduction (section I) is followed by section II (1-66) on the Ectomycorrhizae covering morphology and structure, identification, nutritional studies, estimation, surveys, mycorrhizal introduction, nursery management and mycorrhiza in site productivity prediction. Section III (69-76) on Endomycorrhizae includes endomycorrhizal forest soils and soil fertility in relation to development.

*0107 BOULLARD, B. [Mycothalli, Mycorrhizomes and mycorrhizae.] *Annali di Microbiologia ed Enzimologia* (1974) 24, 105-123 [Fr, en, it, Review, 35 refs.] Faculté des Sciences de l'Université de Rouen, France.

0108 GERDEMANN, J. W. Mycorrhizae. *The Plant Root and its Environment. Proceedings held at Virginia Polytechnic and State University, 1971. E.W. Carson (Editor)* (1974) 205-217 [En] Department of Plant Pathology, Illinois University, Urbana, Illinois 61801, USA.

A review, with fifty-seven references, of ectomycorrhizae, endomycorrhizae, and of plants that are nonmycorrhizal in wet habitats but may become mycorrhizal in well drained soil.

0109 MEYER, F. Physiology of mycorrhiza. *Annual Review of Plant Physiology* (1974) 25, 567-586 [En] Institute for Landscape Management and Nature Conservation, 3 Hannover German Federal Republic.

*0110 CRUSH, J. R. (Grassl. Div., Dep. Sci. and Ind. Res., Christchurch, N. Z.) Significance of endomycorrhizas in tussock grassland in Otago, New Zealand. N Z J BOT 11(4): 645-660. Illus. 1973[recd. 1974]. [In Engl. with Engl. summ.]--Endomycorrhizas and Endogone spores are ubiquitous in Otago tussock grassland. Typical Endogone endophytes predominate, but Rhizophagus tenuis is common in high-altitude grasses, and predominates in transplants brought to low altitude. Glasshouse and field experiments indicate that only at higher altitudes in Otago tussock grasslands is the P available in soil in the range (< 8 ppm Truog test) where grasses are likely to be mycotrophic. Of the 5 tussock grasses investigated (Festuca novae-zelandiae, Poa laevis, P. colensoi, Chionochloa rigida, C. macra), only C. rigida and P. colensoi seem likely to benefit from endomycorrhizal infection in their natural soils.

0111 HACSKAYLO, E.; TOMPKINS, C. M. **World literature on mycorrhizae.** *Contributions of Reed Herbarium* (1973) No. 22, 142pp. [En] Forest Physiology Laboratory, Agricultural Research Center, West Beltsville, Maryland 20705, USA.

0112 MINISTRY OF AGRICULTURE, QUEBEC [Summary of results 1971/1972.] Sommaire des résultats 1971/1972. Recherches Agronomiques (1973) No. 17, 157pp.

The crop section of this report contains subsections on phytopathology (79-83) and virology (95-99), with notes by various workers on diseases of strawberry, maize, onion, cucumber, potato, oats, barley and bean (*Phaseolus vulgaris*), on intercations between *Rhizobium* and *Endogone* and plant pathogens, nutrition of *Corynebacterium sepedonicum*, epidemiology and biology of *Verticillium* and the mechanism of seed transmission of plant viruses.

0113 MOSSE, B. **Advances in the study of vesicular-arbuscular mycorrhiza.** Annual Review of Phytopathology

(1973) 11. 171-196 [En] Department of Soil Microbiology, Rothamsted Experimental Station, Harpenden, UK. [167.11].
A review with 154 references.

*0114 TSERLING, G.I. [The importance of mycorrhiza in the nutrition of larch seedlings.] Znachenie mikorizy y pitanii seyantsev listvennitsy. Mikologiya i Fitopatologiya (1973) 7(1) 30-33 Agric. Inst., Kyunel', Kuibyshev Reg., USSR.

*0115 BAYLIS, G.T.S. Fungi, phosphorus, and the evolution of root systems. Search (1972) 3(7):257-258.
The effect of plant symbiosis with *Endogone* spp. (RPP 49, 663; 51, 1126) on the evolution of root systems includes the elimination of root hairs and the contraction of branch roots into nodules with an annualyy renewed cortex and repeated cycles of infection, as in the Podocarpaceae and Araucariaceae. The trees and shrubs of the moist podocarp forests of New Zealand appear to be deficient in root hairs and dependent on *Endogone* for P. It is suggested that root hair length is the best indication of the extent to which spp. may benefit from *Endogone* and that water relationships probably determine the balance towards independence or symbiosis.

0116 HACSKAYLO, E. Mycorrhiza: The ultimate in reciprocal parasitism? Bioscience 22(10):577-1972.

*0117 INDIA, TEA RESEARCH ASSOCIATION Annual scientific report 1971-72. Jorhat, Assam, Tocklai Experimental Station. (1972) 98 pp. [En, 16 pl.]

Reports are included on the following: Clonal trials; effects of single *v.* frequent application of different N levels; N, P and K manuring; sulphate of ammonia and calcium ammonium nitrate compared; response to several trace elements; irrigation/pruning trial; herbicide trials; liming; spacing × N level trial; single hedge and staggered double hedge planting systems compared; standard *v.* fish leaf plucking; mechanical plucking; yields of mulch grasses with different cutting intervals and N level; effect of GA and illumination (daylength) on crop distribution; effect of 2,4-D on winter dormancy; cation exchange capacity of clonal tea roots; leaf K and Ca contents at different applied K levels; soil moisture depletion pattern under pruned and skiffed tea and determination of the crop coefficient; response to different levels of water supply; production of and trials with clonal seed and the selection of vegetative clones; respiration studies; effect of GA on pruned and unpruned tea of several clones; optimum spacing of clones as indicated by the number and distribution of plucking points on mature, widely spaced bushes; effect of mycorrhiza, shade and nutrition on root growth; control of red borer (*Zeuzera coffeae*) and scale insect (*Velataspis serrulata*); clonal resistance to and control of nematodes (*Meloidogyne incognita*); control of caterpillars (*Parasa pastoralis* and *Andraca bipunctata*) and red spider mite [*Oligonychus coffeae*]; control of red rust [*Cephaleuros* sp.], black rot [*Corticium* spp.] and thorny stem blight [*Tunstallia aculeata*]; the effect of climatic conditions on spore production and discharge pattern; the keeping quality of made tea; enzyme activity and total O_2 uptake of green leaf of different clones as an indication of made tea quality; and the effect of pruning, skiffing and season on tea quality.

0118 KHAN, A.G. Mycorrhizae and their significance in plant nutrition. Biologia (Spec. Suppl.):42-78. 1972. (Good Bibliography).
Ectomycorhizae of Pinaceae and a few angiosperms and endomycorrhizae of heath, orchids and vesicular-arbuscular type among plants of West Pakistan are reviewed under the captions of plants involved, morphology of mycorrhizae, fungi involved, ecological factor influencing mycorrhizal development and effects on plant growth. A general discussion of mycorrhiza, together with some important milestones of past and promises of future, is given here. The bibliography is as complete up to 1971 as circumstances would allow.

*0119 MARX, D.H. Mycorrhizae: A type of root infection beneficial to plant growth. Agrichem. Age, 15:13-14, 16. 1972.

0120 ROVIRA, A.D.; DAVEY, C.B. Biology of the rhizosphere. *In*: The plant root and its environment. Southern Reg. Educ. Bd. Inst., Va. 1972.

*0121 SWITZERLAND, EIDGENÖSSISCHE FORSCHUNGSANSTALT FÜR OBST-, WEIN- UND GARTENBAU [Report for 1970/1971 of the activities of the Federal Research Institute for Fruit Growing, Viticulture and Horticulture.] Tätigkeitsbericht 1970/1971. Wädenswil. *Landwirtschaftliches Jahrbuch der Schweiz* (1972) 86 (3/4) 393-490 [De, many pl.]
Work of horticultural interest reported includes studies on mycorrhizae in a range of plants including cherries, apples and grapevines.

*0122 BEVEGE, D.I.; RICHARDS, B.N. Some aspects of *Endogone*-forming mycorrhizas with hoop pine (*Araucaria cunninghamii* Ait.). XV IUFRO Congress, April 1971. (Mimeo).

*0123 DEMIN, A.P. Mycotrophy of meadow plants in relation to the use of fertilizers. (Rus). Byull. Mosh. O-va. Isp. Prirod. Otd. Biolog., 76(6):128-134. 1971.

*0124 HACSKAYLO, EDWARD [Ed.]. Mycorrhizae. Symposium. v+255p. Illus. U.S. Government Printing Office: Washington, D.C., U.S.A. 1971. Pr. $3.00.--This book contains the 17 invited papers and the 9 contributed papers presented at the First North American Conference on Mycorrhizae held April 1-3, 1969, at the University of Illinois. The papers cover many diverse aspects of the mycorrhizae including taxonomy, morphology, physiology, various associations with other plant and animal organisms and studies conducted in various geographic and ecologic environments. A number of tables, plates and diagrams are found throughout, and the book ends with both organism and subject indexes. Selected papers will be indexed in BIORESEARCH INDEX.--W. H. M.

*0125 HACSKAYLO, E. (Editor). Should mycorrhiza be considered in shade tree planting? N.J. Fed. Shade Tree Comm. Proc. Ann. Mtg., 45:30-33. 1971.

*0126 HARLEY, J. L. 1971. Associations of microbes and roots. In "*Microbes and Biological Productivity*", (Hughes, D. E., Rose, A. H., eds), *21st Symp. Soc. gen. Microbiol., Cambridge Univ. Press*, 309-332.
A review, with 73 references, of the rhizosphere and of mycorrhiza and root nodules. [16.03

0127 HARLEY, J.L. 1971. Mycorrhiza. 16pp., 6 fig., 6 diag., 5 graphs, 3 tables, Oxford University Press.
A brief account for students, part 12 of the Oxford Biology Readers edited by HEAD J.J.; LOWENSTEIN, O.E.

*0128 MACURA, J. Some biological and ecological aspects of the rhizosphere effect. Folia Microbiol 16:328-336. 1971.

*0129 MARX, D.H. The beneficial relationship between tree roots and mycorrhizal fungi. Intern. Shade Tree Conf., Arborist's News 1970, 36(7): 89a-94a. 1971.

*0130 MARX, D.H. Root-inhibiting mycorrhizal fungi benefit growth to trees. New Mexico State Univ., Fifth Ann. West. Irrig. Pecan Grow. Assn. Conf. 1971:14-18. 1971.

0131 POSSINGHAM, J.V., GROOT OBBINK, J.; JONES, R.K. 1971. Tropical legumes and vesicular arbuscular mycorrhiza. J. Aust. Inst. Agric. Res. 37(2):160-161
VA mycorrhizas were found in Leucaena leucocephala phaseolus atropurpureus (var. Siratro) Stylosanthes humilis (var. Townsville Stylo) S. guyanensis (C.P.I. 40255) and S. subsericea (C.P.I. 38605) it is suggested that the observed growth of these legumes in low phosphate soils may be partly due to their formation of VA mycorrhizal associations.

*0132 STARK, N.M. Mycorrhizae and nutrient cycling in the tropics In: Hacskaylo, E., ed. 1971. Mycorrhizae. Proceedings of the First North American Conference on Mycorrhizae held at University of Illinois, April 1969. Misc. Publ. USDA Forest Serv. 1189 (228-229).

0133 THEODOROU, C. Introduction of mycorrhizal fungi into soil by spore inoculation of seed. Austral. or., 35:23-26. 1971.

*0134 VOIGT, G.K. Mycorrhizae and nutrient mobilization. In: Hacskaylo, E., ed. 1971. Mycorrhizae. Proceedings of the First North American Conference on Mycorrhizae held at University of Illinois, April 1969. Misc. Publ. USDA Forest Serv. 1189 (122-131).

*0135 VOZZO, J.A. Field inoculations with mycorrhizal fungi In Hacskaylo, E., ed. 1971. Mycorrhizae. Proceedings of the First North American Conference on Mycorrhizae held at University of Illinois, April 1969. Misc. Publ. USDA Forest Serv. 1189 (187-196).

0136 UK, ROTHAMSTED EXPERIMENTAL STATION Report for 1970, Part 1. Harpenden (1971) 385 pp. [En, many ref.]

Brief signed research reports are included on the following: *Chinese cabbages*: Amino acid composition of protein in leaf extracts. *Onions*: P response in relation to mycorrhizal infection. *Peas*: H_2 production by root nodules with different *Rhizobium* strains; and time of insecticide spraying in relation to aphid infestation, virus infection and yield. *Phaseolus beans*: Effects of simazine on yields; photosynthesis of rooted leaves; growth substances involved in the formation of adventitious roots; effects of defoliation on yields; response to growth substances; and response to soil fumigation at several N application rates. *Sweet peppers*: Pepper veinal mottle virus found on all capsicum cvs in Ghana. *Tomatoes*: Seed treatment with 2-n-butyramido-5-bromothiazole (BABT).

*0137 WILDE, S. A. Studies of mycorrhizae in Socialist Republics of Europe. In "*Mycorrhizae*". *Proceedings of the 1st North American Conference on Mycorrhizae, University of Illinois, 1969. Miscellaneous Publication, US Department of Agriculture, Forest Service* (1971) No. 1189, 183-186 [En] University of Wisconsin, Madison, USA.

0138 BECKING, J.H. Plant - Endophyte symbiosis in non-leguminous plants. Plant & Soil, 32:611-654. 1970.

0139 BJÖRKMAN, E. 1970. Forest tree mycorrhiza—the conditions for its formation and the significance for tree growth and afforestation. *Pl. Soil* 32, 589-610. [R. Coll. For., Stockholm, Sweden]

Different types of mycorrhiza are considered. The significance of mycorrhizal associations for trees, the significance of the associations for the fungi, the conditions for the formation of ectotrophic mycorrhiza in forest trees, practical applications and effectivity of different species of mycorrhizal fungi are all reviewed and discussed. 101 references.

*0140 BOULLARD, B. General aspects of the mycorrhizal symbiosis. Importance of the mycorrhizas for agriculture, arboriculture and silviculture. Microbiología (Bucarest) 1:609-617, 619-622. 1970

*0141 HARLEY, J.L. The importance of microorganisms to colonizing plants. Trans. Proc. Bot. Soc. Edinburg. 41: 65-70 1970.

*0142 HARLEY, J.L. Mycorrhiza and nutrient uptake in forest trees. *In:* Luckwill, L.C.; C.V. Cutting (Eds.). Physiology of tree crops, pp.163-179. Academic Press, New York. 1970.

*0143 MARCU, G. Survey of research on mycorrhizas in Rumanian syliculture. Microbiology (Bucarest), 1:623-625. 1970. (R.P.P. 50:188).

*0144 SCHENCK, N.C. Mycorrhizal fungi. Sunshine State Agric. Res. Rept., 15(6):12-14, Illus. 1970. (Endotrophic mycorrhizae on roots of soybeans).

*0145 SCHUEPP, H. Uber das Zusammenleben der Hoheren Pflanzen mit den Mikro-organismen des bodens unter besonderer Berucksichtigung der Mykkorhizen. Schweiz. Zeit. Forstwiesen (J. For Suisse), 121:315-326. 1970.

*0146 SWITZERLAND, EIDGENÖSSISCHE FORSCHUNGSANSTALT FÜR OBST-, WEIN- UND GARTENBAU [Report for 1967/1968/1969 of the Federal Research Institute for Fruit Growing, Viticulture and Horticulture.] Tätigkeitsbericht 1967/1968/1969. *Landwirtschaftliches Jahrbuch der Schweiz* (1970) 84(3/4) 349-457 [De, 284 ref., 10 pl.] Wädenswil.

Among the research projects reported are the following: *Apples*: Variety trials; growing apples for juice production; rootstock and training trials; yields and production costs; experiments with Alar and Ethrel; the effect of grass-free circles around the trunk on the growth of young trees and as protection from vole damage in winter; nutritional experiments with trees grown in containers and in the field; bitter pit control; chemical thinning of Golden Delicious; broom growth on trees caused by a mycoplasma; viral russeting and fruit cracking; mildew control; integrated pest control; life history studies on the apple leaf roller and its control by the autocidal method; the use of chlorinated hydrocarbons against the apple blossom weevil; dicofol and dimethoate residues; harvesting time and storage trials, including storage in polythene bags or sacks; storage diseases; and aroma constituents of apples and juices. *Pears*: Growing fruit for juice production; rootstock and training trials; yields and production costs; and harvesting time and storage trials. *Pome fruits—unspecified*: Studies on fire blight; *Entomosporium maculatum* damage; and fungicides to control scab, mildew and storage diseases. *Cherries*: Variety trials of dessert, preserving and liqueur cherries; rootstock and training trials; yields and production costs; experiments with Alar and Ethrel; distribution and significance of endotrophic mycorrhizae; epidemiology of bacterial blight of sweet cherries; integrated and genetic control of the cherry fruit fly; testing fungicides to control shot hole, bitter rot and *Monilia* on flowers and twigs; and dimethoate residues. *Apricots*: Nutrition of container-grown trees; and prestorage irradiation treatment of fruits. *Plums and damsons*: Yields and production costs; variety trials of damsons; rootstock and training trials with plums; experiments with Ethrel on damsons; and studies of plum pox and its eradication. *Walnuts*: Rootstock and training trials; and grafting. *General*: Mist propagation of stone fruit trees; production of virus-free material; inactivation of viruses by heat treatment; soil cultivation and mulching trials; control of *Glechoma hederacea* in intensive orchards; leaf analysis to determine the nutrient status of orchards; nucleic acid and protein metabolism of the leaves of fruit trees and the effects of prometryn and Ioxynil on these processes; the characterization of *Pseudomonas* spp. pathogenic to fruit trees; a survey of aphids on the leaves of *Prunus* spp.; insecticide trials; the effects of insecticides on fruit flavour; the occurrence of the dock sawfly (*Ametastegia glabrata*) in orchards; biological studies on *Pandemis heparana*; control of the San José scale insect; determining the sorbitol content of fruit juices; freezing and drying fruits; and work study, machinery and equipment in fruit growing.

0147 WONG, J.Y. Research on mycorrhizae in Taiwan. Senior Research Assistant. Asian Vegetable Research and Development Center. Shanhua, Tainan, Taiwan. (Not published)

Thesis

*0148 BIERMANN, B.J. Inoculation of container-grown plants with vesicular-arbuscular mycorrhizae. Ph.D. Thesis Oregon State University, 1982, 144pp.
Studies were conducted on inoculation of container-grown plants wiht vesicular- arbuscular (VA) mycorrhizae.
Intraradical vesicles formed in colonized roots were found to serve as propagules and significantly contribute to the infectivity of these roots. A procedure was developed for separating intraradical vesicles from roots; isolated intraradical vesicles were able to colonize new host roots; isolated intraradical vesicles were able to colonize new host roots. Extraradical vesicles of Gigaspora margarita were not infective propagules. Treatment of mycorrhizal roots with sodium hypochlorite as a surface-sterilant reduced their infectivity.
Pre-transplant inoculation of geranium with Glomus fasciculatum resulted in spreas of the endophyte within the root system and greater and more uniform growth at flowering. Mycorrhizae were sufficiently established on most seedlings at a minimum of 2 weeks after emergence to persist after trasplanting. Pre-trasplant inoculation increased geranium growth over that of controls trasplanted into heavily inoculated soil, even when growth did not differ at the time of transplanting.
Soilless plant growth media such as peat, bark, perlite and vermiculite inhibited formation of VA mycorrhizae and host growth response compared to media containig soil. Peats from different sources varied in effects on mycorrhizal growth response of geranium. Utilization of rock phoshate or bonemeal instead of sodium phosphate as a fertilizer P source did not improve establishment of mycorrhizae and host growth response in various media. Addition of 5-10% Turface, bentonite, silt loam soil or clay subsoil to peat or vermiculite resulted in increased colonization of host roots and significant mycorrhizal growth response, but amendment with liquid sludge inhibited mycorrhiza formation. Differential VA mycorrhiza formation and host growth enhancement in different growth media were attributed to differences in equilibrium solution P concentration after media had been satured with fertilizer.
Growth response of geranium to inoculation with G. fasciculatum increased with increasing-inoculation soil heat treatment temperatures from 45°C to 120°C. Colonization of roots of geraniums inoculated with G. fasciculatum was not affected by soil treatment temperature, but treatment for 30 min at 55°C or higher eliminated colonization by indigenous mycorrhizal fungi. The shoot P concentration of inoculated plants relative to controls increased with increasing temperature of soil treatment.

*0149 BIEVER, L.J. The role of mycorrhizal fungi in ecosystem energetics. Ph.D. Thesis University of Georgia 1982. 170pp.
The vast majority of vascular plants in all nonhydric terrestrial ecosystems are mycorrhizal While the effect of mycorrhizae on nutrition, survival and growth of plants (especially commercially important crops and trees) has been extensively investigated, little attention has been devoted to their role in the ecosystem as a whole. A review of the extensive literature has led me: 1,to conclude that energy flow through the mycorrhizal network represents a distinct and major food chain and 2,to test this hypothesis in a field study on experimental pine plantations.

*0150 GEDDEDA, Y.I. Apple mycorrhizae and their effects on growth and nutrient concentration in apple seedlings grown in two soils with varied levels of P. Thesis Ph.D. Oregon State University, 1983. 81pp.
A study was conducted to characterize the vesicular-arbuscular (VA) fungi of apples grown in Oregon. Using roots and soil from apple orchards as inoculae, six different fungal species were found in pot cultures: *Gigaspora margarita* Becker and Hall, *Glomus fasciculatum* (Thaxter sensu Gerdemann) Gerd. and Trappe, *Glomus mosseae* (Nicol. and Gerd.) Gerd. and Trappe, *Gigaspore calospora* (Nicol. and Gerd.) Gerd. and Trappe, *Glomus monosporum* Gerd. and Trappe and *Sclerocystis rubiformis* Gerd. and Trappe. The first three species grew out of apple root inoculum, suggesting that they are strong competitors in colonizing apple roots in the field. *Gigaspora margarita* has not heretofore been reported in Oregon.
The effectiveness of *Gigaspora margarita*, *Glomus fasciculatum* and *Glomus mosseae* and applied P in promoting growth of apple seedlings grown in two soils which differ in their available P content was studied in a greenhouse experiment. Mycorrhizal inoculation could substitute for P application in low P soil with *G. fasciculatum* being the most effective in promoting growth and P uptake, *G. margarita* being the least effective, and *G. mosseae* intermediate. Also studied were the effects of soil-applied P and VA mycorrhizae on nutrient uptake and growth of maize grown in Willamette soil. Both treatments enhanced plant growth and P uptake. VA mycorrhizal inoculation significantly increased percent leaf Mg and Mn over the controls. Application of P to one-half of the root system did not reduce percent root colonization by VA mycorrhizae in the other half, while combining both treatments reduced percent root colonization.

*0151 FABIG, B. Einfluss von Al und Schwermettalen Fe, Mn, Zn, Pb and Cd auf die Effizienz der VA-Mykorrhiza bei tropischer und subtropischer Pflanzen (Influence of Al and the heavy metals Fe, Mn, Zn, Pb and Cd on development and the efficiency of vesicular-arbuscular mycorrhiza in tropical and subtropical plants). Ph. D. thesis, Uinv. of Gottingen, Gottingen, West Germany (1982) 180pp.

*0152 KING, E.J. Ultrastructure, phosphatases, and phosphatase histochemistry of soybean mycorrhizae. Thesis, Ph.D. University of Missouri-Columbia, 1982. 164pp.
Ultrastructural investigation of vesicular-arbuscular mycorrhizae formed by soybean and Glomus fasciculatus emphasized arbuscule development and host cell response. Fungal entry into host cells involved both wall dissolution and application of mechanical force. Subsequent development of highly branched arbuscules was rapid. Host cell responses to arbuscule formation occurred in three phases, all of which were characterized by progressive invagination of the plasmalemma to surround the arbuscular branches, and by dictyosome-mediated deposition of an interfacial material evidently composed of cell wall components. The first phase of host response also included aggregation of cytoplasm around the first arbuscular branches and disappearance of starch from the plastids. The second phase included rapid increase in cytoplasmic volume, nuclear volume, and organelle numbers. The third phase included disappearance of lipid bodies from the cytoplasm, and extension of the cytoplasm to surround all the arbuscular branches. Polyphosphate granules were infrequently observed in arbuscules and adjacent intercellular hyphae, suggesting that hydrolysis of polyphosphate and transfer of phosphate from fungus to host may occur in inter-and intracellular hyphae as well as in arbuscules. Acid phosphatase activities were detected in extracts of mycorrhizal and non-mycorrhizal soybean and onion roots. At least 25 bands of acid phosphatase activity were distin-

guishable after isoelectic focusing of each estract. No evidence of alkaline phosphatase activity was detected in assays of root extracts, or after swparation of activities by isoelectric focusing. No evidence of acid or alkaline phosphatase activities unique to mycorrhizal roots was obtained.
Ultrhistochemistry demonstrated that acid phosphatase activity was present in the endoplasmic reticulum, dictyosomes, and vacuoles of arbuscule - containing cells, and in the interfacial zone between the invaginated host plasmalemma and the arbuscular branches. These locations are consistent with the view that arbuscule degeneration results from nost cell response to arbuscules. Acid phosphatase activity was not detected in the fungus, and alkaline phosphatase activity was not detected in either host or fungus.

*0153 OJALA, J.C. Soil factors influencing vesicular-arbuscular mycorrhizal plant growth. Thesis Ph.D. University of California, Riverside 1982. 105pp. Chairman: Professor Lesley M. Jarrel.

Plant growth responses to vesicular-arbuscular (VA) mycorrhizae are often highly influenced by soil chemical properties. This dissertation describes the effect of three soil chemical properties, pH, salinity and extractable P, on mycorrhizal plant growth.

The objective of the first study was to obtain mycorrhizal infection in hydroponic sand culture. Tomato plants were inoculated with *Glomus fasciculatus* mycorrhizal fungi while growing in sand through which recycled nutrient solution was automatically passed several times daily. Roots of inoculated plants became highly infected with mycorrhizal fungi, and yield parameters were significantly increased with inoculation over control plants.

The direct effects of pH on mycorrhizal sour orange (*Citrus aurantium*) growth and nutrient absorption were established in hydroponic sand culture. Mycorrhizal infection of citrus roots did not change significantly with pH. The lesser growth of mycorrhizal plants at low pH was due to either (1) the direct effects of pH on the mycorrhizal symbiosis or (2) the lesser ability of mycorrhiza to absorb P with $H_2PO_4^-$ as the dominant form of available P in solution.

The ability of VA mycorrhizal fungi to improve yield, salt tolerance and mineral nutrition of onion was evaluated in saline soil. Onion plants infected with *Glomus fasciculatus* and *Glomus monosporus* mycorrhizal fungi had greater total dry weight than nonmycorrhizal plants in P deficient soil at low (-0.6 bars irrigation water solute potential (Ψ_s)) and intermediate (-2.0 bars Ψ_s) salinity. Only *Glomus monosporus* improved the salt tolerance of onion.

In a greenhouse experiment, mycorrhizal dependency of Troyer citrange was correlated with different methods of extracting soil P. Sodium bicarbonate and dilute acid-fluoride methods of extracting soil P produced the poorest correlations with MD. Saturation extract, anion exchange resin and 1:10 soil-water ratio methods of extracting soil P correlated well with MD, perhaps because the values obtained reflect the equilibrium P concentration in soil solution (intensity) rather than the reserve P (capacity) of the soil system.

*0154 SCHUBERT, T.S. Effects of foliar phosphate, elicitor - induced glyceollin and phloem-ringing on soybean - glomus mosseae mycorrhizae Thesis, Ph.D. University of Missouri Columbia, 1982. 144pp.
The effects of foliar applications of phosphate, glyceollin induced by elicitor of Phytophthora megasperma pv. glycinea, and disruption of phloem transport on soybean-Glomus mosseae mycorrhizae were studied in three separate experiments Foliar phosphate applications increased root phosphorus concentrations 35% and caused a 43% decrease in number of penetration points, a 19% decrease in percent infection, and a 31% increase in total root length. Light and electron microscopic examination of infected roots revealed more older stages of arbuscule development present in treated plants. This observation was interpreted as the result of both earlier and more rapid degeneration of arbuscules in roots with increased phosphate concentrations. At the ultrasturctural level, phosphate treatment affected only the arbuscule morphology at the older developmental/ deterioration stages.
Phytophtora megasperma f. sp. glycinea elicitor was used to elicit glyceollin to test effects of this phytoalexin on mycorrhizae.
Glyceollin elicited at the time of infection had no detectable effect on the number of penetration points by the mycorrhizal fungus. Glyceollin elicited on established mycorrhizae caused only minor modifications in the host cytoplasm of cortical cells containing arbuscules. The endophyte showed no ultrasturctural effects of the glyceollin elicitation.
A disruption of phloem trasport in established mycorrhizae was accomplished by ringing the stem phloem with a jet of steam. Treated plants showed an increase in the number of vesicles, the incidence of interior and exterior ("runner") hyphae and in percent infection, though the total lenght of infected root in treated and control plants was essentially the same. Ultrastructural effects of treatment were very similar to the effects of phosphate treatment.
In none of the experiments described was there any evidence of an extreme unbalance taking place in the mutualistic association as a result of treatment. The association proved remarkably stable when the exchange process between the two symboints were supplemented (phosphate treatment) or interrupted (phloem-ringing treatment) and when the mycorrhizae were exposed to glyceollin at or after the time of infection. The similarity in ultrasturctural response to phosphate and phloem ringing indicates a possible universal response mechanism of V-A mycorrhizal fungi to disruptions of the mutualistic symbiosis.

*0155 BLUME, E. Wechselwirkung zwischen VA-Mykorrhiza und Rhizobien bei tropischen Leguminosen (Interaction between VA- mycorrhiza and Rhizobium in tropical legumes). Ph.D. thesis, Univ. of Gottingen, Gottingen, West Germany (1981) 131pp.

*0156 DIEDERICHS, C. Einfluss des Lichtes auf die Wirksamkeit der vesikular-arbuskularen (VA)-Mykorrhiza bei tropischen und Subtropischen Pflanzen (Influence of light on the efficacy of vesicular-arbuscular (VA) mycorrhiza in tropical and subtropical plants). Ph.D. thesis, Uinv. of Gottingen, Gottingen, West Germany (1981) 179pp.

*0157 EL-DEEPAH, H.R.A. Effizienz der vesikular-arbuskularen Mykorrhiza bei sieben Kulturpflanzenarten in Abhangigkeit von NaCl im Boden (Efficiency of vesicular-arbuscular mycorrhiza in seven crop species, modified by NaCl in the soil) Ph.D. thesis, Univ. of Gottingen, Gottingen, West Germany (1981) 87pp.

*0158 HAMZA, E. A. Wirkung von vesikular-arbuskularer Mycorrhiza auf Baumwolle in Abhangigkeit von NaCl im Boden (Effect of vesicular-arbuscular mycorrhiza on cotton under the influence of NaCl in the soil). Ph.D. thesis, Univ. of Gottingen, Gottingen, West Germany (1981) 95pp.

*0159 KRONE, W. Wirkung von vesikular-arbuskularen (VA-) Mykorrhiza und phosphatlosenden Bakterien auf Wachstum und Phosphataufnahme verschiedener tropischer und subtropischer Pflanzen (Efficiency of vesicular-arbusculer mycorrhiza and phosphate solubilizing bacteria on growth and phosphate uptake of different tropical and subtropical plants). Ph.D. thesis, Univ. of Gottingen Gottingen, West Germany (1981) 66pp.

0160 SAIF, S.R. The influence of soil oxygen, carbon dioxide and soil temperature on the efficiency and development of vesicular-arbuscular myco-

rrhizae. Ph.D. thesis, Univ. of Gottingen, Gottingen, West Germany (1981) 147pp.

The results of this study showed that the growth of three host plants and the development of three VA mycorrhizal fungi was strongly influenced by soil oxygen, carbon dioxide and soil temperature. In general mycorrhizal plants were more sensitive to soil conditions than the non-mycorrhizal plants; however, optimum conditions were similar to both. The plant species differed considerably in their response to soil conditions. The efficiency of three VA mycorrhizal fungi depended on the host and soil conditions. Rise in soil temperature increased the effect of soil oxygen and optimum growth and mineral uptake was observed at 30°C and at 16% soil oxygen.
Generally P uptake was increased more by mycorrhizae than the shoot growth. Mycorrhizae increased the Mg uptake of Guizotia plants more than that of P. The uptake of other elements generally corresponded with the shoot growth.
The concentration of mineral elements was control led by host-fungus physiology and soil conditions The concentration P and Mg was always higher in mycorrhizal plants.
Concentrations of carbon dioxide up to 1% stimulated the growth and mineral uptake, but higher carbon dioxide levels decreased them.
The development of three VA mycorrhizal endophytes was dependent on plant and soil conditions. Optimum infection rates and vesicle numbers were observed at 16% soil oxygen and at 30°C soil temperature. The arbuscule development was favoured by 8% soil oxygen and 252°C soil temperature. The infection rates were little affected by soil carbon dioxide. The increase in growth of plants was not always correlated with the infection rates. The infection rate of Glomus macrocarpus was, however, always positively correlated with shoot growth.

* **0161** SIMANUNGKALIT, R.D.M. Wirkung der vesikular-arbuskularen Mykorrhiza auf Nigersaat (Guizotia abyssinica) und Reis (Oryza sativa) bei verschiedendenen Wasseregimen. Ph.D. thesis, Univ. of Gottingen, Gottingen, West Germany (1981) 86pp.

* **0162** ALLEN, M.F. 1980. Physiological alterations associated with vesicular-arbuscular mycorrhizal infection in *Bouteloua gracilis*. Ph.D. Thesis, Univ. of Wyoming, Laramie, WY, USA.

* **0163** KARAGIANNIDIS, N. Untersuchungen uber dieEffizienz der vesikular-arbuskularen (VA-)Mykorrhiza verschiedener Herkunft bei unterschiedlischen tropischen und subtropischen Pflanzen, Phosphatformen, Boden-pH-Werten und Bodentemperaturen (Effect of soil type, soil pH, phosphate fertilizer and soil temperature on the efficiency of vesicular-arbuscular mycorrhiza in tropical and subtropical plants). Ph.D. thesis, Univ. of Gottingen, Gottingen, West Germany (1980) 140pp.

* **0164** KHANAQA, A. Einfluss der vesikular-arbuskularen (VA-) Mykorrhiza verschiedener Herkunft auf Wachstum und phosphataufnahme von vier Tabaksorten unter Berücksichtigung von Boden-pH-Wert, Phosphatdungungsform und Bodentemperature (Influence of several strains of vesicular-arbuscular mycorrhiza on growth and P uptake of four tobacco cultivars with regard to soil pH, form of P fertilizer and soil temperature). Ph.D. thesis, Uinv. of Gottingen, Gottingen, West Germany (1980) 71pp.

* **0165** SIEVERDING, E. Einfluss der Bodenfeuchte auf Entwicklung und Effektivitat der vesikular-arbuskularen Mykorrhiza(Influence of soil moisture on development and efficacy of vesicular-arbuscular mycorrhiza). Ph.D. thesis, Univ. of Gottingen, Gottingen, West germany(1980) 184pp.

* **0166** HEPPER, C.M. Nutritional and biochemical studies of fungi involved in vesicular-arbuscular mycorrhiza. Ph.D. Thesis. Univ. of London, London, England, 1979.

* **0167** GRAW, D. Der Einfluss der vesikular-arbuskularen Mykorrhiza auf das Wachstum tropischer und subtropischer Pflanzen unter Berucksichtigung von Wirtsspezifitat und pH-Wert des Bodens (The influence of vesicular-arbuscular mycorrhiza on the growth of tropical and subtropical plants with regrd to host specificity and soil pH). Ph.D. thesis, Univ. of Gottingen, Gottingen, West Germany (1978) 178pp.

* **0168** LAMBERT, D.H. Mycorrhizae establishment for strip mine vegetation . M.Sc. Thesis. Pennsylvania State Univ., State College. 1978.

* **0169** METCALF, S.M. 1978. The influence of vesicular-arbuscular mycorrhiza on uptake of zinc and phosphorus by cotton. Ph.D. Thesis, Univ. of California, Berkely, California.

* **0170** DEHNE, H. W. Untersuchungen uber den Einfluss der endotrophen Mykorrhiza auf die Fusarium-Welke der Tomate und Gurke. Ph.D. thesis, Friederich-Wilhelm Univ. Bonn, West Germany (1977).

* **0171** MBAGA, M.T. 1977. Mycorrhizal infections in rice. M.Sc. Thesis, Univ. Dar-Es-Salaam, Tanzania.

* **0172** MEHRAVARAN, H. 1977. Mycorrhizal dependency of six citrus cultivars. Ph.D. Thesis, Univ. of Illinois, Urbana-Champaign, Illinois.

* **0173** NYABYENDA, P. Einfluss der Bodentempratur und organischer Stoff im Boden auf die Wirkung der vesikular-arbuskularen Mykorrhiza (Influence of soil temperature and organic material in the soil on the efficacy of vesicular-arbuscular mycorrhiza) Ph.D. thesis, Univ. of Gottingen, Gottingen, West Germany (1977). 126pp.

* **0174** MIKHAIL, N.B. Der Einfluss symbiontischer Mikroorganismen auf Wachstum und Nahrstoffaufnahme von Eupatorium odoratum L. bei Angebot verschiedener Phosphatformen (The effect of symbiotic microorganisms on growth and nutrient uptake of Eupatorium odoratum L. supplied with different forms of phosphate). Ph.D. thesis, Univ. of Gottingen, Gottingen, West Germany (1976). 79pp.

* **0175** COOPER, K.M. 1973. Mycorrhizal associations of New Zealand ferns. Ph.D. Thesis, Univ. of Otago, Otago, New Zealand.

* **0176** KRUCKELMANN, H.W. Die vesikular-arbuskulare Mykorrhiza und ihre Beeinflussung in landwirtschaftlichen Kulturen. Ph.D. thesis, Tech. Univ. Braunschweig, Braunschweig, West Germany (1973) 55pp.

* **0177** REDHEAD, J.F. Aspects of the biology of mycorrhizal associations occurring in tree species in Nigeria. Ph.D. Thesis, Univ. of Ibadan, Ibadan, Nigeria. 1973.

* **0178** BEVEGE, D.I. 1971. Vesicular-arbuscular mycorrhizas of *Araucaria*. Aspects of their ecology and physiology and role in nitrogen fixation. Ph.D. Thesis, Univ. of New England, Armidale, New South Wales, Australia.

* **0179** TRINICK, M.J. *Rhizobium* interactions with soil microorganisms. Ph.D. Thesis, Univ. W. Australia, Perth. 1970.

0180 BERCH, SHANNON M.* and BRYCE KENDRICK. (Departement Ecologie-Pedologie, Foresterie-Geodesie, Universite Laval, Quebec, P.Q., Canada G1K 7P4.) MYCOLOGIA 74(5): 769-776. 1982. **Vesicular-arbuscular mycorrhizae of southern Ontario, Canada, ferns and fern-allies.**—Thirty-nine species and varieties of common Pteridophytes of southern Ontario were surveyed for the presence of VAM [vesicular-arbuscular mycorrhizae]. The sporophytes of the 3 *Equisetum* spp. and the 2 *Lycopodium* spp. examined were usually non-VA mycorrhizal. The 2 spp. of *Botrychium* were extensively VA mycorrhizal, while the Filicales were in general moderately colonized, though plants from isolated rock outcroppings and crevices were often non-VA mycorrhizal. These observations are discussed in light of Baylis' theory of root morphology and mycotrophism. Various root-inhabiting fungi which could be confused with VAM are illustrated.

0181 BLOSS, H. E. Formation of mycorrhizae in *Plantago ovata*. *Mycologia* (1982) 74 (3) 505-508 [En, 5 ref., 12 fig., 2 tab.] Univ. Arizona, Tucson, USA.

Glomus fasciculatus, *G. macrocarpus* var. *macrocarpus* and *G. mosseae* all formed vesicular-arbuscular mycorrhizae with *P. ovata* in glasshouse inoculations. They enhanced growth rate, seed yields and maturity when inoculated at the seedling stage. *Glomus mosseae* induced the greatest seed yield.

*0182 CHAUBAL, R., G. D. SHARMA and R. R. MISHRA. (Dep. of Botany, North-Eastern Hill Univ., Shillong 793 014, India.) PROC INDIAN ACAD SCI PLANT SCI 91(1): 69-77. 1982. **Vesicular arbuscular mycorrhiza in subtropical aquatic and marshy plant communities.**—Occurrence of vesicular arbuscular mycorrhiza in 5 subtropical ponds, i.e., eutrophic (P1, P2 and P3), running water (P4), oligotrophic lake (P5) and marshy plant community (M) was studied. The plants growing in P1, P5 and M habitats exhibited the vesicular arbuscular mycorrhizal association, whereas the fungal association was lacking in plants of P2, P3 and P4 ponds. The endogonaceous spore population was estimated from water and sediments of the different ponds and it was found that endophytes in sediments are less in terrestrial habitats and completely absent from water samples. The bioassay studies revealed that plants without mycorrhizal association grew poorly, and all the endophytes isolated could establish vesicular arbuscular mycorrhizal associations in pot cultures.

*0183 COETZEE, J. C. A note on *Endogone* and *Acaulospora* in South Africa. *South African Journal of Botany* (1982) 1 (1/2) 38-39 [En, af, 14 ref., 1 fig.] Pl. Prot. Res. Inst., Pretoria, South Africa.

The correct name for a fungus previously assigned to *E.* [*RPP 51*, 3136] appears to be *A. laevis*. Similar spores of this sp. were found in maize rhizosphere soil from eastern Orange Free State. *Endogone* spp. have not yet been recorded from South Africa.

0184 DANIELS, B.A. BLOOM, J. Incidence and species of vesicular-arbuscular mycorrhizal (VAM) fungi associated with winter wheat as compared with undisturbed tall grass prairie grasses. Phytopathology 72(7):951. 1982. Abst.

The Konza prairie and several geographically distinct wheat fields were sampled monthly throughout a growing season. Two previously undescribed sporocarpic VAM species were observed in prairie samples. Moderate infection occurred in regularly burned or unburned prairie plots throughout the year. Infection levels fluctuated monthly, but no seasonal variation was observed. More VAM species sporulated in spring and fall than during other seasons. In contrast, little or no root infection was evident in wheat before flowering in May and June. More VAM species sporulated in spring but spore numbers were consistently lower in these fields than in the native prairie. VAM fungi probably function in nutrient cycling in undisturbed perennial tall grass prairie but the low spore numbers and late growing season infection in wheat make the benefit of VAM infection in wheat less likely.

*0185 DAVIS, R. M. **Mycorrhizal fungi associated with citrus in south Texas.** *Journal of the Rio Grande Valley Horticultural Society* (1982) 35, 127-129 [En, 9 ref.] Texas A&I University Citrus Center, Weslaco, TX 78596, USA.

Mycorrhizal fungi were associated with citrus in all of the 20 orchards of sweet orange or grapefruit trees on sour orange rootstocks sampled in the lower Rio Grande Valley. Eight species forming vesicular-arbuscular mycorrhizae were identified. *Glomus microcarpus*, *G. etunicatus*, and *G. fasciculatus* were the most common. The occurrence of these mycorrhizal fungus spp. is compared with the occurrence of these and other spp. in Californian and Florida citrus orchards.

0186 GAY, P. E.; GRUBB, P. J.; HUDSON, H. J. **Seasonal changes in the concentrations of nitrogen, phosphorus and potassium, and in the density of mycorrhiza, in biennial and matrix-forming perennial species of closed chalkland turf.** *Journal of Ecology* (1982) 70 (2) 571-593 [En, 31 ref., 8 fig., 4 tab.] Botany School, Univ. Cambridge, UK.

Studies on 4 turf-compatible biennial spp., 3 matrix-forming perennial spp., and 6 turf-incompatible annual and biennial spp. of chalk grassland plants are described. Mycorrhizal density showed marked seasonal variation, being highest in the autumn of the first year and the summer of the second. In a field test seedlings of annual, biennial and perennial spp. became mycorrhizal within *c.* 2 wk of germination. The results are discussed in relation to the ability of the turf-compatible biennial plants to survive in chalk grassland.

0187 GLENN, M.G. VA mycorrhizal infection in brassica, a non-host. Phytopathology 72(7): 951. 1992 . Abst.

This work examines the hypothesis that a general lack of functional VA mycorrhizae in the cruciferae and related families is due to presence of glucosinolates (gs) and their hydolysis products, isothiocyanates, in and around roots. Hyphal growth of Glomus mosseae near roots of Brassica napus and B. campestris cultivars with low levels of gs was observed with light and electron microscopy before and after penetration, compared to growth elicited by cultivars with high levels of gs, and also to growth elicited by compatible hosts Nicotiana tabacum and Allium cepa. All brassica roots elicited fewer and shorter pre-penetration branches than did hosts, resulting in fewer attempts to penetrate. Hyphae penetrating brassica fail to produce coils or arbuscles, but grow within the cortex parallel to the root axis, and often form vesicles. The vesicles may serve a protective function, since they resemble vesicles produced externally under adverse conditions.

0188 HÖGBERG, P. **Mycorrhizal association in some woodland and forest trees and shrubs in Tanzania.** *New Phytologist* (1982) 92 (3) 407-415 [En, 42 ref., 2 fig., 2 tab.] Swedish Univ. Agric. Sci., Umeå, Sweden.

Of 47 indigenous trees and shrubs studied, 40 were endomycorrhizal, 1 was endectomycorrhizal and 6 ectomycorrhizal. The results demonstrated dominance of endomycorrhizal tree spp., typical of the tropics, this being further reinforced by taxonomic considerations. However, in the Miombo (*Brachystegia-Julbernardia*) woodlands (a major ecosystem in E. and S. Cent. Africa) ectomycorrhizal trees predominate in vol. In 3 other ecosystems studied, ectomycorrhizal spp. were absent or almost absent.

*0189 JANOS, D. P.; TRAPPE, J. M. **Two new *Acaulospora* species from tropical America.** *Mycotaxon* (1982) 15, 515-522 [En, 11 ref., 2 fig.] Univ. Miami, Coral Gables, Fla., USA.

A. foveata is described from Mexico, Panama and Costa Rica and *A. tuberculata* from Costa Rica and Panama. The former was in mycorrhizal association with cacao, banana, sugarcane and many rain forest tree spp.; the latter with many tropical tree spp.

0190 KUCEY, R.M.N.; PAUL, E.A. Biomass of mycorrhizal fungi associated with bean roots. Soil Biol. Biochem. Vol.14: 413-414. 1982.

0191 LAWLEY, R. A.*, E. I. NEWMAN and R. CAMPBELL. (Public Analyst's Lab., 220 Elgar Rd., Reading RG2 0DG, U.K.) SOIL BIOL BIOCHEM 14(3): 237-240. 1982. **Abundance of endomycorrhizas and root-surface microorganisms on 3 grasses grown separately and in mixtures.**—Three grasses of acid, infertile soils, *Agrostis tenuis*, *Deschampsia flexuosa* and *Festuca ovina* were grown in pots separately and in 2-spp. mixtures. After 8 mo. the abundance of internal mycorrhizal infection and of bacteria and fungi on the root surfaces was determined by microscopic examination of stained root segments. Abundance of bacteria, fungi and mycorrhizas all differed between host species. Abundance of bacteria was not affected by which other grass species (partner) was present, but fungal abundance was consistently lowest when the partner species was *Agrostis* and highest when it was *Festuca*. As a result, in 2 spp. mixtures fungal abundance was always intermediate between the 2 corresponding monoculture values. Mycorrhizal infection was also influenced by the partner species, but in a less regular manner.

*0192 MANJUNATH, A.; BAGYARAJ, D. J. **Vesicular arbuscular mycorrhizas in three plantation crops and cultivars of field bean.** *Current Science* (1982) 51 (14) 707-708 [En, 10 ref., 3 fig., 2 tab.] Univ. Agric. Sci., Bangalore, India.

The mycorrhizas are newly reported in *Elettaria cardamomum*, *Piper betle* and black pepper. The numbers of endomycorrhizal spores in root zone soil as influenced by cultivars of *Lablab purpureus* are tabulated.

0193 McGRAW, A.C.; HENDRIX, J.W. Spore populations and species composition of vesicular arbuscular mycorrhizal fungi in relation to soil fumigation and crop species. Phytopathology 72(7): 951. 1982.

Crop rotations involving four treatments of pepper (cv Yolo Wonder) or tomato (cv Jet Star) grown in fumigated (methyl bromide + chloropicrin [67/33%]) and nonfumigated soil, sudex, or fallow were established in June 1981. Pepper and tomato transplants were planted in rows of fumigated and nonfumigated soil. Sudex was planted in plots of nonfumigated soil. Pepper, but not tomato, yields were improved slightly in fumigated compared with nonfumigated soil. More than ten species of mycorrhizal fungi representing four genera (Acaulospora, Gigaspora, Glomus, Sclerocystis) could be identified from each treatment in June and October. Glomus macrocarpus comprised approximately 50% of the total population of mycorrhizal fungal spores. Crop treatment, particularly sudex, was more important than soil fumigation in manipulating the population level but not the species composition of the mycorrhizal fungi. Certain minority species were detected only with select soil and crop treatments.

0194 MORTON, J.B.; WRIGHT, S.E. Recovery of Rhizobium and vesicular-arbuscular mycorrhizal fungi from red clover in acid mine soils Phytopathology 72(6):709. 1982. Abst.

Red clover may be a useful forage legume for initial re-vegetation of strip mine sites if inoculated with Rhizobium and VA mycorrhizal fungi adapted to acid soil environments. Abandoned or partially reclaimed strip mine sites near Elkins, W.V. were sporadically colonized by red clover, the roots of which were nodulated and strongly mycorrhizal (as high as 91% infection). Rhizosphere soils from these plants with pH levels between 3.5-4.5 and extractable P levels between 2-42 ppm were mixed 1:1 with sand, potted, and re-seeded with Kenstar red clover. Initial seedling mortality ranged from 50-83%. After three months, surviving plants were effectively nodulated and mycorrhizal. Wide variations in incidence and intensity of mycorrhizal infection were observed among soils, which may be attributed either to endophyte efficiency or to inoculum density. Further characterization of interactions between symbionts, soil chemical properties, and red clover genotypes are in progress.

0195 RABATIN, S. C.; RHODES, L. H. *Acaulospora bireticulata* inside oribatid mites. *Mycologia* (1982) 74 (5) 859-861 [En, 14 ref., 1 fig.] Ohio State Univ., Columbus, USA.

Azygospores of the mycorrhizal fungus were found inside the exoskeletons. The possible significance of the observations in the long-range dissemination of the azygous Endogonaceae is considered.

* 0196 RILEY, ROBERT K.* and P. DOUGLAS CURTIS. (Biol. Dep., Frostburg State Coll., Frostburg, Md. 21532.) The 57th Annual Session of the West Virginia Academy of Science, Elkins, W. Va., USA, April 3, 1982. PROC W VA ACAD SCI 54(1): 1. 1982. Preliminary results of the occurrence of endomycorrhizae on surface mine top soil piles./ABSTRACT, GRASS, REVEGETATION, RECLAMATION, EROSION CONTROL

* 0197 ROTHWELL, F. M.; VOGEL, W. G. Mycorrhizae of planted and volunteer vegetation on surface-mined sites. *General Technical Report, USDA Forest Service, Northeastern Forest Experiment Station* (1982) No. NE-66, 12pp. [En, 15 ref.] Northeastern Forest Exp. Sta., Broomall, Pennsylvania, USA.

Plants (with roots) were collected along randomly established transects from surface mined sites revegetated by succession, artificially planted and from adjacent unmined areas. Data are given for endomycorrhizal infection for a wide range of plants including many grass and weed spp.

0198 SCHENCK, N. C.; SMITH, G. S. Additional and unreported species of mycorrhizal fungi (Endogonaceae) from Florida. *Mycologia* (1982) 74 (1) 77-92 [En, 21 ref., 3 fig.] Univ. Florida, Gainesville, USA.

The occurrence of 5 spp. of Endogonaceae previously unreported from Fla. is noted and 7 new spp. are described.

0199 STAHL, P.D.; CRISTENSEN, M. Mycorrizal fungi associated wiht Bouteloua and Agropyron in Wyoming sagebrush-grassland. Mycologia, 74(6) 1982, pp.877-885.

The spore populations of vesicular-arbuscular (VA) mycorrhizal fungi at four sagebrushgrassland sites in Wyoming were examined, characterized, and quantified. The sampled soils contained 232-696 spores per 100 g dry soil and three to six species of VA mycorrhizal fungi (Glomus fasciculatus, G. macrocarpus, G. microcarpus, G. mosseae. Entrophospora infrequens, and an unidentified form.) Community composition and relative prominence (frequency, density) of the six species were related both to geographic location of the site and abiotic factors and to identity of the plant symbiont. Environmental influence on spore populations in discussed.

0200 TABER, R.A. Gigaspora spores and associated hyperparasites in weed seeds in soil. Mycologia, 74(6) 1982. pp.1026-1031.

* 0200a TABER, R.A. Mycorrhizal fungi associated with native and improved varieties of pecans in Texas. Phytopathology 71(7):951. 1982. Abst.

Six genera of ectomycorrhizal fungi were associated with *Carya illinoensis* in managed orchards, urban plantings, and native habitats in 8 counties in Texas. First documentation of the natural occurrence of *Pisolithus tinctorius* on pecan was recorded from managed orchards in 3 counties. Sporocarps were produced in orchards treated with pesticides - Karmex, Princep, Surflan, Benlate, Du-Ter, Zolone, Sevin, and Roundup. They were abundant under canopy drip-lines, in soil depressions, and on roots severed by cultivators. *Astraeus hygrometricus* was found in orchards in 2 counties. *Scleroderma*, including *S. cepa*, fruited sometimes on roots which also had *Pisolithus* associations. *Tuber* was found in urban plantings. *Gyrodon*, *Tylopilus*, and *Russula* fruited only on native trees. VAM fungi included species of *Glomus*, *Gigaspora*, and *Sclerocystis*.

0201 TABER, R. A. Occurrence of *Glomus* spores in weed seeds in soil. *Mycologia* (1982) 74 (3) 515-520 [En, 12 ref., 13 fig.] Texas Agric. Exp. Sta. College Station, USA.

Spores of *Glomus fasciculatus* were found in seeds of *Portulaca oleracea* within soil-contaminated capsules. Seeds of 4 other weed spp. harboured spores of vesicular-arbuscular mycorrhizal fungi.

0202 TABER, R.A.; STRONG, M.E. Vesicular arbuscular mycorrhiza in roots and xylem of Tradescantia. Mycologia 74:152-155. 1982.

0203 TABER, R. A.; TRAPPE, J. M. Vesicular-arbuscular mycorrhiza in rhizomes, scale-like leaves, roots, and xylem of ginger. *Mycologia* (1982) 74 (1) 156-161 [En, 6 ref., 4 fig.] Texas Agric. Exp. Sta., Texas A & M Univ., College Station, USA.

Ginger obtained in Texas, and which originated from Fiji and Hawaii, contained hyphae, vesicles and spores of the *Glomus* type. This is the 1st record of a VA mycorrhiza in ginger and of the invasion of the vascular system of any plant, occurrence in rhizomatous tissue and in scale-like leaves.

0204 TRAPPE, J. M. Synoptic keys to the genera and species of zygomycetous mycorrhizal fungi. *Phytopathology* (1982) 72 (8) 1102-1108 [En, 31 ref., 5 fig.] USDA, For. Sci. Lab., Corvallis, Ore., USA.

Keys are presented to the genera of the Endogonaceae and morphologically similar taxa, and to the spp. of *Acaulospora*, *Gigaspora*, *Glomus* and *Sclerocystis*.

0205 VENKATARAMANAN, M. N.; SINGH, H. D.; BARUAH, J. N. Note of the occurrence of endotrophic mycorrhiza in water-hyacinth and its significance in agriculture. *Indian Journal of Agricultural Sciences* (1982) 52 (1) 39-40 [En, 9 ref., 1 fig.] Reg. Res. Lab., Jorhat, Assam, India.

Endobionts observed in the roots of *Eichhornia crassipes* were also shown to infect maize roots. The use of roots of the former to seed soils where maize and other crops are to be grown is suggested.

* 0206 WALKER, C. Species in the Endogonaceae: a new species (*Glomus occultum*) and a new combination (*Glomus geosporum*). *Mycotaxon* (1982) 15, 49-61 [En, 20 ref., 4 fig.] Iowa State Univ., Ames, USA.

The new sp., common in several parts of the world, is described. It forms vesicular-arbuscular mycorrhizae with a variety of plants. The taxon *G. macrocarpum* var. *geosporum* is raised to full sp. status.

0207 ZAK, J.C.; DANIELSON, R.M.; PARKINSON, D. Mycorrhizal fungal spore numbers and species occurrence in two amended mine spoils in Alberta, Canada. Mycologia (1982) 74(5):785-792.

Amendation of an oil sands tailings and a subalpine coal mine spoil, with either fertilizer, peat, or liquid sewage sludge, had significant effects on the occurrence of mycorrhizal fungi and spore numbers three years after the initial application. Glomus aggregatum and G. mosseae were the most common VA fungi associated with Agropyron trachycaulum on the two mine spoils. Chlamydospores of the E-strain ectomycorrhizal fungus were associated with Picea glauca on the subalpine spoil. In the oil sands spoil, VA fungal spores were only detected in the control and peat-amended plots. While there was no effect of amendation of the subalpine spoil on G. mosseae spore densities, spore numbers of G. aggregatum were highest in the peat- and lowest in the sewage-amended plots. Chlamydospore production by the E-strain fungus was highest in the control and fertilizer-amended plots with few spores collected from the sewage-amended spoil and none detected in the peat. A significantly greater percentage of spores of G. mosseae from the sewage-amended subalpine spoil occurred at the lower end of the size range for the species. By suppressing mycorrhizal spore production and by affecting spore size, sewage sludge application may have adverse effects on reclamation programs.

*0208 ABBOTT, L.K.; ROBSON, A.D. 1981. Charactersitic features of vesicular arbuscular mycorrhizas and their use in ecological studies. Proc. Int. Bot. Congr. 13(0):296.

0209 CHILVERS, M. T.; DAFT, M. F. J. **Mycorrhizas of the Liliflorae. II. Mycorrhiza formation and incidence of root hairs in field grown *Narcissus* L., *Tulipa* L. and *Crocus* L. cultivars.** *New Phytologist* (1981) 89 (2) 247-261 [En, 41 ref., 2 pl.] Dundee University, Dundee DD1 4HN, UK.

Vesicular-arbuscular mycorrhizal (VAM) infections were examined in 30 cvs of *Narcissus, Tulipa* and *Crocus* over 2 years. There was considerable diversity in the morphology of the VAM infections amongst, and variation of levels within, different genera. The possible causes of these variations, such as high levels of soluble phosphorus and host repression of the VAM endophytes, are discussed. Seven endophytes were identified from spore morphology. No apparent relationship existed between level of VAM and spore numbers in the field. *Tulipa* and *Crocus* roots were devoid of root-hairs. Analysis of the incidence of root hairs in *Narcissus* suggested that mycorrhizal roots were less likely to bear root hairs.

0210 DAINESE, M.B.; CARDOSO, E.J.B.N. [Some observations on endomycorrhizal fungi associated with sugar-cane in Piracicaba, São Paulo]. Algunas observacoes sobre fungos endomicorrizic em associacao com can-acucar em Piracicaba, SP. Solo (Brazil) 73(1):24-27. 1981. 8 refs., Summaries (Eng. Port)

This paper presents a survey of vesicular-abuscular mycorrhizal infection in the roots of several sugar-cane varieties and the occurrence of spores in the rhizosphere, under field conditions in Piracicaba, São Paulo. In general there was little or no root infection, although var. IAC 51/205 and NA 56-79 presented infection rates of 22.1 and 16.6%, respectively. Few spores were present in the rhizosphere soil, most belonging to the genus Glomus although Gigaspora spores were also found.

0211 DWIVEDI, R. S.; PATHAK, S. P. **Occurrence of vesicular mycorrhizal infection in an ornamental plant.** *Indian Phytopathology* (1981) 34 (4) 524-525 [En, 4 ref.] Banaras Hindu Univ., Varanasi, India.

An *Endogone* sp. is newly reported forming a VA mycorrhizal association with *Impatiens balsamina*.

0212 FORSTER, S. M.; NICOLSON, T. H. **Aggregation of sand from a maritime embryo sand dune by microorganisms and higher plants.** *Soil Biology & Biochemistry* (1981) 13 (3) 199-203 [En, 10 ref.] Department of Biological Sciences, University of Dundee, Dundee DD1 4HN, UK.

Addition of micro-organisms to sand from an embryo dune increased both plant growth and the amount of aggregation of sand. Roots alone had little effect on aggregation but in association with micro-organisms caused a noticeable increase. The number of micro-organisms isolated from aggregates each month varied during the course of the experiment. Aggregates from a treatment receiving *Penicillium* spores were colonized by the greatest number of micro-organisms, and the least colonized aggregates were from a treatment where the sand w initially sterile.

0213 FORSTER, S. M.; NICOLSON, T. H. **Microbial aggregation of sand in a maritime dune succession.** *Soil Biology & Biochemistry* (1981) 13 (3) 205-208 [En, 14 ref.] Department of Biological Sciences, University of Dundee, Dundee DD1 4HN, UK.

Aggregation of sand by micro-organisms was assessed in a dune succession ranging from unstable foredunes to stable fixed dunes. Fungi, bacteria, actinomycetes and algae, including cyanobacteria, were isolated from aggregates. Aggregation increased as the dunes became stabilized and the higher plant succession developed. The number and weight of aggregates were interrelated, and most aggregates were in the >1 to <1.4 and >2 mm ranges. The smaller aggregates were colonized by fewer fungal species than the larger ones.

0214 GRAND, L. F.; RANDALL, B. L. ***Endogone pisiformis* and *Endogone multiplex* in North Carolina.** *Mycologia* (1981) 73 (6) 1092-1097 [En, 9 ref., 9 fig.] North Carolina State Univ., Raleigh, USA.

Endogone pisiformis is reported for the first time in North Carolina. A species of *Endogone* similar to *E. multiplex* is described. This, apparently, is the first report of *E. multiplex* since its original discovery in 1922.

0215 IQBAL, S. H.; YOUSAF, M.; YOUNUS, M. **A field survey of mycorrhizal associations in ferns of Pakistan.** *New Phytologist* (1981) 87 (1) 69-79 [En, 19 ref.] Department of Botany, University of the Punjab, New Campus, Lahore, Pakistan.

Ferns from a wide range of localities in Pakistan were collected monthly from June to December and the roots examined for the presence of mycorrhizal fungi. All the ferns examined were constantly mycorrhizal, although the frequency of infection varied among fern species and during the sampling season. A mixture of several endophytes infecting a root system was a usual feature. Vesicular-arbuscular endophytes predominated over endophytes with a septate mycelium. Ectomycorrhizal fungi with a septate mycelium bearing clamp-connections ran longitudinally inside the cortex and occasionally these hyphae formed a mantle on the outside of the roots. A displacement of endotrophic mycorrhizas by ectomycorrhizal fungi occurred in *Adiantum venustum* when growing under pine forest.†

*0216 JEHNE, W.; THOMPSON, H. **Endomycorrhizae in plant colonization on coastal sand-dunes at Cooloola, Queensland.** *Australian Journal of Ecology* (1981) 6 (3) 221-230 [En, 22 ref.] CSIRO, Division of Tropical Crops and Pastures, St Lucia, Australia 4067.

In three mobile coastal sand dunes at Cooloola, Queensland, networks of fungal hyphae were very common in the surface 0-20 cm of bare sand in the colonizing zones. These networks, consisting of long threads of hyphae, extended out into the bare sands from the roots of pioneer seedlings, most of which were endomycorrhizal. The fungi intermeshed sand-grains to form aggregates which appeared to be an important factor in stabilizing these loose sands. The sands were dominantly quartz grains partly covered by thin sesquioxide coatings which contained some phosphorus. Phosphorus held by sesquioxide is generally regarded as being unavailable to most plants. However, the close attachment of hyphae to these coatings, the lack of alternative sources of phosphorus and the prominence of endomycorrhizal fungi was consistent with the fungi obtaining phosphorus from these surfaces.

0217 KIANMEHR, H. **Vesicular-arbuscular mycorrhizal spore population and infectivity of saffron (*Crocus sativus*) in Iran.** *New Phytologist* (1981) 88 (1) 79-82 [En, 18 ref.] Sheffield University, Sheffield SIO 2TN, UK.

Vesicular-arbuscular (VA) mycorrhizal infection of saffron was assessed in the major growing areas of Khorasan, in the north-east. The endomycorrhizal spore population

(mainly *Glomus macrocarpus*) in the soil was high in January and low in July. Particularly heavy VA infection occurred in April. When spores of *G. macrocarpus*, recovered from soils, were tested as inoculum on saffron and other bulbous plants, plant dry weight increases in saffron, onion, narcissus, gladiolus, hyacinth and tulip were, respectively, 26%, 42%, 5%, 5%, negligible and negligible.

0218 KIRAN SINGH.; VARMA, A. K. **Endogonaceous spores associated with xerophytic plants in northern India.** *Transactions of the British Mycological Society* (1981) 77 (3) 655-658 [En, 25 ref., 2 fig., 2 tab.] Jawaharlal Nehru Univ., New Delhi, India.

Several *Glomus* and *Gigaspora* spp. were isolated from the rhizospheres of xerophytes including *Zizyphus nummularia, Calotropis procera, Saccharum munja, Murraya paniculata, Solanum xanthocarpum* and *Malvastrum coromandelianum*. Spore production by these endophytes was related to seasonal growth of their hosts.

0219 KOSKE, R.E. A preliminary study of interactions between species of vesicular-arbuscular fungi in a sand dune. *Trans. Br. mycol. Soc.* 76 (3) 411-416 (1981)

Interactions between five species of VA mycorrhizal fungi sporulating in association with the dominant plants on a single barrier dune were examined. The observed frequency of simultaneous occurrence of any two species did not differ significantly from the expected value in any pairing. Spore densities of individual fungal species in the same sample were analyzed to determine if a stimulation or inhibition of sporulation resulted from high or low levels of sporulation by other VA species. The effect of host species on occurrence of VA species and spore density in the rhizosphere also was studied. Two fungi were absent or rare on three hosts, and spore production by Acaulospora scrobiculata was significantly greater in association with Ammophila breviligulata than with Lathyrus japonicus vr. glaber. It was concluded that interaction between VA fungi is of less importance in determining species presence and spore density than are the species of host plant and other environmental factors.

0220 LAFERRIÈRE, J.; KOSKE, R. E. **Occurrence of VA mycorrhizas in some Rhode Island pteridophytes.** *Transactions of the British Mycological Society* (1981) 76 (2) 331-332 [En, 6 ref.] Dep. of Bot., Univ. of Rhode Island, Kingston, Rhode Island 02881, USA.

Sixteen of nineteen pteridophyte species examined showed mycorrhizal infection in at least one of the various sites selected on Rhode Island. The extent of infection varied markedly between species, and among different specimens of the same species.

0221 MALAJCZUK, N.; LINDERMAN, R. G.; KOUGH, J.; TRAPPE, J. M. Presence of vesicular-arbuscular mycorrhizae in *Eucalyptus* spp. and *Acacia* sp., and their absence in *Banksia* sp. after inoculation with *Glomus fasciculatus*. *New Phytologist* (1981) 87 (3) 567-572 [En, 31 ref., 1 fig., 1 tab.] Div. Land Resources Management, CSIRO, Wembley, W. Aust., Australia.

VA mycorrhizae occurred in seedlings of *E. marginalis, E. diversicolor* and *A. pulchella* grown in soil with added *G. fasciculatus*. Infection levels were 30-35% of the root length of the *E.* spp. and 50-70% in *A.* When *A. pulchella* was grown in the same pots with the 2 *E.* spp. its infection was not increased. *B. grandis* did not form mycorrhizae when grown alone or in association with *A. pulchella*. The results are discussed in relation to the evolution of plants in Australia and the ecological significance of VA mycorrhizae in the eucalypt forest ecosystem.

0222 MALLOCH, D.; MALLOCH, B. **The mycorrhizal status of boreal plants: species from northeastern Ontario.** *Canadian Journal of Botany* (1981) 59 (11) 2167-2172 [En, fr, 16 ref., 6 fig., 3 tab.] Univ. Toronto, Ont., Canada.

When 29 vascular plant spp. were examined, 4 were ectomycorrhizal, 4 both ectomycorrhizal and endomycorrhizal, and 15 were endomycorrhizal. Among the Ericaceae 1 had arbutoid and 5 ericoid mycorrhizae. The distribution of *Cenbcoccum geophilum* among the ectomycorrhizal and arbutoid plants is compared. Selected findings are discussed in relation to reports in the literature.

0223 MIRANDA, J.C.C. (The ocurrence of indigenous endomycorrhizal fungi in a cerrado soil of the Federal District and their effect on phosphorus absorption by Brachiaria decumbens) Ocorrência de fungos endomicorrizicos nativos em um solo de cerrado do Distrito Federal e sua influencia na absorcão de fósforo por Brachiaria decumbens Stapi Revista Brasileira de Ciencia de Solo 5(2):102-105. 1981.

Spores of indigenous endomycorrhizal fungi of Gigaspora spp. and Glomus sp. were found in a Dark Red Latosol sown with Brachiaria decumbens in both the dry and rainy season and for both, the spore number was significantly enhanced by the applied phosphate level. In the rainy season, the spore number and % of root infection were higher than in the dry season for the treatment with 86 kg/ha P_2O_5 but at the level of 345 kg/ha P_2O_5 there was an increase in the spore number and a decrease in the % of root infection. In a greenhouse experiment with Brachiaria decumbens grown in the above mentioned soil, the increase in dry matter production and phosphorus absorption by the plant harvested after 60 days were three times higher in the untreated soil containing endomycorrhizal fungi, than in the sterilized one. Author's summary.

***0224** MOURICHON, X. **[Evidence of an endomycorrhizogenous association in pineapples in the Ivory Coast.]** Mise en évidence d'une association endomycorhizogène chez l'ananas en Côte d'Ivoire. *Fruits* (1981) 36 (12) 745-749 [Fr, 13 ref., 3 pl.] IRFA, OIB.P. 1740.01 Abidjan, Ivory Coast.

***0225** NAPPI, P.; JODICE, R.; KOFLER, A. **[Vesicular-arbuscular mycorrhizae in vineyards given different soil treatments in Southern Tyrol.]** Micorrize vescicolo-arbuscolari in vigneti dell'Alto Adige sottoposti a differenti tecniche di lavorazione del suolo. *Allionia* (1980-81) 24, 27-42 [It, en, 27 ref.] Istituto per le Piante da Legno e l'Ambiente, C.so Casale 476, Torino, Italy.

Samples of soil and roots of grape-vines with Kober 5BB root-stock were collected from 9 vineyard plots in Southern Tyrol under 3 different soil treatments: grass mulch (4 plots), bark mulch (3 plots), mechanical and chemical weeding (2 plots). Spore numbers and mycorrhizal incidence were surveyed at different times of the year at 4 depth levels. Spore numbers were higher in superficial soil layers (up to 1162 spores/g under the bark mulch and up to 500 spores/g under grass mulch) than in deeper layers; under weeding the number of spores remained constantly low (50-150 spores/g) in all layers. Spore numbers were highest in March, decreased from spring to summer with lowest values in July, and later increased progressively. Correlations between spore numbers and amount of organic matter, nitrogen, phosphorus and cation exchange capacity were significant at the P = 0,01 level; correlation between spore numbers and amount of potassium were significant at the P = 0,05 level. Mycorrhizal incidence was very high in the top soil and declined with depth in the soils treated with bark mulch and grass mulch; no difference was observed in the weeding treatments. Mycorrhizal infection varied little between treatments; it was lowest in May and increased during the following months in all treatments; these results confirm that the increase of mycorrhizal density is concomitant with the considerable decrease in the number of spores. This is probably due to spore germination and subsequent development of symbiosis. The grass mulch and the bark mulch increased the contents of the most important nutrients of the soil and then produced a large development of absorbent rootlets in the superficial layers where spore numbers and mycorrhizal incidence were highest. Most of the spores belonged to the fungus *Glomus fasciculatus*; the very high number of spores in late winter means a high inoculum density of vine roots in the following seasons.

0226 NEMEC, S.; MENGE, J. A.; PLATT, R. G.; JOHNSON, E. L. V. **Vesicular-arbuscular mycorrhizal fungi associated with citrus in Florida and California and notes on their distribution and ecology.** *Mycologia* (1981) 73 (1) 112-127

[En, 48 ref., 2 pl., 2 fig., 4 tab.] USDA, Sci. Education Admin., Orlando, Fla., USA.

Mycorrhizal fungi were associated with citrus roots or soils in 78 of 79 orchards and nurseries in Calif. and in 64 of 66 orchards and nurseries in Fla. *Glomus fasciculatus, G. macrocarpus, G. etunicatus, G. constrictus,* and *Sclerocystis sinuosa* were present in both States. *G. microcarpus* and *G. monosporus* were found in Calif. *Gigaspora margarita* and *G. mosseae* were associated with citrus in Fla. but not in Calif. *Glomus fasciculatus* was consistently associated with young trees (0-30 yr) and *G. constrictus* likewise with older trees (30-70 yr). Total numbers of mycorrhizal chlamydospores associated with citrus in Calif. were correlated negatively with soil P and organic matter, but positively with soil Na and pH. *G. macrocarpus* was more frequently found in Calif. citrus soils of high P content than was *G. microcarpus*, and *G. monosporus* appeared to inhabit soils of higher B, Ca + Mg, or salinity than several other mycorrhizal fungi. Chlamydospores of *G. fasciculatus* and *G. constrictus* were most numerous from Nov.-May and least numerous from June-Sept. in Calif.

0227 NEWMAN, E.I.; HEAP, A.J.; LAWLEY, R.A. Abundance of mycorrhizas and root- surface micro-organisms of Plantago lanceolata in relation to soil and vegetation: A multi-variate approach. New Phytol. 89, 95-108 1981.

At 40 sites in England and South Wales, mostly in grassland, features of the soil and vegetation were measured. Three Plantago lanceolata individuals were collected from each site, nitrogen, phosphorus and potassium concentrations in the leaves were measured, and the abundance of mycorrhizal infection and of fungi and bacteria on the root surface was determined by microscopic examination of stained root segments. The results were subjected to multiple regression analysis.

Mycorrhizal abundance was most significantly related to vascular plant cover (negatively) and Plantago leaf length (positively), bacteria to soil organic matter (positively), fungi to cover of non-grasses (positively) and leaf phosphorus concentration (negatively). The ecological interpretation of these relationships is discussed.

0228 NICOLSON, T. H. (Dep. of Biol. Sci., The Univ., Dundee DD1 4HN, Scotland.) Meeting of the 13th International Botanical Congress, Sydney, N.S.W., Australia, Aug. 21-28, 1981. PROC INT BOT CONGR 13(0): 158. 1981. **Endomycorrhizas in coastal and montane grasslands in Scotland, UK./ABSTRACT.**

0229 READ, D. J.; HASELWANDTER, K. **Observations on the mycorrhizal status of some alpine plant communities.** *New Phytologist* (1981) 88 (2) 341-352 [En, 32 ref.] Department of Botany, University of Sheffield, Sheffield S10 2TN, UK.

In 12 Austrian alpine plant communities, levels of vesicular-arbuscular mycorrhizal infection were highest in closed herb-rich communities of intermediate altitudes (1900 to 2500 m). In fertilized hay meadows of lower altitudes (1600 m) and in the nival zone above 3000 m, endogonaceous infection was light. In the latter, infection was mainly by *Glomus tenuis*. Many plants throughout the altitudinal range of the survey were infected with dark septate hyphae and, in the Cyperaceae, this was the dominant infection. Ectomycorrhizas occurred on some herbaceous species as well as on *Salix* up to 2500 m. The possible significance of the infection patterns is discussed.

0230 ROSE, S. L. **Vesicular-arbuscular endomycorrhizal associations of some desert plants of Baja California.** *Canadian Journal of Botany* (1981) 59 (6) 1056-1060 [En, fr, 18 ref.] Department of Soil Science, Oregon State University, Corvallis, OR 97331, USA.

Endemic plants of the Sonoran Desert of Baja California were sampled, and examined for mycorrhizal associations. Eight of the 10 plant species examined, in the families Amaryllidaceae, Anacardiaceae, Cactaceae, Euphorbiaceae, Fouquieriaceae and Leguminosae, were colonized by vesicular-arbuscular (VA) mycorrhizal fungi. Soil sievings revealed chlamydospores of *Glomus microcarpus, G. fasciculatus* and *G. macrocarpus*. At the time of sampling, the populations of VA fungal spores in the soil were low, with one to five chlamydospores per 100 g soil sample.

0231 SCHENCK, N. C.; SMITH, G. S. **Distribution and occurrence of vesicular-arbuscular mycorrhizal fungi on Florida agricultural crops.** *Proceedings, Soil and Crop Science Society of Florida* (1981) 40, 171-175 [En, 27 ref.] Dep. of Pl. Path., Florida Univ., Gainesville, FL 32611, USA.

Soil samples taken at 17 sites throughout Florida supporting 38 plant spp. from 14 families varied greatly in type, pH and P availability. *Glomus* spp. represented 63% of indigenous mycorrhizal fungi and *Gigaspora* 25%, *Acaulospora, Sclerocystis, Entrophospora* and *Complexipes* spp. occurring infrequently. The 2 most common spp., *Glomus intraradix* and *G. etunicatus* occurred throughout Florida on acid and alkaline soils with P availability of 2.8-448 p.p.m.; *Gigaspora* spp. were much more common in N. Florida than at other sites. Leguminous plants had the greatest frequency of mycorrhizal fungi associated with their roots.

0232 SINGH, KIRAN* and A. K. VARMA. (Microbiol. Lab., Sch. Life Sci., Jawaharlal Nehru Univ., New Delhi-110067.) TRANS BR MYCOL SOC 77(3): 655-658. 1981[recd. 1982]. **Endogonaceous spores associated with xerophytic plants in northern India./NOTE.**

0233 WAGNER, C. A.; TAYLOR, T. N. Evidence for endomycorrhizae in Pennsylvanian age plant fossils. *Science* (1981) 212 (4494) 562-563 [En, 9 ref., 1 fig.] Ohio State Univ., Columbus, Ohio, USA.

0234 WALKER, C.; TRAPPE, J. M. ***Acaulospora spinosa* sp. nov. with a key to the species of *Acaulospora*.** *Mycotaxon* (1981) 12 (2) 515-521 [En, 5 ref., 12 fig.] Iowa State Univ., Ames, USA.

The sp. (described) formed vesicular arbuscular mycorrhizae with wild strawberry in pot culture and was associated in the field with VA mycorrhizae of grasses, poplar and ash.

0235 WALKER, C.; RHODES, L. H. ***Glomus albidus*: a new species in the Endogonaceae.** *Mycotaxon* (1981) 12 (2) 509-514 [En, 9 ref., 1 fig.] Iowa State Univ., Ames, USA.

The fungus (described) forms vesicular-arbuscular mycorrhizae with onion, sorghum, maize and poplar. It has white reticulate spores.

0236 ALLEN, E. B.; ALLEN, M. F. **Natural re-establishment of vesicular-arbuscular mycorrhizae following stripmine reclamation in Wyoming.** *Journal of Applied Ecology* (1980) 17 (1) 139-147 [En, 43 ref.] Dep. of Bot., Wyoming Univ., Laramie, WO 82071, USA.

Percentage root infection of *Agropyron smithii* and *A. intermedium* by vesicular-arbuscular mycorrhizae was measured and soil spores were counted in 6 reclaimed stripmine sites in Wyoming. On 2- and 3-yr old sites infection and spore counts were < 50% of native prairie levels. Spore counts of a 3-yr old disced prairie site were not different from the undisturbed prairie level, but infection was significantly lower. Spore counts of the reclaimed sites were not highly correlated with root infection.

0237 ALWIS, D.P. DE; ABEYNAYAKE, K. A survey of mycorrhizae in some forest trees of Sri Lanka. *In*: Tropical Mycorrhiza Research (Ed. by P. Mikola) Oxford Univ. Press Oxford, England. pp.146-153 (1980).

0238 BLOSS, H. E. **Vesicular-arbuscular mycorrhiza in guayule.** *Mycologia* (1980) 72 (1) 213-216 [En, 4 ref.] Department of Plant Pathology, University of Arizona, Tucson, Arizona 85721, USA.

Identification of the fungal symbiont isolated from the roots of guayule (*Parthenium argentatum*), an arid-lands latex-producing shrub, collected south of Alpine, Texas, at an altitude of 1,249 m, showed it to be *Glomus fasciculatus*.†

*0239 CHILVERS, M. T.; DAFT, M. J. **Endomycorrhizas and root hairs of *Narcissus*.** In *Daffodils 1980/81. An annual for amateurs & specialists.* London, UK; Royal Horticultural Society. (1980) 33-36 ISBN 0-906603-08-0 [En, 1 pl. (4 fig.), 1 tab., Price £2.00] Dundee Univ., Scotland, UK.

Studies in NE Scotland indicated that in the field endomycorrhizal levels are high and generally beneficial, inducing larger bulbs, although levels may be affected by environmental factors. The use of pelleted spores of non-indigenous, more active mycorrhizal fungi is discussed with reference to the more economic use of fertilizers.

0240 FORD, E. D.; MASON, P. A.; PELHAM, J. **Spatial patterns of sporophore distribution around a young birch tree in three successive years.** *Transactions of the British Mycological Society* (1980) 75 (2) 287-296 [En, 19 ref., 5 fig., 2 tab.] Inst. Terrestrial Ecology, Penicuik, Midlothian, UK.

The 3 mycorrhizal fungi were found in the 5th, 6th and 7th yr after planting in agricultural soil. The spatial patterns of distribution varied both between spp. and years. Sporophores of *Lactarius pubescens* increased in number, spread rapidly from close to the tree and were aggregated in increasingly tighter clumps. The number of sporophores of *Hebeloma* spp. and rate of spread from the tree declined and their aggregation into clumps became lax. The distribution of *Laccaria laccata* sporophores was comparatively static, moving outwards a small distance, with numbers and clumping structure showing little net change. There were distinct areas around the tree which were not occupied by sporophores of any sp. Analysis of the association between spp. was complicated by the clumping. They tended to be negatively associated in the 5th season but subsequently overlapped, and there was no consistent evidence of spatial inhibition between spp. A distinction is drawn between the fairy ring frequently reported for saprophytic fungi of grassland and that for tree mycorrhizal fungi. Some evidence is considered that sporophore distributions reflect the closely adjacent occurrence of mycorrhizas and the processes which affect the colonization of tree root systems by mycorrhizal fungi.

*0241 GIOVANNETTI, M. **Vesicular-arbuscular mycorrhiza in middle Italy: their occurrence in eroded clay soils.** *Annali di Microbiologia ed Enzimologia* (1980) 30, 1-5 [En, it, 14 ref.] Centro di Studio per la Microbiologia del Suolo del C.N.R., Pisa, Italy.

The incidence of vesicular-arbuscular mycorrhiza and of *Endogonaceae* spores was investigated in Pliocene uncultivated clay soils. 105 samples of roots and adjacent soil from seven plant species living on the "calancos" (special formations resulting from erosion effects) were examined. Spores of vesicular-arbuscular mycorrhizal fungi were found in most soil samples, their numbers ranging from 0 to 500/100 g soil; root infection ranged from 0 to 90%. Most soil samples contained one or more types of spores, belonging mostly to the genus *Glomus*, which was widespread in those soils. For the first time vesicular-arbuscular mycorrhizal infection in *Hedysarum coronarium* roots was reported.

0242 HASELWANDTER, K.; READ, D. J. **Fungal association of roots of dominant and sub-dominant plants in high-alpine vegetation systems with special reference to mycorrhiza.** *Oecologia* (1980) 45 (1) 57-62 [En, 28 ref.] Inst. für Mikrobiologie, Univ. Innsbruck, Sternwartestrasse 15, A-6020 Innsbruck, Austria.

Fungal root infection was analysed in healthy dominant and sub-duminant plants of zonal and azonal vegetation above the timberline in the Central and Northern Calcareous Alps of Austria. In the open nival zone vegetation, infection by fungi of the *Rhizoctonia* type was predominant, vesicular-arbuscular mycorrhizal infection, which was mostly of the fine endophyte (*Glomus tenuis*) type, being light and mainly restricted to grasses in closed vegetation patches. More extensive *Glomus teniis* infection was found in the alpine grass heath, but in *Carex*, *Rhizoctonia* was again the most important fungus. The erocaceous plants of the dwarf shrub heath have typical ericoid infection, but quantitative analysis reveals a decrease of infection intensity with increase of altitude. The possible function of the various types of root infection are discussed, and the status of *Rhizoctonia* as a possible mycorrhizal fungus is considered.

0243 HERRERA, R.A.; FERRER, R.L. Vesicular-arbuscular mycorrhiza in Cuba. *In*: Tropical Mycorrhiza Research (Ed. by P. Mikola) Oxford Univ. Press Oxford, England. pp.156-162 (1980).

*0244 INSERRA, R. N.; NEMEC, S.; LO GIUDICE, V. **A survey of endomycorrhizal fungi in Italian citrus nurseries.** *Rivista della Ortoflorofrutticoltura Italiana* (1980) 64 (1) 83-88 [En, it, 8 ref., 1 pl.] Laboratorio di Namatologia Agraria, CNR, Bari, Italy.

Vesicular-arbuscular mycorrhizae (VAM) were found in half the 149 soil and citrus root samples collected in Apulia, Basilicata, Calabria, Messina and Catania. *Gigaspora* and *Sclerocystis* species were detected in 2 samples, both from sour orange nurseries, and 2 unidentified *Glomus*-like species were found in the other samples. The lack of VAM in so many samples may be due to the common use of fumigant nematicides,

0245 IQBAL, S. H.; BUSHRA, P. **Some species of *Sclerocystis* (Endogonaceae) from Pakistan.** *Transactions of the Mycological Society of Japan* (1980) 21 (1) 57-63 [En, 3 ref., 1 pl., 4 fig., 2 tab.] Univ. Punjab, New Campus, Lahore, Pakistan.

S. sinuosa, *S. clavispora* and the new spp. *S. microcarpus* Iqbal & Bushra and *S. pakistanica* Iqbal & Bushra are described and illustrated from the rhizosphere of ferns and cereals.

0246 JENSEN, A.; JAKOBSEN, I. **The occurrence of vesicular-arbuscular mycorrhiza in barley and wheat grown in some Danish soils with different fertilizer treatments.** *Plant and Soil* (1980) 55 (3) 403-414 [En, 20 ref., 1 fig., 5 tab.] Danish Agric. Advisory Cent., Viby J., Denmark.

Soil samples, roots and shoots were collected from: barley crops at 3 locations which had received different combinations of N and P for 10 yr, long-term fertilizer experiments on barley in a sandy soil, and barley and wheat in a loamy soil. Soils were analyzed for available P by an anion exchange resin procedure, roots were examined for intensity of VAM infection and shoots were analyzed for N and P. VAM infection was found at all locations but was most abundant at the 3 with least soil P and least at the 2 high in soil P. Within locations an inverse relation was found between soil P level and intensity of infection. Infection was also decreased by increasing N fertilizer. Spore counts from selected samples correlated well with infection intensity. Shoot P did not differ significantly between treatments in spite of significant differences in soil P.

*0247 MALLOCH, D. W.; PIROZYNSKI, K. A.; RAVEN, P. H. **Ecological and evolutionary significance of mycorrhizal symbiosis in vascular plants (a review).** *Proceedings of the National Academy of Sciences of the United States of America* (1980) 77 (4) 2113-2118 [En, 110 ref.] Department of Botany, University of Toronto, Toronto, Ontario M5S 1A1, Canada.

About four-fifths of all land plants form endomycorrhizae, whereas several groups of trees and shrubs, notably Pinaceae, some Cupressaceae, Fagaceae, Betulaceae, Salicaceae, Dipterocarpaceae, and most Myrtaceae form ectomycorrhizae. Among legumes, Papilionoideae and Mimosoideae have endomycorrhizae and usually form bacterial nodules. The members of the third subfamily, Caesalpinioideae, rarely form nodules, and one of the included groups, the two large, pantropical, closely related tribes Amherstieae and Detarieae, regularly form ectomycorrhizae. Nodules and ectomycorrhizae may well be alternative means of supplying organic nitrogen to the plants that form them. Those plants having endomycorrhizae usually occur in forests of high species richness, whereas those with ectomycorrhizae usually occur in forests of low species richness. The roots of ectomycorrhizal trees, however, support a large species richness of fungal symbionts, probably amounting to more than 5000 species worldwide, whereas those of endomycorrhizal trees have low fungal species richness, with only about 30 species of fungi known to be involved worldwide. Ectomycorrhizal forests are generally temperate or occur on infertile soils in the tropics. They apparently have expanded in a series of ecologically important events through the course of time from the Middle Cretaceous onward at the expense of endomycorrhizal forests.

*0248 MISHRA, R. R.; SHARMA, G. D.; GATPHOH, A. R. **Mycorrhizas in the ferns of north eastern India.** *Proceedings of the Indian National Science Academy, B* (1980) 46 (4) 546-551 [En, 19 ref.] Department of Botany. School of Life Sciences, North Eastern Hill University, Shillong 793 014, India.

All of the 40 fern species examined possessed vesicular-arbuscular mycorrhiza. The endophytes belonged to the genera *Glomus*, *Gigaspora*, *Acaulospora* and *Sclerocystis*. *Sclerocystis* was associated with all except three of the fern species. Infection levels ranged from 63.3 to 92.0%. Different fern species exhibited different stages of fungal invasion ranging from hyphae, arbuscules and vesicles or a combination of all the three.

0249 NADARAJAH, P. Species of Endogonaceae and mycorrhizal association of *Elaeis guineensis* and

Theobroma cacao. *In*: Tropical Mycorrhiza Research (Ed. by P. Mikola) Oxford Univ. Press Oxford, England. pp.232-237 (1980).

0250 PARKE, J. L.; LINDERMAN, R. G. **Association of vesicular-arbuscular mycorrhizal fungi with the moss *Funaria hygrometrica*.** *Canadian Journal of Botany* (1980) 58 (17) 1898-1904 [En, fr, 32 ref., 2 fig., 1 tab.] Oregon State Univ., Corvallis, USA.

Moss plants were colonized by *Glomus* spp. when growing on the soil surface of pot cultures of asparagus and *G.* spp. The possible ecological significance of this association is discussed.

0251 PFEIFFER, C. M. : BLOSS, H. E. **Vesicular-arbuscular mycorrhizal fungi on soybean in Arizona.** *Mycologia* (1980) 72 (5) 1038-1041 [En, 4 ref.] Department of Plant Pathology, University of Arizona, Tucson, Arizona 85721, USA.

Spores of vesicular-arbuscular (VA) mycorrhizal fungi were recovered from rhizosphere soil and root surfaces of soya bean in Arizona. The VA mycorrhizal fungi were identified as *Glomus macrocarpus* var. *geospores, Gigaspora calospora* and *Glomus microcarpus*.†

0252 POWELL, C. L. **Mycorrhizal infectivity of eroded soils.** *Soil Biology and Biochemistry* (1980) 12 (3) 247-250 [En, 12 ref.] Ruakura Soil & Plant Res. Sta., Ministry of Agric. and Fisheries, Private Bag, Hamilton, New Zealand.

A method to assess the mycorrhizal inoculum infectivity of soils is described. Mature pasture soils in the North Island, New Zealand, contained 6-19 mycorrhizal propagules g^{-1} soil. Of 31 samples taken from extensive areas of eroded soil around Gisborne and Masterton 22 had fewer than 1.0 mycorrhizal propagule g^{-1} soil, and 13 of these soils had less than 0.2 propagules g^{-1}. In a pot trial, mycorrhizal inoculation of white clover plants increased shoot growth in seven eroded soils, by 1-12-fold.†

0253 RABATIN, S. C. **The occurrence of the vesicular-arbuscular-mycorrhizal fungus *Glomus tenuis* with moss.** *Mycologia* (1980) 72 (1) 191-195 [En, 16 ref.] Department of Biological Sciences, University of Pittsburg, Pittsburg, Pennsylvania 15260, USA.

This report deals with ecological aspects of the relationship between the VA fungus *Glomus tenuis* and moss as it occurs at the soil surface in an acid, phosphorus-deficient hayfield in western Pennsylvania. Mowed annually, the field is dominated by the grasses *Holcus lanatus, Agropyron repens* and *Phleum pratense* (65% cover).†

0254 REDHEAD, J.F. Mycorrhiza in natural tropical forests. In: Tropical mycorrhiza research (Mikola, P. ed.) Oxford Univ. Press Oxford, England. pp. 127-142. (1980)

0255 ROSE, S. L. **Mycorrhizal associations of some actinomycete nodulated nitrogen-fixing plants.** *Canadian Journal of Botany* (1980) 58 (13) 1449-1454 [En, fr, 36 ref.] Department of Soil Science, Oregon State University, Corvallis, OR, USA 97331.

Flowering plants that fix atmospheric nitrogen in actinomycete-induced nodules were sampled for mycorrhizal associates. 25 species from seven families (Betulaceae, Casuarinaceae, Myricaceae, Rhamnaceae, Rosaceae, Elaeagnaceae and Datiscaceae) collected from USA, Japan and England were examined. Both mycorrhizae and actinomycete-induced nitrogen-fixing nodules were present on species of *Alnus, Casuarina, Ceanothus, Myrica, Shepherdia, Hippophae, Cercocarpus, Dryas, Purshia, Comptonia* and *Datisca*. Soil sieving revealed species of the following genera of vesicular-arbuscular (VA) mycorrhizal fungi: *Gigaspora, Glomus, Acaulospora, Entrophospora* and three undescribed taxa. Spores in the first three genera of fungi were most common. The VA mycorrhizal fungi exhibited distinct distribution patterns when associated with nonleguminous nitrogen-fixing hosts in different habitats. The ectomycorrhizae were not characterized.

0256 ROSE, S. L.; TRAPPE, J. M. **Three new endomycorrhizal *Glomus* spp. associated with actinorrhizal shrubs.** *Mycotaxon* (1980) 10 (2) 413-420 [En, 9 ref., 9 fig.] Oregon State Univ., USA.

G. halonatus, G. lacteus and *G. scintillans* are described in field association with vesicular arbuscular mycorrhiza of *Ceanothus velutinus* and *Hippophae rhamnoides, C. velutinus* and *Purshia tridentata*; and *Cercocarpus ledifolias* and *P. tridentata*, respectively.

0257 RIESS, S.; RAMBELLI, A. Preliminary notes on mycorrhizae in a natural tropical rain forest. *In*: Tropical Mycorrhiza Research (Ed. by P. Mikola) Oxford Univ. Press Oxford, England. pp.143-145 (1980).

0258 SALEH-RASTIN, N.; DJAVANSHIR, K. Mycorrhizal studies of Iranian forest trees. *In*: Tropical Mycorrhiza Research (Ed. by P. Mikola) Oxford Univ. Press Oxford, England. pp-154-155 (1980).

0259 SCHENCK, N. C. **Incidence of mycorrhizal fungi on six field crops in monoculture on a newly cleared woodland site.** *Mycologia* (1980) 72 (3) 445-456 [En, 34 ref.] Plant Pathology Department, University of Florida, Gainesville, Florida 32611, USA.

The yearly incidence of root colonization and extramatrical spores of vesicular-arbuscular (VA) mycorrhizal fungi were determined for six agronomic crops grown in monoculture for 7 yr on a newly cleared woodland site in northwest Florida. Thirteen species of VA-mycorrhizal fungi were identified from the test site from 1972 to 1978. Sorghum yielded the greatest number of species (12) from a single crop during this period. The highest number of spores was associated with soybean and the lowest number of spores was found in the native woodland. Spores of *Gigaspora margarita, G. gregaria* and *G. gigantea* were most numerous from soil around soybeans while *Glomus fasciculatus* and *G. clarus* were most numerous around roots of bahia grass. *Acaulospora* spp. were most abundant from soil around cotton and peanut. The yearly incidence of *Gigaspora margarita* spores increased while *G. gregaria* and *G. gigantea* decreased in numbers during the 7-yr study. *Glomus macrocarpus* var. *geosporus* and *G. fasciculatus* were observed in 1971 and/or 1972 but were not recovered again until 1978. Only two species, *Gigaspora margarita* and *G. gregaria*, were recovered each year that samples were taken. The highest level of root colonization occurred in 1972 and was followed by a decline in 1973-1974 but mycorrhizae showed a general increase in 1975-1976. It is suggested that the observed changes in the incidence of VA-mycorrhizal fungi were primarily due to the agricultural system of monoculture.

* 0260 SCHÜEPP, H.; MILLIOUD, D.; DEFAGO, G. **[Investigations on the appearance of VA-mycorrhizae in some tobacco-growing regions of Switzerland.]** Untersuchungen zum Auftreten von VA-Mykorrhizen in einigen Tabakanbaugebieten der Schweiz. *Bulletin, Bodenkundliche Gesellschaft der Schweiz* (1980) No.4, 50-56 [De, 5 ref.] Eidg. Forschungsanstalt, CH-8820 Wädenswil, Switzerland.

A correlation was found between the spore density of VA-mycorrhizae in the soil and the degree of mycorrhizal infection. The latter was also correlated with the pH and phosphate content of the soil; in one area it was inversely correlated with humus content. Inoculation with spores of *Glomus mossae* increased mycorrhizal formation in soils of two regions, but not in soils of a third region.

* 0261 SMITH, S. E. **Mycorrhizas of autotrophic higher plants.** *Biological Reviews* (1980) 55 (4) 475-510 [En, 9pp. of ref.] Dep. of Agric. Biochem., Waite Agric. Res. Inst., Glen Osmond, S.A., Australia 5064.

The range of mycorrhizal types is compared with respect to structure and nutritional mode of the symbionts. Ectotrophic, vesicular-arbuscular and ericaceous mycorrhizas of autotrophic plants are considered. A generalized qualitative model of interactions between symbionts is presented with the aim of providing a framework for discussion of the similarities and differences between the mycorrhizas of autotrophic plants. The model describes the biomass distribution, the flow of C and mineral nutrients, and the effects of distribution of fungal inoculum and environmental conditions. Experimental work pertaining to the model is discussed with emphasis on experimental problems, growth depressions, changes in root:shoot ratio and effects on the nutrition of P, N and other nutrients. The importance of mycorrhizas in agriculture is discussed.

* 0262 ST. JOHN, T. V. **[A list of Brazilian tropical plants naturally infected by vesicular-arbuscular mycorrhizas.]** Uma lista de plantas tropicais brasileiras

naturalmente infectadas com micorriza vesicular-arbuscular. *Acta Amazonica* (1980) 10 (1) 229-234 [Pt, en, 23 ref., 1 tab.] Nat. Resources Ecol. Lab., Colorado Sta. Univ., Fort Collins, Colo., USA.

The list includes 131 wild, ornamental and economic spp. of 49 families.

0263 ST. JOHN, T. V. **A survey of mycorrhizal infection in an Amazonian rain forest.** *Acta Amazonica* (1980) 10 (3) 527-533 [En, pt, 22 ref., 2 tab.] Natn. Res. Inst., Manaus, Amazonia, Brazil.

*0264 TARASOVA, ZH. G. **[Mycotrophism of *Heracleum trachyloma* Fisch. & C. A. Mey.]** Mikotrofizm *Heracleum trachyloma* Fisch. et C. A. Mey. *Biologicheskiĭ Zhurnal Armenii* (1980) 33 (8) 878-881 [Ru, armenian, en, 15 ref., 2 fig.] Armen. Inst. Bot., Erevan, USSR.

Typical phycomycete endomycorrhizas were observed in *H. trachyloma* growing near or in water in the vicinity of Germuck, Armenia.

0265 THOMAZINI-CASAGRANDE, L. I. **[Mycorrhiza of plants of enclosed pastures: *Cassia occidentalis* L.]** Micorriza em plantas do cerrado: *Cassia occidentalis* L. *Phyton, Argentina* (1980) 39 (1/2) 113-120 [Pt, en, 7 ref., 5 fig.] Inst. Biosci., Univ. São Paulo, Rio Claro, Brazil.

Anatomical and morphological features of the mycorrhizas are described.

*0266 TZEAN, S.-S.; HUANG, Y.-S. **The occurrence and formation of vesicular-arbuscular mycorrhizae of citrus and maize.** *Botanical Bulletin of Academia Sinica* (1980) 21 (2) 119-134 [En, ch, 23 ref., 4 fig., 2 tab.] Inst. Bot., Academia Sinica, Nankang, Taipei, Taiwan.

Spp. of *Glomus, Gigaspora, Acaulospora* and *Sclerocystis* were recovered from the rhizosphere in maize and citrus growing areas of Taiwan. The natural vesicular-arbuscular mycorrhizal formation in these crops is fairly low since only 1-100 spores were retrieved/100 g soil sampled. Some of the Endogonaceae spores were parasitized internally or externally with other fungi and bacteria. In glasshouse tests 4 *Glomus* spp. were established on maize, but attempts to establish *G. mosseae* on citrus were unsuccessful until the seedlings were transplanted into pots containing mycorrhizal maize. The endomycorrhizal infection process on these hosts, except for the formation of lateral arbuscules, was comparable with that in other crops.

0267 WAIDYANATHA, U.P. DE S. Mycorrhizae of *Hevea* and leguminous ground covers in rubber plantations. *In*: Tropical Mycorrhiza Research (Ed. by P. Mikola) Oxford Univ. Press Oxford, England. pp.238-241 (1980).

0268 ABBOTT, L. K.; ROBSON, A. D. **A quantitative study of the spores and anatomy of mycorrhizas formed by a species of *Glomus*, with reference to its taxonomy.** *Australian Journal of Botany* (1979) 27 (4) 363-375 [En, 23 ref.] Dep. of Soil Sci. and Pl. Nutr., Univ. of Western Australia, Nedlands, Western Australia 6009.

The development of spores and sporocarps was studied in two isolates of a species of *Glomys* collected in Western Australia. Anatomical characteristics of mycorrhizas of *Trifolium subterraneum, Erodium botrys* and *Lolium rigidum* formed with this species were essentially the same and were largely unaffected by nitrogen supply: the hyphae in N-deficient plants were slightly wider than those in N-adequate plants of *T. subterraneum* and *E. botrys*. Phosphorus had no effect on the formation of arbuscles, the density of hyphae within infected roots, or the branching pattern of the endophyte hyphae within the root of *T. subterraneum*. However, P added in excess of that required for maximum plant yield eliminated vesicle formation. Anatomical characteristics of the mycorrhizas changed little with time except for arbuscle number, which decreased markedly between 29 and 50 days after sowing.†

0269 AMES, R.N.; SCHNEIDER, R.W. 1979. *Enthrophosporia*, a new genus in the Endogonaceae. Mycotaxon, 8, 347-352.

0270 BAGYARAJ, D. J.; MANJUNATH, A.; PATIL, R. B. **Occurrence of vesicular-arbuscular mycorrhizas in some tropical aquatic plants.** *Transactions of the British Mycological Society* (1979) 72 (1) 164-167 [En, 12 ref., 3 fig., 1 tab.] Univ. Agric. Sci., Bangalore, India.

VA mycorrhizas were present in 3 of the 12 spp. examined, viz. *Cyanotis cristata, Eichhornia crassipes* and *Salvinia cucullata*. The last is a rootless aquatic fern but one leaf at each node functions as a root. This is the 1st report of VA mycorrhiza in roots and modified submerged leaves of tropical aquatic plants.

0271 BLOSS, H. E. **Vesicular-arbuscular mycorrhizae in jojoba and mariola.** *Mycologia* (1979) 71 (4) 831-834 [En, 5 ref., 1 pl.] Arizona University, Tucson, Arizona 85721, USA.

Vesicles were found in jojoba (*Simmondsia chinensis*) and mariola (*Parthenium incanum*) roots. It is suggested that inoculation of jojoba and mariola seedlings grown in sand culture before transplanting to the field would enhance their productivity.

0272 DANIELS, B. A.; TRAPPE, J. M. ***Glomus epigaeus* sp.nov., a useful fungus for vesicular-arbuscular mycorrhizal research.** *Canadian Journal of Botany* (1979) 57 (1) 539-542 [En, fr, 4 ref.] Oregon State University, Department of Botany and Plant Pathology, Corvallis, OR, USA 97331.

Glomus epigaeus, which has been found in the soil of a Mexican tropical forest, has not been shown to form mycorrhizal associations in the field, but forms endomycorrhizae on various species of potted plants in the greenhouse. *G. epigaeus* produces abundant chlamydospores in sporocarps on the soil surface, has been maintained for more than a year on potted plants, and produces 8-15 sporocarps monthly in each pot. A simple technique of shaking sporocarps in water with broken glass chips is described for the separation of spores from sporocarps. The epigeous habit, narrow, thin-walled, inserted hyphal attachment, and bright yellow to yellow-brown wall color in transmitted light separate *G. epigaeus* from *Glomus macrocarpus*, which normally does not fruit epigeously and has a much broader, thick-walled, noninserted hyphal attachment and brown wall color in transmitted light.†

0273 FERRAZ, J. M. G. **[Survey of vesicular-arbuscular mycorrhiza in some Amazonian crops.]** Levantamento de micorriza vesículo-arbuscular em culturas da Amazônia. *Revista Brasileira de Ciencia do Solo* (1979) 3 (3) 194-196 [Pt, en, 17 ref.] From *Soils and Fertilizers 44*, 8606.

Natural mycorrhizal infections were investigated in guarana (*Paulinia cupana*), black pepper, mallow (*Urena lobata*) and jute. All spp. were infected by VA mycorrhizae, but different spp. exhibited different degrees of infection and numbers of spores. The predominant spores were of *Acaulospora*, indicating their tolerance of the high temp. and acidity of Amazonian soils.

0274 HALL, I. R.; FISH, B. J. **A key to the Endogonaceae.** *Transactions of the British Mycological Society* (1979) 73 (2) 261-270 [En, 33 ref.] Invermay Agric. Res. Cent., Mosgiel, New Zealand.

From the published literature, type material and personal communications, a key was compiled using a computer programme. Both formally and informally described taxa, and some which have yet to be described, are included in the key.

0275 HAYMAN, D. S.; STOVOLD, G. E. **Spore populations and infectivity of vesicular arbuscular mycorrhizal fungi in New South Wales.** *Australian Journal of Botany* (1979) 27 (3) 227-233 [En, 16 ref.] Dep. of Agric., Biol. and Chem. Res. Inst., Rydalmere, N.S.W., Australia 2116.

The distribution of vesicular arbuscular mycorrhizal fungi in different crops in New South Wales was studied. Spore numbers varied considerably between sites and were fewer in uncultivated native grassland than in sown pastures, lucerne and cereals. The crops examined were wheat, oats, barley, maize, sorghum, lucerne, mixed pasture, *Paspalum dilatatum*, native grasses, soyabean, cotton, tobacco and sunflower. 8 spp. of Endogonaceae were found of which *Acaulospora laevis* and *Glomus mosseae* were most common.

*0276 MEJSTRÍK, V.; KELLEY, A. P. **Mycorrhizae in *Sequoia gigantea* Llndl. et Gard. and *Sequoia sempervirens* Endl.** *Česká Mykologie* (1979) 33 (1) 51-54 [En, cs, 5 ref., 3 fig.] Ústav krajinné ekologie ČSAV, Průhonice, Czechoslovakia.

Mycorrhizas of the vesicular-arbuscular type were observed in these *S.* spp. Thick brown roots showed more

severe mycorrhizal infection than thin white roots. Development of endophytic hyphae was max. in the central and inner cortical cell layers. Arbuscules and vesicles occurred in the parenchyma. The roots were without root hairs.

0277 MILLER, R. H.; CARDOSO, E. J. B. N.; CARDOSO, C. O. N. **Some observations on mycorrhizal infection of tropical forage legumes and grasses in Brazil.** *Summa Phytopathologica* (1979) 5 (3/4) 168-172 [En, pt, 8 ref.] Dep. of Agron., Ohio State Univ., Colombus, OH 43210, USA.

The occurrence of vesicular arbuscular mycorrhizal spores in rhiosphere soil and the infection percentage of roots of forage legumes and grasses at Nova Odessa grown on a Cerrado soil was studied. The most heavily infected spp. were Bermuda grass (74%), *Centrosema pubescens* (65%), *Brachiaria plantaginio* (60%), *B. decumbens* (50%), *Pennisetum clandestinum* (52%), *Paspalum notatum* (49%), *P. virgatum* (45%) and *Eragrostis curvula* (45%). The relative amount of external hyphae and occurrence of arbuscules were positively correlated with the degree of infection.

0278 MILLER, R. M. **Some occurrences of vesicular-arbuscular mycorrhiza in natural and disturbed ecosystems of the Red Desert.** *Canadian Journal of Botany* (1979) 57 (6) 619-623 [En, fr, 18 ref.] Land Reclamation Program, Argonne National Laboratory, Argonne, IL, USA 60439.

Studies on the occurrence of vesicular-arbuscular mycorrhiza (VAM) in plant communities of revegetated mine spoils and undisturbed areas of the Red Desert of Wyoming showed that the majority of plants in undisturbed environments in this area are mycorrhizal. On disturbed sites, no mycorrhiza were encountered. Of interest for both the undisturbed and disturbed communities was the predominance of plants belonging to the family Chenopodiaceae. The major difference between the plant species encountered in each community is associated with their reproductive strategy, as well as whether the plants possessed VAM. The major species encountered on undisturbed sites are *Atriplex gardneri, Atriplex confertifolia, Ceratoides lanata, Grayia spinosa, Kochia americana*, and *Sarcobatus vermiculatus*, all possessing mycorrhiza. *Halogeton glomeratus* predominated in disturbed sites and

0279 MINDIASHVILI, ZH. M. **[Data on mycotrophy of potato under cultivation conditions in Eastern Georgia.]** *Trudy Instituta Botaniki Akademii Nauk Gruzinskoĭ SSR* (1979) No.29, 133-140 [Georgian, ru, 21 ref., 6 fig.] Inst. Bot., Georgian Acad. Sci., USSR.

Mycorrhiza of potato was widespread in all the main ecological zones of the region; all were of the *Endogone* type. Mycorrhizal infection appeared from the earliest stages of plant development, reaching a max. at the end of growth. It was intense at high altitudes, somewhat less so in the middle region, increasing again in the valleys.

0280 NICOLSON, T. H.; SCHENCK, N. C. **Endogonaceous mycorrhizal endophytes in Florida.** *Mycologia* (1979) 71 (1) 178-198 [En, 14 ref.] Plant Pathology Department, University of Florida, Gainesville, Florida 32611, USA.

In Florida 21 species of Endogonaceae forming vesicular-arbuscular mycorrhizae are reported. Eight species of the genus *Glomus*, including a new species *G. clarus*, and three species of *Sclerocystis* constitute the chlamydospore species. Seven species of *Gigaspora*, including four new species, *G. nigra, G. pellucida, G. rosea*, and *G. gregaria*, and three species of *Acaulospora* including one new species, *A. gerdemannii*, constitute the azygospore species. Ten species are reported from Florida for the first time.

0281 NICOLSON, T. H.; JOHNSTON, C. **Mycorrhiza in the gramineae. III. *Glomus fasciculatus* as the endophyte of pioneer grasses in a maritime sand dune.** *Transactions of the British Mycological Society* (1979) 72 (2) 261-268 [En, 36 ref.] Department of Biological Sciences, University of Dundee, Dundee DD1 4HN, UK.

In a sand-dune system in Scotland, *Glomus fasciculatus* was the only endophyte present on roots of pioneer colonizing grasses. This fungus formed sporocarps and spore aggregates in the soil and in association with organic fragments, particularly root tissues. The amounts of infection and external mycelium varied with vegetation zone and season but both became greater with dune stabilization, and infection increased during summer and autumn. Growth of *Ammophila arenaria* and *Agropyron junceiforme* in pots containing unsterile foreshore sand was improved by the formation of mycorrhizae *G. fasciculatus* and *G. macrocarpus* var. *geosporus*. In dune sands maize grew better with both these endophytes than with either alone. The possible significance of mycorrhizae in nutrient-poor and unstable habitats is discussed.

*0282 NOZADZE, L. M. **[Mycotrophy of Compositae species in relation to vertical distribution in Georgia.]** *Trudy Instituta Botaniki Akademii Nauk Gruzinskoĭ SSR* (1979) No.29, 117-132 [Georgian, ru, 2 tab.] Inst. Bot., Georgian Acad. Sci., USSR.

Endotrophic-vesicular mycorrhizas were characteristic of 97 out of 115 spp. at 0-3600 m above sea level studied in 1962-74. Of these, 62 were strongly mycotrophic, 15 moderately and 20 weakly so. Mycorrhizal infection within a particular sp. varied with plant age and season.

*0283 OSHIMA, S. **[The occurrence of vesicular-arbuscular mycorrhizae in tobacco by means of inoculating with endomycorrhizal root pieces of *Ophiopogon japonicus* Ker-Gawl.]** *Bulletin of the Okayama Tobacco Experiment Station* (1979) No. 40, 67-71 [Ja, en, 10 ref., 8 fig.]

Excised mycorrhizal roots of *O. japonicus* were kept alive under moist conditions for >30 days and hyphae grew out of pieces of root plated on agar, reaching 10 mm after 8 days at 25°C and anastomosing frequently. The mycorrhizal fungus penetrated tobacco roots, forming abundant vesicular-arbuscular mycorrhizae within 15 days at 22°, when 5 mm pieces of mycorrhizal root were placed in the rhizosphere of pot-grown plants.

0284 REEVES, F. B.; WAGNER, D.; MOORMAN, T.; KIEL, J. **The role of endomycorrhizae in revegetation practices in the semi-arid west. 1. A comparison of incidence of mycorrhizae in severely disturbed *vs.* natural environments.** *American Journal of Botany* (1979) 66 (1) 6-13 [En, 33 ref.] Dep. of Bot. and Pl. Physiol., Colorado State Univ., Fort Collins, CO 80523, USA.

A comparison of a natural undisturbed ecosystem, a mid-elevation sage community, with a severely disturbed old roadbed through this community revealed that > 99% of the plant cover in the natural community was mycorrhizal (vesicular-arbuscular), whereas < 1% of the plant cover in the disturbed area (roadbed) was mycorrhizal. Examples of non-mycorrhizal plants as primary successional spp. in severely disturbed habitats are discussed. The importance of maintaining or re-establishing the mycorrhizal fungal component in reclamation programmes designed to produce stable ecosystems is emphasized.

0285 RICH, J. R.; SCHENCK, N. C. **Survey of north Florida flue-cured tobacco fields for root-knot nematodes and vesicular-arbuscular mycorrhizal fungi.** *Plant Disease Reporter* (1979) 63 (11) 952-955 [En, 15 ref., 2 tab.] Univ. Florida, Live Oak, USA.

A survey in 1977 showed that *Gigaspora margarita* and *Acaulospora trappei* were the predominant VA mycorrhizal fungi, although 3 or 4 spp. were present in most fields. The number of such spp. was low compared with other agronomic crops in the region.

0286 ROSE, S.; DANIELS, B.A.; TRAPPE, J.M. Glomus gerdemannii sp. nov. Mycotaxon, 8:297-301 (1979)

0287 ROTHWELL, F.M.; TRAPPE, J.M. Acaulospora bireticulata, sp. nov. Mycotaxon: 8:471-475 (1979).

0288 THOMAZINI, L. I. **[Mycorrhiza on plants of fenced-in land: *Davilla rugosa* Poir.]** Micorriza em plantas de cerrado: *Davilla rugosa* Poir. *Revista de Agricultura, Piracicaba, Brazil* (1979) 54 (4) 195-199 [Pt, 6 ref.] Inst. Biosci., Univ. Júlio de Mesquita Filho, Rio Claro, SP, Brazil.

Endotrophic mycorrhiza belonging to the *Paris quadrifolia* type were noted on *D. rugosa*.

0289 THOMAZINI, L. I. **[Vesicular-arbuscular mycorrhiza in *Solanum lycocarpum* St. Hil.]** Micorriza vesicular-arbuscular em *Solanum lycocarpum* St. Hil. *Phyton, Argentina* (1979) 37 (2) 97-103 [Pt, en, 11 ref., 2 fig.] Inst. Biosciences, Univ. Rio Claro, São Paulo, Brazil.

The mycorrhiza, occurring under natural conditions in the Rio Claro and Corumbataí regions, Brazil, are described.

0290 TRAPPE, J. M. *Glomus segmentatus* sp. nov. *Transactions of the British Mycological Society* (1979) 73 (2) 362-363 [En, 2 fig.] Pacific Northwest Forest Range Exp. Sta., For. Sci. Lab., Corvallis, Ore., USA.

A description is given of *G. segmentatus* Trappe, Spooner & Ivory collected on bare soil in Belize.

0291 WALKER, C. *Complexipes moniliformis*: a new genus and species tentatively placed in the Endogonaceae. *Mycotaxon* (1979) 10 (1) 99-104 [En, 7 ref., 1 fig.] Iowa State Univ., Ames, USA.

A description is given of an endogonaceous spore collected from soil around roots of virginia creeper (*Parthenocissus quinquefolia*) in a pine plantation in Ames.

0292 WEIJMAN, A.C.M.; MEUZELAAR, H.L.C. Biochemical contributions to the taxonomic status of the endogonaceae. Can. J. Bot. 57: 284-291. 1979.

The Endogonaceae are generally considered as zygomycete representatives, although zygospores have only been observed in the type genus Endogone, Consequently, the oomycetous or chytridiomycetous nature of some fungi classified in the Endogonaceae cannot be excluded. The presence or absence of chitin in cell walls can indicate the oomycetous or zygomycetous relationship. The occurrence of glucosamine was investigated by gas-liquid chromatographic analysis of intact cell hydrolyzates, a process requiring small quantities of material. The cells were also characterized by Curie-point pyrolysis mass spectrometry. These two techniques were applied to lyophilized spores or sporocarps of Endogone Glomus, Glaziella, and Gigaspora. Mucor mucedo, Allomyces arbuscula, Pythium spinosum, and Saprolegnia ferax were included for comparison. In all endogonaceous isolates tested, a strong predominance of chitin was indicated, supporting their classification within the Zygomycetes. The phylogenetic significance of chitin and cellulose distribution in fungal cell walls is discussed.

0293 WILLIAMS, S. E. Vesicular-arbuscular mycorrhizae associated with actinomycete-nodulated shrubs, *Cerocarpus montanus* Raf. and *Purshia tridentata* (Pursh) DC. *Botanical Gazette* (1979) 140 (supplement) 115-119 [En, 38 ref.] Div. of Pl. Sci., Wyoming Univ., Laramie, WY 82071, USA.

Roots and rhizosphere soil of several representative plants of *C. montanus* and *P. tridentata* were collected from several locations in New Mexico and the Laramie and Medicine Bow Mountains of SE Wyoming and examined for vesicular-arbuscular (VA) mycorrhizal symbionts. Spores of VA mycorrhizal fungi were isolated from rhizosphere soil and identified. Field plants were found to be heavily infected with VA mycorrhizal fungi. The isolated mycorrhizal symbionts were identified as *Glomus* spp. Microscopic examination of roots suggested *Gigaspora* and *Acaulospora* spp. were also present.

*0294 ALTINTAŞ, N.; ÖNER, M. [Investigation on the mycorrhizal condition of herbaceous and woody plants in Izmir province.] Izmir ili dahilinde bulunan bazı otsu ve odunlu bitkilerin mikorizal durumları hakkında bir araştırma. *Ege Üniversitesi Fen Fakültesi Dergisi, B* (1978) 2 (1) 33-54 [Tr, en, 35 ref., 1 tab.] Dep. Bot., Ege Univ., Bornova, Izmir, Turkey.

0295 CARDOSO, E. J. B. N. [Occurrence of mycorrhiza on coffee.] Ocorrência de micorriza em café. *Summa Phytopathologica* (1978) 4 (2/3/4) 136-137 [Pt, en, 1 ref., 3 fig.] Luiz de Queiroz Agric. Coll., Piracicaba, Brazil.

Mycorrhizal infection is reported on coffee seedlings grown in the nursery on natural soil mixed with forest soil, without fumigation and mineral fertilization. A possible relation between mycorrhizas and better development of the seedlings is discussed.

0296 CLOUGH, K. S.; SUTTON, J. C. Direct observation of fungal aggregates in sand dune soil. *Canadian Journal of Microbiology* (1978) 24 (3) 333-335 [En, fr, 4 ref., 6 fig.] Res. Sta., Agric. Canada, Charlottetown, PEI, Canada.

The mycorrhizal fungus *Glomus* in association with bean (*Phaseolus vulgaris*) hosts in pot cultures and grass hosts on Lake Huron sand dunes produced extensive external mycelium which was the dominant factor in the aggregation of soil particles. Light and scanning electron microscopy indicated that the sand grains were attached to the hyphae. An amorphous deposit, often present at the interfaces of sand grains and hyphae, appeared to act as an adhesive. Staining procedures indicated that this material contained polysaccharide. Other micro-organisms were observed in association with the *G.* hyphae and the amorphous deposits.

0297 CRUSH, J. R. Changes in effectiveness of soil endomycorrhizal fungal populations during pasture development. *New Zealand Journal of Agricultural Research* (1978) 21 (4) 683-685 [En, 8 ref., 1 fig., 1 tab.] DSIR, Palmerston North, New Zealand.

Huia white clover and hill country white clover were used as test plants in a glasshouse experiment consisting of reciprocal inoculations with mycorrhizal populations from 3 soils at different stages of pasture development. There were strong endophyte × host and endophyte × soil interactions. There was a rapid increase in the effectiveness of soil endophyte populations as pasture development proceeded. This is assumed to result from host selection for effective endophyte strs. from a diverse soil population under a changing environment.

0298 DAVISON, D. E.; CHRISTENSEN, M. Root-microfungal and mycorrhyzal associations in a shortgrass prairie. *Science Series, Range Science Department, Colorado State University* (1978) No.26, 279-287 [En, 49 ref.] Dep. of Bot., Wyoming Univ., Laramie, WY 82070, USA.

Mycorrhizal and other root-associated microfungi closely associated with root processes and root decomposition in a short-grass prairie on the Pawnee site of the US/IBP Grassland Biome in N.E. Colorado are described. Direct inspection of 10 plant spp. revealed the abundance of vesicular-arbuscular mycorrhizae in the short-grass prairie. Infection of root pieces 1-2 mm in length ranged from 55% for *Opuntia polyacantha* to 88-90% for *Bouteloua gracilis*, *Aster tanacetifolius* and *Plantago purshii*.

0299 HAYMAN, D. S. Mycorrhizal populations of sown pastures and native vegetation in Otago, New Zealand. *New Zealand Journal of Agricultural Research* (1978) 21 (2) 271-276 [En, 19 ref.] Dep. of Bot., Otago Univ., Dunedin, New Zealand.

Vesicular-arbuscular mycorrhizal fungi (Endogonaceae) were present as resting spores (6-1590/100 g soil) and as root infection (4%-85% of cortex infected) at 34 of the 35 sites examined. They were most abundant under native scrub and mixed forest and least abundant under tussock grasslands. Their variable occurrence under sown pastures was attributed partly to their abundance under the preceding vegetation; it was not related to soil phosphate availability. Of the 10 spp. distinguished, the 4 most widespread were the white reticulate type, *Acaulospora laevis*, *Sclerocystis rubiformis* and the *Glomus fasciculatus* group. It was suggested that since there was no distinctive distribution pattern there is some ecological equivalence between spp.

0300 HERSKOWITZ, J. M.; ESTEY, R. H. Endogonacene from Quebec soils. *Canadian Journal of Botany* (1978) 56 (8) 1095-1098 [En, fr, 13 ref., 1 fig.] Macdonald Coll. McGill Univ., Ste. Anne de Bellevue, Que., Canada.

Spores isolated from soils near Macdonald Coll. included those of *Glomus mosseae*, *G. macrocarpus* var. *geosporus*, *G. caledonius* and *Acaulospora laevis*. Sporocarps of *Sclerocystis rubiformis* were also found. The ectocarpic spore population was lowest in May or June, increasing in late summer to reach a peak in Sept. or Oct.

0301 HIRREL, M. C.; MEHRAVARAN, H.; GERDEMANN, J. W. Vesicular-arbuscular mycorrhizae in the Chenopodiaceae and Cruciferae: do they occur? *Canadian Journal of Botany* (1978) 56 (22) 2813-2817 [En, fr, 20 ref.] Dep. of Plant Pathology, Univ. of Illinois, Urbana, 61801, USA.

Published reports of VA mycorrhizae in Chenopodiaceae and Cruciferae are summarized. Sparse vesicular (chlamydospore) infection by *Glomus fasciculatus* was found in 4 out of 6 species of Chenopodiaceae (*Chenopodium album*, *C.amaranticolor*, *C.quinoa* and *Spinacea oleracea*) and two out of five species of Cruciferae (*Brassica nigra* and *Raphanus sativus*) but only when grown in the presence of a mycorrhizal companion plant, citrus or onion. No arbuscules

were observed in infected roots. *C.album* had the highest incidence of infection (5%). Infection was restricted to older tissue and penetration of the vascular cylinder was common, which is atypical of VA mycorrhizae. As hyphae from companion plants grew through the soil, they encountered older roots of the test plants which probably offered little resistance to infection. In documenting the occurrence of VA mycorrhizae in any species, it is important to observe whether there are mycorrhizal plants closely associated with it. Care should be taken not to confuse common root parasites for the fungal structures of VA mycorrhizae.

*0302 IQBAL, S. H.; TAUQIR, S.; AZIZ, A. I.; AHMAD, J. S.; IQBAL, H. M. **A field survey of vesicular arbuscular mycorrhizal associations in cereals.** *Biologia, Pakistan* (1978) 24 (1) 97-113 [En, 19 ref., 9 tab.] Univ. Punjab, Lahore, Pakistan.

VA mycorrhizal infection was present in both young and mature oats, sorghum, barley, wheat, maize and rice under field conditions. Generally no correlation was found between the infections caused by mixed *Endogone*-type spores and growth parameters, such as fresh and dry wt., number of tillers, plant heights or number of leaves. Cultivation of strongly mycorrhizal plant spp. did not affect the frequency of a particular *E.* spore type. In mixed populations, white reticulate spores were selectively decreased by urea and yellow vacuolate spores selectively increased. The effect of water regime, cutting host plants and the occurrence of *E.* spores and VA mycorrhizae are discussed.

0303 KHAN, A. G. **Vesicular-arbuscular mycorrhizas in plants colonizing black wastes from bituminous coal mining in the Illawarra region of New South Wales.** *New Phytologist* (1978) 81 (1) 53-63 [En, 40 ref.] Science Department, Goulburn College of Advanced Eduction, Goulburn, N.S.W., Australia, 2580.

On three commercial coal tips all the plants examined, except species of *Personia* and *Banksia* (Proteaceae), were infected by VA mycorrhizal fungi. Infection level ranged from 0 to 88%. Three main types of fungal endophytes, namely *Glomus macrocarpus* var. *macrocarpus, Glomus mosseae,* and *Sclerocystis rubiformis,* were identified. The possible role of VA mycorrhizas in plant colonization of coal spoil areas is discussed. Colorimetric quantification of VA infection was a useful alternative to the slow and tedious method of clearing and staining. However, the pigment-extraction method is reliable only for measuring mycorrhizal infection in controlled short term experiments, and cannot be used to analyse infection in field-grown, long established roots.

0304 MOLINA, R. J.; TRAPPE, J. M.; STRICKLER, G. S. **Mycorrhizal fungi associated with *Festuca* in the western United States and Canada.** *Canadian Journal of Botany* (1978) 56 (14) 1691-1695 [En, 27 ref.] Pacific Northwest Forest and Range Experiment Station, Forestry Sciences Laboratory, Corvallis, OR, USA 97331.

Vesicular-arbuscular mycorrhizal infection and associated mycorrhizal fungi were examined for *Festuca viridula, Festuca idahoensis, Festuca scabrella, Festuca thurberi, Festuca ovina,* and *Festuca arizonica* occurring in *Festuca*-dominated grasslands. All plants were mycorrhizal. Nearly all had mycorrhizal infection in 75% or more of their fine root length. Although levels of infection were consistently high, spore numbers were generally low. No differences in the degree of infection between *Festuca* species or habitats were observed. Eleven mycorrhizal fungi were identified and ranked by decreasing frequency as follows: *Glomus fasciculatus, Glomus tenuis, Gigaspora calospora, Acaulospora laevis, Glomus macrocarpus* var.*macrocarpus, Glomus microcarpus, Acaulospora scrobiculata, Glomus mosseae, Glomus macrocarpus* var.*geosporus, Sclerocystis rubiformis,* and an unidentified *Acaulospora* species. It was common to find two or more species infecting an individual plant. The mean number of fungal associates/community site ranged from 2.7 species for *F.idahoensis* to 5.0 species for *F.arizonica*. None of the mycorrhizal fungi appeared to be specific for any particular *Festuca* host.

0305 POTTY, V. P. **Occurrence of vesicular-arbuscular mycorrhiza in certain tuber crops.** *Journal of Root Crops* (1978) 4 (1) 49-50 [En, 10 ref., 5 fig.] Cent. Tuber Crops Res. Inst., Trivandrum, India.

Typical VA mycorrhiza were found for the first time in roots of cassava, sweet potato and *Coleus* examined but not in those of *Dioscorea, Colocasia* or *Amorphophallus.*

0306 REECE, P. E.; BONHAM, C. D. **Frequency of endomycorrhizal infection in grazed and ungrazed blue grama plants.** *Journal of Range Management* (1978) 31 (2) 149-151 [En, 18 ref.] Range Science Dep., Colorado State Univ., Fort Collins, Colorado, USA 80523.

A study was conducted in eastern Colorado to examine the occurrence and extent of endomycorrhiza infection in roots of blue grama (*Bouteloua gracilis*) plants under grazed and ungrazed conditions on two soil types, loamy sand and sandy loam. The frequency of mycorrhizal infection in blue grama roots was determined from two criteria: occurrence of any mycorrhizal element, and occurrence of fungal vesicles. No significant differences were observed with respect to grazing using the first frequency criteria. However, roots of previously grazed plants had significantly higher frequencies of vesicles than those collected from exclosures. Frequency of vesicles was found to increase linearly with increase in rooting depth of blue grama. Significant grazing effects on the frequency of vesicles were observed primarily in the first sample depth, 0-10 cm.

*0307 ROTHWELL, F. M.; HOLT, C. **Vesicular-arbuscular mycorrhizae established with *Glomus fasciculatus* spores isolated from the faeces of cricetine mice.** *USDA Forest Service Research Note* (1978) No. NE-259, 4 pp. [En, 6 ref., 1 fig., 1 tab.] USDA, Forest Service, Broomall, Pa., USA.

The mice were trapped on 2 revegetated surface-mined areas, one with a freshly seeded grass legume cover and one with an early successional grass-forb cover. Chlamydospores of *G. fasciculatus* isolated from the mice produced representative endomycorrhizae with maize under glasshouse conditions.

0308 SPARLING, G. P.; TINKER, P. B. **Mycorrhizal infection in Pennine grassland. 1. Levels of infection in the field.** *Journal of Applied Ecology* (1978) 15 (3) 943-950 [En, 42 ref.] Macaulay Inst. for Soil Res., Craigiebuckler, Aberdeen AB9 2QL, UK.

Roots collected from 3 contrasting types of permanent grassland in the Pennines were consistently infected by vesicular-arbuscular (VA) mycorrhizal fungi. About half of the root material with cortex was infected and there was little variation in infection with soil depth. Seasonal changes in infection were small. The greatest total wt. of root and total wt. of infected root occurred in summer, although the highest levels of infection were in winter. Spores of the VA fungi were not common and it is likely that many of them are non-sporing forms. Top-dressings of P fertilisers (250 kg P/ha) decreased mycorrhizal infection during the 1st yr of application, but this effect declined after 2 yr at 2 of the sites. Lime, N and K dressings did not appreciably affect the amount of mycorrhizal infection.

*0309 SPITKO, R. A.; TATTAR, T. A.; ROHDE, R. A. **Incidence and condition of vesicular-arbuscular mycorrhizae infections in the roots of sugar maple in relation to maple decline.** *Canadian Journal of Forest Research* (1978) 8 (4) 375-379 [En, fr, 22 ref.] Department of Plant Pathology, University of Massachusetts, Amherst, MA, 01003, U.S.A.

Twelve sugar maples (*Acer saccharum* Marsh.) on the campus of the University of Massachusetts ranging from healthy to severely declined were assigned to crown-condition classes of increasing severity from I to IV. Whole root samples from each tree were cleared in 10% KOH and stained in trypan blue to assess the degree of vesicular-arbuscular infection. Five sections of secondary feeder roots from each tree were selected at random and examined under a microscope. The number of infected cortical cells per centimetre of roots was counted to give an estimate of percent mycorrhizal infection for each tree. An inverse relationship was found between the degree of decline shown by the crown and the amount of mycorrhizal infection in the roots. Trees of class I had young infections showing extensive arbuscule development and few vesicles. In classes II to IV there was a decrease in the number of cortical cells infected by the fungus and an increase in vesicle formation, at times to the point where cortical cells were disrupted by their presence. In class IV, arbuscules that were present had undergone digestion of the fine branches so that only the collars were in evidence. Soil pH and nutritional status were determined but no relationship was found between those factors and the health of the fungal symbiont in the roots.

0310 SWARD, R. J.; HALLAM, N. D.; HOLLAND, A. A. ***Endogone* spores in a heathland area of south-eastern Australia.** *Australian Journal of Botany* (1978) 26 (1) 29-43

[En, 29 ref., 1 tab., 25 fig.] Monash Univ., Victoria, Australia.

The relative spore numbers of vesicular-arbuscular mycorrhizal fungi in a heath area on sandy podzolic soil at Cranborne were monitored over 2 yr in sites containing disturbed and undisturbed native vegetation, as well as recolonizing areas of mixed indigenous and introduced spp. Many *Endogone* spores were found, and some correlation between peak spore numbers and periods of high rainfall was recorded in the disturbed sites. No such correlation was found in undisturbed heath. Many spores of varying morphology were examined, and 8 spore types belonging to non-sporocarpic members of the Endogonaceae are described in detail. The viability of a white, bulbous-based spore type was investigated following storage under different conditions for varying lengths of time.

0311 THOMAZINI, L. I. **[Vesicular-arbuscular mycorrhiza in *Annona coriacea* Mart.]** Micorriza vesicular-arbuscular em *Annona coriacea* Mart. *Phyton, Argentina* (1978) 36 (1) 75-84 [Pt, en, 8 ref.] Departamento de Génetica, Evolução Faculdade de Filosofia, Ciências e Letras de Rio Claro, Estado de São Paulo, Brazil.

Annona coriacea in the "cerrado" had an endotropic mycorrhiza, which belonged to the Paris series of Gallaud and to the vesicular-arbuscular group of Burgeff and other authors.

0312 THOMAZINI, L. I. **[Vesicular-arbuscular mycorrhiza on *Tocoyena formosa* (Cham. & Schl.) K.Sch.]** Micorriza vesicular-arbuscular em *Tocoyena formosa* (Cham. & Schl.) K. Sch. *Revista de Agricultura* (1978) 53 (1/2) 64-67 [Pt, 11 ref.] Faculdade de Filosofia, Ciência e Letras de Rio Claro, SP, Brazil.

0313 ABBOTT, L. K.; ROBSON, A. D. **The distribution and abundance of vesicular arbuscular endophytes in some Western Australian soils.** *Australian Journal of Botany* (1977) 25 (5) 515-522 [En, 22 ref.] Department of Soil Science and Plant Nutrition, University of Western Australia, Nedlands, W.A.6009, Australia.

The distribution and abundance of large-spored vesicular arbuscular (VA) endophytes was examined at three localities in Western Australia. Within each locality, soil samples were collected from sites with a range of soil properties and superphosphate histories. Vesicular arbuscular endophytes were widespread. Spores were found in all but five of 104 samples. In two of the samples where spores were not found, plants grown in the soils formed VA mycorrhizas. Root infection by a fine endophyte resembling *Rhizophagus tenuis* was also frequently observed. Five spore types were found. Honey-coloured sessile spores were present in 85% of the samples. The yellow vacuolate spore type was the second most common endophyte, but its distribution was mostly limited to cultivated and fertilized soils. Endophytes other than the yellow vacuolate spore type occurred on both virgin and agricultural soils. The distribution of honey-coloured sessile and yellow vacuolate spores in cultivated soils appeared to be associated with variation in soil pH. The total numbers of spores collected on a 106 μm sieve were not correlated with soil pH, $NaHCO_3$-extractable phosphorus or superphosphate history.

0314 AMES, R. N.; LINDERMAN, R. G. **Studies on the vesicular-arbuscular mycorrhizae of Easter lily in the Pacific northwest.** [Abstract]. *Proceedings of the American Phytopathological Society* (1977) 4, 201 [En] California University, Berkeley, California 94720, USA.

Vesicular-arbuscular mycorrhizal (VAM) fungus infections in roots of field-grown Easter lilies were sparse in March (5 or fewer arbuscules/infection unit) and increased until September when bulbs were harvested. Four species were found: *Acaulospora trappei, A. elegans, Glomus fasciculatus* and *G. monosporus*. Lily bulbs were inoculated in the greenhouse with spores, roots and soil from trap plants (field inoculated). Controls were uninoculated or given an inoculum suspension (IS) which had passed through a 38 μm sieve to remove VAM spores. Plants were given one of three fertilizer rates: high, low or none. VAM inoculated plants grew less than controls, apparently due to root rot caused by *Fusarium oxysporum*, which had built up on the trap plants. Controls were non-mycorrhizal, and only IS controls were slightly infected with *F. oxysporum*. High fertilizer rates enhanced root rot and inhibited VAM infection. The best growth and most mycorrhizae occurred with plants given the low fertilizer rate. Non-fertilized plants grew poorly and had the fewest VAM infections. In another experiment, lily seedlings inoculated with *A. trappei*, excluding pathogens, grew significantly better than controls, having a greater fresh weight and higher levels of N, P, K, Ca and Mg.

0315 AMES, R. N.; LINDERMAN, R. G. **Vesicular-arbuscular mycorrhizae of Easter lily in the northwestern United States.** *Canadian Journal of Microbiology* (1977) 23 (12) 1663-1668 [En, 27 ref.] Department of Botany and Plant Pathology, Oregon State University, Corvallis, Or, USA 97331.

The vesicular-arbuscular (VA) mycorrhizal fungi of commercially grown Easter lily (*Lilium longiflorum*) were studied. Soil and root samples were collected monthly from March through September 1975 and five fields in the coastal area of southern Oregon and northern California. Soil sievings were inoculated onto clover, onion, and lily to cause infections resulting in the production of many new mycorrhizal spores facilitating identification. Four VA mycorrhizal species were found: *Acaulospora trappei, A. elegans, Glomus monosporus*, and *G. fasciculatus*. All four VA species infected Easter lily, clover, and onion. *Acaulospora trappei* and *G. fasciculatus* were the most commonly isolated species from all five fields. Mycorrhizal infections in roots of field-grown lilies were sparse and presumably young in March and gradually increased in size and number until September when bulbs were harvested. Over 75% of each root system became infected with mycorrhizae in fields with all four fungal species, and those levels were reached by July. In fields with only two mycorrhizal species, usually 50% or less of each root system was infected, even by the end of the growing season.

0316 BECKER, W.N.; GERDEMANN, J.W. Glomus etunicatus sp. Nov. Mycotaxon 6(1):29-32. 1977.

0317 COOPER, K. M. ***Asplenium bulbiferum* is non-mycorrhizal.** *New Zealand Journal of Botany* (1977) 15 (3) 645-647 [En, 19 ref.] Univ. Otago, Dunedin, New Zealand.

Evidence is presented that this fern is non-mycorrhizal, and is possibly the only non-mycorrhizal ground fern in New Zealand. The combination of an extensive root system, copious and long root hairs and slow growth rate probably enables the fern to grow in the absence of a mycorrhizal association in soils low in available P.

0318 GRAW, D.; REHM, S. **[Vesicular-arbuscular mycorrhiza in the pegs of *Arachis hypogaea* L.]** Vesikuläre-arbuskuläre Mykorrhiza in den Fruchtträgern von *Arachis hypogaea* L. *Zeitschrift für Acker-und Pflanzenbau* (1977) 145 (1) 75-78 [De, en, 9 ref.] Institut für Tropischen und Subtropischen Pflanzenbau, Universität Göttingen, 3400 Göttingen, German Federal Republic.

Groundnut plants grown on a soil containing mainly insoluble P were inoculated with VA mycorrhiza. Fungal symbiosis developed in the roots and also very intensively in the pegs. It was assumed that the mycorrhiza enhanced P uptake in these structures.

0319 HALL, I. R. **Species and mycorrhizal infections of New Zealand Endogonaceae.** *Transactions of the British Mycological Society* (1977) 68 (3) 341-356 [En, 47 ref.] Botany Department, University of Otago, Dunedin, New Zealand.

Species of the New Zealand Endogonaceae are described, including four new species and one new combination of *Glomus*, and one new species of *Gigaspora*. The morphology of vesicular-arbuscular mycorrhizas was affected by the nutritional status of the host, the host species, and the species of fungus. Except in the case of the polymorphic vesicles associated with *Acaulospora* infections and the external vesicles of *Gigaspora* species, the inclusion of characteristics of the mycorrhizal infections for species identification does not seem warranted. Spore numbers tended to be low in bush soils but high in disturbed areas and under seral vegetations.

0320 JOHNSON, P. N. **Mycorrhizal Endogonaceae in a New Zealand forest.** *New Phytologist* (1977) 78 (1) 161-170 [En, 21 ref.] Botany Department, University of Otago, Dunedin, New Zealand.

Most vascular plants and some liverworts in a New Zealand coniferous-dicotyledonous forest harboured typical vesicular-arbuscular endophytes, *Rhizophagus tenuis* or mixtures of the two. At least nine sporing fungi were present but non-sporing races probably predominated. Spores were

present in variable densities ($2\text{-}17 \times 10^3\ l^{-1}$) in forest soils but their distribution was not obviously related to that of host plants. In inoculation experiments, the fungi had a wide host range and, in terms of growth response, hosts showed no clear preferences for particular endophytes. There was some indication of fungi being specific to soil type. Many tree seedlings begin growth perched on rocks or logs and *Rhizophagus tenuis* is a pioneer endophyte there.

*0321 KORMANIK, P. P.; BRYAN, W. C.; SHULTZ, R. C. **Quality hardwood seedlings require early mycorrhizal development in nursery beds.** 289-293 [En] In: USA, SOUTHERN FOREST TREE IMPROVEMENT COMMITTEE **Proceedings of the Fourteenth Southern Forest Tree Improvement Conference, Gainesville, Florida, June 14-16, 1977.** Florida, USA; Southern Forest Tree Improvement Committee. (1977, recd. 1979) 305 + vi pp. [En, many ref. Sponsored Publication No. 36 of the Southern Forest Tree Improvement Committee]

*0322 LAPUKHOVA, S. M. [Systematic position of mycorrhiza-forming fungi on wheat.] K sistematicheskomu polozheniyu mikorizoobrazuyushchego griba pshenitsy. *Botanicheskie Materialy Gerbariya Instituta Botaniki Akademii Nauk Kazakhskoĭ SSR* (1977) No.10, 121-123 [Ru, 14 ref.] Inst. Bot., Kazakh Acad. Sci., USSR.

On the basis of anatomical and morphological features a fungus found only in cells of the cortical parenchyma was identified as *Endogone lignicola*. A fungus forming mycorrhiza of the *Paris quadrifolia* type was observed on the surface of and inside wheat rootlets.

0323 POWELL, C. L. **Mycorrhizas in hill-country soils. I. Spore-bearing mycorrhizal fungi in thirty-seven soils.** *New Zealand Journal of Agricultural Research* (1977) 20 (1) 53-57 [En, 14 ref.] Ruakura Agric. Research Centre, Ministry of Agriculture and Fisheries, P.B., Hamilton, New Zealand.

Thirty-seven hill-country soils from the North Island were examined for spores of vesicular-arbuscular mycorrhizal fungi. Spore types of six species were found, in the genera *Glomus, Gigaspora, Acaulospora*, and *Sclerocystis, Glomus fasciculatus* and *A.laevis* being the most common and having the highest number of spores. No spore types were exclusive to soils with efficient mycorrhizal fungi and absent from soils with inefficient fungi. Non-sporing strains of mycorrhizal fungi may be common in soils and mycorrhizal infection may often occur after hyphal growth from infected root segments rather than from spores.

0324 REDHEAD, J. F. **Endotrophic mycorrihizas in Nigeria: species of the Endogonaceae and their distribution.** *Transactions of the British Mycological Society* (1977) 69 (2) 275-280 [En, 18 ref.] Federal Department of Forestry, Ibadan, Nigeria.

The morphology of the mycelium in plant roots and soil was similar to that of temperate Endogonaceae. Endogonaceae spores were widely distributed in the soils, which ranged from those of the moist Lowland Rain Forest to those of the dry Sahel zone, and were generally most frequent in areas with a marked dry season in which herbaceous growth died back. The spores occurred mostly in the top 15 cm of the soil. Several species of Endogonaceae previously recorded in USA, Scotland or Australia were found as well as several species not described elsewhere.

0325 RIAZI-HAMADANI, A.; PARBERY, D.G.; BEILHARZ, V.C. Vesicular-arbuscular mycorrhizal nodules on tomato. Transactions of the British Mycological Society (1977) 68(1):138-140

Nodules of a vesicular-arbuscular mycorrhiza were found on the roots of a tomato plant growing in a pot of Cranbourne (Victoria) soil of low fertility in a pot experiment in which K and P but not N were supplied. The growth and fruiting ability of this plant were markedly superior to others under the same treatment but which did not possess mycorrhiza. No evidence was obtained that the uptake of P was more efficient in the mycorrhizal than in the nonmycorrhizal plants.

0326 RIFFLE, JERRY W. (Rocky Mtn. For. Range Exp. Stn., For. Sci. Lab., E. Campus, Univ. Nebr., Lincoln, Nebr. 68503, USA.) **First report of vesicular-arbuscular mycorrhizae on *Elaeagnus angustifolia*.** MYCOLOGIA 69(6): 1200-1202. 1977[recd. 1978]. [In Engl.]—*E. angustifolia* (Russian olive), a native of Europe and western Asia, has become naturalized in the USA and is distributed from the Pacific coast eastward to New England and from Canada to Mexico. In the Great Plains (USA) it is used in farmstead and field windbreaks as a landscape tree. Examination of 1280 one cm root segments from 160 one yr old seedlings from Lincoln-Oakes Nursery of Bismark, North Dakota (USA) showed that *E. angustifolia* had vesicular-arbuscular (VA) mycorrhizae associated with it. Mycelia of VA fungi were concentrated in the cortex. No mycelium was observed in root hairs or in meristematic, epidermal, endodermal or vascular tissues. Hyphal growth was intercellular. Infection by native VA fungi produced no modification of the external morphology of roots. The VA mycorrhizae were found principally on short, straight, white, lateral rootlets. These rootlets were brittle and easily broken off when seedlings were lifted.

0327 ROSS, J. P.; RUTTENCUTTER, R. **Population dynamics of two vesicular-arbuscular endomycorrhizal fungi and the role of hyperparasitic fungi.** *Phytopathology* (1977) 67 (4) 490-496 [En, 8 ref.] Agricultural Research Service, U.S.Department of Agriculture, and Department of Plant Pathology, North Carolina State University, Raleigh, N.C. 27607, USA.

Populations of *Glomus macrocarpus* var. *geosporus* and *Gigaspora gigantea* as based on the numbers of chlamydospores in roots and azygospores in soil respectively, were followed through two growing seasons in small plots on which peanuts and soybeans were grown. During the second growing season, root infection data were also obtained. Populations of *G.macrocarpus* increased rapidly during the first season only in plots without *G.gigantea*, which suggest indicate either that *G.macrocarpus* does not compete well with *G.gigantea*, or that other factors such as hyperparasites inhibit the former more than the latter. The inhibitory effect of high soil phosphorus on the percentage of root infection was less in doubly-infected roots than in roots infected with *G.macrocarpus* alone. Two hyperparasites, a species of *Phlyctochytrium* and a 'Pythium-like' fungus, were found attacking *G.macrocarpus* at the end of the second season. The hyperparasites were associated with a decline in chlamydospore production in soybean roots growing in soil from the plots.

0328 SAIF, S. R.; ALI, I.; ZAIDI, A. A. **Vesicular-arbuscular mycorrhizae in plants and Endogonaceous spores in the soil of northern areas of Pakistan III. Dir and Chitral.** *Pakistan Journal of Botany* (1977) 9 (2) 129-148 [En, 5 ref., 3 pl. (13 fig.), 1 tab. See *RPP 57*, 1597] Univ. Islamabad, Pakistan.

Incidence of VA mycorrhizae in roots and spores of Endogonaceae in soil surrounding the roots of 200 plants (47 families) were studied. VA mycorrhizae were of general occurrence in all plants examined except members of the Caparidaceae, Commelinaceae, Cyperaceae, Guttiferae, Rutaceae, Violaceae, Zygophyllaceae and 1-10 plants in other families. Percent infected root length was 50-78 in 6% of the plants and 0-48 in the others. *Glomus mosseae, G. macrocarpus* and *Acaulospora laevis* spores occurred frequently, those of *G. mosseae* being the most abundant.

0329 SAIF, S.R.; PARVEEN, D. Vesicular-arbuscular mycorrhizae in plants and endogonaceous spores in the soil of northern areas of Pakistan. II Kaghan Valley & Babusar (Gilgit) Islamabad J. Sci. 4(1):9-17. 1977.

The incidence of vesicular-arbuscular mycorrhizae in roots and Endogonaceous spores in rhizospheres of 87 plants belonging to thirty families collected from Kaghan Valley and Babusar was investigated. Vesicular-arbuscular mycorrhizae were of general occurrence in all plants examined except members of Phytolaceae Saxifragaceae, Monotropaceae, and one to two plants of Chenopodiaceae, Compositae, Euphorbiaceae, Crassulariaceae and Ranunculaceae. The proportion of roots colonized by VA mycorrhizal fungi ranged 50 to 100% in 4th of the plants 12 to 48% in the remaining plants. Spores of four species of Endogonaceae (Glomus macrocarpus var. macrocarpus, G. mosseae, Acaulospora laevis and Gigaspora colospora) were frequently distributed in the soil samples, G. macrocarpus var. macrocarpus was more abundant than others. Two to three types of fungal endophytes were observed in the plant roots. Another endophyte, with broad septate hyphae, stained by trypan blue and

different from an endophyte with narrow hyphae was also frequently observed.

0330 SCHENCK, N. C.; NICOLSON, T. H. A zoosporic fungus occurring on species of *Gigaspora margarita* and other vesicular-arbuscular mycorrhizal fungi. *Mycologia* (1977) 69 (5) 1049-1053 [En, 5 ref., 4 fig., 2 tab.] Univ. Florida, Gainesville, USA.

The occurrence and incidence of sporangia of a *Rhizidiomycopsis* sp. on spores of *G. margarita* and other endogonaceous spp. is reported.

*0331 SCHUBERT, A. [Research on vesicular-arbuscular mycorr' a on grapevine. Experiments on mycorrhizal synthesis in the laboratory and further identification of the endophyte.] Ricerche sulla micorrizia vescicolo-arbuscolare nella vite. Prove di sintesi micorrizica in laboratorio ed ulteriori identificazioni dell' endofita. *Annali della Facoltà di Scienze Agrarie della Università degli Studi di Torino* (1977/1979) 11, 239-254 [It, en, fr, 23 ref., 4 fig., 4 tab.] Fac. Agric. Sci., Univ. Turin, Italy.

In Piedmont infection was widespread and heavy. Chlamydospores were identified as those of *Glomus fasciculatus* and *G. mosseae*. In inoculation experiments in the lab. considerable mycorrhizal development occurred but only on certain substrates.

0332 SØNDERGAARD, M.; LAEGAARD, S. Vesicular-arbuscular mycorrhiza in some aquatic vascular plants. *Nature, UK* (1977) 268 (5617) 232-233 [En, 11 ref., 2 tab.] Bot. Inst., Univ. Aarhus, Risskov, Denmark.

An account of the incidence of VA infection in several aquatic plants including *Littorella uniflora*, *Lobelia dortmanna* and *Isoetes lacustris* in 4 oligotrophic lakes in central Jutland, Denmark.

0333 SPARROW, F. K. A *Rhizidiomycopsis* on azygospores of *Gigaspora margarita*. *Mycologia* (1977) 69 (5) 1053-1058 [En, 10 ref., 5 fig.] Univ. Florida, Gainesville, USA.

R. stomatosa is described as a new sp.

0334 TRAPPE, J. M. Three new Endogonaceae: *Glomus constrictus*, *Sclerocystis clavispora*, and *Acaulospora scrobiculata*. *Mycotaxon* (1977) 6 (2) 359-366 [En, 8 ref., 2 fig.] USDA, Pacific Northwest Forest Range Exp. Sta., Corvallis, Ore., USA.

Descriptions (and mycorrhizal associations) are given of *S. clavispora* Trappe (grasses and sugarcane); *G. constrictus* Trappe (*Cocos*, citrus, *Persea* spp. maize and grasses); and *A. scrobiculata* Trappe (sugarcane, maize and wild grasses).

0335 AMES, R.N.; LINDERMAN, R.G. *Acaulospora trappei* sp. nov. Mycotaxon, 1976, 3(3):565-569. *A. trappei*, described, is a vesicular-arbuscular mycorrhizal fungus isolated from Easter lily (*Lilium longiflorum*) fields in the Pacific Northwst (S. Ore. and N. Calif.).

0336 COOPER, K.M. A field survey of mycorrhizas in New Zealand ferns. New Zealand Journal of Botany (1976) 14(2):169-181.
Roots of most ferns are constantly mycorrhizal in natural or modified communities, even in soils exceeding 200µg/ml Truog P. The entophytes involved are predominantly Endogonaceae. Usually several spore types are present in each rhizosphere and up co 5 dissimilar types may occur in a single root system. Infection in prothalli occurs, if at all, only after the reproductive organs develop. The young sporophyte is infected directly from the soil The only obvious connexion between habitat and infection type is a displacement of endomycorrhizal by ectomycorrhizal infections, which is complete where ferns are the only undergrowth in pure stands of ectomycorrhizal native beech or exotic pine. Details are given, for several ferns, on mycorrhizal development when field soils were used for potting.

0337 BECKER, W.N.; HALL, I.R. 1976. *Gigaspora margarita*, a new species in the Endogonaceae. Mycotaxon 16:155-160 (1976).

0338 DAFT, M.J.; HACSKAYLO, E. Arbuscular mycorrhizas in the anthracite and bituminous coal wastes of Pennsylvania. Journal of Applied Ecology (1976) 13 (2) 523-531.
Most of the herbaceous plants sampled from these sites had arbuscular mycorrhizas. Gigaspora gigantea, isolated from anthracite waste, stimulated the growth of maize in sand culture. Maize with mycorrhiza grew on anthracite waste after adjustment of the pH from 4.1 to 6.4 but not on bituminous waste, even at pH6. Lucerne, nodulated and infected with mycorrhiza, grew well in anthracite waste after the pH was raised, even without supplementary nutrients. The potential importance of arbuscular mycorrhizas in revegetation of coal wastes is discussed.

0339 EL-GIAHMI, A. A.; NICOLSON, T. H.; DAFT, M. J. Endomycorrhizal fungi from Libyan soils. *Transactions of the British Mycological Society* (1976) 67 (1) 164-169 [En] Department of Biological Sciences, University of Dundee, UK.

The percentage mycorrhizal infections in crop plants, *Acacia* spp. and shrubs in the Tripoli district are tabulated. Most of the host plants had infection levels of 40-60 per cent. Practically all the soil samples contained spores of endophytic fungi. Apart from *Glomus mosseae*, several other chlamydospore forms of endophytic fungi occurred in the soils.

0340 GERDEMANN, J. W.; BAKSHI, B.K. Endogonaceae of India: two new species. Transactions of the British Mycological Society (1976) 66(2) 340-343 .
Descriptions are given of Glomus multicaulis Gerdemann & Bakshi and Sclerocystis sinuosa Gerdemann & Bakshi isolated from rhizosphere and soils of forest trees in India.

*0341 GODSE, D. B.; MADHUSUDAN, T.; BAGYARAJ, D. J.; PATIL, R. B. Occurrence of vesicular-arbuscular mycorrhizas on crop plants in Karnataka. *Transactions of the British Mycological Society* (1976) 67 (1) 169-171 [En] Department of Agricultural Microbiology, University of Agricultural Sciences, Bangalore-560024, India.

Vesicular-arbuscular mycorrhizae occurred in all the young crop plants studied; the intensity of infection was greatest in maize. The rhizosphere soil contained large numbers of *Endogone* spores, but the identity of the endophyte has not been established.

0342 HALL, I.R. Vesicular mycorrhizas in the orchid Corybas macranthus. Trans. Br. Mycol. Soc. 66(1) 1976.

0343 HAYMAN, D. S.; BAREA, J.-M.; AZCON, R. Vesicular-arbuscular mycorrhiza in southern Spain: its distribution in crops growing in soil of different fertility. *Phytopathologia Mediterranea* (1976) 15 (1) 1-6 [En, 13 ref., 2 pl.] Estacion Experimental del Zaidin, Avda de Cervantes, Granada, Spain.

In the Granada district vesicular arbuscular mycorrhizal infection was abundant in broad beans, grapevines and olives where an average of 40% of the length of the feeder roots was infected. In tomatoes 15% was infected. The amount of infection varied much from site to site and even within sites. A study of the soils at the growing sites indicated that extensive mycorrhizal infection could occur in soils of high as well as in those of low fertility.

0344 KOUCHEKI, H. K. and D. J. READ. (Dep. Bot., Univ. Sheffield, Sheffield, Yorks. S10 2TN, Engl., UK.) Vesicular-arbuscular mycorrhiza in natural vegetation systems: II. The relationship between infection and growth in *Festuca ovina* L. NEW PHYTOL 77(3): 655-666. 1976.—The effects of vesicular-arbuscular (VA) mycorrhizal association on the growth of *F. ovina* were assessed in soils sterilized by irradiation, in unsterilized soil, and in sand or sand-peat cultures with various nutrient additions. In irradiated soils, effects of mycorrhizal infection were masked by nutrient release which proceeded through the first 4 mo. of growth. However, 9 mo. after inoculation, significant increases of yield and P content occurred in the mycorrhizal plants. When the irradiated soil was recovered and re-used to grow a 2nd crop, marked increases of yield and P content were observed in mycorrhizal plants. Growth in unsterilized field soil was very slow despite the fact that all the plants were heavily infected. In sand culture, mycorrhizal plants were not significantly larger than non-mycorrhizal controls when both were supplied with a full nutrient medium, but differences between the 2 categories were evident when sand-peat mixtures were supplemented with dilute nutrient medium and water. The results are discussed in relation to the possible significance of mycorrhizal infection in the field.

*0345 KRYUGER, L.V.; SELIVANOV, I.A. Endophytic fungi causing the formation of vesicular- arbuscular endomycorrhizas. Endofitnye griby, vyzyvayushchie obrazovanie vezikulyarno-arbuskulyarnykh, endomikoriz. Uch. Zap. Perm. Gos. Ped. Inst. (1975) No.142, 69-95 From Referativnyi Zhurnal, Biologiya (1976) 7 V 275.
The taxonomy of these mycorrhizal fungi is discussed and the life cycle of Endogone spp. is decribed, with a key for their identification.

0346 MORLEY, C. D.; MOSSE, B. Abnormal vesicular-arbuscular mycorrhizal infections in white clover induced by lupin. *Transactions of the British Mycological Society* (1976) 67 (3) 510-513 [En, 8 ref.] Rothamsted Experimental Station, Harpenden, Herts. AL5 2JQ, UK.

In a pot experiment with small pots on constant-water-level sand trays, *Lupinus cosentinii* seedlings were highly resistant to VA mycorrhizal infection by *Glomus mosseae* or a form of *Endogone fasciculata*, even in the presence of heavily infected roots of *Trifolium repens*, and affected the anatomy of the entry points of the fungi on the clover roots. The morphogenetic effects of the lupin seedlings on the clover seedlings may have been caused partly by root exudates but were also caused by toxic substances in the lupin seed coats.

0347 READ, D. J.; KOUCHEKI, H. K.; HODGSON, J. Vesicular-arbuscular mycorrhiza in natural vegetation systems. I. The occurrence of infection. *New Phytologist* (1976) 77 (3) 641-653 [En, 25 ref.] Department of Botany, University of Sheffield, Sheffield S10 2TN, UK.

The intensity of vesicular-arbuscular mycorrhizal infection was assessed in the major vegetation types of east-central England. All of the most important species of grassland, scrub and woodland were mycorrhizal and each individual of any species normally carried a heavy VA infection. Members of the Gramineae were particularly heavily infected. In limestone grassland, infection extended to members of the Cyperaceae and Juncaceae. Infection levels were high throughout the year, the highest levels occurring in the most nutrient-stressed situations. Mycorrhiza develops soon after germination, often while seedlings are still in the cotyledon stage. Since numbers of viable *Glomus*-type spores are low infection is thought to arise from root to root contact rather than from spores. The ecological implications of the widespread infection are discussed.

*0348 ROUSH, K. W.; RUSSELL, D. R. Propagation of *Podophyllum peltatum*. [Abstract]. *Journal of the Mississippi Academy of Sciences* (1976) 21 (Supplement) 11 [En] Mississippi University, University, Mississippi 38677, USA.

Treatment of dormant *Podophyllum peltatum* rhizomes with various concentrations of kinetin, GA and IBA, separately and in combination with various exposures to 4°C, failed to induce bud and aerial stem formation, but did not interfere with the establishment of new root systems. Active rhizomes collected in March formed aerial stems with or without the hormone treatments. An endotrophic mycorrhizal fungus was present in the root of freshly collected plants but was not observed in new root systems. Tetrazolium chloride tests indicated a 32% germination potential in seeds taken from ripened fruits. Exposing these seeds to 0.2% potassium nitrate, CO_2 laser, hot water or chilling failed to influence germination. All seeds that germinated produced chlorotic seedlings.

0349 SAIF, S. R.; IFFAT, N. Vesicular-arbuscular mycorrhizae in plants and endogonaceous spores in the soil of northern areas of Pakistan. *Pakistan Journal of Botany* (1976) 8 (2) 163-179 [En, 25 ref., 5 pl., 1 fig., 1 tab.] Quaid-i-Azam Univ., Islamabad, Pakistan.

In studies with 128 plants (37 families) collected from Hunza, Nagar and Gilgit States, VA mycorrhizae were of general occurrence in most cases. VA mycorrhizal infection was also observed in 30 members of 10 families generally considered to be non-mycorrhizal. In most of the plants arbuscular infection was very poor in contrast to the large numbers of vesicles present in the root cortex. Of 4 different endophyte types observed, 3 were endogonaceous and one possessed brown septate narrow hyphae. Six types of endogonaceous spores were found in soil samples. Rhizosphere soil of most of the plants contained large numbers of 2-4 types of spores, with *Glomus mosseae* and *G.macrocarpus* in great abundance, reaching up to 2579/50g rhizosphere soil.

0350 SANNI, S. O . . Vesicular-arbuscular mycorrhiza in some Nigerian soils and their effect on the growth of cowpea (*Vigna unguiculata*), tomato (*Lycopersicon esculentum*) and maize (*Zea mays*). *New Phytologist* (1976) 77 (3) 667-671 [En, 17 ref.] Federal Dep. of Agric. Res., Moor Plantation, Ibadan, Nigeria.

Cowpea and maize plants inoculated with specific spores collected from 3 soil series at Ibadan showed vesicular-arbuscular mycorrhiza in the roots within a few weeks of growth. The infection was positively correlated to amounts of P and N in the tissues.

0351 SCHENCK, N.C.; KINLOCH, R.A. Mycorrhizal fungi colonizing field crops on a newly cleared woodland site. Univ. of Florida, Gainnesville, 32611 and Agr. Res. Center, Jay, Fla. Proceedings of the American Phytopathol. Soc. 3:274- 1976 Abst.
In the fall of 1971, a woodland area in Northestern Florida (Jay) was cleared and prepared for planting. In the spring of 1972, soybeans corn, peanut, sorghum, bahia grass, and a soybean-wheat rotation were planted in 3 replicated plots in the cleared area. Each year the same crop was grown in the same plot except that the soybean-wheat rotation was changed to cotton in 1974. All plots were then fallowed in winter months. Routine cultural and fertilization practices were followed . All equipment utilized in the area was thoroughly cleaned before use. Vesicular-arbuscular mycorrhizal (VAM) fugni were monitored annually at or near crop maturity by wet sieving rhizosphere soil and clearing and staining roots.
Few VAM spores were found in the plots before the initial planting. The greatest number of VAM spores was recovered after the first crop (1972). The maximum number of VAM species (8) was recovered in 1973. In general, the number of species and total number of spores declined with each successive year. In 1975 only 3 species of VAM fungi were recovered and 75% of the spores were those of Gigaspora margarita. VAM fungi developed selectively on the crops G. gigantea and G. coralloidea spores were recovered mostly from soybean; Aculospora laevis was recovered mostly form sorghum; and Gigaspora margarita and Glomus fasiculatus were recovered mostly from bahia grass. Thus, intensive monocrop agriculture rapidly reduces the population of VAM found in a natural ecosystem.

*0352 SERGEEVA, R. V. [The occurrence of mycorrhiza in apple trees grown hydroponically.] *Uchenye Zapiski Perm. Gos. Ped. In-t* (1976) 150, 238-239 [Ru] From *Referativnyi Zhurnal* (1977) 4.55.879.

The occurrence of endotrophic mycorrhiza was observed on red-leaved Paradise trees growing in a nutrient solution containing N at 1-400 mg/l.

*0353 TUPAS, G.L. ; SAJISE, P.E. Mycorrhizal associations in some savanna and reforestation trees. Kalikasan (1976) 5(2) 235-240. Univ. Phillippines, Los Baños, College, Laguna. Philippines.
Evidence is presented that symbiotic micro-organisms occur in the roots of dominant savanna trees and some reforestation spp. in the Phillippines.

*0354 WILLIAMS, S. E.; ALDON, E. F. Endomycorrhizal (vesicular arbuscular) associations of some arid zone shrubs. *Southwestern Naturalist* (1976) 20 (4) 437-444 [En] Rocky Mountain Forest and Range Experiment Station, Albuquerque, New Mexico 87101, USA.

Vesicular-arbuscular endomycorrhizae were observed in association with the following plants, sampled throughout New Mexico: *Atriplex canescens, Eurotia lanata, Amelanchier oreophilus, Amelanchier utahensis, Cercocarpus montanus, Fallugia paradoxa, Holodiscus dumosus, Purshia*

tridentata, Fendlera rupicola, Philadelphus microphyllus, Quercus gambelii, Symphoricarpos spp., *Artemisia tridentata* and *Rhus trilobata.*

0355 BIRD, G.W. Occurrence of spores of endomycorrhizal fungi in Michigan agricultural soils. Dept. of Entomology and Dept. of Botany and Plant Path., Mich. State Univ., E. Lansing, Mich. Proceedings of American Phy. Society. Vol. 2, 1975. p.28.
During 1974, 59% of 368 of the soil samples processed by the Michigan State University Nematode Diagnostic Service Laboratory contained zygospores, azygospores or chlamydospores of fungi of the cen trifugation-flotation technique with a 1.14 sp gr of sucrose. Occurrence of spores in Michigan agricultural soils decreased from April through July and increased during the fall)100, 100, 100, 62, 42, 42, 32, 49, 60, 76, 80, and 83% occurrence from January through December, respectively). Soil from 10 vegetable crops, 5 field crops, 8 fruit crops, 8 turf and ornamental plants and fallow fields were processed, comprising 20, 10, 44, 19 and 7%, respectively, of the samples analyzed. The recoveries for the five groups were 51, 73, 61, 50 and 70%, respectively. Cabbage was the only crop where spores were not recovered. Spore occurrence appeared to be lower in organic soils used for vegetable production than in general-use mineral soils. While spores were recovered from potato soils, hyphae, arbuscules and vesicles were not observed in stained potato roots collected at various intervals throughout the growing season.

0356 CRUSH, J. R. **Occurrence of endomycorrhizas in soils of the Mackenzie Basin, Canterbury, New Zealand.** *New Zealand Journal of Agricultural Research* (1975) 18 (4) 361-364 [En] Grasslands Division, DSIR, Lincoln, P.B., Christchurch, New Zealand.
Fifteen grasses and 14 legume species from a range of soils and with varying fertiliser histories were examined; all were mycorrhizal. Very high levels of mycorrhizal infection were recorded in sown legumes in fertilised soils. Two mycorrhizal fungi, *Acaulospora laevis* and *Glomus fasciculatus*, were identified from soil-borne spores and a third, *Rhizophagus tenuis*, by its vegetative hyphae. It is suggested that endophyte-host relationships vary between parasitism and mutualism depending on soil available-phosphorus levels.

0357 DAFT, M. J.; HACSKAYLO, E.; NICHOLSON, T. H. **Arbuscular mycorrhizas in plants colonising coal spoils in Scotland and Pennsylvania.** 561-580 [En, 24 ref.] Dep. of Biol. Sci., Dundee Univ., Dundee DD1 4HN, UK.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp. 561 - 580. 1975.
3 coal tips in Pennsylvania and 3 in Scotland were surveyed for general plant cover and mycorrhizal infection in colonizing plants. *Gigaspora gigantea* sieved from anthracite waste was effective in promoting growth and ear and tassel production in maize grown in sand culture. Mycorrhizal and non-mycorrhizal maize plants grew in anthracite spoil adjusted to pH 6.4. Growth rates were similar during the 1st 40 days, after which plants inoculated with *Glomus macrocarpus* var. *geosporus* grew faster.

*0358 FILER, T. H.; JR. **Mycorrhizae and soil microflora in a green-tree reservoir.** *Forest Science* (1975) 21 (1) 36-39 [En] Southern Hardwoods Laboratory, Stoneville, Mississippi, USA.
Yearly flooding in winter and spring did not alter the kinds of ecto- and endomycorrhizal fungi found on roots of *Liquidambar styraciflua, Quercus nuttallii, Q. phellos* and *Q. lyrata.* In most samples the numbers of fungi were temporarily reduced but populations recovered after waters receded and were back to normal by the end of the growing season.

0359 GERDEMANN, J.W.; TRAPPE, J.M. Taxonomy of Endogonaceae. *In:* Endomycorrhizas (Ed. by F.E. Sanders, B. Mosse, and P.B. Tinker) Academic Press, London. pp.35-51 (1975).

0360 HALL, I.R. Endomycorrhizas of metrosideros umbellata and Weinmannia racemosa. New Zealand Journal of Botany (1975) 13(3) 463-472.
In the absence of endogeneous mycorrhizas it was difficult to keep seedlings of W. racemosa alive in soils low in available P, although the seeds contain a high proportion of P in healthy foliage and the root system possessed few and short root hairs. In contrast the seed of M. umbellata has a low P. conc. (0.05%) but seedlings grew slowly without mycorrhizas even in low P soils. There was also a min. of 0.04% P in healthy foliage and there was intermittent production of short (0.3 mm) root hairs. Mycorrhizal plants were stimulated by apatite but uninfected plants were not. Forest soils were estimated to contain 4000 - 20000 endogenaceous spores/l and root infection to be 8-24% in adult trees of W. racemosa and up to 76% in seedlings. Adult infection im M. umbellata was 1-14%.

0361 HAYMAN, D. S. **The occurrence of mycorrhiza in crops as affected by soil fertility.** 495-509 [En, 21 ref.] Rothamsted Exp. Sta., Harpenden, Herts AL5 2JQ, UK.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp.
Quantitative studies at Rothamsted on the effects of fertilizers on the occurrence of VA mycorrhiza and *Endogone* spp. spores under agricultural conditions are summarized. On Broadbalk wheat plots the mycorrhizal population was much larger on plots which had not received fertilizer since 1843 and several *Endogone* spore types were present. Numbers of white reticulate spores were most affected by fertilizer. On Little Knott wheat plots, N treatment reduced VA infection and spore numbers. All spores were of the laminate type. On a light sandy soil at Woburn, where wheat was grown in rotation with potatoes and legumes, mainly spores of the reticulate type were found and their numbers were greatly reduced by N fertilizer. In *Vicia faba*, N had no clear effect on spore numbers. In a rotation of potatoes, barley and swedes, most VA infection was present in plots given least P and most spores occurred in plots given intermediate amounts of P. The results are compared with those of other field and glasshouse experiments.

0362 HAYMAN, D.S. Vesicular-arbuscular mycorrhiza: its occurrence, effects on plant growth, and its significance in Australia. Australian Plant Pathology Society Newsletter (1975) 4 (2) 15-18.

0363 IQBAL, S. H., KAUSAR SULTANA and BUSHRA PERVEEN. (Dep. Bot., New Univ. Campus, Lahore, Pak.) ***Endogone* spore numbers in the rhizosphere and the occurrence of vesicular-arbuscular mycorrhizas in plants of economic importance.** BIOLOGIA (LAHORE) 21(2): 227-237. 1975

—The incidence of both internal fungal associate and *Endogone* spores in the rhizosphere of plants of economic importance was investigated. All soil samples contained *Endogone* spores. In all, 5 spore-types were recognized. Quantitative estimates of *Endogone* population from different rhizospheres are presented. Heavy vesicular-arbuscular mycorrhizal infections were detected in rice (*Oryza sativa*) salads (*Lactuca*) and poppy (*Papaver somniferum*). No infections were detected in parsnip, *Amaryllis*, or carrots.

0364 KOSKE, R.E. Endogone spores in Australian sand dunes. Canadian Journal of Botany (1975) 53(7) 668-672. Univ. Sydney, NSW, Australia.
Five types of spores of the endomycorrhizal fungus (Endogone were abundant in the coastal sand dunes of NSW. These spores have seldom been reported from marine dunes and at least 2 of the spore types recovered from Australian dunes have not previously been reported from this continent. The density of spores was greater in older, more stabilized dunes than in younger foredunes and mobile dunes.

0365 MEJSTŘIK, V. K. **Mycorrhizas in some New-Zealand plant species.** *Revue d'Ecologie et de Biologie du Sol.* (1975) 12 (4) 681-689 [En] Environmental Ecology Institute, Czechoslovak Academy of Sciences, Průhonice, Prague, Czechoslovakia.

The ten indigenous New Zealand species of trees and shrubs studied all possessed endophytic mycorrhizae of vesiculo-arbuscular sub-type. The symbiont was most probably species of *Endogone* because of the frequent occurrence of *Endogone* spores in the rhizosphere. The highest intensity of infection was found in the species *Hedycarya arborea* (Monimiaceae).

0366 MEJSTRÍK, V. K.; HADAC, E. **Mycorrhizas of *Arctostaphylos uva-ursi*.** *Pedobiologia* (1975) 15 (5) 336-342 [En, fr] Ustav Krajinné Ekologie, Československé Akademie Věd Průhonice u Prahy, Czechoslovakia.

0367 NAIR, L.N.; MAHABALE, T.S. Mycorrhiza in ophioglossaceae: I. Morphology of endophytes in vivo. Geophytology 5(1):16-23. 1975.
Morphology of the endophytes in vivo was studied in Ophioglossun reticulatum L., O. pedunculosum Prantl sensu non-Des., O vulgatum L. O. fibrosum Schum., O aitchisoni d'Alm., O. nudicaule L., O. gramineum Wild., Botrychium viginianum var. daucifolium Bedd. and Helminthostachys zeylanica L. It was observed that in the material of Helminthostachys zeylanica collected, no endophytes were present. In all other plants they were present. The mode of entry of fungus and three stages of endophytes that developed viz., mycelial, vesicular and arbuscular were found in succession in all of them. The paper discusses the mode of living of mycorrhiza in the host plant.

0368 POWELL, C. L. **Rushes and sedges are non-mycotrophic.** *Plant and Soil* (1975) 42 (2) 481-484 [En] Botany Department, Otago University, Dunedin, New Zealand.

Few rushes and sedges were infected by endomycorrhizal fungi in the field; infections which formed were mainly of mycelium in the rhizosphere with only occasional lodgements in epidermal cells. In a pot experiment using a soil of very low P availability, rushes and sedges remained non-mycorrhizal and yet produced more shoot dry matter than mycorrhizal *Poa colensoi*. Rushes and sedges had much longer root systems than non-mycorrhizal *Poa colensoi*, but comparable shoot P concentrations. They appear to have evolved extensive, finely branched root systems rather than the mycorrhizal habit for extracting P from infertile soils. In pot experiments, they reject mycorrhizal infection, even if suffering P deficiency.

0369 SAIF, S. R. **The occurrence of mycorrhizas and *Endogone* spores in the rhizospheres of plants growing around University Campus Islamabad.** *Pakistan Journal of Botany* (1975) 7 (2) 175-182 [En] Department of Biology, University of Islamabad, Pakistan.

Vesicular-arbuscular mycorrhizae occurred in most of the seventy-three plants examined. Ectotrophic mycorrhizae occurred in six species. Ectoendomycorrhizae occurred in the Oleaceae. Infection with vesicular-arbuscular mycorrhizae was intense in Euphorbiaceae. Most soil samples contained *Endogone* spores, including some rhizosphere samples from non-mycorrhizal plants. Of the eight types of *Endogone* spores known to occur in Pakistan, four types were found, the yellow vacuolate non-endosporic type being predominant.

0370 SPARLING, G. P.; TINKER, P. B. **Mycorrhizas in Pennine grassland.** 545-560 [En, 35 ref.] Dep. of Pl. Sci., Leeds Univ., Leeds LS2 9JT, UK.545 - 560. 1975.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press.

The proportion of mycorrhizal roots in grasses at 3 sites in the Pennines was assessed by a modified point intersection method. Root wt. declined sharply with depth, with >95% in the top 15 cm of soil. The percentage infection varied little between seasons or with depth above 25 cm, but declined slightly below this. In an acid brown earth soil of the Malham series, 49.2 - 56.1% of the root length in the top 25 cm of soil was infected. P fertilizer reduced infection, but N and K did not. Arbuscular and vesicular-arbuscular mycorrhizal types and non-mycorrhizal endophytes were present. *Agrostis tenuis, Anthoxanthum odoratum, Festuca rubra, Cynosurus cristatus* and *Nardus stricta* were grown in γ-irradiated soil in a glasshouse and were either non-mycorrhizal, mycorrhizal (inoculated with sievings of field soil) or given 80 mg P/kg soil. Responses to P were clear after 12 months and were greatest (35%) in the Malham soil, where mycorrhiza increased the cumulative dry wt. of tops at 14 months by 16%. In Roddlesworth and Brickfield soils there was no yield response to mycorrhiza despite heavy infection and strong responses to P (39 and 29%, resp.). The possible importance of mycorrhiza under field conditions is discussed.

0371 STRZEMSKA, J. **Mycorrhiza in farm crops grown in monoculture.** 527-535 [En, 3 ref.] Acad. of Agric., Olsztyn, Poland.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp. 527 - 535. 1975.

After 5 yr of monoculture there were marked reductions in mycorrhizal infection of rye, wheat, barley and oats given high, and apparently above opt., rates of fertilizer. After 12 yr of monoculture infection of wheat was similar without fertilizer and with low and high rates of FYM, was increased by a low rate of NPK and decreased by high NPK or FYM + NPK. All treatments increased yield. In rye all fertilizer treatments except low FYM markedly decreased infection after 13 yr of monoculture. In *Vicia faba*, mycorrhizal infection remained at a similar level during 5 yr of monoculture at a low rate of NPK, but increased at high NPK; yields were, however, less after 5 yr at both fertilizer rates.

0372 STRZEMSKA, J. **Occurrence and intensity of mycorrhiza and deformation of roots without mycorrhiza in cultivated plants.** 537-543 [En, 11 ref.] Acad. of Agric., Olsztyn, Poland.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp. 537 - 543. 1975.

Mycorrhizal infection ratings were determined for 68 spp. belonging to 13 families. Data are given for barley, oats, wheat and rye, and for 20 leguminous spp.

0373 TANDY, P.A. Sporocarpic species of endogonaceae in Australia. Aust. J. Bot., 1975. 23,849-866.
Fructifications of nine Australian members of the Endogonaceae are described. Five of these are new species: Endogone aggregata, E. reticulata, E. crassa, Glomus tubaeformis, and Glomus tener. Endogone flammicorona Trappe & Gerdemann is reported for the first time in the southern hemisphere, and Glomus macrocarpus Tul.& Tul. var. macrocarpus is a new record for South Australia. A key to the known sporocarpic species of the Endogonaceae in Australia is provided.

0374 TEDESCO DE BRESCIA, A. Presence of endotrophic mycorrhizas in grass. Rev. Biol. Urug. 3(2):175-179.1975.Spa.The endotrophic mycorrhizas present in 13 native Gramineas (Axonopus suffultus, Calamagrostis montevidensis Digitaria phaeotrix, Melica aurantiaca, Paspalum almum,, P. cromyorrhizon, P. dilatatum ssp. dilatatum, P.equitans P.indecorum, P. intermedium., P. Maculosum, Piptochaetium bicolor and Stipa filifolia) and its characteristics, 9 of them with a summer cycle and 4 of them with a winter cycle are presented.

*0375 BONFANTE, P. F.; SCANNERINI, S. **[Bacteria in the root cap in endotrophic mycorrhiza of *Ornithogalum umbellatum* L.]** *Allionia* (1974-1975) 20, 23-33 [It, en] Centro di Studio sulla Micologia del Terreno del C.N.R., Istituto Botanico dell' Università di Torino, Italy.

Ordinary and electron microscopy showed that Gram-negative bacteria occur in the mucigel or the first outer cell layer of the root cap.

0376 DAFT, M.J.; NICOLSON, T.H. H. Arbuscular mycorrhizas in plants colonizing coal wastes in Scotland. *New Phytologist* (1974) 73 (6) 1129-1138 [En] Department of Biological Sciences, Dundee University, Dundee, UK.

All the grasses and nearly all the dicotyledonous plants growing on three coal tips in Scotland were infected by vesicular-arbuscular mycorrhizal fungi. Infection levels ranged

from 20 to 90%. Three main types of fungal endophytes were identified, two being *Endogone* spp. and one with very narrow hyphae. Mixed infections were present in some plants and there was some evidence that the endophytes occurred in different areas of the tips. The ecological importance of the mycorrhizas in these habitats is discussed.

*0377 DOROKHOVA, N.A.; SHORINA, N.I. [Mycorrhiza of Colchicum speciosum Stev. in connexion with the age state of its individuals.] Mikoriza bezvremennika velikolepnogo (Colchicum speciosum Stev.) v svyazi s vozrastnym sostoyaniem ego osobei. Byulleten Moskovskogo Obshhestva Ispytatelei Prirody, Biologicheskii (1974) 79 (6) 118-131.
C. speciosum is infected mainly by Endogone sp., producing vesicular-arbuscular mycorrhiza. The greatest diversity and abundance of fungi was observed in medium and well developed plants at seed maturation.

0378 GERDEMANN, J.W.; TRAPPE, J.M. The endogonaceae in the Pacific Northwest. Mycologia Memoir (1974) No.5 76pp.
Endogone sensu lato is divided into 4 genera and 1 additional new genus, Acaulospora, and 12 new spp. are described. There are keys to the genera and spp. Descriptions of the spp. include distribution and mycorrhizal associations.

0379 KHAN, A. G. The occurrence of mycorrhizas in halophytes, hydrophytes and xerophytes, and of *Endogone* spores in adjacent soils. *Journal of General Microbiology* (1974) 81 (1) 7-14 [En] Biology Department, Islamabad University, Pakistan.
[167.11:85]
None of the 13 hydrophytes (representing 16 genera) examined possessed vesicular-arbuscular mycorrhizas although approximately 50% of the rhizosphere soils contained *Endogone* spores. The spores, however, were rare or absent in permanently waterlogged soils. Of the 21 halophytes examined only those belonging to the Chenopodiaceae (6 spp.), Tamaricaceae (1 sp) and Zygophyllaceae (3 spp) did not possess mycorrhizas. 51 xerophytes were examined and although rhizospheres of *Phoenix dactylifera, Ficus* spp. *Casuarina cunninghamiana, Tribulus* spp. *Zygophyllum atriplicoides* and *Fagonia bruguieri* contained *Endogone* spores there was no mycorrhizal infection. Plants of the families Nyctaginaceae, Portulacaceae, Amaranthaceae, Chenopodiaceae, Tamaricaceae, Oleaceae and Elaeagnaceae had neither mycorrhizas nor *Endogone* spores in their rhizospheres, the remaining 26 halophytes possessed mycorrhizas. Mycorrhizal infection decreased with depth but the abundance of *Endogone* spores did not.

*0380 MEISTRIK, V. The frequency of vesicular-arbuscular mycorrhizae in the roots of *Camellia japonica* L. from different sites in New Zealand. *Pacific Science* (1974) 28 (1) 73-77 [En, 13 ref., 2 pl., 2 fig.] Lincoln College, Canterbury, New Zealand.
In root studies on camellias from several parks and gardens the optimal growth of short (about 1-cm-long) roots and development of mycorrhizal associations occurred at depths of 5-15 cm. The average number of root hairs/cm of root was 80-120 and vesicular-arbuscula mycorrhizas were found most frequently in the short roots with diameters of 1.4-2 mm. Spores of *Endogone* spp. occurred in the rhizosphere of mycorrhizal roots. Roots with and without mycorrhizas did not differ morphologically.

*0381 NOZADZE, L.M. [Mycorrhizas of alpine herbaceous plants in the Kazbeg district.] Trudy Instituta Botaniki, Akademiya Nauk Gruzinskoi SSR (1974) 27, 78-86.

0381a STRZEMSKA, J. Mycorrhiza of cultivated plants of the Papilionaceae family. Part V. Common vetch Vicia sativa and hairy vetch Vicia villosa. Roczniki Gleboznawcze 25: 101-108.1974.

0382 STRZEMSKA, J. The occurence and intensity of mycorrhiza in cultivated plants. *Transactions, 10th International Congress of Soil Science. III.* (1974) 81-88 [En, fr, de, ru] Agricultural and Engineering Academy, Olsztyn-Kortowo, Poland.
Tabular data are reported on the occurrence of mycorrhizae on 20 legume species.

*0383 THAPAR, H.S.; KHAN, S.N. Studies on endomycorrhiza in some forest species. Proceedings of the Indian National Science Academy, B (1973, publ. 1974) 38(6) 687-694 Forest Res. Inst. Dehra Dun. India.
Descriptions are given of endomycorrhizae found in several conifer and broad leaved tree spp.; 4 types of infection were recorded: vesicular, arbuscular, vesicular - arbuscular and peloton. Several spp. of Endogone were identified as symbionts and recovered from soils beneath the trees. The occurrence of spores in the soil depended on the tree sp., land use, soil moisture and texture.

0384 THOMAZINI, L. I. Mycorrhiza in plants of the 'Cerrado'. *Plant and Soil* (1974) 41 (3) 707-711 [En] Dept de Botânica, Faculdade de Filosofia, Ciencias e Letras de Rio Claro, São Paulo, Brasil.
Species of trees on the cerrado regions of Rio Claro that had associated mycorrhizae are reported.

0385 THOMAZINI, LILIAN ISOLDE. (Dep. Bot., Fac. Filos., Cienc. Letras, Rio Claro, Sao Paulo, Braz.) Micorriza vesicular-arbuscular em Aegiphila verticilata Vell. [Vesicular-arbuscular mycorrhiza in Aegiphila verticilata Vell.] PHYTON REV INT BOT EXP 32(1): 53-60. Illus. 1974. [In Port. with Port. and Engl. summ.] --The types, incidence and intensity of mycotrophic infestation developed in natural conditions of the "cerrado" with native or introduced plants, particularly Aegiphila verticilata Vell. were studied. The mycorrhiza belongs to the endotrophic type, and in spite of a few small differences, may be included in the series Paris according to Gallaud and in the vesicular-arbuscular group of the classification employed by Burgeff and other authors.

0386 VANDERPLOEG, J. F.; LIGHTY, R. W.; SASSER, M. Mycorrhizal association between *Lilium* taxa and endogone. *HortScience* (1974) 9 (4) 383-384 [En, 9 ref.] Delaware University, Newark, USA.
Inoculation with the mycorrhizal fungus *Endogone* increased the growth of *Lilium regale* and *Lilium* 'Burgundy' as shown by visual estimation of leaf area and dry weight of shoots, bulbs and roots. Both grew better in topsoil than subsoil whether inoculated or not.

0387 VOZZO, J.A.; HACSKAYLO, E. Endo- and ectomycorrhizal associations in five Populus species. Bulletin of the Torrey Botanical Club. (1974) 101(4, 182-186. USDA Forest Service, Starkville, Miss., USA.
After soil inoculation with mycorrhizal fungi, P. fremontii, P. grandidentita and P. tremuloides formed ectomycorrhizas and P. deltoides and P. d. var. occidentalis formed both ecto- and endomycorrhizas. Spores isolated from endomycorrhizal P. deltoid. appear to be Endogone spp. The rate of respiration was higher in these that in nonmycorrhizal roots and histochemical differences suggest that protein synthesis is more active in the micorrhizal roots.

0388 WILHELM, S.; STORKAN, R.S.; WILHELM, J.M. Preplant soil fumigation with methyl bromide-chloropicrin mixtures for control of soil-borne diseases of strawberries A summary of fifteen years of development. Agriculture and Environment (1974) 1, 227-236.
In Calif. soil fumigation has made lands available for strawberries which were previously avoided. Strawberry lands in turn now are in great demand for vegetable, tuber and salad crops and high yields of head lettuce, bean and potato after strawberries are recorded. Growth depression from soil fumigation due to temporary reduction in the soil population of Endogone has not occurred in strawberries since all planting stocks carry this mycorrhizal fungus in the roots and a better root system develops in fumigated soil.

*0389 BARTOLI, A.; RAMBELLI, A. {Research of mycorrhizal symbiosis in a poplar stand in Central Italy.} Indagine sulla simbiosi micorrhizica in un pioppeto dell'Italia Centrale. Pubblicazioni del Centro di Sperimentazione Agricola e Forestale (1973) 12, 37-42.
In 14 rootlet samples collected at c. 80 cm from trees and at a depth of 30 cm after a long rainy period only 1 mycorrhizal form (described) was found.

0390 KHAN, A.G.; SAIF, S.R. Some observations on mycorrhizae of Olea cuspidata Wall. Pakistan Journal of Botany (1973)5 (1):65-70. Inst. Biol. Sci., Univ. Islamabad.
Mycorrhizas were found on O. cuspidata from the foothills of the Himalayas, ecto and endomycorrhiza occurring on different roots of the same plant. The significance of these findings for olive cultivation is discussed.

*0391 ROSS, J. P.; HARPER, J. A. Hosts of a vesicular-arbuscular *Endogone* species. *Journal of the Elisha Mitchell Scientific Society* (1973) 89 (1/2) 1-3 [En] Department of Plant Pathology, North Carolina State University, Raleigh, USA.

The semi-quantitative infection in the greenhouse of the roots of forty-two species of plants belonging to ten families by a species of *Endogone* closely resembling *E.macrocarpa* var. *geospora* is tabulated. Most leguminous species (except *Arachis hypogaea*), *Ipomoea batatus*, *Helianthus annuus*, *Beta vulgaris* and *Prunus persica* were heavily infected.

*0392 SERGEEVA, R. V.; ZATSEPINA, V. M. [The occurrence of endotrophic mycorrhiza in strawberries.] *Nauchnye Trudy Voronezhskiĭ Sel'skokhozyaĭstvennyĭ Institut* (1973) 55, 134-138 [Ru] From *Referativnyĭ Zhurnal* (1973) 7.55.708.
The presence of mycorrhiza (of the vesicular-arbuscular type) in young plants of the cv. Festival'naya (transplanted in the second half of the summer) was observed during the following spring. The fungus penetrated the roots from the surrounding soil. In 2-year-old strawberries it was found in the plants throughout the year being most abundant during flowering and again during fruiting.

0393 STRZEMSKA, J. Mycorrhiza of cultivated plants of the Papilionaceae family. Part IV. Fenugreek (*Trigonella foenum-graecum*) and soybean (*Glycine hispida*). *Polish Journal of Soil Science* (1973) 6 (1) 57-62 [En, pl] Microbiology Laboratory, Academy of Agriculture, Olsztyn, Poland.

Roots of soya bean and fenugreek growing in a light, slightly loamy sand (pH 4.5) were sampled during flowering for 3 years. Both plants developed endotrophic arbuscular-vesicular mycorrhizae, the spread and intensity of which differed between the years, particularly in fenugreek. In both species, roots which did not develop mycorrhizae were, as a rule, deformed.

0394 DEAL, D. R.; BOOTHROYD, C. W.; MAI, W. F. Replanting of vineyards and its relationship to vesicular-arbuscular mycorrhiza. *Phytopathology* (1972) 62(1) 172-175 [En, 6 ref., 1 pl.] Glenville State College, West Virginia, USA.
The vine vesicular-arbuscular mycorrhiza is ubiquitous in New York State vineyards, *Endogone* sp. invading vine roots within 15 days of their appearance in infected soil. The presence of old vine roots in the soil, the proximity of a replanted vine to the previous position of a vine, and a short time lapse between old vine removal and replanting increased the incidence and the intensity of mycorrhizal development. Applying fertilizer to replanted soil reduced the occurrence and intensity of the mycorrhiza.

0395 FURLAN, V. & FORTIN, J.A. 1972. Premiere mention de l'endogone calospora au Québec. Naturaliste can. 99(2):127-129.
In 1971 spores of E. calospora were collected in large quantities from the rhizosphere of Potentilla tridentata. Symbiosis with onion, resulting in growth stimulation, was demonstrated in inoculation experiments.
highest temp. (21/26°C, night/day) and longest at the lowest temp. (11/16°). The rate of infection was more rapid at 21/26° than at 16/26°; at 11/16° it was always very slow. The final level of infection, indicated by the plateau phase, was highest (82%) at 21/26°, 73% at 16/21° and 11% at 11/16°. Plant growth was strongly stimulated after infection at 21/26° and 16/21° but a significant parasitic decrease of growth could be observed on the 8th week at 11/16°. Spore production curves closely followed the growth curves of inoculated plants and final spore production/plant was 2600, 1800 and 50 for the 21/26°, 16/21 and 11/16° regimes, respectively.

*0396 HATTINGH, M.J. 1972. A note on the fungus Endogone. Jl. S. Afr. Bot. 38(1):29-31.
Large numbers of E. spores were found in rhizosphere soil of a maize plant at the Outenique Exp. Farm, George, Cape Province, the 1st report of their occurrence in S. Africa.

*0397 KATENIN, A.E. Mycorrhiza in tundra plants of northeastern European part of USSR. (Rus, Engl Summ.). 140p., 8 pls. *In*: B.A. Tikhomirov, Ed. The Vegetation of the Far North of the USSR and its Utilization. Fasc. 12. Akad. Nauk SSSR, Bot. Inst. Ameni B.L. Komarova. 1972.

0398 KHAN, A.G. 1972. Podocarp-type mycorrhizal nodules in Aesculus indica. Ann. Bot. 36(144):229-238.
Morphologically the root nodules were similar to those of conifers, and they and the lateral roots contained typical Endogone vesicles. Aesculus forest soils from W. Pakistan contained 2 types of Endogone spores and infection was synthesized when these were added to autoclaved sand in which cuttings were grown.

0399. KESSLER, K.J.; BLANK, R.W. 1972. Endogone sporocarps associated with sugar Maple. Mycologia 64(3): 634-638.
Data are presented on numbers of E. sporocarps found in northern hardwood forest stands where Acer saccharum dominated both the overstory and the established reproduction.

0400 MARTIN, W.J.; BIRCHFIELD, W. 1972. Endogone sp. in roots of sweet potatoes and soybeans in Louisiana. Pl. Dis. Reptr. 56(1):58
Endogone sp. is newly recorded on these host in La, forming vesicular-arbuscular mycorrhiza.

0401 MEJSTRIK, V. K. (Environ. Ecol. Inst., Czech. Acad. Sci., Pruhonice-Prague, Czech.) Vesicular-arbuscular mycorrhizas of the species of a Molinietum coeruleae L. I. association: The ecology. NEW PHYTOL 71(5): 883-890. Illus. 1972.--The frequency and intensity of vesicular-arbuscular mycorrhizas in the species of a Molinietum coeruleae association was studied during the vegetative period. From 55 spp. in the association, only 9 were nonmycorrhizal. There was dependence of the frequency of entry points on the root depth and the vegetative season. The ground water table was relatively stable during the year, and it did not exert strong direct influence on the intensity of mycorrhizal infection.

0402 PORTER, D.M.; BEUTE, M.K. *Endogone* species in roots of Virginia type peanuts. (Abstract). Phytopathology, 62:783. 1972.
Peanut (Arachis hypogaea) plants grown in the greenhouse were colonized by a zygosporic species of Endogone, presumably E. gigantea, recovered from the root zone of field-grown peanuts. Two months after inoculation, numerous zygospores and echinulate vesicles, typical of E. gigantea, were produced on roots of peanut seedlings, but measurable growth responses were negligible. A chlamydosporic species obtained from soybean roots, presumably E. macrocarpa, was not observed to have colonized peanut roots, but aboveground portions of inoculated plants were larger in size

and higher in dry weight than noninoculated plants . Zygospores of E. gigantea were abundant in peanut and corn field soils, but rarely found in soils growing fescue. Endogone zygospores obtained from soil surrounding corn roots germinated readily, colonized, and produced more zygospores on peanut roots. Isolates of E. gigantea from peanuts and corn reproduced equally on peanuts. Peanuts grown in soils maintained at low nitrogen levels had higher zygospore populations of E. gigantea than did peanuts grown in soil maintained at high nitrogen levels.

*0403 TRAPPE, J.M.; GERDEMANN, J.W. *Endogone flammicoronoa* sp. nov., a distinctive segregate from *Endogone lactiflua*. Trans. Brit. Mycol., Soc., 57(3):403-407. 1972.

*0404 ANDRUSZEWSKA, A.; DOMINIK, T. 1971. Mikoryza Prunus cerasus L. x Rhodophyllus clypeatus (Bull. ex Fr.) Quel. (Mycorrhiza of *P. cerasus* x *R. clypeatus*). Zesz. nauk. wyższ. Szk. roln. Szczec., 1971, (37) 3-14.
Cherry root material showed 2 types of mycorrhiza: ectotrophic Hd and endotrophic (thamniscophagic).

*0405 BAYLIS, G.T.S. 1971. Endogonaceous mycorrhizas synthesized in Leptospermum (Myrtacea). N. Z. Jl. Bot. 9(2):293-296.
Honey coloured, sessile *Endogone* spores produced mycorrhizal associations in *L. scoparium* whereas crushed spores did not. Mycorrhizal production also occurred in *Solanum nigrum* and *Lolium perenne*.

*0406 HACSKAYLO, E.; VOZZO, J.A. Mycorrhizae of *Populus* in the United States. XV IUFRO Congress, Gainesville, Florida, Sect. 24:1-2. 1971.

*0407 GERDEMANN, J.W. Fungi that form the vesicular-arbuscular type of endomycorrhiza *In*:Hacskaylo, E., ed. 1971. Mycorrhizae. Proceedings of the First North American Conference on Mycorrhizae held at University of Illinois, April 1969. Misc. Publ. USDA Forest Serv. 1189.(9-18).
A review with 44 references, including a key to *Endogone* species known to be mycorrhizal.

*0408 KELEBERDA, T.N. Change in properties of chernozem of steppes due to Mycorrhiza of trees and shrubs. (Rus). Lesn. Zhurn., 4:122-123. 1971.

*0409 KHAN, A.G. *Endogone* and endotrophic mycorrhizae in west Pakistan. XI Proc. Internat. Union for Res. Organiz., Congr., Gainesville. April. 1971

0410 KHAN, A.G. (Dep. Bot., Univ. Panjab, Lahore, Punjab, India.) Occurrence of Endogone spores in West Pakistan soils. TRANS BRIT MYCOL SOC 56(2): 217-224. Illus. 1971.--Most samples were found to contain 1 or more types of spore. Two new types are described. All spore types formed vesicular-arbuscular mycorrhizas with red clover seedlings. The relationship of spore types and their number with soil category is discussed.

*0411 KHRUSHCHEVA, E.P.; ALEKSANDROVA, E.I.; MILENINA, N.P.; TALTINA, G.A. 1971. Ob otsenke stepeni mikotrofnosti sel'skokhozyaistvennykh kul'tur. Evaluation of the degree of mycotrophic development in agricultural crops. Mikol. i Fitopatol. 5(2):217-219.

The assessment, mainly on the amount of root infection by fungi, is made according to the number of mycorrhizal roots or mycorrhizas; the new method is described. Assessment in maize, because of its thicker roots and yellow-greenish mycorrhiza, can be done with a hand lens. Analysis showed a correlation between the intensive development of mycorrhizas and the increased fungal content in the bark cells.

*0412 REDHEAD, J.F. *Endogone* and endotrophic mycorrhizae in Nigeria. XV IUFRO Congress, April, 1971. (Mimeo).

*0413 RAMBELLI, A. 1971. [Preliminary mycological investigations in savanna and forest soils of the Ivory Coast.] *Revue Écol. Biol. Sol* 8, 219-226. [F.] [Cent. Speriment. Agric. For., Rome, Italy]
Mycorrhiza were more abundant on savanna than on forest vegetation. The scarcity of mycorrhiza on forest plants was probably due to sampling (immediately after the rains) at an early stage in their life-cycle. In both habitats a phycomycete-like endophyte was observed on the roots. Penetration appeared to be intracellular, with the formation of large vesicular and arbuscular structures.

0414 SCHENCK, N.C.; HINSON, K. 1971. Endotrophic vesicular-arbuscular mycorrhizae on Soybean in Florida. Mycologia 63(3):672-674.
VA mycorrhizal fungi occurred in every soil sample examined from washed soybean roots. There were fewer around roots growing in organic or low, poorly drained soils than in sandy, well drained soils. Most roots had > 1 VA fungus associated with them, the most frequent being Endogone calosporu followed by E. gigantea. Others included Sclerocystis coremoides and 2 E. spp.

0415 SHUJA, N. GILANI, U.; KHAN, A.G. Mycorrhizal associations in some angiosperm trees around new university Campus, Lahore. Pak. J. of Forestry. 21(4):367-374. 1971.
A survey of 13 angiosperm trees growing around New University campus revealed the fact that majority of plants growing under natural conditions have mycorrhizal associations. Ectotrophic mycorrhizae were found in Euclyptus citriodora only, while all the other trees had endotrophic or vesicular arbuscular type of mycorrhizae.
In Populus euroamericana those roots which were growing towards the canal water were non-mycorrhizal whereas those growing away from it had both ectotrophic and endotrophic mycorrhizal association.
Rhizospheres of all the trees examined contained Endogone spores. Of 8 types of Endogone spores known to occur is West Pakistan soils, only four types were recovered in the present study.

*0416 SUTTON, J.C. *Endogone* spore populations in Ontario Agricultural Soils. (Abstract). Proc. 37th Session Canad. Phytopath. Soc., Edmonton: 21. 1971.

*0417 TRAPPE, J.M.; GERDEMANN, J.W. A neotype of Endogone pisiformis. Mycologia 71:206-209. 1971.

*0418 WHITNEY, R.D. Mycorrhiza studies in Manitoba and Saskatchewan. *In*:Hacskaylo, E., ed. 1971. Mycorrhizae. Proceedings of the First American Conference on Mycorrhizae held at University of Illinois, April 1969. Misc. Publ. USDA Forest Serv. 1189.(241-242).

*0419 AZEVEDO, N.F. DOS S. DE 1970-71. Micorrizas de plantas espontaneas e cultivadas. (Mycorrhizas of wild and cultivated plants.) Mems. Soc. broteriana 21:329-340.
Ectotrophic, endotrophic and ericoid mycorrhizal types were observed among material collected inthe Algarve Province, Portugal.

0420 BAYLIS, G. T. S. 1970. Root hairs and phycomycetous mycorrhizas in phosphorus-deficient soil. *Pl. Soil* 33, 713-716. [Otago Univ., Dunedin, N.Z.]
Phycomycetous mycorrhizas formed by *Coprosoma robusta* grew well in unsteamed forest soil (pH 5.1) both with and without added NaH_2PO_4, but in steamed (pH 4.6) soil they only grew well on addition of P. On the other species tested (*Leptospermum scoparium*, *Solanum nigrum*, *Lolium*

perenne, Hakea enkiantha, Histoipteris incisa, Marchianthia berteroana), most formed mycorrhizas in unsteamed soil but all grew better in steamed soil. Entry of P apparently occurred through root hairs (or rhizoids), the lack of which in some woody species explains their need for P in the absence of mycorrhizas.

0421 GERDEMANN, J.W.; TRAPPE, J.M. Endogone incrassata: a zygosporic species with hollow sporocarps. Mycologia 62: 1204-1208. 1970.
We found that sporocarps in the type collection of Endogone incrassata have an enclosed cavity. An additional collection of E. incrassata made by Thaxter and a more recent one from Alaska also contain specimens with hollow sporocarps. This character is somewhat variable, since the smaller sporocarps in the Alaskan collection are solid. Spores in the type collection are mature, and the attachments have disappeared; consequently, Thaxter was unable to determine whether they were zygospores or chlamydospores. We found that Thaxter's additional collection of E. incrassata contained immature spores with clearly discernible gametangia. The gametangia are parallel and equal or subequal in size. The tip of one gametangium bends slightly and fuses with the other at or slightly below its tip. The zygospore forms either form the tip of the fertilized gametangium or over the point of union.

0422 KHAN, A.G. 1970. Mycorrhizal associations in Gymnosperms of West Pakistan. Pakist. Jnl. Bot. 2(1):9-18
All the gymnosperms examined showed mycorrhizal associations which were ectotrophic in the Pinaceae and endotrophic in the rest of the Coniferales and members of the Ginkgoales, Texales and Ephedrales. Endogone spores were present in the rhizospheres of endotrophic mycorrhizas.

* 0423 OTTO, G. [Studies on the endotrophic mycorrhiza of nine apple clones.] Untersuchungen über die endotrophe Mykorrhiza an neun Apfelklonen. In *Physiologische Probleme im Obstbau.* E. Berlin, Deutsche Akademie der Landwirtschaftswissenschaften zu Berlin (1970) 187-193 [De, en, ru, 2 ref.] Institut für Obstbau, Dresden-Pillnitz, E. Germany.
Apple clones were obtained as root cuttings from 2-year-old seedlings and were planted out in a non-sterilized substrate. The percentage of fungus-infected roots was 89% in the first year and 97% in the second year of the experiment. The extent of the fungus infection also increased, and in the second year there were significant differences between clones for this characteristic, indicating that fungal development in the roots is controlled by genetic factors. No connection could be established between the morphological characteristics of the mycorrhiza and tree growth. However, the extent of mycorrhizal development was correlated with such clonal characteristics as leaf cover which indicate clonal differences in metabolism during the growing season.

* 0424 STRZEMSKA, J. Mycorrhiza of cultivated plants of the Papilionaceae family. Part III Pea (Pisum sativum) and field pea (Pisum arvense). Polish Journal of Soil Science 3(1):26-29. 1970.

0425 ABBOTT, L.K. Comparative anatomy of vesicular-arbuscular mycorrhizas formed on subterranean clover. Aust. J. Bot., 1982, 30, 485-99.
The anatomy of vesicular-arbuscular mycorrhizas formed by 10 species from the Endogonaceae within subterranean clover roots was compared using light microscopy. In pot cultures of single species of fungi, each fungus formed a characteristic infection pattern within roots of subterranean clover. Fungi from the genera *Glomus* (excluding *G. tenuis*), *Acaulospora* and *Gigaspora* were readily distinguished from each other. Within each genus, species varied in the extent to which they formed hyphae or vesicles with dissimilar morphology. Differences among genera were always greater than those among species within genera. This emphasizes a role for infection morphology in taxonomic descriptions of the fungi which are usually limited to features of spores. A key is provided to the characteristics useful for distinguishing among these 10 species of fungi within roots of subterranean clover.

0426 ABBOTT, L.K.;ROBSON, A.D. Infectivity of vesicular arbuscular mycorrhizal fungi in agricultural soils. Aust. J. Agric. Res., 1982, 33, 1049-59.
The development of vesicular arbuscular (VA) mycorrizas was followed for subterranean clover grown in 20 field soils in a glasshouse experiment. The aims to the study were: to understand the way in which mycorrhizas develop in field soils; to identify those factors which could be used to predict field sites suitable for inoculation with VA mycorrhizal fungi. In each soil, the amount and rate of mycorrhiza formation were estimated for species of each genus represented. The data were examined in relation to differences among soils in numbers of spores of VA mycorrhizal fungi and in soil properties. A poor correlation between total spore numbers and the total amount and rate of infection formed was attributed to two factors. First, infection by fine endophyte (a fungus which does not form large spores that can be counted) was ubiquitous, but the amount of mycorrhizas formed by this fungus varied greatly. Second, species of fungi differed in their rates of infection. In general, there was an association between spore numbers and infection development for individual fungal species. The development of mycorrhizas in any soil fell into one of three categories: I, rapid and extensive;II, extensive but with a lag phase; III, slow and limited in extent. The species of fungi in soils from each category were similar. Category I included the soil which were most deficient in phosphorus for plant growth. However, from measurements of soil properties alone, it is not possible to predict those soils which are suitable for the introduction of inoculant VA mycorrhizal fungi.

0427 BETHLENFALVAY, G. J.; PACOVSKY, R. S.; BROWN, M. S. Parasitic and mutualistic associations between a mycorrhizal fungus and soybean: development of the endophyte. *Phytopathology* (1982) 72 (7) 894-897 [En, 28 ref., 5 fig.] USDA, Berkeley, Calif., USA.
The development of *Glomus fasciculatus* in soybean roots was determined at 2-3 wk intervals for 18 wk. The symbiotic association was grown in 1.5 l pots containing an inert medium supplemented with 200 mhg hydroxyapatite as the P source. Fungal infection, estimated by visual observation of stained mycorrhizal segments, was max. 9 wk after planting. Endophyte biomass, measured by the determination of fungal chitin, increased linearly until wk 15 and declined during the final 3 wk of the experiment. Fungal biomass (as percentage of mycorrhizal dry wt.) peaked at 6-9 wk (20%) and declined thereafter. Max. fungal biomass coincided in time with a reversal in increasing growth inhibition of mycorrhizae relative to uninfected, control roots. Conc. of P in the mycorrhizae increased rapidly during the 1st 9 wk and slowly therafter. The percent difference in P conc. of plant matter increased linearly with decreasing availability of P in the rooting medium. It was concluded that parasitic development of *G. fasciculatus* was due to the diversion of significant amounts of assimilate from the host to the endophyte and to competition for P by the symbionts during the 1st ontogenic stages of the association.

0428 BETHLENFALVAY, G. J.; BROWN, M. S.; PACOVSKY, R. S. **Relationships between host and endophyte development in mycorrhizal soybeans.** *New Phytologist* (1982) 90 (3) 537-543 [En, 27 ref., 3 fig., 2 tab.] USDA, SEA, Berkeley, Calif., USA.
In studies with *Glomus fasciculatus*, the amount of total fungal biomass relative to that of the host plant varied throughout the lifespan of the association, reaching a max. 2.3%, 10 wk after planting. The amount of intraradical mycelium increased throughout the host lifespan. Extraradical fungal structures attained max. wt. at the onset of logarithmic growth of the soybean pods but thereafter decreased. Cessation of rapid growth in the fungus lagged behind that in the host but appeared related to pod development. The fungus: root dry wt. ratio was 12.3% at senescence. The ratio of extra- to intraradical mycelium decreased throughout the association. Since the extraradical hyphae are the organs responsible for enhanced nutrient uptake, this ratio is proposed as an index of the endophyte's usefulness to the host. High values coincided with significant growth enhancement of the host. Source-sink relationships in the host appear to be a determining factor in the growth of the fungal endophyte.

0429 BHATTACHARJEE, M.; MUKERJI, K.G.; TEWARI, J.P.; SKOROPAD, W.P. Structure and hyperparasitism of a new species of Gigaspora. Trans. Br. Mycol. Soc. 78(1):184-189. 1982.

*0430 BONFANTE-FASOLO, P. **Cell wall architectures in a mycorrhizal association as revealed by cryoultramicrotomy.** *Protoplasma* (1982) 111 (2) 113-120 [En, 23 ref.] Centro di Studio sulla Micologia del Terreno del CNR, Viale Mattioli 25, 10125 Turin, Italy.
In a vesicular-arbuscular mycorrhizal association a different texture in the cell wall of the host and fungus is revealed by using cryoultramicrotomy, a powerful tool for studying macromolecular arrangements. This technique shows that the host wall has a fibrillar texture, whilst the fungal wall appears amorphous. The latter is not affected by enzymatic digestions, but is labelled by ferritin linked to wheat germ agglutinin, displaying the presence of N-acetylglucosamine. It is suggested that this sugar is present in single units or in short chains, whilst true chitin fibrils are not formed.

0431 BONFANTE-FASOLO, P.; GRIPPIOLO, R. 1982. Ultrastructural and cytochemical changes in the wall of a vesicular-arbuscular mycorrhizal fungus during symbiosis. Can. J. Bot. 60:2303-2312.
During the various stages of the symbiotic association of the vesicular-arbuscular mycorrhizal (VAM) fungus *Glomus fasciculatus* (Thaxter) Gerd. et Trappe with the roots of *Vitis vinifera* L. cv. Barbera, the hyphal wall undergoes marked modifications as follows: (*i*) a gradual thinning out, from theextraradical hyphae to the intraradical hyphae; (*ii*) changes in its ultrastructural architecture, in that the wall consists of stacked lamellae in both the extraradical and coiled hyphae occurring in the outer layers of the cortical parenchyma, whereas it is monostratified in the intercellular and arbuscular hyphae occurring in the inner parenchymal layers; and (*iii*) different responses to cytochemical reactions. The protein and polysaccharide components, though consistently present in the fungal wall at all stages, vary in their staining characteristics after the PATAg and Swift procedure and in their reponses to alkali extraction, suggesting a gradual simplification

of the wall components from the extraradical hyphae to the intraradical ones.

0432 BUWALDA, J. G.; ROSS, G. J. S.; STRIBLEY, D. P.; TINKER, P. B. **The development of endomycorrhizal root systems. III. The mathematical representation of the spread of vesicular-arbuscular mycorrhizal infection in root systems.** *New Phytologist* (1982) 91 (4) 669-682 [En, 27 ref.] Rothamsted Exp. Sta., Harpenden, Herts AL5 2JQ, UK.

The spread of mycorrhizal infection in roots was modelled mathematically assuming the rate of spread to be proportional to the product of the length of root already infected and the fraction of the total root susceptible to infection at a given time. The model was evaluated on data from trials with wheat and white clover grown at 3 plant densities. The rate of infection was little altered by total root length but differed widely between the 2 spp. It was concluded that infection spreads along roots rather than by random contact between roots and hyphae.

0433 BUWALDA, J. G.; ROSS, G. J. S.; STRIBLEY, D. P.; TINKER, P. B. **The development of endomycorrhizal root systems. IV. The mathematical analysis of effects of phosphorus on the spread of vesicular-arbuscular mycorrhizal infection in root systems.** *New Phytologist* (1982) 92 (3) 391-399 [En, 18 ref.] Rothamsted Experimental Station, Harpenden AL5 2JQ, UK.

A model of root infection by vesicular-arbuscular mycorrhizae is used to study the effects of P on the spread of infection in wheat and leek root systems. Leeks, cv. Musselburgh, were grown with 30-480 mg P/kg. Increasing soil P levels increased plant P concentration and reduced the percentage of root length infected with *Glomus mosseae*. The rate of spread of the fungus was not significantly altered by P application but the maximum proportion of the root system which could become infected was reduced.

0434 CARLING, D. E.; BROWN, M. F. **Anatomy and physiology of vesicular-arbuscular and nonmycorrhizal roots.** *Phytopathology* (1982) 72 (8) 1108-1109 [En, 50 ref.] Alaska Agric. Exp. Sta., Palmer, AK 99645, USA.

This review discusses the influences of vesicular-arbuscular mycorrhizae on the structure and function of roots including those of soyabean, maize, tomatoes, Sudan grass and blue grama.

*0435 DEHNE, H.-W. **[Morphological alterations under the influence of endotrophic mycorrhiza.]** Morphologische Veränderungen unter dem Einfluss der endotrophen Mycorrhiza. *Beiträge zur Biologie der Pflanzen* (1982) 56 (2/3) 209-215 [De, en, 14 ref., 3 fig., 1 tab.] Inst. Pflanzenkrankh. Pflanzenschutz, Hannover, German Federal Republic.

On inoculation with *Glomus mosseae*. bean (*Phaseolus vulgaris*) plants produced less roots but more shoot material than nonmycorrhizal plants. Morphological changes in the root systems were modified. Mycorrhizal roots produced more and larger *Rhizobium* nodules and formation of nematode root galls was decreased.

0436 DOUDS, D.D. Jr.; CHANEY, W.R. Correlation of fungal morphology and development to host growth in a green ash mycorrhiza. New Phytol. (1982) 92, 519-526.

The relationship between the growth of the host, and development and morphology of a vesicular-arbuscular mycorrhizal fungus was studied in green ash (Fraxinus pennsylvanica Marsh.) A yearly cycle with three phases is suggested. Phase I is a period of fast shoot growth, slow root growth, rapid colonization of the root system by the mycorrhizal fungus and greater numbers of fungal arbuscles than vesicles. Phase II is a period of fast root growth and a decline in the percentage of root length infected. Phase III is characterized by senescing leaves, infection percentages increasing to a static level, and greater numbers of vesicles than arbuscles. Mycorrhizal green ash seedlings generally had greater heights, weights and root collar diameters and lower root: shoot ratios than non-mycorrhizal seedlings.

0437 GRAHAM, J. H.; LINDERMAN, R. G.; MENGE, J. A. **Development of external hyphae by different isolates of mycorrhizal *Glomus* spp. in relation to root colonization and growth of Troyer citrange.** *New Phytologist* (1982) 91 (2) 183-189 [En, 17 ref., 1 fig., 2 tab.] Univ. California, Riverside, USA.

Growth enhancement and amount of external hyphae were compared for 8 isolates of 5 spp. that differed in their geographic origin and capacity to enhance growth of Troyer, but were similar in their capacity to colonize roots extensively. Calif. isolates generally increased growth in a P-deficient Calif. soil more than did isolates from Fla. Differences in growth enhancement appeared not to be a function of the extent of root colonization (> 95% of the root length by harvest for all isolates), but was directly related to the amount of external hyphae that had developed as estimated by the wt. of soil they had bound into aggregates. The results suggest that isolates of vesicular-arbuscular mycorrhizal fungi may differ in their capacity to develop an external hyphal system independent of their root colonizing capacity and that it cannot be assumed that high levels of colonization are associated with development of mycelium in the soil needed to transport nutrients involved in plant growth enhancement.

0438 JAKOBSEN, I.; ANDERSEN, A. J. **Vesicular-arbuscular mycorrhiza and growth in barley: effects of irradiation and heating of soil.** *Soil Biology & Biochemistry* (1982) 14 (3) 171-178 [En, 17 ref., 3 fig., 4 tab.] Univ. Aarhus, Risskov, Denmark.

Irradiation at the lowest dose (0.25 Mrad) completely eliminated infectivity of soil containing a high number of propagules of *Glomus mosseae*. Mycorrhiza developed more slowly after inoculation in irradiated soils than in untreated soils; possibly the high conc. of nutrients, particularly available N released by irradiation, was significant. Incubation of inoculum in soil for 40 days before sowing increased mycorrhizal infection.

0439 JOHNSON, C. R.; GRAHAM, J. H.; LEONARD, R. T.; MENGE, J. A. **Effect of flower bud development in chrysanthemum on vesicular-arbuscular mycorrhiza formation.** *New Phytologist* (1982) 90 (4) 671-675 [En, 8 ref., 4 fig., 1 tab.] Univ. Florida, Gainsville, USA.

Roots of single stem *Chrysanthemum morifolium* plants were inoculated with *Glomus fasciculatus* at several stages of flower bud development. Compared with vegetative control plants, mycorrhizal formation was reduced during early stages of flower bud development but not during later bud expansion. A decrease of reducing sugars and amino acids in root extracts during early bud development coincided with a decrease in root exudation of these compounds. This reduction apparently resulted from a decrease in the availability and net leakage of metabolites necessary to sustain the mycorrhiza during pre- and post-infection.

0440 MACDONALD, R. M.; CHANDLER, M. R.; MOSSE, B. **The occurrence of bacterium-like organelles in vesicular-arbuscular mycorrhizal fungi.** *New Phytologist* (1982) 90 (4) 659-663 [En, 13 ref., 1 pl. (4 fig.), 1 tab.] Rothamsted Exp. Sta., Harpenden, Herts., UK.

The organelles, morphologically indistinguishable from those which occur in *Glomus caledonius* and *Acaulospora laevis*, were observed in spores of *G. mosseae*, *Gigaspora margarita*, *G. heterogama* and in an unidentified white reticulate VA mycorrhizal spore. Morphologically different ones were also found in *G. margarita* and the white reticulate spores. Their significance is discussed.

0441 RAO, A. S. and K. PARVATHI. (Dep. of Botany, Nagarjuna Univ., Nagarjunanagar-522 510, A.P., India.) PLANT SOIL 66(1): 133-137. 1982. **Development of vesicular-arbuscular mycorrhiza in groundnut (*Arachis hypogaea*) and other hosts.**—A vesicular-arbuscular mycorrhizal fungus, identified as *Glomus mosseae* Gerdemann and Trappe, was found to occur in groundnut and some other hosts. In groundnut roots under experimental conditions, the fungus showed 3 phases of development—a lag phase of 3-4 wk by the end of which formation of vesicles was noticed, a phase of gradual development up to 12 wk, by which time an average of 6 vesicles per centimeter of root developed and a constant phase where there was no further increase of the fungus. Pigeon-pea, black gram, green gram, angular gourd, onion, maize, sorghum and pearl millet also formed mycorrhizae with this fungus, but tomato and eggplant did not. The lag phase was longer and the average number of vesicles developed per unit root length was less in the non-leguminous hosts.

0442 TEWARI, J. P.; SKOROPAD, W. P.; MUKERJI, K. G.; MISHRA, S. **Surface morphology of *Glomus macrocarpum***

chlamydospores. *Transactions of the British Mycological Society* (1982) 79 (2) 364-366 [En, 12 ref., 3 fig.] Univ. Alberta, Edmonton, Canada.

Scanning electron microscope studies are described.

0443 ZAK, J.C.; PARKINSON. D. 1982. Initial vesicular-arbuscular mycorrhizal development of slender wheatgrass on two amended mine spoils. Can. J. Bot. 60:2241-2248.

The initial vesicular-arbuscular (VA) mycorrhizal development of slender wheatgrass on extracted oil-sands and subalpine coal-mine spoils, amended with either fertilizer, peat, or liquid sewage sludge, was examined. Plants were sampled at 2.6 and 10 weeks after plant emergence and the level of infection was expressed as length of mycorrhizal root per plant and length of root which contained arbuscules, vesicles or only hyphae. Mycorrhizal infection of slender wheatgrass on the oil sands was limited to plants on the peat-amended spoil. Infection of plants on the peat-amended oil-sands spoil was detected by 2 weeks. Plants on the subalpine spoil were infected at 2 weeks only on the peat-amended spoil. While slender wheatgrass on the control and fertilizer- amen-amended spoil developed mycorrhizae by 6 weeks, infection was not observed in plants on the sewage-amended spoil until 10 weeks. At 10 weeks, there were no significant differences in lengths of mycorrhizal root per plant among the amendments. Increased P levels in the fertilizer-and sewage-amended subalpine spoil did not duppress VA mycorrhizal development.

0444 BONFANTE-FASOLO, P.; DEXHEIMER, J.; GIANINAZZI, S.; GIANINAZZI-PEARSON, V.; SCANNERINI, S. Cytochemical modifications in the host-fungus interface during intracellular interactions in vesicular-arbuscular mycorrhizae. *Plant Science Letters* (1981) 22 (1) 13-21 [En, 18 ref., 22 fig.] Centro di Studio sulla Micologia del Terreno del CNR, Istituto Botanico dell'Universita, Torino, Italy.

The modifications occurring in 2 different mycorrhizal associations (onion with *Glomus mosseae* and *Ornithogalum umbellatum* with *G. fasciculatus*) were very similar; marked differences were found only in the wall cytochemistry of the 2 fungi involved. In both cases, host primary wall material, which was deposited around hyphae penetrating cells and which seemed to contain a glycoprotein complex, strongly diminished with development of the finer arbuscule branches and appeared to change in nature. The host plasmalemma was not structurally or cytochemically modified with its invagination during arbuscule development. The analogies and differences between these observations and those reported for pathogenic infections are discussed in relation to the hypothesis that the arbuscule is the preferential site of bi-directional nutrient transfer between the fungus and plant in VA mycorrhizae.

0445 BONFANTE-FASOLO, P.; BERTA, GIANINAZZI-PEARSON, V. Ultrastructural aspects of endomycorrhizas in the Ericaceae. II. Host-endophyte relationships in *Vaccinium myrtillus* L. *New Phytologist* (1981) 89 (2) 219-224 [En, 15 ref.] Centro di Studio sulla Micologia del terreno del C.N.R., Istituto ed Orto Botanico, Università di Torino, 10125 Turin, Italy.

The endomycorrhizal infection in *Vaccinium myrtillus* is limited to the cortical cells of the fine hair roots; the fungi have simple septa with associated Woronin bodies characteristic of Ascomycetes. Hyphae penetrating cells are surrounded by a layer of inner host wall material which diminishes with intracellular development of the fungus. In living cells hyphae are separated from host cytoplasm by continuous host plasmalemma and there is no evidence of their lysis or digestion by the plant cell. This biotrophic relationship (living host cell and fungus) appears to predominate in late summer and autumn when new root formation and mycorrhizal infection are most important. During other periods of the year living or dead fungus in moribund host cells seem to be the most common situation.

0446 BROWN, M.S.; BETHLENFALVAY, G.J.; PACOVISKY, R.S. Growth of an endomycorrhizal fungus under parasitic conditions. Phytopathology 71(9): 1002-1003. 1981.

The symbiotic association (*Glycine max* + *Glomus fasciculatus*) was grown in 1.5 l pots in a sand/perlite rooting medium with 200 g of hydroxyapatite ($Ca_5(PO_4)_3(OH)_2$) as the source of P. Development of the endophyte internal and external to the host plant root was determined at regular intervals throughout the ontogeny of the association. Percent infection was estimated by observation of stained mycorrhizal segments. Fungal biomass was determined by measurement of fungal chitin in the mycorrhiza and the rooting medium. Percent fungal biomass per mycorrhiza was maximum (20%) at week 6 and declined thereafter. The internal mycelium continued to grow till week 15. External fungal mass declined after week 9. Initial growth inhibition of the mycorrhiza (maximum of 50%) was reversed at week 9. Recovery resulted in growth enhancement at week 18. It is concluded that growth depression in the host plant was dueto a diversion of assimilate by the endophyte.

0447 GARDNER, W. K.*, D. G. PARBERY and D. A. BARBER. (Dep. Plant Sciences, Faculty Agriculture Forestry, Univ. Melbourne, Parkville 3052, Victoria, Australia.) PLANT SOIL 60(1): 143-148. 1981[recd. 1982]. **Proteoid root morpnology and function in *Lupinus albus*.**—Current theories of P uptake by plants imply that they can augment diffusion to their root axes by the development of abundant root hairs or mycorrhizas. Some P efficient plants have root morphology with multi-branched roots and localized regions of densely packed root hairs which probably is better suited to the retention of substances exuded by the roots than uptake of substances moving to the root by diffusion. Evidence of substantial exudation by the proteoid roots of *L. albus* is presented.

0448 GIANINAZZI-PEARSON, V.*, D. MORANDI, J. DEXHEIMER and S. GIANINAZZI. (Station d'Amelioration des Plantes, INRA, BV 1540, 21034 Dijon-Cedex, France.) NEW PHYTOL 88(4): 633-640. 1981. **Ultrastructural and ultracytochemical features of a *Glomus tenuis* mycorrhiza.**—The ultrastructural organization and some cytochemical features (protein and polysaccharide distribution) of the mycorrhiza formed by *G. tenuis* in raspberry [*Rubus idaeus* L. cv. Bois Blanc] roots were investigated. Certain aspects of the fine mycorrhizal endophyte (smaller hyphae, thinner walls, distinct 2-layered wall structure following the PATAg test for polysaccharides, complete absence of septa) distinguish it from the coarse vesicular-arbuscular mycorrhizal fungi. The modifications occurring in the host-fungus interface during *G. tenius* mycorrhiza development are, however, very similar to those that have been described in several mycorrhizae formed by coarse vesicular-arbuscular endophytes.

0449 GRAHAM, J. H.; LEONARD, R. T.; MENGE, J. A. Membrane-mediated decrease in root exudation responsible for phosphorus inhibition of vesicular-arbuscular mycorrhiza formation. *Plant Physiology* (1981) 68 (3) 548-552 [En, 18 ref.] Dep. of Bot. and Pl. Sci., California Univ., Riverside, CA 92521, USA.

Vesicular-arbuscular mycorrhiza formation in Sudan grass was investigated in pot trials with a P-deficient sandy soil supplied with 0, 28, 56 or 226 µg superphosphate/g soil. The root P content of 4-wk-old plants was correlated with soil P level. Plants grown with insufficient P showed altered membrane permeability with high K efflux and exuded more amino acids and reducing sugars. P-deficient plants inoculated at 4 wk with *Glomus fasciculatus* were 88% infected after 9 wk; this was correlated with root exudation at the time of inoculation. P-sufficient plants were only 25% infected. Infected roots had higher P levels and thus reduced root membrane permeability and exudation compared with uninfected roots.

0450 KARIYA, N.; TOTH, R. Ultrastructure of the mycorrhizal association formed between *Zea diploperennis* and *Glomus fasciculatus*. *Mycologia* (1981) 73 (6) 1027-1039 [En, 24 ref., 9 fig.] Northern Illinois Univ., DeKalb, USA.

Initial stages of mycorrhizal establishment were marked by development of intercellular hyphae ramifying between cortical cells. Penetration of cortical cells by the invading intracellular hyphae was accompanied by a thinning of the cortical cell wall and the formation of a collar around the endophyte. Arbuscules were formed by repeated branching of the endophyte. Host cell cytoplasm was never observed in direct contact with the arbuscular system but was separated by an interfacial zone consisting of the host plasmalemma, the interfacial matrix and the fungal cell wall. Deterioration

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of the arbuscular system began from the finer branches and proceeded backwards to the point of penetration. Septum formation was not observed. Deteriorated arbuscular material accumulated into clumps. Cortical cells did not appear to degenerate during arbuscular breakdown.

0451 KOSKE, R. E. *Labyrinthula* inside the spores of a vesicular-arbuscular mycorrhizal fungus. *Mycologia* (1981) 73 (6) 1175-1180 [En, 12 ref., 3 fig.] Univ. Rhode Island, Kingston, USA.

Approx. 20% of the ruptured spores ("spore shells") of *Gigaspora gigantea*, collected from the face of a barrier sand dune, contained spindle cells of *L.* sp. Single large spore shells harboured from a few to thousands of spindle cells. Cultures of *L.* were obtained by incubating surface-sterilized spore shells on a modified serum-seawater agar medium. Only spore shells from the dune face contained spindle cells. The absence of *L.* from spore shells from other areas of the dune correlates with lower salinities at these sites. Because *G. gigantea* spores and spore shells are common in the barrier dune, the occurrence of *L.* within them may represent a significant reservoir of inoculum able to enter the waters on either side of the dune.

0452 MACDONALD, R. M. and MURIEL R. CHANDLER. (Department of Soil Microbiology, Rothamsted Experimental Station, Harpenden, Herts AL5 2FQ, U.K.) NEW PHYTOL 89(2): 241-246. 1981. **Bacterium-like organelles in the vesicular-arbuscular mycorrhizal fungus *Glomus caledonius*.**— Bacterium-like organelles (BLO) were found by EM in the vesicular-arbuscular (VA) mycorrhizal fungus *G. caledonius*. They were morphologically similar to those found by others in other VA mycorrhizal fungi, in the ectendomycorrhizal fungus *Endogone flammicorona* and in the Discomycete *Scutellinia*. They occurred free in the cytoplasm of *G. caledonius* spores and in the intercellular hyphae and thick arbuscule branches in infected roots. They were irregularly coccal with diameters of 0.3 ± 0.06 μm and had a conspicuous cell membrane and simple cell wall and appeared to divide by median constriction and separation. The fungal cytoplasm did not show any cytopathic effects in the vicinity of the BLO. A completely different type of bacterium colonizied and eroded the walls of reproductive spores of *G. caledonius*. These bacteria did not enter the fungal cytoplasm and had a thick complex wall and peripheral membranes. In contrast to BLO, their cytoplasm was clearly differentiated into electron-dense and transparent areas.

0453 MANJUNATH, A.* and D. J. BAGYARAJ. (Dep. Agric. Microbiol., Univ. Agric. Sciences, G.K.V.K. Campus Bangalore 560 065 India.) PLANT SOIL 63(2): 295-298. 1981[recd. 1982]. **Intensity of mycorrhizal infection and response of onion at different stages of growth.**— A time course experiment was conducted to study the intensity of root infection and the response of onion. Mycorrhizal infection with internal hyphae and arbuscules was observed in onion roots 15 days after sowing and infection percentage progressively increased up to 35 days. Plants inoculated with the mycorrhizal fungus weighed less than non-mycorrhizal plants during initial stages up to 35 days but grew faster later after 38 days.

0454 MOIROUD, A., CAPELLANO, A.; BARTSCHI, H. 1981. Fixation d'azote chez les especes ligneuses symbiotiques. I. Ultrastructure des nodules, mycorhizes á vésicules et á arbuscules et activité réductrice de C2H2 de jeunes plants de Robinia pseudoacacia cultivés au laboratoire. Can. J. Bot. 59:481-490.

Black locust (Robinia pseudoacacia L.), a native species of North America, has found a specific and efficient Rhizobium strain in French soils.

Ultrastructural studies of young nodules showed that infection of the host cell occurred by numerous infection threads. Rhizobia are liberated in the cell by endocytotic processes. No important differences were found between rhizobia in the infection threads and bacteroids in the host cell; the bacteroid cells were only enlarged, without any structural change. This Rhizobium strain is a "fast grower".

Roots were also infected by an endomycorrhizal fungus producing numerous vesicles and arbuscules in the root cortex. Nitrogen-fixing activity assayed by the acetylene reduction method, was measurable only 5 to 10 days after nodular development. Until the 50th day after seed germination, the activity increased slowly, then more rapidly, by the 80th day, fixing activity was about 9 u mol/h per plant.

No relationships between the form, age, and fixing activity of the nodules were found.

0455 NEMEC, S. . Histochemical characteristics of *Glomus etunicatus* infection of *Citrus limon* fibrous roots. *Canadian Journal of Botany* (1981) 59 (5) 609-617 [En, fr, 42 ref., 1 fig., 5 tab.] USDA, Orlando, Fla., USA.

Lipid in vesicles and hyphae in rough lemon roots reacted positively to a variety of reagents that have an affinity for neutral lipids. In contrast, arbuscules did not appear to contain neutral lipid, but did react positively to phosphoglyceride tests and glycolipid. Walls of vesicles and hyphae contained chitin, arbuscule walls mainly glycolipid. Young arbuscules, hyphae and immature vesicles were rich in basic protein. Phenolics were detected in vesicle walls and hyphal attachments but none accumulated around infected areas, even though laccase activity occurred in cortical regions occupied by young arbuscules. Dehydrogenases were present in young arbuscules, hyphae and in immature vesicles still containing noticeable amounts of cytoplasm. Peroxidase and catalase activity in senescing arbuscules were probably associated with fatty acid oxidation in the fungus.

*0456 RIESS, S.; PUPPI, G. [Preliminary observations on morphological characteristics of mycorrhizal associations in tufa soils in Latium.] Osservazioni preliminari sulle caratteristiche morfologiche delle associazioni micorriziche in terreni di tufo nel Lazio. *Micologia Italiana* (1981) 10 (2) 43-48 [It, en, 14 ref., 3 fig., 2 tab.] Istituto dell'Orto Botanico, Univ. Rome, Italy.

0457 SMITH, G. W. Effect of inoculation level and sieving on the *Gigaspora gigantea*-soybean mycorrhizal symbiosis. *Soil Biology & Biochemistry* (1981) 13 (6) 539-540 [En, 14 ref., 2 tab.] Clemson Univ., Clemson, S. Carol., USA.

An inoculum level of 4 azygospores/kg soil was not sufficient to induce adequate mycorrhial infection of soyabean unless pre-infected mycorrhizal roots were also included. All inoculated roots were 50-80% infected except those receiving sieved 1 g/kg soil inoculum (*c.* 10%). Inoculum level was not of major importance provided it was sufficient to assure approx. 50% infection.

0458 SWARD, R.J. The structure of the spores of Gigaspora margarita. I. The dormant spore. New Phytol. (1981) 87, 761-768.

Histochemical tests, light and electron microscopy have been used to investigate the structure of the dormant spore of Gigaspora margarita (Endogonaceae). There is a plug in the neck of the mature spore consisting of a dense matrix of highly osmiophilic material bounded by wall-like depositions. The complex spore wall is composed of four prominent layers, an inner and outer layer that contain polysaccharide, protein and lipid; a laminated chitinous layer and an ill-defined cementing layer.

The cytoplasm is composed of amorphous material and a variety of granules and particles that form a fine network between large oil droplets. In certain areas the cytoplasm is concentrated and forms two dense regions named the 'synthesizing' and 'nuclear' centres which contain different proportions of various organelles

Two unusual types of organelles found in the cytoplasm of G. margarita spores have been previously described in honey-coloured, sessile spores of Acaulospora laevis.

0459 SWARD, R. J. (Plant Research Inst., Swan St., Burnley, Victoria, Australia 3121.) NEW PHYTOL 88(4): 661-666. 1981. **The structure of the spores of *Gigaspora margarita*: 2. Changes accompanying germination.**— Light microscopy and EM were used to study the changes that accompany germination in the spores of *G. margarita* [a vesicular arbuscular mycorrhiza]. Regular germination is achieved following surface sterilization of the spores. The possible role played by NaClO in spore activation is discussed. Following spore activation there is considerable redistribution of cytoplasm with a subsequent accumulation of cytoplasmic and wall material in the region of the bulbous-shaped attachment. Germ-tube development occurs in this region without the production of peripheral compartments described for other spore types. The possible significance of this feature and the mode of germ-tube wall development are discussed.

0460 SWARD, R. J. (Plant Research Inst., Swan St., Burnley, Victoria, Australia 3121.) NEW PHYTOL 88(4): 667-674. 1981. **The structure of the spores of *Gigaspora margarita*: 2. Germ-tube emergence and growth.**— Light microscopy and EM were used to study the emergence through the spore wall and subsequent growth and development of the germ-tube of *G.*

margarita [a vesicular arbuscular mycorrhiza]. Spore-wall penetration by the germ-tube is unusual as 2 different mechanisms seem to be operating, 1 for the inner spore-wall layers and another for the outer layer. As the germ-tube develops a primary wall layer is formed and can be traced to its origin as a layer continuous with the thickened region of the innermost spore-wall layer. In the maturing germ-tube a highly osmiophilic 2 wall is deposited and this may be the wall layer that persists when the fungus penetrates a host root and sets up a mycorrhizal association. The ultrastructural organization found in *G. margarita* can be categorized into approximately 3 zones: the apical zone, the subapical zone and the zone of vacuolation. Other features of the cytoplasmic organization are also discussed including the possible significance of bacteria-like organisms, membrane-bound crystals, osmiophilic granules and glycogen particles. Features of the culture-grown germ-tubes are also compared with those of host-associated stages of the fungus reported in the literature.

*0461 VARMA, A. K.; KIRAN SINGH; LALL, V. K. **Lumen bacteria from endomycorrhizal spores.** *Current Microbiology* (1981) 6 (4) 207-211 [En, 29 ref., 4 fig., 3 tab.] Jawahar Lal Nehru Univ., New Delhi, India.

Bacteria were detected by scanning electron microscopy in chlamydospores of *Glomus macrocarpus* obtained from rhizosphere soils of xerophytic plants. Spp. of *Enterobacter, Pseudomonas* and *Streptococcus* were identified.

0462 BARTSCHI, H.; GARREC, J.-P. **[Comparative study of the cytological localization of some mineral elements in the cortex of healthy roots and of mycorrhizas of *Vitis vinifera* L.]** Étude comparative de la répartition cytologique de quelques éléments minéraux dans lécorce de racines saines et d'endomycorhizes de *Vitis vinifera* L. *Comptes Rendus des Séances de l'Académie des Sciences, D* (1980) 290 (13) 919-922 [Fr, en, 8 ref., 3 pl.] Univ. Claud-Bernard, Lyon, France.

X-ray microanalysis showed that phosphorus accumulated in the hyphae in cortical cells of mycorrhizal grapevine roots. Other elements were not affected.

*0463 BROWN, S. L.; STERNE, R. E. **Total root length of cotton and other field crops infected by mycorrhizal fungi.** 22-23 [En, 18 ref.]
In: WORLD METEOROLOGICAL ORGANIZATION; INTERNATIONAL RICE RESEARCH INSTITUTE Proceedings of a symposium on the agrometeorology of the rice crop. Los Baños, Laguna, Philippines; IRRI. (1980) 254pp. [En]

0464 DAFT, M. J.; CHILVERS, M. T.; NICOLSON, T. H. **Mycorrhizas of the Liliiflorae. I. Morphogenesis of *Endymion non-scriptus* (L.) Garcke and its mycorrhizas in nature.** *New Phytologist* (1980) 85 (2) 181-189 [En, 39 ref.] Department of Biological Sciences, University of Dundee, Dundee, DD1 4HN, UK.

Bluebell (*Endymion non-scriptus*) annually produces a new root system that becomes mycorrhizal very quickly after the roots emerge from the bulb. Morphogenesis of the mycorrhizae is rapid during the autumn and cold winter periods whilst the host is subterranean. Infection is restricted to roots free in the soil and never extends to the root tissues enclosed within the bulb. Environmental conditions alter the rates of host and mycorrhizal development. On the basis of spore and mycelial characters, five species of endophytes were identified. The importance of mycorrhizae to the bluebell and other members of the Liliiflorae is discussed.

*0465 GRIPPIOLO, R. **[Infection process of a vesicular-arbuscular fungus. I. Ultrastructural observations on fungal penetration from cell to cell in the root.]** Il processo di infezione di un fungo vescicolo-arbuscolare. I. Osservazioni ultrastrutturali sulla penetrazione del fungo da cellula a cellula nella radice. *Allionia* (1980/81) 24, 49-53 [It, en, 12 ref., 4 fig.] Istituto Botanico, Univ. Turin, Italy.

Results are presented of transmission electron microscope observations on colonization of cortical cells of grapevine roots by *Glomus fasciculatus*. In the 1st and 2nd cell layers the fungus mostly formed intracellular coils, which filled up the host cell and were ensheathed by the host plasmalemma. As a result of plasmalemma fusion, decomposition of the middle lamella, host wall distension, and host plasmalemma invagination hyphae penetrated deeply into the inner cortex.

0466 GUNZE, C. M. B.; HENNESSY, C. M. R. **Effect of host-applied auxin on development of endomycorrhiza in cowpeas.** *Transactions of the British Mycological Society* (1980) 74 (2) 247-251 [En, 20 ref.] Department of Botany, University of Dar es Salaam, Tanzania.

The morphology of endomycorrhizas attributed to a *Gigaspora* sp. and a *Glomus* sp. in cowpeas (*Vigna unguiculata*) was similar to that described in other plant species. Arbuscule frequency increased when host carbohydrates were reduced by shading or defoliation and decreased when the shoot apex was removed, but this decrease was counteracted by applications of 1000 ppm indole-3-acetic acid (IAA) to the cut apex. Vesicle formation was reduced by shading and defoliation but was unaffected by removal of the stem apex or by application of IAA.

*0467 JALALI, B. L.; THAREJA, M. L. **Development of vesicular-arbuscular mycorrhiza in plants in relation to phosphate uptake.** *Haryana Agricultural University Journal of Research* (1980) 10 (3) 352-357 [En, 13 ref.] Dep. of Pl. Path., Haryana Agric. Univ., Hissar, Haryana, India.

Relationships between plant P uptake and growth stage and root colonization by *Endogone* spp. were studied for wheat cv. S 308, and pearl millet [*Pennisetum americanum*] cv. T 55 grown under controlled conditions. Vesicular-arbuscular mycorrhizal development in both crops was low at the vegetative stage of host development but became extensive at the reproductive stage. Mycorrhizal inoculation increased plant P uptake and total dry wt./plant. 3 different types of *Endogone* spores were observed in the test soils.

0468 JOHN, T. V. ST. **Root size, root hairs and mycorrhizal infection: a re-examination of Baylis's hypothesis with tropical trees.** *New Phytologist* (1980) 84 (3) 483-487 [En, 6 ref.] Inst. Nacional de Pesquisas da Amazônia, Manaus, Brazil.

A series of 89 Brazilian tree species, whose root characteristics and VA mycorrhizal condition were known, was used to test an aspect of Baylis's magnolioid root hypothesis. A non-parametric statistical test showed a significant association between magnolioid root characteristics (coarsely branched, generally lacking root hairs) and VA infection.

0469 OCAMPO, J. A. **Effect of crop rotations involving host and non-host plants on vesicular-arbuscular [VA] mycorrhizal infection of host plants.** *Plant and Soil* (1980) 56 (2) 283-291 [En, 10 ref.] Estación Experimental del Zaidín, CSIC, Granada, Spain.

The effects of crop rotations involving 2 host (lettuce and lavender) and 2 non-host (cabbage and radish) plants on the development of mycorrhizal infection in host plants were studied in non-sterile soil and in sterilized soil with or without rock phosphate and inoculated with *Glomus mosseae*. Pre-cropping with non-host plants did not decrease VA infection in the host plants, but pre-cropping with a host plant increased VA infection in the same or another host plant grown afterwards. These effects were noted irrespective of rock phosphate addition or soil sterilization.

0470 WARNER, A.; MOSSE, B. **Independent spread of vesicular-arbuscular mycorrhizal fungi in soil.** *Transactions of the British Mycological Society* (1980) 74 (2) 407-410 [En, 12 ref., 2 fig., 1 tab.] Rothamsted, Harpenden, UK.

Inoculum of each of 4 endophytes (*Glomus fasciculatus, G. mosseae, Acaulospora laevis* and *Gigaspora margarita*) consisting of roots, mycelium and spores, was placed in nylon fabric pouches and buried in irradiated (1 Mrad) soils in pots with the open end tied above soil level. The pots were covered and kept moist for 6 months, after which the pouches were removed and the holes filled with fresh, irradiated soil sown with clover to detect infectivity. After 2 months the clover roots were examined for mycorrhiza. All 4 endophytes had spread from the pouches into the surrounding soil and survived there for 6 months in a condition suitable for establishing new infection. The results confirm that these organisms possess some saprophytic ability and evidence was obtained that in these and similar experiments, with buried polypropylene tubes, the fungi penetrate the containers by hyphae which can presumably establish a base in organic particles from which a host plant can be infected.

*0471 DEXHEIMER, J.; GIANINAZZI, S.; GIANINAZZI-PEARSON, V. **Ultrastructural cytochemistry of the host-fungus interfaces in the endomycorrhizal association *Glomus mosseae* – *Allium cepa*.** *Zeitschrift für Pflanzenphysiologie* (1979) 92 (3) 191-206 [En, 26 ref., 14 fig., 1 tab.] Univ. Nancy, France.

In: The continuous, highly invaginated host plasmalemma surrounding the intracellular fungal structures in onion retains its affinity for phosphotungstic acid and continues to produce polysaccharide fibrils, but in the presence of the endophyte it progressively loses the capacity to organise these into well-structured wall material. At the point of cell penetration and in the primary arbuscule branches, the fungal

wall is surrounded by a collar of host wall material which has the same cytochemical properties as the primary walls of the plant cell. The fine arbuscule branches are surrounded by a layer of condensed matrical fibrils. When the arbuscule branches senesce and collapse, they become encased by the polysaccharide fibrillar material derived from the host. The interfacial matrix separating the host plasmalemma from the fungal wall contains membranous vesicles and scattered polysaccharide fibrils, both elaborated by the host plasmalemma. These vesicles are often in contact with the walls of the endophytic hyphae. In the fungus, bulbous or tubular configurations of the plasmalemma may become very numerous and occupy the whole hyphal width. Although these structures may be involved in host-fungus exchanges, their eventual participation in wall synthesis is also proposed.

*0472 GRADA-YAUTENTZI, R.; VALDÉS, M. [Development of vesicular-arbuscular mycorrhiza on some crops.] Desarrollo de micorriza vesículo-arbuscular en algunos cultivos. *Boletín de la Sociedad Mexicana de Micología* (1979) No.13, 47-53 [Es, en, 9 ref., 5 fig., 2 tab.] Escuela Nacional de Ciencias Biológicas, IPN, Mexico.

Ten weeks after inoculating clover, onion, maize and sorghum with spores of *Glomus mosseae, G. fasciculatus, Gigaspora calospora* and *G. gigantea* structures characteristic of vesicular-arbuscular mycorrhiza were observed in the cortical cells. Dry wt. was greater in inoculated plants, growth increase being 103% in onion inoculated with *G. mosseae.*

0473 HOLLEY, J. D.; PETERSON, R. L. Development of a vesicular-arbuscular mycorrhiza in bean roots. *Canadian Journal of Botany* (1979) 57 (19) 1960-1978 [En, fr, 46 ref., 41 fig.] Univ. Guelph, Ont., Canada.

Electron-dense particles adjacent to external hyphae of a *Glomus* sp. bind Fe, as shown by X-ray microprobe analysis, when roots of *Phaseolus vulgaris* are fixed by glutaraldehyde-ferric chloride. This material is thought to be phenolic. External spores, each with a subtending hyphal stalk, were hyaline to black. Intercellular hyphae, initially densely cytoplasmic, become progressively more vacuolate, with some vacuoles containing electron-dense particles. The hyphae form peg-like projections causing the cell to be stretched inwards. Penetration of the inner cortex is followed by the formation of a simple haustorial trunk which dichotomizes successively until fine hyphae fill the cell. The endophyte is at first enclosed by a wall layer but the finer branches are covered only by an extrahaustorial matrix and cortical cell plasma membrane. Cortical cell cytoplasm changes in response to the fungus. Most arbuscules collapse or degenerate to some extent. Initially the cytoplasm loses its well-defined appearance and small vacuoles develop which then fuse into larger vacuoles until the cytoplasm is a thin dense band at the periphery. The hyphae then collapse and coagulate into successively larger clumps until only a dense residual mass remains in the cell. A membrane encloses the developing hyphal clumps and the cortical cytoplasm degenerates as clumping advances. No cell wall matrix is seen around the clumped endophyte.

0474 JASPER, D. A.; ROBSON, A. D.; ABBOTT, L. K. Phosphorus and the formation of vesicular-arbuscular mycorrhizas. *Soil Biology and Biochemistry* (1979) 11 (5) 501-505 [En, 21 ref.] Department of Soil Science and Plant Nutrition, University of Western Australia, Nedlands, Western Australia 6009.

Infection of ryegrass roots by vesicular-arbuscular mycorrhizal (v.a.m.) endophytes occurring in an unfertilized virgin soil of low P status was more sensitive to increasing P supply than that by endophytes occurring in an adjacent fertilized agricultural soil. P application to soil depressed mycorrhiza formation in subterranean clover by increasing plant P status and not by direct effects of soil P on v.a.m. endophytes. Localized placements of superphosphate by banding or topdressing did not affect the development of mycorrhizas of roots in the fertilized zones differently from those of roots not in fertilized zones. The amount of infection was not correlated with P concentrations within the plant at harvest. However, the extent of infection could be correlated with P concentrations of roots at early stages of penetration by the fungi. Additionally, the effects of P supply on frequency of penetration by hyphae and subsequent mycorrhiza development closely paralleled effects of P supply on soluble carbohydrate concentrations in roots.

0475 POWELL, C. L. Spread of mycorrhizal fungi through soil. *New Zealand Journal of Agricultural Research* (1979) 22 (2) 335-339 [En, 15 ref., 1 fig., 4 tab.] Ruakura Agric. Res. Cent., Minist. Agric. Fisheries, Hamilton, New Zealand.

The spread was estimated by transplanting clover plants infected with morphologically distinct mycorrhizal fungi into troughs of soil. Mycorrhizal fungi spread into non-mycorrhizal seedlings at 0.6-1.5 m/yr and into mycorrhizal seedlings at 0.9-3.2 m/yr. Mycorrhizal infestation of the trough soil greatly reduced the spreading rate of an introduced fungus. A precrop of kale or mustard grown in the trough soil repressed mycorrhizal infectivity of the soil and allowed an introduced fungus to spread rapidly.

0476 SANDERS, F. E.; REED, L. E. The effect of inoculum density on the development of vesicular-arbuscular mycorrhizas of crop plants. In *In The Soil Root Interface. Proceedings of an International Symposium, Oxford, 1978.* Harley, J.L.; Russell, R.S. (Editors). London, U.K.; Academic Press Inc. (London) Ltd. (1979) 432 [En] Department of Plant Sciences, University of Leeds, UK.

During vegetative growth of annual crops, mycorrhizal infection establishment is followed by a phase of extending infection where the proportion of mycorrhizal roots increases rapidly. Eventually an equilibrium is reached where the proportion of mycorrhizal roots becomes constant although the root weight of the crop may continue to increase. Many factors appear to have effects on this pattern of development. These are reviewed. One factor of potential importance, the effect of varying inoculum density, was investigated in a series of pot experiments using maize. Variation of inoculum density was found to produce large effects on infection development. Similar effects occurred on barley in the field.

0477 SCANNERINI, S.; BONFANTE-FASOLO, P Ultrastructural cytochemical demonstration of polysaccharides and proteins within the host-arbuscule interfacial matrix in an endomycorrhiza. *New Phytologist* (1979) 83 (1) 87-94 [En, 22 ref.] Centro di Studio sulla Micologia del Terreno del C.N.R., Istituto Botanico dell'Università, 10125 Torino, Italy.

The host-fungal arbuscule interfacial matrix in the VA mycorrhiza produced in *Ornithogalum umbellatum* L. by *Glomus fasciculatus* has been studied at the ultrastructural level by various fixation methods, cytochemical techniques and by selective enzymic digestion. The interfacial matrix, though varying in size and ultrastructure, always contains polysaccharides (mainly pectin and occasionally some cellulose) and proteins. Combined morphological and cytochemical results show that this structure is made up of wall material from the host cell.

0478 SCHWAB, S. Rate of formation of VA mycorrhizae in seedlings of seven species native to the mid-elevation sage community of Northwestern Colorado. Journal of the Colorado Wyoming Academy of Science. 11(1):28, 1979. Abst.

Seedings of seven plants native to the mid-elevation sage community of the Piceance Basin in northwestern Colorado were grown in the greenhouse in soil collected from an undisturbed site in the Piceance Basin and sampled at weekly intervals to determine the age at which these plants became mycorrhizal. and the length of time required for each species to reach its maximun level of infection. Artemisia tridentata Chrysothamnus nauseosus. and Agrophyron smithu became heavily infected within four weeks of seedling emergence and maintained these high levels of infection throughout the four month sampling period. Sphaeralcea munroana also became heavily infected within four weeks, but the proportion of mycorrhizal roots then decreased as the thick tap root typical of this species developed.

Oryzopsis hymenoides became only moderately mycorrhizal and showed the greatest variability in regard to mycorrhizal formation among the species examined. Neither Atriplex canescens nor Ceratoides lanata showed any sign of mycorrhizal formation in six months. These results correlate

with the relative success of these species as invaders of disturbed sites, with those species that are least mycorrhizal as seedlings being the most successful invaders.

*0479 WALKER, G. D.; POWELL, C. L. **Vesicular-arbuscular mycorrhizas in white clover: a scanning electron microscope and X-ray microanalytical study.** *New Zealand Journal of Botany* (1979) 17 (1) 55-59 [En, 12 ref., 8 fig.] DSIR, Lower Hutt, New Zealand.

Seedlings were inoculated with several mycorrhizal strs. and cultured until the endophytes developed and matured. Roots were then freeze fractured and freeze dried. The results indicated an accumulation of elements within mature arbuscules. Evidence of endophyte breakdown, accompanied by a reduction of the expected P conc., was also obtained and the implications are discussed.

0480 WHITE, J. A.; BROWN, M. F. **Ultrastructure and X-ray analysis of phosphorus granules in a vesicular-arbuscular mycorrhizal fungus.** *Canadian Journal of Botany* (1979) 57 (24) 2812-2818 [En, fr, 19 ref., 6 fig.] Univ. Missouri, Columbia, USA.

Glomus mosseae was examined by transmission electron microscopy and energy dispersive X-ray analysis. Electron-dense granules, found within vacuoles, contained high concs. of P and Ca and were similar in appearance to the polyphosphate granules described in other organisms. Highly vacuolated intercellular hyphae and vesicles possessed the greatest number of P granules, which were present in vacuolated arbuscular hyphae but absent from completely collapsed arbuscules. The active arbuscule was the most probable site of breakdown of P granules. Two other types of cellular inclusion, one vacuolar and one cytoplasmic, could not be identified by X-ray analysis and could easily be mistaken for P granules. It was concluded that general morphological appearance and location were not adequate criteria for the identification of P granules.

*0481 BONFANTE-FASOLO, P. **Some ultrastructural features of the vesicular-arbuscular mycorrhiza in the grapevine.** *Vitis* (1978) 17 (4) 386-395 [En, fr, 21 ref.] Centro di Studio sulla Micologia del Terreno del CNR, Cattedra di Viticoltura dell'Università di Torino Italy.

A morphological analysis of the mycorrhizal roots of grapevine was conducted using transmission and scanning electron microscopy. Intercellular hyphae and intracellular arbuscules of a phycomycetous fungus, tentatively identified as *Glomus* sp., were detected in the root cortex. The hyphae contained highly vacuolated areas with dense globules, glycogen particles and bacteria-like micro-organisms. Following host cell penetration the arbuscule was formed, composed of many fungal branches and filling the cortical cell, but separated from the host cytoplasm by the host plasma membrane. Amyloplasts were present in infected host cell, in close association with the fungal branches.

*0482 FONTANA, A.; BONFANTE-FASOLO, P.; SCHUBERT, A. **[Morphological characteristics of vesicular-arbuscular mycorrhizae associated with vines.]** Caratterizzazione morfologica della micorrizia vescicolo-arbuscolare nella vite. [Review]. *Quaderni del Corso di Specializzazione in Viticoltura ed Enologia* (1978) 2, 137-146 [It, 17 ref.] Centro di Studio sulla Micologia del Terreno del CNR Cattedra di Viticoltura dell'Università di Torino, Italy.

A review and discussion with particular reference to grapevines in Italy. The occurrence of mycorrhizas appeared to be largely independent of the rootstock used.

*0483 IQBAL, S. H.; MALIK, K. S. **The effect of transplanting on the development of mycorrhiza and subsequent growth of crops normally raised from seed under field conditions.** *Biologia, Pakistan* (1978) 24 (2) 349-355 [En, 7 ref., 4 fig.] Univ. Punjab, New Campus, Lahore, Pakistan.

Mycorrhizal and nonmycorrhizal plants of sunflower and lettuce were transplanted at 5, 7 and 9 weeks. Immediately after transplanting mycorrhizal plants showed a fall in vesicular and arbuscular infections and a reduction in growth rate. This phase is short-lived in plants transplanted at an early stage and these show better growth and more VA infections than the controls.

0484 MCILVEEN, W. D.; COLE, H., JR. **Influence of zinc on development of the endomycorrhizal fungus *Glomus mosseae* and its mediation of phosphorus uptake by *Glycine max* 'Amsoy 71'.** *Agriculture and Environment* (1978/1979) 4 (4) 245-256 [En, 36 ref.] Pesticide Research Laboratory, Pennsylvania State University, University Park, Pa., 16801, USA.

Germination of spores of *Glomus mosseae* was stimulated on agar media supplemented with trace amounts (0.1-1.0 μg/ml) of zinc. Spore germination was inhibited at higher concentrations. Mycorrhizal development on soybean plants grown in the greenhouse in soil amended with $ZnSO_4$ was enhanced by 18 mg zinc per kg soil on a dry weight basis. Higher rates of 45 and 135 mg/kg Zn resulted in decreased infection. The percent root length colonized was slightly stimulated by lower rates of added zinc but the higher rates were inhibitory. Increased development of the mycorrhizal fungus in roots was positively correlated with higher concentrations of phosphorus in the foliage. The number of infections per cm of root was the most important factor in determining increased phosphorus uptake. Phosphate soil amendments resulted in a consistent trend of decreased mycorrhizal colonization on soybean roots.

0485 MENGE, J. A.; STEIRLE, D.; BAGYARAJ, D. J.; JOHNSON, E. L. V.; LEONARD, R. T. **Phosphorus concentrations in plants responsible for inhibition of mycorrhizal infection.** *New Phytologist* (1978) 80 (3) 575-578 [En, 11 ref.] Dep. of Pl. Path., California Univ., Riverside, CA 92521, USA.

Using a split root technique, it was found that P fertilization of half of the root system of *Sorghum sudanense* could significantly reduce the number of chlamydospores of the mycorrhizal fungus *Glomus fasciculatus* in the unfertilized half of the root system. In a 2nd experiment vials of soil containing different conc. of P were inserted into pots of *S. sudanense* which were fertilized with different amounts of P and inoculated with *G. fasciculatus*. The numbers of chlamydospores, vesicles and arbuscles and the amount of hyphae produced by *G. fasciculatus* on roots within the vials were not influenced by the soil P in the vials, but were inversely correlated with the conc. of P in roots outside the vial. All evidence indicated that it was the conc. of P within the plant and not the soil P which led to a reduction in colonization, infection and spore production in *G. fasciculatus*.

*0486 OSHIMA, S. **[Development of vesicular-arbuscular mycorrhizae in tobacco.]** *Bulletin of the Okayama Tobacco Experiment Station* (1978) No. 39, 81-84 [Ja, en, 12 ref., 6 fig.]

The mycorrhiza was found in the roots of flue-cured tobacco. Far more vesicles and arbuscules developed in roots of plants with insufficient fertilizer than in those given adequate amounts.

*0487 STRULLU, D. G. **[Histology and cytology of endomycorrhizas.]** Histologie et cytologie des endomycorhizes. *Physiologie Végétale* (1978) 16 (4) 657-669 [Fr, en, 27 ref., 8 fig.] UER Sciences Biologiques, Rennes, France.

In a study of endomycorrhizas formed by yew in France the cytology of the fungus, its position in the host cells, modifications of the latter and phagocytosis of the fungus cells were observed. The results are compared with those for other vesicular-arbuscular and orchid mycorrhizas.

0488 SWARD, R. J. **Infection of Australian heathland plants by *Gigaspora margarita* (a vesicular-arbuscular mycorrhizal fungus).** *Australian Journal of Botany* (1978) 26 (3) 253-264 [En, 23 ref., 32 fig.] Monash Univ., Clayton, Vict., Australia.

The large, white, bulbous-based spores of *G. margarita*, which were sieved from soils collected in a heathland area at Cranbourne (Vict.), were germinated and cultures on artificial media and their growth patterns observed. Certain host spp. including *Leptospermum juniperinum* and *Trachymene anisocarpa* were infected in pot culture with the fungus and the morphology and anatomy of the resulting association were studied. A variation on the mode of entry and spread of the fungus within the root from that described for another vesicular arbuscular mycorrhizal association is discussed.

*0489 BONFANTE-FASOLO, P.; SCANNERINI, S. **Cytological study of the vesicular-arbuscular mycorrhiza in *Ornithogalum umbellatum* L.** Uno studio citologico sulla micorrhiza vescicolo-arbuscolare di *Ornithogalum umbellatum* L. *Allionia* (1977) 22, 5-34 [En, 20 ref.] Centro di studio sulla Micologia del Terreno del CNR, Torino, Italy.

Under the optical microscope two distinct layers were

observed in the endomycorrhiza in *Ornithogalum umbellatum* roots: 1) a layer consisting of the outermost cortical cells with inter- and intracellular coiled mycelia; 2) a layer consisting of the middle and internal cortical cells, with extensive inter- and intracellular infection, derived respectively from the infection spreading hyphae and from the fungus in arbuscular form. Ultrastructurally, thick granular and/or lamellar walls, few organelles and abundant fat accumulation were virtually a constant feature in layer 1, whereas in layer 2, either active protoplasm, or large, extensively vacuolar zones rich in electro-dense granules were visible. In the internal cells, the process ended with lysis of the arbuscular stage. Intra and intercellular vesicles were observed; their cytology however did not seem to be related to their position within the roots. Differences in the host-symbiont relationship appeared to be reflected in the ultrastructure of the interface.

*0490 BONFANTE-FASOLO, P.; SCANNERINI, S. A cytological study of the vesicular-arbuscular mycorrhiza in *Ornithogalum umbellatum* L. *Allionia* (1977) 22, 5-21 [En, 28 ref., 27 fig.] Centro di Studio sulla Micologia del Terreno del CNR, Turin, Italy.

Two layers were distinguished in roots infected by *Glomus fasciculatus* [*RPP 57*, 1594], formed of (1) the outermost cortical cells, with inter- and intracellular coiled mycelia and (2) the middle and internal cortical cells, with extensive inter- and intracellular infection, derived respectively from hyphae and arbuscules. In (1) thick granular and/or lamellar walls, few organelles and abundant accumulation of fat occurred almost constantly, while in (2) active protoplasm or large, extensively vacuolized zones rich in electron dense granules were seen. In the internal cells the process ended with lysis of the fungus in the arbuscule stage. Intra- and intercellular vesicles, whose position in the root appeared unrelated to their cytology, were noted.

0491 CARLING, D. E., J. A. WHITE and M. F. BROWN. (Dep. Plant Pathol., Univ. Mo., Columbia, Mo. 65201, USA.) **The influence of fixation procedure on the ultrastructure of the host-endophyte interface of vesicular-arbuscular mycorrhizae.** CAN J BOT 55(1): 48-51. 1977. [In Engl. with Engl. and Fr. summ.]—The ultrastructure of the interfacial zone which separates the intracellular structures of vesicular-arbuscular mycorrhizal fungi from host cytoplasm has been described in a variety of ways by recent investigators. Evidence is presented which suggests that previous interpretations of the ultrastructure of the interfacial zone have been based on an artifact of fixation. Using as improved procedure, a dense, granular material was found in the interfacial zone. This material was preserved by simultaneous glutaraldehyde-osmium fixation but not by conventional prefixation and postfixation in glutaraldehyde and osmium, respectively.

*0492 BONFANTE-FASOLO, P.; SCANNERINI, S. Cytological observations on the mycorrhiza *Endogone flammicorona* - *Pinus strobus*. *Allionia* (1977) 22, 23-34 [En, 20 ref., 18 fig.] Centro di Studio sulla Micologia del Terreno del CNR, Turin, Italy.

Under the light microscope a well-developed Hartig net was noted, but not a differentiated fungal sheath. At the ultrastructural level the aseptate hyphae showed small nuclei, few mitochondria, bacteria in vacuoles, electron dense globules, glycogen particles and large lipid areas. The fungal wall appeared amorphous or sometimes thickened, with a granular texture. The cortical cells of the host showed small plastids and much homogenous or granular tannin material.

0493 POWELL, C. L.; SITHAMPARANATHAN, J. **Mycorrhizas in hill country soils. 4. Infection rate in grass and legume species by indigenous mycorrhizal fungi under field conditions.** *New Zealand Journal of Agricultural Research* (1977) 20 (4) 489-494 [En, 18 ref.] Soil and Field Res. Org., Ruakura Agric. Res. Cent., MAF, Hamilton, New Zealand.

Indigenous mycorrhizal fungi quickly infected oversown white clover in Waingaro steepland (hill-country) soil throughout the yr, except in late winter when the rate was reduced as the soils became waterlogged. Infection rates and growth responses in Dunmore silt loam were determined for *Phalaris tuberosa* [*P. aquatica*] cv. G14, *Bromus catharticus* cv. Matua, tall fescue cv. G4710, (a) white clover, (b) red clover cv. Grasslands Pawera and (c) *Lotus pedunculatus* cv. Grasslands Maku infected with the indigenous and other mycorrhizal fungi and grown in the field and in sterilised soil in the glasshouse. Mycorrhizal infection rates were slower and dependence on infection for growth and P uptake was usually less in (c) and in grasses than in (a) and (b). Of the fungi tested, *Gigaspora margarita* was the most efficient at stimulating growth of grasses and (a) + (b) but was less efficient than the indigenous fungi at stimulating growth in (b). Mycorrhizal infection greatly stimulated legume nodulation.

0494 SANDERS, F. E.; TINKER, P. B.; BLACK, R. L. B.; PALMERLEY, S. M. **The development of endomycorrhizal root systems: I. Spread of infection and growth-promoting effects with four species of vesicular-arbuscular endophyte.** *New Phytologist* (1977) 78 (2) 257-268 [En, 21 ref.] Dep. of Plant Sciences, Univ. of Leeds, UK.

Four vesicular-arbuscular endophytes (*Glomus mosseae*, *Gigaspora calospora*, and spore types similar to *Glomus macrocarpus* var. *geospora* and *Glomus microcarpus*) were inoculated onto onions cultured in soil in a growth chamber. Dry weight, root length, infected root length, P content and quantity of external mycelium were measured at intervals. Three endophytes produced similar hyphal inflows, growth increments and external mycelium. The *G. microcarpus*-type spore produced no growth increase in the host, and had little external mycelium and slow increase in percentage infection.

0495 SCANNERINI, S.; BONFANTE, P.F. Ultrastructural and cytochemical features of matrix material in a vesicular-arbuscular mycorrhiza. Caryologia: 30(4):499. 1977.

0496 SCANNERINI, S.; BONFANTE-FASOLO, P. **Unusual plastids in an endomycorrhizal root.** *Canadian Journal of Botany* (1977) 55 (18) 2471-2474 [En, fr, 11 ref.] Istituto Botanico dell'Univ. e Centro di Studio per la Micologia del Terreno del C.N.R., Torino, Italy.

Unusual plastids, identified as globular chromoplasts directly developed from proplastids, observed in the root cells of *Ornithogalum umbellatum* infected with a phycomycete tentatively identified as *Glomus fasciculatus* are interpreted as an expression of host reaction to fungus infection.

0497 TRINICK, M.J. Vesicular-arbuscular infection and soil phosphorus utilization in Lupinus spp. New Phytol. 78:297-304. 1977. Lupinus angustifolius, L. cosentinii and L. luteus were weakly infected (<10% of root length) with vesicular-arbuscular endophytes and hence VA mycorrhizas were not considered of any value in their phosphorus uptake on the nutritionally poor sandy soils of Western Australia. Vesicles were present in aproximately 30% of field plants and less often in the glasshouse. Arbuscules were observed on only one specimen of L. cosentinii in a restricted section of one lateral root. Infection was reduced further when soil moisture was high and by small additions of phosphorus to the soil. Under certain conditions, VA mycorrhizal infection in L. cosentinii was stimulated by the growth of red clover. Proteoid'-like rootlets were observed on lupins and these had specialized root-soil surface properties that may be responsible for improved phosphorus uptake.

*0498 BONFANTE-FASOLO, P.; SCANNERINI, S. The ultrastructure of the zygospore in *Endogone flammicorona* Trappe & Gerdemann. Mycopathologia (1976) 59(2):117-123.

*0499 IQBAL, S. H.; QURESHI, K. S. **The influence of mixed sowing (cereals and crucifers) and crop rotation on the development of mycorrhiza and subsequent growth of crops under field conditions.** *Biologia, Pakistan* (1976) 22 (2) 287-298 [En, 35 ref., 1 fig., 2 tab.] New Univ. Campus, Lahore, Pakistan.

When 8 wheat vars. were grown alone in phosphorus-deficient soil, containing 4 types of *Endogone* spores, they became heavily infected with vesicular arbuscular endophytes but infection was reduced when they were grown with *Brassica campestris*. Higher mycorrhizal infections were accompanied by more numerous tillers and longer ears, producing more grain. *B. campestris* roots did not become infected. Wheat grown with *B. napus* (sulphur free) showed the same amount of infection as the controls. The influence of exudates of crucifer roots was further elucidated by growing wheat in soil containing *B. campestris* roots. The mycorrhizal infections were reduced by almost 25% and resulted in c. 25% loss in yield.

0500 KINDEN, D.A.: BROWN, M.F. Electron microscopy of vesicular-arbuscular mycorrhizae of yellow poplar. IV. Host-endophyte interactions during arbuscular deterioration. Canadian Journal of Microbiology (1976) 22(1):64-75.
In studies on morphological alterations and cytological phenomena associated with deterioration of arbuscules in yellow poplar (Liriodendron tulipifera)degradation was initiated at the tips of the finest branches and progressed basipetally. Cytoplasm in arbuscular hyphae progressively deteriorated, followed by fungal wall collapse. Degraded portions of the arbuscules aggregated into clumps comprised of host wall material and the distorted fungal walls. Host nuclei, abundant mitochondria and proplastids were closely associated with arbuscular branches undergoing cytoplasmic deterioration, and with clumped portions of the arbuscule containing degraded hyphal branches. Most arbuscules observed had deteriorated to the clumped stage. Some cortical cells contained several clumped arbuscules and nearly mature intact arbuscules, indicating that reinfection occurs even as degradative phenomena were in progress. It is suggested that substantial quantities of mineral nutrients may be made available to the host via degradation of fungal cytoplasm in the arbuscular hyphae preceding aggregation of degraded hyphae into discrete clumps.

0501 POWELL, C. L. Development of mycorrhizal infections from *Endogone* spores and infected root segments. *Transactions of the British Mycological Society* (1976) 66 (3) 439-445 [En] Rothamsted Experimental Station, Harpenden, Herts., UK.
Germination, hyphal growth and root penetration from *Endogone* spores, and from root-segments infected by *Endogone*, were studied on agar-coated glass slides buried in soil. In most cases the spores germinated readily within 16 days, with or without the presence of onion roots. Germ tubes grew either through the old spore attachment or direct through the spore walls. Hyphae from spores were not attracted to the onion roots, until in very close proximity, when they formed fan-like structures of predominantly septate hyphae. Successful infections only occurred from aseptate hyphae, which developed later in the pre-infection fans. Hyphae from infected root-segments were always aseptate, and infected the roots without forming fan-like structures. The different infection patterns are probably due to different nutrient supply in resting spores and mycorrhizal root-segments.

0502 BEVEGE, D. I.; BOWEN, G. D. *Endogone* strain and host plant differences in development of vesicular-arbuscular mycorrhizas. 77-86 [En, 13 ref.] Div. of Soils, CSIRO, Glen Osmond, S.A., Australia 5064.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp. 77 - 86. 1975.
The time-course of infection of subterranean clover by 3 *Endogone* spp. is described. Subsidiary observations were made on other spp. including maize.

0503 KASPARI, H. Fine structure of the host-parasite interface in endotrophic mycorrhiza of tobacco. 325-334 [En, 24 ref.] Institut für Pflanzenkrankheiten, Bonn, German Federal Republic.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp. 325 - 334. 1975.
Stages in the intracellular development of *Endogone mosseae* mycorrhiza in tobacco are described, with particular reference to membrane structure.

0504 KINDEN, DARRELL A. and MERTON F. BROWN. (Dep. Plant Pathol., Univ. Mo., Columbia, Mo. 65201, USA.) Electron microscopy of vesicular-arbuscular mycorrhizae of yellow poplar: II. Intracellular hyphae and vesicles. CAN J MICROBIOL 21(11): 1768-1780. Illus. 1975. [In Engl. with Engl. and Fr. summ.]--Intracellular hyphae and vesicles in mycorrhizal roots of yellow poplar [Liriodendron tulipifera] were examined by electron microscopy. An investing layer of host wall material and cytoplasm enclosed the endophyte within the cells. Young developing hyphae contained abundant cytoplasm and few vacuoles. As hyphae matured, they became highly vacuolated and accumulated carbohydrate (glycogen) and lipid reserves. Mature vesicles were engorged with lipid droplets, possessed a trilaminate wall, and were also enclosed by host wall material and cytoplasm. Compared with uninfected cells, infected cortical cells showed an increase in cytoplasmic volume, enlarged nuclei, and a reduction of starch reserves. Host nuclei were always proximal to the hyphae during hyphal development and deterioration. While other cytoplasmic components of infected and uninfected cells were comparable, large electron-dense bodies occurred in vacuoles of most cells containing hyphae. Deterioration of intracellular hyphae occurred throughout the samples examined. Septa separated functional and degenerating portions of the hyphae. Hyphal deterioration involved degeneration and ultimate disappearance of fungal cytoplasm as well as collapse of hyphal walls. These observations suggest that deterioration of the endophyte may release significant quantities of mineral nutrients, via hyphal contents, which are absorbed by the host.

0505 KINDEN, DARRELL A. and MERTON F. BROWN. (Dep. Plant Pathol., Univ. Mo., Columbia Mo. 65201, USA.) Electron microscopy of vesicular-arbuscular mycorrhizae of yellow poplar: III. Host-endophyte interactions during arbuscular development. CAN J MICROBIOL 21(12): 1930-1939. Illus. 1975. [In Engl. with Engl. and Fr. summ.]--Scanning- and transmission-electron microscopy were used to examine developing and mature functional arbuscules in mycorrhizal roots of yellow poplar [Liriodendron tulipifera L.]. Arbuscules developed from intracellular hyphae which branched repeatedly upon penetration into the host cells. Intermediate and late stages of development were characterized by the production of numerous, short, bifurcate hyphae throughout the arbuscule. Mature arbuscules exhibited a coralloid morphology which resulted in a considerable increase in the surface area of the endophyte exposed within the host cells. Distinctive ultrastructural features of arbuscular hyphae included osmiophilic walls, nuclei, abundant cytoplasm, glycogen and numerous small vacuoles. All arbuscular components were enclosed by host wall material and cytoplasm during development and at maturity. In infected cells, host nuclei were enlarged and the cytoplasm associated with the arbuscular branches typically contained abundant mitochondria, endoplasmic reticulum and proplastids. Ultrastructural observations suggested that nutrient transfer may be predominantly directed toward the fungal endophyte during arbuscular development and while mature arbuscules remain functional.

0506 LILY, V.G. Note on the development of vesicular-arbuscular mycorrhiza - Endogone fasciculata in coonut root. Current Science (1975) 44(6) 201-202 CPCRI, Rg. Sta., Kayangulam, Krishnapuram, Kerala, India.

*0507 SCANNERINI, S.; FASOLO, P.B. [Preliminary data on the ultrastructure of intracellular vesicles in endomycorrhiza of Ornithogalum umbellatum L.] Dati preliminari sull'ultrasturttura di vescicole intracellulari nell' endomicorriza di Ornithogalum umbellatum L. Atti dell' Accademia delle Scienze di Torino, I (1975) 109, 619-621.
Spherical or oblong organs 30-50 μ x 80-100 μ with a rather thin but stratified cell wall were observed. Lipids and electron dense granules in a greatly vacuolated protoplasm, and a few euplasmatic areas with peripheral nuclei and mitochondria, were also found.

*0508 SCANNERINI, S. [The ultrastructure of mycorrhizas.] le ultrastrutture delle micorrize Giornale Botanico Italiano (1975) 109 (3): 109-144.
A study of ultrastructure of ecto-,ectoendo- and endomycorrhizas shows that they can be described in terms of balanced parasitic relations. Common to all these cytological interactions is the establishment of different interfaces between the partners, which are described and classified here. A closer cytochemical, biochemical and electro-physiological study of the interfaces is suggested for a better understanding of mycorrhizal interactions.

0509 SCANNERINI, S.; BONFANTE, P.F.; FONTANA, A. An ultrastructural model for the host-symbiont interaction in the endotrophic mycorrhizae of *Ornithogalum umbellatum* L. In: Endomycorrhizae (Ed. by F.E. Sanders, B. Mosse, and P.B. Tinker) Academic Press London. pp.313-324 (1975).

0510 COX, GUY and FRANCIS SANDERS. (Dep. Plant Sci., Agric. Sci. Build., Univ., Leeds LS2 9JT, Engl., UK.) Ultrastructure of the host-fungus interface in a vesicular-arbuscular mycorrhiza. NEW

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PHYTOL 73(5): 901-912. Illus. 1974. [In Engl. with Engl. summ.]-- An ultrastructural study was made of the vesicular-arbuscular mycorrhiza formed by Endogone (Glomus) mosseae with roots of Allium cepa. The fungal arbuscules consist of highly branched hyphae that have a characteristic reticulate vacuolation. The host plasmalemma surrounds the individual branches of the arbuscule. Around the penetration point and the trunk of the arbuscule a collar of wall material lies between the host plasmalemma and the fungal wall. This layer is absent from the branches. When the arbuscule senesces, the branches collapse and the empty fungal walls aggregate into a clump. Within the clump the fungal walls appear to fragment and disintegrate. The host plasmalemma at this stage surrounds the clump as a whole. When an entire infection becomes senescent, a thick layer of wall material apparently derived from the host encases all intracellular fungal structures.

*0511 PROTSENKO, M. A. [The ultrastructure of pea mycorrhiza.] *Botanicheskiĭ Zhurnal* (1974) 59 (6) 868-874 [Ru, 24 ref., 1 fig.] Institut Biokhimii A.N. Bakha, Moscow, USSR.

The fine structure of the arbuscles and surrounding tissues in the bark parenchyma of mycorrhizal pea roots was determined by electron microscopy.

*0512 PROTSENKO, M.A.; SHEMAKHANOVA, N.M. [On the ultrastructura of external and intra-root vesicles of mycorrhizal fungi.] Ob ul' trastrukture nauzhnykh; vnutrikornevykh vezikul mikorizoobrazuyushchego griba [Endogone on pea]. Mikologiya i Fitopatologiya (1974) 8(5):441-442 Bakh Inst. Biochem., Moscow, USSR.

*0513 GRENY, A. [Anatomical and morphological study of endomycorrhizas assoicated with maize, oats, wheat, barley and various pasture and wild grasses.] Etude anatomo-morphologique des endomycorrhizes constituées par le mais, l'avoine, le blé l'orge et diverses graminées prairiales et adventices. Comptes Rendus des Séances de l'Académie d'Agriculture de France (1973) 59(14) 1077-1083.
A summary of a thesis presented at Rouen. Factors affecting mycorrhizal symbiosis, including season, soil and root development, are discussed. Evidence is presented that the association is beneficial to gramineae. It is concluded that soil inoculation with Endogone or preinoculation of seed with the fungus may emerge as a practical biological technique.

0514 KASPARI, H. [Electron microscopical study on the fine structure of the endotrophic mycorrhiza of tobacco.] Elektronenmikroskopische untersuchung zur feinstruktur der endotrophen Tabakmykorrhiza [Endogone mosseae]. Archiv für Mikrobiologie (1973) 92 (3) 201-207. Univ. Bonn, German Federal Republic.

0515 OLD, K.M.; NICHOLSON, T.H.; REDHEAD, J.F. A new species of mycorrhizal Endogone from Nigeria with a distinctive spore wall. New Phytologist (1973) 72(4): 817-823. Dundee Univ., UK.
Optical and electron microscope observations on an unnamed sp. with a spore wall resembling that of a 'honey coloured' sp. are presented. The most conspicuous feature is in the outer layers which show a porous and meshwork construction.

0516 SUTTON, J. C. Development of vesicular-arbuscular mycorrhizae in crop plants. *Canadian Journal of Botany* (1973) 51 (12) 2487-2493 [En, fr, 16 ref.] Guelph University, Ontario.

Vesicular-arbuscular mycorrhizae developed extensively in a wide range of vegetable crop plants grown in the field and in controlled environment. At 25-28 days after sowing, generally few roots (0.6-19%) were colonized by the mycorrhizal fungus *Endogone*. The proportion of roots colonized subsequently increased rapidly to maximum levels ranging from 48 to 84%. A 3-phase pattern of mycorrhizal development involving sequentially a lag phase, a phase of extensive development, and a phase of constancy in the proportion of mycorrhizal to non-mycorrhizal roots was found in beans. A similar multiphase development of mycorrhizae was evident also in some other hosts. The relationship of the different phases to physiological changes in the host is discussed.

*0517 MEDVE, R.J. Anatomical study of the endotrophic mycorrhizae of *Acer rubrum*. Bull. Torr. Bot. Club, 98:41-45. 1971.

*0518 PANDEY, S.; MISRA, A.P. 1971. Rhizophagus in mycorrhizal association with Litchi chinensis Sonn. Mycopath. Mycol. appl. 45(3-4) 337-354.
The morphology and mycotrophic habit of a new sp., R. litchii Pandey and Misra, is described. It is vesicular-arbuscula and could only be cultured in the presence of L. chinensis root segments, when growth ceased after 10-12 days.

*0519 PROTSENKO, M.A.; SHEMAKHANOVA, N.M. 1971. Vliyanie mikorizoobrazuyushchego griba na razmery yadra i yadryshka v kletkakh kornya Pisum sativum. [The effect of a mycorrhiza-forming fungus on the size of nucleus and nucleolus in root cells of pea.] Mikol. i Fitopatol. 6(4):335-339.
The size of the nucleus and nucleolus in infected cells increased and there were similar, less marked reactions in neighbouring uninfected cells.

*0520 PROTSENKO, M.A.; SHEMAKHANOVA, N.M.; METLITSKII, L.V. Ultrastructure of mycorrhiza of garden pea (*Pisum sativum* L.). (Rus). Acad. Sci. USSR, Dokl. Bot Sci., 199-201, 120-122. 1971.

*0521 KAZAKOVA, G.I. The causes of the formation of various types of Mycorrhizae. Uch. Zap. Permsk. Gos. Ped. Inst., 64:228. 1968; Trans. in Biol. Abstr., 51:99649. 1970.

0522 MOSSE, B. Honey-Coloured, sessile Endogone spores. I. life history. Arch. Mikrobiol. 70 167-175 (1970).
The life history of a mycorrhizal Endogone sp. with honey-coloured, sessile resting spores is described. The spores originate as lateral outgrowths from the subtending hypha of a previously formed mother spore that collapses when its contents migrate in to the resting spore. Before the resting spore germinates, dense regions develop within it and the wall splits. Peripheral compartments with normal cytoplasmic contents develop within the split wall. Several germ tubes, originating in these compartments, penetrate the outer wall when the spore germinates.
The possibility is discussed that the resting spore may be a zygospore, and the peripheral compartments analogous to a sporangium.

0523 MOSSE, B. Honey-coloured, sessile *Engonone* spores: II. Changes in fine structure during spore development. Arch. Mikrobiol. 74:129-145. 1970.

The fine structure of honey-coloured, sessile Endogone spores is described from initiation of the mother spore to dormancy of the resting spore Three unusual organelles occur viz. pigment granules, large crystals and selfduplicating bacteria-like organisms. The first two are very numerous, and are specifically associated with spore formation. The pigment granules are involved in the deposition of the honey-coloured wall, and change into myelin-like figures when cytoplasm moves from the mother into the resting spore. The crystals, whose function is not known, are most conspicuous just before the resting spore reaches dormancy. The bacteria-like organisms, which may be actinomycete spore living symbiotically in the fungus, multiply greatly as the spore enters dormancy. The

dormant spore contains very little cytoplasm compressed into a fine network between very large polygonal oil globules and large round bodies thought to contain a storage polysaccharide.

0524 MOSSE, B. Honey-Coloured, sessile Endogone spores III. Wall structure. Arch. Mikrobiol. 74, 146-153 (1970).
Wall structure is described in the parent and resting spores of an Endogone sp. with honey-coloured, sessile spores. Wall thickness increases in the parent spores and subtending hypha by passage of material through the plasmalemma, or by formation of an apparently separate inner wall and degeneration of the trapped cytoplasm. Structure and development of the multi-layered wall of the mature resting spore are described. Unusual featrues are: 1. the incorporation of many pigment granules into the coloured outer wall, 2. the presence between the outer coloured and inner transparent walls of a tripartite membrane and adjacent layer with a regular periodicity and 3. a sectored layer with a crystalline component. The structure of the wall is discussed with reference to that of other mucoraceous fungi, to spore germination and to the mechanism of wall formation.

0525 SIEVERGING, E. Manual de métodos para la investigación de la micorriza vesiculo-arbuscular en el laboratorio. [Methodological manual for laboratory research on vesicular-arbuscular mycorrhizae.] Centro Internacional de Agricultura Tropical CIAT. Proyecto Micorriza. Cali. Colombia. Marzo, 1983. 121pp. 124 ref. (Mimeografiado.)
En once capítulos se describen métodos de laboratotio para la investigación de la simbiosis entre hongos microrrizógenados y diferentes plantas, incluyendo metodologías para su determinación (suelo-planta), cuantificación, producción de cepas puras y conservación. La determinación de la densidad de hongos micorrizógenos por recuentos indirectos, tambien es incluida.
In eleven chapters laboratory methods are described to investigate the symbiotic-relationship between mycorrhizal producing fungis and different plants, The manual includes methodologies for determination (soil-plant) quantification, production of pure strains and conservation of the above mentioned organisms. The determination by means of indirect counting of the density of mycorrhiza producing fungi is also included.

0526 AMES, R. N.; INGHAM, E. R.; REID, C. P. P. **Ultraviolet-induced autofluorescence of arbuscular mycorrhizal root infections: an alternative to clearing and staining methods for assessing infections.** *Canadian Journal of Microbiology* (1982) 28 (3) 351-355 [En, fr, 15 ref.] Natural Resource Ecol. Lab., Colorado State Univ., Fort Collins, CO 80523, USA.

Arbuscules in vesicular-arbuscular mycorrhizal (VAM) infections in untreated roots autofluoresced when viewed with an epifluorescence microscope. UV-induced fluorescence was observed with the same filtering system used to detect fluorescein staining. Roots of several spp., including *Bouteloua gracilis*, grown under a variety of conditions and infected with several species of VAM fungi were examined. In every case, autofluorescent arbuscules were observed. Vesicles, spores and hyphae did not autofluoresce under these same conditions. Fluorescence was not observed in ectomycorrhizae or pathogenic fungal infections. Cut mycorrhizal root segments from greenhouse- and field-grown plants were evaluated for infection using UV light or clearing and staining. No significant differences were found in the percent VAM infection as determined by the 2 methods on the same root segments. Applications and considerations in the use of the UV method for measuring infections as well as some preliminary observations on using fluorescein diacetate are discussed.

*0527 AMES, R.N.; INGHAM, E.R.; REID, C.P.P. Ultraviolet- induced autofluorescence: a new method for decteting and quantifying vesicular arbuscular mycorrhizal root infections. Phytopathology 72:950. 1982. Abst.

Arbuscules but not hyphae or spores of vesicular-arbuscular mycorrhizal (VAM) fungi autofluoresce when excited with ultraviolet light. Washed roots were viewed with an epifluorescent microscope at 455-490 nm excitation and 520-560 nm emission wavelengths. There was no significant difference in determining VAM infection by the UV or staining methods. Pathogenic fungal root infections did not autofluoresce. The UV method may not be useful for haustoria-forming foliar pathogens. Further examination of the autofluorescent compound(s) may provide information on the mechanisms of carbon and/or phosphorus exchange between the host and fungus. Significance and applications of the UV method will be discussed.

0528 KUCEY, R. M. N.; MCCREADY, R. G. L. **Isolation of vesicular-arbuscular mycorrhizal spores: a rapid method for the removal of organic detritus from wet-sieved soil samples.** *Canadian Journal of Microbiology* (1982) 28 (3) 363-365 [En, fr, 7 ref., 1 tab.] Res. Sta., Agric. Canada, Lethbridge, Alta., Canada.

After wet sieving (> 63μm), flotation on 50% glycerol and suspension in Ringer's saline sol., spores were separated from other organic material by centrifuging the mixture on a 2-layer discontinuous solution gradient (50% glycerol overlaid with 30% glycerol). Efficiency of recovery was 84 ± 3.4% of the spores present after the initial flotation.

0529 MCKAY, H.M. A multiple-plant module for aseptic nutritional studies and the synthesis of mycorrhizas. Plant and Soil 66, 257-262 (1982).
A general design of seedling chambers, set into sections controlling root temperature and supplying nutrients and within which aseptic conditions are maintained by membrane filters, is described. The designed module was used to study the formation of mycorrhizas and their effect on seedling growth at various levels of nutrient sypply and root temperature.

0530 SCHENCK, N. C. (EDITOR) **Methods and principles of mycorrhizal research.** St. Paul, Minn., USA; American Phytopathological Society (1982) 244 pp. ISBN 0-89054-046-2 [En, 8 col. pl., 30 fig., Price $24.00]

The book contains 18 chapters contributed by 39 authors. The 1st section covers the endomycorrhizae and deals predominantly with the vesicular-arbuscular types. The 2nd section, on ectomycorrhizal fungi, includes the ectendomycorrhizae. The last section covers areas relating to both the endo- and ectomycorrhizae.

0531 TOMMERUP I. N. **Airstream fractionation of vesicular-arbuscular mycorrhizal fungi: concentration and enumeration of propagules.** *Applied and Environmental Microbiology* (1982) 44 (3) 533-539 [En, 27 ref., 2 fig., 1 tab.] Univ. Western Australia, Nedlands, Australia.

Spores and fragments of the fungi in dry soils were concentrated up to 100-fold when the soils were partitioned by fluidization and elutriation with a series of upward airstreams at progressively increasing velocities. The propagules were transported with the finer soil particles according to their equivalent spherical diameters. The system was used to predict the transport of propagules by wind. Conc. propagules were rapidly separated from the soil particles in each soil fraction by an aq. flotation method. The quantitative technique is proposed for estimating the numbers of spores and fragments of mycorrhizae. The scheme includes a viability test that was used to differentiate between potentially infective propagules and those which were either dormant or incapable of regrowth.

0532 TOTH, R.; TOTH, D. **Quantifying vesicular-arbuscular mycorrhizae using a morphometric technique.** *Mycologia* (1982) 74 (2) 182-187 [En, 23 ref., 1 fig.] Northern Illinois Univ., DeKalb, USA.

A technique employing the basic principle of morphometric cytology on squashed roots is offered as a compromise between qualitative studies using whole roots and laborious methods involving chitin assays and the use of thin sections. By employing a symmetrical grid of dots over the image of a root squash, counts of invaded cortical cells may be made. This technique is faster to apply than sectioning and yields quantitative information concerning the number of the cortical cells containing arbuscules.

0533 BETHLENFALVAY, G.J.; PACOVSKY, R.S.; BROWN, M.S. 1981. Measurement of mycorrhizal infection in soybeans. Soil Sci. Soc. Am. J. 45:871-875.
Infection of soybean (*Glycine max* (L.) Merr.) roots by the vesicular-arbuscular mycorrhizal fungus *Glomus fasciculatus* (Thaxt. *sensu* Gerd.) Gerd. and Trappe was assessed throughout the ontogeny of the symbiotic association. Degree of infection was evaluated by a histological method as percent infection and colorimetrically as mg chitin/g mycorrhiza. Correlation of data by the two methods was highly significant ($r = 0.99$) below 60% infection and not significant ($r = 0.62$) at higher levels. Assessment of infection by the histological method did not yield significantly different data above 60% infection. Data by the colorimetric method were statistically distinct at all levels of infection. The effects of biological and chemical contaminants on the colorimetric assay were determined. The fungal component of mycorrhizae was compared to purified chitin standards. Use of chitin for standard curves in the absence of degradation products from uninfected root materials significantly ($p < 0.05$) over

overstated the degree of infection. Colorimetric determination of fungal infection in mycorrhizae is recommended when high levels of infection are expected.

0534 BIGG, W.L.; ALEXANDER, I.J. A culture unit for the study of nutrient uptake by intact mycorrhizal plants under aseptic conditions. Soil Biol. Biochem. 13:77-78. 1981.

0535 CRUSH, J.R.; HAY, M.J.M. A technique for growing mycorrhizal clover in solution culture. N.Z. Journal of Agricultural Research 24 (1981): 371-372.

White clover (*Trifolium repens* L.) grown in aerated solution culture readily formed endomycorrhizas with *Gigaspora margarita* when the solution phosphate concentration was 1 µm $H_2PO_4^-$. The plants were grown in pockets of sand on wire mesh, supported by a polystyrene raft floating on the culture solution. Germinated seed was sown in the sand and inoculated with *Gigaspora* spores. The clover roots grew down into the solution, followed by the fungal hyphae. Mycorrhizas formed in the solution had internal structures identical with those formed in soil, and extensive external mycelia.

0536 HALL, I.R.; KELSON, A. An improved tecnique for the production of endomycorrhizal infested soil pellets. N. Z. J. Agric. Res. 24(2): 221-222. 1981. 4 ref.

A technique is described which enables two people to produce 10 000 vesicular-arbuscular mycorrhizal fungal infested soil pellets per day for use in large-scale field trials. Pot experiments showed these pellets to be effective in converting the roots of establishing white clovers to mycorrhizas. The results suggest that pellet size may have some effect on the ability of infested pellets to convert roots of establising white clover to mycorrhizas. Authors' summary.

0537 HAYMAN, D. S.; MORRIS, E. J.; PAGE, R. J. **Methods for inoculating field crops with mycorrhizal fungi.** *Annals of Applied Biology* (1981) 99 (3) 247-253 [En, 21 ref., 2 fig., 1 tab.] Rothamsted, Harpenden, UK.

Four methods were compared for inoculating red clover with selected mycorrhizal fungi when sown in a field containing an indigenous mycorrhizal population. Most infection (*c.* 65% of root length infected) was obtained by placing inoculum with the seeds in furrows. Standard soil inoculum from stock plant cultures was spread by hand, or the same inoculum concentrated to *c.* 1/7 by wet-sieving and then fluid-drilled. The effectiveness of multiseeded pellets (seeds stuck on pellets of soil inoculum) applied broadcast was more variable, infection ranging widely around an av. 30%. Applying both soil inoculum and seeds broadcast produced just under 10% infection, similar to that in the controls given autoclaved inoculum. Seedling establishment, in contrast, was better where seeds were applied broadcast than in furrows. It seemed therefore that multiseeded pellets might be the best compromise for achieving reasonable infection in most plants, but fluid drilling had the advantages of greatly reducing the amount of inoculum needed and of readily combining seeds and inoculum in a single carrier.

0538 HEPPER, C. M. **Techniques for studying the infection of plants by vesicular-arbuscular mycorrhizal fungi under axenic conditions.** *New Phytologist* (1981) 88 (4) 641-647 [En, 19 ref.] Rothamsted Experimental Station, Harpenden, Hertfordshire, UK.

Methods of growing axenic seedlings infected by vesicular-arbuscular mycorrhizal fungi are described, using agar, paper or glass as a support. Two of the techniques (agar, glass) are particularly suitable for studying the interaction between the fungus and the host plant, for example the germination of the spore inoculum, hyphal growth around the roots before the symbiosis has been initiated and the early stages of root penetration.

0539 HOWELER, R. H.; EDWARDS, D. G.; ASHER, C. J. **Application of the flowing solution culture techniques to studies involving mycorrhizas.** *Plant and Soil* (1981) 59 (1) 179-183 [En, 22 ref.] CIAT, Apartado aéreo 6713, Cali, Colombia.

A technique is described to study mycorrhizal effects on the growth and P-uptake of cassava (*Manihot esculenta*) in flowing solution culture. Phosphorus concentrations were carefully maintained constant at 0.1, 1, 10 and 100 µM by daily adjustment of the nutrient solutions. Inoculaton with mycorrhizal roots resulted in root infection and increased plant growth and/or P content of plant tissue only at the two lowest concentrations of P in solution. These concentrations are 3 to 4 orders of magnitude lower than those normally used in conventional nutrient solution cultures.

0540 MACDONALD, R. M. **Routine production of axenic vesicular-arbuscular mycorrhizas.** *New Phytologist* (1981) 89 (1) 87-93 [En, 15 ref.] Department of Soil Microbiology, Rothamsted Experimental Station, Harpenden, AL5 2JQ, UK.

A compact autoclavable hydroponic culture system is described for the production of axenic vesicular-arbuscular mycorrhizas formed between *Trifolium parviflorum* and *Glomus caledonius*. Liquid is circulated by means of a low pressure air supply and sterility is maintained by glass fibre air-filters. Provision is made for sampling of the nutrient solution for analysis and sterility tests.

*0541 MONZÓN DE ASCONEGUI, M. A.; HALBINGER, R. E. [A technique of isolating spores of endotrophic mycorrhizas.] Técnica de aislamiento de esporos de micorrizas endótrofas. *Revista Argentina de Micología* (1981) 4 (1) 19-23 [Es, en, 19 ref., 7 fig.] Dep. Agric. Microbiol., Univ. Buenos Aires, Argentina.

The wet sieving and decanting method [*RAM 42*: 740] was used on soil samples from the rhizosphere of Gramineae and Leguminosae. Mesh sizes were 1000, 500, 250 and 100 µm. Root fragments were stained with trypan blue and lactophenol [*RPP 50*, 1080]. Using a steroscopic microscope, spherical, golden yellow spores typical of Endogonaceae chlamydospores were seen. Root cortex infections were of the vesicular-arbuscular and vesicular type.

0542 SCHRODER, V. N.; GAMBLE, J. F.; SCHENCK, N. C.; DANTZMAN, C. L. **Field establishment of vesicular-arbuscular mycorrhizae.** *Proceedings, Soil and Crop Science Society of Florida* (1981) 40, 142-143 [En, 6 ref.] Dep. of Agron., Florida Univ., Gainesville, FL 32611, USA.

A method is described for inoculation of the rapidly spreading *Digitaria decumbens* in the greenhouse with the mycorrhizal fungi *Glomus clarus*, *Gigaspora heterogama*, *Acaulospora laevis* or *Sclerocystis sinuosa* before transplanting to the field in mid-May 1977. Although *G. clarus* was the most effective and widespread sp. after 1 yr all spp. were still present after 3 yr and *G. heterogama* was the most successful sp.

0543 SMITH, S. E.; WALKER, N. A. **A quantitative study of mycorrhizal infection in *Trifolium*: separate determination of the rates of infection and of mycelial growth.** *New Phytologist* (1981) 89 (2) 225-240 [En, 24 ref.] Waite Agric. Res. Inst., Adelaide Univ., Glen Osmond, S.A., Australia 5064.

A mathematical model of vesicular-arbuscular mycorrhizal infection of subterranean clover roots is presented. From the model daily infection frequency was calculated at 40.8 mycorrhizal propagules/m and the rate of fungal growth along the root cortex from a single entry point at 12.2×10^{-4} m/day. The root tip was nearly 10 times more infectible than the av. root system value.

0544 ST. JOHN, T. V.; HAYS, R. I.; REID, C. P. P. **A new method for producing pure vesicular-arbuscular mycorrhiza-host cultures without specialized media.** *New Phytologist* (1981) 89 (1) 81-86 [En, 11 ref.] Natural Resource Ecology Laboratory, Colorado University, Fort Collins, Colorado 80523, USA.

A method is reported for synthesizing pure two-membered vesicular-arbuscular mycorrhiza infections without complex media. Growth of *Trifolium repens* infected with *Gigaspora margarita* or *Glomus mosseae* was comparable to that in non-sterile systems.

0545 BIERMANN, B.; LINDERMAN, R. G. **Quantifying vesicular-arbuscular mycorrhizae: a proposed method towards standardization.** *New Phytologist* (1980) 87 (1) 63-67 [En, 13 ref.] Department of Botany and Plant Pathology, Oregon State University, Corvallis, Oregon 97331, USA.

A method is described for the quantification of root colonization by vesicular-arbuscular (VA) mycorrhizal fungi. Examination of roots from three host species showed that the estimation of the percentage of the length of root segments containing VA mycorrhizal fungal structures was more accurate than the determination of the percentage of root segments with VA mycorrhizal fungal structures. It was no more time consuming, and was not influenced by segment size. Examination of a minimum of seven samples, each with 25 randomly selected 0.5 to 1.0 cm root segments, was needed for confidence limits to be within 10% of the mean. It is proposed that, for the sake of comparability between studies, this procedure be adopted as a standard method.

0546 FURLAN, V.; BARTSCHI, H.; FORTIN, J.-A. **Media for density gradient extraction of endomycorrhizal spores.** *Transactions of the British Mycological Society* (1980) 75 (2) 336-338 [En, 8 ref., 3 fig.] Univ. Laval, Que., Canada.

The results are compared of centrifugation of endomycorrhizal spores on various radiopaque media, including Renografin-60, d=1.33; Telebrix 30, d=1.35; Telebrix 38, d=1.43; Radioselectan, d=1.32; and Percoll, d=1.13. These media are suitable for spore extraction since they have low viscosity and do not exert osmotic pressure. The viability of the spores recovered after centrifugation with the different media showed no significant difference from that of spores extracted with the flotation bubbling system using aqueous glycerol.

0547 GIOVANNETTI, M.; MOSSE, B. **An evaluation of techniques for measuring vesicular arbuscular mycorrhizal infection in roots.** *New Phytologist* (1980) 84 (3) 489-500 [En, 37 ref.] Rothamsted Exp. Stn., Harpenden, Herts AL5 2JQ, UK.

Assessment of infection is an essential part of many studies involving vesicular arbuscular mycorrhiza. A summary is given of the range of techniques that have been used. The standard error of 4 methods of assessment based on observations of stained root samples of cowpea, maize and bean (*Phaseolus vulgaris*) either randomly arranged in a Petri dish or mounted on microscope slides was calculated. The methods were based on presence or absence of infection at root/grid intersect points, on a visual estimate of percentage cortex occupied by fungus or on estimates of length, or presence or absence of infection in root pieces mounted on slides. The number of replicate observations required for a given standard error percentage infection could be read from the curves provided. The advantages of the different methods of assessment were discussed and reasons given why they all probably overestimate the true values.

0548 KORMANIK, P. P.; BRYAN, W. C.; SCHULTZ, R. C. **Procedures and equipment for staining large numbers of plant root samples for endomycorrhizal assay.** *Canadian Journal of Microbiology* (1980) 26 (4) 536-538 [En, 6 ref.] Institute for Mycorrhizal Research and Development, Southeastern Forest Experiment Station, Forest Service, United States Department of Agriculture, Athens, GA, 30602, USA.

A simplified method of clearing and staining large numbers of plant roots for vesicular-arbuscular (VA) mycorrhizal assay is presented. Equipment needed for handling multiple samples is described, and two formulations for the different chemical solutions are presented. Because one formulation contains phenol, its use should be limited to basic studies for which adequate laboratory exhaust hoods are available and great clarity of fungal structures is required. The second staining formulation, utilizing lactic acid instead of phenol, is less toxic, requires less elaborate laboratory facilities, and has proved to be completely satisfactory for VA assays.

0549 OJALA, J. C.; JARRELL, W. M. **Hydroponic sand culture systems for mycorrhizal research.** *Plant and Soil* (1980) 57 (2/3) 297-303 [En, 8 ref.] California University, Riverside, CA 92521, USA.

Tomato plants were inoculated with *Glomus fasciculatus* while growing in sand through which recycled nutrient solution was automatically passed several times daily. Concentrations of P and N in the solution were maintained at relatively low levels. Roots of inoculated plants became highly infected with mycorrhizal fungi, and yield parameters were significantly increased over those of uninoculated control plants.

*0550 TACON, F. LE. [New techniques of plant growing in the forest nursery (growing plants on turf and controlled mycorrhization).] Nouvelles techniques d'élevage de plantes en pépinière forestière (élevage de plantes sur tourbe et mycorhization contrôlée). *Revue Horticole* (1980) No.208, 55-59 [Fr, 2 fig., 4 tab.] Conseil National de Recherches Forestières, France.

Topics discussed include general features of mycorrhizas, selection of efficient mycorrhizal fungi, inoculation with ecto- and endomycorrhizal fungi in the nursery, behaviour in the forest of plants inoculated in the nursery and future of controlled mycorrhizal infection.

0551 TOMMERUP, I. C.; KIDBY, D. K. **Production of aseptic spores of vesicular-arbuscular endophytes and their viability after chemical and physical stress.** *Applied and Environmental Microbiology* (1980) 39 (6) 1111-1119 [En, 27 ref.] Department of Soil Science and Plant Nutrition, Institute of Agriculture, University of Western Australia, Nedlands 6009, Australia.

The survival of germinating spores of vesicular-arbuscular endophytes after treatments with oxidizing agents, antibiotics, moist heat, ultrasonic radiation and ultraviolet radiation was compared with that of their contaminating microbes. Spores of three species were rapidly decontaminated by treatment with 0.42% (wt/vol) chlorine available from 5.0% (wt/vol) chloramine-T at 30°C for 20 to 40 min depending on the species and the soil from which they were extracted. This treatment did not change spore viability. The survival of spores was reduced by exposure for 20 min to 1.11% chlorine at 30°C for *Glomus caledonius* or at 35°C for *Acaulospora laevis*. Growth of any bacteria surviving treatment with oxidizing agents was inhibited by 100 μg of chloramphenicol per ml in agar; however, spore germination and germ tube growth were reduced only by concentrations greater than 200 μg/ml in agar. Spore germination was decreased by high concentrations of pimaracin, which controlled fungal growth. The spores survived moist heat at 40°C for 80 min, 55°C for 10 min, and 60°C for less than 1 min. The viability of spores was unaffected by ultrasonic irradiation for up to 4 min. Spores of *G. caledonius* and *A. laevis* were extremely resistant to ultraviolet radiation. Their viability was unaffected by exposure to 5×10^3 ergs cm^{-2} from an ultraviolet source of 253.7 nm. The spores had very thick, pigmented walls, and the possibility that these provided some protection against the physical and chemical treatments is discussed. The degree of physiological damage to the spores caused by the treatments demonstrated some adverse effects of basic laboratory procedures. This information, together with that on the comparative sensitivity of contaminating microbes to the treatments, was used in the development of protocol for producing large numbers of uncontaminated spores.

0552 HALL, I. R. **Soil pellets to introduce vesicular-arbuscular mycorrhizal fungi into soil.** *Soil Biology & Biochemistry* (1979) 11 (1) 85-86 [En, 13 ref.] Invermay Agric. Res. Centre, Private Bag, Mosgiel, New Zealand.

Pellets consisting of 20 parts soil and white clover roots infested with *Glomus fasciculatus* to two parts clay were prepared 28, 14 and 1 day before sowing. They were buried singly in pots of soil just below three white clover seeds. Inoculation was 97% effective, and there were no significant differences amongst pellet types with respect to mycorrhizal infection, shoot P concentration or shoot dry weight. However, pooled data for 14 and 28 day pellets showed lower shoot dry weights than for 1 day pellets.

0553 MOORMAN, T. M.; REEVES, F. B. **The role of endomycorrhizae in revegetation practices in the semi-arid west. 2. A bioassay to determine the effect of land disturbance on endomycorrhizal populations.** *American Journal of Botany* (1979) 66 (1) 14-18 [En, 29 ref.] Dep. of Bot. and Pl. Physiol., Colorado State Univ., Fort Collins, CO 80523, USA.

Populations of the endomycorrhizal fungus *Glomus fasciculatus* were significantly reduced following land disturbance in W. Colorado soil. A bioassay was developed to measure changes in the endomycorrhizal population. In the bioassay, inoculum levels were measured by comparing the percentage infection in maize root systems 30 days after sowing in undisturbed or disturbed soils. The percentage infection was 2% in the disturbed soil compared with 77% in the adjacent undisturbed soil. *G. fasciculatus* was identified as the endophyte in both soils. Considering the importance and

function of endomycorrhizal fungi to their plant hosts, the reduction of active inoculum in the disturbed soil may be an important ecological factor in subsequent succession.

0554 PORTER, W. M. **The 'most probable number' method for enumerating infective propagules of vesicular arbuscular mycorrhizal fungi in soil.** *Australian Journal of Soil Research* (1979) 17 (3) 515-519 [En, 17 ref.] Department of Soil Science and Plant Nutrition, University of Western Australia, Nedlands, W.A. 6009, Australia.

Estimates of the number of infective propagules of vesicular-arbuscular (VA) endophytes in two soils were obtained using a most probable number (MPN) method. These estimates were compared with counts of the number of spores in the same soils obtained using a conventional wet sieving method. In one soil, there was good agreement between the number of coarse endophyte propagules, estimated by the MPN technique, and the number of germinable spores extracted using the wet sieving technique. However, a large population of fine endophyte propagules (more than 230 per 50 g soil) could only be enumerated using the MPN technique. In the second soil, fewer coarse endophyte propagules were found using the wet sieving technique than when using the MPN technique. The MPN technique appears to give a more realistic estimate of the number of infective propagules of VA endophytes in field soils than the conventional method.

0555 SMITH, G. W.; SKIPPER, H. D. **Comparison of methods to extract spores of vesicular-arbuscular mycorrhizal fungi.** *Soil Science Society of America Journal* (1979) 43 (4) 722-725 [En, 15 ref.] Department of Agronomy & Soils, Clemson University, Clemson, SC 29631, USA.

Vesicular-arbuscular mycorrhizal spores were extracted from soil (pot cultures) using adhesion-flotation, sucrose-centrifugation, gelatin column, wet-sieve, and a new plating method. Counts of 150- to 300-μm diam spores were significantly higher for the plate method by 528, 370, and 258% than for the adhesion-flotation, sucrose-centrifugation, and gelatin column methods, respectively. Counts of 100- to 300-μm diam spores were higher for the plate method by 200 and 149% than for the wet-sieve and modified wet-sieve methods. Spore counts within four spore size ranges (50 to 100, 100 to 150, 150 to 300, and > 300 μm diam) were greater for the plate method than for the wet-sieve and modified wet-sieve methods by approximately four and two times, respectively. The plate method was consistently higher than the wet-sieve method only for small spores (50 to 100 μm diam) from soybean field soils. Although the new plate method is not applicable for extracting and quantifying large spores (N 100 μm diam) for low spore population soils (field soils), it is recommended for the purpose of quantifying spores in high population soils (> 20 spores/g) as might be encountered in pot cultures.

0556 TOMMERUP, I. C.; KIDBY, D. K. **Preservation of spores of vesicular-arbuscular endophytes by L-drying.** *Applied and Environmental Microbiology* (1979) 37 (5) 831-835 [En, 16 ref.] Department of Soil Science and Plant Nutrition, Institute of Agriculture, University of Western Australia, Nedlands 6009, Australia.

Spores of *Glomus caledonius, Acaulospora laevis, Glomus monosporus* and *Gigaspora* sp. were L-dried at 22 °C and their viability was subsequently determined after heating at 80 °C for up to 40 minutes. L-drying of the spores in the soil in which they had been formed preserved the spores of all the species studied very effectively. Slow L-drying of spores separated from soil and supported in glass fibre filters resulted in low viability for *A. laevis* and zero viability for *G. caledonius*. A scheme for the long-term preservation of vesicular-arbuscular endophyte spores is proposed.

0557 CALLOW, J. A.; CAPACCIO, L. C. M.; PARISH, G.; TINKER P. B. **Detection and estimation of polyphosphate in vesicular-arbuscular mycorrhizas.** *New Phytologist* (1978) 80 (1) 125-134 [En, 30 ref., 4 fig., 1 tab.] Univ. Leeds, UK.

Polyphosphates were extracted from onion roots infected with *Glomus mosseae* by the phenol-detergent technique. They could not be detected in uninfected roots. It was calculated that the polyphosphate forms a substantial proportion (40%) of the total P present in the fungal component of mycorrhizal roots, and that this conc. is sufficient to support the proposed phosphorus translocation.

0558 AMBLER, J. R.; YOUNG, J. L. **Techniques for determining root length infected by vesicular-arbuscular mycorrhizae.** *Soil Science Society of America Journal* (1977) 41 (3) 551-556 [En, 30 ref.] Oregon State University, Corvallis, OR 97331, USA.

Techniques are described for (1) quantitative extraction of plant roots from soil samples, and (2) determination of root length by the line-root intersection method which involves observation of roots at 100 × magnification. Roots are cleared and stained to reveal vesicular-arbuscular fungal infection, and to determine stage/types of infection, lengths of infected roots, and other root characteristics.

0559 BARROW, N. J.; MALAJCZUK, N.; SHAW, T. C. **A direct test of the ability of vesicular-arbuscular mycorrhiza to help plants take up fixed soil phosphate.** *New Phytologist* (1977) 78 (2) 269-276 [En, 13 ref.] Division of Land Resources Management, CSIRO, Private Bag, P.O., Wembley, W.A.6014, Australia.

In the laboratory, the increase in the fixation of phosphate by soil with increasing soil temperature extended to at least 80 C. Incubation of soil and phosphate at high temperatures was therefore used to provide treatments with firmly bound phosphate equivalent to the treatment achieved after a much longer period of contact in the field. Incubation of soil and phosphate for 12 days at 70 C decreased the availability of the phosphate to plants to about one fifth of that of freshly added phosphate. Inoculation with VA endophytes more than doubled the availability of the phosphate to *Trifolium subterraneum* and *Allium cepa* but the improvement was no bigger for firmly bound phosphate than for freshly added phosphate.

0560 BECKER, W. N.; GERDEMANN, J. W. **Colorimetric quantification of vesicular-arbuscular mycorrhizal infection in onion.** *New Phytologist* (1977) 78 (2) 289-295 [En, 26 ref.] Dep. of Plant Pathology, Univ. of Illinois, Urbana, 61801, USA.

A colorimetric method of estimating vesicular-arbuscular mycorrhizal infection was developed using onions inoculated with *Glomus fasciculatus*. Absorbances at 400 nm of water extracts from mixtures of yellow (mycorrhizal) and white (nonmycorrhizal) roots showed a significant correlation with percent yellow roots by weight in the mixtures. The percentage of mycorrhizal infection determined by a chitin assay or by a staining method was significantly correlated with the percentage of yellow roots by weight. The percentage of mycorrhizal infection determined by the colorimetric method was also significantly correlated with root/shoot ratios.

0561 HEPPER, C. M. **A colorimetric method for estimating vesicular-arbuscular mycorrhizal infection in roots.** *Soil Biology & Biochemistry* (1977) 9 (1) 15-18 [En, 16 ref.] Rothamsted Experimental Station, Harpenden, Herts AL5 2JQ, UK.

A colorimetric method measuring the conversion of fungal chitin to glucosamine has been used successfully with four plant genera and with four different endophytes.

*0562 HERRERA, R. A.; FERRER, R. L. **[Preliminary report on a method of determining infection density in vesicular-arbuscular mycorrhizas.]** Informe preliminar sobre un método para determinar la densidad de infección en micorrizas vesículo-arbusculares. *Ciencias Biológicas* (1977) No.1, 147-148 [Es, 4 ref.] Inst. Bot., Acad. Sci., Cuba.

Solvent mixtures of lactophenol and 2N HCl at 2:1 and 1:1 could be used to extract trypan blue from internal mycelium of roots stained by Phillips and Hayman's method [*RPP 50*, 1080]. Absorption characteristics of the stain molecule disappeared in UV (200-400 nm) but not in visible light (400-700 nm), where max. absorption was at 590-610 nm. Using a concentration curve of trypan blue in lactophenol-2N HCl 1:1 with known optical densities the infection density in mycorrhizas can be determined, if roots stained with pure lactophenol or non-mycorrhizal root extracts are used as blanks.

*0563 VERSCHOYLE, M. J. S. **An approach to improving the speed and efficiency of staining root samples for mycorrhizal study.** *Tropical Agronomy Technical Memorandum* (1977) No.6, 12pp. [En, 1 ref.] Div. of Trop. Crops and Pastures, CSIRO, St. Lucia, Qld., Australia 4067.

0564 FURLAN, V.; FORTIN, J.A. A flotation bubbling system for collecting Endogonaceae spores from sieved soil. Naturaliste Can.

102: 663-667. 1975.
A flotation-bubbling system using an aqueous solution of glycerol is described for the recovery of Endogonaceae spores from soil sievings. According to the results obtained the efficien of such a system is quite unquestionable. Wit a glycerol solution of 50% it has been possibl to recover from soil sievings, without any damage, 99.5% of the spores, while only 47% were recovered when water was used.

0565 HEPPER, C. M.; MOSSE, B. Techniques used to study the interaction between *Endogone* and plant roots. 65-75 [En, 12 ref.] Rothamsted Exp. Sta., Harpenden, Herts AL5 2JQ, UK.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press.
The establishment of VA mycorrhiza in root organ cultures and by the buried slide technique is described with particular reference to red clover.

0566 KINDEN, DARRELL A. and MERTON F. BROWN. (Dep. Plant Pathol., Univ. Mo., Columbia, Mo. 65201, USA.) Electron microscopy of vesicular-arbuscular mycorrhizae of yellow poplar: I. Characterization of endophytic structures by scanning electron stereoscopy. CAN J MICROBIOL 21(7): 989-993. Illus. 1975. [In Engl. with Engl. and Fr. summ.]--Vesicular-arbuscular mycorrhizae of yellow poplar (Liriodendron tulipifera L.) were examined by scanning electron microscopy. The morphology and spatial distribution of endophytic structures are illustrated. The use of stereoscopic techniques in conjuction with removal of host cytoplasm permits detection of subtle morphological alterations and progressive deterioration of the fungal component.

0567 KINDEN, D. A.; BROWN, M.F. Technique for scanning electron microscopy of fungal structures within plant cells. Phytopathology (1975) 65(1) 74-76 Univ. Missouri, Columbia. U.S.A.
A procedure for the removal of host cytoplasm from infected cells and the preservation of fungal structures for SEM is described. The technique permits the use of SEM for studying the morphology and spatial relatinships of intracellular structures produced by parasitic fungi. Some haustoria of Puccinia graminis, P. hordei and Erysiphe graminis and vesicular-arbuscular structures of Endogone are illustrated.

*0568 BHUTTA, A.A. Siphon technique for isolating buoyant spores. Pakistan Journal of Botany (1974) 6(1):87-88.
The technique described was developed to isolated petrified, spherical, uncompressed, buoyant spores dispersed in soil or embedded in mineral matter. It proved useful for isolating *Endogone* spores.

*0569 JOHNSON, L.F.; CURL, E.A. Methods for research on the ecology of soil-borne plant pathogens. 247p. Burgess PUbl. Col, Minneapolis, Minn. 1972. (Isolation of mycorrhizal fungi).

0570 SUTTON, J.C.; BARRON, G.L. 1972. Population dynamics of Endogone spores in soil. Can. J. Bot. 50:1909-1914.
A flotation-adhesion technique is described for the rapid recovery of Endogone spores using small (5-10g) soil samples. The method proved 94-98% efficient in the recovery of spores from Ontario soils. Spore counts averaged 20-92 per gram with exceptional individual counts reaching 132. Effects of soil type, soil depth, and "host" plant on spore population are discussed.

0571 PHILLIPS, J.M.; HAYMAN, D.S. Staining mycorrhizal roots. Rothamsted Exp. Sta. Report, Part I, 1970:88. 1971.

0572 PHILLIPS, J.M.; HAYMAN, D.S. Improved procedures for clearing roots and staining parasitic and vesicular-arbuscular mycorrhizal fungi for rapid arrersment of infection. Trans. Br. Mycol. Soc. 55: 158-161. 1970.

0573 ALLEN, M. F. Influence of vesicular-arbuscular mycorrhiza on water movement through *Bouteloua gracilis* (H.B.K.) Lag ex Steud. *New Phytologist* (1982) 91 (2) 191-196 [En, 25 ref., 4 tab.] Univ. Nebraska-Lincoln, Lincoln, USA.

Root growth characteristics and water transport were compared in pot tests between non-mycorrhizal plants and those infested with *Glomus fasciculatus*. The latter did not have significantly different leaf area or root length from non-mycorrhizal plants but had fewer and shorter root hairs. Leaf resistance was 50% lower with no change in leaf or root water potentials; thus transpiration was increased 100% with a 50% reduction in whole-plant, soil to root and root to leaf resistance. Assuming that the difference in water uptake was due to transport via the mycorrhizal hyphae, estimated fungus to root transport was 2.8×10^{-5} mg/s for each hyphal entry point, which compares favourably with evapotranspiration rates measured in other coenocytic fungi. Thus, the increased surface area provided by the hyphae may be a major factor in increased water transport and reduced resistance to water through-flow associated with mycorrhizal infection.

0574 ALLEN, M. F. Influence of vesicular-arbuscular mycorrhizae on water movement through *Bouteloua gracilis* (H.B.K.) Lag ex Steud. *New Phytologist* (1982) 91 (2) 191-196 [En, 25 ref.] Dep. of Pl. Path., Nebraska Univ., Lincoln, NE 68583, USA.

In pot trials, leaf area and root length and leaf and root water potentials of *B. gracilis* were not affected by infection with *Glomus fasciculatus*. Mycorrhizal plants had fewer root hairs, 50% lower leaf resistance and 100% increased transpiration. Assuming that the difference in water uptake was due to transport via the mycorrhizal hyphae, estimated fungus to root transport was 2.8×10^{-5} mg/s for each hyphal entry point. Increased water transport was attributed to increased surface area provided by the hyphae.

0575 BAGYARAJ, D. J.; SREERAMULU, K. R. **Preinoculation with VA mycorrhiza improves growth and yield of chilli transplanted in the field and saves phosphatic fertilizer.** *Plant and Soil* (1982) 69 (3) 375-381 [En, 21 ref.] University of Agricultural Sciences, Bangalore-560005, India.

In Nursery beds were inoculated with *Glomus fasciculatus* or any of three local vesicular arbuscular mycorrhizal fungus isolates, and the resulting mycorrhizal *Capsicum annuum* (cv. Jwala) seedlings were transplanted into plots receiving fertilizer P. One of the fungi, isolate I_4, increased plant growth, P and Zn uptake, flowering, and ascorbic acid levels in the fruits; and the fruit yield of I_4-inoculated plants given 37.5 kg/ha P exceeded that of uninoculated plants given 75 kg P (2.14 and 1.81 kg fruit, respectively, per 12-plant plot).

0576 BETHLENFALVAY, G.J.; FULLER, G. Mycotrophic growth of host plant and endophyte development in mycorrhizal soybeans. Phytopathology 72:950 1982. Abst.

The relationships between growth parameters of host plant and fungal endophyte were studied. Soybean [Glycine max (L.) Merr.] plants colonized by the vesicular-arbuscular mycorrhizal (VAM) fungus Glomus fasciculatus Gerdemann and Trappe were grown in pot cultures utilizing a composite greenhouse rooting medium. Development of fungal mycelia inside and outside the host root and total fungal biomass were determined from assays of fungal chitin. Growth and phosphorus uptake by VAM plants and uncolonized controls were compared. Mycotrophic growth in VAM plants occurred during the final six weeks of the 19-week growth period, when the concentration of available soil P fell below 10 µg P/g soil. Growth enhancement was most pronounced in the reproductive organs. The data suggest a relationship between the initiation of the reproductive phase in the host and the cessation of growth in the endophyte. Source-sink relationships and P availability appear to be factors influencing interactions between the symbionts.

*0577. BETHLENFALVAY, G.J. Conditions affecting parasitic o mutualistic growth in mycorrhizal plants. Phytopathology 72: 950. 1982. Abst.

Soybean [Glycine max (L.) Merr.] plant colonized by the vesicular-arbuscular mycorrhizal fungus Glomus fasciculatus Gerd. and Trappe were grown in pot cultures using hydroxyapatite [$Ca_{10}(PO_4)_6(OH)_2$] as a slightly soluble source of P. Growth response of host plants to VAM fungal infection varied from growth depression (parasitic growth of the endophyte) to growth enhancement (mutualism). Host-plant and endophyte development were correlated with P availability. At very low levels of $NaHCO_3$-extractable P (1 µg P/g soil) host plant and endophyte development were inhibited. At an intermediate level of P availability (4 to 10 µg P/g soil) host-plant growth was enhanced, while at higher levels (10-20 µg P/g soil) it was inhibited. Total fungal biomass varied with P availability and plant age, and was maximally 20% of root dry weight. It is concluded that host-plant growth response to VAM fungal infection depended on the availability of and competition for P and photosynthate.

0578 BETHLENFALVAY, G.J.; PACOVSKY, R.S.; BAYNE, H.G.; STAFFORD, A.E. Interactions between nitrogen fixation, mycorrhizal colonization, and host-plant growth in the *Phaseolus-Rhizobium-Glomus* symbiosis. Plant Physiol. (1982) 70, 446-450.

Bean (*Phaseolus vulgaris* L. cv. Dwarf) roots were inoculated with *Rhizobium phaseoli* and colonized by the vesicular-arbuscular mycorrhizal (VAM) fungus *Glomus fasciculatus* Gerd. and Trappe or left uncolonized as controls. The symbiotic associations were grown in an inert substrate using 0, 25, 50, 100, or 200 milligrams hydroxyapatite (HAP) [$Ca_{10}(PO_4)_6(OH)_2$] per pot as a P amendment. Plant and nodule dry weights and nodule activity increased for both VAM and control plants with increasing P availability, but values for VAM plants were significantly lower in all parameters than for controls. Inhibition of growth and of N_2 fixation in VAM plants was greatest at the lowest and highest P regimes. It was smallest at 50 milligrams HAP, where available P at harvest (7 weeks after planting) was 5 micrograms P per gram substrate. At this level of P availability, the association apparently benefited from increased P uptake by the fungal endophyte. Percent P values for shoots, roots, and nodules did not differ significantly ($p > 0.05$) between VAM and control plants. The extent of colonization, fungal biomass, and the fungus/association dry weight ratio increased several fold as HAP was increased from 0 to 200 milligrams. It is concluded that intersymbiont competition for P and photosynthate was the primary cause for the inhibition of growth, nodulation, and nodule activity in VAM plants. Impaired N_2 fixation resulted in N stress which contributed to inhibition of host plant growth at all levels of P availability.

0579 BETHLENFALVAY, G. J.; BROWN, M. S.; PACOVSKY, R. S. **Parasitic and mutualistic associations between a mycorrhizal fungus and soybean: development of the host plant.** *Phytopathology* (1982) 72 (7) 889-893 [En, 26 ref., 6 fig., 3 tab.] USDA, Berkeley, Calif., USA.

Plants of Kent soybean inoculated with *Glomus fasciculatus* were grown in 1.5 l pots in a perlite and sand rooting medium containing 200 mg of hydroxyapatite as the P source. Plants were harvested at 2- or 3-wk intervals for 18 wk. Fungal biomass as percent total dry wt. (of host + symbiont) was calculated from measurements of fungal chitin and had a max. value of 7.3% at 6 wk after planting. Total and percent of vesicular-arbuscular mycorrhiza (VAM)-infected and uninfected control plants were determined, and the decrease of available P in the rooting medium was monitored. As a result of development of the endophyte, growth inhibition of VAM plants relative to the controls increased up to the 9th wk. It was then reversed and after 15 wk VAM plants had significantly greater dry wt. and P contents than the controls. The data suggest that early growth inhibition was a result of carbohydrate demand on the host by the endophyte, at a time when the shoot-to-root ratio and photosynthetic source capacity of the host were low. Available P in the rooting medium of VAM plants decreased to 10 µg P/g rooting medium during the 3 wk preceding the reversal in growth inhibition, indicating that mycotrophic growth of the host induced by increased P uptake by the endophyte began at this P conc.

0580 BUWALDA, J. G.; GOH, K. M. **Host-fungus competition for carbon as a cause of growth depressions in**

vesicular-arbuscular mycorrhizal ryegrass. *Soil Biology & Biochemistry* (1982) 14 (2) 103-106 [En, 38 ref.] Dep. of Soil Sci., Lincoln Coll., Canterbury, New Zealand.

The effect of *Gigaspora margarita*, an endomycorrhiza-forming fungus on the growth and chemical composition of perennial ryegrass plants grown at 3 rates and 2 sources of N were studied. The yield of plant tops was significantly depressed by mycorrhizal infection. Mycorrhizal plants had higher conc. of free NH_4 (and, consequently, higher cation excess concentrations), suggesting an impairment of protein synthesis possibly resulting from an inhibited supply of C. Total oxidizable C, soluble sugar content and C:N ratios were lower in mycorrhizal plants, suggesting that the mycorrhizal fungi were competing with the host for photosynthetically-derived C, consequently causing growth depressions. A possible mechanism of this competition is discussed.

0581 CABALA-ROSAND, P.; WILD, A. Direct use of low grade phosphate rock from Brazil as fertilizer. II. Effects of mycorrhizal inoculation and nitrogen source. Plant and Soil 65:363-373 (1982).
The response of plant dry matter to addition of a low grade Brazilian (Patos) phosphate rock was increased by mycorrhizal inoculation (strain E_3) of *Stylosanthes guianensis* and *Desmodium intortum*, but less so by inoculation of *Cenchrus ciliaris* and *Paspalum plicatulum*. The effect was related partly to the extent of root development. In the presence of a nitrification inhibitor the utilisation of Patos rock phosphate by *Paspalum* was higher with NH_4^+-N than with NO -N. This effect was attributed to acidification which in turn was related to the organic anion content of the plants. The results indicate the potential for improving the utilization of the low grade phosphate rock on an acid oxisol by mycorrhizal inoculation of herbage legumes and by soil acidification when growing grasses.

0582 CHIARELLO, N.; HICKMAN, J. C.; MOONEY, H. A. **Endomycorrhizal role for interspecific transfer of phosphorus in a community of annual plants.** *Science, USA* (1982) 217 (4563) 941-943 [En, 18 ref.] Dep. of Biol. Sci., Stanford Univ., Stanford, CA 94350, USA.

^{32}P applied to the leaves of *Plantago erecta* in a serpentine annual grassland reached the shoots of about 20% of close neighbours including grasses and legumes. Vesicular-arbuscular mycorrhizae are shown to connect the root systems of different spp. enabling P transfer between them.

0583 CRUSH, J. R. **Effects of endomycorrhizas and phosphorus fertilizer on nodulation and acetylene reduction activity of white clover seedlings.** *New Zealand Journal of Experimental Agriculture* (1982) 10 (3) 297-299 [En, 19 ref.] Grasslands Div., DSIR, Palmerston North, New Zealand.

Inoculation of white clover cv. Grasslands Huia with perennial ryegrass × *Glomus tenuis* mycorrhizas and a suspension of *Rhizobium trifolii* had no effect on nodule initiation over a wide range of soil P levels. Acetylene reduction assays of 21- to 60-day-old seedlings showed that nitrogenase activity/unit plant P was the same in mycorrhizal and non-mycorrhizal seedlings. The endomycorrhizal fungus did not directly affect nodule activity but did improve P nutrition in poor soils.

0584 EZETA, F.N.; CARVALHO, DE P.C.L. Influencia da endomicorriza na absorcao de P e K no crescimento da mandioca. (Influence of endomycorrhiza on P and K uptake and growth of cassava). R. Bras Ci. Solo 6:25-28. 1982.
The dependance of cassava on vesicular-arbuscular mucorrhiza formed with endogenaceous fungi was studied under greenhouse conditions. Native spores of Acaulospora sp. were inoculated on the roots of cassava cuttings wich were planted in sterilized soil. Endomycorrhiza was essential to cassava growth. The plants without inoculation did not develop, showing low tissue concentration of phosphorus. Potassium concentration, on the contrary, was higher in the leaves of non inoculated plants in sterilized soil. Sterilization decreased root infection but increased the number of spores of the inoculated VA species in the soil at the end of the experiment. In spite of their high rates of root infection, the plants in the non-sterile soil grew less than those inoculated and grown in sterilized soil.

0585 FAIRWEATHER, J. V.; PARBERY, D. G. **Effects of four vesicular-arbuscular mycorrhizal fungi on growth of tomato.** *Transactions of the British Mycological Society* (1982) 79 (1) 151-153 [En, 12 ref.] Melbourne University, Parkville, Victoria 3052, Australia.

In growth chamber experiments tomato plants (cv. Rouge de Marmande) were grown in soil containing no Olsen-extractable phosphorus. At first-leaf-emergence roots were inoculated with *Gigaspora gigantea*, *G. marginata*, *Acaulospora laevis* or an unidentified mycorrhizal fungus. Uninoculated plants grew poorly and showed phosphorus deficiency symptoms. All the fungi stimulated root growth, the greatest stimulation being with *G. marginata*, 49.5 mg dry weight compared with 3.7 mg/plant for untreated controls. Increased shoot growth occurred only with *G. marginata*, being 32.8 mg compared with 3.2 mg/plant for the controls and 4.9 to 6.7 mg with the other mycorrhizal species.

0586 GANRY, F.; DIEM, H.G.; DOMMERGUES, Y,R. Effect of inoculation with Glomus mosseae on nitrogen fixation by field grown soybeans. Plant and Soil 68, 321-329 (1982).
This field study was undertaken to determine the effect of inoculation with Glomus mosseae on N2 fixation and P uptake by soybean. The inoculation with Glomus mosseae was achieved using a new type of inoculant, alginate-entrapped (AE) endomycorrhizal fungus. N2 fixation was assessed using the A value method. In P-fertilized plots, inoculation with AE Glomus mosseae increased the harvest index based on dry weight (+20%) and N content of seeds (+17%). the A value (+31%) and % N derived from fixation (+75%). Inoculation with AE Glomus mosseae decreased the coefficient of variation for the A value and for the dry weights of the different plant parts.

0587 GUTTAY, A. J. R. **The growth of three woody plant species and the development of their mycorrhizae in three different plant composts.** *Journal of the American Society for Horticultural Science* (1982) 107 (2) 324-327 [En, 11 ref.] Connecticut University, Storrs, CT 06268, USA.

Composts of maize, eastern hemlock (*Tsuga canadensis*) and sugar maple (*Acer saccharum*) were each used as the medium for container-grown hemlocks, sugar maples and rhododendrons (*Rhododendron catawbiense* cv. Roseum Elegans) over 3 years. Maize compost was high in available nutrients but hemlock and maple composts were relatively low in nutrients and were used both with and without the addition of fertilizer + limestone. No vesicular-arbuscular mycorrhiza (VAM) development was observed in maize compost, while a moderate development was found in the hemlock compost and a high development in the maple compost. Sugar maples showed the greatest growth and VAM incidence in maple compost, and also showed a positive growth response to fertilizer. Maize compost killed 50% of the maples, retarded growth and led to a very low VAM incidence in the survivors. Hemlocks had the greatest growth and ectomycorrhiza incidence in either unfertilized hemlock compost or unfertilized maple compost. A significant retarded growth response to fertilizer was found with hemlocks. Rhododendrons showed the greatest growth in maize compost and the fertilized composts. A negative correlation was found between growth and the incidence of ericoid mycorrhizae in rhododendrons.

0588 HALE, K.A.; SANDERS,F.E. Effects of benomyl on vesicular-arbuscular mycorrhizal infection of red clover (*Trifolium pratense* L.) and consequences for phosphorus inflow. J. Plant Nutrition 5(12):1355-1367 (1982).
The roots of red clover plants inoculated with the vesicular-arbuscular mycorrhizal fungus *Glomus clarus* Nicolson & Schenck were treated with a drench of benomyl at a time when mycorrhizal infection was already well established. Benomyl halted further infection and reduced phosphorus inflow by one order of magnitude compared to un-

treated controls. The fungicide also decreased the rate of plant growth probably as consequence of reduced phosphorus inflow.

0589 HALOS, P. M., ELSA M. LUIS and MARILYN S. BORJA. (Dep. Plant Pathol., Coll. Agriculture, Univ. Philippines Los Banos, College, Laguna.) PHILIPP AGRIC 65(1): 93-102. 1982. Synergism between endomycorrhizas, *Rhizobium japonicum* CB 1809 and soybean (*Glycine max*).—Soybean plants responded differently to the 8 exotic and indigenous endomycorrhizal isolates both in field and pot experiments. Differences in mean height between treatments were significant. Inoculated plants were noticeably larger, taller, greener, healthier, and more vigorous than the control plants. In the field experiment, the number of pods, yield, dry weight and height of soybeans inoculated with endomycorrhizas and *R. japonicum* were significantly higher than those of plants inoculated with either endomycorrhizas or *R. japonicum* alone. Not all plants inoculated with the endomycorrhizal isolates alone exhibited significant nodule formation. However, when such isolates were combined with *R. japonicum*, the plants showed strikingly increased nodule formation compared with plants inoculated with *R. japonicum* alone.

0590 HAYS, R.*, C. P. P. REID, T. V. ST JOHN* and D. C. COLEMAN. (Natural Resource Ecol. Lab., Colorado State Univ., Fort Collins, Colo. 80523, USA.) OECOLOGIA (BERL) 54(2): 260-265. 1982. Effects of nitrogen and phosphorus in blue grama (*Bouteloua gracilis*) growth and mycorrhizal infection.—The growth response was examined of *B. gracilis*, with and without the vesicular-arbuscular mycorrhiza (VAM), *Glomus fasciculatus*, to varying levels of P and N (as NH_4^+) and to determine whether N and P levels influence VAM establishment. *B. gracilis* was grown in 225 g of soil in a factorial experiment combining 4 levels of NH_4^+-N (4, 30, 60 and 126 μg/g), 4 levels of P (3, 7, 12 and 22 μg/g), and with VAM spores or no spores. *B. gracilis* showed enhanced growth with increased nutrients over the entire range of experimental admendments. Shoot N concentration for all plants ranged from an average of 0.73% at the low amendment level to 1.61% at the high level, whereas shoot total averages ranged from 2.43 mg at the low amendment to 16.4 mg at the high amendment. Mean shoot P concentrations ranged from 0.109% at the low amendment level to 0.150% at the high amendment, while totals averaged 5.29 mg at the low amendment and 11.8 mg at the high amendment level. Infected plants were consistently smaller than uninfected plants. This reduction was significant at high N-low P where percent infection was highest (71%). At low N levels, moderate infection (17%) was established at all P levels. No infection occurred when both N and P levels were high. The lack of a positive nutrient or biomass response to VAM establishment is contrary to most published reports, but is similar to a lack of response shown with certain grasses and other plants. It is possible that the parasitic nature of the response to infection represents the early phase of infection.

0591 HOWELER, R. H.; ASHER, C. J.; EDWARDS, D. G. Establishment of an effective endomycorrhizal association on cassava in flowing solution culture and its effects on phosphorus nutrition. *New Phytologist* (1982) 90 (2) 229-238 [En, 35 ref.] Centro Internacional de Agricultura Tropical, Cali, Colombia.

8 cassava cv. were compared with rice, maize, cowpea and *Phaseolus vulgaris* in flowing sol. culture containing 0.1, 1, 10 or 100μM phosphate with or without mycorrhizal inoculation. Dry wt. of cassava reached a max. at > 10μM PO_4 compared with >1 μM for the other spp. Mycorrhizal infections were only observed on cassava roots and only at 0.1 and 1 μM PO_4. Infection increased plant dry wt., P content and P uptake at 1 μM PO_4 but at 0.1 μM growth was not improved.

0592 HOWELER, R.H.; SIEVERDING, E. La importancia de las micorrizas en la absorción de fósforo por la yuca. Suelos Ecuatoriales 12(2):182-195. 1982.

0593 HOWELER, R.H. Mycorrhizal associations: important for cassava grown on soils low in P. *Cassava Newsletter* (CIAT) no.11: 10-11. 1982.

Manihot esculenta, cassava, mycorrhiza, COLOM

Cassava is an inefficient absorber of phosphate. Nevertheless, it seems to be less responsive to P fertilizers than many other crops while high yields are sometimes obtained without P fertilization. This may be due to an association with vesicular-arbuscular mycorrhiza. CIAT is studying this problem in a GTZ-funded programme.

0594 HOWELER, R.H.; CADAVID, L.F.; BURCKHARDT, E. Responses of cassava to VA mycorrhizal inoculation and phosphorus application in greenhouse and field experiments. Plant and Soil 69 327-339 (1982).

Cassava (Manihot esculenta Crantz) was grown in the greenhouse and in the field at different levels of phosphorus applied, with or without inoculation with VA mycorrhiza in sterilized or unsterilized soil. When grown in a sterilized soil to which eight levels of P had been applied the non-inoculated plants required the application of 3200 kg P ha-1 to reach near-maximum yield of plant dry matter (DM) at 3 months. Inoculated plants, however, showed only a minor response to applied P. Mycorrhizal inoculation in the P check increased top growth over 80 fold and total P uptake over 100 fold.

Ralating dry matter produced to the available P concentration in the soil (Bray II), a critical level of 15 ppm P was obtained for mycorrhizal and 190 ppm P for non-mycorrhizal plants. This indicates that the determination of critical levels of P in the soil is highly dependent on the degree of mycorrhizal infection of the root system. In a second greenhouse trial with two sterilized and non-sterilized soils it was found that in both sterilized soils, inoculation was most effective at intermediate levels of applied P resulting in a 15-30 fold increase in DM at 100 kg P ha-1. In the unsterilized soil inoculation had no significant effect in the Quilichao soil, but increase DM over 3 fold in the Carimagua soil, indicating that the latter had a native mycorrhizal population less effective than the former.

When cassava was grown in the field in plots with 11 levels of P applied, uninoculated plants grown in sterilized soil remained extremely P deficient for 4-5 months after which they recuperated through mycorrhizal infection from unsterilized borders or subsoil. Still, after 11 months inoculation had increased root yields by 40%. In the non-sterilized soil inoculation had no significant effect as the introduced strain was equally as effective as the native mycorrhizal population.

These trials indicate that cassava is extremely dependent on an effective mycorrhizal association for normal growth in low-P soils, but that in most natural soils this assoication is rapidly established and inoculation of cassava in the field can only be effective in soils with a low quantity and quality of native mycorrhiza. In that case, plants should be inoculated with highly effective strains.

0595 JENSEN, A. Influence of four vesicular-arbuscular mycorrhizal fungi on nutrient uptake and growth in barley (*Hordeum vulgare*). *New Phytologist* (1982) 90 (1) 45-50 [En, 21 ref., 3 tab.] Bot. Inst., Univ. Aarhus, Risskov, Denmark.

Plants inoculated with *Glomus constrictus* and 2 isolates of *G. fasciculatus* in sterilized soil in pots showed increases in total uptake of P, Cu and Zn, and in grain and straw yield. Those inoculated with *G. margarita* were similar to the controls. Growth increase was not related to intensity of infection.

*0596 JOHNSON, C. R.; MENGE, J. A.; JOHNSON, E. L. V. Effect of vesicular-arbuscular mycorrhizae on growth of *Chrysanthemum morifolium* Ramat. *Scientia Horticulturae* (1982) 17 (3) 265-269 [En, 7 ref.] Florida University, Gainesville, FL 32611, USA.

Benefits of inoculation with *Glomus fasciculatus* on growth of *C. morifolium* cv. Circus were determined for varied conditions of N fertilization (375, 1500 or 3000 kg N/ha/year) and irradiance (6 or 800 μE m^2/s) during long-day lighting treatments. High N fertilization combined with high level of irradiance produced the most mycorrhizal infection. Mycorrhizal infection generally increased plant height, especially with continuation of long-day lighting to 8 weeks. Mycorrhizae also improved flower, stem and root dry weight for most treatments, particularly at high N and 4- or 8-week, long-day treatments. Although mycorrhizal inoculation increased plant growth most under extended long-day treatments, only the 2-week duration night lighting resulted in commercially acceptable plant size.

*0597 KABRE, A.; GARBAYE, J.; TACON, F. LE [Influence of mycorrhiza and fertilization on sycamore (*Acer pseudoplatanus* Link.) seedlings.] Influence de la mycorhization et de la fertilisation sur le comportement de jeunes plants d'érable sycomore (*Acer pseudoplatanus* Link.). *European Journal of Forest Pathology* (1982) 12 (2) 97-103 [Fr, en, de, 15 ref., 1 fig., 2 tab.] Lab. Microbiol., Dakar, Senegal.

In glasshouse experiments with seedlings in soil from eastern France mycorrhizal formation, especially *Glomus mosseae*, improved seedling growth and mineral nutrition, particularly utilization of Cu and P. Mycorrhizal inoculation was superior to natural infection, even when fertilizers were applied. Mycorrhizal formation increased the coefficient of utilization of P fertilizers 5-10-fold and of N and K fertilizers 3-5-fold.

0598 KAYE, J.W.; PFLEGER, F.L.; STEWART, E.L. Interaction of fertilizer and Glomus fasciculatus on greenhouse grown poinsettia (Euphorbia pulcherrima). Phytopathology 72(7): 951. 1982. Abst.

Rooted poinsettia plants were either inoculated with Glomus fasciculatus (GF) or not inoculated (controls) and planted in a potting medium of 1 part peat:1 vermiculite:1 soil containing 5 or 12 ppm phosphorous (P). Both GF-inoculated and control plants were fertilized with 125 or 250 ppm (once/wk) or with 300 ppm (twice/wk) NH_4SO_4 and KNO_3. Inoculation with GF had the following effects on the plants: (1) greater dry weights and total numbers of cuttings taken from plants grown at 5 ppm P fertilized with 250 or 300 ppm N and K, (2) foliar analysis revealed a greater uptake of P and Cu at 12 ppm P fertilized with 125 ppm N and K, and at 5 ppm P fertilized with 125, 250 or 300 ppm N and K, (3) increased uptake of K at 5 ppm P fertilized with 125 or 250 ppm N and K. In general, % root infection by GF increased with decreasing levels of fertilizer. More chlamydospores were recovered from soil of plants grown at 5 ppm P fertilized with 250 ppm N and K.

0599 KILLHAM, K.; FIRESTONE, M.K. V.A. Mycorrhizal mediation of grass response to heavy metal and acidic depositions. University of Californiz, Berkeley. Agronomy Abst. 1982. pag.10.

To determine the effect of V.A. mycorrhizae on the response of a perennial grass to heavy metal and acidic depositions the perennial bunchgrass Ehrharta calycina was grown with and without V.A. mycorrhizal infection (Glomus fasciculatus) in a sandy soil exposed to a range of heavy metal and acidic treatment for 14 weeks. Heavy metals (Cu, Ni, Pb, Zn, Fe, and Co) were applied in simulated acid rain (pH 3.0, 4.0, and 5.6.) at concentrations approximately equivalent to a range of observed smelter effluents. Non-V.A.M.- infected plants also received a phosphate amendment to offset enhanced uptake of this nutrient due to mycorrhizal infection. Growth yield of infected plants was half that of non- less extreme treatments. Increased metal uptake, particularly with respect to copper (3.3 times greater internal shoot concentration in mycorrhizal plants compared to non-mycorrhizal) and nickel (3.5 times), provides a possible mechanism to explain differences in observed plant yields.

0600 KORMANIK, P. P.; SCHULTZ, R. C.; BRYAN, W. C. **The influence of vesicular-arbuscular mycorrhizae on the growth and development of eight hardwood tree species.** *Forest Science* (1982) 28 (3) 531-539 [En, 10 ref.] SEFES, USDA For. Serv., Athens, GA 30602, USA.

Seeds of box elder (*Acer negundo*), red maple (*A. rubrum*), sugar maple, green ash (*Fraxinus pennsylvanica*), black walnut, sweetgum, sycamore (*Platanus occidentalis*) and black cherry (*Prunus serotina*) were sown in May 1977 in plots in Georgia in (*a*) fumigated soil, or in soil infested with (*b*) *Glomus fasciculatus*, (*c*) a mixture of *G. mosseae* and *G. etunicatus*, or (*d*) a mixture of several fungal species in the genera *Glomus* and *Gigaspora*. Seedlings were harvested in Nov., and measured. Treatments (*b*) to (*d*) significantly increased stem wt. in all species except black cherry and sugar maple. Root wt. was significantly increased in all except black cherry. Root infection varied from 55 to 86%, and was n.s.d. among host species. Differences among tree species were observed in the numbers of hyphae, arbuscules and vesicles produced by the fungi.

0601 KRISHNA, K. R.; BAGYARAJ, D. J. Effect of vesicular arbuscular mycorrhiza and soluble phosphate on *Abelmoschus esculentus* (L.) Moensch. *Plant and Soil* (1982) 64 (2) 209-213 [En, 14 ref., 3 tab.] Univ. Agric. Sci., GKVK Campus, Bangalore, India.

Increase in soluble P reduced the intensity of mycorrhizal infection of *A.* [*Hibiscus*] *esculentus* as well as number of *Glomus* chlamydospores in the soil. Root, shoot and total plant dry wt. were greater in mycorrhizal than in non-mycorrhizal controls at all levels of added P. Mycorrhizal dependency decreased with increase in P. When 200% of the recommended P was added growth of mycorrhizal plants was depressed, compared with that at 100%.

0602 KOCH, B. L.; COVEY, R. P.; LARSEN, H. J. Response of apple seedlings in fumigated soil to phosphorous and vesicular-arbuscular mycorrhiza. *HortScience* (1982) 17 (2) 232-233 [En, 12 ref., 1 tab.] Washington State Univ., Tree Fruit Research Cent., Wenatchee, USA.

When P was incorporated into fumigated soil at planting the nonmycorrhizal plants exhibited a 25-fold growth response and reached max. size at 200 mg additional P/kg soil. Mycorrhizal plants exhibited less growth response but had greater max. growth (78 as against 67.9 cm) than nonmycorrhizal ones. Max. growth of mycorrhizal plants occurred with 100-200 mg P/kg soil.

0603 KUO, C. G.; HUANG, R. S. Effect of vesicular-arbuscular mycorrhizae on the growth and yield of rice-stubble cultured soybeans. *Plant and Soil* (1982) 64 (3) 325-330 [En, 12 ref.] Asian Vegetable Res. and Development Cent., Shanhua 741, Taiwan.

Inoculation of soyabeans grown in sterilized soil using the fungi *Glomus fasciculatus, G. mosseae, G. etunicatus* or *Acaulospora scrobiculata* increased plant dry wt. and seed yields. Inoculation with *G. fasciculatus* or a mixture of all 3 *Glomus* spp. increased the growth and seed yields of soyabeans established without tillage in a rice stubble field.

0604 LAMONT, B. Mechanisms for enhancing nutrient uptake in plants, with particular reference to mediterranean South Africa and Western Australia. (About mycorrhiza pp.618-635). Botanical Review 48(3):598-689 (1982).

0605 MIRANDA, J.C.C. DE Influencia de fungos endomicorrízicos inoculados a campo, na cultura de sorgo e soja en un solo sob cerrado. R. Bras. Ci. Solo 6:19-23, 1982.

A field experiment was established in an argillaceous Dark Red Latosol fertilized with different levels of simple superphosphate and Patos de Minas rock phosphate. It was successively cultivated with sorghum and soybean in presence of native endomycorrhizal fungi and the introduced species *Gigaspora margarita* and *Glomus macrocarpus*. Spore number, root infection percentage, P absorption and grain yield of sorghum and soybean were measured for all treatments. In the treatments with simple superphosphate, the yield of both crops, was significantly higher in the presence of introduced endomycorrhizal fungi. These results were probably due to the low native fungal population of the soil. The endomycorrhizal association effect was less evident for soybean because of the lower P availability in the soil, in the second crop. There was no yield of sorghum in the treatments with Patos de Minas rock phosphate and the endomycorrhizal association effect on the soybean yield was observed only at the highest level of P_2O_5 applied. The endomycorrhizal association effectiveness might be dependent on a minimum degree of P available in the soil. The spore number in the soil and root infection percentage shoudl be considered as an indication of fungi establishment in the soil rather than an indication of the endomycorrhizal effectiveness on plant growth. An increase of K, Ca and Mg ab-

sorption by soybean inoculated with *Glomus macrocarpus* was also observed.

0606 MENGE, J. A.; JARRELL, W. M.; LABANAUSKAS, C. K.; OJALA, J. C.; HUSZAR, C.; JOHNSON, E. L. V.; SIBERT, D. **Predicting mycorrhizal dependency of Troyer citrange on *Glomus fasciculatus* in California citrus soils and nursery mixes.** *Soil Science Society of America Journal* (1982) 46 (4) 762-768 [En, 36 ref.] California University, Riverside, CA 92521, USA.

In a greenhouse experiment the mycorrhizal fungus, *Glomus fasciculatus*, significantly increased growth of Troyer citrange (TC) seedlings in 20 of 26 methylbromide-fumigated citrus soils from southern California. Of the 6 soils in which *G. fasciculatus* provided no growth increase, 2 were greenhouse soils, 3 were nursery soils, and only one was a field soil. *G. fasciculatus* increased foliar P, K, and Cu concentrations and decreased foliar Mg and Na concentration of TC grown in the majority of the 26 citrus soils. Foliar concentrations of P, K, Ca, Na, Zn, Mn, Cu, and Fe from either mycorrhizal or nonmycorrhizal TC could not be significantly correlated with the mycorrhizal dependency of TC in the soils studied. A positive correlation was observed between foliar concentrations of Mg in nonmycorrhizal TC and mycorrhizal dependency. Mycorrhizal dependency of TC was also positively correlated with soil pH and inversely correlated with extractable soil P (bicarbonate), Zn, Mn, Cu, percent organic matter, and cation exchange capacity. In the fumigated soils studied, it was highly probable that inoculations with *G. fasciculatus* would induce significant growth response in TC provided the soils had <34 p.p.m. extractable P, 27 p.p.m. extractable Mn, 12 p.p.m. extractable Zn, or 3% organic matter. The magnitude of the mycorrhizal dependency of TC on *G. fasciculatus* in the 26 citrus soils was accurately predicted with equations which used soil P, Mn, Zn, and also Cu and pH as independent variables.

0607 MOSSE, B.; WARNER, A.; CLARKE, C. A. **Plant growth responses to vesicular-arbuscular mycorrhiza. XIII. Spread of an introduced VA endophyte in the field and residual growth effects of inoculation in the second year.** *New Phytologist* (1982) 90 (3) 521-528 [En, 11 ref.] Rothamsted Exp. Sta., Harpenden, Herts AL5 2JQ, UK.

Field plots at Rothamsted were inoculated with *Glomus caledonius* and *G. mosseae* and cropped with lucerne + barley in 1978 and pure lucerne resown in 1979. *G. caledonius* spread 7.5-22.5 cm from the inoculation point after 13 wk and throughout the plot after 15 months. After 21 months *G. caledonius* spores had multiplied 5-fold within the plot. Inoculation had residual effects on the growth of lucerne sown 1 yr after inoculation.

0608 ORUKO, B.A.; MUNNS, D.N. Effects of vesicular-arbuscular mycorrhizal fungi and phosphorus on cowpea nutrition under sand culture conditions. Agronomy Abst. 1982. p.195 Abstr.
The response of cowpea (Vigna unguiculata (L) Walp) to inoculation with two species of vesicular-arbuscular mycorrhizae (Glomus mosseae and Glomus fasciculatus) was investigated at four levels of P (0.5, 1.2 and 4 µM) in a greenhouse factorial experiment replicated three times. The cowpea plants were grown on sand in pots through which recycled nutrient solution contained in 100 liter buckets was automatically passed several times daily. Roots of inoculated plants became mycorrhizal within two weeks. Both species of VA mycorrhizal fungi increased P content of plants significantly, but their effect on shoot dry matter yield was differentially affectd by P-level: maximal yield was obtained at 1 µM-P with Glomus fasciculatus. P fertilization increased both P- content and dry matter yield significantly.

0609 PARFITT, R. L.; HART, P. B. S.; MEYRICK, K. F.; RUSSELL, M. **Response of ryegrass and white clover to phosphorus on an allophanic soil, Egmont black loam.** *New Zealand Journal of Agricultural Research* (1982) 25 (4) 549-555 [En, 14 ref.] Soil Bureau, DSIR, Lower Hutt, New Zealand.

Growth of perennial ryegrass cv. Grasslands Nui and white clover cv. Grasslands Huia was compared in a pot trial in a P-deficient black loam soil. 0, 65, 330, 460, 680 or 1110 mg P/kg soil was applied as calcium dihydrogen phosphate. White clover was inoculated with *Rhizobium trifolii* before transplanting and the soil was left untreated or inoculated with *Glomus tenuis* at this time. Both plants desorbed P from soil surfaces but clover had a higher P requirement for max. growth. Soil sol. P levels of 10 and 2µM P were required for near opt. growth of clover and ryegrass, resp. Clover responded to mycorrhiza at low rates of P but ryegrass gave no significant response.

0610 PLENCHETTE, C.; FURLAN, V.; FORTIN, J. A. **Effects of different endomycorrhizal fungi on five host plants grown on calcined montmorillonite clay.** *Journal of the American Society for Horticultural Science* (1982) 107 (4) 535-538 [En, 16 ref.] Service de recherche en sols, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, 2700 rue Einstein, Ste-Foy, Québec, Canada, G1P 3W8.

Series of greenhouse experiments were made to determine the effects of different endomycorrhizal fungi on the growth of oat (*Avena sativa* cv., Alma), strawberry (*Fragaria* × *ananassa*, cv. Redcoat), leek (*Allium porrum* cv. American Flag), apple (*Malus domestica* cv. Beautiful Arcade), and asparagus (*Asparagus officinalis* cv. Mary Washington) plants which were grown in a calcined montmorillonite clay (Turface) medium and fertilized with a Long Ashton nutrient solution at 100 ml/week pot (20 cm diameter). Plants were inoculated with 1 g of fresh ash (*Fraxinus americana*) roots harboring the different fungi. Out of 5 endomycorrhizal inocula used, 4 were well-identified: *Gigaspora calospora*, *Glomus epigaeus*, *Glomus macrocarpus* var. *macrocarpus*, and *Glomus monosporus*. The results indicate that Turface is a good growing medium for this type of study, as it permits good plant growth and abundant mycorrhiza formation with standard growing conditions. The fungi used produced different effects according to plant host. There was no correlation between the percentage of root infection and the stimulation of growth in the case of strawberry. Contrarily, there was a significant correlation (1% level) in the case of apple, asparagus, leek, and oats plants. No fungal specificity of the endophyte for the host plant was observed. The unknown endomycorrhizal species had effects on plant growth comparable to those of *Glomus epigaeus* with apple and strawberry plants.

0611 POWELL, C.LL.; CLARK, G.E.: VERBERNE, N.J. Growth response of four onion cultivars to several isolates of VA mycorrhizal fungi. New Zealand Journal of Agricultural Research 25:467-470. 1982.

Four onion cultivars were grown in sterilised Patumahoe soil and inoculated with 5 different VA mycorrhizal fungi. Three cultivars were then grown in unsterilised Patumahoe and Horotiu soils with 6 different mycorrhizal inoculants. Mycorrhizal fungi greatly stimulated onion growth and P uptake in sterilised soil and there were very significant fungi x cultivar interactions in both unsterilised soils. Glomus spp. and F 20 were the most efficient inoculants over all onion cultivars in Patumahoe and Horotiu soils respectively.

0612 POWELL, C.L. Phosphate response curves of mycorrhizal and nonmycorrhizal plants: 3 cultivar effects in Lotus pedunculatus and Trifolium repens. N.Z.J. Agric. Res. 25(2)217-222. 1982.
Yeo loyud [cv. Grasslands Maku and Grassland 4703] and 2 white clover cultivars [Grassland Huia and selection C3938] were grown in pots of 2 pasture soils at 6 superphosphate rates with or without mycorrhizal fungi. In Horotiu sandy loam (P retention 95%) there were no differences between clover and lotus cultivars in their growth responses to mycorrhizal inoculation. In Waingaro steepland soil (P retention 56%). inoculation stimulated the growth of only 1 lotus and 1 clover cultivar. Shoot growth of white clover responded to mycorrhizal fungi and to superphosphate over all P fertilizer rates (0-180mg P/600 ml pot) whereas lotus responded up to 45 and 90 mg P/pot .

0613 RANGELEY, A.; DAFT, M. J · NEWBOULD, P. **The inoculation of white clover with mycorrhizal fungi in unsterile hill soils.** *New Phytologist* (1982) 92 (1) 89-102 [En, 41 ref.] Hill Farming Res. Org., Penicuik, Midlothian EH26 0PY, UK.

White clover cv. Aberystwyth S184 and Grasslands Huia, grown under laboratory and field conditions, were inoculated with *Glomus mosseae* or *G. etunicatus* in 2 hill soils. In deep peat soil in the laboratory, mycorrhizal infection was increased by 2-70% with inoculation with either *Glomus* sp., being less at higher P fertilizer rates. Shoot growth was increased by inoculation at low P fertilizer levels but decreased at high P levels. In brown earth soil, infection with indigenous endophytes was 30-50% and was only increased by inoculation at 40 kg P/ha. However the introduced endophytes replaced 25-50% of the indigenous spp. without affecting shoot or root weight. In the field trials, *G. mosseae* inoculation increased infection from 18 to 42% in the deep peat soil but did not affect shoot growth or P content. In brown earth soil, infection was not increased but with 40 kg P/ha *G. etunicatus* inoculation doubled the shoot dry wt./ha of uninoculated plants and gave 75% greater yields than that produced with *G. mosseae*.

0614 RONCADORI, R.W. and POKORNY, F.A. **Growth of Juniperus chinensis var. sargentii as influenced by vesicular-arbuscular mycorrhizae and soil fertility.** Hort Science 17(6):917-918. 1982. Total fresh weight and crown spread of Juniperus chinensis var. sargentii Henry plants, grown in microplots containing a low fertility medium of 4 soil: 1 sand: 1 milled pine bark and amended with 10N-4.4P-8.3K fertilizer at rates of 0, 110, or 220 g/g, were significantly increased by inoculation with a spore mixture of 3 different vesicular-arbuscular (VA) mycorrhizal fungi. Higher fertilizer concentrations improved crown spread but did not affect plant growth. Root colonization by the endophytes ranged from 24.4 to 39.2% and was unaffected by fertilization rates.

***0615** SCHENCK, N.C. ; SMITH, G.S. ZAMBOLIM, L. **Effect of spore versus soil inoculum of the mycorrhizal fungus Glomus mosseae on growth of soybean.** Phytopathology 72: 950. 1982. Abst.

EFFECT OF SPORE VERSUS SOIL INOCULUM OF THE MYCORRHIZAL FUNGUS GLOMUS MOSSEAE ON GROWTH OF SOYBEAN. N. C. Schenck, G.S. Smith, and L. Zambolim. Plant Pathology Dept., Univ. of Florida, Gainesville 32611 and Univ. of Viçosa, Viçosa, M.G., Brazil.

Our purpose was to compare the rate of root colonization and plant growth to initial differences in inoculum of G. mosseae. Inoculum consisted of spores alone or spores plus associated soil and roots from a bahiagrass pot culture (soil inoculum). Spore concentrations ranged from 20 to 2000 per 15-cm pot of steamed soil (2kg). Inoculum was placed 5-10 cm below the surface or was distributed uniformly throughout the soil just prior to planting. The experiment had 5 replicates of each treatment and was repeated 3 times. In some experiments, soil inoculum resulted in less growth stimulation than spore inoculum because Fusarium solani was introduced with the soil inoculum. In all experiments, regardless of inoculum source, soybean nodulation was consistently increased by G. mosseae and weight of mycorrhizal soybean was greater than nonmycorrhizal soybeans at 10-11 wks but were less than nonmycorrhizal soybeans at 2-4 wks. Both the rate of and final root colonization by G. mosseae increased as inoculum levels increased.

0616 SCHENCK, N. C.; SMITH, G. S. **Responses of six species of vesicular-arbuscular mycorrhizal fungi and their effects on soybean at four soil temperatures.** *New Phytologist* (1982) 92 (2) 193-201 [En, 11 ref., 1 fig., 6 tab.] Univ. Florida, Gainesville, USA.

The mean values for all fungus and plant variates in 3 tests were generally greatest at 30 and least at 18°C. *Glomus claroideum*, *G. clarum*, *Gigaspora pellucida* and *G. gregaria* produced the greatest number of spores/g colonized root at 24°, while *Glomus mosseae* and *Acaulospora laevis* did so at 30°. *G. gregariae* had its max. root colonization at 36°, *G. mosseae* at 24° and the remaining spp. at 30°. *G. claroideum* and *A. laevis* were the only spp. with max. colonization and sporulation at the same temp. (30°). Spore diam. was generally less at 30 than at 24° but this varied with sp. and test. Flower numbers, pod set and seed yield varied considerably in the 3 tests but plant height was little affected by soil temp. or fungus sp. Generally the plants colonized with *G. mosseae* had an increased plant response and those with *A. laevis* had a reduced one. There was considerable variation in plant response to various combinations of temp. and fungus sp., with both stimulatory and repressive effects on growth.

0617 SMITH, S. E. **Inflow of phosphate into mycorrhizal and non-mycorrhizal plants of *Trifolium subterraneum* at different levels of soil phosphate.** *New Phytologist* (1982) 90 (2) 293-303 [En, 35 ref., 3 fig., 4 tab.] Waite Agric. Res. Inst., Univ. Adelaide, Glen Osmond, S. Aust., Australia.

During early growth of subterranean clover plants fertilized with soluble phosphate, inflow of phosphate into mycorrhizal roots from soil exceeded that into non-mycorrhizal roots over a range of phosphate levels. High rates of uptake were associated with reductions in root:shoot dry wt. ratios. The length of mycorrhizal root/plant was little affected by phosphate fertilization. However, rapid growth of roots at high Na_2HPO_4 levels resulted in reductions in percentage root length infected by mycorrhizae. Results are discussed in relation to rate of uptake by whole plants and to differences in distribution of phosphate between roots and shoots in mycorrhizal and non-mycorrhizal plants.

0618 STEINBERG, M.D.; BLOSS, H.E. **Selection of VA mycorrhizal fungi for use on alfalfa grown in Arizona.** Phytopathology 72: 950. 1982. Abst.

Alfalfa varieties were inoculated with five species of VA mycorrhizal fungi and screened for optimum biomass enhancement in the greenhouse. Based on results from the study conducted in the greenhouse three species of Glomus (G. deserticola, G. mosseae, and an undescribed Glomus) were selected for use with one variety of alfalfa (Hayden Px-1) to obtain biomass increases in Arizona field conditions. Alfalfa plants were either preinoculated with the mycorrhizal fungi, grown in the greenhouse and transplanted to the field, or were direct seeded into rows in which a layer of mycorrhizal inoculum had been incorporated. Phosphorus was added to the soil (100 lbs treble super-phosphate/acre) whereas phosphorus was not added to controls. A 65% increase biomass of plants preinoculated with the undescribed Glomus in the absence of phosphorus occurred over controls. A 90% increase occurred in plants preinoculated

0619 STRONG, M. F.; DAVIES, F. T., JR. **Influence of selected vesicular-arbuscular mycorrhizal fungi on seedling growth and phosphorus uptake of *Sophora secundiflora*.** *HortScience* (1982) 17 (4) 620-622 [En, 17 ref.] Texas A & M University, College Station, TX 77843, USA.

S. secundiflora seedlings were grown in 10.2 cm diameter pots containing sterilized media individually inoculated with 1 of 4 vesicular-arbuscular (VA) mycorrhizal fungi and fertilized with Osmocote (18N-6P-12K) at rates of 0, 1.2, or 4.2 kg/m³. After 263 days, seedlings with *Glomus mosseae* and with *Gigaspora margarita* showed increased fresh and dry weights of shoots and roots and root quality at the 1.2 kg/m³ fertilizer level. Increased growth responses of seedlings inoculated with either *G. mosseae* or *G. margarita* at 1.2 kg/m³ Osmocote were comparable to non-inoculated controls at 4.2 kg/m³. *Glomus etunicatus* and *G. fasciculatus* did not enhance seedling growth at any fertilizer rate tested, nor were they colonized on seedling roots. Microscopic examination of roots confirmed VA mycorrhizal colonization at all 3 fertilizer levels with *G. mosseae* and at the 2 lowest levels with *G. margarita*. Increased P uptake occurred only with *G. mosseae*-inoculated seedlings at 0 and 1.2 kg/m³ fertilization rates.

0620 WALLACE, L. L.*, S. J. MCNAUGHTON and M. B. COUGHENOUR. (Dep. of Botany and Microbiol., Univ. of Okla., Norman, Okla. 73019, USA.) OECOLOGIA (BERL) 54(1): 68-71. 1982. **The effects of clipping and fertilization on nitrogen nutrition and allocation by mycorrhizal and nonmycorrhizal *Panicum coloratum*, a 4-carbon pathway grass.**—Mycorrhizal and nonmycorrhizal plant of *P. coloratum* L. were grown in a factorial treatment design under 2 N levels and 2 clipping heights with an unclipped control. The N concentration in different plant components was determined following 9 wk of growth under experimental conditions. Mycorrhizal infection increased green leaf and sheath N concentration by a relatively small, but significant percentage and had no effect on N allocation to the various plant components. Clipping increased leaf N concentration but inhibited growth to the extent that, when compared with the unclipped controls, less N remained in residual plant biomass with up to half of the total N allocated to offtake (the material removed by clipping). Plants receiving the higher N fertilization had higher tissue concentration of N and more N allocated to aboveground living tissues. Mycorrhizal infection interacted with clipping height and also with N availability significantly. Infection was unable to ameliorate the negative effects of the most severe clipping regime and of the low N availability on leaf and sheath N content. This is possibly due to mycorrhizal demand for carbohydrates competing with the carbohydrate requirement of roots for N uptake.

0621 WHITTINGHAM, J.; READ, D. J. **Vesicular-arbuscular mycorrhiza in natural vegetation systems III. Nutrient transfer between plants with mycorrhizal interconnections.** *New Phytologist* (1982) 90 (2) 277-284 [En, 14 ref.] Dep. of Bot., Sheffield Univ., Sheffield S10 2TN, UK.

Young plants of *Festuca ovina* were grown in pots in close association with adults of the same sp. infected or not infected with mycorrhizal fungi and transport of ^{32}P, supplied in nutrient sol., from the old to the young plants was studied. P movement was greater in roots of mycorrhizal plants and the accompanying young plants had greater yields after 18-30 wk than those with nonmycorrhizal plants.

0622 YOST, R. S.; FOX, R. L. **Influence of mycorrhizae on the mineral contents of cowpea and soybean grown in an oxisol.** *Agronomy Journal* (1982) 74 (3) 475-481 [En, 28 ref.] Dep. of Agron. and Soil Sci., Hawaii Univ., Honolulu, HI 96822, USA.

In field trials in Oahu, Hawaii, cowpea and soyabean were sown on soils maintained for the previous 8 yr at 0.003-1.6 p.p.m. P/l and either untreated or fumigated with methyl bromide to destroy mycorrhizae 1 month before sowing. Soyabean CGR and availability and uptake of P affected the content of the main plant nutrients excluding Si. Si content of mycorrhizal soyabean plants was greater than non-mycorrhizal plants at all levels of soil P but Si content of cowpea was unaffected by mycorrhizal activity. It is suggested that Si uptake of plants such as soyabean may be used as an indicator of mycorrhizal activity.

0623 ABBOTT, L. K.; ROBSON, A. D. **Infectivity and effectiveness of five endomycorrhizal fungi: competition with indigenous fungi in field soils.** *Australian Journal of Agricultural Research* (1981) 32 (4) 621-630 [En, 28 ref.] Dep. of Soil Sci. and Pl. Nutr., Western Australia Univ., Nedlands, W.A., Australia 6009.

5 spp. of endomycorrhizal fungi differed in their ability to stimulate P uptake and growth of subterranean clover when inoculated into 2 untreated field soils which were P deficient. Each soil contained a different indigenous endomycorrhizal fungus. The amount of roots converted to mycorrhizas by each indigenous and inoculant fungus was estimated by using differences in the morphology of the infection within the roots and a line-intercept method. Effectiveness of the inoculant fungi in increasing plant growth was related to the infectivity of the fungi from the inocula used. The fungi indigenous to the 2 soils used did not appear to affect the extent to which mycorrhizas were formed by any of the inoculant fungi.

0624 ABBOTT, L. K.; ROBSON, A. D. **Infectivity and effectiveness of vesicular arbuscular mycorrhizal fungi: effect of inoculum type.** *Australian Journal of Agricultural Research* (1981) 32 (4) 631-639 [En. 19 ref.] Dep. of Soil Sci. and Pl. Nutr., Western Australia Univ., Nedlands, W.A.; Australia 6009.

Plants, inoculated with vesicular arbuscular mycorrhizal fungi (*Glomus fasciculatus, G. monosporus* and 2 isolates of *Acaulospora laevis*), were grown from 4 to 16 wk, and the development of infection and spores was followed. Infected roots from pot cultures of different ages were used to examine the effect of mycorrhiza development on the infectivity of each fungus. The effectiveness of each fungus was assessed by measuring its ability to increase the growth of subterranean clover on a P-deficient soil. For all fungi the percentage of root length infected increased rapidly up to 10 wk after sowing and thereafter it either increased only slightly or decreased. Infectivity of root inocula increased with increasing percentage of root length infected in the inoculum for all fungi, except where large numbers of mature spores (24/g infected root) had been produced by one isolate of *A. laevis*. The infectivity of inoculum roots from pots containing mature spores of this isolate declined rapidly, although it was not decreased by the onset of sporulation by *A. laevis*. For all fungi, irrespective of the inoculum used, the fresh wt. of tops of subterranean clover grown on P-deficient soil was very closely correlated with the percentage of its root length infected at an early stage of plant growth. The effectiveness of the spp. of fungi examined at increasing P uptake into plants was related to the infectivity of the inoculum used.

0625 AZCON-AGUILAR, C.; BAREA, J. M. **Field inoculation of *Medicago* with a V-A mycorrhiza and *Rhizobium* in phosphate-fixing agricultural soil.** *Soil Biology and Biochemistry* (1981) 13 (1) 19-22 [En, 37 ref.] Microbiology Department, Estación Experimental del Zaidín C.S.I.C. Granada, Spain.

Following field inoculation of *Medicago sativa* with *Rhizobium meliloti* and the endomycorrhizal fungus *Glomus mosseae* in untreated arable phosphate-fixing soil, the micro-organisms were successfully introduced, and each stimulated plant growth and N and P uptake. The dual inoculation of *Rhizobium* + *Glomus* more than doubled yield in comparison with an uninoculated control.

0626 ALLEN, M. F.; SMITH, W. K.; MOORE, T. S., JR.; CHRISTENSEN, M. **Comparative water relations and photosynthesis of mycorrhizal and non-mycorrhizal *Bouteloua gracilis* H.B.K. Lag ex Steud.** *New Phytologist* (1981) 88 (4) 683-693 [En, 45 ref.] Dep. of Bot., Wyoming Univ., Laramie, WY 82071, USA.

Inoculation of *B. gracilis* with *Glomus fasciculatus* in pot trials increased leaf chlorophyll content by 28%, increased P content by 89 and 47% in leaves and roots, resp., reduced leaf water vapour resistance by 50-70%, increased transpiration by > 100%, reduced stomatal resistance and mesophyll resistance to CO_2 uptake by 33 and 67%, resp., and increased the photosynthetic rate by 68%.

0627 ALLEN, M. F.; SEXTON, J. C.; MOORE, T. S. JR.; CHRISTENSEN, M. **Influence of phosphate source on vesicular-arbuscular mycorrhizae of *Bouteloua gracilis*.** *New Phytologist* (1981) 87 (4) 687-694 [En, 33 ref.] Dep. of Bot., Wyoming Univ., Laramie, WY 82071, USA.

Non-mycorrhizal and vesicular-arbuscular mycorrhizal *B. gracilis* infected with *Glomus fasciculatus* grown in defined media containing different P sources were compared. The P sources were (a) sodium monobasic phosphate, (b) a mixture of sodium monobasic phosphate and calcium phytate and (c) calcium phytate. Inositol and inositol plus Ca were added to the sodium phosphate medium as additional treatments. Mycorrhizal infection was highest in roots of (c) at 75% compared with (a) 19% and (b) 22%. No penetration by fungi occurred in plants from (a) + inositol or inositol and Ca media. Dry wt. of non-mycorrhizal plants were highest when grown in (b) + inositol and Ca followed in decreasing order by (a) + inositol, (b) and (a). Mycorrhizal infection increased leaf dry wt. in plants from (a) and root dry wt. from (c). P conc. in the plants were highest when grown in (b) followed by (a) and (c). Mycorrhizal infection always significantly increased leaf P conc. but increased root P conc. only in (c). Phosphates were found predominatnly as organically-bound compounds in leaves of mycorrhizal plants whereas in leaves of non-mycorrhizal plants, most of the P was inorganic. Chlorophyll conc. increased significantly with mycorrhizal infection with no change in a:b ratios. Mycorrhizal plants grown in (c) had substantially higher alkaline phosphatase activity than did non-mycorrhizal plants; acid phosphatase activity was not affected by mycorrhizal condition.

0628 BETHLENFALVAY, G.J.; PACOVSKY, R.S.; FULLER, G. Effect of an endomycorrhizal fungus on soybean growth. HortScience 16(3):404. 1981. Mycorrhizal soybena plants (*Glycine max* cv. Kent and *Glomus fasciculatus*) were grown in an inert rooting medium under different phosphorus regimes. Plants were harvested at intervals till maturity. Development of the endophyte was determined histologically and by measuring the chitin content of fungal structures external and internal to the host root. The extent of fungal infection depended on the amount and solubility of the phosphorus used. Grown with limiting concentrations of soluble phosphorus in the nutrient solution initial growth enhancement of the host occurred due to the presence of the endophyte. With a slightly soluble calcium phosphate salt (hydroxyapatite) as the only phosphorus source, the endophyte developed parasitically. The ratio of fungal organs external or internal to the host root appeared to influence the endophyte's effect on the host. The source of phosphorus available to this symbiotic association appears to determine the extent of endophyte development and a concomitant host plant response.

0629 BETHLENFALVAY, G. J.; YODER, J. F. **The *Glycine-Glomus-Rhizobium* symbiosis. 1. Phosphorus effect**

on nitrogen fixation and mycorrhizal infection. *Physiologia Plantarum* (1981) 52 (1) 141-145 [En, 29 ref.] USDA, Western Reg. Cent., Berkeley, CA 94710, USA.

Soyabean plants were grown in a sterile rooting medium given nutrient sol. containing 4, 20, 100 or 500 μM P/daily. Plants were inoculated with *Rhizobium japonicum* strain 61A118 and grown in the presence or absence of the endomycorrhizal fungus *Glomus fasciculatus*. Plants grown at the highest P regime had 6 times higher shoot dry wt. than those grown in the lowest P regime. Nodulation did not occur at 4 μM P. Nodule dry wt. increased 200-fold from the 20 to the 500 μM P treatment. Percentage P in shoots and nodules differed significantly among all treatment levels. Acetylene reduction by nitrogenase increased logarithmically with increasing amounts of P. Hydrogen evolution was not detectable at the 20 μM P level. The relative efficiency of N_2 fixation increased with increasing P stress. Infection by *G. fasciculatus* at the 500 μM P level was negligible and did not affect the parameters measured. At all other treatment levels the mycorrhizal plants had significantly higher rates of N_2 fixation, plant and nodule mass and P content.

0630 BLOSS, H. E.; PFEIFFER, C. M. **Growth and nutrition of mycorrhizal guayule plants.** *Annals of Applied Biology* (1981) 99 (3) 267-274 [En, 19 ref., 1 pl.] Arizona University, Tucson, AZ 85721, USA.

Establishment of mycorrhiza in *Parthenium argentatum* plants was achieved by inoculation of 8-day-old seedlings with hyphae and chlamydospores of an undescribed *Glomus* species. There was a five-fold increase in total dry weight of 30-day-old mycorrhizal seedlings compared with nonmycorrhizal seedlings grown in sterile loamy sand without additional fertilizer. Thirty-day-old, inoculated and uninoculated seedlings were transplanted in sterile or unsterile soil and grown for an additional 60 days. The greatest total dry weight of guayule was attained by inoculated transplants grown in sterile soil. Inoculated transplants increased two- to three-fold in total dry weight compared with uninoculated transplants, both grown in unsterile soil. After 90 days, uninoculated plants grown in unsterile soil had formed mycorrhizae with resident vesicular-arbuscular (VA) mycorrhizal fungi to the same extent as inoculated plants grown in unsterile soil. Total mineral uptake increased in inoculated guayule, irrespective of soil treatment or the presence of resident VA mycorrhizal fungi.

*0631 BOWEN, G. D. **The effects of mycorrhizas on nitrogen uptake by plants.** 237-247 [En, 55 ref.]

In: CLARK, F. E.; ROSSWALL, T. (EDITORS) **Terrestrial nitrogen cycles. Processes, ecosystem strategies and management impacts (Proceedings of an International Workshop at Gysinge Värdshus, Österfärnebo, Sweden, 16-22 September, 1979).** *Ecological Bulletins* (1981) No. 33, 714pp. [En]

0632 BROWN, R. W.; SCHULTZ, R. C.; KORMANIK, P. P. **Response of vesicular-arbuscular endomycorrhizal sweetgum seedlings to three nitrogen fertilizers.** *Forest Science* (1981) 27 (2) 413-420 [En, 29 ref.] Univ. Georgia, Athens, Ga., USA.

Mycorrhizal development in *Liquidambar styraciflua* seedlings in soil inoculated with *Glomus etunicatus* was max. in treatments that produced max. growth. Ammonium salts were better than potassium nitrate, and ammonium nitrate was considered better than ammonium sulphate because of a lesser tendency to acidify the soil.

*0633 CHENG, Y.-H. **[The beneficial effects of endomycorrhizae on plant growth.]** In *Scientific Meeting Report 1980, Tainan District Agricultural Improvement Station.* Tainan, Taiwan. (1981) 111-115 [Ch, en, 11 ref.] Tainan District Agric. Improvement Sta., Tainan, Taiwan.

In glasshouse experiments inoculation of cotton with vesicular arbuscular mycorrhizal fungus increased vegetative growth and square production with a greater effect at low fertility. Endomycorrhizal fungi were found in soil from the rhizosphere of soyabean at 20 sites in 1979 with *Glomus clarus* as the most common sp. Inoculating soyabean cv. Tainan No.4 and Shih-shih with *G. clarus* increased top growth and pod production in glasshouse experiments.

*0634 BOWEN, G. D.; SMITH, S. E. **The effects of mycorrhizas on nitrogen uptake by plants.** 237-247 [En, 58 ref.] Div. of Soils, CSIRO, Glen Osmond, South Australia

In: CLARK, F. E.; ROSSWALL, T. (EDITORS) **Terrestrial nitrogen cycles. Processes, ecosystem strategies and management impacts.** Stockholm, Sweden; Swedish Natural Science Research Council. (1981) 714pp. ISBN 91-546-0290-4 [En, ref. at ends of papers] AR, W. Region, Colorado-Wyoming Area, Fort Collins, CO 80522, USA.

Evidence for mycorrhizal involvement in N uptake and assimilation by green plants is reviewed.

0635 CLARKE, C.; MOSSE, B. **Plant growth responses to vesicular-arbuscular mycorrhiza. XII. Field inoculation responses of barley at two soil P levels.** *New Phytologist* (1981) 87 (4) 695-703 [En, 21 ref.] Rothamsted Exp. Sta., Harpenden, Herts AL5 2JQ, UK.

The results are described of an experiment in which barley was inoculated in the field by placing 20 g of soil containing infected roots below each sowing position. *Glomus mosseae, G. fasciculatus,* and *G. caledonius* were used as inoculants and half the plots were given phosphate before sowing. Growth and infection were recorded twice during the experiment and at harvest. In the plots without added P the fresh wt. of ears was doubled by inoculation to approx. 100 g/m² irrespective of endophytes. Added P increased this more than inoculation and wt. of ears rose to 200-300 g/m². With *G. caledonius* dry wt. of ears was 35% greater than with P only, but with the other 2 it was marginally less. The results are discussed in relation to other experiments with barley and to the levels of infection throughout the experiment.

0636 COOPER, K. M.; TINKER, P. B. **Translocation and transfer of nutrients in vesicular-arbuscular mycorrhizas. IV. Effect of environmental variables on movement of phosphorus.** *New Phytologist* (1981) 88 (2) 327-339 [En, 32 ref.] Dep. of Pl. Sci., Leeds Univ., Leeds LS2 9JT, UK.

The effects of environmental variables on the movement of P_2O_5 by external hyphae of the mycorrhizal fungus *Glomus mosseae*, infecting white clover, across the barrier in soil-agar/agar split-plate cultures were studied. Increasing the transpiration rate of the host increased the total P translocated by the fungus: the max. rate obtained at full transpiration was 2.3 times that at low transpiration. Temp. also affected P transport, which was at a max. at 15-25°C, but at 5° only a small amount of P was transported. The max. P flux in the hyphae, calculated for 20-25° and a moderate host transpiration rate, was 2×10^{-9} mol/cm² s. A cytoplasmic streaming inhibitor (cytochalasin B) prevented detectable movement of P across the barrier by the fungus and consequently had inhibited either the uptake or translocation of P by the fungus. Osmotic potentials of 1-2 bar in the medium from which ^{32}P was being absorbed did not appreciably alter the rate of transport of P. It was concluded that translocation of P in the hyphae occurs normally by protoplasmic streaming but there may also be a 'bulk flow' of hyphal contents under a water potential gradient.

0637 COVEY, R. P.; KOCH, B. L.; LARSEN, H. J. **Influence of vesicular arbuscular mycorrhizae on the growth of apple and corn in low-phosphorus soil.** *Phytopathology* (1981) 71 (7) 712-715 [En, 25 ref.] Washington State Univ., Tree Fruit Res. Cent., Wenatchee, Washington 98801, USA.

Increased growth and uptake of phosphorus were observed in apple and maize grown in a fumigated low phosphorus soil in response to inoculation with *Glomus mosseae*, alone or in combination with *G. microcarpus*. In contrast, roots of these crops did not become infected after inoculation with *G. microcarpus* alone, and no growth responses were observed. Maize was protected from arsenic toxicity (up to 200 ppm As) by *G. mosseae*.

0638 CSINOS, A. *Gigaspora margarita* **Inoculation of** *Nicotiana tabacum*: **responses to fertilization.** *Canadian Journal of Botany* (1981) 59 (1) 101-103 [En, fr, 13 ref.] Dep. of Pl. Path., Georgia Univ., Coastal Plain Exp. Sta., Tifton, GA 31794, USA.

Tobacco cv. NC 2326 was inoculated at transplanting with 500 (in 1978) or 4050 (in 1979) azygospores of *G. margarita*/plant and fertilized with 3 rates of NPK. Positive growth responses to inoculation and significantly greater numbers of spores were observed in both yr only at the lowest NPK rate. In 1978, frenching occurred only at the low fertilizer rate and was significantly less in the mycorrhizal inoculated treatment than in the control.

0639 EZETA, F. N.; SANTOS, O. M. **[Importance of endomycorrhizas in the mineral nutrition of cocoa.]** Importância da endomicorriza na nutrição mineral do

cacaueiro. *Revista Brasileira de Ciência do Solo* (1981) 5 (1) 22-27 [Pt, en, 17 ref.] Centro Nacional de Pesquisa de Mandioca e Fruticultura, Cruz das Almas, Bahia, Brazil. From *Abstracts on Tropical Agriculture* 7, 37465.

Mycorrhizas for cocoa were studied in pot experiments under non-sterile and partially sterile soil conditions. Plants grown in sterile soil were stunted, showing symptoms of zinc deficiency. Plants inoculated with *Gigaspora margarita* recovered after 15 weeks while control plants remained stunted. Zn concentration as well as total Zn uptake increased after inoculating with *G. margarita*. In sterile soil, inoculation with *G. margarita* doubled total nutrient uptake compared with other mycorrhizal species.

0640 GIANINAZZI-PEARSON, V.; FARDEAU, J.-C.; ASIMI, S.; GIANINAZZI, S. Source of additional phosphorus absorbed from soil by vesicular-arbuscular mycorrhizal soybeans. *Physiologie Végétale* (1981) 19 (1) 33-43 [En, fr, 36 ref.] Station d'Amélioration des Plantes, INRA, 21034 Dijon, France.

Soyabean cv. Amsoy 71 seedlings grown in growth chambers were inoculated with the vesicular-arbuscular (VA) mycorrhiza *Glomus mosseae* or another *Glomus* sp. (E_3) in addition to *Rhizobium japonicum* and harvested after 14 wk. VA and E_3 significantly increased pod and DM yield from 0.86 and 3.64 g/plant to 2.57 and 7.92 and 3.11 and 8.22 g, resp., and significantly increased uptake of P and other nutrients from soil sol. Insoluble tricalcium phosphate added to the soil was not used but Ca phytate was hydrolysed by mycorrhizal and non-mycorrhizal plants and PO_4-ion accumulation in soil sol. was greater in the presence of mycorrhiza. It was concluded that VA mycorrhiza absorb P from the same sources as non-mycorrhizal roots and that their principal role is to exploit efficiently the pool of soil P. The advantages of introducing VA into P-deficient soils to improve utilization of P fertilizers are stressed.

*0641 HAMILTON, D. F.; GRACA, M. E. C.; VERKADE, S. D. **Critical effects of fertility on root and shoot growth of selected landscape plants.** *Journal of Arboriculture* (1981) 7 (11) 281-290 [En, 15 ref.] Agric. Exp. Sta., Purdue Univ., West Lafayette, IN 47907, USA.

Cuttings of *Cotoneaster divaricata* were treated with N (0,250 and 500 mg/litre as NH_4NO_3, applied weekly) and P (0,5 and 5 mg/litre as H_3PO_4, applied once); KCl was maintained at 150 mg/litre. Shoot and root growth were determined weekly. After 9 wk, the plants were harvested and fresh and dry wt. of roots and shoots were recorded. Application of N increased shoot but not root growth; root length/g plant tissue was reduced at 500 mg/litre (p.p.m.) N. P increased shoot growth only at the highest N concn. Seedlings of *Liriodendron tulipifera* in the greenhouse were treated with a slow release NPK fertilizer and half inoculated with *Glomus fasciculatus*. Mycorrhizal inoculation did not increase root or shoot growth without fertilizers, but the response to fertilization was significantly higher in mycorrhizal plants. Current landscape fertilization practices are reviewed.

0642 HARDIE, K.; LEYTON L. **The influence of vesicular-arbuscular mycorrhiza on growth and water relations of red clover.** *New Phytologist* (1981) 89 (4) 599-608 [En, 24 ref.] Dep. of Forestry, Oxford Univ., Oxford OX1 3RB, UK.

In pot trials with red clover cv. Redhead, inoculation with *Glomus mosseae* increased clover growth and P content and reduced the root:shoot ratio in P deficient soils. Phosphate fertilizer stimulated growth and P content to a lesser extent and did not affect the root:shoot ratio. Mycorrhizal infection increased the root conductivity and increased transpiration when water was not limiting; under water stress, transpiration was less in mycorrhizal than in nonmycorrhizal plants although wilting was more rapid because of their higher water demands. Mycorrhizal plants extracted soil moisture to lower water potentials than nonmycorrhizal plants and recovered from stress more quickly.

0643 HART, A.L.; JESSOP, D.J.; GALPIN, J. The response to phosphorus of white clover and lotus inoculated with rhizobia or given KNO3. N.Z. Journal of Agricultural Research 24 (1981) 27-32.

White clover and lotus were grown in a controlled environment at P levels of 50, 500 and 1500 ppm and either inoculated with rhizobia (N2) or given KNO3 (NO3). N2 plants of lotus and white clover had different responses to P. The response of NO3 plants to P was the same in both species. This implies that the reason(s) for the difference in response between N2 plants lie in differences in the structure and function of the symbiotic association. Lotus plants had a greater proportion of plant dry weight, P, and N in their nodules than did white clover. White clover nodules had higher relative growth rates and relative rates of accumulation of P and N than those of lotus and, in the early stages of growth, were more efficient. At 1500 ppm P. the yield of NO3 plants was greater than that of N2 plants in both species. It is suggested that the growth of N2 plants at the high P level was limited by N. These plants appear to have been unable to fix sufficient N for them to have yields similar to NO3 plants.

0644 ISLAM, R.; AYANABA, A. Effect of seed inoculation and pre-infecting cowpea (Vigna unguiculata) with Glomus mosseae on growth and seed yield of the plants under field conditions. Plant and Soil 61(3):341-350. 1981.

Vigna unguiculata, cowpea, seed inoculation, mycorrhiza, planting methods, NIGIA

Effects of inoculation with Glomus mosseae and planting method on performance of 2 cowpea cultivars were studied in field trials on a sandy loam soil. Inoculation increased percentage of infected roots, shoot dry matter and nodule yields of both cultivars (TVx1836-44G and VITA-4). Transplanting or direct sowing had no significant effect on dry matter production and nodule yield of both cultivars; transplanted VITA-4 had higher root infection % than plants from directly sown seed. Planting method had no effect on seed yield. Results indicated that initial advantage of transplanted plants was not important in determining yield.

0645 ISLAM, R.; AYANABA, A. **Growth and yield responses of cowpea and maize to inoculation with *Glomus mosseae* in sterilized soil under field conditions.** *Plant and Soil* (1981) 63 (3) 505-509 [En, 9 ref.] International Inst. of Trop. Agric., Ibadan, Nigeria.

Drenching the soil with a 49:1 dilution of commercial formaldehyde at 20 l/m² followed by covering with black polythene for 2 days significantly but temporarily decreased root infection by indigenous endophytes and increased the grain/seed yields of maize and cowpeas. Inoculation with *Glomus mosseae* increased root infection, shoot yields, plant P content and grain/seed yields.

0646 JAKOBSEN, I.; JENSEN, A. Influence of vesicular-arbuscular mycorrhiza and straw mulch on growth of barley. *Plant and Soil* (1981) 62 (1) 157-161 [En, 21 ref., 3 tab.] Univ. Aarhus, Denmark.

Plants were grown in cylinders buried in field soil. Mycorrhizal (VAM) infection was reduced in the upper soil layer by the mulch. By the 2nd harvest VAM had increased growth by 56% in the non-mulched plots through increased P uptake, but not in mulched plots. Mulch increased growth by 85% in the non-mycorrhizal plots and 28% in the mycorrhizal ones.

0647 KHAN, A. G. **Growth responses of endomycorrhizal onions in unsterilized coal waste.** *New Phytologist* (1981) 87 (2) 363-370 [En, 32 ref., 1 fig., 3 tab.] Goulburn Coll. Advanced Educ., NSW, Australia.

The effect of 4 VA endophytes on onion growth was compared in unsterilized, coal washery waste from collieries in Illawarra, NSW, Australia. Mycorrhizal onions were significantly larger with respect to all growth measurements than nonmycorrhizal controls. Different endophytes had quantitatively different effects on growth. Growth was always poorest with *Sclerocystis rubiformis* and consistently good with *Endogone* str. E_3, due to the former producing a more localized infection and the latter more extra-matrical hyphae than any other endophyte used. Among widespread spp. *Glomus mosseae* was the most efficient stimulator of plant

growth. The possible role of VA mycorrhizae in plant colonization of coal spoil areas is discussed.

0648 KORMANIK, P. P.; BRYAN, W. C.; SCHULTZ, R. C. Effect of three vesicular-arbuscular mycorrhizal fungi on sweetgum seedlings from nine mother trees. *Forest Science* (1981) 27 (2) 327-335 [En, 17 ref., 4 tab.] Inst. Mycorrhizal Res., SE Forest Exp. Sta., Athens, Ga., USA.

Mycorrhizal *Liquidambar styraciflua* seedlings in plots infested with *Glomus fasciculatus* were only slightly larger than those with mixed *Glomus* spp. or a VA mixture (*Glomus* and *Gigaspora*); seedlings from all mycorrhizal treatments were larger than non-mycorrhizal ones. From a given mother tree no significant difference in progeny ranking was observed among treatments. Differences in percentage of roots infected and intensity of infection within root segements among the 3 treatments were not correlated with seedling growth.

0649 KRISHNA, K. R.; SURESH, H. M.; SYAMSUNDER, J.; BAGYARAJ, D. J. Changes in the leaves of finger millet due to VA mycorrhizal infection. *New Phytologist* (1981) 87 (4) 717-722 [En, 9 ref.] Dep. of Agric. Microbiol., Univ. of Agric. Sci., Bangalore 560 065, Karnataka, India.

Anatomical and histochemical differences in the leaves of non-mycorrhizal and mycorrhizal *Eleusine coracana* were studied. Striking increases in the thickness of leaves, size of midrib vein, major vein, minor vein, last vein, motor cells, mesophyll cells and number of plastids were noticed in the leaves of mycorrhizal plants. The leaves of mycorrhizal plants contained higher amounts of insoluble polysaccharides and insoluble proteins. These features are discussed from the view point of the effect of endomycorrhizas on the stimulation of plant growth.

0650 KRISHNA, K. R.; BAGYARAJ, D. J. Note on the effect of VA mycorrhiza and soluble phosphate fertilizer on sorghum. *Indian Journal of Agricultural Sciences* (1981) 51 (9) 688-690 [En, 14 ref., 3 tab.] Univ. Agric. Sci., Gandhi Krishi Vignana Kendra, Bangalore, India.

In pots with sorghum seedlings autoclaved red sandy loam soil deficient in P was inoculated with extramatrical chlamydospores and *Panicum maximum* root pieces infected by *Glomus fasciculatus*. Mycorrhizal plants were taller at lower levels of added soluble P (no P or 50% of the recommended dose), growth of mycorrhizal and non-mycorrhizal plants being similar at higher levels. Mycorrhizal plants accumulated more P in roots and shoots than non-mycorrhizal plants. This difference decreased with an increase in added P. In roots and shoots the P content of mycorrhizal plants treated with 50% of the recommended P level was almost equal to that of non-mycorrhizal plants receiving the full amount of P.

0651 MANJUNATH, A.; BAGYARAJ, D. J. Components of VA mycorrhizal inoculum and their effects on growth of onion. *New Phytologist* (1981) 87 (2) 355-361 [En, 7 ref.] University of Agricultural Sciences, G.K.V.K. Campus, Bangalore-560065, India.

Application of mycorrhizal inoculum containing extramatrical chlamydospores and infected root segments containing mycelium, vesicles and arbuscules increased onion cv. Chikkaballapur red shoot dry weight from 274 mg/plant in uninoculated sterilized soil to 593 mg/plant, and root dry weight from 99.7 to 195.5 mg/plant. P contents were increased from 120.6 to 253.9 µg/shoot and from 51.4 to 75.8 µg/root, respectively. The increases in root and shoot weights and P contents were attributed mainly to chlamydospore application.

*0652 MISHRA, R. R.; SHARMA, G. D.; KHARSYNTIEW, I. B. Response of maize to different inoculum densities of vesicular arbuscular mycorrhizal endophytes. *Experientia* (1981) 37 (6) 568-569 [En, 13 ref., 2 tab.] North Eastern Hill Univ., Shillong, Assam, India.

The effect of inoculum density on growth and development was investigated in sterilized soil in the glasshouse. Mycorrhizal plants were robust and produced 3 times more dry wt. than non-mycorrhizal plants. Forty or more endophytes/plant produced the highest mycorrhizal association and max. growth of plants. Uninoculated plants were chlorotic.

*0653 MOSSE, B.; TINKER, P.B. 1981. Effects of mycorrhizas on nutrition of higher plants. CRC Handbook of Nutrition and Food, Critical Reviews Rubber Co., Rockville, MD. (In press).

0654 MUROMTSEV, G.S.; YAKOBI, L.M.; MARSHUNOVA, G.N.; FEDOROVA, L.N. Increase in oat-grain yield and phosphorus content under the action of endomycorrhizal fungi. Sov. Agric Sci. (6)·1-4. 1981.

It has been demonstrated that it is possible in principle for the phosphorus uptake of an oat plant to be intensified by infection of its roots system with endomycorrhizal fungi when it is cultivated in a soil with a low mobile-phosphate content. Mycorrhizization has been found to significantly increase the coefficient of phosphorus assimilation by oat plants from low-solubility tricalcium phosphate.

0655 PLENCHETTE, C.; FURLAN, V.; FORTIN, J. A. Growth stimulation of apple trees in unsterilized soil under field conditions with VA mycorrhiza inoculation. *Canadian Journal of Botany* (1981) 59 (11) 2003-2008 [En, fr, 33 ref., 1 fig., 4 tab.] Minist. Agric. Pêch. Aliment., Ste-Foy, Que., Canada.

Glasshouse-grown seedlings were inoculated with endomycorrhizal roots originating from a nursery-grown *Fraxinus* [ash] before planting out in unsterilized field soil. Uninoculated seedlings in soil, either unamended or amended with 100 kg/ha P as superphosphate, were controls. Shoot length, leaf surface, root vol., stem diam. and dry mass of inoculated plants were all greater than in both fertilized and unfertilized controls. No significant difference could be observed in foliar mineral content but the level of N, P, Ca, Cu and possibly K was higher in the roots of inoculated plants. Intracortical vesicles were absent or very uncommon in the roots of both fertilized and unfertilized controls, whereas they were abundant in roots of inoculated plants. It was concluded that seedling inoculation before field planting in unsterilized P-deficient soil could lead to a significant growth stimulation in spite of the presence of a natural endomycorrhizal flora.

0656 POWELL, C. L. Inoculation of barley with efficient mycorrhizal fungi stimulates seed yield. *Plant and Soil* (1981) 59 (3) 487-489 [En, 21 ref., 1 tab.] Ruakura Soil Plant Res. Sta., Hamilton, New Zealand.

Barley was inoculated in the seed bed with a mixture of *Glomus mosseae, G. fasciculatus* and *Gigaspora margarita* or with the indigenous mycorrhizal fungi. The introduced fungi stimulated seed yield by 27% and seed P content by 35%.

0657 POWELL, C. L. Phosphate response curves of mycorrhizal and non-mycorrhizal plants I. Responses to superphosphate. *New Zealand Journal of Agricultural Research* (1980) 23 (2) 225-231 [En, 16 ref., 6 fig., 4 tab.] Ruakura Soil Pl. Res. Sta., Minist. Agric. Fisheries, Hamilton, New Zealand.

Clover plants were grown with or without mycorrhiza (*Gigaspora margarita* or *Glomus tenuis*) in 2 soils fertilized with superphosphate at 0-280 mg P/610 ml pot, (0-248 kg/ha). After 175 days' growth in Dunmore soil, mycorrhizal plants significantly outyielded non-mycorrhizal controls at fertilizer levels up to 200 mg P/pot. Mycorrhizal growth responses were smaller in Waingaroo soil, but after 91 days the control and mycorrhizal plants showed 80% of max. shoot growth at 125 and 50 mg P/pot, respectively. Recovery of phosphate fertilizer was low, 5-20% in Dunmore and 6-25% in Waingaroo soil.

0658 POWELL, C. L.; METCALFE, D. M.; BUWALDA, J. G.; WALLER, J. E. Phosphate response curves of mycorrhizal and non-mycorrhizal plants II. Responses to rock phosphates. *New Zealand Journal of Agricultural Research* (1980) 23 (4) 477-482 [En, 20 ref., 2 fig., 3 tab. See *RPP 60*, 3016] Ruakura Soil Pl. Res. Sta., Minist. Agric. Fish., Hamilton, New Zealand.

Mycorrhizal and non-mycorrhizal white clover plants were grown in a sterilized P-deficient soil and fertilized with either pelleted Christmas Island 'C' grade phosphate rock or with powdered or pelleted Chatham Rise phosphate rock at 8 rates (0-2.8g/pot). In another experiment, ryegrass (*Lolium perenne*) plants were fertilized with pelleted Chatham Rise rock phosphate. Mycorrhizal inoculation (*Glomus fasciculatus, G. tenuis*) greatly increased shoot growth and P uptake compared with that of non-mycorrhizal plants at

fertilizer rates of up to 1.4g/pot. The recovery of P fertilizer from soil was generally low, with max. values of 11.3 and 17.2% in soil fertilized with pelleted Christmas Island and Chatham Rise rock phosphates, respectively, and a max. of 48% with powdered Chatham Rise rock phosphate.

0659 POWELL, C. LL. **Effect of inoculum rate on mycorrhizal growth responses in pot-grown onion and clover.** *Plant and Soil* (1981) 62 (2) 231-239 [En, 21 ref.] Ruakura Soil and Plant Research Station, Ministry of Agriculture and Fisheries, Private Bag, Hamilton, New Zealand.

White clover and onion were grown from seed in pots of sandy loam above pads of mycorrhizal inoculum soil supplied at rates equivalent to 250-2000 kg/ha, and harvested on four occasions. In sterilized soil increasing inoculum rates increased the onset and size of the mycorrhizal growth response of white clover. In unsterilized soil the indigenous mycorrhizal fungi greatly stimulated growth of both clover and onion. All mycorrhizal inoculum rates further stimulated shoot growth in onion (92% increase over all harvests), while only the highest inoculum rate significantly stimulated clover growth (52% increase).

0660 REDENTE, E. F.; REEVES, F. B. **Interactions between vesicular-arbuscular mycorrhiza and *Rhizobium* and their effect on sweetvetch growth.** *Soil Science* (1981) 132 (6) 410-415 [En, 24 ref.] Department of Range Science, Colorado State University, Fort Collins, Colorado 80523, USA.

The effect and interactions of *Glomus fasciculatus* and *Rhizobium* sp. on the growth of sweetvetch (*Hedysarum boreale*) were studied in order to determine the dependence of the plant on these symbionts.

Plants were grown under controlled conditions in sterilized soil or sterilized soil infested with *G. fasciculatus*, *Rhizobium*, or a combination of the symbionts. Following a 12-week growth period, above- and belowground plant production, percent mycorrhizal infection, nitrogen and phosphorus content, and rate of nitrogen fixation were quantified. Plants inoculated with either a combination of mycorrhizal fungi and rhizobia or mycorrhizal fungi alone grew taller and produced more aboveground plant material than plants infected with rhizobia alone or control plants. The presence of rhizobia increased the nitrogen content of the aboveground foliage, and inoculation with mycorrhizal fungi increased the phosphporus content. Mycorrhizal fungi and rhizobia also were found to be synergistic with respect to nitrogen fixation rates and mycorrhizal infection levels. The results point to a need for having appropriate inocula for normal plant growth and nitrogen fixation when growing sweetvetch on disturbed lands.

0661 ROSE, S. L.; YOUNGBERG, C. T. **Tripartite associations in snowbrush (*Ceanothus velutinus*): effect of vesicular-arbuscular mycorrhizae on growth, nodulation, and nitrogen fixation.** *Canadian Journal of Botany* (1981) 59 (1) 34-39 [En, fr, 29 ref., 1 fig., 3 tab.] Oregon State Univ., Corvallis, USA.

Symbiotic associations were established between N-fixing nonleguminous (actinorrhizal) *C. velutinus* seedlings and 2 categories of micro-organisms: vesicular-arbuscular mycorrhizae and a filamentous actinomycete which induces formation of nodules where N fixation occurs. The mycorrhizal fungus is both inter- and intracellular within the root tissue and may be found within the nodules. Dually infected plants showed increases in total dry wt. of shoots and roots, number of nodules and wt. of nodular tissue, as well as higher levels of N, Ca and P, and an increase in nitrogenase activity as measured by acetylene reduction.

*0662 SCHENCK, N.C.; SMITH, G.S. 1981. Responses of six species of VA mycorrhizal fungi and their effects on soybean at four soil temperatures. *In* Fifth North American Conference on Mycorrhizae, Quebec, Aug. 16-21. 1981. Abst.

In a greenhouse experiment, six species of VA mycorrhizal fungi were compared for their response on soybean (*Glycine max*) at four soil temperatures (18, 24, 30, 36 C). Greenhouse air temperatures were not controlled and varied from 26 at night to 33 C during the day with occasional extremes ranging from 21 to 40 C. Fifty spores were added 2.5 cm below the seed in each plastic pot which contained 2 kg of Arredondo fine sand (pH 5.5, 38 ppm P). There were three replicate pots with one soybean plant for each fungal species at each soil temperature and the experiment was repeated twice. The mean values for all fungus and plant parameters in three tests were generally greatest at 30 C and lowest at 18 C soil temperatures. Soybean flower numbers, pod set, and seed yield varied considerably in the three tests but plant height was little affected by soil temperature or fungal species. The nonmycorrhizal control plants were lowest in shoot and root weights at 36 C but they were usually superior to plants colonized by *Acaulospora laevis*, *Gigaspora pellucida*, and *Glomus clarus* at 18, 24, and 30 C. Root and shoot weights of plants colonized by *Glomus mosseae*, *C. claroideus*, and *Gigaspora gregaria* were usually superior to the nonmycorrhizal plants at all soil temperatures. Spore size was generally less at soil temperatures of 30 cm than 24 C but this varied with fungal species and test. Four species produced the greatest number of spores per gram of colonized root at 36 C while *G. pellucida* and *A. laevis* reached their maximum for this parameter at 30 C. *Gigaspora gregaria* attained maximum root colonization at 36 C while *Glomus mosseae* attained its maximum at 18 C. *Glomus claroideus* and *A. laevis* were the only species with maximum root colonization and sporulation occurring at the same temperature, 30 C. The number of spores per gram of colonized root was a more consistent measure of fungus response to temperature than either indicate considerable variation in temperature response to the various soyben-fungus combinations.

*0663 SCHUBERT, A.; BONFANTE-FASOLO, P.; FONTANA, A. **[Interactions between vesicular-arbuscular mycorrhiza and fertilizer phosphorus in grapevine.]** Interazioni tra micorrizia vescicolo-arbuscolare e apporti di fosforo nella vite. *Allionia* (1980-81) 24, 19-25 [It, en, 21 ref.] Cattedra di Viticoltura dell'Università di Torino, Italy.

The development of mycorrhizal grapevine plants, grown at different levels of soluble phosphate, was studied in comparison with that shown by non-mycorrhizal plants. Higher fungal colonization (percentage and intensity) and growth stimulation were clearly shown in a phosphate-poor soil by the mycorrhizal plants, whilst the fungal positive effect became less evident in soils containing additional P. Fungal colonization decreased after addition of P.

0664 SCHULTZ, R.C.; KORMANIK, P.P.; BRYAN, W.C. Effects of fertilization and vesicular-arbuscular mycorrhizal inoculation on growth of hardwood seedlings. Soil Sci. Am. J. 45:961-965. 1981.

Eight hardwood species were grown in fumigated soil without vesicular-arbuscular mycorrhiza (VAM) or in soil infested with a mixture of Glumus mosseae and Glomus etunicatus. Three fertilizer treatments of 140,560 and 1,120 kg/ha of 10-10-10 fertilizer were establish in combination with the two mycorrhizal treatments. Ten equal applications of NH_4NO_3, totaling 1,680 kg/ha, were added to all the treatment plots during the growing season. For six of the eight species, the VAM seedlings showed grater height and diameter growth and dry weight production than nonmycorrhizal seedlings. Sugar maple (Acer saccharum Marsh.) and walnut (Juglans nigra L.) displayed no height growth differences. Only boxelder (Acer negundo L.) of the inoculated seedlings, consistently responded to increases in fertilizer level. Nonmycorrhizal seedlings generally showed increased growth with increased fertilizer applications. The growth of the nonmycorrhizal seedlings at the higher fertilizer levels was not sufficient to produce plantable seedlings for artificial regeneration. A difference in host preference for the Glomus spp. symbionts is suggested by the large difference in infection between species. Infection values varied from

a high of about 80% for sycamore (Plantanus occidentalis L.) green ash (Fraxinus pennsylvanica Marsh.) and boxelder to a low of 40% for sugar maple and sweetgum. The growth data suggest that high quality seedling stock of most of these hardwood tree species can be obtained in nurseries as long as cultural practices in the nursery encourage VAM development.

*0665 SHANMUGAM, N.; BABU, R. C.; THALAMUTHU, C. Studies on the response of acid lime (*Citrus aurantifolia* Swingl.) to vesicular arbuscular mycorrhizae. *Current Science* (1981) 50 (17) 772-773 [En, 5 ref., 1 tab.] Tamil Nadu Agric. Univ., Hort. Res Sta., Periyakulam, India.

Growth parameters in 1-yr-old seedlings 6 months after inoculation with *Glomus mosseae* and *G. etunicatus* are tabulated. Both VA mycorrhizal fungi significantly increased shoot height, stem thickness, leaf number, root length and root and shoot weight. Top inoculation (near the soil surface) was more effective than bottom (in the root zone).

0666 SMITH, S. E.; SMITH, F. A.; NICHOLAS, D. J. D. Effects of endomycorrhizal infection on phosphate and cation uptake by *Trifolium subterraneum*. *Plant and Soil* (1981) 63 (1) 57-64 [En, 7 ref.] Dep. of Agric. Biochem., Adelaide Univ., Adelaide, S.A., Australia 5001.

In experiments with subterranean clover cv. Mt. Barker, mycorrhizal fungi increased the rate of P uptake at a range of soil P levels even when mycorrhizal growth increases no longer occurred. The fungi appeared to play a direct part in uptake and translocation of P to the roots; effects on nodulation and N fixation were largely indirect. Interactions between P nutrition and cation uptake were also indirect and could be modified by the pattern of N assimilation.

0667 SMITH, F. A.; SMITH, S. E. Mycorrmizal infection and growth of *Trifolium subterraneum*: comparison of natural and artifical inocula. *New Phytologist* (1981) 88 (2) 311-325 [En, 13 ref.] Dep. of Bot., Adelaide Univ., Adelaide, S.A., Australia 5001.

Mycorrhizal infection and growth of subterranean clover were measured, using plants grown in soil/sand mixtures containing natural inoculum, and plants grown in sterilized mixtures to which mycorrhizal roots were added as an artificial inoculum. As control treatments, plants were grown in sterilized mixtures without the addition of roots, and in mixtures with the addition of non-mycorrhizal roots. In 1 experiment, the 2 methods of inoculation resulted in similar increases in leaf numbers and in wt. In the 2nd experiment, the growth responses of plants artificially inoculated were less than those of plants with natural inoculum and this was related to delayed mycorrhizal infection. In the 3rd experiment, mycorrhizal infection was again delayed when artificial inoculum was used; this experiment was terminated before increases in wt. occurred. The extent and location of mycorrhizal infection from artificial inoculum depended on the location (in the pots) of the added inoculum. The advantages and disadvantages of these methods of studying mycorrhizal infection are assessed in relation to the different aims of investigations of the mycorrhizal symbiosis.

0668 SMITH, F. A.; SMITH, S. E. Mycorrhizal infection and growth of *Trifolium subterraneum*: use of sterilized soil as a control treatment. *New Phytologist* (1981) 88 (2) 299-309 [En, 15 ref.] Dep. of Bot., Adelaide Univ., Adelaide, S.A., Australia 5001.

Effects of mycorrhizal infection on the growth of subterranean clover were studied by comparing plants grown in sterilized soil/sand mixtures with plants grown in untreated mixtures. The original soil contained a high level of endomycorrhizal inoculum. Plants in the untreated mixtures became significantly larger than plants in the sterilized mixtures about 4 wk after planting. This rsponse was associated with rapid infection by vesicular-arbusecular mycorrhizal fungi; it still occurred when nitrate replaced N_2 as the N source. Addition of soluble P_2O_5 enhanced the growth of the non-mycorrhizal plants to a level similar to that of the mycorrhizal plants. Mixing sterilized and untreated soil did not depress mycorrhizal infection or growth. It was concluded that the growth difference was a classic mycorrhizal response, and did not reflect toxic effects of soil sterilization.

0669 STRIBLEY, D.P.; TINKER, P.B.; SNELLGROVE, R.C. Phosphorus and carbon relationships in plants infected with besicolar-arbuscular mycorrhizal fungi. J. Science Food and Agriculture 32:627-628. 1981.

Vesicular-arbuscular mycorrhizas supply phosphorus to the host plants at a greater rate than simple roots, but the mycosymbiant requires a supply of carbon from the host plant. The benefit to the host of the incressed phosphorus supply depends on the phosphate-deficiency status of the host and on the speed and extent of infection. In leeks, increases in mean relative growth rate of up to 30% have been observed, with 2.74-fold increases in the concentration of phosphorus in the tissues. Plants with mycorrhizal infection very often have greater concentrations of phosphorus than similar-sized plants without infection, but which have received phosphorus fertiliser. This may be connected with the carbon demand of the mycorrhizas.

*0670 THAREJA, M.L.; JALALI, B.L. Growth and development of chickpea (Cicer arietinum L.) in response to vesicular-arbuscular mycorrhizal inoculation in rock-phosphate amended soils Chickpea Newsletter. (ICRISAT) (4):19-21. 1981.

Cicer arietinum, chickpea, fertilizer response, mycorrhiza, phosphorus source/rock phosphate, plant growth & development, INDIA, Haryana

Chickpea was grown on three different test soils (P-deficient sterilized and non-sterilized and P-rich non-sterilized) which were treated with 0.5% rock phosphate and 0.5% rock phosphate + mycorrhiza in addition to a control. Root and shoot dry weights were greater in the P-deficient than in the P-rich soils. The response to rock phosphate in the P-deficient soil was significantly increased by inoculation with mycorrhiza but only for the sterilized test soil. In the P-rich soil, rock phosphate only gave a response in combination with mycorrhiza inoculation.

*0671 WALLACE, L.L. Growth, morphology and gas exchange of mycorrhizal and non-mycorrhizal Pannicum coloratum L, a C4 grass species, under different clipping and fertilization regimes. Oecologia, 49: 272-278 (1981)

0672 YOST, R. S. Influence of VA mycorrhizae on early growth and P nutrition of *Leucaena*. *Leucaena Research Reports* (1981) 2, 84 [En, 2 ref.] Dep. of Agron. and Soil Sci., Hawaii Univ., Honolulu, HI 96822, USA.

In trials in which *L. leucocephala* was grown in soils fumigated with methyl bromide to prevent the formation of vesicular arbuscular mycorrhizae and grown at various soil P levels from 0.003 to 1.600 mg solution P/l, fumigation decreased DM accumulation at up to 0.050 mg solution P/l but increased it at higher soil P levels.

0673 ZANDSTRA, B.H.; FURUTANI, S.C.; NELSEN, C.E. Interaction of mycorrhizae and phosphorus levels on onions on muck soil (Allium cepa.) 78th Annual Meeting of the American Society for Horticulatural Science, Atlanta, Ga., USA Aug. 9-14, 1981. Hortscience 16(3 Sect.2):403-404. 1981.

Onions (Allium cepa, L.) were growun in 2 muck soil fields, with available P levels of 3 kg/ha and 97 kg/ha, respectively, which contained an indigenous population of mycorrhizal spores (Glomus sp.) Treatments included 4 levels of added P (0,30, 97, 193, kg/ha P) and inoculum containing spores of the mycorrhizal fungus (Glomus etunicatus). In the low P field bulb weight increased with added P. Root infection and spore numbers were negatively correlated with added P. Bulb weight and spore numbers increased when mycorrhizal inoculum was added to the soil. In the high P field there were no responses in bulb weight, root infection, or spore numbers to either added P or added inoculum. Root infection data from both fields indicated that there was

a threshold level of soil P below which infection was high and above which infection was low.

0674 ASIMI, S.; GIANINAZZI-PEARSON, V.; GIANINAZZI, S. Influence of increasing soil phosphorus levels on interactions between vesicular-arbuscular mycorrhizae and *Rhizobium* in soybeans. *Canadian Journal of Botany* (1980) 58 (20) 2200-2205 [En, fr, 29 ref., 4 fig., 3 tab.] Inst. Natn. Recherche Agronomique, Dijon, France.

The beneficial effects of inoculating nodulated plants, growing in unamended sterile soil, with *Glomus mosseae* include improved P uptake, lower root:shoot ratio and better nodulation with higher nitrogenase activity. Addition of 0.25 g KH_2PO_4/kg to the soil eliminated the mycorrhizal effect on plant growth but not on nodule formation and nitrogenase activity. Effects on nodulation were, however, eliminated with 0.5 g KH_2PO_4, and on nitrogenase activity with 1 g/kg. These higher levels of phosphate fertilization considerably diminished infection and in particular fungal spread within the roots.

0675 BAGYARAJ, D. J.; MANJUNATH, A. Response of crop plants to VA mycorrhizal inoculation in an unsterile Indian soil. *New Phytologist* (1980) 85 (1) 33-36 [En, 13 ref.] Dep. of Agric. Microbiol., Univ. of Agric. Sci., Bangalore 560 065, Karnataka India.

Cotton, cowpea and *Eleusine coracana* grown in an unsterile Indian soil low in available P were inoculated with the VA mycorrhizal fungus *Glomus fasciculatus*. Inoculation increased mycorrhizal infection, shoot and root dry wt. and top P and Zn contents but did not effect Mn uptake.

*0676 BAGYARAJ, D. J.; MANJUNATH, A.; KULKARNI, J. H.; VENUGOPAL, N. Effect of grass-legume association and legume inoculation on native VA mycorrhiza and grass yield. *Current Research* (1980) 9 (7) 123-125 [En, 9 ref.] Dep. of Agric. Microbiol., Univ. of Agric. Sci., GKVK Campus, Bangalore 560 065, Karnataka, India.

The cultivation of *Pennisetum purpureum* × *P. typhoides* [=*P. americanum*] hybrid NB-21 in mixture with 5 legumes (*Macroptilium atropurpureum*, *Glycine wightii*, *Desmodium uncinatum*, *Mimosa invisa* or *Lotononis bainesii*) grown from inoculated or uninoculated seeds had no significant effect on DM yield and N contents of hybrid NB-21, but significantly increased the P content and spore count of vesicular-arbuscular mycorrhizae in the rhizosphere of NB-21; mixture of NB-21 with *M. atropurpureum* grown from inoculated seed was the most effective.

0677 BAREA, J. M.; ESCUDERO, J. L.; AGUILAR, C. A.-G. DE Effects of introduced and indigenous VA mycorrhizal fungi on nodulation, growth and nutrition of *Medicago sativa* in phosphate-fixing soils as affected by P fertilizers. *Plant and Soil* (1980) 54 (2) 283-296 [En, 32 ref.] Estación Experimental del Zaidín, CSIC, Granada, Spain.

Lucerne was grown in 2 P-fixing soils which received soluble or rock phosphate. The effects of the inoculation with *Glomus mosseae* on plant nutrition and nodulation were studied. The introduced vesicular-arbuscular (VA) fungi became successfully established and improved the degree of infection over the level achieved by native endophytes. In all experimental conditions tested, plant dry wt., the total uptake of N and P and nodulation by *Rhizobium meliloti* were increased by mycorrhizal inoculation. The size of the increase was inversely correlated with soluble P content in the soil. Mycorrhization, enhanced by introduction of suitable VA fungi, had similar effects to that of the dose of soluble P tested. Indigenous and native endophytes cooperated in these effects. Results are discussed in terms of reducing the input of soluble P fertilizer to P-fixing soils and the possibility of restoring the P stock using a more rational supply of soluble P that allows cooperation with VA fungi or by the use of less soluble and less expensive forms of P fertilizers.

0678 BERTHET, Y.; GIANINAZZI-PEARSON, V.; GIANINAZZI, S. [Development and expression of endomycorrhizal associations in wheat. 1. Evidence of a varietal effect.] Développement et expression de l'association endomycorhizienne chez le Blé. 1. Mise en evidence d'un effet variétal. *Annales de l'Amélioration des Plantes* (1980) 30 (1) 67-78 [Fr, en, 31 ref.] Station d'Amélioration des Plantes, INRA, 21034 Dijon, France.

Seedlings of 20 wheat cv. (*Triticum aestivum* and *T. durum*) were inoculated with the vesicular-arbuscular (VA) mycorrhizal fungus *Glomus mosseae* when the coleoptiles were 1 cm long and were grown in growth chambers or greenhouse conditions until maturity. Significant increases in grain yield occurred in cv. Azteca and Champlein; significant decreases occurred in cv. Clairon and Wells, while in cv. Kolibri and Pascal there was little effect. Straw yields were increased in cv. Sirius and decreased in cv. César, Chrismar and Wells by mycorrhizal inoculation. Level of infection and grain yields were not correlated. In trials with 3 isogenic lines of cv. Centana, mycorrhizal infection and yield were modified by the presence or absence of a dwarfing gene from cv. Norin 10.

0679 BLACK, R. The role of mycorrhizal symbiosis in the nutrition of tropical plants. *In:* Tropical Mycorrhiza Research (Ed. by P. Mikola) Oxford Univ. Press Oxford, England. pp.191-202 (1980).

0680 BUWALDA, J. G. Growth of a clover-ryegrass association with vesicular arbuscular mycorrhizas. *New Zealand Journal of Agricultural Research* (1980) 23 (3) 378-383 [En, 16 ref.] Ruakura Soil and Plant Res. Sta., MAF, Hamilton, New Zealand.

White clover cv. Grasslands Huia and perennial ryegrass cv. Grasslands Ruanui were grown together in pots in an open screenhouse with or without vesicular-arbuscular mycorrhizas at a range of soil P and N levels. Mycorrhizal infection significantly increased clover shoot yields at all levels of P and N, and ryegrass shoot yields were generally depressed. The competitive advantage of mycorrhizal clover was reduced at higher P and N levels, suggesting that the supply of P and N to clover and ryegrass, influenced by mycorrhizal infection, is a major influence on their relative growth.

0681 CARLING, D. E.; BROWN, M. F. Relative effect of vesicular-arbuscular mycorrhizal fungi on the growth and yield of soybeans. *Soil Science Society of America Journal* (1980) 44 (3) 528-532 [En, 22 ref.] Virginia Truck & Ornamentals Res. Stn., 1444 Diamond Springs Road, Virginia Beach, VA 23455, USA.

The growth and yield response of greenhouse-grown soybean plants to colonization by 19 isolates (including 6 *Glomus* and 3 *Gigaspora* species) of vesicular-arbuscular mycorrhizal fungi is reported. Each isolate was evaluated in a high (169 kg/ha Bray-I P_2O_5) and a low (50 kg/ha Bray-I P_2O_5) fertility soil. Colonization by most *Glomus* isolates significantly increased plant top dry weight and seed yields, and of these isolates most produced larger increases in dry weight in the low fertility soil. Colonization by five of the *Gigaspora* isolates did not significantly affect top dry weight and seed yield in the high or low fertility soil. The value of comparative testing of species is discussed.

0682 CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL Annual Report, Cassava Program 1979. Cali, Colombia; CIAT. (1980) 93pp. [En].

Soils and plant nutrition. Effect of mycorrhiza on P uptake and plant growth. 67-69 [En].

In pot experiments in Queensland, Australia, using a high P fixing Oxisol, DM production of cassava cv. M Aus 10 grown for 8 wk on sterilized soil without or with mycorrhizal inoculation and given P at 8 rates from 0 to 16 t/ha was 11.4 and 29.1 g/plant, resp., with 1 t P/ha and did not differ significantly at P rates <0.5 or >4 t P/ha. P uptake/plant was markedly greater on inoculated than on uninoculated soil at P rates <8 t/ha. Growth and P uptake was generally greater and the effect of mycorrhizal inoculation always lower on unsterilized than on sterilized soil. In sol. culture experiments, 8 cassava cv. and 1 maize, rice, bean [*Phaseolus vulgaris*] and *Vigna unguiculata* cv. were grown without or with mycorrhizal inoculation and 0.1, 1, 10 or 100 μM P. Inoculation increased cassava root and top P content with the lowest P rate, markedly increased DM production with 1 μM P and had no effect at the higher P rates at which rates roots were not infected with mycorrhiza. The other spp. did not become infected with mycorrhiza and reached their highest yields at 1 μM P, whereas cassava needed 10 μM P for max. yield.

0683 CRUSH, J. R.; CARADUS, J. R. Effect of mycorrhizas on growth of some white clovers. *New Zealand Journal of Agricultural Research* (1980) 23 (2) 233-237 [En, 13 ref., 2 fig., 2 tab.] Grasslands Div., DSIR, Palmerston North, New Zealand.

Phosphate response curves for mycorrhizal and non-

mycorrhizal plants of 10 cvs. were determined in the glasshouse. In contrast to the result of raising soil available P, the effects of mycorrhizas on plant growth were small and confined to the lowest soil phosphate treatments used. Mycorrhiza × clover type interactions were rare for any of the response parameters recorded and root morphology had little influence on mycotrophy. The results suggest that mycorrhizal relationships may not be important in clover selection that aims at identifying plants which use soil phosphate efficiently.

0684 EZETA, F.N.; SANTOS, O.M. Beneficio da introducao de endomicorriza eficiente na utilizacao de nutrientes em latossolos do sul da Bahia. (Beneficial effect of the introduction of effeicient endomycorrhiza on nutrient utilization in Latosols of Southern Bahia). R. Bras. Ci. Solo 4:13-17. 1980.
The efficiency of mycorrhizal symbiosis formed between Gigaspora margarita and the roots of Vigna unguiculata, in relation to growth and nutrient uptake, was evaluated under greenhouse conditions. Plant growth and nutrient uptake were greater with Gigaspora margarita than with native fungal symbionts. Inoculation increased absorption of all nutrients but potassium whose concentration in the tissue of inoculated plants decreased by the dilution effect resulting from improved growth. The indigenous species infected the roots with the same intensity as the introduced species, however the latter resulted in higher efficiency of nutrient utilization. Although phosphorus was not the only one element whose absorption was enhanced by inoculation the results indicate that the increase in growth was derived mainly from a better utilization of soil and fertilizer phosphorus. Preliminary studies with seven species of vesicular arbuscular endophytes showed that Gigaspora margarita. Gigaspora heterogama and Glomus macrocarpus were those best adapted to the soil conditions of the "Tabuleiros" of Southern Bahia

0685 FOGEL, R. Mycorrhizae and nutrient cycling in natural forest ecosystems. *New Phytologist* (1980) 86 (2) 199-212 [En, 78 ref., 6 tab.] Univ. Michigan Herbarium, Ann Arbor, USA.

Although widespread and important in the mineral nutrition of almost all plants, mycorrhizae have not been included in nutrient cycling studies of forest ecosystems. Measurements of biomass or surface area and data on mycorrhizal production, senescence and decomposition are required. A recent study indicated that mycorrhizae account for 50% of the annual throughput of biomass and for 43% of the N released annually in a Douglas fir (*Pseudotsuga menziesii*) ecosystem. These transfers are 5 times larger than the releases from litter fall or litter decomposition.

0686 HALL, I. R. Growth of *Lotus pedunculatus* Cav. in an eroded soil containing soil pellets infested with endomycorrhizal fungi. *New Zealand Journal of Agricultural Research* (1980) 23 (1) 103-105 [En, 12 ref., 2 tab.] Invermay Agric. Res. Cent., Minist. Agric. Fisheries, Mosgiel, New Zealand.

In a field experiment on an eroded soil the cv. Grasslands Maku was successfully inoculated with *Glomus fasciculatus* using infested soil pellets [*RPP 58*, 5705]. The treatment increased plant growth considerably. The non-mycorrhizal pellet also increased growth and possible explanations for this are mentioned. Unlike the earlier results [*RPP 59*, 1600] there was no suggestion that mycorrhiza stimulated growth less with the application of 50 kg P/ha than with 10 kg P/ha.

0687 HEAP, A. J.; NEWMAN, E. I. The influence of vesicular-arbuscular mycorrhizas on phosphorus transfer between plants. *New Phytologist* (1980) 85 (2) 173-179 [En, 10 ref., 1 fig., 2 tab.] Bristol Univ., UK.

In 6 pot experiments *Lolium perenne* and *Plantago lanceolata* were grown alone or together and *L. perenne* was grown with *Trifolium repens* [white clover]. In 5, sterile soil was used with or without mycorrhizal reinoculation. The shoots of some plants in each pot (donors) were injected with ^{32}P and removed a week later; the remaining plants (receivers) were harvested after a further week and assessed for ^{32}P. In all cases some ^{32}P was transferred to the shoots of both mycorrhizal and nonmycorrhizal receiver plants but transfer was 2-8 times greater in the former than in the latter. There was no clear difference between the different spp. combinations in enhancement of ^{32}P transfer by mycorrhizae. The results show that mycorrhizae can increase P transport between plants but do not show whether there is direct transport via interconnecting hyphae or whether the P must leave the donor root before being taken up by the mycorrhizal hyphae.

0688 HIRREL, M. C.; GERDEMANN, J. W. Improved growth of onion and bell pepper in saline soils by two vesicular-arbuscular mycorrhizal fungi. *Soil Science Society of America Journal* (1980) 44 (3) 654-655 [En, 7 ref.] Dep. of Plant Pathology, Univ. of Illinois, Urbana, IL 61801, USA.

The effect of 5 levels of salinity on the growth of onions and bell peppers inoculated with the mycorrhizal fungi, *Glomus fasciculatus* or *Gigaspora margarita*, was compared to uninoculated nonmycorrhizal controls. In soils with saturation extracts (ECe) of 1, 3, 4, 6, and 12 mmho/cm, mycorrhizal plants consistently outweighed the controls. Plants inoculated with *Gl. fasciculatus*, also, grew larger than those inoculated with *Gi. margarita*. In both onion and bell pepper, the effect of salinity on decreasing percent fresh weight was greatest in the nonmycorrhizal controls. Also, in bell pepper, decreases in percent fresh weights were less with plants infected by *Gl. fasciculatus* than with those infected by *Gi. margarita*. Thus, plants infected with mycorrhizal fungi may be more salt tolerant than uninfected nonmycorrhizal plants.

0689 HOWELER, R.H. The effect of mycorrhizal inoculation on the phosphorus nutrition of cassava. *In* Cassava Cultural Practices. Ed. by E.J. Weber; J.C. Toro; M. Graham. International Dept. Research Center, Ottawa. pp.131-152. 1980.
The effect of mycorrhizal inoculation of cassava on plant growth and P uptake was studied in sterilized and usterilized soil, to which eight levels of P had been applied, as well as in flowing nutrient solution at four different P concentrations. Inoculation had the greatest beneficial effect on cassava grown in sterilized soil to which 2 t P/ha was applied, increasing dry matter production nearly threefold and total P uptake about sevenfold. In the unsterilized soil both dry matter production and P uptake increased about 50% when 0.5 t P/ha was applied. In the soil experiment cassava became mycorrhizal only at the intermediate P application rates of 0.1 to 4 t/ha, corresponding to soil solution P concentrations of about 2 to 52 µM. Without applied P and at the two highest rates of applied P (8 and 16 t/ha) mycorrhizal inoculation had no beneficial effect and the percent infection was low, especially in the unsterilized soil. In flowing solution culture, inoculation significantly increased DM production of eight cassava cultivars at the intermediate P concentration of 1 µM, whereas it had no effect on maize, rice, cowpea, and *Phaseolus* beans. The latter species produced maximum yields at 1 µM P, but after inoculation, whereas at the lowest concentration of 0.1 µM P the roots became mycorrhizal, but this had no significant effect on yield. Some implications of cassava's apparent dependence on mycorrhiza are discussed.

0690 ISLAM, R.; AYANABA, A.; SANDERS, F. E. Response of cowpea (*Vigna unguiculata*) to inoculation with VA-mycorrhizal fungi and to rock phosphate fertilization in some unsterilized Nigerian soils. *Plant and Soil* (1980) 54 (1) 107-117 [En, 18 ref., 6 tab.] Int. Inst. Trop. Agric., Ibadan, Nigeria.

In pot and field tests on 4 different soil series, inoculation with vesicular-arbuscular mycorrhizal fungi caused very rapid root infection. A higher infection was maintained during subsequent plant growth in the field. Rock phosphate (RP) application reduced infection without affecting plant growth. Nodulation, N fixation and RP utilization were increased by mycorrhizae in the pot but not

in the field experiments. In pots inoculated plants supplied with RP flowered earlier and took up more P than either uninoculated plants or those inoculated but without RP. The largest response to incoulation in terms of shoot dry matter, nodule yield and N content of the shoots was obtained in Alagba soil under both pot and field conditions.

0691 JANOS, D. P. Vesicular-arbuscular mycorrhizae affect lowland tropical rain forest plant growth. *Ecology* (1980) 61 (1) 151-162 [En, 66 ref., 2 fig., 2 tab.] Univ. Michigan, Ann Arbor, USA.

In pot experiments mycorrhizae increased seedling growth of 23 out of 28 spp. and improved survival of 6 and cotyledon retention of 5. Mycorrhizae also increased the size of bacterial nodules and the proportion of nodulated plants among 3 leguminous spp. Growth of seedlings without mycorrhizae was greatly inhibited. Removing cotyledons from individuals of 2 spp. dependent on mycorrhizae, however, did not increase their response to inoculation. Thus, seed reserves are important for mycorrhiza formation as well as for seedling growth before infection. Large seeds are advantageous to plants that depend on VA mycorrhizae because they provide mineral reserves upon which the seedling can draw while awaiting infection. Seedlings of some spp. could not grow without mycorrhizae, but inoculation did not affect the growth of other spp. Spp. least dependent on mycorrhizae had light seeds and colonized disturbed habitats.

*0692 JODICE, R.; NAPPI, P.; LUZZATI, A. [Effect of vesicular-arbuscular mycorrhizas and organic matter on boron nutrition of sunflower.] Influenza delle micorrize vescicolo-arbuscolari e della sostanza organica sulla nutrizione borica del girasole. *Allionia* (1980/81) 24, 43-48 [It, en, 20 ref., 3 tab.] Istituto per le Piante da Legno, Turin, Italy.

In a pot experiment on a B-deficient soil root yield of plants receiving boron, organic fertilizer and mycorrhizal treatments separately was twice that of control plants, while plants receiving all the treatments together had a yield 7 × greater. In the B-deficient soil mycorrhiza (*Glomus fasciculatus*) redoubled boron uptake. Incidence and intensity of mycorrhizas and spore number decreased with increasing root yield.

0693 JOHNSON, C. R.; JOINER, J. N.; CREWS, C. E. Effects of N, K, and Mg on growth and leaf nutrient composition of three container grown woody ornamentals inoculated with mycorrhizae. *Journal of the American Society for Horticultural Science* (1980) 105 (2) 286-288 [En, 13 ref.] Florida University, Gainesville, FL 32611, USA.

High N fertilization reduced infection by *Glomus* spp. (*G. fasciculatus* and *G. mosseae*) endomycorrhizae on inoculated *Podocarpus macrophyllus, Pittosporum tobira* and *Rhododendron simsii* plants. Inoculation with *Glomus* spp. benefited growth of the 3 species even at high levels of fertilization (1250 N, 1250 K and 230 Mg kg/ha), although leaf nutrient levels showed little difference from non-inoculated plants.

0694 KANG, B. T.; ISLAM, R.; SANDERS, F. E.; AYANABA, A. Effect of phospbate fertilization and inoculation with VA-mycorrhizal fungi on performance of cassava (*Manihot esculenta* Crantz) grown on an alfisol. *Field Crops Research* (1980) 3 (1) 83-94 [En, 19 ref., 5 fig., 4 tab.] Int. Inst. Trop. Agric., Ibadan, Nigeria.

Inoculation with mixed native vesicular-arbuscular mycorrhizal fungi or with *Glomus mosseae* improved growth, lowered P response and increased P uptake in plant tops of pot-grown cassava in sterilized soil. Inoculation with *G. mosseae* reduced growth and P uptake in nonsterilized soil. The low P requirement of field-grown cassava may be related to its association with VA-mycorrhizal fungi.

0695 KEELEY, J. E. Endomycorrhizae influence growth of blackgum seedlings in flooded soils. *American Journal of Botany* (1980) 67 (1) 6-9 [En, 14 ref., 1 fig., 1 tab.] Occidental Coll., Los Angeles, Calif., USA.

Nyssa sylvatica seedlings grown for 1 yr under flooded conditions established endomycorrhizal associations with *Glomus mosseae*. Lowland ecotypes with endomycorrhizae showed a significant increase in biomass over non-mycorrhizal controls; the greatest difference was in above ground biomass. Upland ecotypes survived flooding poorly, established fewer endomycorrhizae than lowland ecotypes and did not show any enhanced growth over controls. In general, most endomycorrhizae were formed near main roots and they decreased in abundance with distance from the main axes of the root system. It is suggested that under flooded conditions internal O_2 transport may be limiting to mycorrhizae in the more distal roots.

*0696 KRIKUN, J.; LEVY, Y. Effect of vesicular arbuscular mycorrhiza on citrus growth and mineral composition. *Phytoparasitica* (1980) 8 (3) 195-200 [En, 8 ref., 3 tab.] ARO, Gilat Reg. Exp. Sta., Negev, Israel.

Glomus mosseae was retrieved from citrus trees growing in loess soil in the Negev region of Israel. Inoculation of citrus seedlings with the mycorrhizal fungus greatly increased the growth of plants in soil low in P. Rough lemon responded more than sour orange. Vesicular-arbuscular mycorrhiza led to higher concs. of P and Cu and lower concs. of N, K and Ca in leaves of inoculated plants.

0697 KRIKUN, J.; LEVY, Y. Phytoparasitica. *Effect of vesicular arbuscular mycorrhiza on citrus growth and mineral composition.* (1980) 8 (3) 195-200 [En, 8 ref.] Division of Plant Pathology, ARO, Gilat Regional Experiment Station, Mobile Post Negev, Israel.

The vesicular arbuscular fungus *Glomus mosseae* was retrieved from citrus trees growing in loess soil in the Negev region of Israel. Inoculation of citrus seedlings with the mycorrhizal fungus greatly increased the growth of plants in soil low in phosphorus. Rough lemon responded more than Sour orange. Vesicular arbuscular mycorrhiza caused higher concentrations of P and Cu and lower concentrations of N, K and Ca in leaves of inoculated plants.

0698 LAMBERT, D. H.; COLE, H., JR. Effects of mycorrhizae on establishment and performance of forage species in mine spoil. *Agronomy Journal* (1980) 72 (2) 257-260 [En, 21 ref.] Dep. of Pl. Path., Pennsylvania State Univ., University Park, PA 16802, USA.

Lathyrus sylvestris, Coronilla varia and birdsfoot trefoil were grown in a limed low P strip mine soil with or without a covering of field soil as a mycorrhizal inoculum. Dry wt./plant and survival were significantly higher in the mycorrhizal treatments. With 0, 41, 81 or 162 kg P/ha or soil inoculum + 0 or 41 kg P/ha, the yields of mycorrhizal and nonmycorrhizal plants converged with increase in P rate, but yield with soil + 41 kg P was significantly greater than in all other treatments. In greenhouse trials, white clover was grown in strip mine soil containing different inocula at 2 pH levels. Plant yields and mycorrhizal colonization were not significantly different between the 2 pH levels.

0699 LAMBERT, D. H.; COLE, H., JR.; BAKER, D. E. The role of boron in plant response to mycorrhizal infection. *Plant and Soil* (1980) 57 (2/3) 431-438 [En, 18 ref., 3 tab.] Pennsylvania State Univ., University Park, Pa., USA.

In a sandy loam marginal in boron, fertilization with 1.1 p.p.m. B increased shoot dry wt. of mycorrhizal red clover by 16% but did not affect that of non-mycorrhizal plants. With lucerne in soil in which B deficiency was intensified, inadequate B reduced shoot dry wt. by 71% (mycorrhizal plants) and 35% (non mycorrhizal). B deficiency delayed onset of infection and spread of the mycorrhizal fungi in the roots.

0700 LAMBERT, D. H.; COLE, H., JR.; BAKER, D. E. Variation in the response of alfalfa clones and cultivars to mycorrhizae and phosphorus. *Crop Science* (1980) 20 (5) 615-618 [En, 17 ref., 3 tab.] Ohio Agric, Res. Development Cent., Wooster, USA.

In the glasshouse 6 clones from each of 6 lucerne cvs. were grown in partially sterilized, low-P soil treated with either 0, 20, or 80 p.p.m. P, no P but mycorrhizal inoculum, or 80 p.p.m. P and mycorrhizal inoculum. At 0 p.p.m. plant growth without mycorrhizae was less than that of mycorrhizal plants (MR), while at 80 p.p.m. P growth of nonmycorrhizal plants (NMR) was greater than that of mycorrhizal ones for most clones. Cv. × MR and clones in cv. × MR interactions for plant growth were significant. Maximizing P deficiency to select P-efficient clones was unsuccessful as dry wts. of NMR low-P plants were not correlated with dry wts. of any other treatments and only the 2 mycorrhizal treatments were highly correlated. At 80 p.p.m. P mycorrhizae increased P, Cu, Zn and Fe, decreased Mg and Ca and did not affect Mn and K concs. Cv. × MR interactions were significant for Cu and Zn concs., and clones in cv. × MR interactions were significant for all elements. The results indicate that screening of lucerne lines for P efficiency or content of P, Cu and Zn should be conducted under natural i.e. mycorrhizal conditions.

0701 LEVY, Y.; KRIKUN, J. Effect of vesicular-arbuscular mycorrhiza on *Citrus jambhiri* water relations. *New Phytologist* (1980) 85 (1) 25-31 [En, 21 ref.] Agricultural Research Organization, Gilat Regional Experiment Station, Mobile Post Negev, Israel.

Recovery from water stress was studied on similarly sized VA mycorrhizal and non-mycorrhizal rough lemon seedlings. VA mycorrhiza affected seedling stomatal conductance, photosynthesis and proline accumulation, but not leaf water potential, suggesting that most of the effect of the mycorrhizal association is on stomatal regulation rather than on root resistance.†

0702 LOPES, E. S.; OLIVEIRA, E. DE; NEPTUNE, A. M. L. [Effects of species of vesicular-arbuscular mycorrhizas on Siratro (*Macroptilium atropurpureum*).] Efeito de espécies de micorrizas vesicular-arbusculares em Siratro (*Macroptilium atropurpureum*). *Bragantia* (1980) 39 (1) 241-245 [Pt, en, 6 ref.] Instituto Agronômico, 13.100 Campinas, SP, Brazil.

In pot trials using a γ-irradiated latossol of low P content, 5-day-old seedlings of *M. atropurpureum* were inoculated with effective *Rhizobium* spp. plus a mycorrhizal fungus belonging to 1 of 3 *Gigaspora* spp., 5 *Glomus* spp. or *Acaulospora laevis*. Inoculation with *Glomus macrocarpus* or *G. fasciculatus* increased DM yield at 75 days after transplanting by 1400% compared with non-inoculated plants. There was a significant increase in nodule numbers, size and DM after 82 days. Other mycorrhizal spp. varied greatly in their effect on growth.

0703 MARONEK, D. M.; HENDRIX, J. W.; KIERNAN, J. Differential growth response to the mycorrhizal fungus *Glomus fasciculatus* of southern magnolia and Bar Harbor juniper grown in containers in composted hardwood bark-shale. *Journal of the American Society for Horticultural Science* (1980) 105 (2) 206-208 [En, 13 ref., 2 pl.] Kentucky University, Lexington, KY 40546, USA.

Magnolia grandiflora and *Juniperus horizontalis* cv. Bar Harbor were grown in a composted hardwood bark + expanded shale medium in containers in a greenhouse. All plants received either a low rate (1.1 kg/m³) or the manufacturer's recommended rate (4.5 kg/m³) of 18N-6P-12K slow-release fertilizer (Osmocote) and half the plants were inoculated with *Glomus fasciculatus*. After 6 months, the height of inoculated magnolia plants was nearly twice that of uninoculated plants, and the height difference increased with time. The juniper plants showed little or no growth response to infection with the mycorrhizal fungus. Fertilization of magnolia plants at the recommended rate compared with a quarter of the rate did not inhibit the degree of mycorrhizal infection of roots. Roots of inoculated juniper plants were heavily infected at both fertilizer rates, but the degree of infection was significantly greater at the lower fertilizer rate.

0704 MCGRAW, A. C.; SCHENCK, N. C. Growth stimulation of citrus, ornamental, and vegetable crops by select mycorrhizal fungi. *Proceedings of the Florida State Horticultural Society* (1980, publ. 1981) 93, 201-205 [En, 17 ref., 2 pl.] Florida University, IFAS, Gainesville, FL 32611, USA.

Mycorrhizal plants, including citrus, tomato, peach, chrysanthemum and *Podocarpus* sp. showed increased vegetative and reproductive growth in a greenhouse study. Sour orange shoot height and total dry weight and tomato (cv. Walter) fruit yields were increased by 200-300%. Peach (breeding line 3-123N) shoot height was increased by 25-75%, chrysanthemum flowered earlier and the number of flowers was increased by up to 100%, and *Podocarpus* shoot height was increased slightly. Inoculations with *Glomus etunicatus*, *G. fasciculatus* and *G. mosseae* provided the greatest growth improvement to the majority of crops. *G. epigaeus*, *G. macrocarpus*, *G. microcarpus* and *Gigaspora margarita* were also beneficial to certain plants.

0705 MENGE, J. A.; LARUE, J.; LABANAUSKAS, C. K.; JOHNSON, E. L. V. The effect of two mycorrhizal fungi upon growth and nutrition of avocado seedlings grown with six fertilizer treatments. *Journal of the American Society for Horticultural Science* (1980) 105 (3) 400-404 [En, 22 ref.] California University, Riverside, CA 92521, USA.

Seedlings of avocado, cv. Topa Topa, were grown in steamed loamy sand soil with no fertilizer, complete fertilizer (N, P, K, S, Ca, Mg, Cu, Zn, Mn, Fe, Mo, B), -P, -Zn, -P and Zn, and -Zn + 10 × P (640 p.p.m. P). Seedlings were inoculated separately with one or 2 isolates of *Glomus fasciculatus* or were inoculated with a water filtrate of the mycorrhizal inoculum plus autoclaved mycorrhizal inoculum. Growth of mycorrhizal seedlings was 49-254% larger than nonmycorrhizal, except at the -Zn + 10 × P regime where mycorrhizal and nonmycorrhizal plants were of similar size. Both mycorrhizal isolates increased absorption of N, P and Cu at all fertilizer treatments and absorption of Zn was increased with all fertilizer treatments by one mycorrhizal isolate. Fertilization with P did not alter P concentrations in leaves of nonmycorrhizal plants but increased P concentrations in leaves of mycorrhizal seedlings. Poor growth of avocado seedlings in steamed or fumigated soil can be related to poor mineral nutrition due to the destruction of mycorrhizal fungi.†

*0706 NOPAMORNBODI, O. The effect of endomycorrhizas on growth and nutrient absorption ability of corn In: Tahiland National Corn and Sorghum Program Kasetsant Univ. Bangkok Ann. Report 1979. pp. 390-394. 1980.

Zea mays, maize, mycorrhiza, plant growth & development, nutrient uptake, THAIL

Vesicular-arbuscular mycorrhiza (VAM) increase plant growth especially in infertile soil. Growth increases are the result of enhanced ability of the infected root to absorb nutrients. A pot trial was conducted with the aim of studying the effect of an unnamed endomycorrhiza on growth of maize (Zea mays). Spores and infected roots were placed near maize roots during planting, then the pots were filled with sterilized soil. It was shown that growth of VAM-infected maize plants was increased and that their phosphorus, potassium and magnesium contents were significantly higher than in the non-mycorrhizal treatment.

0707 O'BANNON, J. H.; EVANS, D. W.; PEADEN, R. N. Alfalfa varietal response to seven isolates of vesicular-arbuscular mycorrhizal fungi. *Canadian Journal of Plant Science* (1980) 60 (3) 859-863 [En, fr, 19 ref.] Irrigated Agric. Res. and Extension Cent., USDA, Prosser, WA 99350, USA.

The endomycorrhizal fungi *Acaulospora trappei*, *Glomus epigaeus*, *G. monosporus* and 2 isolates each of *G. fasciculatus* and *G. mosseae* were compared for their influence on the growth of lucerne cv. Du Puits, Ladak 65, Moapa and Vernal. Mycorrhiza enhanced growth of all cv. in the order *G. epigaeus* > *G. fasciculatus* > *A. trappei* = *G. mosseae* > *G. monosporus*.

0708 OCAMPO, J. A. [VA Mycorrhiza. II. Effect on plant growth.] Micorrizas VA. II. Efecto sobre el crecimiento de las plantas. *Anales de Edafología y Agrobiología* (1980) 39 (5/6) 1049-1069 [Es, en, 149 ref.] Departamento de Microbiología, Estación Experimental del Zaidín, Granada, Spain.

Aspects of vesicular arbuscular mycorrhiza are reviewed in relation to the infection dynamics, specificity and the physiology of P uptake and the effect of the association on plant growth and nutrition.

0709 OWUSU-BENNOAH, E.; WILD, A. Effects of vesicular-arbuscular mycorrhiza on the size of the labile pool of soil phosphate. *In*: Tropical Mycorrhiza Research (Ed. by P. Mikola) Oxford Univ. Press Oxford, England. pp.231 (1980).

0710 OWUSU-BENNOAH, E.; WILD, A. Effects of vesicular-arbuscular mycorrhiza on the size of the labile pool of soil phosphate. *Plant and Soil* (1980) 54 (2) 233-242 [En, 23 ref.] Soil Sci. Dep., Univ. of Reading, UK.

Inoculation of lettuce, onion and red clover with VA mycorrhizal fungus (*Glomus mosseae*) increased plant yields and phosphate uptake in three phosphate-depleted soils where the labile pool of phosphate was labelled with ^{32}P. In two soils the specific activity of plant phosphate was the same in mycorrhizal and non-mycorrhizal plants. In the third soil the specific activity was lower in lettuce and clover when the plants were mycorrhizal. When the experiment was repeated with this soil under conditions giving slower growth rates, the specific activity was the same in mycorrhizal and non-mycorrhizal plants. The lower specific activity in lettuce and clover in the first experiment is attributed to greater release of slowly exchanging phosphate (which is not in equilibrium with the added ^{32}P), caused by the high uptake of phosphate

by the mycorrhizal plants. Lower specific activities in mycorrhizal plants may therefore not necessarily indicate solubilization of soil phosphate by mycorrhiza.

0711 PAIRUNAN, A. K.; ROBSON, A. D.; ABBOTT, L. K. **The effectiveness of vesicular-arbuscular mycorrhizas in increasing growth and phosphorus uptake of subterranean clover from phosphorus sources of different solubilities.** *New Phytologist* (1980) 84 (2) 327-338 [En, 33 ref.] Dep. of Soil Sci. and Pl. Nutr., Western Australia Univ., Nedlands, W.A., Australia 6009.

The effect of inoculation with a vesicular-arbuscular (VA) mycorrhizal fungus on growth and P uptake of subterranean clover was examined using 3 P sources with different solubilities. Mycorrhizas markedly increased growth and P content of tops at intermediate rates of P application for all sources. The effectiveness of P for plant growth for mycorrhizal plants relative to non-mycorrhizal plants was the same for a water-soluble source (superphosphate) and 2 insoluble sources (C-grade Christmas Island rock phosphate and calcined Christmas Island rock phosphate). The effectiveness of P from each of the 3 sources for P uptake by mycorrhizal plants relative to non-mycorrhizal plants was also independent of the solubilities of the P sources applied. At a given P conc. in tops, non-mycorrhizal plants produced more DM than mycorrhizal plants supplied with superphosphate. Mycorrhizal and non-mycorrhizal plants supplied with C-grade rock phosphate had the same dry wt. at a given P conc. in their tops. VA mycorrhizas increased Zn but not Ca uptake by subterranean clover.

0712 PANG, P. C.; PAUL, E. A. **Effects of vesicular-arbuscular mycorrhiza on ^{14}C and ^{15}N distribution in nodulated fababeans.** *Canadian Journal of Soil Science* (1980) 60 (2) 241-250 [En, fr, 28 ref.] Department of Soil Science, University of Saskatchewan, Saskatoon, Sask. S7N 0W0, Canada.

A two-compartment growth chamber in which the aboveground plant materials were exposed to $^{14}CO_2$ and the belowground portion was exposed to $^{15}N_2$ under normal atmospheric pressure was designed for carbon and nitrogen transfer studies. *Vicia faba* infected with vesicular-arbuscular fungus *Glomus mossae* and non-mycorrhizal plants fixed similar quantities of N_2 at an age of 6.5 wk. Approximately 0.10 mg N was fixed g^{-1} dry plant materials day^{-1} and 40 mg C g^{-1} dry matter day^{-1} were synthesized by mycorrhizal and non-mycorrhizal fababeans during 48 h exposure to $^{14}CO_2$ at 6.5 wk with no apparent difference in yield of dry matter. The non-mycorrhizal plants transferred 37% of the fixed ^{14}C beneath ground. The mycorrhizal ones transferred 47% of the fixed ^{14}C beneath ground. Most of the difference could be accounted for in the belowground respiration. The $^{14}CO_2$ produced by root-microbial systems of the mycorrhizal fababeans was twice as great as that of the nonmycorrhizal; both contained active rhizobium.

0713 PICHOT, J.; TRUONG, B. Effect of the endomycorrhizae on growth and phosphorus uptake of *Agrostis* in a pot experiment. In: Tropical Mycorrhiza Research (Ed. by P. Mikola) Oxford Univ. Press Oxford, England. pp.206-209 (1980).

0714 POPE, P. E. **Influence of *Glomus fasciculatus* mycorrhizae on some physical and chemical characteristics of *Platanus occidentalis* seedlings.** *Canadian Journal of Botany* (1980) 58 (14) 1601-1606 [En, fr, 26 ref., 2 fig., 4 tab.] Purdue Univ., West Lafayette, Ind., USA.

After 12 weeks inoculated seedlings were 73% taller, and 200% greater in total dry wt.; the largest dry wt. increase was recorded for foliage (212%) followed by stem (202%) and root (171%). On average foliar P conc. was 22% greater for the inoculated seedlings. Nutrient regimes influenced *inter alia* the degree of root colonization. This increased from 42% of the root length in the unfertilized control to 48% in 1 × Hoagland's No 2 sol. nutrient regime and sharply declined at the 2× and 4× levels Total dry wt. of inoculated seedlings was significantly greater at each nutrient level. Seedling growth attributed to *G. fasciculatus* is directly related to degree of mycorrhizal colonization and inversely related to the amount of extractable soil P.

0715 POWELL, C. **Boosting fruit yields in blueberries with mycorrhizal fungi.** *New Zealand Commercial Grower* (1980) 35 (10) 27, 39 [En] Ruakura Soil and Plant Research Station, Hamilton, New Zealand.

A survey of nursery and field plants of [highbush] blueberries in one area showed that, where unsterilized peat had been used in the potting mixture, up to 50% of 2-year-old plants were mycorrhizal. Between 60-70% of field plants (3-7 years old) were mycorrhizal but the level of fungal infection was very variable. In a field trial, 2-year-old plants of 6 cvs were inoculated using mycorrhizal peat when they were planted in a humidified peat soil. By the first cropping season, the vegetative growth was about 17% greater and the yields larger by 11% (cv. Dixi) to 92% (Stanley) in mycorrhizal than in non-mycorrhizal plants. Yields are tabulated and advice is given on inoculation.

0716 POWELL, C. L.; GROTERS, M.; METCALFE, D. **Mycorrhizal inoculation of a barley crop in the field.** *New Zealand Journal of Agricultural Research* (1980) 23 (1) 107-109 [En, 16 ref., 2 tab.] Ruakura Soil Pl. Res. Stn., Minist. Agric. Fisheries, Hamilton, New Zealand.

Zephyr barley was grown in small field plots with or without a layer of *Gigaspora margarita* or *Glomus tenuis* inoculum soil placed below the seed. *G. margarita* inoculation greatly increased mycorrhizal infection levels in the roots, vegetative growth, and N and K concs. in plants before flowering. Vegetative growth response decreased from 92% to 25% as the grain filled, and nutrient levels greatly decreased in mycorrhizal and non-mycorrhizal plants. There was no response to inoculation with *G. tenuis*.

0717 RHODES, L.H.; GERDEMANN, J.W. Nutrient translocation in vesicular-arbuscular mycorrhizal. In: Cook, C.B.; Pappas, P.W. Rudolhp, E.D. eds. Cellular interactions in symbiosis and parasatism. pp.173-195. Ohio State Univ. Press (Columbus). 1980.

*0718 SCHUBERT, A.; BOLLANTE-FASOLO, P.; FONTANA, A. **[Interactions between vesicular-arbuscular mycorrhiza and phosphorus additions in grapevine.]** Interazioni tra micorrizia vescicolo-arbuscolare e apporti di fosforo nella vite. *Allionia* (1980/81) 24, 19-25 [It, en, 21 ref., 2 tab.] Dep. Vitic., Univ. Turin, Italy.

In a phosphate-poor soil mycorrhizal plants showed a higher percentage and intensity of fungal colonization and greater stimulation of growth. With addition of P fungal colonization was reduced and its effect on growth became less evident.

0719 STRIBLEY, D. P.; TINKER, P. B.; SNELLGROVE, R. C. **Effect of vesicular-arbuscular mycorrhizal fungi on the relations of plant growth, internal phosphorus concentration and soil phosphate analyses.** *Journal of Soil Science* (1980) 31 (4) 655-672 [En, 28 ref.] Department of Soils and Plant Nutrition, Rothamsted Experimental Station, Harpenden, Herts, AL5 2JQ, UK.

The effect of infection by vesicular-arbuscular mycorrhiza on the predictive value of soil analysis for available P was tested in a glasshouse experiment. Leeks (*Allium porrum*) were grown on ten Rothamsted soils with a wide range of initial $NaHCO_3$-soluble P, each of which also received 5 levels of added P. Soils were partially sterilized with 1 Mrad of γ-radiation, or left untreated; plants on sterilized soil were infected with yellow-vacuolate endophyte (*Glomus mosseae*) or left non-mycorrhizal. The $NaHCO_3$-soluble P in the soils was measured 5 days after phosphate addition. Yields from all P levels on all soils were plotted against soil $NaHCO_3$-soluble P content and separate smooth response curves were obtained for non-infected and artificially-infected plants. Infection increased yield only on soils with less than 100 mg P kg^{-1}. In contrast, naturally-infected plants gave no clearly defined response curve to P, and on three soils the yields were consistently low. These soils gave very low natural infections and had low spore densities probably due to the cropping history of the sites. Artificially-infected plants had much higher shoot P concentrations than did uninfected plants of similar dry weight, over a large range of soil phosphate levels; this effect was also noted with the endophyte *G. fasciculatus*. Naturally-infected plants showed a poor relationship between shoot P concentration and yield.

0720 STRIBLEY, D. P.; TINKER, P. B.; RAYNER, J. H. **Relation of internal phosphorus concentration and plant weight in plants infected by vesicular-arbuscular mycorrhizas.** *New Phytologist* (1980) 86 (3) 261-266 [En, 23 ref., 2 fig., 1 tab.] Rothamsted, Harpenden, UK.

Earlier studies and a review of the literature indicate that shoots of plants infected with VA-mycorrhiza normally

contain higher internal P concs. than those of uninfected plants of equal size, over wide ranges of external P supply and of host plants. Increased demand for C by infected roots is a possible explanation for this and simple graphical methods of estimating the resulting dry wt. loss are suggested.

*0721 TANG, Z. Y.; WAN, Z. L. [Effects of inoculation of mycorrhizal fungi on phosphorus nutrition and growth of citrus seedlings.] *Acta Pedologica Sinica* (1980) 17 (4) 336-345 [Ch, en, 7 ref.] Institute of Citrus, Chinese Academy of Agricultural Science, China.

Two mycorrhizal fungi CC-1, CC-2, which anatomical investigations showed, were capable of association with the host plant to form endomycorrhiza were used to inoculate the roots of three citrus species. At 4½ months after inoculation, the injection of the root system with CC-1 was 65% with glorious orange (*Citrus sinensis*) and 60% with rough lemon (*Citrus jambhiri*) respectively; mycelia were plentiful and some arbuscules were present on the root surfaces in both species. With CC-2, the infection rate of rough lemon was 70%; nomycelium was present on the root surface. No results are given for *C. sinensis* with this fungus. The infection rate of *Poncirius trifoliata* was minimal with both fungi. Experiments with phosphorus fertilizer labelled with ^{32}P showed that mycorrhiza enhanced the P uptake of citrus seedlings, either from fertilizer or from soil. Fresh weight, shoot length, leaf length and stem diameter were greater in the inoculated seedlings than in the control.

0722 TIMMER, L. W.; LEYDEN, R. F. The relationship of mycorrhizal infection to phosphorus-induced copper deficiency in sour orange seedlings. *New Phytologist* (1980) 85 (1) 15-23 [En, 21 ref., 1 pl., 1 fig., 2 tab.] Texas A & I Univ. Citrus Cent., Weslaco, USA.

Inoculation of seedlings in sand with *Glomus fasciculatus* greatly increased growth with or without P or Cu fertilization. Application of P or Cu to non-mycorrhizal seedlings in sand did not stimulate growth whereas in sandy loam P increased growth but induced Cu deficiency symptoms and reduced foliar Cu concs. With mycorrhizal seedlings P did not induce Cu deficiency symptoms, but slightly reduced foliar Cu concs. In a complete factorial experiment, described, non-mycorrhizal seedlings receiving no Cu developed Cu deficiency symptoms with low P levels (most severe at 200 mg P/l) which disappeared with P at 800 mg/l. On inoculated seedlings without Cu fertilization, increasing P rates decreased mycorrhizal infection, chlamydospore number/g soil and foliar Cu concs. Cu deficiency symptoms occurred only at 800 mg P/l and were mild. Apparently P induces Cu deficiency by stimulating growth of non-mycorrhizal seedlings until Cu becomes the limiting factor, whereas P-induced Cu deficiency appears to be due to P inhibition of mycorrhizal development on inoculated seedlings.

*0723 WEIR, R. G.; LETHAM, D. B.; BROADBENT, P.; NICHOLLS, P. J. The effect of phosphorus and vesicular-arbuscular mycorrhizal development on growth of citrus in a Sandmount series soil. In *Proceedings of the International Society of Citriculture 1978*. Griffith, NSW, Australia. (1980) 288-292 [En, 12 ref.] Biological and Chemical Research Institute, Rydalmere, NSW 2116, Australia.

Death of *Citrus jambhiri* [rough lemon] seedlings, grown in steam-air treated (60°C for 30 min) or unheated Sandmount sand, decreased with rising P rate from 21.9% at 0 μg P/g soil to 3.1% at 42 μg P/g soil. Seedling growth increased with each P increment in both heated and unheated soil. Growth in unheated soil was much greater than in heated soil at low P rates, but not at the highest rate (42 μg). The relative response to P was 20-fold in heated soil and 6-fold in unheated soil. Growth in the unheated soil was positively correlated with the percentage of vesicular-arbuscular mycorrhizal infection (mean 76%) while infection was absent in roots from heated soil. Fumigation of Sandmount sand with chloropierin (200 litres/ha), Di-Trapex [methyl isothiocyanate] (500 litres/ha) or Basamid [dazomet] (400 kg/ha) reduced growth and mycorrhizal infection. Root samples from 5-year-old stunted and normal Valencia orange trees growing on a range of rootstocks in Sandmount sand in an orchard irrigated using the drag hose system showed that stunted trees had on average only half the mycorrhizal infection of normal trees. In comparison, trees grown with trickle irrigation were all normal and had high levels of mycorrhizal infection.

0724 ALLEN, M. F.; MOORE, T. S., JR.; CHRISTENSEN, M.; STANTON, N. Growth of vesicular-arbuscular-mycorrhizal and nonmycorrhizal *Bouteloua gracilis* in a defined medium. *Mycologia* (1979) 71 (3) 666-669 [En, 16 ref.] Department of Botany, University of Wyoming, Laramie, Wyoming 82071, USA.

A rapid technique for isolating endophyte (*Glomus fasciculatus*) spores from the roots of *Bouteloua gracilis* has been derived from methods described by Ohms (1957) and Sutton and Barron (1971), and the root-organ culture medium of Mosse and Hepper (1975) for growing mycorrhizal and nonmycorrhizal plants of *B.gracilis* has been modified.

0725 ALLEN, M F. Physiological parameters influencing improved growth of Buoteloua gracilis associated with vesicular-arbuscular mycorrhizae. Journal of the Colorado Wyoming Academy of Science. 11(1):28-29, 1979. Abst.

I therefore measured and compared some physiological factors which vesicular-arbuscular (VA) mycorrhizae could influence growth of B. gracilis. Root surface phosphatase activity using p-nitropheny I phosphate as a substrate increased 60% with infection. Total phosphorus (P) concentration increased 50% in both shoots and leaves in infected plants Mycorrhizal plants therefore, had 110% and 50% more P per plant in the roots and shoots, respectively, than controls. Bound P concentrations increased 61% in shoots with infection but was equal in roots. Ninety percent increases in both chlorophyll a and b concentrations also were associated with infection. Four-fold increases in transpiration rates due primarily to 50-75% decreases in leaf resistance were demonstrated in greenhouse grown mycorrhizal over nonmycorrhizal plants. These changes correlated closely with increased phytohormone activity due specifically to VA mycorrhizal infection. I concluded that VA mycorrhizae improve plant growth not only through increased nutrient and water uptake but also because of more efficient utilization of resources via enhanced phytohormone activity. Root biomass of 50-day-old Bouteloua gracilis grown in phytatecontaining agar culture increased by 40% without increased leaf biomass when infected with Glomus fasciculatus.

0726 AZCON-G. DE AGUILAR, C.; AZCON, R.; BAREA, J. M. Endomycorrhizal fungi and *Rhizobium* as biological fertilizers for *Medicago sativa* in normal cultivation. *Nature, UK* (1979) 279 (5711) 325-327 [En, 29 ref., 1 fig., 1 tab.] Estación Exp. Zaidín CSIC, Granada, Spain.

Inoculation of a lucerne crop on irrigated calcareous soil in Granada with *Glomus mosseae* in combination with *Rhizobium meliloti* enhanced activity of the latter and resulted in a 211% increase in yield. These results suggest that it may be possible to reduce the chemical fertilizers added to neutral to alkaline soils in which the total P is high but available P is actually quite low.

0727 BAGYARAJ, D. J.; MANJUNATH, A.; PATIL, R. B. Interaction between a vesicular-arbuscular mycorrhiza and *Rhizobium* and their effects on soybean in the field. *New Phytologist* (1979) 82 (1) 141-145 [En, 17 ref., 4 tab.] Univ. Agric. Sci., Bangalore, India.

Results of dual inoculations on plants in a phosphorus deficient sandy loam suggest that *Glomus fasciculatus* can greatly assist nodulation and nitrogen fixation in field grown soybeans with *R. japonicum*.

0728 CARLING, D. E.; BROWN, M. F.; BROWN, R. A. Colonization rates and growth responses of soybean plants infected by vesicular-arbuscular mycorrhizal fungi. *Canadian Journal of Botany* (1979) 57 (17) 1769-1772 [En, fr, 15 ref., 3 fig.] Univ. Missouri, Columbia, USA.

The interactions with *Glomus fasciculatus* and *G. caledonius* were examined. The number of infection units in seedlings increased to a max. in the presence of increasing quantities of *G. fasciculatus* inoculum. Seedlings remained

free from mycorrhizal infection during the early stages of development. First infection units appeared 10-12 days after planting which was also the approx. time that *Rhizobium* root nodules and tertiary roots were first observed. The response to colonization by VA mycorrhizal fungi was evident as early as 6 weeks after planting.

0729 DELORENZINI, C.; BAREA, J.M; OLIVARES, J Fertilización biológica (micorriza + Rhizobium + fosfobacterias) de Trifolium pratense en diferentes condiciones de cultivo. Revista Latinoamericana de Microbiologia. 21(3): 129-134. 1979.
Se estudia la cooperación entre Rhizobium, micorrizas vesículo-arbusculares y fosfobacterias en cuanto a la capacidad que confieren a plantas de Trifolium pratense para utilizar roca fosfotada en un suelo neutro- alcalino. Los ensayos se realizaron en suelo esterilizado y no esterizado. La inoculación con los 3 tipos de microorganismos incrementón en las plantas el crecimiento, el no. de nódulos, el grado de micorrización y la capacidad para captar N y P, en cada tratamiento del suelo ensayasdo. Los Rhizobium y endofitos V-A introducidos lograron establecerse y formar las correspondientes simbiosis con las raíces, en competencia con los microorganismos propios del suelo en cuestión; pero la inoculación no estimuló la utilización de roca fosfatada por plantas de T. pratense en suelo no estéril, como se deduce de los efectos sobre el crecimiento de las plantas y su contenido de N y P.

0730 GRAW, D.; MOAWAD, M.; REHM, S. **[Host specificity and the effectiveness of VA mycorrhiza.]** Untersuchungen zur Wirts- und Wirkungsspezifität der VA-Mykorrhiza. *Zeitschrift für Acker- und Pflanzenbau* (1979) 148 (2) 85-98 [De, en, 29 ref.] Institut für Tropischen und Subtropischen Pflanzenbau der Universität Göttingen, German Federal Republic.

In a pot experiment in which 19, mainly tropical, species of higher plants were inoculated with 8 species of Endogonaceae, mycorrhizal effectiveness in promoting plant growth was generally, but not always, correlated with host specificity. *Glomus macrocarpus* Göttingen formed an efficient mycorrhiza on most species. *Glomus gerdemanni* from Brazil produced mycorrhiza only on *Eupatorium odoratum*. Mycorrhizal effectiveness depended primarily on the ability of the host plant to take up P from unavailable P. The growth of *Helianthus annuus*, which readily absorbs unavailable P, was not affected by the development of a vigorous mycorrhiza which increased P uptake. Mycorrhizal effectiveness was greatest in *Ageratum houstonianum* and *Eupatorium odoratum*, which do not take up unavailable P.

0731 HALL, I. R.; ARMSTRONG, P. **Effect of vesicular-arbuscular mycorrhizas on growth of white clover, lotus, and ryegrass in some eroded soils.** *New Zealand Journal of Agricultural Research* (1979) 22 (3) 479-484 [En, 17 ref.] Invermay Agric. Res. Cent., MAF, Mosgiel, New Zealand.

In pot trials, eroded soils collected from 10 sites in South Island, New Zealand were inoculated with *Glomus fasciculatus* culture and sown with *Lotus corniculatus* or with mixtures of this or white clover with perennial ryegrass. Soil inoculation increased the number of mycorrhizal infected plants and shoot dry wt. of *L. corniculatus*. Clover shoot dry wt. were increased by inoculation together with the application of 0, 4.5 and 13.5 mg P/pot, decreased with 40.5 mg P/pot and were not affected by 121.5 mg P/pot. Ryegrass shoot dry wt. were unaffected by P, and inoculation only stimulated growth at the highest P level. Inoculation increased *L. corniculatus* shoot growth with no P but had no effect with 11.3 and 45.3 mg P/pot. In clover, inoculation increased shoot growth with no P and depressed it with 45.3 mg P/pot.

0732 HAYMAN, D. S.; MOSSE, B. **Improved growth of white clover in hill grasslands by mycorrhizal inoculation.** *Annals of Applied Biology* (1979) 93 (2) 141-148 [En, 28 ref., 1 pl., 5 tab.] Rothamsted, Harpenden, UK.

Field trials in mid-Wales showed that growth could be improved by inoculation with selected vesicular-arbuscular mycorrhizal fungi. After one growing season inoculation had approx. doubled shoot dry wt., runner number and nodulation at 2 sites previously improved by adding lime and fertilizer, and by replacing the native vegetation mainly with rye grass [*Lolium perenne*] and white clover. At a previously unimproved site, limed at the time of planting, mycorrhizal inoculation increased shoot dry wt. by up to $2^1/_2$ times, almost doubled runner formation and increased nodulation up to 5-fold where 90 kg P/ha as basic slag had been applied. Responses to mycorrhiza at this site were smaller with 22.5 kg P/ha and were absent where no P was added. After 2 growing seasons inoculation responses were even more pronounced at the unimproved site. Where clovers were being overgrown by adjacent native grasses only those given both 90 kg P/ha and mycorrhizal inoculation survived well.

0733 HIRREL, M. C.; GERDEMANN, J. W. **Enhanced carbon transfer between onions infected with a vesicular-arbuscular mycorrhizal fungus.** *New Phytologist* (1979) 83 (3) 731-738 [En, 19 ref., 1 pl., 4 tab.] Univ. Illinois, Urbana, USA.

C transfer between onion plants was enhanced by mycorrhiza formed by *Glomus etunicatus*. By applying PCNB [quintozene] to hyphae C translocation to the root was reduced but not elimated, indicating that 2 transfer processes may be involved; cytoplasmic translocation within hyphae and mass flow along hyphal walls. Most of the transferred C remained in the roots; little or no C was translocated to the shoots. Therefore it is uncertain whether C was released to the recipient plant or retained in the fungal tissue.

0734 HUGHES, M.; CHAPLIN, M. H.; MARTIN, L. W. **Influence of mycorrhiza on the nutrition of red raspberries.** *HortScience* (1979) 14 (4) 521-523 [En, 16 ref.] Oregon State University, Corvallis, OR 97331, USA.

Mycorrhizal raspberry plants colonized by *Glomus fasciculatus* had a higher concentration of plant P than non-mycorrhizal plants at 0, 22 and 44 p.p.m. soil P levels. Total P uptake was greater in mycorrhizal plants at 22 and 44 p.p.m. added P. The presence of mycorrhizae did not influence N, Mg, B or Zn concentrations at any soil P level. K concentration in mycorrhizal plants was lower than in controls at 22 p.p.m. added P, but total K uptake was the same. Cu concentration was higher in mycorrhizal plants at the highest P level. P additions significantly influenced the total uptake of all elements except Cu and the concentration of all elements except Zn and Mn.

0735 LAMBERT, D. H.; BAKER, D. E.; COLE, H., JR. **The role of mycorrhizae in the interactions of phosphorus with zinc, copper, and other elements.** *Soil Science Society of America Journal* (1979) 43 (5) 976-980 [En, 37 ref.] Department of Plant Pathology, Pennsylvania Agricultural Experiment Station, University Park, PA 16802, USA.

Mycorrhizae increase the uptake of Zn and Cu by many plants, but mycorrhizal activity is suppressed by P fertilization. Soybean (*Glycine max* Mer.) and two lines of corn (*Zea mays* L.) were used to determine if this mechanism is a major cause of P-induced Zn and Cu deficiencies. Shoot dry weights and concentrations or total uptake of P, Zn, Cu, Fe, Mn, K, Ca and Mg were determined for mycorrhizal and nonmycorrhizal plants given 0, 25, 75, or 200 ppm P. Phosphorus fertilization significantly reduced Zn and Cu concentrations in mycorrhizal soybeans, but concentrations in nonmycorrhizal treatments were not affected. Concentrations of Zn and Cu in mycorrhizal and nonmycorrhizal corn were reduced by P fertilization, but the reduction for mycorrhizal plants was significantly greater than the decrease for nonmycorrhizal plants. Reductions in Zn and Cu concentrations in nonmycorrhizal corn were the result of a dilution effect and could be attributed to increased plant size rather than increased P fertility *per se*. The concentrations of the other analyzed elements were all affected by P level and/or mycorrhizal condition. In general, mycorrhizal and nonmycorrhizal dry weights and element concentrations converged as soil P was increased. Patterns of response to P and mycorrhizae differed slightly between corn lines, and such differences were marked for certain elements when corn was compared with soybean.

0736 McGRAW, A.C.; GAMBLE, J.F.: SCHENCK, N.C. Vesicular-arbuscular mycorrhizal uptake of Cesium-134 in two tropical pasture grass species. Phytopathology 69:(9): 1038. 1979. Abst.

Ten mycorrhizal species from the genera Glomus, Gigaspora, Acaulospora, and Sclerocystis were independently inoculated on two grass species, Pensacola bahiagrass (Paspalum notatum), and Pangola digitgrass (Digitaria decumbens), in miniature soil chambers and analyzed for mycorrhizal hyphal transport of cesium-134 (^{134}Cs) to the plants. Mycorrhizal or check plant roots were confined to soil in partitioned soil chambers (15 x 1.5 cm) and ^{134}Cs was injected 5 cm from roots in the vicinity of invading mycorrhizal hyphae. Digitgrass root growth in the injection area precluded any conclusions concerning this species. Infection of bahiagrass roots by two of the ten mycorrhizal species resulted in a two-fold increase of the radioactivity in leaf tissue 48 hours after injection, indicating that some mycorrhizal species enhance ion uptake. Limited hyphal growth or lack of mycorrhizal hyphal uptake of ^{134}Cs may account for the fact that the remaining species did not enhance uptake.

0737 NEMEC, S.; O'BANNON, J. H. **Response of *Citrus aurantium* to *Glomus etunicatus* and *G. mosseae* after soil treatment with selected fumigants.** *Plant and Soil* (1979) 53 (3) 351-359 [En, 18 ref.] USDA, Orlando, Florida 32803, USA.

Fumigants tested were: SMD (sodium methyldithiocarbamate) 33%, at 235, 469 and 938 l/ha; NaN_3 98%, at 28, 84 and 140 kg/ha; EDB [ethylene dibromide] 83%, at 141, 235 and 468 l/h; DBCP [1,2-dibromo-3-chloropropane] 86%, at 28, 56 and 84 l/ha; and 1,3-D (1,3-dichloropropene and related chlorinated C_3 hydrocarbons) 92%, at 168 l/ha. With *G. mosseae* sour orange plant height in the SMD, NaN_3 and two highest EDB treatments was less than in the non-fumigated control. Although root vesicle formation was low, chlamydospore production suggested that *G. mosseae* was least affected by EDB and DBCP. With *G. etunicatus* plant height was less in the SMD treatment than in the control but sporulation occurred in all fumigant treatments. The highest *G. etunicatus* chlamydospore numbers occurred in all EDB treatments and at the lowest NaN_3 rate. More vesicles formed in roots at the high DBCP rate but fewer formed with SMD and high NaN_3 than in the control.

0738 NEMEC, S. **Response of six citrus rootstocks to three species of *Glomus*, a mycorrhizal fungus.** *Citrus Industry* (1979) 60 (5) 5, 6, 8, 9, 11, 12, 14 [En, 25 ref.] Agricultural Research, Science and Education Administration, U.S.Department of Agriculture, Orlando, FL 32803, USA.

In a pot experiment the combined shoot growth of six citrus rootstocks in a fine sand subsoil receiving a 12-0-6 liquid fertilizer was increased 21-, 8- and 6-fold by inoculation with the vesicular-arbuscular mycorrhizal fungi *Glomus etunicatus, G. mosseae* and *G. fasciculatus*, respectively. Shoot growth of plants receiving a 12-6-6 fertlizer was increased only 1.8-, 1.4- and 1.6-fold by the same fungi. The extent of mycorrhizal dependency varied among citrus rootstocks, and there was an interaction between rootstocks and mycorrhizal species. Phosphorus concentration in the leaves of plants fertilized with 12-0-6 was higher in mycorrhizal than non-mycorrhizal plants.

0739 NEMEC, S. **Response of six citrus rootstocks to three species of *Glomus*, a mycorrhizal fungus.** *Proceedings of the Florida State Horticultural Society* (1978, publ. 1979) 91, 10-14 [En, 25 ref.] USDA, Orlando, FL 32803, USA.

Combined top growth of 6 seedling citrus rootstocks was increased 21-, 8- and 6-fold by inoculation with *Glomus etunicatus, G. mosseae* and *G. fasciculatus*, respectively, at the 4-5-leaf stage when a 12:0:6 NPK liquid fertilizer was used, but growth was only increased < 1.8-fold when a 12:6:6 liquid fertilizer was used. The rootstocks decreased in dependency on the mycorrhizae in the order: sour orange, Cleopatra mandarin, sweet orange, rough lemon, Rangpur lime and Carrizo citrange. Rootstocks with less tendency to branch were usually the tallest. Root/shoot ratios indicated that rootstock dependency decreased as capacity for root production increased.

0740 OWUSU-BENNOAH, E.; WILD, A. **Autoradiography of the depletion zone of phosphate around onion roots in the presence of vesicular-arbuscular mycorrhiza.** *New Phytologist* (1979) 82 (1) 133-140 [En, 25 ref.] Reading University, Reading RG1 5AQ, UK.

Using autoradiography a comparison was made of the depletion zones of ^{32}P-labelled phosphate around mycorrhizal (*Glomus mosseae*) and non-mycorrhizal onion roots grown in silty clay loam for 42 days. Mycorrhizal inoculation increased the growth and ^{32}P content of the onion plants in both γ-irradiated (i.e. sterilized) and non-irradiated soil. Successive autoradiographs showed that for the mycorrhizal and non-mycorrhizal roots most P uptake was within 0.2 and 0.1 cm, respectively, of the root surface. The effect of the mycorrhiza was similar to that of a cylinder of root hairs 0.1 cm long.

0741 OWUSU-BENNOAH, E.; MOSSE, B. **Plant growth responses to vesicular-arbuscular mycorrhiza XI. Field inoculation responses in barley, lucerne and onion.** *New Phytologist* (1979) 83 (3) 671-679 [En, 31 ref., 1 pl., 1 fig., 3 tab.] Rothamsted, Harpenden, UK.

The plants were inoculated with 1 of 2 endophytes placed below the seed in a replicated field trial. After 13 weeks shoot growth was increased by 77% (onion), 79% (lucerne) and 33% (barley) with 1 inoculum and by 4-, 6-fold and 30% respectively, with the other. Lucerne and onion responded most from inoculation in the subplots with most available P, whereas barley responses were confined to those with less available P. The uninoculated plants reached approx. 45% infection from indigenous endophytes and the inoculated plants c. 70%. Inoculation responses were not related to infection level. One introduced endophyte spored profusely and spread 22 cm from the point of inoculation, the other formed only few new spores; the indigenous fungi hardly sporulated at all. Spore production was little affected by host sp. or soil P level and was unrelated to root infection. The rationale of field inoculation is discussed with particular reference to amounts of inoculum required.

0742 MORANDI, D.; GIANINAZZI, S.; GIANINAZZI-PEARSON, V. [The use of endomycorrhizae for the establishment and growth of axenically propagated raspberry plants after transplanting.] Intérêt de l'endomycorhization dans la reprise et la croissance du framboisier issu de multiplication végétative *in vitro*. *Annales de l'Amélioration des Plantes* (1979) 29 (6) 623-630 [Fr, en, 15 ref., 1 fig., 4 tab.] Sta. Amélioration des Plantes, INRA, Dijon, France.

In growth room and glasshouse tests, growth was better when plants were inoculated with a mycorrhizal fungus at the time of transplanting from the culture tubes into the soil. Mycorrhizal levels were high (80-90% infection) and mycorrhizal plants were more vigorous and more uniform in size than controls. Shoot dry wt. production of cv. Bois Blanc transplanted into an acid soil was increased by 71% when inoculated with *Glomus tenuis* and that of Nagymarosi in neutral soil by 53 and 130% after inoculation with *G. mosseae* and *G. fasciculatus* respectively. Increased NK fertilization improved the mycorrhizal effect and growth stimulation, compared with nonmycorrhizal controls, was 209 and 174% for a first and second crop respectively of Nagymarosi infected by *G. fasciculatus*. The results clearly demonstrate the potential advantage of using endomycorrhizae to improve the establishment and growth of axenically propagated raspberries after transplanting.

0743 PARFITT, R.L. The availability of P from phosphategoethite bridging complexes. Desorption and uptake by ryegrass. Plant and Soil 53, 55-65 (1979).

Pot trials using phosphated-goethite (bridging complex) as the source of P for ryegrass were established. no P was readily available to ryegrass untel the surface was >40% covered with phosphate ions. Availability increased as the P level in solution increased up to 2uM. Maximum availability was attained when the initial concentration of P in solution was 2uM. which occurred at about 75% coverage on goethite. Mycorrhiza increased the availability of phosphate at a level of about 0.5-2 uM P (60-70% coverage of the goethite surface).

Laboratory experiments showed that citrate ions were particularly effective in displacing P from goethite and the Olsen reagent was a good predictor of P availability to ryegrass.

0744 POWELL, C. L. **Effect of mycorrhizal fungi on recovery of phosphate fertilizer from soil by ryegrass plants.** *New Phytologist* (1979) 83 (3) 681-694 [En, 31 ref.] Ruakura Agric. Res. Cent., Hamilton, New Zealand.

Perennial ryegrass plants were inoculated with *Gigaspora margarita, Glomus tenuis* or the indigenous mycorrhizal fungi and transplanted into pots containing 4 New Zealand hill country soils fertilized with finely ground superphosphate or one of 5 finely-ground phosphate rocks. After 7 harvests from

Dunmore soil and 4 from 3 other soils, Peru rock was shown to be the best fertilizer overall (av. of 24% of applied fertilizer P recovered by plants), followed by superphosphate, Chatham Rise rock, Nauru Island rock, Christmas Island rock and Queensland rock (23, 15, 4, 4 and 2% of the P recovered, resp.). The fertilizer value of superphosphate decreased rapidly over successive harvests in all soils, with slower decreases in the fertilizer value of Peru and Chatham rock phosphate. Values for Queensland, Nauru and Christmas Island rock phosphate were very low and largely unaffected by repeated harvesting. Mycorrhizal inoculation greatly influenced P uptake from soil by plants. In 11 out of 23 soil-fertilizer treatments, P uptake by plants inoculated with *G. tenuis* was increased significantly over plants inoculated with indigenous mycorrhizal fungi. The increased P uptake following inoculation with efficient mycorrhizal fungi tended to decrease over successive harvests as the available P levels in soil were depleted.

0745 POWELL, C. L. **Inoculation of white clover and ryegrass seed with mycorrhizal fungi.** *New Phytologist* (1979) 83 (1) 81-85 [En, 19 ref.] Soil and Field Res. Org., Ruakura Agric. Res. Cent., MAF, Hamilton, New Zealand.

Seeds of white clover and perennial ryegrass were pelleted with soil heavily infested with the indigenous mycorrhizal fungi or efficient strains of (a) *Glomus tenuis* or (b) *Gigaspora margarita* and laid out on unsterilized pasture soils. Ryegrass plants inoculated with (a) produced up to 48% more shoot growth than plants infected with the indigenous mycorrhizal fungi in Dunmore soil in glasshouse conditions. Similar inoculation of clover increased shoot growth by up to 91% in Te Kuiti soil in the glasshouse and 37% in the field. Inoculation of clover with (b) increased shoot DM by 79% in Te Kuiti soil in the field.

0746 SCHULTZ, R. C.; KORMANIK, P. P.; BRYAN, W. C.; BRISTER, G. H. **Vesicular-arbuscular mycorrhiza influence growth but not mineral concentrations in seedlings of eight sweetgum families.** *Canadian Journal of Forest Research* (1979) 9 (2) 218-223 [En, fr, 30 ref., 3 tab.] Sch. For. Resources, Univ. Georgia, USDA, Athens, USA.

Seedlings of 8 $^1/_2$-sib *Liquidambar styraciflua* families were grown for 6 months in a fumigated soil mixture, with or without inoculum from a mixture of *Glomus mosseae* and *G. etunicatus*, at 140, 280, 560 and 1120 kg/ha of 10-10-10 fertilizer. All seedlings received 3 additions of 187 kg/ha N during the growing season. Inoculated seedlings had greater biomass, height and stem diam. at each fertilizer level than nonmycorrhizal seedlings. Differences in growth occurred between families in mycorrhizal plants. However fertilizer did not significantly affect growth or nutrient uptake of the seedlings. Inoculation with VA mycorrhiza did not increase N, P, K or Mg concs. in the leaves, stems or roots. Leaves of VA mycorrhizal seedlings had higher concs. of Ca, but stems and roots had lower concs., than the nonmycorrhizal seedlings. Seedlings with endomycorrhizae contained higher absolute quantities of each nutrient simply because of their greater biomass. The results suggest that the role of VA mycorrhiza in the initial growth of *L. styraciflua* seedlings may be the result of physiological stimuli other than increased nutrient uptake.

*0747 SHUFFSTALL, W. C.; MEDVE, R. J. **Growth performances and mycorrhizae of native and exotic hardwoods on bituminous stripmine spoils.** *Ohio Journal of Science* (1979) 79 (6) 274-279 [En, 15 ref. EMB] Dep. Biol., Slippery Rock State Coll., Slippery Rock, PA 16057, USA.

Growth (late leaf length, stem extension, and numbers of leaf primordia and scars) and mycorrhizal characteristics were compared in 6- to 10-yr-old samples of 10 broadleaved species naturally invading spoils and 4 exotics (*Alnus glutinosa, Betula pendula, Elaeagnus umbellata*, and hybrid poplar) commonly planted on reclaimed soils, in western Pennsylvania. *Sassafras albidum, Acer rubrum, Populus tremuloides, Crataegus* spp., and *Robinia pseudoacacia* grew better on spoil than on non-spoil sites. Best total growth on spoils was by *A. rubrum, Rhus glabra, P. tremuloides, Aralia spinosa*, and *R. pseudoacacia*, which all grew better than the 4 exotics. All species had mycorrhizae but type or % were not related to successful growth.

0748 SMITH, S. E.; NICHOLAS, D. J. D.; SMITH, F. A. **Effect of early mycorrhizal infection on nodulation and nitrogen fixation in *Trifolium subterraneum* L.** *Australian Journal of Plant Physiology* (1979) 6 (3) 305-316 [En, 34 ref.] Dep. of Agric. Biochem., Waite Agric. Res. Inst., Glen Osmond, S.A., Australia 5064.

Rapid establishment of vesicular-arbuscular mycorrhiza in roots of subterranean clover cv. Mt Barker, using natural soil inoculum, was associated with improved nodulation, increased nitrogenase activity and increased nodule efficiency. In 2 trials on soil low in nutrients this increase occurred before any positive growth response to mycorrhizal infection was apparent. In all experiments mycorrhizal infection was associated with high root P contents, but was not accompanied by any change in nodule P content. In a 3rd trial, on soil with higher nutrient levels, mycorrhizal establishment was accompanied by increased growth, P and N contents within 35 days. The rate of P uptake was higher in mycorrhizal plants and decreased with delay in mycorrhizal formation.

0749 SWAMINATHAN, K.; VERMA, B. C. **Responses of three crop species to vesicular-arbuscular mycorrhizal infection on zinc-deficient Indian soils.** *New Phytologist* (1979) 82 (2) 481-487 [En, 39 ref.] Central Potato Research Institute, Simla, India.

Maize, wheat and potato plants were grown on three very zinc-deficient Indian soils in a pot experiment. The treatments were inoculation of seed with the spores of the vesicular-arbuscular (VA) mycorrhizal organism *Glomus macrocarpus*, dressing with $^{65}ZnSO_4$ to supply 10 ppm Zn, and a combination of both treatments (all with appropriate controls). Plants raised from inoculated seed usually exhibited root infection and assimilated significantly more Zn from the soil than non-mycorrhizal plants did. For maize on Daurala soil, Zn application appeared to stimulate endomycorrhizal transfer of Zn to the host plant; for other crops and on other soils, fertilizer-Zn did not improve plant uptake of Zn, and so it was concluded that mycorrhizal infection by itself could supply the total Zn requirement of the higher symbiont. Yield responses closely followed the pattern of Zn uptake, except that tuber production by the potato plants was unaffected by any of the treatments on any of the soils. The starch contents of the tubers did, however, increase commensurately with the level of Zn in the leaves. It is concluded that the observed mycorrhizal effect is restricted to the more easily available fractions of Zn in deficient soils. The value of artificial inoculation with VA-mycorrhizae under field conditions in order to upgrade nutrient-deficient soils is discussed in the light of the above findings.

0750 WAIDYANATHA, U. P. DE S.; YOGARATNAM, N.; ARIYARATNE, W. A. **Mycorrhizal infection on growth and nitrogen fixation of *Pueraria* and *Stylosanthes* and uptake of phosphorus from two rock phosphates.** *New Phytologist* (1979) 82 (1) 147-152 [En, 17 ref.] Rubber Res. Inst., Agalawatta, Sri Lanka.

Growth and nodulation of *P. phaseoloides* and *S. guianensis* and nitrogenase activity of *P. phaseoloides* grown from seed in methyl bromide-treated soil were severely retarded unless the plants were infected with vesicular-arbuscular (VA) mycorrhiza or given large amounts (500 mg/kg of soil) of rock phosphate obtained locally as apatite or imported from Jordan. Added rock phosphate further stimulated growth, nodulation and nodule activity of mycorrhizal plants. Mycorrhizae also enhanced uptake of P, which was increased further by the addition of rock phosphate. The comparative levels of P in plants and growth responses were clearly different with respect to the sources of rock phosphate in both mycorrhizal and non-mycorrhizal plants. These observations refer particularly to *P. phaseoloides*; the treatment effects were less pronounced with *S. guianensis*, because the uninoculated plants were naturally contaminated with mycorrhizae; but to a lesser degree than those inoculated.

0751 YOST, R. S.; FOX, R. L. **Contribution of mycorrhizae to P nutrition of crops growing on an Oxisol.** *Agronomy Journal* (1979) 71 (6) 903-908 [En, 25 ref.] Dep. of Agron. and Soil Sci., Univ. of Hawaii, Honolulu, 96822, USA.

The influence of mycorrhizae on the P requirements of crops in a tropical field environment on a Tropeptic Eutrustox was studied. Growth and P uptake by non-mycorrhizal and mycorrhizal plants in methyl bromide-fumigated and non-fumigated soil were measured at 10 levels of soil P using seven plant species. *Brassica chinensis*, which does not form symbiotic mycorrhizal associations, consistently grew better and took up more P from the fumigated than from the non-fumigated soil. All other species growing in

non-fumigated plots formed associations with mycorrhizae. In general, plants growing on fumigated soil did not become infected with mycorrhizae. In P-deficient treatments plant concentration of P was enhanced by the mycorrhizal associations. The levels of soil P at which fumigation ceased to reduce in the P percentage in plants were as follows: *Glycine max* (0.1 μg P/ml), *Vigna unguiculata* (0.2 μg P/ml), *Allium cepa* (0.8 μg P/ml), *Leucaena leucocephala* (1.6 μg P/ml), *Stylosanthes hamata* and *Manihot esculenta* (> 1.6 μg P/ml). P uptake by mycorrhizal plants growing on the two lowest soil P levels was 25 times greater than by plants without mycorrhizal associations. Some crops therefore appear to depend upon a mycorrhizal association for P absorption from a soil of high sorption capacity.

0752 ZAAG, P. VANDER; FOX, R. L.; PENA, R. S. DE LA; YOST, R. S. **P nutrition of cassava, including mycorrhizal effects on P, K, S, Zn and Ca uptake.** *Field Crops Research* (1979) 2 (3) 253-263 [En, 28 ref.] Coll. of Trop. Agric., Hawaii Univ., Honolulu, HI 96822, USA.

The nutritional requirements of cassava are ill-defined. The P requirements of cassava and the effect of P on other nutrients both in the presence of vesicular-arbuscular (VA) mycorrhizae and in soils when VA mycorrhizae were eliminated by fumigation were investigated. Cassava was grown on field plots with 10 levels of P (0.002-1.6 p.p.m. P in sol.) on 2 Oxisols in Hawaii. 6 cv. were compared at 1 location. At the other location the significance of VA mycorrhizae on the nutrition of cassava was investigated. There was a substantial increase in vegetative growth with increased P fertilization in the cv. experiment; however, tuber yields were not greatly affected. Even at very low extractable soil P (Bray-1 P level 1 p.p.m.) 5 out of the 6 cv. did not respond to P fertilization. 1 cv., Ceiba, produced 42-48 t tubers/ha when P in sol. was in the range 0.003-0.025 p.p.m. In the 2nd experiment the role of VA mycorrhizae was studied by fumigating half of each plot with methyl bromide which destroyed VA mycorrhizal fungi. Plants grown on the fumigated plots did not become infected with VA mycorrhizae during the 1st 80 days of the growing period. Cv. Ceiba was grown along with 6 other spp. Leaves from non-mycorrhizal plants (fumigated plots) invariably contained less P on a percentage basis than leaves from mycorrhizal plants (non-fumigated plots). On the low-P plot, leaf P decreased from 0.30 to 0.11% when VA mycorrhiza formation was precluded by fumigation. Likewise, K and S conc. in leaves decreased by 30% and Zn by 10%. There was no evidence that mycorrhiza promoted Ca uptake. These observations provide a basis for explaining why the P requirements of cassava in nutrient sol. culture are very high whereas cassava is generally unresponsive to P fertilization in the field.

0753 ABBOTT, L. K.; ROBSON, A. D. **Growth of subterranean clover in relation to the formation of endomycorrhizas by introduced and indigenous fungi in a field soil.** *New Phytologist* (1978) 81 (3) 575-585 [En, 23 ref.] Dep. of Soil Science and Plant Nutrition, Univ. of Western Australia, Nedlands, 6009, Australia.

Three vasicular arbuscular (VA) endophytes differed in their ability to increase the growth of subterranean clover when introduced into a freshly collected field soil. Four indigenous endophytes infected the roots in both the control and inoculated treatments. Two of the introduced endophytes, isolates of *Glomus monosporus*, differed in their ability to increase growth and P content of subterranean clover. These two were superior to the third introduced endophyte, *G. fasciculatus*. Differences in the growth of subterranean clover when limited by P supply were related to the rate of mycorrhiza development. Inoculation of soil with the three introduced endophytes did not reduce initial infection by the four indigenous endophytes. Mycorrhizas formed by *G. monosporus* and *G. fasciculatus* were distinguished from those formed by indigenous endophytes on the basis of morphology. Plants inoculated with isolates of G. monosporus had a greater proportion of their dry weight and P content in the tops than plants inoculated with *G. fasciculatus* or the control plants.

* 0754 ALDON, E. F. **Endomycorrhizae enhance shrub growth and survival on mine spoils.** In *The Reclamation of Disturbed Arid Lands.* Albuquerque, New Mexico, USA; University of New Mexico Press. (1978) 174-179 ISBN 0-8263-0476-1 [En, 14 ref.] Rocky Mountain Forest and Range Exp. Sta., Albuquerque, New Mexico, USA.

The importance of vesicular-arbuscular endomycorrhizae on arid zone plant communities was investigated. Fourtern important southwestern shrub species were found to form endomycorrhizae under field conditions. *Atriplex canescens* and *Chrysothamnus nauseosus* showed significant growth and yield responses when greenhouse plants were inoculated with *Glomus mosseae*. *A. canescens* inoculated with *G. mosseae* and then planted on coal mine spoils in western New Mexico had significantly higher survival and growth rates after two growing seasons than uninoculated plants. Examinations at several locations in New Mexico indicated that *G. fasciculatus* and *G. macrocarpus* commonly formed associations with several shrub species.

0755 BARROWS, J. B.; RONCADORI, R. W. **Endomycorrhizal synthesis by *Gigaspora margarita* in poinsettia.** *Mycologia* (1977, publ. 1978) 69 (6) 1173-1184 [En, 16 ref., 3 fig., 4 tab.] USDA Southeastern For. Exp. Sta., Athens, Ga., USA.

Roots of poinsettia (*Euphorbia pulcherrima*) cuttings became mycorrhizal when inoculated with *G. margarita*. Max. endomycorrhizal formation occurred following application of azygospores to both the rooting medium in the mist bed and subsequently to rooted cuttings at transplanting. Cuttings inoculated in the mist bed or at transplanting only, however, developed fewer mycorrhiza. Application of 125 p.p.m. NPK/potted plant weekly favoured mycorrhizal formation but there was no associated plant growth stimulation. Increasing fertility to 250 p.p.m. resulted in a mycorrhiza-induced growth response but the plants eventually became chlorotic. Application of 125 p.p.m. or 250 p.p.m. twice weekly significantly improved plant growth and appearance. At the lower rate mycorrhizal synthesis was repressed, occurring as scattered hyphae in the roots and at the higher rate it was completely inhibited. *G. margarita*, in conjunction with rootone, stimulated rooting of cuttings in the mist bed by markedly increasing the number and weight of roots over cuttings treated with rootone alone. The mycorrhizal cuttings withstood transplant shock under high temp. and low moisture conditions better than the nonmycorrhizal ones. Thus endomycorrhizal plants grew better than nonsymbiotic plants under conditions of low fertility and moisture stress but the relationship appeared to be of min. importance under cultural conditions favourable to the plant.

0756 COOPER, K. M.; TINKER, P. B. **Translocation and transfer of nutrients in vesicular-arbuscular mycorrhizas. 2. Uptake and translocation of phosphorus, zinc and sulphur.** *New Phytologist* (1978) 81 (1) 43-52 [En, 19 ref.] Dep. of Pl. Sci., Leeds Univ., Leeds LS2 9JT, UK.

White clover infected with the mycorrhizal fungus *Glomus mosseae* was grown in split-plate cultures, so that nutrients could be supplied to the external hyphae only. The uptake and translocation of ^{32}P, ^{65}Zn and ^{35}S by hyphae of the fungus was measured. A lag phase of 2-3 days in the appearance of ^{32}P in the shoot was caused by a delay in the uptake and translocation of P by the hyphae, rather than in transfer from fungus to host. The molar amounts of P, S and Zn translocated were in the ratio of 35:5:1 and the mean fluxes in the ratio of 50:8:1.

0757 CREWS, C. E.; JOHNSON, C. R.; JOINER, J. N. **Benefits of mycorrhizae on growth and development of three woody ornamentals.** *HortScience* (1978) 13 (4) 429-430 [En, 6 ref., 1 pl.] Florida University, Gainesville, Florida 32611, USA.

Container-grown plants of *Viburnum suspensum*, *Podocarpus macrophyllus* and *Pittosporum tobira* increased in height, stem caliper and fresh weight of shoots and roots when the peat:sand medium was inoculated with either *Glomus fasciculatus* or *G. mosseae*.

0758 DAFT, M. J. **Nitrogen fixation in nodulated and mycorrhizal crop plants.** *Annals of Applied Biology* (1978) 88 (3) 461-462 [En, 9 ref.] Dundee University, Dundee, DD1 4HN, UK.

A review and discussion of *Rhizobium* spp. and *Glomus macrocarpus* var. *geosporus* and *G. mosseae* in relation to yields of several crops in response to cultural practices. Nodulation of *Phaseolus vulgaris* was increased by a *Glomus* sp. infection with a consequent increase in plant N and P contents. A 60% defoliation of tomato plants reduced the supply of photosynthates to the roots and mycorrhizal infection from 84 to 34%.

0759 GAUNT, R. E. **Inoculation of vesicular-arbuscular mycorrhizal fungi on onion and tomato seeds.** *New Zealand Journal of Botany* (1978) 16 (1) 69-71 [En, 14 ref.] Lincoln College, Canterbury, New Zealand.

The growth of plants in sterile soil from seed pelleted with endotrophic mycorrhizal fungi was compared with that of non-inoculated plants and with that of plants grown in sterile soil to which mycorrhizal spores were added. The dry weight of onion and tomato plants grown in the presence of mycorrhizal fungi was greater than for the non-mycorrhizal control treatments, in a range of soil-vermiculite mixtures. There were no significant differences between the effects of different methods of mycorrhizal inoculation.

*0760 GODSE, D. B.; WANI, S. P.; PATIL, R. B.; BAGYARAJ, D. J. Response of cowpea (*Vigna unguiculata* (L.) Walp.) to *Rhizobium*-VA mycorrhiza dual inoculation. *Current Science* (1978) 47 (20) 784-785 [En, 7 ref.] Dep. of Agric. Microbiol., Univ. of Agric. Sci., Bangalore 560 065, Karnataka, India.

In pot trials with cowpea in red sandy loam soil of pH 5.8, seed inoculation with *Rhizobium* and application of vesicular arbuscular (VA) mycorrhiza (mixture of yellow vacuolate and white reticulate type *Endogone* fungus spores from the rhizosphere of maize) near to the seeds gave the greatest increases in root and shoot wt, of plants and nodulation. When applied alone, VA mycorrhiza was superior to *Rhizobium* It was suggested that the increased plant development and nodulation with VA mycorrhiza was due to the increased uptake of P.

0761 HALL, I. R. **Effect of vesicular-arbuscular mycorrhizas on two varieties of maize and one of sweetcorn.** *New Zealand Journal of Agricultural Research* (1978) 21 (3) 517-519 [En, 14 ref.] Invermay Agric. Res. Cent., Mosgiel, New Zealand.

The effects of vesicular-arbuscular mycorrhizas (VAM) on the growth of maize cv. PX610 and W415 and sweet corn cv. Yates Golden Cross Bantam were compared. Among the 3 cv. there were highly significant differences in responsiveness to VAM as well as in root dry wt./total dry wt. ratios, lamina P conc. and growth rate. In the absence of P, PX610 outgrew the other 2 cv. and was well infected, but it failed to respond to VAM. In the non-mycorrhizal state the superiority of PX610 over the other cv. was attributed to its superior ability to produce roots and its low lamina P conc. VAM depressed the root dry wt./total dry wt. ratio of PX610 but not of sweet corn or W415.

0762 HALL, I. R. **Effects of endomycorrhizas on the competitive ability of white clover.** *New Zealand Journal of Agricultural Research* (1978) 21 (3) 509-515 [En, 20 ref.] Invermay Agric. Res. Cent., Mosgiel, New Zealand.

In a pot experiment, white clover and perennial ryegrass were grown separately and together at 5 soil P levels and with or without vesicular-arbuscular mycorrhizas (VAM). In the absence of ryegrass, VAM increased total clover DM at 0 and 4 kg P/ha but decreased it at 36 and 108 kg P/ha. In the presence of ryegrass, VAM increased clover DM at 0-12 kg P/ha, but had no significant effect at higher levels. VAM and P had little effect on ryegrass growth. VAM increased clover P conc. at 0-36 kg P/ha in the absence of ryegrass and at all P levels in the presence of ryegrass. Ryegrass decreased clover P conc. with or without VAM. In the presence of ryegrass, clover shoot N conc. were increased by VAM at 0-36 kg P/ha and decreased at 108 kg/ha. Without ryegrass, VAM decreased N conc. at 0 kg P/ha but differences were small at higher P levels.

*0763 HERRERA, R.; MERIDA, T.; STARK, N.; JORDAN, C. F. Direct phosphorus transfer from leaf litter to roots. *Naturwissenschaften* (1978) 65 (4) 208-209 [En, 7 ref.] Centro de Ecologia, Instituto Venezolano de Investigaciones Cientificas, Apdo.1827, Caracas 101, Venezuela.

In an experiment in which an intact root from the living root mass covering the mineral soil in an area draining towards the river Amazon was placed in contact with leaves, labelled with ^{32}P, from the dominant tree species, ^{32}P was transferred from the labelled leaves to the root by numerous septate fungal hyphae bridges in the rhizoplane. A complete hyphal connection between living root tissue and a decomposing leaf was revealed by electron microscopy.†

0764 HUGHES, M.; MARTIN, L. W.; BREEN, P. J. **Mycorrhizal influence on the nutrition of strawberries.** *Journal of the American Society for Horticultural Science* (1978) 103 (2) 179-181 [En, 18 ref.] Oregon State University, Corvallis, OR 97331, USA.

Strawberries (*Fragaria* × *ananassa*) were grown on a clay loam soil at three levels of soil P and inoculated with either *Glomus fasciculatus* or *Gigaspora calospora* mycorrhizal fungus. P and N concentration in the aerial part of inoculated plants were higher than in controls; highest concentrations were found in plants inoculated with *Glomus fasciculatus*. Inoculation with this fungus also resulted in the greatest length of mycorrhizal roots and the highest percentage of total root length infected.†

*0765 IQBAL, S. H.; TAUQIR, S.; AHMAD, J. S. **The effect of vesicular-arbuscular mycorrhizal associations on growth of rice (*Oryza sativa*) under field conditions.** *Biologia* (1978) 24 (2) 357-366 [En, 16 ref.] Dep. of Bot., Punjab Univ., Lahore, Pakistan.

The effect of VA mycorrhizal associations on rice was studied by transplanting 5-wk-old seedlings in fields with indigenous spores. Mycorrhizal infection increased tillering, grain production and plant wt. VA infections in the transplants were considerably reduced by the flooded field conditions initially and growth and tillering was slowed. There was thus no advantage in transplanting mycorrhizal seedlings as non-mycorrhizal seedlings soon became infected in the field. Mycorrhizal seedlings and controls differed in their pattern of growth and tiller formation. Arbuscles and vesicules were equally distributed.

*0766 MATARÉ, R. The effect of mycorrhizal fungi on growth and root development of seedlings. *Information Bulletin, Citrus and Subtropical Fruit Research Institute* (1978) No. 73, 13-14 [En, 3 pl.] Nelspruit, South Africa.

Citrus seedlings, rough lemon, Troyer citrange, Cleopatra mandarin and Swingle tangelo and avocado seedlings, cv. Fuerte, were inoculated with a mycorrhizal fungus (*Glomus* sp.) or not inoculated, and the effects on growth were assessed after 7 months. Mycorrhizal infection greatly enhanced top growth and root development in all cvs except rough lemon, the effects being most marked with Cleopatra mandarin.

0767 MENGE, J. A.; DAVIS, R. M.; JOHNSON, E. L. V.; ZENTMYER, G. A. **Mycorrhizal fungi increase growth and reduce transplant injury in avocado.** *California Agriculture* (1978) 32 (4) 6-7 [En, 1 pl.] California University, Riverside, California, USA.

Avocado seeds, cv. Topa Topa, were germinated in sterilized sand with or without a layer of mycorrhizal inoculum 1 inch below the seeds. The inoculum comprised soil, roots and spores from a pot in which sudangrass [*Sorghum vulgare*] infected with *Glomus fasciculatus* had been grown for 105 days. The seedlings were transplanted to pots of sterilized sandy loam containing only 12 p.p.m. P and fertilized with Hoagland's solution minus P once a week. Seedlings from inoculated soil thrived and grew much faster than non-inoculated seedlings, many of which wilted and died shortly after transplanting.

0768 MENGE, J. A.; JOHNSON, E. L. V.; PLATT, R. G. **Mycorrhizal dependency of several citrus cultivars under three nutrient regimes.** *New Phytologist* (1978) 81 (3) 553-559 [En, 29 ref.] California University, Riverside, California 92521, USA.

Seedlings of 6 rootstock seedling cvs, rough lemon, Brazilian sour orange, alemow (*Citrus macrophylla*), Bessie sweet orange, *Poncirus trifoliata* and Troyer citrange were grown in pots fertilized each week with a nutrient solution (complete except for P), or with $^1/_2$ rate nutrient solution or without nutrients. Half the seedlings were inoculated with the mycorrhizal fungus *Glomus fasciculatus*. The average mycorrhizal dependencies (the degree to which a plant is dependent on the mycorrhizal condition to produce its maximum growth or yield at a given level of soil fertility) of rough lemon and Brazilian sour orange were greater than those of alemow, Troyer citrange, Bessie sweet orange and *P. trifoliata*. The mycorrhizal dependency of each cv., except Bessie sweet and *P. trifoliata*, was substantially altered by at least one of the fertilizer regimes. On the average, the cvs exhibited the greatest mycorrhizal dependency with the least fertilization. The average percentage P in non-mycorrhizal leaf tissues was inversely correlated with mycorrhizal dependency at the medium fertilizer regime. An inverse correlation was observed between the dry weights of non-mycorrhizal roots and the mycorrhizal dependency.

0769 MENGE, J. A.; LABANAUSKAS, C. K.; JOHNSON, E. L. V.; PLATT, R. G. **Partial substitution of mycorrhizal fungi for phosphorus fertilization in the greenhouse culture of citrus.** *Soil Science Society of America Journal* (1978) 42 (6) 926-930 [En, 22 ref.] Univ. Calif., Riverside, USA. From *Soils and Fertilizers 43*, 707.

Mycorrhizal and nonmycorrhizal Brazilian sour orange and Troyer citrange seedlings were grown in an autoclaved, loamy sand (natural P content 4.6 p.p.m.) with various levels of added P, and with or without subsequent inoculation with *Glomus fasciculatus*. After 5 months mycorrhizal sour orange and citrange receiving no additional P were as large as those receiving up to 278 and 56 p.p.m. P, respectively. Dry wts. were similarly greater in mycorrhizal seedlings at most P levels. The percentage of P in leaves of both cvs. was enhanced by mycorrhizal association at all P levels. Variation in Zn, Cu and Mn absorption appeared to be influenced by both P conc. in the seedlings and presence of the fungus. Number of *G.* spores in the soil associated with inoculated plants decreased with increasing P levels. There was no correlation between soil P or percentage P in the seedlings and the elimination of spore production at P levels where the seedlings are no longer dependent on *G. fasciculatus* for improved growth

*0770 LEE, A. T. C.; BROEMBSEN, L. A. VON; HATTINGH, M. J. **Endomycorrhizal fungi enhance growth of rough lemon seedlings in fumigated nursery soil.** *Citrus and Subtropical Fruit Journal* (1978) No.536, 5-8 [En, 8 ref., 2 pl.] Outspan Citrus Centre, Nelspruit, South Africa.

Rough lemon seeds were sown in October in virgin soil fumigated with methyl bromide + chloropicrin at 97 g/m², inoculated with a mycorrhizal fungus (*Gigaspora margarita, Glomus caledonius* or *Glomus fasciculatus*) or not inoculated, amended or not with double superphosphate at 0.4 kg/m³ or non-sterile virgin soil at about 16 litres/m². Seedling vigour, visually assessed between February and September the following year, was greatest on soil inoculated with *G. fasciculatus*, followed by *G. caledonius*-inoculated soil and amended soil; *G. margarita* slightly depressed vigour. After 390 days shoot mass and seedling height were greatest in soil inoculated with *G. fasciculatus*; root mass and stem diameter, however, differed little between this treatment and inoculation with *G. margarita*. The other treatments had little or no effect on any of these growth parameters.

*0771 MOSSE, B. 1978. Mycorrhiza and plant growth. In: Structure and functioning of plant populations. (Ed. A.H.J. Freyren and J.W. Woldendrop). North Holland Publ. Co. Elsevier. pp. 269-291.

0772 POWELL, C. LL.; DANIEL, J. **Growth of white clover in undisturbed soils after inoculation with efficient mycorrhizal fungi.** *New Zealand Journal of Agricultural Research* (1978) 21 (4) 675-681 [En, 25 ref.] Soil and Field Res. Org., Ruakura Agric. Res. Cent., Hamilton, New Zealand.

White clover seedlings were inoculated with the indigenous or 1 of 3 introduced mycorrhizal fungi (*Glomus tenuis, G. fasciculatus* or *G. margarita*) and transplanted into undisturbed cores of 8 hill country soils. After several harvests, at least 1 of the introduced fungi had increased shoot growth in each soil by between 16 and 117%. In most soils the growth benefit from inoculating with an introduced mycorrhizal fungus tended to decrease after the initial shoot harvest, and was then maintained at a lower level over subsequent harvests. In a Taihape silt loam, however, the growth benefit from *Glomus tenuis* inoculation increased steadily over 6 harvests. In 4 out of 5 soils, previous application of phosphate fertilizer (50 kg P/ha yr) did not reduce mycorrhizal growth responses.

0773 POWELL, C. LL.; DANIEL, J. **Mycorrhizal fungi stimulate uptake of soluble and insoluble phosphate fertilizer from a phosphate-deficient soil.** *New Phytologist* (1978) 80 (2) 351-358 [En, 23 ref.] Soil and Field Research Organization, Ruakura Agricultural Research Centre, Hamilton, New Zealand.

In the greenhouse, one crop of white clover and three following crops of ryegrass (*Lolium perenne*) were infected with several mycorrhizal fungi and grown in sterilized soil which had received soluble phosphate (NaH_2PO_4) or Nauru rock phosphate. Plant growth responses to mycorrhizal infection were larger in later crops. *Glomus tenuis* was successfully introduced into soil already infested with the indigenous mycorrhizal fungi, and was the most efficient fungus used for stimulating phosphate uptake. In all four crops, Nauru rock phosphate was available to mycorrhizal plants but unavailable to non-mycorrhizal plants. Plants infected with *G. tenuis* and the indigenous mycorrhizal fungi recovered 10-27% of the phosphate fertilizer applied to the soil while non-mycorrhizal plants recovered only 0.4-13%.†

0774 RHODES, L. H.; GERDEMANN, J. W. **Hyphal translocation and uptake of sulfur by vesicular-arbuscular mycorrhizae of onion.** *Soil Biology & Biochemistry* (1978) 10 (5) 355-360 [En, 18 ref.] Department of Plant Pathology, University of Illinois, Urbana, Illinois 61801, USA.

In a soil chamber, ^{35}S and ^{32}P injected into the soil 8 cm away from onion roots appeared in mycorrhizal plants in soil inoculated with *Glomus fasciculatus*, but did not appear in non-mycorrhizal plants in uninoculated soil. In a second soil-chamber experiment, mycorrhizal onions took up more ^{35}S per unit dry weight than non-mycorrhizal controls did when ^{35}S was injected into soil chambers in a region 3-6 cm from roots. Severing of external hyphae between the application area and the roots reduced the concentration of ^{35}S in tops of mycorrhizal plants but not in roots. Volatile ^{35}S per unit dry weight collected from all plants in each treatment was highest in the mycorrhizal-hyphae intact treatment, and higher in the mycorrhizal-hyphae severed treatment than in the non-mycorrhizal treatment. Movement of ^{35}S in soil from the area of application to roots was similar for all treatments. Increased uptake of S from soil by VA mycorrhizal plants can result from hyphal translocation of S to infected roots by external mycorrhizal hyphae.†

0775 RHODES, L. H.; GERDEMANN, J. W. **Influence of phosphorus nutrition on sulfur uptake by vesicular-arbuscular mycorrhizae of onion.** *Soil Biology & Biochemistry* (1978) 10 (5) 361-364 [En, 19 ref.] Department of Plant Pathology, University of Illinois, Urbana, Illinois 61801, USA.

In a pot experiment, mycorrhizal and non-mycorrhizal plants were grown in soil inoculated with *Glomus fasiculatus* and in uninoculated soil respectively, and were supplied with 2 rates of fertilizer P. Following ^{35}S injection into the soil, both mycorrhizal and non-mycorrhizal plants from high P treatments had significantly higher ^{35}S concentrations in their roots than did non-mycorrhizal, low P controls. Mycorrhizal, low P plants had higher concentrations of ^{35}S in their shoots than did non-mycorrhizal, low P plants. In a second experiment, detached non-mycorrhizal onion roots from plants given a nutrient solution containing P for 26 days before short-term uptake experiments absorbed S at greater rates from solution than did roots from plants given a minus-P nutrient solution. This occurred at all three concentrations of S tested, 1mM, 10μM and 0.1GmM. Increased S uptake by mycorrhizal plants can result from the increased S absorbing power of roots with enhanced P status.†

0776 RHODES, L. H.; GERDEMANN, J. W. **Translocation of calcium and phosphate by external hyphae of vesicular-arbuscular mycorrhizae.** *Soil Science* (1978) 126 (2) 125-126 [En, 12 ref.] Illinois University, Urbana, Illinois 61801, USA.

^{45}Ca and ^{32}P were injected into soil 4.5 cm from onion root surfaces at rates designed to label available pools of Ca and P at equivalent specific activities. Both tracers were detected in mycorrhizal but not in non-mycorrhizal plants after 5 days. ^{45}Ca was detected in much lower amounts than ^{32}P, indicating that Ca is not translocated to roots through mycorrhizal hyphae as readily as P.

*0777 RIAZI, H.A.; DOUGLAS, L.A. Effect of patassium and nitrogen fertilizers and mycorrhiza on tomato plants in pots containing podzolic soil. Inf. Ser. N.Z. Dept. Sci. Ind. Res. 134 (Plant Nutr. v2) 411-417 (1978)

0778 SPARLING, G. P.; TINKER, P. B. **Mycorrhizal infection in Pennine grassland II. Effects of mycorrhizal infection on the growth of some upland grasses on γ-irradiated soils.** *Journal of Applied Ecology* (1978) 15 (3) 951-958 [En, 22 ref., 4 tab.] Leeds Univ., UK.

Glomus tenuis was the dominant endophyte in grasses that received a mixed mycorrhizal inoculum. Mycorrhizal infection did not significantly increase plant dry wt. after 20 weeks and frequently depressed it, but it did increase dry wt.

and shoot phosphorus of grasses grown for 19 months on soil with least available phosphate. Grasses inoculated with *G. mosseae* formed mycorrhizas on only 1 soil, and after 43 weeks the infected plants were smaller than the controls but had higher shoot phosphorus percentage. The generally negative effects of mycorrhizas on grass growth can probably be attributed initially to the greater availability of nutrients in irradiated soil. The fine, much-branched root system permits efficient uptake of phosphate, and mycorrhizal uptake is not significant until the soil is very severely depleted.

0779 SPARLING, G. P.; TINKER, P. B. **Mycorrhizal infection in Pennine grassland. 3. Effects of mycorrhizal infection on the growth of white clover.** *Journal of Applied Ecology* (1978) 15 (3) 959-964 [En, 19 ref.] Macaulay Inst. for Soil Res., Craigiebuckler, Aberdeen AB9 2QJ, UK.

The effects of mycorrhizal infection on the growth of white clover were assessed, using γ-irradiated soil of the Malham series amended with P fertilizer and lime. 2 types of field inocula, obtained from limed soil and from P-fertilized soil of the Malham series, gave up to 20-fold increases in the growth of clover when little or no P was added, but had little effect when P was added. Infection with *Glomus mosseae* was slight and had only a small effect on plant growth when little or no P was applied, though infection was greater and plant growth stimulated when the soil was fertilized with basic slag. The differing responses of the various mycorrhizal fungi to P and lime applications could be important for the establishment of clover during improvement of hill grassland.

0780 TIMBER, P.B. Effect of vesicular-arbuscular mycorrhizas on plant nutrition and plant groth Phisiologie Vegetale ; 16: 743-751 1978.

0781 TIMMER, L. W.; LEYDEN, R. F. **Stunting of citrus seedlings in fumigated soils in Texas and its correction by phosphorus fertilization and inoculation with mycorrhizal fungi.** *Journal of the American Society for Horticultural Science* (1978) 103 (4) 533-537 [En, 16 ref.] Texas A&M Univ. Citrus Center, Weslaco, 78596, USA.

Stunting of sour orange seedlings was observed in seedbeds which had been fumigated chemically or heat-treated, and in seedlings planted in soil-less media. Mycorrhizae were consistently absent from stunted seedlings and present in vigorous seedlings in seedbeds and nurseries and also present in orchards. Inoculation with *Glomus fasciculatus* increased seedling height more than 300% and increased foliar P concentrations in greenhouse experiments on sour orange seedlings grown in sand culture with complete nutrient solution. Preplant application of P at 200 mg/l did not increase growth or foliar P concentrations. Inoculation of seedlings increased growth where 0 or 100 mg P/l was added, but not where higher rates of P were used. Application of high rates of P induced copper deficiency symptoms, which were more severe on non-mycorrhizal than on mycorrhizal plants.

0782 TINKER, P.B. Effects of vesicular-arbuscular mycorrhizas on plant nutrition and plant growth Physiolo. Veg. 16(4):743-751. 1978.

Vesicular-arbuscular (VA) mycorrhizas have been studied for nearly 100 years, but their effects on plans have only been understood recently. They improve the phosphorus nutrition and possibly that of some other elements, of the host plant by absorbing phosphate into external hyphae and translocating it to the host root, probably in the form of polyphosphate. Other effects have been suggested, and occasionally infection with the fungus decreases growth, but no other mechanism except the nutritional one has been established with certainty VA mycorrhizas probably do not utilize sources of phosphorus which are unavailable to uninfected plants.
The interaction between VA infection and environmental conditions is not well established, though it is clear that pH, P and N content and temperature are important. Different species of VA endophytes can give very different response and introduced species have often given better responses than native ones in pot experiments; some useful responses in the field are now being obtained.

0783 ABBOTT, L. K.; ROBSON, A. D. **Growth stimulation of subterranean clover with vesicular arbuscular mycorrhizas.** *Australian Journal of Agricultural Research* (1977) 28 (4) 639-649 [En, 31 ref.] Dep. of Soil Sci. and Pl Nutr., Western Australia Univ., Nedlands, W.A., Australia 6009.

Growth of subterranean clover with 2 types of vesicular arbuscular endophytes was compared with that of uninoculated plants at 5 rates of applied superphosphate-fixing soil. Plants were grown in both untreated soil and soil steamed to eliminate the natural population of mycorrhizal fungi. Marked increases in the growth and P content of plants inoculated with a fungus isolated in Western Australia were apparent at intermediate levels of superphosphate in both soils. This fungus, which resembles *Glomus mosseae*, was more efficient at increasing growth and P content of subterranean clover than *G. fasciculatus*. The greater growth response of plants inoculated with the fungus resembling *G. mosseae* was associated with a greater amount of mycorrhizal roots. Responses in nodulation closely paralleled responses in growth. Non-mycorrhizal plants produced more DM at a given P content in tops than did mycorrhizal plants.

0784 BLACK, R. L. B.; TINKER, P. B. **Interaction between effects of vesicular-arbuscular mycorrhiza and fertiliser phosphorus on yields of potatoes in the field.** *Nature, UK* (1977) 267 (5611) 510-511 [En, 20 ref.] Department of Plant Sciences, University of Leeds, Leeds, UK.

This inoculation experiment was sited on an area left fallow for 2 yr, so that the spore density was only about one per ml. The inoculum consisted of topsoil from nearby plots, on the same soil series, on which barley had been grown for 3 yr, and which contained 13 spores per ml. The most frequent spore type was *Glomus macrocarpus*. Infection with soil inoculum was much greater than the low control level, but as expected phosphorus fertilizer suppressed it considerably. At harvest, fertilizer phosphorus increased yield, but least so in the presence of cereal soil inoculum. Interaction between inoculum and fertilizer phosphorus is indicated by the large increase in yield caused by inoculum, but only in the absence of phosphorus fertilizer. Other organisms in the inoculum soil may have infected or altered the crop, but the increase in mycorrhizal infection, and the interaction with phosphorus fertilizer leaves little doubt that it was principally vesicular-arbuscular organisms which affected the yield.

0785 BRYAN, WILLIAM C. and PAUL P. KORMANIK. (Southeast. For. Exp. Stn., For. Sci. Lab., US For. Serv., Athens, Ga. 30602, USA.) **Mycorrhizae benefit survival and growth of sweetgum seedlings in the nursery.** SOUTH J APPL FOR 1(1): 21-23. 1977.—In small plots where soil was fumigated with methyl bromide before sowing, roots of sweetgum (*Liquidambar styraciflua* L.) seedlings were non-mycorrhizal. When such soil was inoculated with naturally occurring endomycorrhizal fungi, or with a pure culture of *Glomus mosseae*, 1-0 seedlings were thrifty, averaging 8 times taller and approximately 80 times greater in oven-dry top weight than the non-mycorrhizal controls.

0786 COOPER, K. M. **Endomycorrhizas affect growth of *Dryopteris filix-mas*.** *Transactions of the British Mycological Society* (1977) 69 (1) 161-164 [En, 18 ref.] Botany Dep., Univ. of Otago, Dunedin, New Zealand.

In laboratory studies on soils of low Truog P content, growth of *D.filix-mas* sporophytes during the first 24 weeks was dependent largely on the addition of P or the presence of mycorrhizae. However, soil with a high Truog P level supported good non-mycorrhizal growth without added P. Addition of a complete nutrient solution minus P to this soil, by slightly reducing available soil P, induced a positive response to mycorrhizal infection. When P was added to the high-P soil, growth was depressed by mycorrhizal infection at both 12 and 24 weeks; growth reduction also occurred at 12 weeks in this soil in the absence of added P. P levels in shoots of mycorrhizal plants were generally higher, and less sensitive to added P, than levels in nonmycorrhizal shoots. Growth and development of the prothallus was unaffected by mycorrhizal infection. Effects on the sporophytes are compared with previous data for *Histiopteris incisa* and *Pteridium aquilinum* and discussed in relation to root morphology.

0787 DAFT, M. J.; HACSKAYLO, E. **Growth of endomycorrhizal and nonmycorrhizal red maple seedlings in sand and anthracite spoil.** *Forest Science* (1977) 23 (2) 207-

216 [En, 28 ref., 3 fig., 3 tab.] Univ. Dundee, Scotland, UK.

The growth of *Acer rubrum* was increased when the plants, grown in either sand or anthracite waste containing bonemeal, were infected with *Glomus macrocarpus* var. *geosporus* or *Gigaspora gigantea*, respectively. The importance of phosphate and nitrate for normal development was shown in plants grown in sand culture. Mycorrhizal plants grown in both media contained more phosphorus than non-mycorrhizal plants. Effects of various nutrient treatments and mycorrhizal infection on the size of the plants, leaf number, leaf areas, stem anatomy and chemical composition of the plant tissues are reported. Both the secondary and beaded tertiary roots became infected with the fungal endophytes. The possible exploitation of this symbiosis on anthracite spoil areas is discussed.

0788 FITTER, A. H. Influence of mycorrhizal infection on competition for phosphorus and potassium by two grasses. *New Phytologist* (1977) 79 (1) 119-125 [En, 11 ref.] Dep. of Biol., York Univ., Heslington, York YO1 5DD, UK.

A seedling each of (a) perennial ryegrass and (b) *Holcus lanatus* were grown in sterilized soil on opposite sides of 125-mm pots with mycorrhizal infection and/or root competition. Root competition was excluded by separating the roots of the 2 species by perspex partitions. Root competition and mycorrhizal infection both gave a slight advantage to (b) but together suppressed growth of (a) considerably. Root length of (a) was reduced by mycorrhizal infection, which was itself increased by root competition. Competitive effects could be explained solely in terms of mycorrhizal infection.

0789 GEBBING, H.; SCHWAB, A.; ALLEWELDT, G. [Mycorrhiza of vines.] Mykorrhiza der Rebe. *Vitis* (1977) 16 (4) 279-285 [De, en, 8 ref.] Institut für Obstbau, Gemüsebau und Weinbau der Universität Hohenheim, Lehrstuhl für Weinbau, Stuttgart, German Federal Republic.

The growth and morphology of the endotrophic mycorrhizae of two vine cultivars (Silvaner and Aris) are described. Shoot growth and P uptake were stimulated by mycorrhizal inoculation especially when the P supply was limited.

0790 HALL, I. R. Effect of applied nutrients and endomycorrhizas on *Metrosideros umbellata* and *Leptospermum scoparium*. *New Zealand Journal of Botany* (1977) 15 (2) 481-484 [En, 19 ref., 3 tab.] Univ. Otago, Dunedin, New Zealand.

L. scoparium ceased growth and *M. umbellata* grew only slowly in Te Anau soil unless infected by vesicular-arbuscular mycorrhizas or given additional phosphorus. Mycorrhizas stimulated P uptake but did not always supply the host's full P requirements. High shoot P concs., effected by applying P, reduced mycorrhizal infection. In *L. scoparium* shoot P rose to a toxic level but the fungus was not eliminated. The application of nutrients other than P stimulated growth of mycorrhizal plants, generally lowered the conc. of P in the shoots and increased infection levels. Because of the presence of residual infections, it was concluded that infection level is an indication of a host's mycotrophic status only when it is known the endophyte is benefitting growth.

0791 HALL, I. R.; SCOTT, R. S.; JOHNSTONE, P. D. Effect of vesicular-arbuscular mycorrhizas on response of 'Grasslands Huia' and 'Tamar' white clovers to phosphorus. *New Zealand Journal of Agricultural Research* (1977) 20 (3) 349-355 [En, 19 ref.] Invermay Agric. Res. Cent., MAF, Mosgiel, New Zealand.

White clover cv. Huia and Tamar seeds were inoculated with *Rhizobium trifolii*, germinated, inoculated with *Sclerocystis rubiformis*, *Glomus monosporous* and *G. tenuis* or given no mycorrhiza, and grown on sterilized Warepa silt loam (1.4 kg/pot) with 0, 10, 30, 60, 90, 120, 160, 180, 210 or 240 kg P/ha. At 0 and 10 kg P/ha, DM yield from mycorrhizal-treated pots was 0.303 g/pot and from pots without mycorrhiza and uninoculated 0.231 g/pot; at >30 kg P/ha, means were 0.831 and 1.047 g/pot, resp. Tamar yielded more than Huia with >30 kg P/ha in both mycorrhizal and non-mycorrhizal plants. Herbage P conc. was lower in plants without mycorrhiza at 0 and 10 kg P/ha, and in mycorrhizal-treated plants percentage infection decreased with increased P.

0792 HAYMAN, D.S.; DAY, J.M. Influence of VA mycorrhiza on plant growth. Uptake of molybdenum. Rothamsted Annu. Report for 1977. Rothamsted Exp. Sta; Harpenden, England. p.240

0793 HAYMAN, D. S. Mycorrhizal effects on white clover in relation to hill land improvement. *ARC Research Review* (1977) 3 (3) 82-85 [En, 2 ref., 1 tab., 1 fig.] Rothamsted Exp. Sta., Harpenden, Herts.

A synthesis is presented of the main principles and facts established at a meeting held at Leeds Univ. in July 1977 on ways of using mycorrhiza to improve clover establishment and growth in hill grasslands. Pot tests in phosphate-deficient upland peat soils indicated benefits with mycorrhizal inoculation resulting from improved phosphate nutrition. Field tests are now in progress at 3 locations in Argyll, Dyfed and Yorkshire involving co-operation between ARC institutes, universities and ADAS. Future work will concentrate on evaluating native and introduced mycorrhizal fungi in relation to land reclamation schemes, their ecology and relative symbiotic effectiveness in the cool wet upland environment, their interaction with rhizobia, and methods of inoculum production and field inoculation.

0794 ISLAM, R. Effect of several Endogone spore types on the yield of Vigna unguiculata Internal Report, Internat. Inst. Trop. Agric., Ibadan, Nigeria, 19pp. 1977.

*0795 IQBAL, S. H.; QURESHI, K. S. The effect of vesicular arbuscular mycorrhizal associations on growth of sunflower (*Helianthus annus* L.) under field conditions. *Biologia, Pakistan* (1977) 23 (2) 189-196 [En, 17 ref., 1 pl. (4 fig.), 3 tab.] Univ. Punjab, New Campus, Lahore, Pakistan.

Sunflower plants became mycorrhizal as early as the 2-leaf stage when grown in P deficient soil. A correlation was found between the extent of *Endogone* infections and the number of leaves. The VA endophyte responsible for mycorrhizal infections included white reticulate, honey coloured sessile, red brown laminate and yellow vacuolate types of spores. Mycorrhizal plants at harvest were taller, stouter, had more numerous and larger leaves, and bore bigger disks producing viable seeds than nonmycorrhizal plants. The latter showed P deficiency symptons and produced smaller disks with *c.* 50-60% nonviable seeds. Mycorrhizal plants removed more P from the rhizosphere.

*0796 JANOS, D.P. Vesicular-arbuscular mycorrhizae affect the growth of Bactris gasipaes. Principes (1977) 21(1) 12-18 Smithsonian Trop. Res. Inst., Balboa, Panama Canal Zone.

In sterilized soil uninoculated seedlings of B. gasipaes grew very little and most of them died within 1 yr of planting, whereas 7 out of 9 seedlings inoculted by adding chopped mycorrhizal cacao roots to the soil survived to the end of the experiment. They were also significantly taller and had larger and more leaves than uninoculated plants. Roots of the uninoculated plants remained uninfected, whereas those of the inoculated plants developed vesicular-arbuscular mycorrhizae. The importance of mycorrhizae to palms and its implication for the palm grower are discussed.

*0797 KORMANIK, P. P.; BRYAN, W. C.; SCHULTZ, R. C. Influence of endomycorrhizae on growth of sweetgum seedlings from eight mother trees. *Forest Science* (1977) 23 (4) 500-505 [En, 10 ref., 3 fig., 2 tab.] SE Forest Exp. Sta., Athens, Ga., USA.

Liquidambar styraciflua seedlings in plots of fumigated soil containing *Glomus mosseae* were endomycorrhizal after 6 months and outgrew the non-mycorrhizal control seedlings, regardless of soil fertility. Adequate endomycorrhizal inoculum in nursery beds may allow the use of less fertilizer.

0798 KORMANIK, P. P.; BRYAN, W. C.; SCHULTZ, R. C. The role of mycorrhizae in plant growth and development. In *Physiology of root-microorganisms association [Vines, H. M. (Editor)]*. (1977) 1-10 [En, 22 ref.] Inst. for Mycorrhizal Res. and Development, Southeastern Forest Exp. Sta., Athens, GA 30601, USA.

The morphology of ectomycorrhizal and endomycorrhizal fungi and the role they play in plant growth and development are described. The methods used to study uptake often reduce the effectiveness of these root symbionts, and so extrapolation of the data from such work to plants growing in soil may not be correct. Root symbionts may be deeply involved in the transfer, synthesis and stimulation of

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growth hormones within the host plant, but the extent of such involvement is unknown.

*0799 LINDSEY, D. L.; CRESS, W. A.; ALDON, E. F. **The effects of endomycorrhizae on growth of rabbitbrush, fourwing saltbush, and corn in coal mine spoil material.** *USDA Forest Service Research Note RM* (1977) No.343, 6pp. [En, 12 ref.] Department of Botany, New Mexico State University, Las Cruces, USA.

Vesicular arbuscular endomycorrhizae formed by *Glomus fasciculatus* increased the survival and growth of *Chrysothamnus nauseosus*, but had no effect on *Atriplex canescens* or maize on coal mine spoil.

0800 MOSSE, B. **Plant growth responses to vesicular-arbuscular mycorrhiza 10. Responses of *Stylosanthes* and maize to inoculation in unsterile soils.** *New Phytologist* (1977) 78 (2) 277-288 [En, 29 ref.] Rothamsted Exp. Sta., Harpenden, Herts AL5 2JQ, UK.

Results of inoculation with vesicular-arbuscular endophytes (VA) in 12 non-sterile soils (11 of which were of tropical origin), with and without added rock phosphate or Hyperphosphat, on the growth, dry weight, P uptake, nodule weight and nitrogenase activities of *S. guyanensis* and maize are presented. VA endophytes established well in all but one soil. Growth was best in inoculated plants in 11 out of 12 soils given added P and significantly so in 5 out of 12 soils. In general, P utilization was increased by VA inoculation, though there was no evidence of increased P availability. Inoculation often stimulated nodulation by rhizobia but, in contrast to irradiated soils, there was no clear relationship between percentage plant P and nodulation. The results in terms of possible field inoculation with VA endophytes are discussed.

0801 NEMEC, S. **Reaction of six citrus rootstocks to three *Glomus* species.** [Abstract]. *Proceedings of the American Phytopathological Society* (1977) 4, 227 [En] USDA, Orlando, FL 32803, USA.

Seedlings of 6 citrus rootstocks were inoculated with the vesicular-arbuscular mycorrhizal (VAM) fungi, *Glomus etunicatus*, *G. mosseae* and *G. fasciculatus* in sand in the greenhouse. One set was fertilized monthly with a liquid 12-6-6 formulation and another with 12-0-6. All inoculated seedlings grown with either fertilizer grew well. Combined growth of all rootstocks was increased 21-, 8- and 6-fold by *G. etunicatus*, *G. mosseae* and *G. fasciculatus*, respectively, with 12-0-6. Growth of similar seedlings increased no more than 1.8-fold with VAM fungi and 12-6-6. Height difference between VAM-inoculated rootstocks and controls was ranked highest to lowest in the order: sour orange, Cleopatra mandarin, sweet orange, rough lemon, Rangpur lime and Carrizo citrange. With *G. mosseae*, growth rates varied from 0.32 cm/day for Cleopatra to 0.19 cm/day for Carrizo citrange. A 40-50-day lag period occurred after inoculating seedlings of all rootstocks. Only *G. mosseae* sporulated in soil around roots when 12-6-6 was used. *G. etunicatus* and *G. mosseae* sporulated in soil when 12-0-6 was used.

0802 POWELL, C. LL. **Mycorrhizas in hill-country soils II. Effect of several mycorrhizal fungi on clover growth in sterilised soils.** *New Zealand Journal of Agricultural Research* (1977) 20 (1) 59-62 [En, 13 ref., 4 tab.] Ruakura Agric. Res. Cent., Minist. Agric. Fisheries, Hamilton, New Zealand.

White clover seedlings were inoculated with the indigenous and 5 introduced strs. of mycorrhizal fungi and planted in 4 sterilized hill-country soils. After 10 weeks growth infection with the indigenous mycorrhizal fungi had caused increases in shoot dry matter over nonmycorrhizal plants from 130% in Waingaro steepland soil (south aspect) to 3700% in Te Kuiti silt loam. E_3 was more efficient than the indigenous fungi at increasing P uptake and plant growth in 2 silt loams. The indigenous fungi in 2 steepland soils were more efficient than all 5 introduced fungi at stimulating plant growth. The relative efficiencies of the 5 introduced mycorrhizal fungi were different in each soil. There was no correlation in any soil between the P uptake efficiency of mycorrhizal fungi and the frequency of their hyphal connexions between the soil and the root system.

0803 POWELL, C. LL. **Mycorrhizas in hill country soils III. Effect of inoculation on clover growth in unsterile soils.** *New Zealand Journal of Agricultural Research* (1977) 20 (3) 343-348 [En, 14 ref., 6 tab.] Soil Field Res. Org., Minist. Agric. Fisheries, PB, Hamilton, New Zealand.

Shoot growth in glasshouse clover seedlings, preinoculated with a sporocarpic *Glomus* sp. (E_3) and transplanted into soil cores of Te Kuiti silt loam from hill country paddocks, was 90% greater than that of plants preinoculated with the indigenous mycorrhizal fungi. There were large but non-significant growth increases in Mahoenui silt loam and in south aspect Waingaro steepland soil. Clover seeds were also sown in hill country paddocks above pads of soil inoculated with E_3 or the indigenous mycorrhizal fungi. E_3 caused 50% more shoot growth in south aspect Waingaro steepland soil, but 42% less shoot growth in north aspect Waingaro soil. Clover seedlings were preinoculated with E_3 or the indigenous mycorrhizal fungi and grown in a glasshouse in soil cores of Te Kuiti silt loam, which had been annually fertilized with P at 0, 11.2 or 44.8 kg/ha. E_3-inoculated plants took up 108% more P than plants inoculated with the indigenous mycorrhizal fungi at the highest fertiliser rate, increases at lower fertiliser rates were smaller and non significant. These experiments suggest that E_3 can be introduced into hill country soils and increase the uptake of residual and fertiliser P from soil.

0804 POWELL, C. L. **Mycorrhizas in hill country soils. 5. Growth responses in ryegrass.** *New Zealand Journal of Agricultural Research* (1977) 20 (4) 495-502 [En, 16 ref.] Soil and Field Res. Org., Ruakura Agric. Res. Cent., MAF, Hamilton, New Zealand.

Mycorrhizal fungi stimulated shoot growth of perennial ryegrass in soils with up to 60 μg P/ml although responses were generally greater in less-fertile soils. The size of the mycorrhizal response was also influenced by soil type, the sp. of mycorrhizal fungus used and the number of ryegrass crops grown in the test soil. In the 1st ryegrass crop grown in 4 hill-country soils, *Gigaspora margarita* stimulated from 8% less to 213% more P uptake than the indigenous mycorrhizal fungi. After 4 successive crops, the increased uptake by *Gigaspora*-infected plants was 59-550% in the 4 soils. As soils became depleted of P with successive crops, non-mycorrhizal plants and those infected with inefficient mycorrhizal fungi became less able to extract P from soil.

*0805 POWELL, C. L. **Efficient mycorrhizal fungi reduce fertilizer requirements.** In *Proceedings of the Ruakura Farmers' Conference 1977, 29th Conference Hamilton, New Zealand.* Wellington, New Zealand; Ministry of Agriculture and Fisheries. (1977) 24-27 [En] Soil and Field Res. Org., Ruakura Agric. Res. Cent., Hamilton, New Zealand.

6 pasture soils with quick-test P contents ranging from 3 to 30 were sterilized, [white] clover seedlings were re-infected with the local mycorrhizal fungi or left uninfected, planted into the soils and grown for 10 wk. Fungi increased shoot DM, especially in soils with P <6. In a 2nd experiment, clover was grown in Te Kuiti soil which was sterile or infected with local fungi or strain E_3 with 0, 300 or 600 kg superphosphate/ha. At the high P rates, E_3-infected plants were larger than those under other treatments. Methods of inoculating field soils with efficient mycorrhizal fungi to stimulate pasture growth are briefly discussed.

0806 SAIF, S. R.; KHAN, A. G. **The effect of vesicular-arbuscular mycorrhizal associations on growth of cereals III. Effects on barley growth.** *Plant and Soil* (1977) 47 (1) 17-26 [En, 20 ref., 2 fig. 2 tab. Univ. Islamabad, Pakistan.

Barley seedlings already mycorrhizal when planted in the field in phosphorus deficient soil grew much better than non-mycorrhizal plants, removed more phosphorus from the soil and had more dry matter. Yield was increased 4-fold but individual grain wt. was not affected. Differences between mycorrhizal and non-mycorrhizal plants were almost eliminated by the application of phosphate fertilizer, indicating that the fungus does not enhance barley growth in soils containing enough available phosphate. *Endogone* spore number, mycorrhizal development, root infection and increased growth were positively correlated. The extent of root infection was greatest in mycorrhizal plants in soil not supplemented with phosphate and it decreased in inoculated plants in the plot with superphosphate. Number of tillers and ears/plant were more than double in mycorrhizal plants compared with non-mycorrhizal ones.

0807 SMITH, S. E.; DAFT, M. J. **Interactions between growth, phosphate content and nitrogen fixation in mycorrhizal and non-mycorrhizal *Medicago sativa*.** *Australian Journal of Plant Physiology* (1977) 4 (3) 403-413 [En, 35 ref.]

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Dep. of Biol. Sci., Dundee Univ., Dundee DD1 4MN, UK.

Nodulated plants of lucerne cv. Europe, both non-mycorrhizal and mycorrhizal (inoculated with *Glomus mosseae*), were grown in sand or soil at a range of P levels, and intensity of mycorrhizal infection, intensity of nodulation, growth, nitrogenase activity (acetylene reduction) and N and P content were measured. Both nodulation and mycorrhizal infection had occurred within 2 wk of inoculation with the appropriate endophytes. Major increases in dry wt. of mycorrhizal plants were not apparent until approx. 10 wk from inoculation. However, mycorrhizal plants showed more extensive nodulation, coupled with higher rates of nitrogenase activity from 2 wk onwards, and at the final (12-wk) harvest had higher N content. P content of mycorrhizal plants (μg P/g dry wt.) was also greater than non-mycorrhizal plants at 7 wk. By 10 or 12 wk, when significant mycorrhizal enhancement of growth was apparent, the total N and total P/mycorrhizal plant were also higher, but nitrogenase activity and P content measured on a dry wt. basis showed no significant differences between mycorrhizal and non-mycorrhizal plants. It is clear that mycorrhizal enhancement of P uptake and N fixation precedes any effect on growth and the results indicate the importance of the time factor in the development of this tripartite symbiosis between legume, *Rhizobium* and mycorrhizal fungus.

*0808 SWAMINATHAN, K.; VERMA, B. C. **Symbiotic effect of vesicular-arbuscular mycorrhizal fungi on the phosphate nutrition of potatoes.** *Proceedings of the Indian Academy of Sciences, B* (1977) 85 (5) 310-318 [En, 40 ref., 2 fig., 3 tab.] Cent. Potato Res. Inst., Simla, India.

Glomus macrocarpus, occurring widely in Indian soils, increases P uptake from the soil. Inoculating the seed tuber with a slurry of the spores gave better results than direct inoculation of the soil. In an infertile soil mycorrhizal plants took up ×8 more P and made ×5 more growth than non mycorrhizal plants. Under natural conditions only 23% of the potato fields surveyed carried spores of, or root infection by endomycorrhizal fungi.

0809 ALI, B. **Influence of the endophytes of *Nardus* on plant growth.** *Plant and Soil* (1976) 44 (2) 329-340 [En] Department of Agricultural Botany, University College of Wales, Aberystwyth, Dyfed, UK.

Results of experiments with autoclaved or gamma-irradiated soils showed that, under the experimental conditions, the vesicular-arbuscular endophytes of *Nardus stricta* had no statistically significant effects on plant growth.

0810 BARROWS, J. B. **Endomycorrhizal synthesis in poinsettia.** [Abstract]. *Proceedings of the American Phytopathological Society* (1976) 3, 265 [En] Georgia University, Athens, Georgia 30602, USA.

Poinsettia plants inoculated with the endomycorrhizal fungus *Gigaspora calospora* became infected with hyphae, arbuscules and vesicles of the fungus developing in the root cortex. Addition of spores to the rooting medium in the mist bed increased the survival of transplanted cuttings by 20% over the controls. Mycorrhizal plants showed a 25-45% increase in total fresh weight as compared with nonmycorrhizal plants. Application of a low rate (125 p.p.m) of the nutrient compound Miller Nutri-Leaf 60 resulted in a three-fold increase in mycorrhizal infection and equally good plant growth as compared with responses to a high (250 p.p.m.) rate.

0811 BENSON, N.R.; COVEY, R.P. Jr. Respons of apple seedlings to zinc fertilization and mycorrhizal inoculation. HortScience 11(3):25 253. 1976.

Zinc fertilization (5 ppm) of apple seedlings (Malus sp.) grown in chloropicrin-fumigated soil increased shoot weight slightly and Zn concentration significantly after 70 days. Inoculation of seedling with vesicular-arbuscular mycorrhizal fungus Glomus mosseae (Nicol. Gerd.) Gerd. & Trappe. or G. fasciculatus (Thaxter) Gerd. & Trappe without Zn fertilization increased shoot weight but not plant Zn concentration. Zinc fertilization plus mycorrhizal inoculation increased shoot weight and Zn concentration. Total Zn uptake was increase 7 fold by combined Zn fertilization and G. fasciculatus inoculation. G. mosseae was slightly less effective than G. fasciculatus in promoting seedling growth.

*0812 BRYAN, W.C.; RUEHLE, J.L. Growth stimulation of sweetgum seedlings induced by the endomycorrhizal fungus *Glomus mosseae*. Tree Planter's Notes 27(9):24. 1976.

0813 COX, G.; TINKER, P. B. **Translocation and transfer of nutrients in vesicular-arbuscular mycorrhizas.** *New Phytologist* (1976) 77 (2) 371-378 [En, 24 ref., 4 pl., 1 fig.] Leeds University, LS2 9JT, UK.

Digestion of the fungus by the host (onion) was probably not a significant factor in PO_4 transfer. Transfer across the membranes of the living fungus and host was more likely.

0814 CRUSH, J. R. **Endomycorrhizas and legume growth in some soils of the Mackenzie Basin, Canterbury, New Zealand.** *New Zealand Journal of Agricultural Research* (1976) 19 (4) 473-476 [En, 24 ref.] Grasslands Div., DSIR, Lincoln, Christchurch, New Zealand.

In a glasshouse trial endomycorrhizal plants of *Trifolium repens* and *T. pratense* grew better than non-mycorrhizal plants in a range of fertilized and unamended soils. The relative benefit of mycorrhiza formation increased as P availability and DM yields decreased. The same mycorrhizal fungus was parasitic on *T. hybridum* and *Medicago sativa*, reducing growth by 3-16%. These results indicate that endophyte-host relationships in the symbiosis change from mutualism to parasitism as P availability increases.

0815 DAFT, M. J.; EL-GIAHMI, A. A. **Studies on nodulated and mycorrhizal peanuts.** *Annals of Applied Biology* (1976) 83 (2) 273-276 [En] Department of Biological Sciences, University of Dundee, DD1 4HN, UK.

Yields of fruits, plant size and chemical content of shoots, roots and seeds were higher in peanuts infected with *Glomus mosseae*. Infection with *Glomus* and *Rhizobium* stimulated nodulation and acetylene reduction rates. Dually infected plants given various phosphorus treatments produced more fruits, dry matter and nodules, and contained more phosphorus and nitrogen, compared with nodulated-only plants. Mycorrhizal infections were high in all treatments. Together these two endophytes contributed greatly to the vigour of the host.

0816 GRAHAM, S. O.; GREEN, N. E.; HENDRIX, J. W. **The influence of vesicular-arbuscular mycorrhizal fungi on growth and tuberization of potatoes.** *Mycologia* (1976) 68 (4) 925-929 [En, 11 ref.] Department of Plant Pathology, Washington State University, Pullman, Washington 99163, USA.

In a three-year experiment in which potato plants were grown by the misted-root culture, inoculation of the roots with *Glomus fasciculatus* almost doubled the average number of tubers/plant and increased the dry weights of the tops and roots. In a one-year experiment, inoculation with *G.mosseae* did not affect the average number of tubers/plant but did increase the dry weights of the tops and roots. Neither fungus affected the percentage content of dry matter in the tubers.

0817 HAINES, B. L.; BEST, G. R. ***Glomus mosseae*, endomycorrhizal with *Liquidambar styraciflua* L.seedlings retards NO_3, NO_2 and NH_4 nitrogen loss from a temperate forest soil.** *Plant and Soil* (1976) 45 (1) 257-261 [En] Botany Department, University of Georgia, Athens, Ga.30602, USA.

The influence of a mycorrhizal fungus on downward movement of NH_4, NO_2, and NO_3 nitrogen in forest soil was determined by establishing combinations of soil, fungus and seedlings in plastic pipes and monitoring the nitrogen content of water percolating to two depths. Compared with controls of soil alone and of soil + seedling alone, treatments containing the mycorrhizae showed a significant reduction of NH_4-N loss from 5 and 25 cm depths and significant reduction of NO_3-N loss from the 5 cm depth. No significant effect was observed on nitrite loss.

0818 HALL, I. R. **Response of *Coprosma robusta* to different forms of endomycorrhizal inoculum.** *Transactions of the British Mycological Society* (1976) 67 (3) 409-411 [En, 16 ref.] Botany Department, University of Otago, Dunedin, New Zealand.

In a pot experiment, *Coprosma robusta* seedlings were inoculated with spores or root segments infected by a small-spored species of *Glomus* or *Acaulospora laevis*. More rapid growth stimulation occurred with root segments than with

spores and with *Glomus* than with *Acaulospora*. Accordingly the *Glomus* infected plants were ultimately the larger, but the *Acaulospora* infection seemed no less effective once established. Application of P or complete fertilizer decreased the ultimate shoot weight of the mycorrhizal plants, probably by delaying mycorrhizal infection.

*0819 LAMBERT, D.H.; COLE, H. Jr. Establishment of legume mycorrhizae for strip mine revegetation. Proceedings of the American Phytopathological Society. Vol. 3, 1976. p.107. Abstract. Growth response to mycorrhizae is greatest where available phosphorus is low, plants are coarse-rooted and little or no fungal inoculum is presented. These three conditions exist for legumes and mine spoil, which suggest substantial improvement in growth will follow establishment of endomycorrhizae.
Pesistant stands of birdsfoot trefoil (Lotus corniculatus), crown vetch (Coronilla varia), sweet clover (Melitotus alba) and flatpea (Lathyrus sylvestris) were established on limed but otherwise unfertilized mine spoil using field soil (5% v/v) as inoculum for endomycorrhiza formation. Increases in dry matter production due to infection ranged from 7-19 fold in the second year. Five % sterilized soil or soil from which mycorrhiza spores were removed did not produce mycorrhizal infection or improve growth when added to spoil. The benefit of the inoculum used was equivalent to 30 Kg/ha P for birdsfoot trefoil at low to moderate levels of available P. Fungal strains form soils of PH 4.0 or lower performed equally well or better at a spoil pH of 4.8 than at 5.7 in constrast to two reference strains from higher pH soils. Performance of several grasses was not substantially improved by mycorrhiza formation.

0820 MOSSE, B., C. L. POWELL and D. S. HAYMAN. (Rothamsted Exp. Stn., Harpenden, Herts, Engl., UK.) **Plant growth responses to vesicular-arbuscular mycorrhiza: IX. Interactions between VA mycorrhiza, rock phosphate and symbiotic nitrogen fixation.** NEW PHYTOL 76(2): 331-342. 1976.—Interactions between vesicular-arbuscular (VA) mycorrhiza, utilization of rock phosphate and nodulation were examined in 3 legumes (clover, *Stylosanthes* and *Centrosema*) and in onions, grown in 8 P-deficient soils with pH 8.1-5.3. Irrespective of pH, inoculation with VA endophytes increased P uptake in all host plants in all the soils when the indigenous endophytes had been removed by irradiation, but appreciable increases in plant dry weight occurred only when P concentrations of the uninoculated plants were low, generally below 0.15%. In the acid soils adding rock phosphate generally improved growth of the non-mycorrhizal plants and inoculation with VA endophytes greatly improved its utilization. The effects persisted when the soil was used a 2nd time. In neutral and alkaline soils rock phosphate was unavailable to non-mycorrhizal plants and remained so after inoculation with VA endophytes. Legumes inoculated with the appropriate *Rhizobium* strain nodulated only in the most P-deficient soils when they were also mycorrhizal, and added rock phosphate greatly improved nodulation and N fixation of the mycorrhizal plants. Some pilot experiments in unsterile soils are described and the bearing of these results on field inoculation with VA endophytes is discussed.

0821 PICHOT, J.; BINH, T. **[Effect of endomycorrhizae on growth and phosphate nutrition of potgrown *Agrostis* and on soil isotopically exchangeable phosphorus (L value).]** Action des endomycorrhizes sur la croissance et la nutrition phosphatée de l'*Agrostis* en vases de végétation et sur le phosphore isotopiquement diluable du sol (valeur L). *Agronomie Tropicale* (1976) 31 (4) 375-378 [Fr, en, es, 15 ref.] Lab. de radio-agronomie, IRAT-Gerdat, BP 5035, 34032 Montpellier Cedex, France.

Inoculation of non-sterile acid organic ferrallitic soil with fragments of fresh roots infested with *Endogone* had a marked effect on early growth of common agrostis and on P uptake. The L value for soil P did not reveal an effect of the endomycorrhizae on the pool of mobile soil phosphate or on solubilization of applied rock phosphate.

0822 POWELL, C. **Mycorrhizal fungi stimulate clover growth in New Zealand hill country soils.** *Nature* (1976) 264 (5585) 436-438 [En, 12 ref.] Ruakura Agricultural Research Centre, Hamilton, New Zealand.

Samples of 37 hill country soils in the North Island, in some cases from forest, recent pasture and old pasture on the same soil types, were collected for laboratory study. P contents ranged from 8 to 120 ppm. In most of the soils, the indigenous mycorrhizal fungi were very infective for germinating white clover. When grown under P-limiting conditions, clover growth was greatly increased by the indigenous mycorrhizal fungi, especially in the infertile forest soils. However, in most of the soils, strain E_3 (a *Glomus* species from Rothamsted) was more effective than the indigenous fungi in increasing plant growth, sometimes much more so. Increases in plant growth were not related to extent of root infection.

0823 RHODES, L. H.; GERDEMANN, J. W. **Effect of vesicular-arbuscular mycorrhiza on sulfate uptake by onion plants.** [Abstract]. *Proceedings of the American Phytopathological Society* (1976) 3, 274-275 [En] Illinois University, Urbana 61801, Illinois, USA.

Mycorrhizal onion plants grown in soil chambers showed significantly greater uptake of ^{35}S in a 5-day period than non-mycorrhizal plants under similar conditions. More volatile ^{35}S was collected from mycorrhizal plants on a dry-weight basis than from non-mycorrhizal controls. Severing of external hyphae did not significantly reduce ^{35}S uptake. Movement of ^{35}S from the application area to the root (approximately 3-6 cm) was similar for all treatments, indicating that ^{35}S mobility in soil was not rate-limiting for accumulation of ^{35}S by plants.

0824 SANNI, SHERIFF O. (Fed. Dep. Agric. Res., P.M.B. 5042, Moor Plant., Ibadan, Nigeria.) **Vesicular-arbuscular mycorrhiza in some Nigerian soils: The effect of *Gigaspora gigantea* on the growth of rice.** NEW PHYTOL 77(3): 673-674. 1976.—Azygospores of *G. gigantea* isolated from soil in Moor Plantation [Ibadan, Nigeria] area were used to inoculate rice in a glasshouse experiment. There was a positive correlation between the presence of vesicular-arbuscular mycorrhiza, the numbers of spores in individual root system and the growth of rice. Better growth was observed in mycorrhizal plants than either control or treatment with strengite alone.

0825 TIMMER, L. W.; LEYDEN, R. F. **Relationship of mycorrhizal fungi to fertilization of Texas citrus. [Abstract].** *Proceedings of the American Phytopathological Society* (1976) 3, 274 [En] Texas A & I University Citrus Center, Weslaco, Texas 78596, USA.

In a survey of Texas citrus, mycorrhizas were consistently found in orchards and field-grown nurseries, but were absent from stunted seedlings and nursery stock grown in sterile potting media or fumigated soils. In initial experiments, addition of P to seedbed soil previously fumigated with sodium *N*-methyl dithiocarbamate stimulated growth of sour orange seedlings and compensated for the temporary absence of mycorrhizas. Addition of P to fumigated seedbed soil at 24-70 g/m² increased growth of sour orange seedlings above controls receiving no P, but at 196 g/m² it significantly reduced the percentage of mycorrhizal roots and the uptake of Cu. In heat-sterilized sand, non-mycorrhizal seedlings failed to grow despite weekly applications of complete nutrient solution. In heat-sterilized sandy loam P, at 0.05-0.8 g/litre soil, increased seedling growth 2-6 fold above controls receiving no P, with 0.2g/litre giving optimal growth. Many seedlings receiving higher rates eventually developed Cu deficiency symptoms. In another trial, seedlings growing in heat-sterilized sand and fertilized with complete nutrient solution were: 1) inoculated with *Glomus fasciculatus*, 2) treated with P at 0.2 g/litre sand or 3) both. Inoculation produced an 8-fold increase in growth, but addition of P had no effect on either inoculated or non-inoculated seedlings.

0826 COOPER, K.M. Growth responses to the formation of endotrophic mycorrhizas in solanum, leptospermum, and New Zealand ferns. *In*: Encomycorrhizas (Ed. by F.E. Sanders, B. Mosse, and P.B. Tinker) Academic Press London. pp.391-407 (1975).

0827 COX, G.; SANDERS, F.E., TINKER, P.B.,; WILD, J.A. Ultrastructural evidence relating to host-endophyte transfer in a vesicular-arbuscular mycorrhiza. *In*: Endomycorrhizas (Ed. by F.E. Sanders, B. Mosse, and P.B. Tinker) Academic Press London. pp.297-312 (1975).

0828 DAFT, M. J.; EL-GIAHMI, A. A. **Effects of *Glomus* infection on three legumes.** 581-592 [En, 17 ref.] Dep. of Biol. Sci., Dundee Univ., Dundee DD1 4HN, UK. *In:* Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp.

Phaseolus vulgaris cv. Canadian Wonder and lucerne cv. Du Puits were grown in sand with bone meal providing 30

mg P/kg sand and were inoculated with effective *Rhizobium* strains (R) or *Rhizobium* + *Glomus* sp. (RG) and fed with nutrient sol. minus N and P. The RG plants were larger than the R plants and had lower shoot:root ratio and more leaves, flowers and fruits. Mycorrhizal infection increased fresh wt. number and leghaemoglobin content of nodules in *P. vulgaris* and increased nitrogenase activity in both *P. vulgaris* and lucerne. In groundnut cv. Tripoli No.4 not inoculated with *Rhizobium* and given nutrient sol. containing N but not P, plants inoculated with *Glomus* sp. were larger than uninoculated plants.

0829 HATTINGH, M. J.; GERDEMANN, J. W. **Inoculation of Brazilian sour orange seed with an endomycorrhizal fungus.** *Phytopathology* (1975) 65 (9) 1013-1016 [En, 6 ref.] Stellenbosch University, Stellenbosch, South Africa.

Brazilian sour orange seed pelleted with inoculum of *Glomus fasciculatus* (*Endogone fasciculata*) produced seedlings with mycorrhizal infection in greenhouse and field experiments. In the greenhouse, Arasan (thiram) treatment of seed retarded and reduced mycorrhizal infection. In a nursery fumigated with methyl bromide, seed inoculation prevented stunting and chlorosis of seedlings. Seed inoculation appears to be a practical method for obtaining mycorrhizal infection of citrus in fumigated or heat-treated soil.

0830 HATTING, M.J. Uptake of ^{32}P-labelled phosphate by endomycorrhizal roots in soil chambers. *In*: Endomycorrhizas (Ed. by F.E. Sanders, B. Mosse, and P.B. Tinker) Academic Press London. pp.289-295 (1975).

0831 KHAN, A. G. **The effect of vesicular arbuscular mycorrhizal associations on growth of cereals. II. Effects on wheat growth.** *Annals of Applied Biology* (1975) 80 (1) 27-36 [En] Institute of Biological Sciences, University of Islamabad, Pakistan.

The growth of wheat seedlings which were already mycorrhizal when transplanted to a field deficient in phosphorus was improved compared with non-mycorrhizal controls, and grain yield was increased three-fold by *Endogone* fungus. Differences between mycorrhizal and non-mycorrhizal wheat were eliminated by the application of phosphate. It is probable that the mycorrhizal effect is primarily to improve the supply of phosphate. There were clear relationships between spore number in the soil and mycorrhizal development and between the extent of root infection and increased growth. The extent of root infection was greatest in mycorrhizal plants in soil not supplemented with phosphate and it decreased with superphosphate. The non-centrospermous and non-zygophyllaceous weeds growing on the experimental field had typical vesicular arbuscular infection and indigenous *Endogone* spores in their rhizospheres. The centrospermous plants were non-mycorrhizal and had no *Endogone* spores in their rhizospheres.

0832 KHAN, A. G. **Growth effects of VA mycorrhiza on crops in the field.** 419-435 [En, 30 ref.] Dep. of Biol., Islamabad Univ., Islamabad, Pakistan.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp. 419 - 435. 1975.

Wheat cv. Maxi-Pak and maize seedlings were grown in steam-sterilized sand inoculated with *Endogone mosseae* and transplanted after 4 wk to field plots with or without 280 kg triple superphosphate/ha. The effects of the treatments on the spore population of *E. mosseae*, soil pH and P uptake are described. After 45 days in maize and 30 days in wheat, dry wt. of mycorrhizal (M) plants was greater than that of the controls (NM). NM plants showed symptoms of P deficiency. The initial rate of leaf area increase was greater in M than in NM maize plants, but after 90 days their leaf areas were similar. Growth of NM plants improved as natural VA infection developed. NM, non-P wheat plants had shorter peduncles and smaller epidermal cells than M plants. With P fertilizer there was little difference in dry wt. between M and NM plants. Root growth in M maize plants was slower than in NM plants at first, but later they produced more DM and were more branched. Root: shoot ratios were 0.29 and 0.40 in NM and M maize plants, resp., and 0.29 and 0.21 in wheat. The effects of P on mycorrhizal infection are described. The favourable effects of mycorrhiza and/or P on grain yields were attributed to improved P uptake.

0833 LARUE, J. H.; MCCLELLAN, W. D.; PEACOCK, W. L. **Mycorrhizal fungi and peach nursery nutrition.** *California Agriculture* (1975) 29 (5) 6-7 [En, 2 pl.] Farm Advisor, Tulare County, USA.

Peach seedlings were planted in a commercial nursery in methyl bromide fumigated soil and the effects were compared of fertilization with P_2O_5 (200 lb/acre phosphoric acid) + 6.5% Zn chelate solution at 2 gal/acre, and soil inoculation with vesicular-arbuscular mycorrhizae, either alone or together. Zn-deficiency symptoms were evident in all treatments until the following June, but subsequent new growth on mycorrhizal-inoculated seedlings was normal; seedlings receiving P + Zn still showed moderate Zn deficiency, but growth was not retarded as severely as on untreated plants. By the end of the year seedlings inoculated with mycorrhiza, either alone or with fertilization, had grown best and their leaf Zn content was higher than on non-inoculated plants. Leaf P and K levels differed little between treatments, but leaf N and Mn contents were higher in untreated seedlings.

0834 MCCLELLAN, W.D.; PEACOCK, W.L.; LARUE, J. H. Mycorrhizal fungi and peach nursery nutrition. Proceedings of American Phytopath. Soc. Vol.2,. 1975. pp.115. Abstr.
Peach seedlings in California nurseries frequently display nutrient deficiency symptoms when methyl bromide is used as a preplant fumigant. The addition of an endomycorrhizal fungus, *Glomus fasciculatus*, to fumigated soil was effective in overcoming nutrient deficiency effects in peach seedlings. Both height and trunk diameter measurements showed a significant increase in growth brought about by the presence of either mycorrhizal fungi or phosphorus and zinc fertilizer as compared to controls which were fumigated with neither fertilizer nor mycorrhizal fungus added. Leaf analysis showed that the mycorrhizal inoculated plants had significantly higher levels of zinc than did noninoculated plants. Levels of phosphorus were not significantly different. Evidence of *G. fasciculatus* was found only in inoculated peach roots.

0835 MCILVEEN, W. D.; SPOTTS, R. A.; DAVIS, D. D. **The influence of soil zinc on nodulation, mycorrhizae, and ozone sensitivity of pinto bean.** *Phytopathology* (1975) 65 (5) 645-647 [En, 15 ref.] Pennsylvania State University, University Park, USA.

High rates of Zn often occur in soil from industrial sources or from the repeated application of sewage sludge. Experimental Zn amendments of 45 and 135 μg/g of soil reduced both nodulation and mycorrhizal development, and increased O_3 sensitivity.

0836 MOSSE, B. **Specificity in VA mycorrhizas.** 469-484 [En, 29 ref.] Rothamsted Exp. Sta., Harpenden, Herts AL5 2JQ, UK.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp. 469 - 484. 1975.

In experiments with various spp. including *Centrosema pubescens, Paspalum notatum* and *Brachiaria* sp. there was evidence that VA endophytes differed in their ability to improve plant growth, and that non-indigenous endophytes introduced into both irradiated and unsterile soils could become established in competition with indigenous endophytes and improve plant growth.

0837 PAGET, D.K. The effect of *Cylindrocarpon* on plant growth responses to vesicular-arbuscular mycorrhizas. *In*: Endomycorrhizas (Ed. by F.E. Sanders, B. Mosse, and P.B. Tinker) Academic Press London. pp.593-606 (1975).

0838 POWELL, C.L. The need for mycorrhizas for cocksfoot growth at high altitude: a note. N.Z. Journal of Agricultural Research 18:95. 1975.

0839 POWELL, C. L. **Plant growth responses to vesicular-arbuscular mycorrhiza. VIII. Uptake of P by onion and clover infected with different *Endogone* spore types in**

^{32}P labelled soils. *New Phytologist* (1975) 75 (3) 563-566 [En, 8 ref.] Rothamsted Experimental Station, Harpenden, UK.

Onions were preinfected with 7 *Endogone* spore types and then grown in P-deficient soils labelled with ^{32}P. P uptake was much greater in onions infected with 5 of the spore types than in non-mycorrhizal control plants but the specific activities of the absorbed P were the same in all mycorrhizal plants and controls. This showed that mycorrhizal and non-mycorrhizal plants absorbed P in the same relative proportions from the same (or similarly labelled) fractions of soil P.

0840 POWELL, C.L. Potassium uptake by endotrophic mycorrhizas. *In*: Endomycorrhizas (Ed. by F.E. Sanders, B. Mosse, and P.B. Tinker) Academic Press London. pp.461-468 (1975).

0841 RAMIREZ, B.N.; MITCHELL, D.J.; SHENCK, N.C. Establishment and growth effects of three vesicular- arbuscular mycorrhizal fungi on papaya. Mycologia (1975) 67 (5) 1039-1041 Univ. Florida, Gainesville, USA.
After 40 days in fertilized soil, papaw plants inoculated with Gigaspora [Endogone] calospora or Glomus macrocarpus [E.macrocarpa] were significantly taller than those inoculated with Gigaspora [E] heterogama or those not inoculated.

0842 RHODES, L. H.; GERDEMANN, J. W. Phosphate uptake zones of mycorrhizal and non-mycorrhizal onions. *New Phytologist* (1975) 75 (3) 555-561 [En] Department of Plant Pathology, University of Illinois, Urbana, Illinois 61801, USA.

Mycorrhizal and non-mycorrhizal onion seedlings were grown in individual soil chambers in which roots were confined to one side of a barrier. External hyphae of *Glomus fasciculatus* arising from mycorrhizal roots grew into an adjacent volume of soil. ^{32}P was injected into soil at 1-cm intervals up to a distance of 8 cm from the confined roots. Relatively high levels of radioactivity were subsequently detected in root segments of mycorrhizal plants at all distances from tracer injection. High levels of radioactivity were detected also in leaf segments of plants. Radioactivity of root or leaf segments of non-mycorrhizal plants did not exceed background level at any distance from tracer injection. ^{32}P did not move more than 7.5 mm from the point of injection as indicated by gross autoradiography. Absorption of phosphate and its translocation to the host by hyphae of *G. fasciculatus* can extend the phosphate uptake zone of mycorrhizal onions to at least 7 cm from the root surface.

0843 LA RUE, J.H.; McCLELLAN, W.D.; PEACOCK, W.L. Mycorrhizal fungi and peach nursery nutrition. California Agriculture (1975) 29(5):6-7. Univ. of California Farm Advisory Ser., Tulare County, U.S.A.
In a field trial in a commercial nursery inoculation with the vesicular-arbuscular mycorrhizal fungus Glomus fasciculatus [Endogone fasciculata]. agter soil fumigation with methyl bromide, helped peach seedlings to extract Zn from the soil and was equally or more effective in overcoming soil fumigation nutrient deficiency effects in the seedlings than the standard practice of side dressing with P.

0844 TINKER, P. B. Soil chemistry of phosphorus and mycorrhizal effects on plant growth. 353-371 [En, 34 ref.] Dep. of Pl. Sci., Leeds Univ., Leeds LS2 9JT, UK.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp.

The mechanism of uptake of labile soil phosphate by roots, the relative efficiency of root hairs and mycorrhizal hyphae and the possible function of root exudates are discussed. The possible part played by mycorrhiza in absorption of organic, non-labile inorganic and rock phosphate is considered.

0845 BANNISTER, P.; NORTON, W. M. The response of mycorrhizal and non-mycorrhizal rooted cuttings of heather (*Calluna vulgaris* (L.) Hull) to variations in nutrient and water regimes. *New Phytologist* (1974) 73 (1) 81-89 [En] Department of Biology, Stirling University, UK.

The dry matter production of rooted heather cuttings was highest under drained regimes and a frequent nutrient supply. It was generally lower with mycorrhizal plants than with non-mycorrhizal plants, although the position was reversed under corresponding drainage conditions and a low nutrient supply. N concentrations in the shoot and K and P concentrations in the root were higher in mycorrhizal plants than in non-mycorrhizal plants; the effects were most marked in well-drained regimes with minimum addition of nutrients. In general, alterations in nutrient and water regimes had more significant effects on dry matter production than did the presence or absence of mycorrhiza.

0846 BOWEN, G.D.; SKINNER, M.F.; BEVEGE, D.I. Zinc uptake by mycorrhizal and uninfected roots of *Pinus radiata* and *Araucaria cunninghamii*. Soil Biol. Biochem. 6:141-144. 1974.
Uptake of zinc from solution by uninfected roots, ectomycorrhizas of *Pinus radiata*, and endomycorrhizas of *Araucaria cunninghamii* occurred by a non-metabolic phase and by metabolically mediated absorption. The metabolically mediated absorption of Zn was 1.4-4.5 times greater for ectomycorrhizas than for uninfected roots and 2.6 times greater for endomycorrhizas than for uninfected roots. Part of the increase with ectomycorrhizas was due to their larger size than uninfected roots and when corrected for this, the uptake/cm^2 was 1.4-3.0 times greater. The roles of mycorrhizas in uptake of Zn and other trace elements from soil are discussed.

0847 CRUSH, J. R. Plant growth responses to vesicular-arbuscular mycorrhiza. VII. Growth and nodulation of some herbage legumes. *New Phytologist* (1974) 73 (4) 743-752 [En] Rothamsted Experimental Station, Harpenden, UK.

In P-deficient soils, VA mycorrhizas strongly stimulated nodulation and growth of *Centrosema pubescens, Stylosanthes guyanensis, Trifolium repens* and *Lotus pedunculatus*. The tropical legumes were much more dependent on mycorrhizas than the temperate species and this difference seemed to be related to the degree of root hair development. When *T. repens* and *Lolium perenne* were grown together, mycorrhizas preferentially stimulated growth of the legume.

0848 DAFT, M. J.; EL-GIAHMI, A. A. Effect of *Endogone* mycorrhiza on plant growth. VII. Influence of infection on the growth and nodulation in French bean (*Phaseolus vulgaris*). *New Phytologist* (1974) 73 (6) 1139-1147 [En] Department of Biological Sciences, Dundee University, Dundee, UK.

Infections of *Phaseolus* with *Endogone* and *Rhizobium* compared with *Rhizobium* alone had increased growth, reproduction, number and weight of nodules, acetylene reduction rates, leghaemoglobin, phosphorus and total protein contents. Shoot/root ratios were lower in the dual infected plants. Level of infection by *Endogone* influenced nodulation and the application of soluble phosphate simulated the effects of the fungus. The significance of these additive effects of dual symbiotic infections is discussed.

*0849 KADMAN, A.; SLOR, E. Experiments with propagation of the litchi (*Litchi chinensis*) in Israel. *Indian Journal of Horticulture* (1974) 31 (1) 28-33 [En, 6 ref.] Volcani Institute of Agricultural Research, Bet Dagan, Israel.

Experiments on marcotting and grafting, and germination and the growth of seedlings are reported. In all marcotting experiments rooting began after about 6 weeks. It was improved by girdling and IBA treatment and the use of a peat moss substrate rather than vermiculite or wood chips. In one experiment rooting was 85% on 9-year-old trees and only 50% on 30-year-old trees. The results of top-grafting experiments in the spring were good in one year but not in the next. Hundreds of container-grown seedlings were side-grafted with 80-90% success; the techniques used are described. Seed treatments included storage in water, air or vermiculite for up to 48 h and sowing in mycorrhizal or normal soil. Germination was 100% in seeds kept in water for not more than 24 h. Both germination and seedling

development were improved by the use of large seeds, and the latter by the use of mycorrhizal soil.

0850 JOHNSON, C.R.; MICHELINI, S. Effect of mycorrhizae on container grown Acacia. Proceedings of the Florida State Horticultural Society 1974,87:520-522.

Growing medium consisting of sand:pine-bark:peat (1:1:1) was steam pasteurized at 180°F for different times. The pasteurized medium was placed in gallon containers and some infested with Endogone calospora to evaluate the effects of growth of Acacia farnesiana. Plant size (height + width/2) and a visual rating indicated benefits from infesting pasteurized soil

0851 RICH, J. R.; BIRD, G. W. Association of early-season vesicular-arbuscular mycorrhizae with increased growth and development of cotton. *Phytopathology* (1974) 64 (11) 1421-1425 [En] Department of Plant Pathology and Plant Genetics, University of Georgia, Athens 30602, USA.

Vesicular-arbuscular mycorrhizae of *Endogone calospora* are associated with *Gossypium hirsutum* in Georgia producing increased early-season root and shoot growth, earlier flowering and boll maturation. In field experiments, these mycorrhizae were present five days after seedling emergence, confined mainly to the radicle. Arbuscules were the predominant sign of infection. Seven days later, arbuscules and vesicles were equally predominant and their presence was restricted to the cortex of feeder roots. The logarithm phase of growth for vesicular-arbuscular mycorrhizal infection of cotton was from 5 to 25 days after seedling emergence. Under field conditions a significant positive correlation existed between early-season mycorrhizae and vegetative growth and development of cotton. The data are discussed in relation to control of plant parasitic nematodes and the possible joint role of vesicular-arbuscular mycorrhizae and nematodes in the cotton stunt disease complex.

0852 SCHENCK, N. C.; TUCKER, D. P. H. Endomycorrhizal fungi and the development of citrus seedlings in Florida fumigated soils. *Journal of the American Society for Horticultural Science* (1974) 99 (3) 284-287 [En] Florida University, Gainesville, USA.

The inoculation of fumigated soil with *Endogone calospora* significantly increased shoot and root growth of *C.aurantium*, *C.reticulata* and *C.jambhiri* in the greenhouse but not in the field. *E.macrocarpa* significantly increased the growth of transplants and seedlings in non-fumigated, methyl bromide- and dichloropropene-fumigated field soil. Citrus stunting was greater after methyl bromide fumigation than after dichloropropane fumigation but stunting of seedlings was not as severe as that observed in some commercial nurseries.

0853 WILLIAMS, S. E.*, A. G. WOLLUM, II* and EARL F. ALDON. (N. C. State Univ., Raleigh, N. C. 27607, USA.) Growth of Atriplex canescens (Pursh) Nutt. improved by formation of vesicular-arbuscular mycorrhizae. SOIL SCI SOC AM PROC 38(6): 962-965. Illus. 1974[recd. 1975]. [In Engl. with Engl. summ.]--Fourwing saltbush [A. canescens] roots were stained for detection of endomycorrhizal fungi by simmering in an acid fuchsin-chloral hydrate solution. Naturally occurring endomycorrhizal fungi were observed in symbiotic association with the roots. Mycorrhizal fourwing saltbush grown in nonsterile soil had a greater dry weight and accumulated more P than nonmycorrhizal plants grown in sterile soil. Inoculation of fourwing saltbush with a known endomycorrhizal fungi, Endogone mosseae tended to stimulate the plants to greater growth than uninoculated plants.

0854 CRUSH, J. R. The effect of *Rhizophagus tenuis* mycorrhizas on ryegrass, cocksfoot and sweet vernal. *New Phytologist* (1973) 72 (5) 965-973 [En] University of Otago, New Zealand.

A high percentage of root infection by *R.tenuis* was necessary for growth of ryegrass in a highly P deficient soil. Added nutrients further increased growth of infected plants, but uninfected plants responded only to P. Symbiosis with *R.tenuis* was also beneficial to cocksfoot and sweet vernal under conditions of extreme P deficiency, but all three grasses grew better without the fungus in slightly more fertile soil, where *R.tenuis* grew mainly in the rhizosphere of inoculated plants, and with much less penetration.

0855 DAFT, M. J.; OKUSANYA, B. O. Effect of *Endogone* mycorrhiza on plant growth. VI. Influence of infection on the anatomy and reproductive development in four hosts. *New Phytologist* (1973) 72 (6) 1333-1339 [En]

Mycorrhizal infection increased the amount of vascular tissue in tomato, petunia and maize plants. Lignification of the xylem was greater in mycorrhizal tomato and petunia plants, and more vascular bundles were produced in the maize plants. Mycorrhizal infection stimulated flower production in petunia, the formation of fruit in strawberry and the development of pollen in maize.

0856 GRAY, L. E.* and J. W. GERDEMANN. (U. S. Reg. Soybean Lab., Urbana, Ill., USA.) Uptake of sulphur-35 by vesicular-arbuscular mycorrhizae. PLANT SOIL 39(3): 687-689. 1973[recd. 1974]. [In Engl. with Engl. summ.]--Vesicular-arbuscular mycorrhizae on red clover and maize absorbed S^{35} at higher rate than did comparable nonmycorrhizal roots.

0857 HATTINGH, M. J.; GRAY, L. E.; GERDEMANN, J. W. Uptake and translocation of ^{32}P-labeled phosphate to onion roots by endomycorrhizal fungi. *Soil Science* (1973) 116 (5) 383-387 [En] Department of Plant Pathology, University of Stellenbosch, South Africa.

Segments of onion roots infected with *Endogone mosseae* and *E.fasciculata* had high levels of radioactivity when ^{32}P-labelled phosphate was incorporated in soil 27 mm from the root surface. Autoradiography indicated diffusion of 7.5 mm or less from the point of application. Nonmycorrhizal roots had little radioactivity. When hyphae growing from mycorrhizae were severed, mycorrhizal roots did not differ significantly in ^{32}P-labelled phosphate content from nonmycorrhizal roots. Evidence indicates that the mycelial network of endomycorrhizal fungi enables plants to remove phosphate from a larger soil volume, extending beyond the immediate vicinity of the root surface.

0858 HO, I.; TRAPPE J.M. Translocation of ^{14}C from Festuca plants to their endomycorrhizal fungi. Nature New Biology (1973) 244 (131) 30-31 Festuca plants inoculated with Endogone mosseae were exposed for 6 weeks to $^{14}CO_2$, after which the mycorrhizal fungus formed chlamydospores. The observed accumulation of 14C in the spores was best explained by translocation of photosynthates from host plants to spores through the connecting mycelium.

0859 JACKSON, N. E. (Bookers Sugar Estates Ltd., 22 Church St., Georgetown, Guyana.), R. H. MILLER and R. E. FRANKLIN. The influence of vesicular-arbuscular mycorrhizae on uptake of ^{90}Sr from soil by soybeans. SOIL BIOL BIOCHEM 5(2): 205-212. Illus. 1973.--The Stanford-DeMent technique was used in a study of the influence of the vesicular-arbuscular (VA) mycorrhizal fungus Endogone mosseae on ^{90}Sr uptake by soybean. Thirteen-day-old mycorrhizal soybean plants absorbed significantly more ^{90}Sr than control plants after 1, 3 or 7 days contact with ^{90}Sr amended sterilized or nonsterilized soil. The same positive influence of E. mosseae on Sr absorption was observed in a 2nd study which allowed for ^{90}Sr uptake concurrent with mycorrhizal infection and development. In the Stanford-DeMent study, soil sterilization exerted a short (1 day) negative influence on the uptake of ^{90}Sr by mycorrhizal roots. In the 2nd study, mycorrhizal roots absorbed more ^{90}Sr from sterilized soil than from unsterilized soil while the reverse occurred with the control plants. Infected plants in both studies showed an early decrease in dry matter yield.

0860 MOSSE, B. Influence of *Endogone* strains of phosphorus uptake. Rothamsted Exp. Sta. Report 1972:8-81. 1973.

0861 MOSSE, B. Plant growth responses to vesicular-arbuscular mycorrhiza. IV. In soil given additional phosphate. *New Phytologist* (1973) 72 (1) 127-136 [En, 23 ref., 11 pl.] Rothamsted Experimental Station, Harpenden, UK.

The growth of mycorrhizal and non-mycorrhizal onions plants was compared in several soils receiving increasing amounts of $Ca(H_2PO_4)_2$. In some soils mycorrhizal plants grew better at all levels of applied phosphate. In other soils, where high P concentrations built up rapidly in the plants, those with mycorrhiza grew worse when more than 0.2 g $Ca(H_2PO_4)_2$ was added per kg of soil. Because their roots take up more phosphate, mycorrhizal plants could contain supra-optimal P concentrations with smaller amounts of added phosphate.

0862 MOSSE, B., D. S. HAYMAN and D. J. ARNOLD. (Rothamsted Exp. Stn., Harpenden, Herts., Engl., UK.) Plant growth responses to vesicular-arbuscular mycorrhiza: V. Phosphate uptake by three plant species from P-deficient soils labelled with ^{32}P. NEW PHYTOL 72(4): 809-815. Illus. 1973. [In Engl. with Engl. summ.]--The uptake of P from ^{32}P-labeled soil solution by 3 plant species, with and without mycorrhiza [of the Endogone spore type] was measured. All soils contained very little $CaCl_2$- and $NaHCO_3$-soluble phosphorus. In 2 soils the specific activity of P taken up by mycorrhizal and non-mycorrhizal Melinis minutiflora was very similar, indicating that even in very P-deficient soils mycorrhizal plants used the same source of phosphate as as non-mycorrhizal. In 2 other soils non-mycorrhizal Paspalum notatum and Centrosema pubescens contained no ^{32}P activity, suggesting that they had not taken up any soil P, whereas mycorrhizal plants of both species contained ^{32}P activity and grew much better. It is suggested that non-mycorrhizal roots of some plant species do not utilize phosphate present at extremely low concentrations in the soil solution, but that mycorrhizal roots or fungal hyphae do. The implications of this finding for the mechanism of phosphate uptake by VA mycorrhiza are discussed.

*0863 MOSSE, B. 1973. The role of mycorrhiza in phosphorus solubilization. *In*: J.S. Furtado (Ed.) Global impacts of applied microbiology (GIAM). Proc. Fourth Internat. Conf. São Paulo, Brazil, 1971. pp.543-561.

*0864 NUTMAN, P.S. Soil microbiology department. 79-89 In: Rothamsted Experimental Station Report for 1972. Part 1. (1973) 406pp.

Mycorrhizal studies concentrate on the capacity of vesicular-arbuscular mycorrhiza to improve the P nutrition of the host plant by examining the extent, intensity and limitations of mycorrhizal infection in natural and agricultural habitats and by investigating possible mechanisms of mycorrhiza stimulate P uptake.

0865 ROSS, J. P.; GILLIAM, J. W. Effect of *Endogone* mycorrhiza on phosphorus uptake by soybeans from inorganic phosphates. *Soil Science Society of America Proceedings* (1973) 37 (2) 237-239 [En] Department of Soil Science, North Carolina State University, USA.

When rock phosphate, Fe, Al or monocalcium phosphate was added to a soil low in available P, growth of mycorrhizal soya bean was greater than that of non-mycorrhizal plants. In a soil with more available P, less Al-P and Fe-P remained in the soil after mycorrhizal than after non-mycorrhizal plants. The greatest difference was in the Al-P fraction. The mycorrhiza-enhanced absorption of P by soya bean plants under P stress was principally from P sources most available under mycorrhizal conditions.

*0866 SANDERS, F.E.; TINKER, P.B. Phosphate flow into mycorrhizal roots. Pesticide Science (1973) 4(3):385-395.

The mechanism whereby host response to mycorrhizal infection is associated with improved P nutrition is considered. Evidence was found that the ultimate limitation on P uptake by a simple cylindrical root is the diffusion ... impedance in the surrounding soil and that widely spreading hyphae effectively short-circuit this impedance. Some data on hyphal length and estimated net flux of P through the hyphae are given, with a discussion of possible mechanism driving this flux.

0867 SCHENK, N.C.; HINSON, K. Response of nodulating and nonnodulating soybeans to a species of Endogone mycorrhiza. Agronomy Journal 1973 65(5):849-850.

Inoculation with Endogone significantly increased seed yield and growth of the nodulating isoline of var. Hardee in field soil fumigated with methyl bromide, but had no such effect on the non-nodulating isoline. It is suggested that the fungus did not significantly increase N absorption in the latter.

*0868 BENIANS, G.J.; BARBER, D.A. 1972. Influence of infection with *Endogone* mycorrhiza on the absorption of phosphate by barley plants. Letcombe Lab. Annu. Report. Letcombe, England. pp.6-9.

0869 DAFT, M. J.; NICOLSON, T. H. Effect of *Endogone* mycorrhiza on plant growth. IV. Quantitative relationships between the growth of the host and the development of the endophyte in tomato and maize. *New Phytologist* (1972) 71(2) 287-295 [En, 23 ref., 2 pl.] Dundee University, UK.

Endotrophic mycorrhizas in tomatoes, induced by chlamydosporic varieties of *E. macrocarpa*, were examined quantitatively by estimating the infection of roots, pigmentation of roots and production of ectocarpic chlamydospores.

0870 HAYMAN, D. S.; MOSSE, B. Plant growth responses to vesicular-arbuscular mycorrhiza. III. Increased uptake of labile P from soil. *New Phytologist* (1972) 71(1) 41-47 [En, 16 ref.] Rothamsted Experimental Station, Harpenden, UK.

Onion plants were grown in a range of soils labelled with ^{32}P. Although the mycorrhizal plants had taken up more P and grown larger, the proportion of ^{32}P to total P (specific activity) taken up by mycorrhizal and non-mycorrhizal plants after 10 weeks was not significantly different. There was no indication that mycorrhizal roots had access to sources of phosphate different from those accessible to non-mycorrhizal roots. The specific activity of $NaHCO_3$-extractable P differed considerably between the 8 soils, but the specific activity of absorbed P in the plants always corresponded closely to that of the soil in which they had grown. [For part II see *H.A.*, 41: 6778.]

0871 HAYMAN, D. S.; MOSSE, B. The role of vesicular-arbuscular mycorrhiza in the removal of phosphorus from soil by plant roots. *Revue d'Écologie et de Biologie du Sol* (1972) 9 (3) 463-470 [En, fr] Rothamsted Experimental Station, Harpenden, UK.

Sources of soil P that may be available to mycorrhizal plants were examined. In sand with known organic phosphate added, plants did not benefit from mycorrhizae except on a few of these phosphates when a little soil was present which could have adsorbed some phosphate. There was a response to mycorrhizae in sand mixed with humus, but the extra phosphate absorbed could have come from the soluble pool instead of complex organic sources. In a range of soils containing unknown sources of phosphate, plants responded to mycorrhizae when there was much Fe and Al but little available P. It is concluded from these studies and from experiments in ^{32}P-labelled soils which indicated that mycorrhizal roots obtained their extra P from the soluble fraction, that the major role of vesicular-arbuscular mycorrhizae in increasing the uptake of soil P by roots is a physical one, namely the provision of extra absorbing surface.

0872 JACKSON, NELROY E. (Bookers Sugar Estates Ltd., 22 Church St., Georgetown, Guiana.), R. E. FRANKLIN and R. H. MILLER. Effects of vesicular-arbuscular mycorrhizae on growth and phosphorus content of three agronomic crops. SOIL SCI SOC AM PROC 36(1): 64-67. Illus. 1972.--Several placements of vesicular-arbuscular (VA) mycorrhizal inoculum [Endogone sp.] in soil were compared in a greenhouse study of the potential use of VA fungi for increasing yields of agronomic crops on low P-status soils. Placement of VA mycorrhizal inoculum and rock phosphate was considered an integral treatment. Inoculation with VA fungi increased corn yields about 50% over the increases due to indigenous mycorrhizal fungi. Placements of inoculum in a layer 5 cm below the seeds or mixed with a 5-cm layer of soil below the seeds were effective; while 2 other placements, with the seeds or in a band with rock phosphate, were ineffective in increasing yields. None of the treatments that used rock phosphate were as effective as concentrated superphosphate in increasing yields, which indicated that lack of P was still limiting plant growth in the rock phosphate treatments. There were no effects of VA mycorrhizal inoculation of soil on growth of soybeans (Glycine max L. Merrill 'Harosoy 63') and only a minor effect on sudangrass (Sorghum bicolor var. sudanense) for the placements that were tested.

0873 KHAN, A. G. (Bot. Dep., Univ. Panjab, New Campus, Lahore, Pak.) The effect of vesicular-arbuscular mycorrhizal associations on growth of cereals: I. Effects on maize growth. NEW PHYTOL 71(4): 613-619. 1972.--The subsequent growth of maize seedlings which were already mycorrhizal when planted in the field was improved compared with non-mycorrhizal controls. Mycorrhizal plants removed more P from the soil and had greater dry matter and P. There were positive correlations between spore number in the soil and mycorrhizal development, and between extent of root infection and increased growth. Root infection decreased with an increase in P level of the soil. The onset of the reproductive process in non-mycorrhizal plants growing without added fertilizer was delayed and, even in those cases where ears did form, their quality was poor. Number of grains/ear and grain weight were increased almost 12 times by the fungus.

0874 KLEINSCHMIDT, G.D.; GERDEMANN, J.W. Relationship of endomycorrhizae to citrus stunting in fumigated soils. Univ. Illinois, Urbana. Phytopathology. 62: 769- 1972.
Citrus plants grew poorly in fumigated or heat-treated nursery soils but good growth folowed inoculation with Endogone mosseae. Mycorrhizal plants had a greater dry wt. and higher P content than non-mycorrhizal plants.

0875 KLEINSCHMIDT, G. D.; GERDEMANN, J. W. **Stunting of citrus seedlings in fumigated nursery soils related to the absence of endomycorrhizae.** *Phytopathology* (1972) **62** (12) 1447-1453 [En] University of Illinois, Urbana 61801, USA.

Stunted and chlorotic citrus seedlings growing in fumigated nurseries were non-mycorrhizal, and *Endogone* spores were not found associated with their roots. Seedlings growing normally in scattered areas of these nurseries were mycorrhizal, and *Endogone* spores were present. Stunted plants from nurseries grew normally after inoculation with *Endogone mosseae*. Non-inoculated citrus seedlings grew poorly in steamed, autoclaved, or methyl-bromide treated soil in greenhouse experiments. Plants inoculated with *E.mosseae* produced excellent growth in these treated soils. Mycorrhizal plants had greater dry weights and higher P percentages than did non-mycorrhizal plants. The evidence indicates that the major cause of stunting and chlorosis of citrus in fumigated or heat-treated soils is inadequate nutrition caused by the killing of mycorrhizal fungi.

0876 MOSSE, B. **Effects of different *Endogone* strains on the growth of *Paspalum notatum*.** *Nature* (1972) **239** (5369) 221-223 [En] Rothamsted Experimental Station, Harpenden, UK.

Seedlings were grown in 2 Brazilian soils. The soils were unsterilized, sterilized by gamma radiation and treated with a leachate from unsterile soil, or were sterilized by gamma radiation and inoculated with 3 strains of *Endogone* or with mycorrhizal roots (probably formed by *Endogone*) of *P.notatum* from another part of Brazil. In one soil, inoculation increased the dry weight of 11-week-old seedlings up to 11 times in limed soil and up to 5 times in unlimed soil. In the other soil, the increase was only about 2-fold in unlimed soil. The laminate strain of *Endogone* was always the least effective and the Ez strain was the most consistently good.

* 0877 MOSSE, B.; HAYMAN, D.S.;ARNOLD, D.J.S. Effects of VA-mycorrhiza on phosphate cycling at Neathop Wood, Lancashire. The source of extra phosphorus in mycorrhizal plants. Rothamsted Exp. Sta. Report 1972:79-80.

* 0878 MOSSE, B.; BROWN, M.E. Source of extra phosphate in mycorrhizal plants. Effect of VA mycorrhiza on phosphate cycling at four IBP sites. Rothamsted Exp. Sta. Report 1971:93-94. 1972.

0879 SAFIR, G.R.; BOYER, J.S.; GERDEMANN, J.W. Nutrient status and mycorrhizal enhancement of water transport in soybean. Plant Physiol. (1972) 49, 700-703.
Mycorrhizal soybean (Glycine max L. Merr. var, Harosoy-63) plants have lower resistances to water transport than nonmycorrhizal plants after 4.5 weeks of growth. Although resistances of whole plants differ by 40%, there were no differences in the resistances of stems plus leaves, indicating that the major effect of the mycorrhizae was to reduce the resistance of the roots. Since the fungitoxicant, p-chloronitrobenzene, had no effect on resistances to water transport reduced resistances were probably not caused by a direct modification of the transport pathway by the fungus. Differences in resistance between mycorrhizal and nonmycorrhizal soybean were esssentially eliminated by the application of nutrients to the soil. Thus, lowered resistances of mycorrhizal roots growing in soil with low levels of nutrient probably resulted from the enhanced nutrient status of the plant brought about by the fungus. Mycorrhizal infection increased growth at both low and high nutrient levels.

* 0880 DAFT, M.J. Relationships of phosphate nutrition with *Endogone* mycorrhiza under experimental conditions and in nature. XV IUFRO Congress, April 1971. (Mimeo).

0881 GILMORE, A. E. 1971. **The influence of endotrophic mycorrhizae on the growth of peach seedlings.** *J. am. Soc. hort. Sci.* **96**, 35-38. [Univ. Calif., Davis, U.S.A.]

Seedlings had severe Zn-deficiency symptoms and grew poorly in pots of steamed Yolo loam with or without sand admixed. Growth was greatly improved by inoculating with one of a number of *Endogone* cultures, which formed vesicular-arbuscular mycorrhizae. Plants with inocula disinfested of associated field organisms by chloramine T were larger than those inoculated with untreated spores. All 6 inocula tested were beneficial, although only 2 completely prevented appearance of Zn-deficiency symptoms. Seedlings grown with 1 of these 2 had foliar-Zn levels 2-3 times greater than those of the controls.

0882 HAYMAN, D. S.; MOSSE, B. 1971. **Plant growth responses to vesicular arbuscular mycorrhiza. I. Growth of *Endogone*-inoculated plants in phosphate-deficient soils.** *New Phytol.* **70**, 19-27. [Rothamsted Exp. Stn, Harpenden, England]

In soils containing very little available P, large increases of shoot dry weight of *Coprosma* (up 18-fold) and onion (up to 19-fold) were obtained by adding P. Similar increases were obtained by mycorrhizal inoculation. Response to P equalled or slightly exceeded response to mycorrhiza, except in 2 soils rich in P where there was no response to either, and in one soil in which mycorrhizal plants were twice as heavy as those given P. Increased growth in either treatment was associated with a large increase in P uptake. In all inoculated soils mycorrhizal infection was extensive. The sources of P available to mycorrhizal but not to non-mycorrhizal roots differed in the various soils. In some, inhibitory factors might make vesicular-arbuscular mycorrhiza less effective in promoting growth of the host plant.

* 0883 KHAN, A.G. Growth responses of maize in field to inoculation with *Endogone* spores and to added phosphorus. XV Proc. Internat. Union for Res. Organiz., Congress, Gainesville. April, 1971.

0884 MARX, D. H.; BRYAN, W. C.; CAMPBELL, W. A. **Effect of endomycorrhizae formed by *Endogone mosseae* on growth of citrus.** *Mycologia* (1971) 63(6) 1222-1226 [En, 8 ref., 1 pl.] USDA Forestry Sciences Laboratory, Athens, Georgia.

E. mosseae was shown to be symbiotic with rough lemon and sour orange seedlings. It increased the growth of rough lemon but not of sour orange.

0885 MOSSE, B.; HAYMAN, D. S. 1971. **Plant growth responses to vesicular-arbuscular mycorrhiza. II. In unsterilized field soils.** *New Phytol.* **70**, 29-34. [Rothamsted Exp. Stn, Harpenden, England]

The benefits of mycorrhizal infection were compared in 4 irradiated and unsterilized soils containing little soluble P. In all soils, irradiated or not, mycorrhizal seedlings grew very much better than non-mycorrhizal ones. In 2 soils natural infectivity was very low and most uninoculated seedlings remained non-mycorrhizal even after 16 weeks. In the other 2 soils most plants became mycorrhizal in the unsterilized soils. In one of them the indigenous mycorrhizal fungi aided P uptake of the host plant, in the other they did not. Infections produced by the indigenous fungi in the 2 soils were anatomically different, though both were typical vesicular-arbuscular mycorrhiza. It is concluded that inoculation may have practical

significance in some low phosphate soils containing either few indigenous mycorrhizal fungi or ineffective strains.

*0886 MOSSE, B. Specificity of *Endogone*. Effect of *Endogone* mycorrhiza on plant growth. Rothamsted Exp. Sta. Report (Part 1) 1970:88-90. 1971.

0887 POSSINGHAM, J. V.; ORRINK, J. G. Endotrophic mycorrhiza and the nutrition of grape vines. *Vitis* (1971) 10(2) 120-130 [En, 24 ref., 6 pl., 1 map] Division of Horticultural Research, CSIRO, Adelaide, Australia.

The roots of vines from a number of localities throughout Australia were infected with vesicular-arbuscular mycorrhizas, and a range of *Vitis* species and hybrids and a number of *V. vinifera* cvs all displayed microscopic evidence of mycorrhizal infection. The growth of vine seedlings in soils sterilized by autoclaving or gamma irradiation was less than in similar but non-sterile soil. The seedlings in sterile soils were not infected with mycorrhiza whereas those in non-sterile soils were. Normal seedling growth in sterile soils was obtained by inoculating with vine roots infected with live mycorrhiza, but inoculating with roots containing dead mycorrhiza (autoclaved) or with filtered soil suspensions did not stimulate growth. The shoots of seedlings grown in non-sterile soil or in sterile soils inoculated with live mycorrhiza had a significantly higher P content than non-infected seedlings. It is suggested that in many of the habitats in which vines are grown in Australia and Europe vesicular-arbuscular mycorrhizas aid their nutrition.

0888 ROSS, J.P. Effect of phosphate fertilization on yield of mycorrhizal and nonmycorrhizal soybeans. Phytopathology 61(11):1400-1403. 1971.

Mycorrhizal infection by Endogone prevented soybean yield from being related to PO_4, levels in fumigated soil. At low, medium and high PO_4, yield increases due to Endogone were 122, 67 and 12%, respectively, Concs. of N,P, Ca and Cu in the leaves were greater in mycorrhizal plants at the various PO_4, levels.
The P conc. in leaves of mycorrhizal plants at the lowest PO_4 level was greater than that of nonmycorrhizal plants at the highest level. It is suggested that mycorrhiza may aid the plants in functions other than PO_4 uptake.

0889 SANDERS, F. E.; TINKER, P. B. Mechanism of absorption of phosphate from soil by *Endogone* mycorrhizas. *Nature* (1971) 233(5317) 278-279 [En, 7 ref.] Oxford University, UK.

A sandy loam soil low in P was labelled with ^{32}P and partially sterilized to eliminate indigenous fungi. Onions were grown in the soil in pots and half were inoculated with *Endogone mosseae*. After 2 weeks infected plants were clearly larger and had 5 times the dry weights and twice the P contents of control plants. Infected plants were found to have endotrophic mycorrhizas with the hyphae extending into the soil around the roots. Data obtained supports the simplest theory of the mycorrhizal effect, namely that the hyphae form a better distributed surface for absorbing P from the soil solution than the roots alone.

0890 SAFIR, G.R., BOYER, J.S.; GERDEMANN, J.W. 1971. Mycorrhizal enhancement of water transport in soybean. Science, N.Y. 172(3983): 581-583. Mich. Sta. Univ., E. Lansing.

At Univ. Ill., Urbana, the resistance to water transport in soybean was decreased by mycorrhizal formation by Endogone mosseae and was associated with an increase in shoot growth but not in root growth. Details of procedure and methods of calculation are given.

0891 ROSS, J.P.; HARPER, J.A. Effect of endogone mycorrhiza on soybean yields. Phytopathology 60 (11) 1552-1556. 1970.

Growth and yield of soybean plants growing in previously fumigated small isolated plots were increased 34-40% in the presence of a chlamydosporic species of the vesicular-arbuscular mycorrhizal fungus Endogone . Inoculum for these plots was produced by culturing Endogone monoxenically on soybean roots to assure the absence of other soil microorganisms. Mycorrhizal plants accumulated greater amounts of P, N, Ca, Cu and Mn in their foliage than nonmycorrhizal plants. Infesting previously fumigated field plots with Endogone resulted in yield increases of 29% over fumigated-non-infested plots. This effect did not occur in nonfumigated soil.

*0892 SAFIR, G.R.; BOYER, J.S.; GERDEMANN, J.W. Mycorrhizal enhancement of water transport in soybean. (Abstract) Phytopathology, 60:1311. 1970.

*0893 SCHWEERS, W.; MEYER, F.H. Einfluss der Mykorrhiza auf den Transport von Assimilaten in die Wurzel. (Eng) summ.). Ber. Deut. Bot. Ges., 83:109-119. 1970.

*0894 BUCKALEW, DAVID W., ROBERT K. RILEY, WAYNE A. YODER and WILLIAM J. VAIL. (Biol. Dep., Frostburg State Coll., Frostburg, Md. 21532.) The 57th Annual Session of the West Virginia Academy of Science, Elkins, W. Va., USA, April 3, 1982. PROC W VA ACAD SCI 54(1): 1. 1982. **Invertebrates as vectors of endomycorrhizal fungi and *Rhizobium* on surface mine soils.**/ABSTRACT, GRASSHOPPER, EARTHWORM, CLOVER, GRASS, LEGUME, REVEGETATION, ROOT NODULES

0895 CHILVERS, M. T.; DAFT, M. J. F. **Effects of low temperature on development of the vesicular-arbuscular mycorrhizal association between *Glomus caledonium* and *Allium cepa*.** *Transactions of the British Mycological Society* (1982) 79 (1) 153-157 [En, 13 ref., 2 pl.] Dundee University, Dundee DD1 4HN, UK.

In a pot experiment onions (cv. Rijnsberger Conquest) were grown for 35 days at 20° followed by 27 days at 15°, 25 days at 10°, 25 days at 5° and finally 25 days at 20°C. The roots of half the plants were inoculated with *G. caledoni* . The average dry weight of shoots from the mycorrhizal-plants was always greater than that of non-mycorrhizal (control) plants. The average growth rate of mycorrhizal plants increased as the temperature decreased from 20° to 15° to 10°, but then fell as the temperature decreased to 5°, rising again when plants were returned to 20°. The development of the endophytes in relation to temperature and plant growth is discussed.

0896 DIEDERICHS, C. Influence of light on the efficacy of vesicular-arbuscular mycorrhiza in tropical and subtropical plants. Angew. Botanik 56: 325-333. 1982.

Capsicum annuum and Ageratum houstonianum, inoculated with three VA mycorhizal endophytes, were grown under three light intensities and with or without P fertilization. In the treatments fertilized with hydroxylapatite, C. annuum inoculated with Glomus macrocarpus or "white reticulate" showed the highest mycorrhizal efficiency under full hight, while plants inoculated wiht Acaulospora spinosa responded only weakly to the light levels. With A. houstonianum, the effectivity of all three mycorrhizal fungi was lowest under full light. Without P fetilization, the efficacy of the VA mycorrhiza was generally reduced, but showed the same pattern as in the P-fertilized treatments. P uptake was more enhanced by the mycorrhiza than plant growth. Accordingly, mycorrhizal plants had higher P concentrations than non-mycorrhizal. Correlations between infection intensity and effectiveness of the VA mycorrhiza were weak or lacking. Thus, the influence of light intensity on the efficacy of the VA mycorrhiza depended on the host species, the fungus species; and the availability of P.

0897 FERGUSON, J. J.; MENGE, J. A. **The influence of light intensity and artificially extended photoperiod upon infection and sporulation of *Glomus fasciculatus* on Sudan grass and on root exudation of Sudan grass.** *New Phytologist* (1982) 92 (2) 183-191 [En, 24 ref., 1 fig., 4 tab.] Univ. California, Riverside, USA.

Mycorrhizal inoculum of *G. fasciculatus*, as measured by root infection and sporulation, increased with increasing light intensity. Compared with natural glasshouse daylight, spore numbers also increased dramatically when mycorrhizal plants were exposed to extended photoperiods with high intensity Hg vapour or metal halide lamps. There were indications that the level of sugars, but not amino acids, in root exudates from 2-month-old plants was correlated with the spore production. Growing Sudan grass at greater light intensities and under extended photoperiods should thus increase the quality and quantity of commercial inoculum.

0898 GRAHAM, J. H.; LEONARD, R. T.; MENGE, J. A. **Interaction of light intensity and soil temperature with phosphorus inhibition of vesicular-arbuscular mycorrhiza formation.** *New Phytologist* (1982) 91 (4) 683-690 [En, 14 ref.] Dep. of Bot. and Pl. Sci., California Univ., Riverside, CA 92521, USA.

VA mycorrhiza formation in Sudan grass seedlings inoculated with *Glomus fasciculatus* was reduced more by added soil P at low light than at high light intensity. With no P, infection was unaffected by light intensity. Increased root P conc. (by adding soil P or decreasing light) was associated with decreased membrane permeability and exudation of amino acids and sugars. It was concluded that P inhibition of mycorrhiza was more severe at low light intensity due to decreased membrane-mediated exudation. P inhibition was overcome by increasing the soil temp. which increased root membrane permeability and also increased fungal activity.

0899 HAYMAN, D. S. **Influence of soils and fertility on activity and survival of vesicular-arbuscular mycorrhizal fungi.** *Phytopathology* (1982) 72 (8) 1119-1125 [En, 47 ref., 4 fig.] Rothamsted, Harpenden, Herts., UK.

This review deals with the occurrence in different soils, survival, endophyte adaptability and symbiotic activity of VA mycorrhizal fungi.

0900 JOHNSON, C. R.; MENGE, J. A.; SCHWAB, S.; TING, I. P. **Interaction of photoperiod and vesicular-arbuscular mycorrhizae on growth and metabolism of sweet orange.** *New Phytologist* (1982) 90 (4) 665-669 [En, 16 ref.] Florida University, Gainesville, Florida 32611, USA.

Root infection by *Glomus fasciculatus* and growth of sweet orange seedlings in pots in the greenhouse were increased by longer photoperiods (13 vs. 9 hours' daylength). Photosynthesis and stomatal conductances were greater for mycorrhizal plants, but were unaffected by daylength. P levels in leaf tissue from mycorrhizal plants were 2-3 fold greater than those in non-mycorrhizal plants and P levels were reduced in plants grown under long-day photoperiods. Root exudation of reducing sugars was greatest for non-mycorrhizal plants grown under long-day photoperiods, but exudation of amino acids was variable.

0901 MUKERJI, K.G.; BHATTACHARJEE, M.; MOHAN, M. Ecology of the Indian Endogonaceae. Angew. Botanik, 56, 121-131. 1982.

The ecology of the Endogonaceae in Delhi soils was studied. Spore numbers were found to vary according to the development of the host plant as well as the seasons. Different horizons in the soil harboured different numbers c spores; and the rhizosphere of diseased plants harboured more spores than that of healthy plants.

0902 NELSEN, C. E.; SAFIR, G. R. **Increased drought tolerance of mycorrhizal onion plants caused by improved phosphorus nutrition.** *Planta* (1982) 154 (5) 407-413 [En, 27 ref.] Michigan State University, East Lansing, MI 48824, USA.

Onion plants (cv. Downing Yellow Globe), grown in pots and infected with *Glomus etunicatus*, were more drought tolerant than non-mycorrhizal plants when exposed to several periods of soil water stress separated by periods of high water supply, and their fresh and dry weights were distinctly higher. The tissues of stressed, non-mycorrhizal plants were deficient in P despite the fact that only non-mycorrhizal plants were given high levels of P. Differences in plant water relations and changes in soil P levels which may have affected plant growth were discounted as important factors. It was concluded that the ability of the mycorrhizal fungus to maintain adequate P nutrition in the onions during water stress was a major factor in the improved drought tolerance. Infection of the root by the fungus was not affected by water stress or P fertilization but fungal reproduction was lessened by water stress and by P fertilization.

0903 McCOOL, P.M.; MENGE, J.A.; TAYLOR, O.C Effect of ozone injury and light stress on response of tomato to infection by the vesicular-arbuscular mycorrhizal fungus, Glomus fasciculatus. J. Amer. Soc. Hort. Sci. 107(5):839-42. 1982.

Tomato seedlings (Lycopersicon esculentum Mill. Heinz 1350) were inoculated with the vesicular-arbuscular mycorrhizal fungus Glomus fasciculatus (Thaxter)Gerd. & Trappe and either exposed

to 30 pphm (589 p g/m3) ozone or to filtered air for 3 hours once weekly, beginning 3 weeks after inoculation, under long photoperiods (12-13.3 hr). Root infection by G. fasciculatus in ozone-exposed plants was retarded from week 3 to 5 compared to controls but recovered by week 7. Growth rates of mycorrhizal control plants were significantly greater than ozone-exposed mycorrhizal plants, but there were no differences in growth rates of nonmycorrhizal controls, mycorrhizal ozone-exposed plants, and nonmycorrhizal ozone-exposed plants. Under short photoperiods (less than 12 hr). growth rates of mycorrhizal controls were less than nonmycorrhizal controls and ozone did not significantly affect growth rates of nonmycorrhizal, or exposed to ozone.

0904 REICH, L. A.; KORCAK, R. F.; THOMPSON, A. H. **Effects of two mycorrhizal isolates on highbush blueberry at two soil pH levels.** *HortScience* (1982) 17 (4) 642-644 [En, 15 ref., 3 pl.] USDA, Agricultural Research Service, Beltsville, MD 20705, USA.

Seedlings of highbush blueberry (*Vaccinium corymbosum*) subjected to 3 fungal treatments (inoculation of sterilized or unsterilized soil with 1 or 2 strains of [unspecified] mycorrhizal fungi) and 2 soil pH levels (4.2 and 6.0) displayed no significant treatment interaction in respect to growth, mycorrhizal infection intensity, or nutrient uptake. Among the fungal treatments, there were differences in nutrient uptake and infection intensity, but no difference in total linear stem growth or number of shoots. Lower soil pH gave significantly greater stem growth and number of shoots but infection intensity was not significantly different from that at high pH soil.

0905 ROLDAN-FAJARDO, B. E.; BAREA, J. M.; OCAMPO, J. A.; AZCÓN-AGUILAR, C. **The effect of season on VA mycorrhiza of the almond tree and of phosphate fertilization and species of endophyte on its mycorrhizal dependency.** *Plant and Soil* (1982) 68 (3) 361-367 [En, 23 ref.] Estación Experimental del Zaidín, CSIC, Granada, Spain.

Under glasshouse conditions the growth and leaf-P level of non-mycorrhizal almond trees given P fertilizer (150 kg/ha P) were lower than those of mycorrhizal plants. Dependency of the trees on mycorrhizas was higher when a mixture of locally isolated forms, mainly *Glomus fasciculatus*, was used rather than *Glomus mosseae* from a collection. The indigenous endophytes were also more tolerant of added fertilizer than *G. mosseae*. The amount of vesicular arbuscular infection and the number of endogonaceous spores in the rhizosphere of field-grown almond trees increased steadily from flowering time until summer or early autumn.

0906 WARNER, A.; MOSSE, B. **Factors affecting the spread of vesicular mycorrhizal fungi in soil I. Root density.** *New Phytologist* (1982) 90 (3) 529-536 [En, 10 ref., 5 fig., 3 tab.] Rothamsted Exp. Sta., Harpenden, Herts., UK.

Seeds of clover and *Festuca rubra* were sown in large troughs at 3 different distances apart, which resulted in different root densities that persisted for up to 15 wk. For clover, colonization and linear spread were favoured by greater root densities and at the greatest density colonization seemed to proceed faster than root extension. In *F. rubra* root density was positively related to linear spread up to *c.* 23 cm root/cm³ soil; greater root density was supra-opt. for linear spread but not for colonization. Although root density had important effects on spread of infection, spp. effects were much greater. *F. rubra* had 5 times more total root than clover but it supported less than half the total length of infected root.

0907 AZCON-AGUILAR, C.; RODRIGUEZ-NAVARRO, D. N.; BAREA, J. M. **Effects of Ethrel on the formation and responses to VA mycorrhiza in *Medicago* and *Triticum*.** *Plant and Soil* (1981) 60 (3) 461-468 [En, 32 ref.] Dep. of Microbiol., Estación Experimental del Zaidín, CSIC, Granada, Spain.

Ethephon applied to the rooting medium or sprayed on the foliage depressed vesicular-arbuscular mycorrhiza formation in lucerne and wheat.

0908 AZCÓN, R.; OCAMPO, J. A. **Factors affecting the vesicular-arbuscular infection and mycorrhizal dependency of thirteen wheat cultivars.** *New Phytologist* (1981) 87 (4) 677-685 [En, 31 ref., 3 tab.] Soil Microbiol. Dep., Estación Experimental del Zaidín, Granada, Spain.

Cvs. inoculated with *Glomus mosseae* showed different degrees of mycorrhizal infection and mycorrhizal dependency. The latter was affected by root and root/shoot ratio dry wts., but neither mycorrhizal dependency nor mycorrhizal infection levels were directly affected by N, P, K, Ca or Mg concs. in plant tissues. Absence of mycorrhizal infection from some cvs. was associated with lack of sugar exudation from the roots rather than with their sugar content. VA infection led to a decrease in the reducing and total sugar content of root extracts, and this effect was correlated with the degree of mycorrhizal infection.

0909 BRADLEY, R.; BURT, A. J.; READ, D. J. **Mycorrhizal infection and resistance to heavy metal toxicity in *Calluna vulgaris*.** *Nature, UK* (1981) 292 (5821) 335-337 [En, 12 ref., 2 fig., 1 tab.] Univ. Sheffield, UK.

The growth, survival and heavy metal content of 2 races of *C. vulgaris*, one from a metal-polluted site and one from an unpolluted, natural heathland, were compared when plants were grown in the mycorrhizal (M) and non-mycorrhizal (NM) condition in sand cultures supplemented with different levels of Cu and Zn. NM plants showed no tolerance of these metals at high concs., but mycorrhizal infection provided a high degree of resistance to the toxicity and infection led to a significant reduction in the heavy metal content of the shoot. This capacity may help to explain the success of ericaceous plants on heathland soils in which the low pH increases the availability of metallic cations, in particular Al and Mn, to levels which are toxic to many other plants.

*0910 CHAMBERS, C.A.; SMITH, F.A.; SMITH, S.E. Effects of salts on mycorrhizal infection in Trifolium subterraneum. Proc. Int. Bot. Congr. 13(0) 296. 1981.

0911 DIEM, H. G.; GUEYE, I.; GIANINAZZI-PEARSON, V.; FORTIN, J. A.; DOMMERGUES, Y. R. **Ecology of VA mycorrhizae in the tropics: the semi-arid zone of Senegal.** *Acta OEcologica, OEcologia Plantarum* (1981) 2 (16) (1) 53-62 [En, fr, 28 ref., 5 fig., 3 tab.] ORSTOM, CNRS, Dakar, Sénégal.

In the tropics vesicular-arbuscular mycorrhizae seem to play a major role in the growth of trees and crop plants. VA mycorrhizal associations in Senegal with *Azadirachta indica*, *Casuarina equisetifolia* and *Acacia senegal* illustrate variability in infection of trees in semi-arid zones, mycorrhizal fungi being mainly *Glomus* or *Gigaspora* spp. Two problems often overlooked in the region are the interactions between VA mycorrhizae, soil moisture and soil type. The main problems concerning the occurrence and role of VA mycorrhizae in the tropics are discussed with particular emphasis on the variability of environmental conditions.

0912 GILDON, A.; TINKER, P. B. **A heavy metal-tolerant strain of a mycorrhizal fungus.** *Transactions of the British Mycological Society* (1981) 77 (3) 648-649 [En, 7 ref., 2 tab.] Rothamsted, Harpenden, Herts., UK.

A str. of *Glomus mosseae* from soil in the Shipham area of Somerset which is heavily contaminated with Zn and Cd was significantly more tolerant of these metals than a str. of the endophyte from Rothamsted soil. Results suggested that, in studies of heavy metal tolerance on contaminated soils, the tolerance of the endophyte may be as important as that of the host, where the former is essential for reasonably healthy growth.

0913 GROTH, D.E.; MARTINSON, C.A. Vesicular-arbuscular mycorrhizal infection of maize as affected by rotation, fertilization and metalaxyl. Phytopathology 71(2): 221. 1981. Abstr.

Root samples were collected in maize plots from a 30 year rotation experiment with fertilizer subplots. Vesicular-Arbuscular (VA) mycorrhizal infection was expressed as the percent of 1 cm root segments infected. Three different rotations of maize, oats, and alfalfa had no significant effect on infection. Manure and phosphorus fertilization decreased infection to 44% compared to the average 63% infection of the unfertilized plots; combined they decreased root infection to 35%. An experimental fungicide, metalaxyl, when incorporated into field soil in a greenhouse experiment at 1.4 and 9 mg/kg, increased VA

infection from 57% to 62 and 72% respectively after 30 days. When inoculum of Glomus fasciculatus was added to the soil VA infection increased 16% but metalaxyl had no additional effect on infection.

0914 KOSKE, R. E.; HALVORSON, W. L. **Ecological studies of vesicular-arbuscular mycorrhizae in a barrier sand dune.** *Canadian Journal of Botany* (1981) 59 (8) 1413-1422 [En, fr, 38 ref.] Department of Botany, University of Rhode Island, Kingston, Rhode Island 02881, USA.

An ecological survey of the vegetation of a barrier dune on the south coast of Rhode Island showed *Ammophila breviligulata, Solidago sempervirens, Lathyrus japonicus* and *Myrica pensylvanica* to be the dominant plant species. All plants were mycorrhizal. Six species of vesicular-arbuscular (VA) fungi occurred in association with these plants, with *Gigaspora gigantea* and *Acaulospora scrobiculata* the most abundant. Also present were *Gigaspora calospora, Glomus etunicatus, Glomus fasciculatus* and an undescribed species of *Gigaspora*. Spore densities and frequencies were measured in a transect across the dune and were compared with plant cover and physical factors (pH, soil moisture, organic matter, soil nutrients, chlorides and sand grain size). Areas on the dune with greatest vegetation cover by *Ammophila* were associated with greatest spore densities and fungal diversity in the rhizosphere. For most plant species, maximum spore density occurred in the front half of the plant's distribution range, nearest the dune crest. There was little correlation between spore populations in the soil and physical characteristics, with the exception of sand grain size, where a negative correlation occurred between grain size and spore densities of *G. gigantea*. The importance of VA mycorrhizae in sand dune stabilization programs is discussed.

*0915 MOSSE, B.; STRIBLEY, D. P.; LETACON, F. Ecology of mycorrhizae and mycorrhizal fungi. *Advances in Microbial Ecology* (1981) 5, 137-210 [En, approx. 420 ref.] Rothamsted Experimental Station, Harpenden, Herts, AL5 2JQ, UK.

The main topics considered include: the hosts (types of mycorrhizal structures and large-scale distribution of hosts); the fungi; the association; factors affecting the development of mycorrhizae; interactions with other components of the ecosystem; succession; and the effects of man on distribution.

0916 NELSEN, C. E.; BOLGIANO, N. C.; FURUTANI, S. C.; SAFIR, G. R.; ZANDSTRA, B. H. **The effect of soil phosphorus levels on mycorrhizal infection of field-grown onion plants and on mycorrhizal reproduction.** *Journal of the American Society for Horticultural Science* (1981) 106 (6) 786-788 [En, 23 ref.] Michigan State University, East Lansing, MI 48824, USA.

Seeds of onion cvs Spartan Banner and Downing Yellow Globe were sown on 2 organic soils that were high and low in available P and which contained a natural population of mycorrhizal spores (*Glomus* sp.). Treatments were 4 levels of P (0, 30, 97 and 193 kg/ha) and inoculum of the mycorrhizal fungus *G. etunicatus*. In the soil that was low in available P (3 kg/ha) bulb weight increased with added P. Root infection by the mycorrhizal fungus and mycorrhizal spore numbers in the soil were negatively correlated with added P. Bulb weight and mycorrhizal spore number at harvest increased when mycorrhizal inoculum was added to the soil. In the soil that was high in available P (97 kg/ha) bulb weight, root infection and spore numbers were not influenced by added P or added mycorrhizal inoculum. Root infection data suggested a threshold level of soil P (about 10 kg/ha) below which mycorrhizal infection was high and above which infection was low.

*0917 NELSEN, C.E.; SAFIR, G.R. Increased drought resistance of mycorrhizal onion (Allium cepa) plants. 73rd. Annual Meeting of the American Phytopathological Society, Aug. 2-6 1981. Phytopathology 71(8):896-897. 1981. Abstract.

Onion plants (Allium cepa L.) inoculated with soil containing spores of the mycorrhizal fungus Glomus etunicatus were grown in a growth chamber under low soil phosphorus conditions (15 ppm P). Non-mycorrhizal (NON-MYC) onions grown under the same conditions were fertilized with a solution of KH_2PO_4 equivalent to 110 kg P/ha (56ppm) to maintain top growth similar to that of the mycorrhizal (MYC) onions. Four weeks after sowing, one-half of the MYC and NON-MYC onions were subjected to cyclic periods of drought by witholding water. Drought stressed plants were watered each time the soil water potential dropped below - 10 bars as measured with calibrated soil moisture blocks. Controls were watered daily ' After 12 weeks of growth, drought-stressed MYC plants were 4.3 times larger than drought-stressed NON-MYC plants (1.8 vs. 0.4 g F. wt.) Well-watered MYC controls were only 1.4 times larger than NON-MYC controls (5.6 vs 4.0 g. F. wt.) The role of increased phosphorus nutrition of mycorrhizal plants subjected to drought stress will be discussed.

0918 PUGH, L. M.; RONCADORI, R. W.; HUSSEY, R. S. **Factors affecting vesicular-arbuscular mycorrhizal development and growth of cotton.** *Mycologia* (1981) 73 (5) 869-879 [En, 11 ref., 6 fig.] Univ. Georgia, Athens, USA.

The effects of inoculum level, soil fertility, soil temp. and cotton cv. were determined. In a P-deficient soil either 200 or 400 azygospores of *Gigaspora margarita*/plant significantly stimulated growth, whereas 10, 50 and 100 spores/plant had little or no effect. In a soil deficient in N and P, *G. margarita* increased growth only when sufficient N was added, but the mycorrhizal growth response was not as great as when both N and superphosphate were added to nonmycorrhizal plants. When P was deficient mycorrhizal plants consistently had a higher content of this element in the foliage than did nonmycorrhizal cotton. The addition of superphosphate (25 μg or more of P/g soil) to a soil containing 10 μg/g P produced a growth increase at least equal to the growth response produced by *G. margarita* or *Glomus etunicatus*, and rates of 50 and 150 μg/g suppressed root infection. Max. mycorrhizal development by *G. margarita*, and subsequent growth stimulation, occurred at 30 and 24°C; it was slight or absent at 19 or 14°. Growth stimulation of 5 cvs. inoculated with *G. margarita* varied considerably; Coker 310 and Stoneville 213 responded best, Acala 1517-70 and Deltapine 16 were marginally affected and Paymaster 909 was relatively unaffected.

*0919 RABATIN, SUSAN C. and D. T. WICKLOW. (Pymatuning Lab. Ecol., Univ. Pittsburgh, Pittsburgh, PA.) Stuckey, R. L. and K. J. Reese (Ed.). Ohio Biological Survey Biological Notes, No. 15. The Prairie Peninsula: In the 'shadow' of Transeau; Proceedings of the 6th North American Prairie Conference, Columbus, Ohio, Aug. 12-17, 1978. x+278p. College of Biological Sciences the Ohio State University: Columbus, Ohio. Illus. Maps. Paper. ISBN 0-86727-090-X. p265-266. 1981[recd. 1982]. **The ecology of vesicular-arbuscular mycorrhizae in a western Pennsylvania, USA relic prairie./ABSTRACT.**

0920 RICH, J. R.; SCHENCK, N. C. **Seasonal variations in populations of plant-parasitic nematodes and vesicular-arbuscular mycorrhizae in Florida field corn.** *Plant Disease* (1981) 65 (10) 804-807 [En, 25 ref., 3 fig., 1 tab.] Univ. Florida, Agric. Res. Cent., Live Oak, USA.

When VA mycorrhizal spores were monitored every 26-42 days for 1 yr at 4 depths (15, 30, 45 and 60 cm) at 5 sites in a maize field, 14 spp. (4 gen.) were found. The most common was *Gigaspora margarita*, whilst *Glomus macrocarpus* var. *macrocarpus, G. clarus* and *Sclerocystis sinuosa* regularly occurred. Numbers of spores were max. in Aug. and min. in May. More spores were found in the top 15 cm of soil than at lower depths but depth distribution varied with sp. Spore numbers also varied greatly among sites. There were positive correlations between spore numbers and nematode populations, indicating that most of the fungal spp. coexist on maize with most of the nematodes recovered.

*0921 RUISSEN, M. A. The effect of agricultural practices on VA-mycorrhizas in Dutch polder soils. In proceedings of 5th North American Conference on Mycorrhizae, Quebec, Aug. 16-21, 1981 The development of VA-mycorrhizae as influenced by different agricultural practices in field grown winterwheat (Triticum aestivum L.) and potato (Solanum tuberosum L.) was studied during two successive years (1979-1980). Samples were collected from existing trials of an experimental farm on the newly reclaimed calcareous clay soil in the North-East Polder. The sampled plots

were parts of field experiments on the influence of: (1) crop sequences, (2) the use of green manure, (3) the use of farmyard manure. (4) soil tillage and (5) P-availability on the productivity of the soil. The experimental design was monofactorial and different nitrogen levels were applied. Mycorrhizal development was estimated as percentage root infection by means of the line intersection method.
In general, the results in winterwheat were negatively influenced by application of nitrate-nitrogen but in potato they were not. In experiment (1) the level of VAM infection in wheat roots was affected by the frequency of the wheat ocurrence in the rotation. In experiment (2) a slight tendency was found that the use of red clover (Trifolium pratense L.) as green manure decrease VAM infection in wheat at the highest N-level: Presumptive evidence was found for an effect of the host species and probably also of the inoculum density on the relation between N-availability and VAM development. With farmyard manure no effect was found on the development of VAM in potato and a slight effect on that in wheat. Soil tillage clearly influenced the root infection in wheat. In the plots with the lowest level of soil tillage the highest level of infection was found. As expected, low P-availability increased VAM infection. Even with almost 60% of root infection, however, the yield of winterwheat was not as high as on the plots with a high amount of available P.
It can be concluded that VAM development in relation to N-availability is host dependent. The effects of different agricultural practices can partly be explained as effects of different nutrient availabilities and the building up of inoculum densities.

0922 SAIF, S. R. **The influence of soil aeration on the efficiency of vesicular-arbuscular mycorrhizae. I. Effect of soil oxygen on the growth and mineral uptake of *Eupatorium odoratum* L. inoculated with *Glomus macrocarpus*. *New Phytologist* (1981) 88 (4) 649-659 [En, 15 ref.] Institut für Tropischen und Subtropischen Pflanzenbau der Universität Göttingen, 3400 Göttingen, German Federal Republic.**

Oxygen concentrations in the soil atmosphere greatly influenced the growth and mineral uptake of *Eupatorium odoratum* inoculated with *Glomus macrocarpus*. Shoot and root dry weights and lengths of mycorrhizal plants increased with O_2 concentration up to 16%. Mycorrhizal plants at 21% O_2 or non-aerated controls were smaller than those at 12 and 16% O_2. Non-mycorrhizal plants had lower shoot and root dry weights than mycorrhizal plants at all O_2 levels except at 0%, and showed little or no response to O_2 concentrations above 4%. P, N, K, Ca and Mg uptake was greater in mycorrhizal plants than in non-mycorrhizal plants, and showed a positive response to O_2 level up to 12-16% in mycorrhizal plants only. Inoculation and increased soil O_2 resulted in higher concentrations of K and Mg but not of N and Ca. P concentrations were higher in mycorrhizal plants than in non-mycorrhizal plants and did not increase with increasing O_2 above 2%. The development of *Glomus macrocarpus* showed positive responses to soil O_2 levels.

***0923** SAIF, S.R. Influence of soil carbon dioxide on the efficiency and development of vesicular-arbuscular (VA) mycorrhiza. In: Proceed of 5th North American Conference on mycorrhizae, Quebec, Aug. 16-21 pp.20 1981. Abst.
Pot experiments under growth room conditions were carried out with Eupatorium odoratum, Sorghum bicolor and Guizotia abyssinica inoculated with Glomus macrocarpus. Soil was fertilized with hardly soluble CA5 (PO4)3 OH. Carbon dioxide was supplied continuosly at a rate of 1 /h to each pot till the and of the experiment. Throughout one oxygen level (16%) was used.
Eupatorium: Dry matter increased from 0 to 1% carbon dioxide and than decreased with increasing carbon dioxide. Inoculation increased the dry matter of plants. The mycorrhizal plants were more sensitive to carbon dioxide than non-mycorrhizal plants. The mineral uptake (except nitrogen) at lower concentration of carbon dioxide showed only minor effects of carbon dioxide levels but it was strongly reduced in mycorrhizal plants at 16%. The uptake and concentration of P was more strongly improved by mycorrhiza than those of the other elements. The uptake and concentration of the elements showed the following order of mycorrhizal efficiency: P > Mg > K > Ca > N. The mycorrhizal infection was slightly increased at lower but decreased at higher concentrations of carbon dioxide. The vesicle number decreased with increasing carbon dioxide. At each carbon dioxide level, the infection intensity was very low and arbuculas were generally absent.
Sorghum: Shoot dry weight showed no response to carbon dioxide and inoculation. Root dry weight increased up to 4% carbon dioxide and also by inoculation. Uptake of P was more strongly improved by inoculation than the uptake of other elements. The uptake and concentration of the elements showed the following order of mycorrhizal efficiency: P > K > N > Mg > Ca. The percentage of root length infected and the number of vesicles increased up to 4% and decreased at 8% carbon dioxide. The infection intensity was very low and arbuscules were generally absent.
Guizotia: Increase in soil carbon dioxide reduced the dry matter of mycorrhizal and non-mycorrhizal plants; inoculation increased it significantly, with increasing carbon dioxide the mineral uptake decreased but the mineral concentration increased. The uptake and concentration of Mg was more strongly increased by inoculation than that of the other elements. The uptake and concentration of the elements showed the following order of mycorrhizal efficiency: Mg > P > Ca > N > K. The infection rate and the number of vesicles increased up to 4% carbon dioxide. The infection intensity was appreciably high but no arbusculas were observed.

***0924** SAIF, S.R. Influence of soil oxigen and soil temperature on the efficiency and development of vesicular-arbuscular (VA) mycorrhiza. In proceeding of 5Th North American Conference on Mycorrhizae, Quebec, August 16-21, pp.20. 1981. Abst.
Pot experiment under growth room conditions was carried out with Eupatorium odoratum inoculated with Glomus macrocarpus. Soil was fertilized with hardly soluble Ca5 $(PO4)_3$ OH. Oxygen was supplied continously at a rate of 1 l/h.
Dry matter increased markedly with rising oxygen up to 16% and with soil temperature up to 30C°. In the 35C° treatment, dry matter increased up to 21% oxygen. The inoculation effect at 20 and 25C° decreased with increasing oxygen up to 21% but at 30 and 35C° it increased countinously up to 21% and the affect in the 35C° treatment at 16 and 21% oxygen was greater than at correponding oxygen concentrations in the 20°C treatment
The uptake of all elements increased with rising oxygen up to 16% and with soil temperature up to 30°C. In the 35°C treatment, the mineral uptake increased up to 21% oxygen, except N and Mg. The P uptake was more strongly improved by inoculation than the uptake of other elements. The mineral concentration, at 20, 25 and 30°C was generally little affected by soil oxygen but at 35°C it increased up to 21% oxygen. The P concentration increased but the concentration of N decreased with increasing soil temperature.

up to 30°C but the concentrations of Ca and Mg were little affected by soil temperature. Inoculation increased the concentrations of P,K and Mg but decreased N and Ca concentrations.

The incidence of mycorrhiza was lower at 2% than at higher oxygen concentrations at all soil temperatures. The percentage of root length infected and the number of vesicles increased with rising soil temperature up to 30°C with greatest values at 16 and 21% oxygen. The incidence of mycorrhiza at 35°C was appreciably higher than at 20°C except at 2% oxygen where the infection rate was very low and no arbuscules were observed. Generally, the percentage of root segments with arbusculas increased from 20 to 25°C and than decreased at 30 and 35°C. The arbuscule development was strongest in roots at 25°C with 8 and 16% oxygen in the soil atmosphere, and in unaerated control roots.

0925 SCHWAB, S.; REEVES, F. B. **The role of endomycorrhizae in revegetation practices in the semi-arid west. III. Vertical distribution of vesicular-arbuscular (VA) mycorrhiza inoculum potential.** *American Journal of Botany* (1981) 68 (10) 1293-1297 [En, 23 ref.] Department of Botany and Plant Pathology, Colorado State University, Fort Collins, Colorado 80523, USA.

The changes in vesicular-arbuscular (VA) mycorrhiza inoculum potential (MIP) in soil profiles from a mid-elevation sage community were measured using a corn bioassay. The MIP was significantly reduced below 30 cm depth and approached zero below 1 m depth. The decrease in inoculum potential with depth in soils diluted with sand, vermiculite and perlite did not always parallel changes in the nondiluted soil, indicating that factors other than numbers of inoculum units also may be important in determining the extent of mycorrhiza formation.

0926 SIEVERDING, E. **Influence of soil water regimes on VA mycorrhiza. 1. Effect on plant growth, water utilization and development of mycorrhiza.** *Zeitschrift für Acker- und Pflanzenbau* (1981) 150 (5) 400-411 [En, de, 19 ref., 6 tab.] CIAT, Cali, Colombia.

In experiments with sorghum and *Eupatorium odoratum* the favourable effect of mycorrhiza (*Glomus macrocarpus*) on plant growth was more pronounced in a drier water regime, particularly with restricted P uptake. Mycorrhizal plants were less sensitive to temporary water shortage than non-mycorrhizal plants. It is concluded that under conditions of insufficient soil moisture mycorrhiza can improve the water relations of crops, depending on plant sp. and soil type.

*0927 SPITKO, R. A.; MANNING, W. J. **Irradiated digested sewage sludge: effects on plant-symbiont associations in the field.** *Environmental Pollution, A* (1981) 25 (1) 1-8 [En, 27 ref.] Massachusetts University, Amherst, 01003, USA.

Anaerobically digested sewage sludge (composition given) irradiated with high energy electrons as a means of disinfestation, was hosed as a liquid sludge onto limed soil. Applications were made at 4.7 and 9.4 t dry sludge per ha and were repeated in the second year. All treatments inhibited rhizobial nodulation of bush beans, cv. Contender, and vesicular arbuscular mycorrhizal infection of onions, cv. Downing Yellow Globe. Heavy metal accumulation and N and P status in soil and plant, and soil pH and soluble salt content were monitored but no explanation was found.

0928 TOMMERUP, I.C.; BRIGGS, G.G. Influence of agricultural chemicals on germination of vesicular-arbuscular endophyte spores. Trans. Br. Mycol. Soc. 76(2) (1981).

0929 TOMMERUP, I. C.; BRIGGS, G. G. **Influence of agricultural chemicals on germination of vesicular-arbuscular endophyte spores.** *Transactions of the British Mycological Society* (1981) 76 (2) 326-328 [En, 14 ref., 1 tab.] Univ. Western Australia, Nedlands, Australia.

Neither germination nor growth of hyphae from spores of *Acaulospora laevis, Glomus caledonius* and *G. monosporus* was affected by carbendazim, captafol and 3 herbicides at soil concs. approx $^1/_1$ – 10 fold of those likely to be found after field applications.

0930 ANTIBUS, R. K.; TRAPPE, J. M.; LINKINS, A. E. **Cyanide resistant respiration in *Salix nigra* endomycorrhizae.** *Canadian Journal of Botany* (1980) 58 (1) 14-20 [En, fr, 37 ref., 5 fig., 2 tab.] Virginia Polytechnic Inst., State Univ., Blacksburg, USA.

Plants growing on an abandoned railway grade in Va. were heavily colonized with vesicular-arbuscular mycorrhizae, with which *Glomus fasciculatus* was unequivocally associated. Addition of 5 mM KCN to *S. nigra* endomycorrhizae or *S. rotundifolia* ectomycorrhizae inhibited respiration by *c.* 50%, suggesting the possible involvement of a cyanide insensitive alternate oxidase in root respiration. Addition of 2.5 mM salicylhydroxamic acid (SHAM) to KCN-inhibited roots caused an additional significant reduction of O_2 uptake in both root types. The results suggest the participation of a SHAM sensitive oxidase in root respiration. When SHAM was added alone to *S. nigra* endomycorrhizae, a slight but insignificant reduction in O_2 uptake was observed. Conversely, SHAM caused a stimulation of O_2 uptake in *S. rotundifolia* ectomycorrhizae. When SHAM was followed by the addition of KCN, the net result was a significant inhibition of respiration in both root types. The results suggest that an alternate oxidase exists in willow roots which is characterized by some of the same basic features described for beech ectomycorrhizal roots. [*RPP 56*, 2357]

0931 CHAMBERS, C. A.; SMITH, S. E.; SMITH, F. A. **Effects of ammonium and nitrate ions on mycorrhizal infection, nodulation and growth of *Trifolium subterraneum*.** *New Phytologist* (1980) 85 (1) 47-62 [En, 51 ref.] Dep. of Bot. and Agric. Biochem., Adelaide Univ., Adelaide, S.A., Australia 5001.

In pot trials the effects of nitrate and ammonium N in the conc. range 0 to 12 meq N/pot, mixed throughout the soil or in the top 2-3 cm before sowing, on subterraneum clover mycorrhizal infection, nodulation and growth were studied. Both forms of N decreased VA mycorrhizal development; ammonium N was more effective than nitrate N. Sodium bisulphate also decreased infection. Both N forms inhibited nodulation and N fixation; at low levels (1-2 meq N/pot) ammonium N had a less severe effect than nitrate N. The results are discussed in relation to the effects of N on mineral nutrition of plants with particular reference to the effect of VA mycorrhiza on plant growth.

0932 CHAMBERS, C. A.; SMITH, S. E.; SMITH, F. A.; RAMSEY, M. D.; NICHOLAS, D. J. D. **Symbiosis of *Trifolium subterraneum* with mycorrhizal fungi and *Rhizobium trifolii* as affected by ammonium sulphate and nitrification inhibitors.** *Soil Biology & Biochemistry* (1980) 12 (2) 93-100 [En, 44 ref.] Dep. of Bot., Adelaide Univ., Adelaide, S.A., Australia 5001.

The symbioses between *T. subterraneum*, mycorrhizal fungi and *Rhizobium* were affected by ammonium sulphate and by the nitrification inhibitors 2-chloro-6 (trichloromethyl) pyridine (N-Serve) and 2-trichloromethyl pyridine (2TMP). At 50 µg/g soil, N-Serve and 2TMP had toxic effects on plant growth, measured as leaf expansion, root length and dry wt. Lower conc. of N-Serve also produced some toxic symptoms. The addition of ammonium sulphate to the soil at 2 and 6 meq NH_4^+/pot resulted in reduced root length and nodulation. Shoot dry wt. was reduced at 6 meq NH_4^+/pot. In the presence of ammonium sulphate the toxic effects of the nitrification inhibitors on plant growth were less. Both nitrification inhibitors reduced development of mycorrhizal entry points and extent of root colonization (percentage infection). Percentage infection of the root system was also reduced by ammonium sulphate. Development of nodules on the lateral roots was increased in the presence of N-Serve at 5 and 15 µg/g. This effect, however, was accompanied by a marked reduction in nitrogenase activity. Smaller increases in nodulation were apparent with 2TMP and were associated with variable nitrogenase activity.

*0933 GIANINAZZI-PEARSON, V.; TROUVELOT, A.; MORANDI, D.; MAROCKE, R. **Ecological variations in endomycorrhizas associated with wild raspberry populations in the Vosges region.** *Acta Ecologica* (1980) 1 (2) 111-119 [En, fr, 24 ref., 2 fig., 3 tab.] Station de la Flore pathogène du Sol, INRA, Dijon, France.

Vesicular-arbuscular mycorrhizal fungi, predominantly *Glomus* spp., were associated with all the *Rubus idaeus* populations in the region. Variations in resting spore numbers (227-2386/100 g soil) and root infection (29-86% of the length) between experimental sites could not be consistently

correlated with any one ecological factor. Root infection by a fine endophyte resembling *G. tenuis* was common in high altitude ecosystems (15-41% root length infected) where soil pH was lower, but it was very restricted at lower altitudes in soils of higher pH. The 2 types of endophytes were not incompatible and mixed infections were frequent.

0934 LAMBERT, D. H.; COLE, H., JR.; BAKER, D. E. **Adaptation of vesicular-arbuscular mycorrhizae to edaphic factors.** *New Phytologist* (1980) 85 (4) 513-520 [En, 25 ref.] Ohio Agric. and Development Cent., Wooster, OH 44691, USA.

In 3 field soils, birdsfoot trefoil transplants infected with mycorrhizal fungi from 42 soils showed no clear superiority of strains from these individual soils after 1 yr growth. Differences among strains decreased with time and were only significant for all 3 soils at the 1st cut. There were low-level correlations between yield and various chemical properties of the soils from which the cultures were derived. In the greenhouse, with sterilized soils low in P, trefoil yield was always greatest when the inoculum used was indigenous to the soil in which the plants were grown as compared with inocula from 5 different soils.

.0935 MOAWAD, M. Ecophysiology of vesicular-arbuscular mycorrhiza. In : Tropical Mycorrhiza Research (Ed. by P. Mikola) Oxford Univ. Press Oxford, England. pp.203-205 (1980).

0936 NEMEC, S. **Effects of 11 fungicides on endomycorrhizal development in sour orange.** *Canadian Journal of Botany* (1980) 58 (5) 522-526 [En, fr, 24 ref.] US Department of Agriculture, Orlando, Florida 32803, USA.

Methyl bromide, at present used in Florida to control fungal pathogens in seedbeds, adversely affects the beneficial vesicular-arbuscular mycorrhizal (VAM) fungi. In an attempt to find safer alternatives, 11 fungicides were applied at field rates to sour orange seedlings in soil with or without VAM fungi. Their effects on plant growth and on *Glomus etunicatus* and *G. mosseae* development are shown in tables. Growth of mycorrhizal plants was better and fungus sporulation higher than with mycorrhizal controls in all plots treated with sodium azide at 7.9-31.4 kg/ha. Captan, chloroneb, metalaxyl and captafol did not adversely affect plant growth, whereas benomyl and thiabendazole did so. The last 3 compounds were toxic to VAM fungi. Copper was more phytotoxic than fungitoxic.

0937 OCAMPO, J. A. **[VA mycorrhizae. III. Ecology.] Micorrizas VA. III. Ecología.** *Anales de Edafclogía y Agrovioloqía* (1980) 39 (5/6) 1071-1088 [Es, en, Review, many ref.] Dep. de Microbiol., Estación Exp. del Zaidín, Granada, Spain.

Ecological factors affecting the infection of higher plants by VA mycorrhizal endophytes and the effectiveness of the subsequent symbiosis are reviewed, including N and P fertilizer applications, soil pH, interaction between host plants, crop rotations, pesticides and interactions with fungi, bacteria, viruses and nematodes in the soil. The distribution and dispersion of the spores of mycorrhizal fungi are described. The value of VA mycorrhizae for the colonization of marginal soils by higher plants is discussed.

*0938 PONDER, F., JR. **Rabbits and grasshoppers: vectors of endomycorrhizal fungi on new coal mine spoil.** *USDA Forest Service Research Note NC* (1980) No.250, 2 pp. [En, 9 ref.] c/o North Central Forest Experiment Station, 1992 Folwell Ave., St. Paul, MN 55108, USA.

Rabbit droppings and grasshoppers were collected on recently graded coal mine spoil to determine if they were vectors of endomycorrhizal fungi. After 6 weeks of growth, roots of rye grass and sudan grass grown in mixtures of sterilized sand containing either unsterilized rabbit droppings or grasshoppers were endomycorrhizal, while the roots of plants grown in sterilized mixtures of these were not.

*0939 RABATIN, S. C. **Factors influencing the distribution and activity of vesicular-arbuscular mycorrhizal fungi in mesic herbaceous plant communities.** *Dissertation Abstracts International, B* (1980) 41 (6) 2047 [En, Order No. 8028049] Pittsburgh Univ., Pittsburg, PA 15213, USA.

The effects of season and soil type on vesicular-arbuscular (VA) mycorrhiza in a meadow, a hayfield and a pasture were examined. Out of 16 VA fungi identified, *Glomus fasciculatus* was the dominant sp. at each site.

*0940 SAIF, S.R. **Influence of soil aeration on the efficiency of vesicular-arbuscular mycorrhizae (P).** In Botanikertagung in Bochum, West Germany. 26. Bis 31. Mai 1980. pp.155. Abst.

While a great deal of attention has been paid to the role of VA mycorrhizae in nutrient uptake by plants, almost nothing is known of their function at different levels of soil oxygen. The present report is the first experimental study of this problem. Mycorrhizal (*Glomus macrocarpus*) and non-mycorrhizal plants of *Eupatorium odoratum* (Compositae) were grown in pots with 1 kg soil and aerated with different concentrations of oxygen. Mycorrhizal (M) plants showed significant increase in lenght with increasing oxygen till 12% which further did not differ from 16%. Plants at 21% were significantly smaller than at 12% and 16%. Non-mycorrhizal (NM) plants did not respond to different O_2 levels and remained smaller than M plants. Similar results were obtained for stem and root dry weights. Non-aerated M plants showed significantly lower values for all growth parameters than plants at 12% and 16%. M and NM plants, except at 0% oxygen, showed no difference in P concentration with increasing oxygen. However, between each other they showed highly significant difference at all oxygen levels. P and N uptake in mycorrhizal plants was similar to the increase in stem dry weight. N concentration in NM plants increased with increasing oxygen and was higher than in M plants where it remained much the same except at 0%. The percentage of root segments and root length infected increased with increasing soil oxygen till 16%. Values at 21% were slightly lower than at 16%. Vesicle number per 50 cm root also increased with increasing soil oxygen, with values smaller than 1000 at 2% to greater than 5000 at 21% soil oxygen. Studies with *Sorghum* and *Guizotia* using *G. macrocarpus* showed similar results. Experiments using other mycorrhizal endophytes are under investigation. The results show that for effective utilization of VA mycorrhiza the soil should be well aerated; consequently, soil compaction and water logging should be avoided in agronomic practice.

0941 SMITH, T. F. **The effect of season and crop rotation on the abundance of spores of vesicular-arbuscular (V-A) mycorrhizal endophytes.** *Plant and Soil* (1980) 57 (2/3) 475-479 [En, 17 ref.] Agric. Protection Board of W.A., South Perth, W.A., Australia 6151.

Spores of V-A mycorrhizal endophytes were extracted and counted from 3 different soils under 3 different rotations, (continuous wheat, annual pasture and an alternating crop/pasture rotation). High V-A spore abundance in the autumn fell at the onset of plant growth. Spore abundance remained low under wheat but recovered under pasture regimes in the spring, coincidently with host maturation in all except 1 of the experiments sampled. Weak positive correlations were found between V-A spore abundance and components of pasture biomass, while wheat biomass was negatively correlated with V-A spore numbers.

*0942 WARNER, A. Factors affecting the spread of vesicular-arbuscular mycorrhizal fungi. Ph.D. Thesis, Univ. of London, England, 174pp. 1980.

*0943 BISHOP, C.L. Effects of light intensity on vesicular-arbuscular mycorrhizal infection in Zea mays Journal of the Colorado Wyoming Academy of Science. 11(1):28, 1979. Abst.

Corn plants were cultivated over a 24 day period in a growth chamber (14 hrs. light at 30°C and 10 hrs. dark at 20°C) under three different light intensities. Plants grown under 400 ft-c showed signigicantly lower levels of vesicular-arbuscular endomycorrhizal infection and less plant growth enhancement as compared to plants grown under the higher light intensities (800 and

1600 ft-c). These results demonstrate the importance of controlling environmental factors when evaluating the effects of endomycorrhizal fungi on growth enhancement of higher plants.

0944 BLACK, R.; TINKER, P. B. **The development of endomycorrhizal root systems. II. Effect of agronomic factors and soil conditions on the development of vesicular-arbuscular mycorrhizal infection in barley and on the endophyte spore density.** *New Phytologist* (1979) 83 (2) 401-413 [En, 36 ref., 2 fig., 6 tab. See *RPP 56*, 3418] Leeds Univ., UK.

The percentage of roots with VA mycorrhizal fungi and numbers of spores were measured over 2 yr in a field experiment with different crop rotations. Spore numbers, and subsequent infections of barley crops, were largest following barley; both kale and fallow breaks reduced spore population and infection similarly. With all rotations there was a long delay before appreciable percentage infection of roots developed, followed by a rapid increase, and then a constant value. Such late infections appear unlikely to improve crop nutrition, and final yield was negatively related to infection. A survey of barley crops over 2 yr on commercial fields following at least 3 yr barley showed that infection was rather similar in most fields. There was a very slight correlation between infection percentage, clay content and pH, but no other soil factor had any influence. Early-sown crops tended to have low infection.

*0945 DAFT, M. J. **Effects of calcium, phosphorus and potassium on mycorrhizal plants.** [Abstract]. In *The soil-root interface [Harley, J.L.; Scott Russell, R. (Editors)]*. London, UK; Academic Press. (1979) 420-421 [En] Dep. of Biol. Sci., Dundee Univ., Dundee DD1 4HN, UK.

Defoliation and reduction in daylength and in irradiance reduced the mycorrhizal growth response and the development of the endophyte. Mycorrhizal development was much lower at low pH, particularly when compared with high pH + adequate Ca levels. In tripartite associations of plant, mycorrhizal fungus and a nodulating bacterium there were responses to Ca, P and K which were detected as increased rates of N fixation, changes in C:N ratios and increased growth rates.

*0946 ELST, F. VAN DER; BATES, P. M. **The effect of mulches and mycorrhiza on blueberry establishment on humified peat.** *New Zealand Commercial Grower* (1979) 33 (11) 23 [En] Soil and Field Research Organization, New Zealand.

The treatments comprised weed control with dichlobenil (as Casoron) at 22 kg/ha, or mulching with sawdust or black plastic in 60-cm-wide strips, all with or without mycorrhiza collected from around vigorous bushes. New growth during the season was greatest with a plastic mulch + mycorrhiza, followed by a sawdust mulch alone.

0947 GRAW, D. **The influence of soil pH on the efficiency of vesicular-arbuscular mycorrhiza.** *New Phytologist* (1979) 82 (3) 687-695 [En, 16 ref.] Institut für Tropischen und Subtropischen Pflanzenbau, Grisebachstrasse 6, D-3400 Göttingen, German Federal Republic.

Tagetes minuta and *Guizotia abyssinica* reacted differently to changes in soil pH and phosphate fertilizers in spite of inoculation with the same strain of *Glomus macrocarpus*. At pH 4.3, mycorrhizal *Guizotia* was unable to absorb P from any of the fertilizers, so growth was severely inhibited by inoculation, whereas mycorrhizal *Tagetes* grew well at this pH in the presence of $Ca(H_2PO_4)_2.H_2O$, $Ca_5(PO_4)_3OH$ and $AlPO_4$. Phosphorus uptake and growth of mycorrhizal *Guizotia* were improved at pH 5.6 and surpassed the performance of non-mycorrhizal plants at pH 6.6. The growth of mycorrhizal *Tagetes* was reduced at pH 5.6 in the presence of $Ca(H_2PO_4)_2.H_2O$ and $Ca_5(PO_4)_3OH$, but was improved at pH 6.6 in all treatments with the exception of $Ca_5(PO_4)_3OH$ as P source.

*0948 HIRREL, M.C.; J.W. GERDEMANN. Effects of salinity on the growth and P nutrition of vesicular-arbuscular mycorrhizal bell Pepper and on the germination of Gigaspora margarita. In: Abstr. Fourth North Amer. conf. on Mycorrhizae (Fort Collins, Colorado, 1979).

0949 MCCOOL, P. M.; MENGE, J. A.; TAYLOR, O. C. **Effects of ozone and HCl gas on the development of mycorrhizal fungus *Glomus fasciculatus* and growth of 'Troyer' citrange.** *Journal of the American Society for Horticultural Science* (1979) 104 (2) 151-154 [En, 20 ref.] California University, Riverside, CA 92521, USA.

Troyer citrange seedlings were exposed to 82 p.p.m. HCl for 20 min or 100 p.p.h.m. ozone for 4 h at 5, 12, or 16 weeks after inoculation with the mycorrhizal fungus, *Glomus fasciculatus*. One group of seedlings was exposed in a 2nd experiment to ozone at 90 p.p.h.m. for 6 h, once weekly, and a second group was exposed to 45 p.p.h.m. for 3 h, twice weekly, for a period of 19 weeks beginning 1 week after fungal inoculation. Intermittent HCl and ozone exposures significantly reduced height and dry weight of mycorrhizal, but not of non-mycorrhizal plants. Fungal chlamydospore production was reduced 57% in ozone treatments but was not reduced by HCl. Weekly exposures to 90 p.p.h.m. ozone reduced total dry weight in mycorrhizal plants by 42%, but reduced that of non-mycorrhizal plants by only 19%. However, 45 p.p.h.m. ozone did not cause a similar reduction in either type of plant. Mycorrhizal infection was reduced 15% and spore production 39% at 90 p.p.h.m. ozone. The lower ozone level (45 p.p.h.m.) reduced infection 22%, but had no effect on spore production. Phosphorus absorption was not reduced by ozone treatments in either mycorrhizal or non-mycorrhizal plants.

0950 MENGE, J. A.; JOHNSON, E. L. V.; MINASSIAN, V. **Effect of heat treatment and three pesticides upon the growth and reproduction of the mycorrhizal fungus *Glomus fasciculatus*.** *New Phytologist* (1979) 82 (2) 473-480 [En, 21 ref., 3 tab.] Univ. California, Riverside, USA.

Mycorrhizal inocula were killed when exposed for 10 min to 52.5°C but not to 51.5°. Although inocula survived a 10 min soaking in PCNB [quintozene] at several concs., infection and sporulation on Sudan grass were consistently inhibited by soil drenches with this fungicide. Soil drenches with DBCP at 15-20 μg/ml or ethazol [etridiazole] (10-40 μg), applied 30-60 days after inoculation, increased infection and sporulation.

0951 MOAWAD, M. **Ecophysiology of vesicular-arbuscular mycorrhiza in the tropics.** In *The soil-root interface [Harley, J.L.; Scott Russell, R. (Editors)]*. London, UK; Academic Press. (1979) 197-209 [En, 27 ref.] Institut für Tropischen und Subtropischen Pflanzenbau, Göttingen, German Federal Republic.

In glasshouse trials, a number of spp. including sorghum were grown with and without inoculation of *Glomus macrocarpus*. Ca, Al and Fe phosphates + N were applied and soil temp. were maintained at 20°, 25°, 30° or 35°C. There was an increase in dry wt. and P content of sorghum plants up to 30° which was significantly greater in infected than non-infected plants. In another trial, non-inoculated and inoculated plants of sorghum were grown at different soil m.c. with Ca, Al and Fe phosphates. In the presence of mycorrhiza, water utilization was improved; the amount of water used to produce 2 g of DM with $Ca_5(PO_4)_3OH$ was much smaller in mycorrhizal than in non-mycorrhizal plants.

0952 RABATIN, S. C. **Seasonal and edaphic variation in vesicular-arbuscular mycorrhizal infection of grasses by *Glomus tenuis*.** *New Phytologist* (1979) 83 (1) 95-102 [En, 26 ref.] Dep. of Biol. Sci. and Pymatuning Lab. of Ecol., Pittsburgh Univ., Pittsburgh, PA 15260, USA.

Seasonal differences in percentage length of gramineous host root infected with *G. tenuis* were measured at 3 field sites in Pennsylvania, USA. Highest *G. tenuis* infection levels were generally found in the spring in very P-deficient soils low in m.c. In roots sampled from soils with a high spring soil m.c., fine endophyte infection increased to a max. later in the growing season. A higher percentage frequency of fine endophyte infection on fine grass feeder roots in spring is taken as evidence for the hypothesis that *G. tenuis* is a vesicular-arbuscular mycorrhizal fungus particularly adapted to penetrating host roots during brief seasonal fluxes of P availability. The implications of these data are discussed in relation to mechanisms in grasses which adapt them to nutrient stress.

0953 REID, C. P. P.; BOWEN, G. D. **Effects of soil moisture on V/A mycorrhiza formation and root development in *Medicago*.** In *The soil-root interface [Harley, J.L.; Scott Russell, R. (Editors)]*. London, UK; Academic Press. (1979) 211-219 [En, 20 ref.] Dep. of Forest and Wood Sci., Colorado State Univ., Fort Collins, CO 80523, USA.

Medicago truncatula was grown in Mallee Loam soil containing yellow-vacuolate spores of Endogonaceae at

approx. constant soil m.c. After 8 days, primary root length, length of laterals and number of laterals were all greatest at a water content of 0.22 g/g soil and decreased above and below this. The number of V/A infections/unit root length at this soil m.c. was 4 times greater than at 0.15 g/g and 2 times greater than at 0.28 g/g (saturation). Although primary root diam. decreased with decreasing water content, root hair length increased. The vol. of soil occupied by root hairs/unit root length was 3.3 times greater at a water content of 0.09 than of 0.22 g/g soil. Root hairs were absent at saturation.

*0954 SCHENCK, N.C.; RICH, J.R. Monthly spore incidence of vesicular-arbuscular mycorrhizal fungi in corn rhizosphere soil at four depths. Phytopathology 69(9): 1044 1979. Abst.

Monthly samples of soil were collected at 4 depths from 5 sites in a field of Zea mays. Sampling began in December 1977 before planting and continued through November of 1978. Samples were wet seived to extract spores of mycorrhizal fungi. Spores of Gigaspora margarita, G. heterogama, G. gregaria, G. pellucida, G. rosea, G. nigra, Glomus macrocarpus, G. clarus, G. etunicatus, G. mosseae, G. microcarpus, G. fasciculatus, Sclerocystis sinuosa and Acualospora gerdemanni were recovered. Spores of G. margarita were most abundant, predominating at the 0-15cm depth, while Glomus species occurred most at the 31-45cm depth. Spores averaged 1200/liter of soil, consisting of 75% Gigaspora spp., 18% Glomus spp., and 7% other species. About 61% of the spores occurred at 0-15cm, 19% at 16-30cm, 12% at 31-45 cm and 8% at 46-60cm depth. Monthly spore numbers fluctuated most at 0-15cm with spore numbers being greatest in August for Gigaspora spp. and in December for Glomus spp.

0955 SIEVERDING, E. [Influence of soil water regimes on the efficacy of the VA-mycorrhiza.] Einfluss der Bodenfeuchte auf die Effektivität der VA-Mykorrhiza. *Angewandte Botanik* (1979) 53 (1/2) 91-98 [De, en, 13 ref., 3 tab.] Inst. für Tropischen und Subtropischen Pflanzenbau, Göttingen, German Federal Republic.

Glasshouse tests were conducted on *Eupatorium odoratum, Guizotia abyssinica,* sorghum and *Trigonella foenum-graecum.* When soluble phosphate was supplied, some plants without mycorrhiza were more sensitive to water shortage than plants with mycorrhiza. In the presence of insoluble phosphate, the utilization of water for the production of dry matter was considerably better in mycorrhizal than non-mycorrhizal plants. With sorghum the development of mycorrhiza was better under conditions of water deficiency than in well watered plants. The dependence of mycorrhiza on soil temp. modified the efficiency of mycorrhiza in the 3 water regimes.

0956 SKIPPER, H. D.; SMITH, G. W. Influence of soil pH on the soybean – endomycorrhiza symbiosis. *Plant and Soil* (1979) 53 (4) 559-563 [En, 11 ref., 1 tab.] Clemson Univ., S. Carol., USA.

When cvs. were inoculated with *Gigaspora gigantea* and *Glomus mosseae,* the specific response depended on soil pH. Overall responses in unlimed soil (pH 5.1) were greater for *G. gigantea* than *G. mosseae.* The cv. Bossier and *G. gigantea* combination was particularly responsive in unlimed soil, showing a 10% increase in shoot length, 35% in shoot dry wt., 75% in root dry wt. and 397% in nodule dry wt. over uninoculated controls. Little cv. response was observed with *G. mosseae* in unlimed soil. In limed soil (pH 6.2), the larger responses were obtained with *G. mosseae,* although inoculation with either fungus appeared to be effective. In general nodulation was greater on mycorrhizal roots than on controls.

0957 SMITH, S. E.; BOWEN, G. D. **Soil temperature, mycorrhizal infection and nodulation of *Medicago truncatula* and *Trifolium subterraneum.*** *Soil Biology and Biochemistry* (1979) 11 (5) 469-473 [En, 21 ref.] Department of Agricultural Biochemistry, Waite Agricultural Research Institute, University of Adelaide, Glen Osmond, S.A., Australia.

Establishment of vesicular-arbuscular mycorrhizal fungi in plant roots involves a pre-infection phase of propagule germination, hyphal growth and appressorium formation, followed by growth of the fungus within the root. The effect of soil temperature on the pre-infection stage was examined by counting the numbers of fungal "entry-points" on the main roots of *Medicago truncatula* and *Trifolium subterraneum,* grown at soil temperatures of 12°, 16°, 20° and 25°C for periods up to 12 days. Increased root temperature was positively associated with increased numbers of "entry-points". This effect was more marked between 12° and 16°C than at higher temperatures, as shown by comparing plants at the same stage of development (emergence of spade leaf) and by calculating the results as entry points per cm root. The first root nodules appeared sooner at higher temperatures (20° and 25°), but subsequent development of nodules (measured as nodule number and aggregate volume of nodules per plant, up to 21 days) was best at 16°C for both host *Rhizobium* combinations in non-sterile and autoclaved soil. There was no evidence that competition between mycorrhizal fungi and *Rhizobium* for infection sites occurred. A method of obtaining numbers of infective propagules of vesicular-arbuscular mycorrhizal fungi in soil is described.†

0958 AZCÓN, R.; MARIN, A. D.; BAREA, J. M. **Comparative role of phosphate in soil or inside the host on the formation and effects of endomycorrhiza.** *Plant and Soil* (1978) 49 (3) 561-567 [En, 15 ref.] Microbiology Dep., Estación Exp. del Zaidín C.S.I.C., Granada, Spain.

Non-mycorrhizal lettuce plants grown for 5 weeks in a low-phosphate soil with varying additions of soluble P were transplanted to soil also with different levels of phosphate and inoculated with VA mycorrhiza (*Endogone* type). The intensity of mycorrhizal infection as affected by the interaction of different levels of phosphate in soil and in the host was examined after a further 8 weeks. In the soil with no added phosphate mycorrhizal infection was not affected by the initial P content of the plants. When 0.8 or 1.5 g K_2PO_4 was given per kg soil both the external and the internal P negatively influenced the infection. In some conditions a P content that was supraoptimal for infection was not so for plant growth. The critical P concentration in plants depends on the age of the host. An interaction between P and N as a factor contributing to phosphate 'toxicity' is discussed.†

0959 AZCON, R.; AZCON-G DE AGUILAR, C.; BAREA, J. M. **Effects of plant hormones present in bacterial cultures on the formation and responses to VA endomycorrhiza.** *New Phytologist* (1978) 80 (2) 359-364 [En, 17 ref.] Soil Microbiology Department, Estación Experimental del Zaidín, Granada, Spain.

The growth and infection levels in mycorrhizal *Lavandula, Lycopersicum* and *Medicago* plants (with *Glomus* as endophyte) were compared after treatment with preparations from *Rhizobium, Azotobacter* and phosphobacteria (a *Pseudomonas*). The bacterial cultures are known to contain growth substances. Cell-free supernatants and, in some instances, the whole bacterial culture behaved like pure plant hormones in improving dry weight and mycorrhizal infection levels.†

0960 DAFT, M. J.; EL-GIAHMI, A. A. **Effect of arbuscular mycorrhiza on plant growth. 8. Effects of defoliation and light on selected hosts.** *New Phytologist* (1978) 80 (2) 365-372 [En, 20 ref.] Dep. of Biol. Sci., Dundee Univ., Dundee, UK.

Defoliation of maize reduced the mycorrhizal growth response and development of the endophyte, estimated as percentage infection, root pigmentation and spore production. More fresh wt. and DM were produced in mycorrhizal grasses harvested on 3 separate occasions than from a single final harvest. The total from 2 harvests and the yield from a single harvest of lucerne were similar although nodulated and mycorrhizal plants were larger at each harvest. In both grasses and lucerne, periodic harvesting halved the mycorrhizal infection. Reduction in daylength and irradiance depressed growth more in mycorrhizal than in uninfected maize plants. In *Rhizobium*- and *Glomus*-infected lucerne plants, a daylength of 16 h produced the highest C contents and C:N ratios. Plants exposed to short days produced more smaller nodules and had higher N contents than plants given long days. Long days favoured the development of the mycorrhizal infection and dually-infected plants produced more DM, reduced acetylene faster and contained more N than plants which were only nodulated. The supply of photosynthate was probably an important factor controlling the development of the mycorrhiza.

0961 PORTER, W. M.; ABBOTT, L. K.; ROBSON, A. D. **Effect of rate of application of superphosphate on populations of vesicular arbuscular endophytes.** *Australian Journal of Experimental Agriculture and Animal Husbandry* (1978) 18 (93) 573-578 [En, 20 ref.] Dep. of Soil Science and Plant Nutrition, Univ. of Western Australia, Nedlands, Australia.

The effect of superphosphate on the population of vesicular arbuscular (VA) endophytes in a pasture soil was

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studied during 1976. Between 1950 and 1965 a pasture near Bakers Hill, Western Australia had received an average of 150 kg superphosphate/ha per year. For the ten years prior to 1976, five rates of superphosphate were applied to plots. Applying 56 kg superphosphate/ha per year increased spore numbers by 40% compared with the unfertilized plots. Spore numbers in plots receiving rates of superphosphate higher than 56 kg/ha were similar to those in unfertilized plots. The relative abundance of spores of endophytes (*Glomus monosporus, Acaulospora laevis, Gigaspora* sp. and 'White reticulate') was unaffected by superphosphate. In a glasshouse experiment VA endophytes from plots that had received 224 kg superphosphate/ha per year did not differ from those which had received no superphosphate in their ability to infect and increase the P uptake and growth of subterranean clover.

0962 SMITH, T. F. A note on the effect of soil tillage on the frequency and vertical distribution of spores of vesicular-arbuscular endophytes. *Australian Journal of Soil Research* (1978) 16 (3) 359-361 [En, 10 ref.] Muresk Agric. College, Western Australian Inst.of Technology, Northam, 6401, Australia.

Spores of vesicular-arbuscular endophytes resembling *Acaulospora laevis* and *Glomus monosporus* were common in the surface layers of a soil under wheat and pasture, declining in numbers down the profile until rare at 500 mm. Tillage had no effect on total spore numbers, but direct drilled wheat had more spores in the surface 80 mm and fewer from 80 mm to 150 mm than conventionally tilled plots. This is thought to be a consequence of mechanical inversion of the soil during cultivation.

0963 ST. JOHN, T.; MACHADO, A. D. [Effect of depth and management system of a terra firme soil (latosol) upon mycorrhizal infection.] Efeitos da profundidade e do sistema de manejo de um solo de terra firme (latossolo) em infestações por micorrizas. *Acta Amazonica* (1978) 8 (2) 139-141 [Pt, en, 7 ref.] Div. Agron., INPA, Manaus, Brazil.

The incidence of mycorrhizae was measured at three soil depths (to 70 cm) on plots near Manaus: a cocoa plantation, natural regeneration with and without burning, and primary forest. The number of roots/m² in a vertical surface of soil profile was also counted at different depths in the profile (to 100 cm). The proportion of infected roots and the number of roots per unit area were greatest in the top 10 cm of soil in all the plots; no difference in the degree of infection was found between the plots.

0964 FURLAN, V.; FORTIN, J. A. Effects of light intensity on the formation of vesicular-arbuscular endomycorrhizas on *Allium cepa* by *Gigaspora calospora*. *New Phytologist* (1977) 79 (2) 335-340 [En, 20 ref.] Dep. d'écologie et pédologie, Fac. de foresterie et géodésie, Univ. Laval, Quebec, Canada.

Four different light intensities exerted distinctly different effects on the formation, reproduction and influence of vesicular-arbuscular mycorrhiza on onion plants. Over a growth period of 100 days, the rate of infection under low intensities (5 and 10 klux) was more rapid and the percentage of infection higher than on mycorrhizal plants cultivated under a light of 15 and 20 klux. The production of spores increased with light intensity. Plant growth enhancement occurred at all light levels but was most pronounced under 10 klux.

*0965 MEJSTŘIK, V. Ecology of endomycorrhizae of *Trisetum flavescens* (L.) P. Beauv. and *Alopecurus pratensis* L., and the intensity of soil cultivation. *Acta Mycologica* (1977) 13 (1) 179-190 [En, pl, 9 ref., 2 pl., 4 graphs, 3 tab.] Inst. Environmental Ecol., Průhonice, Czechoslovakia.

The mycorrhizal endophyte in both spp. was of the vesicular-arbuscular type. The roots harboured 2 types of hyphae: those of the *Endogone* type and thin, straight, septate hyphae. Mycorrhizal development was restricted in more intensively cultivated grassland soils fertilized with high doses of nitrogen and phosphorus.

0966 SAIF, S. R. The influence of stage of host development on vesicular-arbuscular mycorrhizae and endogonaceous spore population in field-grown vegetable crops. I. Summer-grown crops. *New Phytologist* (1977) 79 (2) 341-348 [En, 21 ref.] Dep. of Biol. Sciences, Univ. of Islamabad, Pakistan.

The pattern of mycorrhizal infection of roots of several fully grown vegetable crops [chilly (*Capsicum annuum*), tinda (*Praecitrullus fistulosus*), bitter gourd (*Momordica charantia*), sponge gourd (*Luffa cylindrica*), pumpkin, musk melon, tomato, lady's finger (*Abelmoschus esculentus*), cucumber and bringel (*Solanum melongena*)] showed three phases, a lag phase, a phase of rapid development and a constant phase. Twenty-one days after sowing or transplanting, 0-24% of the roots were infected, but the proportion then increased rapidly to a more or less constant value of 55-92%. [illegible] musk melon, tomato and bringel, no constant phase was observed within the sampling period. During the first 4-8 weeks of crop growth, the Endogonaceous spore population of the soil decreased, but it then increased to final harvest time. Three main types of endophytes were identified, two being members of Endogonaceae. The relationship between the different phases of mycorrhizal development, spore number in the soil and physiological changes in the host is discussed.

0967 SAIF, S. R. The influence of stage of host development on vesicular-arbuscular mycorrhizae and Endogonaceous spores in field-grown vegetable crops II. Winter-grown crops. *Pakistan Journal of Botany* (1977) 9 (2) 119-128 [En, 18 ref., 4 fig., 3 tab. See *RPP 57*, 954] Univ. Islamabad, Pakistan.

The pattern of mycorrhizal infection of roots of the fully grown vegetable crops showed 3 phases (lag, rapid development and constant). At 28 days after sowing or transplanting, 12-21% of the root length was infected, the proportion increasing progressively to a more or less constant value (58-90% according to host sp.). No constant phase was observed within the sampling period in carrot, coriander, onion and fenugreek (*Trigonella foenum-graecum*). No vesicular-arbuscular mycorrhizae were found in cauliflower, radish, turnip, spinach beet and beet. During the first 4-8 weeks of crop growth, the Endogonaceous spore population of the soil decreased but then increased to final harvest time.

0968 GUTTAY, A. J. R. Impact of deicing salts upon the endomycorrhizae of roadside sugar maples. *Soil Science Society of America Journal* (1976) 40 (6) 952-954 [En] Univ. Connecticut, Storrs, USA. From *Biological Abstracts 64*, 4549.

Root, soil and leaf samples were examined from 44 roadside *Acer saccharum* in Connecticut. Progressively greater dieback was significantly correlated with a decrease in endomycorrhizae, an increased depth to viable roots and increased Na and chloride in roots and in the soil of the rhizosphere. Salt damage to trees was attributed to progressive root destruction as annual salt applications continued and an increasing top dieback as the diminishing root system was unable to sustain the top.

*0969 JOHNSON, P. N. Effects of soil phosphate level and shade on plant growth and mycorrhizas. *New Zealand Journal of Botany* (1976) 14 (4) 333-340 [En, 16 ref.] Otago University, P.O. Box 56, Dunedin, New Zealand.

Seedling growth of 11 species, including *Fuchsia excorticata, Griselinia littoralis, Leptospermum scoparium, Nertera depressa* and *Pittosporum tenuifolium* was compared in steamed soils containing 11, 14, 25, and 60 p.p.m. Truog available phosphorus. Species with coarse root systems required progressively higher soil-P levels for growth without mycorrhizas. In the soil with 60 p.p.m. Truog P, coarse-rooted plants were still mycorrhizal but fine-rooted plants were not. *F. excorticata* with fine roots benefited from mycorrhizas only at 11 p.p.m. P; at 25 p.p.m. P the presence of mycorrhizas decreased its growth. Mycorrhizal seedlings of shade-tolerant species had less infection when grown in heavy shade than in full sun and did not accumulate P, whereas light-demanding species retained high infection levels and accumulated P in heavy shade. *Rhizophagus tenuis* appeared to be a more effective mycorrhizal inoculum than *Acaulospora laevis*.

0970 McILVEEN, W.D.; COLE, H.,Jr. Spore dispersal of Endogonaceae by worms, ants, wasps, and birds. Canadian Journal of Botany. 1976. 54(13):1486-1489. Pennsylvania State Univ., Park, USA.

The role of earthworms and several other organisms in spore dispersal was examined using living-host detection methods.

*0971 MINGE, J.A.; MINASSIAN, V.; JOHNSON, E.L.V. The effects of heat treatments and three pesticides upon inoculum of the vesicular-arbus-

cular mycorrhizal Glomus fasciculatus. Dept. Plant Pathology, University of California, Riverside, California. Proc. Amer. Phytopathol. Soc. 3:275. 1976. Abstr.

Glomus fasciculatus inoculum was exposed to hot water at a range of temperatures (38-54C) or was soaked or drenched in one of the following pesticides: pentachloronitrobenzene (PCNB), 5-ethoxy-3-trichloromethyl-1,2,4-thiadiazole (ethazole) or 1,2-dibromo-3-chloropropane (DBCP). Inoculum consisted of soil and roots from either Citrus sinensis or Sorghum vulgare (sudangrass) and contained hyphae, vesicles, arbuscles, and chlamydospores of G. fasciculatus. Inoculum was viable at or below 51.5C but not at or above 52.5C. The inoculum survived soaking in PCNB, ethazole and DBCP at all concentrations tested. The highest concentration tested for each pesticide was 4000, 80 and 240 µg/ml active ingredient, respectively. Sudangrass inoculated with G. fasciculatus was drenched separately with PCNB (1000 µg/ml), ethazole (50 µg/ml) and DBCP (30 µg/ml). When the pesticides were applied at the time of inoculation, PCNB reduced spore production by G. fasciculatus by 70% after 104 days. Ethazole and DBCP did not significantly alter spore production. When the pesticides were applied 60 days after inoculation, ethazole and DBCP increased spore production 76% and 63% respectively; PCNB reduced spore production by 90%, when examined 104 days after inoculation.

*0972 ELEUSINOVA, N.G.; SELIVANOV, I.A. [Seasonal changes in the mycorrhiza of desert plants] Sezonnye izmeneniya mikoriz pustynnykh rastenii. Mikologiya i Fitopatologiya (1975) 9 (6) 473-476. Permskii Pedagog. Inst., USSR.

0973 HAYMAN, D. S.; JOHNSON, A. M.; RUDDLESDIN, I. The influence of phosphate and crop species on endogone spores and vesicular-arbuscular mycorrhiza under field conditions. *Plant and Soil* (1975) 43 (2) 489-495 [En] Rothamsted Experimental Station, Harpenden, Herts., UK.

The numbers of Endogone spores (mainly of the laminate type) and the amount of vesicular-arbuscular (VA) mycorrhiza were examined in field soil given different phosphate treatments and planted with a rotation of potatoes, barley and swedes. Most spores usually occurred in barley and potato plots given intermediate amounts of phosphate, and there was most VA infection in barley and potato roots from plots given least phosphate. The effects of phosphate were much less marked than those reported for nitrogen under field conditions. Swede roots were not infected. In pot experiments swede seedlings inoculated with Endogone did not become mycorrhizal and they inhibited mycorrhizal development in seedlings of onion, which is normally a strongly mycorrhizal plant.

0974 KOSKE, R.E.; SUTTON, J.C.; SHEPPARD, B.R. 1975. Ecology of Endogone in Lake Huron sand dunes. Can. J. Bot. 53: 87-93

Grasses and herbs in the sand dunes of the eastern shores of Lake Huron were heavily colonized by the endomycorrhizal fungus Endogone. The fungus produced an extensive external mycelium in the dune sand. Numerous sand grains were firmly bound to the external mycelium, which was of structural importance in sand aggregates and was implicated as an important factor in dune stabilization. Sand aggregates constituted about 5 to 9% of the dry weight of sand collected from the surface 30 cm of the dunes. The weight of sand aggregates per kilogram of dune sand increased from 0.9 g to 25 g and 127 g after one and two crops, respectively, of mycorrhizal Phaseolus vulgaris L. grown in pots in a controlled environment. The increased aggregation was attributed largely to the binding of sand grains to a proliferated mycelium of Endogone. Organic fragments in the dune sand were colonized frequently by Endogone. Spores and spore-like bodies were numerous in many organic particles, which were sources of viable inoculum of Endogone. Five types of Endogone spores were found in the dune sand.

0975 KRUCKELMANN, H. W. Effects of fertilizers, soils, soil tillage, and plant species on the frequency of *Endogone* chlamydospores and mycorrhizal infection in arable soils. 511-525 [En, 11 ref.] Forschungsanstalt für Landwirtschaft, Braunschweig, German Federal Republic. *In:* Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp.

Chlamydospores of *Endogone* spp. were more frequent in loamy soils than in sandy ones. In a silty clay loam, most spores occurred in unfertilized plots and numbers were reduced by long-term fertilizer treatments; in a sandy soil the reverse was true. The total spore population was influenced by crop sp. and in pot experiments mycorrhizal infection ranged from 1 to 100% in 14 crop and 17 weed spp.

0976 REDHEAD, J.F. Endotrophic mycorrhizas in Nigeria: some aspects of the ecology of the endotrophic mycorrhizal association of *Khaya grandifoliola* c. dc. *In:* Endomycorrhizas (Ed. by F.E. Sanders, B. Mosse, and P.B. Tinker) Academic Press London pp. 447-459 (1975).

0977 SAIF, S. R.; KHAN, A. G. The influence of season and stage of development of plant on *Endogone* mycorrhiza of field-grown wheat. *Canadian Journal of Microbiology* (1975) 21 (7) 1020-1024 [En] Biology Department, University of Islamabad, Islamabad, Pakistan.

The number of *Endogone* spores in wheat field soil in Pakistan remained relatively unchanged in winter until January, during the period of vegetative growth and tillering of wheat plants. The spore number increased after the period of maximum root growth. The extent of mycorrhizal infection was related to the number of *Endogone* spores in soil. The extent of formation of arbuscules was influenced by the stage of development of the plants.

0978 SAIF, S.R.; SHEIKH, N.A.; KHAN, A.G. Ecology of Endogone. I-Relationship of Endogone spore population with physical soil factors. Islamabad, J. Science. 2(1):1-5. 1975.

In the present study, a qualitative and quantitative survey of different soil samples from different habitats of Pakistan for Endogone spore population was made and a attempt to correlate the variations in their frequency and in the frequency of different types with different physical soil factors was made. Soil samples examined yielded three types of spores namely, yellow vacuolate, red brown laminate and bulbous reticulate. Endogone spore number was larger in the upper layers of soil than in the lower. Loamy soils were rich with Endogone spores compared to sandy loam and loamy sand. Sandy soils contained least number of Endogone spores. Yellow vacuolate and red brown laminate spores were recovered most from loamy soils whereas bulbous reticulate spores were absent in loamy soils. A positive correlation between the Endogone spore population and the percentage of water holding capacity of that soil was established.

0979 SANDERS, F.E. The effect of foliar-applied phosphate on the mycorrhizal infections of onion roots. *In:* Endomycorrhizas (Ed. by F.E. Sanders, B. Mosse, and P.B. Tinker) Academic Press London. pp. 261-276 (1975).

0980 SCHENCK, N.C.; GRAHAM, S.O.; GREEN, N. E. Temperature and light effect on contamination and spore germination of vesicular-arbuscular mycorrhizal fungi. Mycologia (1975) 67(6) 1189-1192.

In tests with VA mycorrhizal fungi a wash. isolate of Glomus [Endogone.] mosseae gave max. spore germination at 20°C whereas in the Fla. isolates of Gigaspora [E] heterogama and G. [E] coralloidea this was at 34°. Spore germination of the latter 2 spp, was significantly better in the dark than in the light.
Spores of G. Heterogama did not germinate at 20°

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or less. The results corroborate earlier findings that Fla. isolates are adapted to higher temps.

0981 SHEIKH, N.A.; SAIF, S.R.; KHAN, A.G. Ecology of Endogone. II Relationship of Endogone spore population with chemical soil factors. Islamabad. J. Science 2(1): 6-9. 1975.
In the present study distribution of Endogone spores in soil was related to soil chemical factors. Acidic soils with the pH 6.2 contained greatest number of spores, the number being decreased with increase in pH. Loamy soils were mostly acidic as compared to sandy soils. No vertical correlation was found between pH and soil depth. Total phosphourus, available phosphorus, total nitrogen and organic matter content of soil showed a vertical gradient with regard to soil depth. Endogone spore number was not related to total phosphorus. Soils with less available phosphorus were rich in spore population. Endogone spore population was directly related to organic matter content of the soil and soil containing 1-2% organic organic matter contained maximum number of spores whereas spores were very rare in soils with organic matter content below 0.5%

0982 HAYMAN, D. S. **Plant growth responses to vesicular-arbuscular mycorrhiza. VI. Effect of light and temperature.** *New Phytologist* (1974) 73 (1) 71-80 [En, 27 ref., 3 pl.] Rothamsted Experimental Station, Harpenden, UK.

Light and temperature greatly influenced the development of vesicular-arbuscular mycorrhiza and growth of onions in a phosphate-deficient soil. There were more large arbuscules and host growth was stimulated more with 25 000 lx than with 13 000 lx at 23°C and in a 14-23° diurnal cycle. At 14° and 13 000 lx mycorrhiza caused no growth stimulation even in 3 low-phosphate soils. At 18° infection was much sparser in a 6-h daylength than in 12 and 18 h. Mycorrhizal plants kept in daylengths of 6 h at 13 000 lx were 3.5 times heavier than their non-inoculated controls. The effect of infection increased in longer daylengths and higher light intensities to 14.2 times the weight of controls with 18 h at 25 000 lx. The addition of soluble phosphate stimulated growth to the same extent as mycorrhizal inoculation did in the highest light conditions but phosphate stimulated growth more than did mycorrhiza under intermediate light conditions. The amounts of soluble carbohydrate, in the roots of plants given phosphate and in those that were mycorrhizal, did not differ significantly, but there was more soluble carbohydrate in plants growing in the most light. Plants both with and without mycorrhiza contained much glucose, fructose, sucrose and an unidentified sugar with a low R_F value, but there was no indication of fungal carbohydrates such as trehalose and mannitol.

0983 KHAN, A. G. and S. R. SAIF. (Dep. Biol., Univ. Islamabad, Islamabad, Pak.) The influence of season and stage of plant development on microorganisms associated with field-grown wheat mycorrhizae. J MATH SCI 1(2): 163-169. Illus. 1974. [In Engl.]--A quantitative and qualitative survey of microorganisms in a wheat-field soil and along the mycorrhizal wheat roots as influenced by stage of wheat development and season was conducted. Populations of fungi (Penicillium spp., Mucor spp., Alternaria spp., Phoma spp. and others) and others) and bacteria (Pseudomonas spp., Micrococcus spp. and others) were followed through the season. The microflora recovered from the rhizoplane was different from that of the wheat root balls. Endogone spore populations were also studied; vesicular arbuscular mycorrhiza development was profoundly affected by season and growth stage of the plant, microhabitat on plant roots and micropopulation of the soil.

*0984 MEJSTRIK, V. Ecology of mycorrhizae of tree species applied in reclamation of lignit spoil banks. Nova Hedwigia (1974) 22 (3/4):675-698. Land use Protection Inst., Ricany, Prague, Czechoslovakia.
With the exception of oak, max. mycorrhizal development occurred in autumn at a depth of 0-10 cm. On alder, poplar and oak, ectotrophic, endotrophic and ectendotrophic mycorrhizas were found; on birch ectotrophic and ectendrotrophic; on Tilia tomentosa ectotrophic and endotrophic and on ash and Sambucus racerosa only endotrophic mycorrhizas. Generally the thickness of the hyphal mantle of ectotrophic mycorrhizas diminished at a depth of 10-12 cm.

0985 SCHENCK, N. C.; SCHRODER, V. N. **Temperature response of *Endogone* mycorrhiza on soya bean roots.** *Mycologia* (1974) 66 (4) 600-605 [En] Florida University, Gainesville, 32611, USA.

Soya beans were grown in an autoclaved and untreated fine sand inoculated with *Endogone* sp. and maintained at soil temperatures of 17-41°C starting one week after seedling emergence. Maximum arbuscular development of *Endogone* in the roots occurred near 30°C. Mycelial development on the root surface was greatest at 28-34°C. Spores/50 ml of soil and echinulate vesicle clusters/55 cm of root were most numerous at 35°C with an abrupt decline in numbers above 35°C. Root growth after 60 days was less in uninoculated plants but shoot development was similar in both inoculated and uninoculated plants. No plant growth occurred at 41°C.

0986 SLANKIS, V. **Soil factors influencing formation of mycorrhizae.** *Annual Review of Phytopathology* (1974) 12, 437-457 [En] Ministry of Natural Resources, Forest Research Branch, Maple, Ontario, Canada.

A review with 169 references.

0987 FURLAN, V.; FORTIN, J.A. Formation of endomycorrhizae by Endogone calospora on Allium cepa under three temperature regimes. Naturaliste Canadien (1973) 100(5) 467-477.
The infection process in onion plants grown at 3 temps. and inoculated with the fungus followed a sigmoid curve which was affected by temp. throughout; the lag phase was shortest at the highest temp. (21/26°C, night/day) and longest at the lowest temp. (11/16°). The rate of infection was more rapid at 21/26° than at 16/26°; at 11/16° it was always very slow. The final level of infection, indicated by the plateau phase, was highest (82%) at 21/26°, 73% at 16/21° and 11% at 11/16°. Plant growth was strongly stimulated after infection at 21/26° and 16/21° but a significant parasitic decrease of growth could be observed on the 8th week at 11/16°. Spore production curves closely followed the growth curves of inoculated plants and final spore production/plant was 2600, 1800 and 50 for the 21/26°, 16/21 and 11/16° regimes, respectively.

0988 TRAPPE, J. M.; STAHLY, E. A.; BENSON, N. R.; DUFF, D. M. **Mycorrhizal deficiency of apple trees in high arsenic soils.** *HortScience* (1973) 8 (1) 52-53 [En, 17 ref.] USDA, Corvallis, Oregon.

Rootlets of apple trees growing in soil low in As and trees in As-toxic soil were compared for mycorrhizal development. Healthy trees had abundant, vigorous rootlets that were mostly intensely mycorrhizal. Stunted trees, in contrast, had moderately abundant but badly stunted rootlets that were sparsely mycorrhizal, and these symptoms were associated with high soil As content.

0989 BAYLIS, G.T.S. Minimum levels of available phosphorus for non-mycorrhizal plants. Plant & Soil 36:233-234. 1972.
In phosphorus-deficient soil an inverse relationship was established experimentally between the root-hair production of the species and the amount of phosphate that must be added to produce a significant increase in the dry weight of its seedlings when mycorrhizal fungi were excluded.

0990 MOSSE, B. **The influence of soil type and *Endogone* strain on the growth of mycorrhizal plants in phosphate deficient soils.** *Revue d'Écologie et de Biologie du Sol* (1972) 9 (3) 529-537 [En, fr] Rothamsted Experimental Station, Harpenden, UK.

Growth effects of 7 different strains of *Endogone* were compared on onion and *Paspalum notatum* test plants. The benefit of mycorrhizal infection varied greatly with the particular strain of *Endogone*, and the relative merit of a strain varied with soil type and liming. Of 3 *Endogone* strains tested on rye-grass in 5 soils with and without added lime, the establishment of 2 strains appeared to be pH dependent,

while the third strain became established in 2 soils only, irrespective of pH. The concept of specificity is discussed with reference to vesicular-arbuscular mycorrhizae; it is suggested that effects on plant growth may depend more on interactions between a fungal strain and the soil than between a fungal strain and its host.

*0991 MEDVE, R.J. Vesiculo-arbuscular mycorrhizas of the species in association *Molinietum coerulae*. I. The ecology of mycorrhizas. XV IUFRO Congress, Arpil, 1971. (Mimeo).

0992 MOSSE, BARBARA and J. M. PHILLIPS. (Rothamsted Exp. Stn., Harpenden, Herts., Engl., UK.) The influence of phosphate and other nutrients on the development of vesicular-arbuscular mycorrhiza in culture. J GEN MICROBIOL 69(2): 157-166. Illus. 1971[recd. 1972].--Vesicular-arbuscular mycorrhiza were established in Trifolium parviflorum in culture by inoculation with Endogone spores. In a medium containing 265 mg P/l as $CaHPO_4$ and K_2HPO_4, infection occurred only when the medium lacked N. In a medium containing only 100 mg P/l, infection occurred readily in the presence of 0.5 g KNO_3/l. Ca monohydrogen phosphate, Ca phytate, Na phytate, Fe phytate, phytin, lecithin and DNA were adequate sources of phosphate for both plant and fungus. Ca phytate and DNA greatly stimulated fungal growth, and DNA also stimulated spore formation, in the agar medium. With Na in the medium infections in the root were sparse. Inositol may serve as a C source for Endogone. Mycorrhizal infection occurred with either $FeCl_3$ or Fe-EDTA in the medium; when so little Fe was present that plants grew poorly, there was also little mycorrhizal infection.

*0993 HAYMAN, D.S. *Endogone* in Great Field IV soil under arable cultivation. The effects of light intensity on VA-mycorrhiza. *In*: Rothamsted Exp. Sta. Report 1972:79, 81. 1973.

0994 HAYMAN, D. S. 1970. *Endogone* spore numbers in soil and vesicular-arbuscular mycorrhiza in wheat as influenced by season and soil treatment. *Trans. br. mycol. Soc.* 54, 53-63. [Rothamsted Exp. Stn, Harpenden, England]

Endogone spores were more numerous in wheat plots (some partially sterilized with formalin) that received no fertilizers ($Ca(NO_3)_2$ and/or basal PK) than in fertilized plots; mycorrhizal infection increased during the summer to a peak in September and was most abundant in plots that contained the most *Endogone* spores.

*0995 HAYMAN, D.S. Influence of daylenght and light intensity on *Endogone* mycorrhizae. Rothamsted Exp. Sta. Report 1970 (Part 1):89. 1971.

*0996 HAYMAN, D.S. Influence of temperatures and light intensity on *Endogone* mycorrhiza. Rothamsted Exp. Sta. Report 1969 (Part 1):97. 1970.

0997 HUSSEY, R. S.; RONCADORI, R. W. **Vesicular-arbuscular mycorrhizae may limit nematode activity and improve plant growth.** *Plant Disease* (1982) 66 (1) 9-14 [En, 8 ref., 5 col. fig., 2 tab.] Univ. Georgia, Athens, USA.

The interaction between nematodes and VA mycorrhizal fungi is described and discussed.

0998 GRAHAM, J. H.; MENGE, J. A. **Influence of vesicular-arbuscular mycorrhizae and soil phosphorus on take-all disease of wheat.** *Phytopathology* (1982) 72 (1) 95-98 [En, 22 ref., 3 tab.] Univ. California, Riverside, USA.

Wheat grown for 4 weeks in P-deficient sandy soil (0.5 μg P/g soil) had significantly greater levels of root P as a result of the addition of 50 μg P/g soil or inoculation with *Glomus fasciculatus*. For plants growing in P-deficient soil, the formation of high levels (> 70% root colonization) of vesicular-arbuscular mycorrhizae (VAM) increased root P content nearly to the level of P-amended plants, whereas 50 μg P/g soil severely inhibited VAM formation (< 10%). Root exudation of amino acids and reducing sugars, which was lower in heavily mycorrhizal and P-treated plants than the untreated controls, was inversely correlated with root P content. When 4-week-old plants of each P-VAM treatment combination were inoculated with *Gaeumannomyces graminis* var. *tritici* at 2 inoculum levels, P-deficient nonmycorrhizal plants developed more take-all at the high inoculum level (0.5% w/w, g of oat kernel inoculum/g soil) than at the low inoculum level (0.1%). By comparison, P-treated plants developed fewer take-all symptoms, irrespective of inoculum density or presence of low levels of mycorrhizal infection. High levels of VAM infection in plants grown in P-deficient soil significantly decreased take-all at the low inoculum level only. The decrease in disease severity in P and VAM treatments was not a result of significant increases in root growth but was apparently related to improved root P status and decreased root exudation prior to pathogen inoculation. The influence of soil P and mycorrhizae on take-all disease appears to be the same; these factors increase the P status of the host, which leads to a decrease in net leakage of root exudates and thereby reduces pathogen activity.

0999 DEHNE, H. W. **Interaction between vesicular-arbuscular mycorrhizal fungi and plant pathogens.** *Phytopathology* (1982) 72 (8) 1115-1119 [En, 45 ref.] Institut für Pflanzenkrankheiten und Pflanzenschutz, Universität Hannover, 3000 Hannover 21, German Federal Republic.

The influence of vesicular-arbuscular mycorrhizae on plant pathogens infecting tobacco, tomato, cotton, soyabean and other crops is discussed. Papers on the subject are tabulated with the relevant crops named. Instances of vesicular-arbuscular mycorrhizae reducing infection by pathogens or increasing crop yields are given.

*1000 CHENG, Y. H.; TU, C. C. [Investigation of endomycorrhizal fungi and their relation with parasitic nematodes on soybean.] *Research Bulletin Tainan District Agricultural Improvement Station* (1982) No. 16, 45-59 [Ch, en, 22 ref., 8 fig., 3 tab.] Agric. Improvement Sta., Tainan, Taiwan.

Of fungi isolated from soybean roots and rhizosphere *Glomus clarus* was the most common, followed by *Acaulospora laevis*, *Gigaspora margarita*, *Glomus mosseae* and *G. macrocarpus*. Inoculation of soybean with chlamydospores of *G. clarus* significantly increased top growth and pod production.

1001 KRISHNA, K. R.; BALAKRISHNA, A. N.; BAGYARAJ, D. J. **Interaction between a vesicular-arbuscular mycorrhizal fungus and *Streptomyces cinnamomeous* and their effects on finger millet.** *New Phytologist* (1982) 92 (3) 401-405 [En, 18 ref., 2 tab.] Univ. Agric. Sci., G.K.V.K. Campus, Bangalore, India.

Growth and P nutrition of *Eleusine coracana* on a sterile P-deficient soil was improved by inoculation with either *Glomus fasciculatus* or *S. cinnamomeous*. The micro-organisms interacted antagonistically when added simultaneously or with a 2-wk interval between them: *S.* reduced spore production and development of infection by *G.* while *G.* reduced the multiplication of *S.* Because of this antagonism dual inoculations stimulated plant growth less than single ones.

1002 MENGE, J. A. **Effect of soil fumigants and fungicides on vesicular-arbuscular fungi.** *Phytopathology* (1982) 72 (8) 1125-1132 [En, 65 ref.] Dep. of Pl. Path., California Univ., Riverside, CA 92521, USA.

The stunting of growth in cotton, soyabean and white clover and in horticultural and forestry spp. by soil fumigation is discussed; it was considered to be caused by the absence of vesicular-arbuscular mycorrhizae. The effects of soil fumigants on mycorrhizal infection are tabulated for many crop spp.

1003 NEMEC, S. **Aspects of vesicular-arbuscular mycorrhizae in plant disease research.** *Phytopathology* (1982) 72 (8) 1102 [En] USDA, Orlando, Fla., USA.

A brief introduction is presented to the 5 other papers in this symposium on aspects of VA mycorrhizae and plant disease research at the 73rd annual meeting of the American Phytopath. Soc., New Orleans, La., on 4 Aug. 1981.

1004 POWELL, C.Ll. Effects of kale and mustard crops on response of white clover to VA mycorrhizal inoculation in pot trials. New Zealand Journal of Agricultural Research, 1982. Vol. 25:461-464.

White clover seed was coated with 3 VA mycorrhizal soil inocula and a control (non-mycorrhizal) inoculum and sown onto 2 soils in pot trials which had been pre-cropped with kale or mustard or left fallow. Pre-cropping decreased clover yield in both soils and increased the clover growth response to mycorrhizal inoculation in one soil.

1005 SCHWAB, S. M.; JOHNSON, E. L. V.; MENGE, J. A. **Influence of simazine on formation of vesicular-arbuscular mycorrhizae in *Chenopodium quinoa* Willd.** *Plant and Soil* (1982) 64 (2) 283-287 [En, 14 ref., 1 pl., 2 tab.] Univ. California, Riverside, USA.

Low levels of mycorrhizal formation were found when plants of this normally non-mycorrhizal sp. [*C. quinoa*] were sprayed with sublethal doses of the herbicide. Exudation of sugars and amino acids from the roots was also increased, and this may be responsible for the unusual formation of mycorrhiza.

1006 STROBEL, N. E.; HUSSEY, R. S.; RONCADORI, R. W. **Interactions of vesicular-arbuscular mycorrhizal fungi, *Meloidogyne incognita*, and soil fertility on peach.** *Phytopathology* (1982) 72 (6) 690-694 [En, 20 ref., 3 fig., 4 tab.] Univ. Georgia, Athens, USA.

Growth of Lovell peach trees infected with *M. incognita*, or free from the nematode, was enhanced by *Gigaspora margarita* and *Glomus etunicatus* in some glasshouse tests, but not in others. Beneficial effects of the mycorrhizal fungi on growth were accompanied by improved foliar P, Cu and Zn status and were greater on nematode free plants grown in soil with 500 μg than in one containing 1000 μg 10-10-10 NPK/g soil. *G. margarita* suppressed reproduction of *M. incognita* only in tests where the fungus improved plant growth; however *G. etunicatus* had no effect on nematode reproduction in either case. Sporulation of the fungi was not significantly affected by the nematode. In split-root studies *G. margarita* suppressed nematode reproduction, and the nematode was injurious to growth of mycorrhizal plants only if both micro-organisms occupied the same half-root system.

1007 WARNOCK, A. J.; FITTER, A. H.; USHER, M. B. **The influence of a springtail *Folsomia candida* (Insecta, Collembola) on the mycorrhizal association of leek *Allium porrum* and the vesicular-arbuscular mycorrhizal endophyte *Glomus fasciculatus*.** *New Phytologist* (1982) 90 (2) 285-292 [En, 21 ref., 3 tab.] Woodbridge Sch., Suffolk, UK.

In a factorial experiment the growth of leek seedlings was increased by mycorrhizal infection and, to a lesser extent, by the addition of soil leachings, but reduced by *F. candida*. There was a strong interaction between the effects of mycorrhizal infection and the presence of *F. candida*, since infected plants in pots with *F. candida* grew little better than uninfected plants. The evidence suggested that this was due to grazing of the external hyphae of *G. fasciculatus*, so rendering the infection ineffective.

*1008 WICK, R.L.; MOORE, L.D. Interaction of endomycorrhizae and Thielaviopsis basicola

black root disease of japanese holly. Phytopathology 72(6): 712, 1982. Abst.

An histological study was undertaken to determine if Glomus mosseae or a mixed population (MP) of holly rhizosphere endomycorrhizal fungi altered the host-parasite interactions of T. basicola black root disease of Japanese holly. Mycorrhizal and non-mycorrhizal plants were inoculated with T. basicola and examined over time. Periderm formation in response to T. basicola colonization was considered a measure of resistance. Thielaviopsis basicola was not excluded from host cells previously colonized by G. mosseae or MP fungi. No correlation was found between incidence of mycorrhizae and incidence of periderm formation in individual roots. However, when incidence of periderm formation in roots was averaged for individual plants, the G. mosseae, but not the MP treatment, was found to compartmentalize T. basicola at a faster rate than the non-mycorrhizal control. This suggested that the G. mosseae-induced increased resistance was due to enhanced host vigor as opposed to a direct effect by the mycorrhizal fungi.

1009 ATILANO, R. A.; MENGE, J. A.; GUNDY. S. D. VAN **Interaction between *Meloidogyne arenaria* and *Glomus fasciculatus* in grape.** *Journal of Nematology* (1981) 13 (1) 52-57 [En, 25 ref.] Departments of Nematology and Plant Pathology, University of California, Riverside, CA 92521, USA.

Root zones of grape (*Vitis vinifera* cv Thompson Seedless) cuttings were infested with chlamydospores of *Glomus fasciculatus* or eggs of *Meloidogyne arenaria* or both. Growth of grapevines was greatest in mycorrhizal (*G. fasciculatus*) plants. Mycorrhizal development and growth of mycorrhizal and nonmycorrhizal plants were reduced in the presence of *M. arenaria*. At low initial nematode inoculum (PI) levels (approx. 200 eggs/plant), the presence of mycorrhizae enhanced plant growth during 1 yr, but no significant benefit was achieved by mycorrhizae where PI was high (approx. 2,000 eggs/plant). Final nematode populations were highest in mycorrhizal plants.

*1010 BARKLUND, P. 1981. {Mycorrhiza protect against root pathogens.} Mycorrhiza ger skydd mot rotpatogenes (a review). Vaxtskyddsnotiser 45(2):73-79 (1981).

1011 BARTSCHI, H.; GIANINAZZI-PEARSON, V.; VEGH, I. **Vesicular-arbuscular mycorrhiza formation and root rot disease (*Phytophthora cinnamomi*) development in *Chamaecyparis lawsoniana*.** *Phytopathologische Zeitschrift* (1981) 102 (3/4) 213-218 [En, de, 14 ref., 3 fig.] Univ. Claude-Bernard, Lyon, France.

Different isolates of mycorrhizal fungi did not provide equal protection against the pathogen. A natural mixed population markedly reduced rot development while *Glomus mosseae* alone only delayed the onset of the disease. Good mycorrhizal establishment was important for protection.

1012 DANIELS, B.A. The influence of hyperparasites of vesicular-arbuscular mycorrhizal fungi on growth of citrus. Phytopathology 71(2): 212-213. 1981.

Three hyperparasites of vesicular-arbuscular mycorrhizal fungi (VAMF) (Anguillospora pseudolongissima, Humicola fuscoatra, and Phlyctochytrium sp.) were added separately to citrus plants inoculated with either Glomus fasciculatus isolate 0-1 G. fasciculatus isolate 92, and G. epigaeus. The possibility that these hyperparasites could be chemically controlled was tested by applying Ethazole and Mancozeb. After 7 months VAMF inoculated plants were significally larger than noninoculated controls and contained high levels of root infection (70-90%) G. fasciculatus isolate 92 and G. epigaeus appeared resistant to the 3 hyperparasites. Alternatively, all hyperparasites appeared to inhibit infection and growth response provided by G. fasciculatus 0-1. Application of Mancozeb and Ethazole did not result in increased infection by G. fasciculatus 0-1 in pots infested with any hyperparasite.

1013 DAVIS, R.M.; MENGE, J.A.; Phytophthora parasitica inoculation and intensity of vesicular-arbuscular mycorrhizae in citrus. New Phytol. (1981) 87, 705-715.

Shoot weights, root weights, and percentages of healthy roots of mycorrhizal (Glomus fasciculatus) sweet orange inoculated with Phytophthora parasitica (20 or 50 chlamydospores g-1 soil) were greater than those of non-mycorrhizal seedlings at either inoculum density. However, the growth response to mycorrhizal infection was reduced 23 and 58% by inoculation with 20 and 50 chlamydospores per g soil, respectively. Mycorrhizal infection was not reduced by P. parasitica at 20 chlamydospores per g soil, but was reduce 72% in seedlings inoculated with 50 chlamydospores per g soil. The latter also reduced the phosphorus content of the leaves. Tests with seven mycorrhizal fungi on two citrus rootstocks showed that different VA infections might confer variable tolerance or resistance to P. parasitica. Two fungi, Glomus mosseae and Gigaspora margarita not isolated from nor as nutritionally efficient as other on citrus, conferred tolerance or resistance.

*1014 GERMANI, G.; OLLIVIER, B.; DIEM, H. G. **Interaction of *Scutellonema cavenessi* and *Glomus mosseae* on growth and N_2 fixation of soybean.** *Revue de Nématologie* (1981) 4 (2) 277-280 [En, fr, 25 ref.] Laboratoire de Nématologie, ORSTOM, B.P. 1386, Dakar, Senegal.

The influence of a parasitic nematode (*Scutellonema cavenessi*) and a vesicular arbuscular mycorrhiza (*Glomus mosseae*) alone or in combination on growth and N_2 fixation of one cultivar of soybean (44 A73) was studied in the greenhouse. In combined inoculations of soybean with *G. mosseae* and *S. cavenessi*, development of mycorrhizae nullified the stunting and the reduction of N_2 fixation caused by the nematode. Growth and N_2 fixation of mycorrhizal plants were greater than that of non mycorrhizal plants.

*1015 GRAHAM, J.H. Influence of vesicular-arbuscular mycorrhizae and soil phosphorus on take-all disease of wheat, Phytopathology 71(8): 877. 1981. Abstr.

The influence of soil P and vesicular-arbuscular mycorrhizae (VAM) on take-all disease of wheat appears to be the same in P deficient soil (0.5 ppm P, pH 8.2), i.e., these factors increase root P content leading to a decrease in root exudation which reduces pathogen activity. For plants grown in P-deficient soil, the formation of high levels of VAM (>70%) by Glomus fasciculatus increased root P content nearly to the level of P-treated plants, whereas 50 ppm soil P severely inhibited VAM formation (10%). Root exudation of amino acids and reducing sugars, which was lower in heavily mycorrhizal and P-treated plants than untreated controls, was correlated with root P content. When plants of each P-VAM treatment combination were inoculated with Gaeumannomyces graminis var. tritici, the P-treated plants and mycorrhizal plants grown in P-deficient soil develop less take-all than the untreated controls.

1016 HUSSEY, R. S.; RONCADORI, R. W. **Influence of *Aphelenchus avenae* on vesicular-arbuscular endomycorrhizal growth response in cotton.** *Journal of Nematology* (1981) 13 (1) 48-52 [En, 17 ref.] Department of Plant Pathology and Plant Genetics, University of Georgia, Athens, GA 30602, USA.

The influence of *Aphelenchus avenae* on the relationship between cotton (*Gossypium hirsutum* 'Stoneville 213') and *Gigaspora margarita* or *Glomus etunicatus* was assessed by its effect on the mycorrhizal stimulation of plant growth and microorganism reproduction. The mycophagous nematode usually did not suppress stimulation of shoot growth resulting from mycorrhizae (*G. margarita*) at inoculum levels of 3,000 or 6,000 nematodes per pot, but retarded root growth at 6,000 per pot. When the nematode inoculum was increased to 10, 40, or 80 thousand, *G. margarita* stimulation of shoot or root growth was retarded at the two higher rates. Shoot

*1017 JALALI, B. L.; THAREJA, M. L. **Suppression of *Fusarium* wilt of chickpea in vesicular-arbuscular**

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mycorrhizal-inoculated soils. *International Chickpea Newsletter* (1981) No. 4, 21-22 [En, 2 fig., 2 tab.] Haryana Agric. Univ., Hissar, India.

Inoculation of pot-grown *Cicer arietinum* plants with VA mycorrhiza resulted in extensive root colonization by the endophyte and an accompanying reduction in the incidence of wilt caused by *F. oxysporum* f.sp. *ciceri* (26.6% in mycorrhizal plants, 80% in non-mycorrhizal).

*1018 LEE, KYUNG JOON, CHANG DUCK KOO; SUK KOO LEE, Res Rep. Inst. for Genet. 0(17):104-116 1981. In Korean with Korean and Engl. summ.] Defense mechanisms of mycorrhizal roots against soil pathogens: A review.

1019 MANJUNATH, A.; MOHAN, R.; BAGYARAJ, D. J. **Interaction between *Beijerinckia mobilis, Aspergillus niger* and *Glomus fasciculatus* and their effects on growth of onion.** *New Phytologist* (1981) 87 (4) 723-727 [En, 9 ref., 5 tab.] Univ. Agric. Sci., Bangalore, India.

Inoculation with *G. fasciculatus* or *B. mobilis* increased the dry wt. and N content of the plant; *A. niger* had no significant effect. *B. mobilis* stimulated sporulation by VA mycorrhizae. A beneficial synergistic effect was observed after combined inoculation with all 3 organisms.

*1020 McGRAW, A.-C.; SCHENCK, N.C. Effects of 2 species of vesicular-arbuscular mycorrhizal fungi on the development of *Fusarium* wilt of tomato. Phytopathology 71(8):894. 1981. Abstr.
In greenhouse experiments, mycorrhizar or nonmycorrhizal tomato (cv Manapal) seedlings or uninoculated seeds were planted into pots containing infested or uninfested autoclaved field soil (available phosphorus = 34-45 µg/g). Treatments having infested soil contained chlamydospores of either *Glomus etunicatus* or *G. mosseae* at 0.1, 0.5, or 1.0 propagule per gram of soil (ppg) and/or of *Fusarium oxysporum* f. sp. *lycopersici* race 2 at 500 ppg. Mycorrhizal *Fusarium*-inoculated plants exhibited earlier onset of chlorosis and wilt than nonmycorrhizal *Fusarium*-inoculated plants, regardless of inoculum level or species of mycorrhizal fungus. Similar results were obtained whether seedlings or seeds were used. These results indicate that mycorrhizal fungi can enhance the development of *Fusarium* wilt of tomato.

1021 OCAMPO, J. A.; HAYMAN, D. S. **Influence of plant interactions on vesicular-arbuscular mycorrhizal infections II. Crop rotations and residual effects of non-host plants.** *New Phytologist* (1981) 87 (2) 333-343 [En, 8 ref., 8 tab. See *RPP 59*, 3606] Rothamsted Exp. Sta., Harpenden, Herts., UK.

The effects of rotation on mycorrhizal development were examined in pot tests using sterilized soil inoculated with *Glomus fasciculatus* 'E3' or *Gigaspora margarita*, or unsterile soil containing mainly a type of *Glomus macrocarpus* var. *geosporus*. In 4 crop pairs the amount of VA mycorrhizal infection in a host plant was not reduced in soil previously cropped with a non-host plant, even where roots of the preceding non-host plant were retained intact in the soil. In fact the early establishment of VA infection in barley, lettuce and maize inoculated in sterilized soil was stimulated by the non-hosts oilseed rape, cabbage and sugar beet, respectively. VA hyphae were sometimes observed growing in moribund non-host roots. Effects of crop rotation in unsterile soil were

1022 POPE, P. E.; HOLT, H. A. **Paraquat influences development and efficacy of the mycorrhizal fungus *Glomus fasciculatus*.** *Canadian Journal of Botany* (1981) 59 (4) 518-521 [En, fr, 14 ref., 1 fig., 1 tab.] Purdue Univ., West Lafayette, Ind., USA.

Paraquat at 2 kg/ha reduced the amount of mycorrhizal hyphae and number of vesicles and chlamydospores formed by *G. fasciculatus* when compared with the control or the 0.5 kg/ha paraquat treatment. When compared with the inoculated control, paraquat at 0.5 kg tended to increase the amount of mycorrhizal hyphae and chlamydospore production. For noninoculated white ash (*Fraxinus americana*) seedlings, total dry wt. and stem height tended to decrease with increases in rates of paraquat applied. In contrast, seedling height and foliar P conc. of inoculated seedlings were greatest for the 0.5 kg paraquat treatment followed by the control and the 2 kg treatment. The amount of mycorrhizal hyphae was correlated to seedling height and diam., total dry wt. and percentage foliar elemental P.

1023 RAJ, J.; BAGYARAJ, D. J.; MANJUNATH, A. **Influence of soil inoculation with vesicular-arbuscular mycorrhiza and a phosphate-dissolving bacterium on plant growth and ^{32}P-uptake.** *Soil Biology & Biochemistry* (1981) 13 (2) 105-108 [En, 12 ref.] Department of Agricultural Microbiology, University of Agricultural Sciences, Bangalore-560065, India.

The influence of inoculation of soil with a vesicular-arbuscular mycorrhizal fungus (*Glomus fasciculatus*) and a phosphate-dissolving bacterium (*Bacillus circulans*) on phosphate solubilization, growth of finger millet (*Eleusine coracana*) and phosphorus uptake from ^{32}P-labelled tricalcium phosphate and superphosphate were studied. The mycorrhizal plants produced more dry matter and removed more ^{32}P from the soil than non-mycorrhizal plants, but did not show increased ^{32}P activity per unit plant mass. The 30 mM NH_4F-HCl extractable ^{32}P (available ^{32}P) in soil, plant ^{32}P activity and total P uptake were enhanced by soil inoculation with the bacterium. In the treatment receiving both inocula a synergistic effect increased P uptake.

*1024 REDDY, M.V., SHARMA, G.D. Some observations on an aphid-mycorrhizal association. SCI. CULT. vol.47, no.9, 1981, pp.339-340. En.
In a survey of mycorrhizal fungi in a subtropical deciduous forest ecosystem near burnihat (Meghalaya) in the lower Khasi Hills, north-eastern India (altitude Ca. 100m MSL, E. 91°51' longitude, N. 26°0' latitude, aphids (Tetraneura sp.) were observed to be associated with mycorrhiza were of Imperata cylindrica var. major (Gramineae); and early colonizer after natural forest burning. The mycorrhiza were of vesicular arbuscular type. The aphids were seen feeding on mycorrhizal roots of the grass. Five to seven aphids were recorded in each colony, out of which three to four were in their developmental stages. All were apterous forms. Nothing was clear about the extent of damage to mycorrhiza caused by these aphids although some differences were noted between the mycorrhizal-roots with and without aphids. These were in the nature of mechanical injuries to fungal mycelium in the former case.

1025 RHODES, L. H.; LARSEN, P. O. **Effects of fungicides on mycorrhizal development of creeping bentgrass.** *Plant Disease* (1981) 65 (2) 145-147 [En, 10 ref., 2 tab.] Ohio State Univ. & Agric. Res. & Development Cent., Columbus, USA.

Chlorothalonil, benomyl and iprodione reduced mycorrhizal development of *Agrostis palustris* when applied in the spring to golf course greens or 4-8 weeks after seeding and inoculation with *Glomus fasciculatus* in the glasshouse. Other fungicides which caused significant reduction in the glasshouse included pentachloronitrobenzene [quintozene], triadimefon, anilazine and chloroneb. Fungicides applied 16-20 weeks after seeding in the glasshouse had no such effect. Results indicated that spring application of several turf fungicides may reduce mycorrhizal development in *A. palustris* turf.

1026 SCHENCK, N. C. **Can mycorrhizae control root disease?** *Plant Disease* (1981) 65 (3) 230-234 [En, 14 ref.] University of Florida, Gainesville, USA.

The responses of various hosts and pathogens to mycorrhizal fungi are indicated. In some cases mycorrhizal fungi can significantly reduce the effects of certain pathogens on their hosts. The mode of action and problems in the usage of these fungi in agriculture are discussed.

*1027 SMITH, T. F.; NOACK, A. J.; COSH, S. M. **The effect of some herbicides on vesicular-arbuscular endophyte abundance in the soil and on infection of host roots.** *Pesticide Science* (1981) 12 (1) 91-97 [En, 12 ref.] Muresk Agric. Coll., Northam, W. Australia.

The effect of di-allate, diquat, diuron, paraquat, tri-allate and trifluralin, at a range of application rates from 0.5 to 32 times that recommended by the manufacturers, on vesicular-

arbuscular (V-A) endophyte spore abundance in the soil and on infection of wheat roots was investigated in field and glasshouse experiments. Paraquate and diquat had no measurable effect on V-A endophyte spore abundance. There was a slight trend to lower V-A endophyte spore numbers at high rates of di-allate and tri-allate but no trend for the other chemicals. Infection intensity (% root length infected) declined at high rates of di-allate and led to lower mycorrhizal root weights. The phosphorus content of the shoots was also reduced by di-allate. High rates of di-allate, diuron, tri-allate and trifluralin reduced most parameters of plant growth more than mycorrhizal parameters. It is therefore concluded that at normal application rates these chemicals are unlikely to affect adversely endomycorrhiza formation or function.

*1028 SPOKES, J. R.; MACDONALD, R. M.; HAYMAN, D. S. Effects of plant protection chemicals on vesicular-arbuscular mycorrhizas. *Pesticide Science* (1981) 12 (3) 346-350 [En, 15 ref.] Soil Microbiology Department, Rothamsted Experimental Station, Harpenden, Herts. AL5 2JQ, UK.

In field and glasshouse experiments the effects of eight plant protection chemicals on the development of vesicular-arbuscular mycorrhizas were influenced by the identity of the host plant and fungal endophyte, the soil type and the composition and concentration of the biocide. These effects ranged from stimulatory (as with the fungicide chloroneb, applied to inocula of *Glomus microcarpus* used with pot grown lettuce), through negligible (aldicarb on *G. mosseae* in pot-grown onions and field grown barley with indigenous mycorrhizal fungi) to short-term inhibition (drazoxolon on *G. mosseae* in onion) and longer term inhibition (the fungicides benomyl and triadimefon on *G. mosseae* in onion). Chlorfenvinphos and chlortoluron reduced mycorrhizal infection of field grown barley, and of pot grown onions inoculated with *G. mosseae*. Effects of etridiazole on lettuce infection were small.

1029 STANTON, N. L.; ALLEN, M.; CAMPION, M. **The effect of the pesticide carbofuran on soil organisms and root and shoot production in shortgrass prairie.** *Journal of Applied Ecology* (1981) 18 (2) 417-431 [En, 39 ref.] Department of Zoology and Physiology, University of Wyoming, Laramie, WY 82071, USA.

Carbofuran was applied once in each of two successive years at 12 lb active ingredient/acre to plots of undisturbed prairie in northeastern Colorado. Bacterial-feeding and phytophagous nematodes were reduced to 10% of the density on untreated plots, but micro- and macro-arthropods were unaffected. Species composition of the fungal flora of the treated soil was greatly changed and colony counts reduced, but incidence of mycorrhizae was unaffected. Although root weight measured in the autumn was significantly greater under treated plots (by 130-150 g m^{-2} and about 25% of net primary production) shoot production was not, possibly due to below average summer rainfall in both years. The results suggest that nematodes may be the most significant consumer in shortgrass prairies.

1030 THOMSON, K. M. and R. S. HUSSEY. (Dep. Plant Pathol., Univ. Georgia, Athens, GA 30602.) 20th Annual Meeting of the Society of Nematologists, Seattle, Wash., USA. Aug. 16-19, 1981. J NEMATOL 13(4): 462. 1981. **Influence of vesicular-arbuscular mycorrhizae and phosphorus on root-knot on tomato.**

*1031 ZAMBOLIM, L.; SCHENCK, N.C. Effect of root rot fungi and vesicular-arbuscular mycorrhizae on the establishment of Rhizobium japonicum on nodulated and nonnodulated hardee soybeans. 72nd Annual Meeting of the American Phytopathological Society and the Canadian Phytopathological Society, Aug. 24-28 1980. Phytopathology 71(2) 267. 1981. Abstract.

The effect of Glomus mosseae (Gm) at 500 chlamydospores/pot on Rhizobium japonicum (Rj) at 0.5% of seed weight, in the presence of Macrophomina phaseolina (Mp) at 40 sclerotia, Rhizoctonia solani (Rs) at 1 sclerotium and Fusarium solani (Fs) at 3.000 chlamydospores/g of soil, respectively, was studeied in autoclaved soil (91.6 ppm P and pH 6.8) in a greenhouse. Root weight was significantly reduced by Mp, Rs and Fs. When Gm was added root, shoot weight and plant height were increased. The number and weight of nodules were greatly reduced by Mp, Rs and Fs but increased considerably in the presence of Gm. The percentage of roots colonized by Gm was reduced by Mp, Rs and Fs but Gm did not affect the severity of the disease. Total nutrients absorbed by shoots were reduced by Mp and significantly increased by Gm. Growth response to Gm was the same on nodulated and non-nodulated plants indicating that Rj did not have a significant effect.

1032 BARADAS, S.N.; HALOS, P.M. Selection of mycorrhizal isolates for biological control of *Fusarium solani* f. sp. *phaseoli* on *Vigna unguiculata*. *In*: Tropical Mycorrhiza Research (Ed. by P. Mikola) Oxford Univ. Press Oxford, England. pp.247-248 (1980).

1033 DANIELS, B. A.; MENGE, J. A. **Hyperparasitization of vesicular-arbuscular mycorrhizal fungi.** *Phytopathology* (1980) 70 (7) 584-588 [En, 15 ref., 4 fig., 4 tab.] Univ. California, Riverside, USA.

Sporocarps of *Glomus epigaeus* and *G. fasciculatus* often contain hyperparasitized spores even when produced in glasshouse pot cultures. Two of these hyperparasites were isolated on agar media and identified as *Anquillospora pseudolongissima* and *Humicola fuscoatra*. *Glomus* spores parasitized by *A. pseudolongissima* contained swollen, sausage-shaped hyphae, constricted at the septa, while those parasitized by *H. fuscoatra* contained slender hyphae and/or aleurospores. *G. epigaeus* spores (visibly free from parasites) when added to water agar or autoclaved soil containing *A. pseudolongissima* became 51.4 and 69.3% parasitized, respectively, while *H. fuscoatra* parasitized 48.2 and 70.9%, respectively. Similarly *G. fasciculatus* became 67.1 and 94.6% parasitized by *A. pseudolongissima* and 56.8 and 91.2% parasitized by *H. fuscoatra*, respectively. Control spores of *G. fasciculatus* or *G. epigaeus* in either soil or on agar without parasitic fungi were only 1.3-3% parasitized. Of 9 fungicides only mancozeb reduced growth of both hyperparasites without inhibiting the germination of mycorrhizal fungi. A third hyperparasite, identified as a *Phlyctochytrium* sp., was isolated from *G. fasciculatus* sporocarps and propagated in sterile pond water on *Gigaspora margarita* spores or pollen of a *Liquidambar* sp. Parasitism by this fungus was nearly eliminated by adding ethazole to the culture water.

1034 DAVIS, R. M.; MENGE, J. A. **Influence of *Glomus fasciculatus* and soil phosphorus on phytophthora root rot of citrus.** *Phytopathology* (1980) 70 (5) 447-452 [En, 17 ref., 1 pl.] Texas A & I University Citrus Center, Weslaco, Texas 78596, USA.

In soil fertilized with less than 15 mg P/g soil roots of sweet orange seedlings infected with *Phytophthora [nicotianae* var.] *parasitica* and the mycorrhizal fungus *Glomus fasciculatus* were healthier and weighed more than roots infected with *P. parasitica* alone. However, the beneficial effect of *G. fasciculatus* was eliminated by *P. parasitica* infection in mycorrhizal seedlings fertilized with more than 56 mg P/g soil. It is suggested that tolerance to *P. parasitica* root rot in citrus infected with *G. fasciculatus* results from the ability of mycorrhizal roots to absorb more phosphorus and possibly other minerals than nonmycorrhizal roots.

1035 DAVIS, R. M. **Influence of *Glomus fasciculatus* on *Thielaviopsis basicola* root rot of citrus.** *Plant Disease* (1980) 64 (9) 839-840 [En, 12 ref., 1 pl.] Texas A & I University Citrus Center, Weslaco 78596, USA.

Sweet orange seedlings, cv. Pineapple, were inoculated with *G. fasciculatus* alone, *T. basicola* alone, both fungi, or neither fungus. Seedlings infected with the vesicular-arbuscular mycorrhizal fungus, *G. fasciculatus*, were larger than nonmycorrhizal seedlings. Growth of both mycorrhizal and nonmycorrhizal seedlings was reduced (by about 37%) by *T. basicola*, but mycorrhizal seedlings were larger. *G. fasciculatus* apparently had little influence on the root disease caused by *T. basicola*.

1036 GERMANI, G.; DIEM, H.G.; DOMMERGUES, Y.R. Influence of 1, 2-dibromo-3-chloro-propane (DBCP) fumigation on mycorrhizal infection of field-grown groundnut. *In*: Tropical Mycorrhiza Research (Ed. by P. Mikola) Oxford Univ. Press Oxford, England. pp.245-246 (1980).

*1037 GERMANI, G.; DIEM, H. G.; DOMMERGUES, Y. R. **Influence of 1,2 dibromo-3-chloropropane fumigation on nematode population, mycorrhizal infection, N_2 fixation and yield of field-grown groundnut.** *Revue de Nématologie* (1980) 3 (1) 75-79 [En, fr, 18 ref.] Lab. de Nématologie. ORSTOM, Dakar, Senegal.

DBCP fumigation of a typical sandy soil in central Senegal, on which groundnut is commonly cultivated, favoured *inter alia* early infection by endomycorrhizae in 2 of the 3 cvs. studied. The results indicated that the nematode *Scutellonema cavenessi* alters the physiology of the groundnut plant by affecting the establishment and functioning of the symbioses between the plant and both endomycorrhizae and *Rhizobium*.

1038 KELLAM, M. K.; SCHENCK, N. C. **Interactions between a vesicular-arbuscular mycorrhizal fungus and root-knot nematode on soybean.** *Phytopathology* (1980) 70 (4) 293-296 [En, 21 ref.] Dep. of Pl. Path., Univ. of Florida, 32611 FL, USA.

Glasshouse tests using an aluminium foil funnel technique were done to study the effect of *Glomus macrocarpus* on the susceptibility of soybean cv. Pickett to *Meloidogyne incognita*. Inoculations were carried out either with one organism given 10 days prior to the second organism or with both organisms given at or 10 days after planting. After 14 weeks, plants which were infected with both organisms had significantly fewer galls, greater root weights and higher yields than those inoculated with *Meloidogyne* alone (254.4/plant 15.8 g and 3.0 g dry seed weight compared with 428.9/plant, 11.2 g and 1.8 g respectively). The presence of *Meloidogyne* did not affect the number of chlamydospores/plant or the % of the root system colonized by *G. macrocarpus*. 57% of the galls were not associated with mycorrhizal roots. Initial infection by either *G. macrocarpus* or *M. incognita* did not predispose the plant to later infection by either organism. Plants inoculated with *G. macrocarpus* alone had the highest yield followed by plants inoculated with both *M. incognita* and *G. macrocarpus*. Those inoculated with *M. incognita* alone had the lowest yield.

1039 NEMEC, S. Endomycorrhizal fungus infection in citrus fibrous roots of trees wit and without blight. Proc. Soil Crop Sci. Soc. Florida 39:141-144. 1980.
Endomycorrihizal fungus development was evaluated in fibrous roots of trees in eight citrus groves with blight. Percentage infection and vesicle and hyphal development did not differ in roots of trees fertilized with nitrogen or an equal mixture of nitrate and ammonium nitrogen in one grove. In two groves where blight was more severe on one of two adjoining soil types, infection was slightly lower in roots of blight trees compared to healthy trees, but infection in the healthy trees did not differ between soil types. In a grove with a shallow clay hardpan, infection did not differ between trees on the pan and trees on deep sand. Percent infection was no different if roots of blight trees had a high or low hydraulic conductivity and infection in them was the same as in roots of healthy trees. In other groves, infection in blight trees was not different from that in healthy trees. Overall, blight trees had a mean of 83.7% vesicular- arbuscular mycorrhizal fungus (VAM) infection and healthy trees had a mean of 90.4% infection. These data suggest that VAM are effective symbionts in both blight and healthy trees.

1040 OCAMPO, J. A.; HAYMAN, D. S. **Effects of pesticides on mycorrhiza in field-grown barley, maize and potatoes.** *Transactions of the British Mycological Society* (1980) 74 (2) 413-416 [En, 22 ref.] Soil Microbiology Department, Rothamsted Experimental Station, Harpenden, Herts. AL5 2JQ, UK.

Results from five field trials with barley, maize and potatoes on clay loam and sandy loam soils indicated that populations of VA mycorrhizal fungi in arable fields are affected, not only by fungicides and general biocides, but also by nematicides and insecticides. Sometimes their effects are slight or even positive, but usually they decrease mycorrhizal infections and spore numbers, an effect that occurred most consistently with benomyl. Since some crops (e.g. maize) are usually strongly mycorrhizal, and many plants can grow better with mycorrhiza, there is a possibility that plant protection chemicals may indirectly affect crop yields through their effects on VA mycorrhiza.

1041 OCAMPO, J. A.; MARTIN, J.; HAYMAN, D. S. **Influence of plant interactions on vesicular-arbuscular mycorrhizal infections. I. Host and non-host plants grown together.** *New Phytologist* (1980) 84 (1) 27-35 [En, 15 ref.] Soil Microbiol. Dep., Rothamsted Exp.Sta., Harpenden, Herts, UK.

Mycorrhizal infections formed by different endophytes were examined in 10 crop species grown separately and in pairs in sterilized and unsterile soils. No infection was observed in cabbage, kale, rape or swede (supposedly non-mycorrhizal family Cruciferae) and only traces in sugar beet (supposedly non-mycorrhizal Chenopodiaceae) when grown alone. However, slight (< 5%) infection (cortical mycelium and vesicles, but no arbuscules) developed in some when a mycorrhizal host plant was present and there were many clumps of endophyte mycelium on their root surfaces, usually attached to entry points which had often aborted. *Glomus fasciculatus* 'E3' was a more infective endophyte than *Gigaspora margarita*. Infection was usually well developed in the host plants barley, lettuce, maize, potato and onion. It was depressed in only a few pairs but no more by the presence of a non-host plant than by a host plant. The results suggest that the barriers to mycorrhizal infection in non-hosts are intrinsic and more related to characteristics of the root cortex or epidermis than to any infection-inhibiting factors that might be released in root exudates.

*1042 RIFFLE, J. W. **Growth and endomycorrhizal development of broad leaf seedlings in fumigated nursery soil.** *Forest Science* (1980) 26 (3) 403-413 [En, 17 ref., 1 fig., 3 tab.] Rocky Mountain Forest Range Exp. Sta., USDA Forest Service, Lincoln, Neb., USA.

Fumigation with methyl bromide resulted in erratic growth of seedlings of *Lonicera tatarica*, *Eleagnus angustifolia*, *Shepherdia argentea* and *Fraxinus pennsylvanica*, related to reduce endomycorrhizal development and 18% fewer plantable seedlings. Density of endomycorrhizae, percentage with vesicles and arbuscules and number of vesicles/cm mycorrhiza were all less than on seedlings from untreated soil.

*1043 SOUTH, D. B.; GJERSTAD, D. H.; CAMPBELL, S. J. **Comparison of methyl bromide and herbicide effects on endomycorrhizal formation, seedling production, and weed control in sweetgum seedbeds.** *European Journal of Forest Pathology* (1980) 10 (6) 371-377 [En, fr, de, 11 ref., 1 fig., 3 tab.] Auburn Univ. Exp. Sta., Auburn, Ala., USA.

Endomycorrhizal formation on *Liquidambar styraciflua* seedlings 1-3 months old was not significantly decreased by applications of trifluralin and napropamide. The herbicides provide better control of weeds and are less harmful to the seedlings than fumigation with methyl bromide.

1044 ATILANO, R. A.; GUNDY, S. D. VAN **Effects of some systemic, nonfumigant and fumigant nematicides on grape mycorrhizal fungi and citrus nematode.** *Plant Disease Reporter* (1979) 63 (9) 729-733 [En, 26 ref.] California University, Riverside, California 92521, USA.

In a trial with grapevines, cv. Thompson Seedless, the effects were compared of soil injection with DBCP (dibromochloropropane, 24 kg/ha) alone or foliar spraying with oxamyl (4800 mg/litre) at 2-week intervals from early June to mid-August either alone or as well as soil treatment with DBCP, aldicarb or phenamiphos (11 kg/ha). *Tylenchulus semipenetrans* populations 3 months after treatments began were greatly reduced by DBCP, but not by any of the other treatments; DBCP also gave the best results in the following year. The number of *Glomus* sp. chlamydospores associated with the roots differed little between treatments, as did yields in the first and second seasons. The percentage infection with fruit rot [*Botrytis cinerea*], however, was greatly reduced by all oxamyl treatments.

1045 BAGYARAJ, D. J.; MANJUNATH, A.; REDDY, D. D. R. **Interaction of vesicular arbuscular mycorrhiza with root knot nematodes in tomato.** *Plant and Soil* (1979) 51 (3) 397-403 [En, 9 ref.] Dep. of Agric. Microbiol. and Pl. Path., Univ. of Agric. Sci., Bangalore-560 065, India.

The interaction between the VA mycorrhizal fungus, *Glomus fasciculatus* and the root-knot nematodes, *Meloidogyne incognita* and *M. javanica*, and their effects on the growth and phosphorus nutrition of tomato was studied in a red sandy loam soil of pH 6.0. Inoculation of tomato roots with root-knot nematodes enhanced infection and spore production by *G. fasciculatus*. Inoculation of tomato plants with *G. fasciculatus* significantly reduced the number and size of the root-knot galls produced by *M. incognita* and *M. javanica*. The total phosphorus contents of plants inoculated with *G. fasciculatus* and of uninoculated plants were not significantly different. Nematode inoculation decreased phosphorus content at later stages of plant growth.

1046 DAVIS, R. M.; MENGE, J. A.; ERWIN, D. C. **Influence of *Glomus fasciculatus* and soil phosphorus on Verticillium wilt of cotton.** *Phytopathology* (1979) 69 (5) 453-456 [En, 16 ref.] Department of Plant Pathology, University of California, Riverside, CA 92521, USA.

A sandy soil received superphosphate at 20 or 300 µg of P per gram of soil, and at each P regime soil was infested with *Verticillium dahliae* alone, *Glomus fasciculatus* alone, both fungi, or neither fungus. In plants fertilized with 20 µg of P per gram of soil, Verticillium wilt was more severe in cotton plants infected with the vesicular-arbuscular mycorrhizal fungus, *G. fasciculatus*, than in nonmycorrhizal plants. However, in plants fertilized with 300 µg of P per gram of soil, Verticillium wilt was equally severe in mycorrhizal and nonmycorrhizal plants. In plants fertilized with 20 µg of P per gram of soil, there were more propagules of *V. dahliae* in petioles of mycorrhizal plants than in petioles of nonmycorrhizal plants. In plants fertilized with 300 µg P per gram of soil, the numbers of propagules of *V. dahliae* were not significantly different in mycorrhizal and nonmycorrhizal plants. Infection of cotton by *G. fasciculatus* was not affected by *V. dahliae* in plants fertilized with 20 µg of P per gram of soil, but infection was inhibited by P and further inhibited by *V. dahliae* in plants fertilized with 300 µg of P per gram of soil. Concentrations of P in leaves of mycorrhizal and nonmycorrhizal plants fertilized with 20 µg of P per gram of soil were similar, but concentrations of P were lower in plants infected with *V. dahliae* alone than in plants infected with both *V. dahliae* and *G. fasciculatus*.

1047 DEHNE, H. W.; SCHONBECK, F. **[The effect of endotrophic mycorrhiza on plant diseases. I. The spread of *Fusarium oxysporum* f.sp. *lycopersici* in tomatoes.]** Untersuchungen zum Einfluss der endotrophen Mycorrhiza auf Pflanzenkrankheiten. I. Ausbreitung von *Fusarium oxysporum* f.sp. *lycopersici* in Tomaten. *Phytopathologische Zeitschrift* (1979) 95 (2) 105-110 [De, en, 10 ref.] Institut für Pflanzenkrankheiten und Pflanzenschutz der Technischen Universität Hannover, German Federal Republic.

In sand cultures in which inoculation with *Fusarium oxysporum* f.sp. *lycopersici* was preceded by inoculation with soil in which mycorrhizal tomato, cucumber, maize and tobacco plants had been growing for a long time, the damage to tomato plants by the fungus was less in mycorrhizal plants than it was in non-mycorrhizal plants to which no mycorrhizal inoculum had been supplied. The decreased damage in the mycorrhizal plants was mainly due to a decrease in the spread of the fungus throughout the plant. The effect of the mycorrhiza decreased as the inoculum density of the fungus was increased.

1048 DEHNE, H.-W.; SCHONBECK, F. **[Influence of endotrophic mycorrhiza on plant diseases. II. Phenol metabolism and lignification.]** Untersuchungen zum Einfluss der endotrophen Mycorrhiza auf Pflanzenkrankheiten. II. Phenolstoffwechsel und Lignifizierung. *Phytopathologische Zeitschrift* (1979) 95 (3) 210-216 [De, en, 16 ref.] Technical University, D-3000 Hanover 21, German Federal Republic.

The presence of the endotrophic mycorrhiza *Glomus mosseae* enhanced lignin deposition in the cell walls of the endodermis and stele of tomato cvs Rheinglut and Haubners Vollendung and cucumber cv. Chinesische Schlangen plants. This change in cell wall structure is considered to be an important factor in increasing resistance to *Fusarium oxysporum* f. *lycopersici* in plants with mycorrhizae.

1049 DEHNE, H.W.; SCHONBECK, F. Untersuchungen zum einfluß der endotrophen mycorrhiza auf pflanzenkrankheiten. I. Ausbreitung von Fusarium oxysporum f. sp. lycopersici in Tomaten. Phytopath. Z. 95, 105-110. 1979.

1050 HALOS, P.M.; ZORRILLA, R.A. Vesicular arbuscular mycorrhizae increase growth and yield of tomatoes and reduce infection by Pseudonomas solanacearum. Philippine Agriculturist. 62(4): 309-315. 1979.

Lycopersicon esculentum, tomato, mycorrhiza, plant growth & development, bacterial diseases/Pseudomonas solanacearum, disease incidence, PHILI

Tomato plants (Lycopersicon esculentum) inoculated with mycorrhizae and grown in baked soil were taller, heavier, healthier, flowered earlier and yielded more than those inoculated with mycorrhizae then followed by Pseudomonas solanacearum, those inoculated with P. solanacearum only and the non-inoculated plants. Seedlings grown in non-baked soil with corresponding treatments responded similarly but were shorter, lighter, flowered less and consequently had poorer yields than those grown in baked soil. Plants inoculated with P. solanacearum in non-baked and baked soils exhibited yellowing, stunted growth and wilting. Prior infection of tomato roots with mycorrhizae reduced the bacterial wilt incidence in both soil media. Authors' summary.

*1051 MENGE, J. A.; NEMEC, S.; DAVIS, R. M.; MINASSIAN, V. **[Mycorrhizal fungi associated with citrus and their possible interactions with pathogens.]** 872-876 [32 ref., 2 pl.] California University, Riverside, CA 92502, USA.
In: INTERNATIONAL SOCIETY OF CITRICULTURE **Proceedings of the International Society of Citriculture, 1977, Volume 3.** Lake Alfred, Florida, USA. (1979) 709-1143 [En]

The beneficial effect of mycorrhizae in citrus nurseries in Florida and California is discussed. The beneficial effect of *Glomus fasciculatus* on the growth of sweet orange seedlings was completely negated by *Phytophthora parasitica* [*nicotianae* var. *parasitica*].

*1052 MILNE, D. L. The impact of new nematicides and irrigation practices on methods of citrus nematode control. In *Proceedings of the International Society of Citriculture, 1977.* Lake Alfred, Florida, USA. (1979) Vol.3, 835-838 [En, 36 ref.] Citrus and Subtropical Fruit Research Institute, Nelspruit 1200, South Africa.

The effect of methyl bromide on mycorrhizae (*Glomus mosseae*) is discussed, and the influence of the new systemic nematicides on methods of nematode (*Tylenchulus semipenetrans*) control in citrus is reviewed. These systemics are well-adapted for use in the new, low-volume irrigation systems such as drip and microjet. Fenamiphos gave effective control of various citrus nematodes when applied in granular or liquid formulation. It may be applied in irrigation basins or as an e.c. through a microjet irrigation system, or by painting on trunks. Increases in yield and fruit size have been recorded, and there has been evidence of *Phytophthora* sp. suppression.

*1053 MINASSIAN, V.; MENGE, J. A. **Interactions between VA mycorrhizae and *Tylenchulus semipenetrans* on sweet orange and Troyer citrange.** In *Abstracts of papers presented at the IX International Congress of Plant Protection, and the 71st Annual Meeting of the American Phytopathological Society, 5-11 August, 1979, Washington, DC, USA.* St.Paul, Minnesota, USA; American Phytopathological Society. (1979) Abs.No.597 [En] Dep. of Plant Path., Univ. of California, Riverside, CA 92521, USA.

Sweet orange (susceptible to *Tylenchulus semipenetrans*) and "Troyer" citrange (tolerant) seedlings with or without the VA mycorrhizal fungus *Glomus fasciculatus*, were inoculated with *T.semipenetrans*. *G. fasciculatus* significantly improved growth of both citrus cultivars whether or not *T.semipenetrans* was present. *T.semipenetrans* did not affect growth of either of the non-mycorrhizal cultivars, but significantly suppressed growth of mycorrhizal sweet orange seedlings. Populations of *T.semipenetrans* were not affected by *G.fasciculatus* on sweet orange seedlings, but were significantly increased on mycorrhizal "Troyer" citrange. *T.semipenetrans* did not affect sporulation of *G.fasciculatus* on either citrus cultivar, but significantly reduced the percent of sweet orange roots infected with *G.fasciculatus*. *T.penetrans* did not affect P, Zn, and Cu in leaves of mycorrhizal or non-mycorrhizal sweet orange. Inoculations of "Troyer" citrange with *T.semipenetrans* 2 months prior to

inoculation with *G.fasciculatus* did not change growth responses in any of the treatments. *T.semipenetrans* more severely inhibited growth of "Troyer" citrange infected with *G. constrictus* or *G. fasciculatus* (isolate 192) than citrange infected with *G.macrocarpus* or *G. fasciculatus* (isolate 212).

*1054 MUNNECKE, D. E. [Methyl bromide for control of soil-borne fungal pathogens.] 853-856 [4 ref., 1 pl.] California University, Riverside, CA 92521, USA.
INTERNATIONAL SOCIETY OF CITRICULTURE Proceedings of the International Society of Citriculture 1977, Volume 3. Lake Alfred, Florida, USA. (1979) 709-1[illegible] [En]

Phytophthora citrophthora, P. parasitica [*nicotianae* var. *parasitica*] and *Armillaria mellea* were controlled but young seedlings could be stunted due to the lack of mycorrhizae.

*1055 NEMEC, S. Effects of five fungicides on endomycorrhizal development in sour orange. USDA, SEA, Orlando, Fl. Phytopathology 69 (5): 531. 1979. Abst.

Copper (Cu) up to 224 kg/ha, CGA 48988 [N-(2, 6 dimethylphenyl) -N-methoxyacetyl) alanine methyl ester] up to 9 kg/ha, and thiabendazole (TBZ) up to 18 kg/ha, were tested against Glomus etunicatus (GE). Chlorothalonil up to 22.4 kg/ha, and sodium azide (NaN_3) up to 31.4 kg/ha were tested against G mosseae (GM). Sour orange seed were planted in 15-cm pots containing low-phosphorus soil mixed with these fungicides and chlamydospores. After 8 mos., the middle and high rates of Cu depressed plant growth ($P = \leq 0.01$) but not infection and sporulation, compared to the GE control. Vesicle number and plant growth were not adversely affected by CGA 48988, but mycelial colonization and chlamydospore numbers were higher than the GE control. All rates of TBZ reduced plant growth ($P = \leq 0.01$) and infection and sporulation decreased as rates increased. Plant growth and sporulation in the middle and high rates of chlorothalonil were significantly less than the control. Plant growth was better ($P = \leq 0.05$), and fungus sporulation higher than the GM control in all NaN_3 treatments.

1056 O'BANNON, J. H.; INSERRA, R. N.; NEMEC, S.; VOVLAS, N. The influence of *Glomus mosseae* on *Tylenchulus semipenetrans*-infected and uninfected *Citrus limon* seedlings. *Journal of Nematology* (1979) 11 (3) 247-250 [En, 17 ref.] US Dept. of Agriculture, SEA, AR, Irrigated Agriculture Research and Extension Center, Prosser, Washington 99350, USA.

Greenhouse studies have shown that when rough lemon seedlings infected with *Tylenchulus semipenetrans* were transplanted into soil infested with *Glomus mosseae*, the mycorrhizal fungus infection increased seedling growth compared to nonmycorrhizal seedlings. *Tylenchulus semipenetrans* significantly suppressed seedling growth below that of mycorrhizal seedlings. Histological observations of nematode-free mycorrhizal roots showed that hyphae penetrated the epidermis and invaded the cortex, giving rise to arbuscules and vesicles. Nematode infection sites in *T. semipenetrans*-infected roots grown in soil infested with *G. mosseae* did not show evidence of vesicle development in the cortex but did show arbuscule development.

1057 O'BANNON, J. H.; NEMEC, S. The response of *Citrus limon* seedlings to a symbiont, *Glomus etunicatus*, and a pathogen, *Radopholus similis*. *Journal of Nematology* (1979) 11 (3) 270-275 [En, 21 ref.] Irrigated Agriculture Research and Extension Center, Agricultural Research, Science and Education Administration, United States Department of Agriculture, Prosser, Washington 99350, USA.

The effects of a vesicular-arbuscular mycorrhiza (*Glomus etunicatus*) and burrowing nematode (*Radopholus similis*), alone and in combination, on the growth of rough lemon seedlings were studied in the greenhouse. Growth of mycorrhizal seedlings was significantly greater than that of nonmycorrhizal seedlings or seedlings inoculated with *R. similis*. Mycorrhizal stimulation of seedling growth was inhibited by nematode infection. When seedlings were inoculated with *G. etunicatus* and *R. similis*, suppression of seedling growth by *R. similis* was less on VAM seedlings than on nonmycorrhizal seedlings. Nonmycorrhizal seedlings infected with *R. similis* were significantly smaller than nonmycorrhizal seedlings free of *R. similis*. Vesicle formation and mycelia growth were less in nematode-infected roots.

*1058 RONCADORI R. W.; HUSSEY, R. S. Interaction of *Glomus entunicatus*, a vesicular-arbuscular mycorrhizal fungus, and *Meloidogyne incognita* on cotton. [Abstract]. *Nematropica* (1979) 9 (2) 108 [En] Dep. of Pl. Path. and Pl. Genetics, Univ. of Georgia, Athens, GA 30602, USA.

In glasshouse experiments the cotton cultivars McNair 511 (*Meloidogyne incognita* resistant) and Stoneville 213 (susceptible) were inoculated with *M. incognita* and *Glomus entunicatus* singly or in combination. Maximum retardation of cotton production by *M. incognita* was observed on McNair 511 under a low fertility regime. Reproduction of both organisms was influenced by concomitant inoculation. Egg number/g of root was significantly lower on mycorrhizal plants at low fertility (McNair 511, 91% and Stoneville 213, 74%).

*1059 RONCADORI, R.W.; HUSSEY, R.S. Interaction of *Glomus etunicatus*, a vesicular-arbuscular mycorrhizal fungus, and *Meloidogyne incognita* on cotton. In *Abstracts of papers presented at the IX International Congress of Plant Protection, and the 71st Annual Meeting of the American Phytopathological Society, 5-11August, 1979, Washington, DC, USA.* St.Paul, Minnesota, USA; American Phytopathological Society. (1979) Abs.No.163 [En] Dep. of Plant Path. & Plant Genetics, Univ. of Georgia, Athens, GA 30602, USA.

In a glasshouse experiment the interaction of the fungus *Glomus etunicatus* and *Meloidogyne incognita* on cotton (*Gossypium hirsutum* cvs. McNail 511 (*M.incognita*-resistant) and Stoneville 213 (susceptible) under 2 different NPK regimes was measured. Inoculation with *Glomus etunicatus* alone resulted in increased yields and shoot and root growth. Nematode infection reduced yields and growth. Reproduction of the fungus was suppressed on McNail 511 when plants were inoculated with fungus plus nematode. *M.incognita* egg production was not increased on plants infected with *G.etunicatus*, which had larger root systems than uninfected plants. There were significantly fewer eggs/g root in mycorrhizal roots at the lower fertilization rate suggesting physiological or physical antagonism towards *M.incognita*.

*1060 SALAWU, E. O.; ESTEY, R. H. Observations on the relationships between a vesicular-arbuscular fungus, a fungivorous nematode, and the growth of soybeans. *Phytoprotection* (1979) 60 (2) 99-102 [En, fr, 9 ref., 1 tab.] Macdonald Coll., McGill Univ., Ste Anne-de-Bellevue, Que., Canada.

Root and shoot development of soybean was significantly inhibited on adding *Glomus* sp. + *Aphelenchus avenae* to root zone soil. Poor fungal sporulation was shown to be due to nematode. Fewer nodules were found on plants treated with both organisms than on those with the fungus alone.

1061 SCHÖNBECK, F.; SPENGLER, G. [Detection of TMV in mycorrhizal cells of tomato by immuno fluorescence.] Nachweis von TMV in Mycorrhiza-haltigen Zellen der Tomate mit Hilfe der Immunofluoreszenz. *Phytopathologische Zeitschrift* (1979) 94 (1) 84-86 [De, en, 7 ref.] Inst. Pflanzenkrankheiten Pflanzenschutz, Technischen Univ., Hannover, German Federal Republic.

Inoculation of mycorrhizal and non-mycorrhizal tomato plants with tobacco mosaic virus resulted in a much higher virus content in the mycorrhizal roots. Increased virus multiplication was observed in cells containing the mycorrhizal fungus in its arbuscular state.

*1062 SCHONBECK, F. Endomycorrhiza in relation to plant diseases. In: Schippers, B.; Gams, W. eds. Soil-borne pathogens. Academic Press London. pp. 271-280 (1979).

*1063 SCHÖNBECK, F.; DEHNE, H.-W. [Investigations on the influence of endotrophic mycorrhiza on plant diseases 4. Fungal parasites on shoots, *Olpidium brassicae*, TMV.] Untersuchungen zum Einfluss der endotrophen Mycorrhiza auf Pflanzenkrankheiten 4. Pilzliche Sprossparasiten, *Olpidium brassicae*, TMV. *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz* (1979) 86 (2) 103-112 [De, en, 17 ref., 2 fig., 4 tab.] Inst. Pflanzenkrankh. Pflanzenschutz, Univ. Hannover, German Federal Republic.

Inoculation tests in the glasshouse showed that diseases caused by *Helminthosporium sativum* [*Cochliobolus sativus*] and *Erysiphe graminis* on barley, *Colletotrichum lindemuthianum* and *Uromyces phaseoli* [*U. appendiculatus*] on bean (*Phaseolus vulgaris*), *Botrytis cinerea* on lettuce, *Erysiphe cichoracearum* on cucumber and tobacco mosaic virus on tobacco were increased whereas *O. brassicae* on lettuce and tobacco was reduced on mycorrhizal (*Glomus mosseae*) plants compared with non-mycorrhizal plants.

Increased susceptibility of bean to *U. appendiculatus* was particularly evident in highly resistant vars. It was concluded that mycorrhiza generally reduce infection by root invading fungi and increase that of aerial parts, caused by fungi or viruses. The principles responsible for increase in resistance appear to be localized in the mycorrhizal sites on the roots, whereas those responsible for the decrease are thought to be systemic and transmitted from roots to aerial parts.

*1064 SIKORA, R. A.; DEHNE, H. W. **Changes in plant susceptibility to *Ditylenchus dipsaci* and *Aphelenchoides ritzemabosi* induced by the endotrophic mycorrhizal fungus *Glomus mosseae*.** In *Abstracts of papers presented at the IX International Congress of Plant Protection, and the 71st Annual Meeting of the American Phytopathological Society, 5-11 August, 1979, Washington, DC, USA.* St.Paul, Minnesota, USA; American Phytopathological Society. (1979) Abs.No.234 [En] Inst. für Pflanzenkrankheiten, Nussallee 9, 5300 Bonn, GFR.

Bush beans (*Phaseolus vulgaris*) were inoculated simultaneously with *Glomus mosseae* and *Ditylenchus dipsaci*. Nematode populations had increased by 43% 40 days after inoculation and decreased by 32% 60 days after inoculation on mycorrhizal plants compared to nonmycorrhizal controls. Total plant weight was reduced by 45%. 6-week-old mycorrhizal tobacco plants inoculated with *Aphelenchoides ritzemabosi* showed a decrease in nematode populations by 48% 30 days after inoculation when compared to nonmycorrhizal controls.

1065 AGUILAR, C. AZCÓN-G. DE; BAREA, J. M. Effects of interactions between different culture fractions of 'phosphobacteria' and *Rhizobium* on mycorrhizal infection, growth, and nodulation of *Medicago sativa*. *Canadian Journal of Microbiology* (1978) 24 (5) 520-524 [En, fr, 25 ref.] Microbiology Department, Experimental Station of Zaidin, Granada, Spain.

In a pot experiment in which uninoculated *Medicago sativa* seedlings and seedlings inoculated with the supernatants, cells or entire cultures of *Rhizobium meliloti* and *Pseudomonas* sp. (a phosphate-solubilizing bacterium), were grown in a soil low in P with and without inoculation with a mycorrhiza-forming *Endogone*, satisfactory nodulation was very dependent on mycorrhiza formation. *Rhizobium* and *Pseudomonas* supernatants promoted plant growth, nodulation and mycorrhiza formation. The active principle in *Pseudomonas* cultures appeared to occur mainly in the supernatant. Inoculation with *Pseudomonas* did not increase the pool of soluble P in the soil. Simultaneous application of entire cultures of *Rhizobium*, *Pseudomonas* and *Endogone* was the most effective treatment

1066 AMES, R. N.; LINDERMAN, R. G. **The growth of Easter lily (*Lilium longiflorum*) as influenced by vesicular-arbuscular mycorrhizal fungi, *Fusarium oxysporum*, and fertility level.** *Canadian Journal of Botany* (1978) 56 (21) 2773-2780 [En, fr, 30 ref.] USDA, SEA/Agric. Res., Oregon State Univ., Corvallis, 97330, USA (R.G.L.).

Easter lily bulbs were inoculated in the greenhouse with pot-culture inoculum containing a mixture of four mycorrhizal fungi as well as other fungi and bacteria, including pathogens. These organisms had multiplied in association with roots of lily, onion, and clover in pot cultures inoculated with sievings from lily field soils. Growth, as measured by bulb weight gain, root volume and total leaf area, of inoculated plants was less than that of controls, especially in plants given the high level of inoculum and the high rate of NPK. The growth reduction apparently was due to greater incidence of *Fusarium oxysporum* root rot, damage to roots from fertilizer, and lower incidence of mycorrhizal infections. More mycorrhizal infections occurred in the low-fertilizer than in the high- or no-fertilizer treatments at both high and low inoculum levels, but more *F. oxysporum* root rot occurred in the high-inoculum, high-fertilizer treatment. Lily seedlings that lacked bulb nutrient reserves were grown at a low fertilizer level and inoculated with *Acaulospora trappei* without any pathogens. Mycorrhizal plants were significantly larger than nonmycorrhizal plants, and their tissues contained more N, P, K, Ca and Mg.

1067 AZCÓN, R.; BAREA, J. M.; MONTOYA, E. **[Biological fertilization with "VA" mycorrhiza and phosphobacteria I. Effect of the addition of phosphorus on the growth and nutrition of *Lavandula spica* and establishment of "VA" symbiosis.]** Fertilización biológica con micorrizas "VA" y fosfabacterias I. Efecto de la adición de fosfato sobre el crecimiento y nutrición de *Lavandula spica* L. y establecimiento de la simbiosis "VA". *Anales de Edafología y Agrobiología* (1978) 37 (1/2) 91-98 [Es, en, 11 ref.] Estación Experimental de Zaidín, Granada, Spain. From *Horticultural Abstracts 50*, 1336.

Lavender plants were grown in pots filled with (a) sterilized or unsterilized soil, (b) soil + phosphobacteria or (c)soil + plants inoculated with *Endogone*. In all treatments KH_2PO_4 at 0.1-1.3 g/kg soil was added. The dry wt. was greatest in plants in sterilized soil receiving 1g KH_2PO_4/kg, followed by plants in (c) receiving 0.5 g.

1068 AZCÓN, R.; BAREA, J. M.; MONTOYA, E. **[Biological fertilization with "VA" mycorrhizae and phosphobacteria. II. Effect of manuring and timing of phosphate applications on mycorrhizal infection of *Lavandula spica* L. in the seedbed.]** Fertilización biológica con micorrizas "VA" y fosfobacterias. II. Influencia del estercolado y epoca de aplicaeión de fosfato sobre la micorrización de *Lavandula spica* L. en sèmillero. *Anales de Edafología y Agrobiología* (1978) 37 (1/2) 99-104 [Es, en, 6 ref.] Dep. de Microbiol., Estación Exp. del Zaidín, CSIC Granada, Spain.

Growth of lavender (*Lavandula spica*) in an unsterilized fertile soil was improved by phosphate application (0.1 g/kg soil) three months after sowing. Inoculation with *Endogone* sp. or phosphobacteria improved plant growth, except when P was applied at sowing. Addition of 2% farmyard manure to soils increased natural mycorrhizal infection and plant growth. In manured soils phosphobacteria and *Endogone* sp. increased dry weight of plants; P applications had no effect on uninoculated plants, and decreased growth of mycorrhizal plants. Greatest plant dry weight was obtained with mycorrhizal plants in manured soil without applied P.

1069 AZCON-G. DE AGUILAR, C.; BAREA, J.M. 1978 Effects of interactions between different culture fractions of 'phosphobacteria' and *Rhizobium* on mycorrhizal infection, growth, and nodulation of *Medicago sativa*. Can. J. Microbiol. 24:520-524. Interactions between cell-free culture supernatants cells, and the whole cultures of *Rhizobium* and phosphobacteria with endomycorrhizal fungi and their effects on growth and nutrition of *Medicago sativa* grown in a low-phosphate soil were studied. A satisfactory nodulation was greatly dependent on the mycorrhizal symbiosis. Cell-free supernatants of *Rhizobium* and phosphobacteria improved plant growth nodulation, and mycorrhiza formation. The activity of phosphobacteria culture seemed to be due mainly to the supernatant and the possibility of plant hormones contained in this culture fraction being involved in such interactions is discussed. An increase of the overall pool of soluble P in soil by the inoculation phosphobacteria cells was not found in the conditions of this experiment. It was noteworthy that the best positive effect was achieved by the treatment which consisted of the whole cultures of *Rhizobium*, phosphobacteria, and the mycorrhizal fungi applied all together.

1070 BAGYARAJ, D. J.; MENGE, J. A. **Interaction between a VA mycorrhiza and *Azotobacter* and their effects on rhizosphere microflora and plant growth.** *New Phytologist* (1978) 80 (3) 567-573 [En, 21 ref.] California University, Riverside, California, USA.

Larger populations of bacteria and actinomycetes were recovered from the rhizospheres of tomato plants inoculated with the mycorrhizal fungus *Glomus fasciculatus* and/or *Azotobacter chroococcum* than from those of non-inoculated plants. Plants inoculated with both *G. fasciculatus* and *A. chroococcum* had greater numbers of bacteria and actinomycetes in the rhizosphere than plants inoculated with either alone. The fungal population of the rhizosphere was unaffected by inoculation with *G. fasciculatus* but reduced by inoculation with *A. chroococcum*. Inoculation of tomato with *G. fasciculatus* increased the *A. chroococcum* population in the rhizosphere (after *A. chroococcum* inoculation) and maintained it at a high level for a longer time. Inoculation of tomato with *A. chroococcum* enhanced infection and spore production by *G. fasciculatus*. The dry weights of tomato plants inoculated with both *G. fasciculatus* and *A. chroococcum* were 62% greater than

those of non-inoculated plants. The results suggest a synergistic or additive interaction between *G. fasciculatus* and *A. chroococcum*.

1071 BAILEY, J. E.; SAFIR, G. R. Effect of benomyl on soybean endomycorrhizae. *Phytopathology* (1978) 68 (12) 1810-1812 [En, 21 ref.] Dep. of Bot. and Pl. Path., Michigan State Univ., East Lansing, MI 48824, USA.

In controlled-environment trials soil drenches of benomyl at 2.5, 25, 125 and 250 µg/g soil were added to pots sown with soyabean and containing 120 chlamydospores of *Glomus fasciculatus*/100 g soil. Mycorrhizal infection (recorded as percentage of root colonized) was decreased from 70-80% to approx. 45% by 25 µg benomyl/g dry soil in one trial and by 2.5 µg/g in another. Conc. as high as 250 µg did not increase infection further. Benomyl prevented increased plant growth due to the vesicular-arbuscular mycorrhizae even with fungal colonization of the root system as high as 48%.

*1072 BERTOLDI, M. DE; PICCI, G.; GIOVANNETTI, M. [Toxic genetic effects, and alterations of the mycorrhizal flora and rhizosphere flora by some agricultural fungicides.] Effetti genotossici ed alterazioni della flora micorrhizica e rizosferica causati da alcuni fungicidi agricoli. *Annali di Microbiologia ed Enzimologia* (1978) 27, 131-142 [It, en, 33 ref.] Istituto di Microbiologia Agraria dell'Università, Pisa, Italy.

Depending on the stage of plant development at which benomyl was applied to the soil in a pot experiment, the benomyl either prevented the formation, or inhibited the development, of endomycorrhiza (attributed to *Endogone*) in *Allium cepa*. Captan had a less dramatic effect. The mycoflora of the rhizosphere was greatly inhibited by both fungicides.

1073 BOATMAN, N.; PAGET, D.; HAYMAN, D. S.; MOSSE, B. Effects of systemic fungicides on vesicular-arbuscular mycorrhizal infection and plant phosphate uptake. *Transactions of the British Mycological Society* (1978) 70 (3) 443-450 [En, 25 ref.] Rothamsted Experimental Station, Harpenden, Herts. AL5 2JQ, UK.

Formation of mycorrhiza in clover roots was prevented by soil drenches of benomyl and thiophanatemethyl and the spread of established infections was halted. Immersion of fungal inoculum in suspensions of the fungicides reduced infectivity. However clover plants grown in benomyl-treated soil did not retain enough fungicide to affect the amount of infection after transplanting into benomyl-free soil. Benomyl and thiophanate-methyl soil drenches reduced phosphate uptake of inoculated onion and strawberry plants when grown in irradiated soil, but not in unsterile soil. The short term uptake of radioactive ^{32}P was reduced by benomyl but the results were variable.

1074 DAVIS, R. M.; MENGE, J. A.; ZENTMYER, G. A. Influence of vesicular-arbuscular mycorrhizae on *Phytophthora* root rot of three crop plants. *Phytopathology* (1978) 68 (11) 1614-1617 [En, 14 ref.] Department of Plant Pathology, University of California, Riverside CA 92521, USA.

Citrus sweet orange, avocado, and alfalfa seedlings, with or without endomycorrhizae formed by *Glomus fasciculatus*, were inoculated with *Phytophthora parasitica*, *Phytophthora cinnamomi*, and *Phytophthora megasperma*, respectively. Little or no differences in response to the *Phytophthora* species were observed between mycorrhizal and nonmycorrhizal citrus or alfalfa seedlings but mycorrhizal avocado seedlings were affected more severely by *P.cinnamomi* than were nonmycorrhizal avocado seedlings. In the citrus and avocado experiments, the growth stimulus caused by the mycorrhizal fungus was eliminated when *Phytophthora* was present. Sporulation by *G.fasciculatus* on citrus was affected adversely by *P.parasitica*. Phosphorus concentrations in leaves of citrus and avocado seedlings infected with *G.fasciculatus* alone were significantly greater than the concentrations in leaves of nonmycorrhizal seedlings. Phosphorus concentrations in seedlings inoculated with both *G.fasciculatus* and *Phytophthora*, however, were similar to the concentrations in nonmycorrhizal seedlings.

1075 DEHNE, H.-W.; SCHÖNBECK, F. [Investigations on the influence of endotrophic mycorrhiza on plant diseases 3. Chitinase activity and ornithine cycle.] Untersuchungen zum Einfluss der endotrophen Mykorrhiza auf Pflanzenkrankheiten 3. Chitinase-Aktivität und Ornithinzyklus. *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz* (1978) 85 (11) 666-678 [De, en, 33 ref., 7 fig., 2 tab.] Inst. Pflanzenkrankh. Pflanzenschutz, Tech. Univ. Hannover, German Federal Republic.

The endotrophic, vesicular-arbuscular mycorrhiza (*Glomus mosseae*) induced on inoculation a higher chitinase activity in roots of tomato, *Phaseolus vulgaris*, maize and tobacco. Arginine accumulation in mycorrhizal roots was mainly due to increased specific activities of some enzymes of the ornithine cycle and blockage of this cycle by arginase. Stimulation of the ornithine cycle in mycorrhizal roots was correlated with the arbuscle stage of the endophyte. Relations between arginine accumulation, chitinase activation and resistance of plants are discussed.

1076 HAYMAN, D.S. MACDONALD, R.M. SIVOBIS, J.R. The effect of pesticides on VA mycorrhiza. Rothamsted Annu. Rep. for 1977. Rothamsted Exp. Sta., Harpenden, England, p.238. 1978.

1077 HUSSEY, R. S. and R. W. RONCADORI. (Dep. Plant Pathol. Plant Genet., Univ. Ga., Athens, Ga. 30602, USA.) Interaction of *Pratylenchus brachyurus* and *Gigaspora margarita* on cotton. J NEMATOL 10(1): 16-20. 1978.—An endomycorrhizal fungus *G. margarita* was more effective in stimulating the growth of cotton (*Gossypium hirsutum*) 'Coker 201' at a low fertility level (1.77 gm 10-10-10 N-P-K/pot) than doubling the fertility rate for nonmycorrhizal plants. *G. margarita* alone stimulated shoot growth (height, wt and flower production by 96, 553 and 760%, respectively) and root growth (385%) over that of nonmycorrhizal controls at low fertility. Plant development was also stimulated by *G. margarita* at the high fertility level (3.54 gm 10-10-10 N-P-K/pot), but the magnitude of the increase was not as great as that at the low fertility level. Although cotton was a suitable host for *P. brachyurus*, plant development was not retarded by this nematode at either fertility level. In concomitant culture, mycorrhizal-induced plant growth and sporulation of the endomycorrhizal fungus were not affected by *P. brachyurus*. Reproduction of *P. brachyurus* was similar on mycorrhizal and nonmycorrhizal cotton.

1078 MATARÉ, R.; HATTINGH, M. J. Effect of mycorrhizal status of avocado seedlings on root rot caused by *Phytophthora cinnamomi*. *Plant and Soil* (1978) 49 (2) 433-435 [En, 8 ref.] Dep. of Plant Pathology, Univ. of Stellenbosch, Stellenbosch 7600, South Africa.

Glomus fasciculatus stimulated growth of avocado seedlings in a sandy soil in the greenhouse, in the presence or absence of *Phytophthora cinnamomi*. It had no effect upon infection by *P. cinnamomi* or subsequent disease development.

1079 MENGE, J. A.; MUNNECKE, D. E.; JOHNSON, E. L. V.; CARNES, D. W. Dosage response of the vesicular-arbuscular mycorrhizal fungi *Glomus fasciculatus* and *G. constrictus* to methyl bromide. *Phytopathology* (1978) 68 (9) 1368-1372 [En, 26 ref., 1 fig., 4 tab.] Univ. California, Riverside, USA.

Propagules of *G. fasciculatus* were fumigated with 3000, 6000 and 12 000 µl methyl bromide (MB)/l air for 1.5-48 h. Propagules fumigated at a conc. × time (CT) of < 84 000 remained viable and infected Sudan grass. *G. fasciculatus* did not reproduce on the roots if inoculum was fumigated with 12 000 µl MB/l air for 7, 12 and 15 h (CT = 84 000, 144 000 and 180 000, respectively) or 6000 µl for 24 h (CT = 144 000). Inoculum remained viable when fumigated at 3000 µl MB/l air for 48 h (CT = 144 000). Dry wt. of Sudan grass was significantly ($P = 0.05$) reduced when seedlings were inoculated with *G. fasciculatus* which had been subjected to 12 000 µl MB/l air for 3 h or longer (CT = 36 000) as compared with nonfumigated inoculum. When chlamydospores of *G. fasciculatus* and *G. constrictus* were treated with 12 000 µl MB/l air for 6 h or more (CT = 72 000) 90% failed to germinate. None germinated after 12 000 µl for > 8 h (CT = 96 000). *G. fasciculatus* and *G. constrictus* are both more sensitive to MB fumigation than most soilborne plant pathogens. Furthermore mycorrhizal fungi can readily be destroyed after fumigation in the top 45 cm of soil by most commercial MB fumigations.

*1080 O'BANNON, J. H.; NEMEC, S. Influence of soil pesticides on vesicular-arbuscular mycorrhizae in citrus soil. *Nematropica* (1978) 8 (2) 56-61 [En, es, 13 ref.] US Horticultural Research Laboratory, Orlando, FL 32803, USA.

In a greenhouse experiment in which *Citrus aurantium* seedlings were grown in a fine sand subsoil steam sterilized and inoculated with soil containing *Glomus mosseae* or *Glomus fasciculatus*, in a natural mycorrhizal soil, and in a natural non-mycorrhizal soil, fumigation with > 242 kg/ha of methyl bromide or > 163 l/ha of chloropicrin prevented

the production of vesicular-arbuscular mycorrhizae (VAM) and decreased seedling growth. VAM was not eliminated and seedling growth was stimulated by 168 l/ha of 1,3-dichloropropene or 141 and 235 l/ha of ethylene dibromide.

1081 SCHENCK, N. C.; KELLAM, M. K. **The influence of vesicular arbuscular mycorrhizae on disease development.** *Technical Bulletin Agricultural Experiment Stations, University of Florida* (1978) No. 798, 16 pp. [En, 59 ref., 1 tab.] Univ. Florida, Gainesville, USA.

A review of the interactions of VA mycorrhizal fungi with plant pathogens and plant parasitic nematodes.

*1082 SCHONDECK, F. [Influence of the endotrophic mycorrhiza on disease resistance of higher plants.] Einfluss der endotrophen Mykorrhiza auf die Krankheitsresistenz höherer Pflanzen. *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz* (1978) 85 (3/4) 191-196 [De, en, 12 ref., 3 fig., 1 tab.] Inst. Pflanzenkrankh. Pflanzenschutz, Techn. Univ. Hannover, German Federal Republic.

Following inoculation with tobacco mosaic virus more lesions occurred on the leaves of mycorrhizal than non-mycorrhizal tobacco plants. Mycorrhizal plants were also more resistant to *Thielaviopsis basicola* on roots of tobacco and cotton, and *Fusarium oxysporum* f. sp. *lycopersici* on tomato. These phenomena are discussed in the light of induced resistance.

*1083 SIKORA, R. A. [Influence of the endotrophic mycorrhiza (*Glomus mosseae*) on the host-parasite relationship of *Meloidogyne incognita* on tomato.] Einfluss der endotrophen Mycorrhiza (*Glomus mosseae*) auf des Wirt-Parasit-Verhältnis von *Meloidogyne incognita* in Tomaten. *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz* (1978) 85 (3/4) 197-202 [De, en, 10 ref.] Inst. für Pflanzenkrankheiten, Univ. Bonn, Nüssallee 9, D-5300 Bonn, German Federal Republic.

In sand culture in the greenhouse, there was a negative relationship between the distribution of *M.incognita* galls and infection by *G.mosseae* within the root system. Penetration by the nematodes 72 hr after inoculation was also reduced by the presence of *G.mosseae*; 64% fewer larvae penetrated *G.mosseae*-inoculated plants compared to uninoculated plants. Larvae were 63 and 27% smaller at 8 and 16 days after inoculation, respectively, in mycorrhizal compared to nonmycorrhizal plants.

1084 SMITH, T. F. **Some effects of crop protection chemicals on the distribution and abundance of vesicular-arbuscular endomycorrhizas.** *Journal of the Australian Institute of Agricultural Science* (1978) 44 (2) 82-88 [En, 26 ref., 2 tab.] Muresk Agric. Coll., Australia.

Data presented in this review are fragmentary and difficult to interpret but indicate the possibility that endomycorrhizal function may be inhibited by the chemicals while spore numbers and infectivity remain unchanged. Further lines of investigation are suggested.

1085 TIMMER, L. W.; LEYDEN, R. F. **Relationship of seedbed fertilization and fumigation to infection of sour orange seedlings by mycorrhizal fungi and *Phytophthora parasitica*.** *Journal of the American Society for Horticultural Science* (1978) 103 (4) 537-541 [En, 21 ref.] Texas A&M Univ. Citrus Center, Weslaco, 78596, USA.

Preplant fumigation with methyl bromide or Vapam and heat treatment temporarily eliminated *Phytophthora parasitica* from most seedbeds, prevented damping-off and reduced root rot on sour orange (*Citrus aurantium*) seedlings. Stunting of seedlings due to elimination of mycorrhizal fungi occurred frequently following these treatments. Seedlings in non-fumigated, captan-treated seedbeds were not affected by damping-off or lack of mycorrhizae, but growth was reduced compared to that in fumigated beds because of severe root infection by *P. parasitica*. Application of 500 to 750 kg P/ha to fumigated seedbeds temporarily stimulated seedling growth, and larger seedlings resulted when mycorrhizae subsequently became reestablished in the beds. P at these rates did not overcome the stunting problem if mycorrhizae failed to re-establish. Application of 1900 to 2000 kg P/ha stimulated early growth of seedlings in fumigated seedbeds but inhibited mycorrhizal formation and induced P deficiency symptoms. Fumigation programs which are effective in eradicating *P. parasitica* also eliminate mycorrhizal fungi and induce severe stunting which is partially reversible by application of P, but completely reversible only by inoculation with mycorrhizal fungi.

*1086 BACKMAN, P. A.; CLARK, E. M. **The effect of carbofuran and other pesticides on vesicular-arbuscular mycorrhizae in peanuts.** Efecto del carbofuran y otros pesticidas sobre las micorrizas vesiculo arbusculares del mani. *Nematropica* (1977) 7 (1) 13-17 [En, es, 8 ref.] Department of Botany and Microbiology, Agricultural Experiment Station, Auburn University, Auburn, Alabama 36830, USA.

Of nine pesticides applied to a sandy loam before planting, only sodium azide (a biocide) and carbofuran (an insecticide and nematicide) decreased the development of VAM on groundnut. The effect of carbofuran was confirmed in the greenhouse.

1087 BAILEY, J.E.; SAFIR, G.R. Uptake and effect of benomyl in mycorrhizal soybean plants Dept. of Botany and Plant Pathology, Michigan State University. E. Lansing, Mi. Proc. Amer. Phytopath. Soc. 4:93 1977. Abst.

Soil drenches of benomyl (methyl-1-(butylcarbamoyl)-2-benzimidazolecarbamate) at 2.5, 25, 125, and 250 ppm (benomyl:oven dry soil) were added to pots newly planted to soybeans (Glycine max (L.)Merrill) and containing 120 chlamydospores/100g soil of the vesicular-arbuscular (VA) mycorrhiza-forming fungus Glomus fasiculatus. Mycorrhizal infection, recorded as percent of root length colonized, was decreased 30 to 45% by benomyl at 25 ppm in one experiment and 2.5 ppm in another. Concentrations as high as 250 ppm did not reduce infection below 32% of the root system. Benomyl at 125 ppm in the first and 2.5 ppm in the second experiment prevented increased growth due to the VA mycorrhizae even with infection as high as 48%. Benomyl uptake was measured in a bioassay using the benomyl-sensitive fungus Pennicillium digitatum and extracts of plant parts. No consistant uptake differences between mycorrhizal and non-mycorrhizal plants was found.

1088 BAILEY, J.E.; SAFIR, G.R. 1977. Effect of benomyl on soybean endomycorrhizae and the uptake of benomyl by mycorrhizal and non-mycorrhizal plants. Abstr. Third North Amer. Conf. on Mycorrhizae (Athens, Georgia, Aug. 23-25, 1977). Inst. of Mycorrhizal Res. Devel. U.S. Dept. Agric.-Forest Serv. p.11.

1089 BERTOLDI, M. DE; GIOVANNETTI, M.; GRISELLI, M.; RAMBELLI, A. **Effects on soil applications of benomyl and captan on the growth of onions and the occurrence of endophytic mycorrhizas and rhizosphere microbes.** *Annals of Applied Biology* (1977) 86 (1) 111-115 [En, 11 ref.] Istituto di Microbiologia agraria dell'Università di Pisa, Centro di studio per la microbiologia del suolo, C.N.R., Pisa, Italy.

When grown for 6 months in the absence of pathogens, repeated soil applications of benomyl or captan significantly and similarly decreased diameter of onion seedlings by 22-25% and dry weight by 31-34%. The losses were associated with differing effects on soil microbes. Whereas captan had no effect on the occurrence of vesicular-arbuscular mycorrhizas it appreciably decreased populations of rhizosphere fungi. In contrast benomyl inhibited mycorrhiza formation but had a relatively small effect on rhizosphere fungi.

1090 DAVIS, R. M.; MENGE, J. A. **The influence of endomycorrhizae on Phytophthora root rot of three crop plants.** [Abstract]. *Proceedings of the American Phytopathological Society* (1977) 4, 146 [En] California University, Riverside, California, USA.

Avocado and citrus seedlings with or without established *Glomus fasciculatus* were inoculated with *Phytophthora cinnamomi* (avocado) and *P. parasitica* [*nicotianae* var. *parasitica*] (citrus), or not inoculated, and growth differences were assessed after 3 months. With avocados, the average height increase of seedlings infected with mycorrhiza alone was 54.4 cm, compared with 40.1 cm for controls, 6.2 cm for those infected with *P. cinnamomi* alone, and 1.7 cm for those infected with both. Citrus seedlings infected with mycorrhiza alone were 7.5 times larger than non-mycorrhizal seedlings, but mycorrhizal infection made little difference to the size of *P. parasitica*-infected plants.

*1091 HUSSEY, R.S.; RONCADORI, R.W. Interaction of Pratylenchus brachyurus and an endomycorrhizal fungis on cotton. In: Third North

Amer. Conf. on Mycorrhizae (Athens, Georgia, Aug. 23-25, 1977) Inst. of Mycorrhizal Research., U.S. Dept. Agric. Forest Service p.2. 1977.

*1092 IQBAL, S. H.; QURESHI, K. S.; AHMAD, J. S. **Influence of vesicular arbuscular mycorrhiza on damping-off caused by *Rhizoctonia solani* in *Brassica napus*.** *Biologia, Pakistan* (1977) 23 (2) 197-208 [En, 16 ref., 2 pl. 4 tab.] Univ. Punjab, New Campus, Lahore, Pakistan.

Damping-off occurred in *Brassica napus* grown in pots infested with *R. solani* and endogonaceous spores, but none occurred in *B. campestris* grown under similar conditions. Poor light and more frequent watering favoured damping-off in *B. napus*. Higher rates of infection resulted in poor plant growth. Mycorrhizal infections increased with plant age.

1093 RIFFLE, J.W. Soil fumigation affects endomycorrhizal development on broadleaf seedlings in a northern plains nursery Proceedings of the American Phytopatological Society. 4:119-120. 1977.

A test with three fumigants (methyl bromide- MB 98% at 46 and 64 kg/ha, and 67% at 46 and 89 kg/ha Mylone, 50%, 3,5-dimethyltetra hydro-1,3,5, 2H-thiadiazine-2-thione at 28 and 37 kg/ha; Vorlex, 20% methyl isothiocyanate and 80% chlorinated C3 hydrocarbons at 38 and 61 l/ha) and one fungicide (Terraclor, 75% pentachloronitrobenzene at 20 kg/ha) was conducted on Mandan silt loam to determine effects on development of endomycorrhizae (EDM) on Lonicera tatarica, Elaeagnus angustifolia, Shepherdia argentea, and Fraxinus pennsylvanica seedlings. Seedbeds were treated in August and seeded in October 1974. At the end of the first growing season, 1280 1-cm root segments from 160 seedlings of each species were evaluated for incidence and density of EDM. All species from nonfumigated soil had 98% occurrence and 91% density EDM compared to 88% occurrence and 79% density EDM for species form fumigated soil. Seedlings from Terraclor plots had 87% density EDM. Seedlings in Mylone fumigated soil had greater stem heights, weights. and diameters than seedlings grown in MB fumigated soil. Root segments form seedlings from Mylone plots had 96% occurrence and 88% density EDM; seedlings from MB 98% plots had 77% occurrence and 66% density EDM. These data show that reduction of EDM by MB fumigation significantly effects growth of broadleaf seedlings during the first growing season. All of the above comparisons are statistically significant.

1094 RONCADORI, R. W.; HUSSEY, R. S. **Interaction of the endomycorrhizal fungus *Gigaspora margarita* and root-knot nematode on cotton.** *Phytopathology* (1977) 67 (12) 1507-1511 [En, 14 ref., 4 fig., 1 tab.] Univ. Georgia, Athens, USA.

Inoculation of cotton (*Gossypium hirsutum* cvs. McNair 511 and Stoneville 213) with azygospores of *G. margarita* significantly increased vegetative growth and square production (flower bud initials and flowers) over nonmycorrhizal plants in glasshouse studies. Growth stimulation and plant development were greater at a low fertility rate (250 μg/g 10-10-10 NPK) than at 500 μg/g. In joint inoculations with the endophyte and *Meloidogyne incognita*, development of endomycorrhizae nullified the stunting caused by the nematode. Azygospore production was greatest in joint culture on McNair 511 at the high fertility rate and on Stoneville 213 at the low fertility level.

1095 SCHONBECK, F.; DEHNE, H. W. **Damage to mycorrhizal and nonmycorrhizal cotton seedlings by *Thielaviopsis basicola*.** *Plant Disease Reporter* (1977) 61 (4) 266-267 [En, 6 ref.] Inst. für Pflanzenkrankheiten und Pflanzenschutz, Tech. Univ. Hannover, Herrenhäuser Str. 2, German Federal Republic.

Cotton seedlings were grown in sandy soil uninoculated or inoculated with *Glomus mosseae* and/or *Thielaviopsis basicola*. Black root rot occurred on mycorrhizal and nonmycorrhizal roots to the same extent, but the nonmycorrhizal plants were more severely damaged than the mycorrhizal plants.

1096 STEWART, E. L.; PFLEGER, F. L. **Influence of fungicides on extant *Glomus* species in association with field-grown peas.** *Transactions of the British Mycological Society* (1977) 69 (2) 318-319 [En, 13 ref., 1 tab.] Univ. Minnesota, St. Paul, USA.

Applications of banrot (1.8, 3.6 kg/ha a.i.) and pyroxychlor (1.1 kg/ha a.i.) both significantly reduced chlamydospore numbers of *G. mosseae* but $CuSO_4$ treatments did not. Although fewer chlamydospores were present in methyl bromide treated plots, the differences were not significant. Fungicides did not significantly affect numbers of *G. fasciculatus* chlamydospores.

1097 AZCON, R.; BAREA, J. M.; HAYMAN, D. S. **Utilization of rock phosphate in alkaline soils by plants inoculated with mycorrhizal fungi and phosphate-solubilizing bacteria.** *Soil Biology and Biochemistry* (1976) 8 (2) 135-138 [En, 21 ref.] Zaidin Experimental Station, Granada, Spain.

Lavender plants in soil inoculated with phosphate-solubilizing bacteria and mycorrhizas (*Endogone*) took up more P from rock phosphate than plants inoculated with bacteria or *Endogone* separately. Uninoculated plants derived no benefit from rock phosphate.

1098 EL-GIAHMI, A. A.; NICOLSON, T. H.; DAFT, M. J. **Effects of fungal toxicants on mycorrhizal maize.** *Transactions of the British Mycological Society* (1976) 67 (1) 172-173 [En] Department of Biological Sciences, University of Dundee, Dundee, DD1 4HN, UK.

The effects of four fungal toxicants on the growth and percentage mycorrhizal infection of maize previously inoculated with *Glomus mosseae* are tabulated.

1099 IYER, J. G.; WOJAHN, K. E. **Effect of the fumigant dazomet on the development of mycorrhizae and growth of nursery stock.** *Plant and Soil* (1976) 45 (1) 263-266 [En] Department of Soil Science, University of Wisconsin, Madison, USA.

The harmful effect of the fumigant Dazomet (DMTT, Mylone 50 D) on the development of mycorrhiza-forming fungi and accompanying growth of nursery stock is usually due to an inadequate pre-seeding detoxification period and/or a prolonged occurrence during this period of temperatures below 10 °C. The eradication of the symbionts is occasionally caused by the lateral movement of water causing local high concentrations of the toxic chemical. A low supply of soil organic matter greatly aggravates the vulnerability of the mycorrhiza-formers to damages by the eradicant. During the past many years, a critical demycorrhization of stock in Wisconsin nurseries was observed predominantly in soils with organic matter content of less than 1.5% in the 15-cm surface layer.

*1100 PFLEGER, F.L.; STEWART, E.L. The influence of fungicides on endemic population of Glomus species in association with field grown peas. Dept. Pl. Path., Univ. of Mn., St. Paul, Mn. 55108 . Proc. Amer. Phytopathol. Soc. 3:274. 1976. Abstr.

Seeds of Green Giant commercial pea cultivar 539 (Pisum sativum) were treated with captan alone or with a solution containing 15 g of $CuSO_4.5H_2O$ plus 1 g methocel in 100 ml water and air dried. Additional fungicides applied as in-furrow sprays included: Pyroxychlor (1.1, 4.5, and 9.0 kg/ha a.i.), Banrot 40 WP (1.8, 3.6, and 6.8 kg/ha a.i.), and $CuSO_4.5H_2O$ at 29 kg/ha a.i.. Pyroxychlor was also applied in an in-furrow granular form (1.1, 4.5, and 9.0 kg/ha a.i.). Specified plots were fumigated with Dowfume MC-2 (340 g methylbromide/9.32 cm) under plastic which was removed after 12 hr. Forty-two days after planting, a cylindrical soil core 15 x 30 cm was taken from all plots. Soil cores were divided into upper and lower 15 cm sections, stored at 5°C and mixed before a 500 ml sample was sieved wet for spore collection. Roots from each treatment were differentially stained using acid fuchsin lactophenol for verification of endomycorrhizae. Populations of Endogonaceae included Glomus mosseae and G. fasciculatus. Chlamydospores of G. mosseae were significantly more numerous in the upper than in the lower 15 mm soil core, whereas vertical distribution of G. fasciculatus chlamydospores did not differ significantly. Fungicides which significantly reduced chlamydospore numbers of G. mosseae were Banrot 40 WP

(1.8, 3.6 kg/ha a.i.), and Pyroxychlor applied as an in-furrow granular form and spray (1.1 kg/ha a.i.) Fungicides had no significant effect on numbers of chlamydospores of G. fasciculatus.

*1101 RONCADORI, R.W.; HUSSEY, R.S. Interaction of a vesicular-arbuscular mycorrhizal fungus and root knot nematode on cotton. Proc. Am. Phytopath. Soc. 3:245. 1976. Abst.
Root knot nematode susceptible (Stoneville 213) and resistant (McNair 511) cotton (Gossypium hirsutum) grown at recommended and 50% recommended fertility rates in the greenhouse were inoculated singly or jointly with Gigaspora calospora and Meloidogyne incognita. Twelve weeks after inoculation, shoot weights of mycorrhizal plants were 25 to 40% greater than the controls; however, root growth was not increased by the treatment regardless of cultivar or fertility level. M. incognita reduced shoot weight of both cultivars at the low fertility rate and suppressed root growth of Stoneville 213 at both fertility levels, but did not affect McNair 511. With joint inoculations G. calospora offset the reduced shoot growth caused by M. incognita. Generally, M. incognita did not inhibit fungal spore production; however, mycorrhizal synthesis in McNair 511 enabled M. incognita to reproduce significantly better then on the nonmycorrhizal plants at low fertility. Histological studies of the roots indicated that G. calospora was not associated with galled tissue 12 weeks after inoculation.

1102 BALTRUSCHAT, H.; SCHÖNBECK, F. **[Studies on the influence of endotrophic mycorrhiza on the infection of tobacco by *Thielaviopsis basicola*.] *Phytopathologische Zeitschrift*** (1975) 84 (2) 172-188 [De, en]

Reductions in dry weight due to *T. basicola* infection were less in mycorrhizal than in non-mycorrhizal tobacco plants. The production of *T.basicola* chlamydospores was strongly inhibited in mycorrhizal roots. Leaves of mycorrhizal plants contained increased levels of glycine, ornithine and phenylalanine and a reduced level of proline; the total free amino acid content was unaffected. Roots of mycorrhizal plants contained 50% more free amino acids, with the greatest increases in arginine and citrulline. Fungitoxicity of mycorrhizal roots was due to arginine. Some other crops also showed increased levels of arginine in mycorrhizal roots.

1103 BAREA, J. M.; AZCÓN, R.; HAYMAN, D. S. **Possible synergistic interactions between *Endogone* and phosphate-soluhilizing bacteria in low-phosphate soils.** 409-417 [En, 12 ref.] Estación Experimental del Zaiden, Granada, Spain.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp.

Maize plants were inoculated with *Endogone* sp., a suspension of phosphate-solubilizing bacteria (*Pseudomonas* sp. and *Agrobacterium* sp.) or both. Control plants were inoculated with autoclaved bacteria. Inoculation with *Endogone* favoured the maintenance of higher populations of phosphate-solubilizing bacteria in the rhizosphere. The bacteria did not affect the development of VA mycorrhiza. Plants with either mycorrhiza or bacteria took up more P and grew better than the control plants. Plants inoculated with both took up most P and grew best in 3 out of 4 cases. The possible parts played by root exudates, increased P supply, growth substances and pH in bringing about the synergistic effect are discussed.

1104 DEHNE, H. W.; SCHÖNBECK, F. **[Investigations on the influence of endotrophic mycorrhiza on *Fusarium wilt of tomato*.]** Untersuchungen über den Einfluss der endotrophen Mykorrhiza auf die *Fusarium*-Welke der Tomate. *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz* (1975) 82 (10) 630-632 [De, en, 7 ref.] Rheinischen Friedrich-Wilhelms-Universität, Bonn, German Federal Republic.

Tomato plants infected with *Fusarium oxysporum* f.sp. *lycopersici* wilted less if they had previously been inoculated with the endotrophic mycorrhizal fungus, *Glomus mosseae*, than plants which had not been previously inoculated. The mycorrhiza-treated plants had fewer yellowed leaves, with a higher chlorophyll content, and a lower ion-efflux from the stem than plants which had no endotrophic mycorrhiza.

1105 DEHNE, H.W; SCHONBECK, F. Untersuchungen uber den EinfluB der endotrophen Mykorrhiza auf die Fusarium-Welke der Tomate. The influence of the endotrophic mycorrhiza on the fusarial wilt of tomato. PflanzenKrakheiten 10:632-640. 1975.
A significant decrease in the degree of wilting caused by Fusarium oxysporum f. sp. lycopersici was detected in mycorrhizal tomato plants previously inoculated with Glomus mosseae. Mycorrhizal plants infested with Fusarium showed a lower percentage of yellowed leaves and a lower ion-efflux out of stem and leaf tissue when compared to non-mycorrhizal plants. In addition, the chlorophyll content was higher in leaves of mycorrhizal plants. The results indicate that endotrophic mycorrhiza decrease the amount of damage caused by Fusarium oxysporum f. sp. lycopersici on tomato.

1106 JALALI, B. L.; DOMSCH, K. H. **Effect of systemic fungitoxicants on the development of endotrophic mycorrhiza.** 619-626 [En, 10 ref.] Institut für Bodenbiologie, Forschungsanstalt für Landwirtschaft, Braunschweig, German Federal Republic.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp. 619 - 626. 1975.

Treatment of wheat seed with benomyl, thiabendazole or ethirimol had an adverse effect on formation of mycorrhiza on the roots by *Endogone* sp.

1107 SCHENCK, N. C.; KINLOCH, R. A.; DICKSON, D. W. **Interaction of endomycorrhizal fungi and root-knot nematode on soybean.** 607-617 [En, 8 ref.] Dep. of Pl. Path., Florida Univ., Gainesville, FL 32601, USA.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp. 607 - 617. 1975.

Soyabean cv. (a) Ransom and (b) Pickett (both susceptible to *Meloidogyne incognita* and (c) Forrest (resistant) were grown in soil inoculated with *Endogone heterogama*, *E. calospora* or *E. macrocarpa* and/or *Meloidogyne incognita*. Generally *M. incognita* reduced soyabean seed yields and *Endogone* spp. increased them. Seed yields of (a) and (b) were increased most by *E. macrocarpa* and those of (c) by *E. heterogama*. Absence of nematodes had least effect on (c). Yield and root wt. were lowest with high nematode inoculum levels and no mycorrhiza. The *Endogone* spp. differed in their interactions with *M. incognita*.

1108 WEAVER, D. J.; WEHUNT, E. J. **Effect of soil pH on susceptibility of peach to *Pseudomonas syringae*.** *Phytopathology* (1975) 65 (9) 984-989 [En, 30 ref.] Southeastern Fruit and Tree Nut Research Station, Byron, Georgia 31008, USA.

Peach seedlings, cv. Elberta, were grown in pots of soil, adjusted to various pH levels, from a peach orchard where bacterial canker had occurred, and were artificially inoculated with *Pseudomonas syringae* after they had become dormant. Seven weeks later, 3 of 5 of the inoculated trees in unadjusted soil (pH 5.6) had died. Two of 5 plants in soil adjusted to pH 6.1 with $MgCO_3$ also died, but no plants died in soil adjusted to pH 6.4, 6.6, 6.9 or 7.2 with $CaCO_3$ or $MgCO_3$. No differences in stem length, fresh weight of roots or discoloration of feeder roots were observed among the treatments. However, percentage of dry matter in roots was greater for plants grown at pH 6.4-6.9 than at 5.6, 6.1 or 7.2. Vesicular-arbuscular mycorrhizas were present in 77 to 94% of the feeder roots, with fewest roots infected at pH 6.6 where $MgCO_3$ was used. *Pythium* spp. propagules in the soil and from roots were positively correlated with soil pH. In December, populations of *Criconemoides xenoplax* were greater in soil adjusted above pH 6.1 but differences were no longer significant in March and April.

1109 BIRD, G. W.; RICH, J. R.; GLOVER, S. U. **Increased endomycorrhizae of cotton roots in soil treated with nematicides.** *Phytopathology* (1974) 64 (1) 48-51 [En] Department of Plant Pathology and Plant Genetics, Georgia University, Athens 30602, USA.

Field fumigation with dibromochloropropane or dichloropropene increased the endomycorrhizal infection of cotton roots. In highly productive soils, DBCP increased arbuscule, vesicle and spore production by mycorrhizal fungi; in unproductive soils there was no increase in arbuscule

formation but vesicle production was greater than in the productive soils. No endomycorrhizae were observed in roots grown in soils treated with methyl bromide.

1110 CHOU, L.G.; SCHMITTHENNER, A.F. Effect of *Rhizobium japonicum* and *Endogone mosseae* on soybean root rot caused by *Pythium ultimum* and *Phytophthora megasperma* var. *sojae*. Plant Disease Reporter (1974) 58(3):221-225.
Soybean (Harosoy-63) roots were exposed to all possible combinations of R. *japonicum*, E. *mosseae*, *Phytophthora megasperma* var. *sojae* races 1 and 3, and *Pythium ultimum*. P. *ultimum* + race 3 killed more plants than the latter alone. Soybeans infected with race 3 alone or with P. *ultimum* had significantly lower mean plants height and lower shoot dry wts. than those infected by P. *ultimum* and/or race 1. Race 3 infected soybeans had lower dry wts. in soil without R. and E. than with them. Fewer plants were killed by race 3 in soil with E. than without E.

*1111 MILNE, D. L. Citrus seedbeds: methyl bromide & mycorrhizae. *Citrus and Sub-Tropical Fruit Journal* (1974) No.488, 9-11 [En, af, 10 ref., 3 pl.] Citrus and Subtropical Fruit Research Institute, Nelspruit, South Africa.
A review. Details are given of the method of applying methyl bromide and its growth retarding effects on seedlings are discussed in relation to nutrient uptake and the presence or absence of endomycorrhizas in the soil.

1112 NEMEC, S. Population of Endogone in strawberry fields in relation to root rot infection. Transactions of the British Mycological Society (1974) 62 (1) 45-49. Southern Illinois Univ., Carbondale.
Generally, higher numbers of E. spores were found from Aug. to July in the rhizosphere of roots in a plot without root rot than in the rhizosphere of roots with root rot or in fallow soil. A large increase in spores occurred from May to July in the rhizosphere of the plot without root rot, with a lesser increase in that of the plot with root rot. The data indicate that early E. activity in young roots is not a direct or indirect cause or root rot symptoms, and that as the root becomes aged or diseased from other cause E. reacts by producing numerous spores in the rhizosphere.

1113 SCHENCK, N.C.; KINLOCH, R.A. Pathogenic fungi, parasitic nematodes and endomycorrhizal fungi associated with soybean roots in Florida. Plant Disease Reporter (1974) 58(2) 169-173.
In a 1971-72 survey of soybean roots and rhizosphere soil from 40 N. Fla. sites, Fusarium spp. were the commonest pathogenic fungi recovered followed by Rhizoctonia spp., Pythium spp. and Macrophomina phaseolina. Spores of endomycorrhizal fungi occurred in every sample and Endogone calospora was the most prevalent. Incidence of R. spp. was increased by the soybean cyst nematode. Incidence of P. spp. was increased and endomycorrhizal fungi decreased by root-knot nematodes.

*1114 BALTRUSCHAT, H.; SIKORA, R. A.; SCHONBECK, F. Effect of VA-mycorrhiza (*Endogone mosseae*) on the establishment of *Thielaviopsis basicola* and *Meloidogyne incognita* on tobacco. In *International Congress of Plant Pathology (2nd), Minneapolis, Minnesota, September 5-12, 1973. Abstracts of papers.* St. Paul, Minnesota, USA; American Phytopathological Society Inc. (1973) Abstract No. 661 [En] Inst. für Pflanzenkrankheiten, Univ. of Bonn, Nussallee 9, Bonn, GFR.
A negative correlation was established between the number of chlamydospores formed on tobacco roots by *Thielaviopsis basicola* and the degree of infestation by *Endogone mosseae*. In glasshouse studies 75% fewer larvae of *Meloidogyne incognita* became adults in plants infested with *E. mosseae* than in non-mycorrhizal plants.

*1115 BAREA, J.M.; BROWN, M.E.; MOSSE, B. Association between VA-mycorrhiza and *Azotobacter*. *In:* Rothamsted Exp. Sta. Report 1972:81-82. 1973.

1116 CHOU, L.G.; SCHMITTHENNER, A.F. Effect of *Rhizobium japonicum* and *Endogone mosseae* on virulence of *Pythium ultimum* and *Phytophthora megasperma* var. *sojae* on soybeans. (Abstract). Second Internat. Congr. Pl. Path., Univ. Minnesota, Minneapolis. 0662. 1973.

1117 DAFT, M.J.; OKUSANYA, B. O. Effect of *Endogone* mycorrhiza on plant growth. V. Influence of infection on the multiplication of viruses in tomato, petunia and strawberry. *New Phytologist* (1973) 72 (5) 975-983 [En] University of Dundee, UK.
Mycorrhizal infection increased the rate of multiplication of tomato ancuba mosaic virus, and the rate of mycorrhizal development affected the production of potato virus X. Mycorrhizal petunia and strawberry plants contained more extractable arabis mosaic virus than did non-mycorrhizal plants. These results are attributed to enhanced P uptake by mycorrhizal plants, as the production of virus was stimulated in non-mycorrhizal plants supplied with increasing levels of soluble P.

*1118 DAVEY, C.B. Nonpathogenic organisms associated with mycorrhizae. *In:* Hacskaylo, E., ed. 1971. Mycorrhizae. Proceedings of the First North American Conference on Mycorrhizae held at University of Illinois, April 1969. Misc. Publ. USDA Forest Serv. 1189 (114-121).
A review with 41 references discussing the effects of various bacteria, fungi, algae, a mycophagous nematode and certain small mites.

*1119 RIFFLE, J.W. Effect of nematodes on root-inhabiting fungi. *In:* Hacskaylo, E., Ed. Mycorrhizae. USDA, For. Serv., Misc. Publ. 1189:97-113. 1971.

*1120 BALTRUSCHAT, H.; SCHONBECK, F. {Studies on the effect of endotrophic mycorrhiza on chlamydospore production of *Thielaviopsis basicola* in tobacco roots.} Untersuchungen uber den Einfluss der endotrophen Mycorrhiza auf die Chlamydosporenbildung von *Thielaviopsis basicola* in Tabakwurzeln. Phytopathologische Zeitschrift, 1972, 74(4):358-361.
T. basicola produced fewer chamydospores on tobacco roots infested by *Endogone mosseae* than on non-mycorrhizal ones. Production was negatively correlated with the amount of mycorrhizal fungus present. The addition of mycorrhizal root extracts to malt agar medium on which *T. basicola* was grown inhibited chlamydospore production by 80-100%.

1121 FOX, J.A.; SPASOFF, L. Interaction of Heterodera solanacearum and Endogone gigantea on tobacco. Journal of Nematology (1972) 4(4) 224-225.
In galsshouse experiments H. solanacearum and E. gigantea mutually suppressed reproduction of one another.

*1122 MARX, D.H. Biological control of root diseases in forest tree nurseries with emphasis on the role of mycorrhizae. *In:* Biological Control of Forest Diseases. XV IUFRO Congress. Subj. Group 2, Ottawa, Canada Forestry Service, 1971:55-65. 1972.

*1123 MOSSE, B.; BROWN, M.E. Interaction between VA mycorrhiza and nitrogen fixation by rhizosphere microorganisms. Rothamsted Exp. Sta. Report 1971:94. 1972.

*1124 RIDGE, E.H.; THEODOROU, C. Effect of soil fumigation on microbial recolonization and mycorrhizal infection. Soil Biol. & Biochem., 4:295-305. 1972.

1125 ROSS, J.P. Influence of Endogone mycorrhiza on Phytophthora rot of soybean.

Phytopathology (1972) 62(8):896-897.
When susceptible soybean plants were grown in soil infested with P. megasperma var. sojae and a chlamydosporic sp. of Endogone, 88% of the plants developed internal stem discoloration and 33% died. In plots infested with P. alone 17% developed discoloration but none died. E. had no effect on rot symptoms in a more tolerant cv.

1126 SCHÖNBECK, F. SCHINZER, URSULA.
1972. Untersuchungen über den einfluss der endotrophen mycorrhiza auf die TMV-Läsionenbildung in nicotiana tabacum L. var. Xanthi-nc [Investigations on the effect of endotrophic mycorrhiza on formation of Tobacco mosaic virus lesions in Tobacco var. Xanthi- n.c.] Phytopath. Z. 73(1): 78-80
After virus inoculation, more local lesions developed in the mycorrhizal (Endogone mossae) than non-mycorrhizal plants.

1127 DANIELS, B. A.; McCOOL, P. M.; MENGE, J. A. Comparative inoculum potential of spores of six vesicular-arbuscular mycorrhizal fungi. *New Phytologist* (1981) 89 (3) 385-391 [En, 10 ref., 2 fig., 2 tab.] Dep. Pl. Path., Univ. California, Riverside, USA.

Glomus mosseae exhibited the highest inoculum potential while *G. constrictus* and 2 isolates of *G. fasciculatus* were c. 1/5, 1/6 and 1/12 as effective. *G. fasciculatus* isolate 185 and *G. epigaeus* were c. 1/50 as effective. The differences were not correlated with differences in spore viability or germinability since c. 75% germination occurred in all spp. after 3 wk. While *G. mosseae* had the largest spores and highest inoculum potential, no further correlation between the 2 parameters was observed. The rate of increase of infection by the 6 fungi differed more when equal spore numbers were used as inoculum than when equalized inoculum potentials were used. The percentage root infection, subjected to the multiple infection correction, was regressed against log of inoculum density and yielded slopes of 0.63 and 0.7 for all the fungi tested. The inoculum density-infection relationships of mycorrhizal fungi are discussed with respect to Baker's epidemiological models [*RPP 51*, 2215].

1128 DANIELS, B. A.; MENGE, J. A. Evaluation of the commercial potential of the vesicular-arbuscular mycorrhizal fungus, *Glomus epigaeus*. *New Phytologist* (1981) 87 (2) 345-354 [En, 14 ref.] Department of Plant Pathology, University of California, Riverside, California, 2521, USA.

The potential of *Glomus epigaeus* for commercial use was evaluated with respect to epigeous spore production, host growth stimulation and methods of spore storage. Significantly more sporocarps were produced on sudan grass watered manually than on tomato, soybean or asparagus plants which were watered manually, misted or enclosed in plastic to increase surface humidity. Sporocarps produced on sudan grass varied in size from 3 to 7 mm to 8 to 12 mm in diameter, depending on age, and each contained approximately 1×10^5 to 7.5×10^6 spores. An average of 4.5 sporocarps were produced per pot monthly. Significant growth average of 4.5 sporocarps were produced per pot monthly. Significant growth responses occurred in tomato, soybean, citrus, maize, sudan, asparagus and cotton but not in olive. Growth responses to *G. mosseae* occurred in tomato, citrus and cotton to *G. fasciculatus* in citrus only, to *G. epigaeus* in tomato, citrus, maize, sudan grass and asparagus, and to *G. constrictus* in maize only. Germinability of nondisinfested and surface disinfested (10% chlorox or chloramine T-streptomycin) *G. epigaeus* spores was tested following storage for 3 months using 13 methods. No surface disinfested spores germinated except those stored in wet loamy sand. 1, 33, 80, 37, 13 and 83% respectively of nondisinfested spores stored in moist loamy sand, dry loamy sand, sterilized bentonite, sterilized H_2O, streptomycin gentamycin solution and as whole sporocarps germinated. The spore producing capacity, efficiency on a wide range of host plants and ease of storage make *G. epigaeus* a vesicular-arbuscular mycorrhizal fungus with considerable commercial potential.

1129 DANIELS, B.A.; McCOOL, P.M. Inoculum potential of spores of six vesicular-arbuscular mycorrhizal fungi. Phytopathology 71(2):212. 1981. Spores were extracted from pot cultures of the vesicular-arbuscular mycorrhizal species *Glomus fasciculatus* (isolates 0-1, 92, and 185), *G. constrictus*, *G. epigacus* and *G. mosseae*. Four three-fold dilutions were made from the standard inoculum density of 2000 spores/20 g sandy loam. Ten replications of the five dilutions per species were utilized. Each vial was seeded with 5 seeds of sudangrass and grown in a growth chamber for 6 weeks.

Based on number of replicates at each dilution level which were scored as infected, *G. mosseae* has the highest inoculum potential. *G. fasciculatus* isolate 92 and *G. constrictus* were only 50% as effective as *G. mosseae* while *G. fasciculatus* (0-1), *G. epigaeus*, and *G. fasciculatus* (185) were only 10.7, 7.2, and 4.1% as effective, respectively, as *G. mosseae* according to probable number table. Differences in spore size did not appear to be related to inoculum potential.

*1130 FERGUSON, J. J.; MENGE, J.A. Inoculation production and field application of endomycorrhizal fungi. Dept. of Plant Pathology, University of California, Riverside, CA 92521. Phytopathology 71(8): 873. 1981. Abstract. Endomycorrhizal spore production was influenced by photoperiod and light intensity. When mycorrhizal sudan grass, inoculated with Glomus fasciculatus, was exposed to extended photoperiods under uniform high intensity mercury vapor and metal halide lamps, significant levels of spore production (60spores/g soil) occurred earlier than in plants grown under normal daylength conditions. Decreasing light intensities reduced infection and sporulation in mycorrhizal sudan grass grown under low soil phosphorus conditions. Mechanized field inoculation of direct seeded and transplanted citrus seedlings can be carried out, utilizing both tractor-mounted fertilizer banding equipment and tractor-drawn seeding machines. After soil inoculation soil inoculum remained consistently infective for up to 10 weeks in fumigated field soil and for up to 7 weeks in greenhouse citrus pot cultures. Under field conditions inoculum densities as low as 2.700 spores/m2 stimulated citrus root infection and growth.

*1131 GIOVANNETTI, M.; BAGNOLI, G.; LEPORINI, C. [Sporocarp production in *Glomus mosseae* in the presence of increasing concentrations of nitrogen.] La produzione di sporocarpi in *Glomus mosseae* in presenza di concentrazioni crescenti di azoto. *Micologia Italiana* (1981) 10 (3) 25-28 [It, en, 15 ref., 1 tab.] Cent. Soil Microbiol., CNR, Pisa, Italy.

Vesicular-arbuscular mycorrhizal infection on sorghum plants on sterile sand was inhibited by addition of N (as $NaNO_3$) at 114 mg/l. Mycelial development outside the matrix and sporocarp formation were totally inhibited. Mycorrhizal development and production of sporocarps and mycelium were max. at 23 mg/l of N. The results are discussed in relation to the importance of maintaining and increasing soil fertility in marginal soils.

1132 GOULD, A. B.; LIBERTA, A. E. Effects of topsoil storage during surface mining on the viability of vesicular-arbuscular mycorrhiza. *Mycologia* (1981) 73 (5) 914-922 [En, 13 ref., 2 tab.] Illinois State Univ., Normal, USA.

The populations of viable VA mycorrhizal inocula decreased after topsoil storage for 4 yr compared with storage for 3 yr.

1133 HIRREL, M.C. The effect of sodium and chloride salts on the germination of Gigaspora margarita. Mycologia 37(4): 610-617. 1981 At various Na+ and Cl- concentrations, germination rates of azygospores of Gigaspora margarita were reduced more in the presence of Cl- than Na+ Viable spores, which had not germinated after 12 da in either 1.71x10-i molar Na+ or Cl-, were transferred to 0.01% glucose for 17 more da. The recovery of germinability by these spores was more rapid if the spores were previously exposed to Na+ rather than exposed to Cl-. Because of possible interactions between ion species in the different salt solutions used in this study, a specific ion effect can not be conclusively demostrated.

1134 KOSKE, R. E. *Gigaspora gigantea*: observations on spore germination of a VA-mycorrhizal fungus. *Mycologia* (1981) 73 (2) 288-300 [En, 33 ref., 2 fig., 2 tab.] Univ. Rhode Island, Kingston, USA.

Spore germination of a vesicular-arbuscular mycorrhizal fungus in the absence of a host plant was investigated. Spores of *G. gigantea* were tested for germination under lab. conditions like those in the field. No differences were noted

between germination of surface sterilized or nonsurface sterilized spores, collected throughout the year, and incubated at several temps. on 2% agar and sterile or nonsterile dune sand. Germination was unaffected by P concs. of up to 500 p.p.m. Spores extracted from the dune sand without washing or sieving germinated as well as those recovered by conventional methods. Germination rates were not improved by cold storage. Water potentials of -10 bars or glucose in the medium slowed the germination rate and the growth of germ tubes. The implications of these results are discussed.

1135 KOSKE, R. E. Multiple germination by spores of *Gigaspora gigantea*. *Transactions of the British Mycological Society* (1981) 76 (2) 328-330 [En, 10 ref.] Dep. of Bot., Univ. of Rhode Island, Kingston, Rhode Island 02881, USA.

Spores of the VA mycorrhizal fungus *Gigaspora gigantea* were able to germinate up to 10 times over a 53 day period when germ tubes were severed as they were produced. Nearly half the spores germinated 4 times, the average number of germinations per spore being 3.8. Spores whose germ tubes were not severed produced up to 9 germ tubes over several weeks.

*1136 REEVES, F.B.; SCHMIDT, S.; SABALONI, J. SCHWAB, S.; REDENTE, E.F. Changes of mycorrhizal inoculum potential in stockpiled topsoil. Annual Meeting og the Pacific Division of the American F Phytopathological Society, June 22-25 1981. Phytopathology: 71(9):1006. 1981. Abstract. Often topsoil is stockpiled for long periods prior to its use in the reclamation of distrubed habitats. The mycorrhizal inoculum potential (MIP) in a topsoil storage pile established in 1978 in the Piceance Basin of western Colorado was measured with a 21 d corn biossay, Soil samples (8cm diam cores) of this pile were taken to a depth of 150 cm in 1978, 1979, and 1980. The MIP (of vesicular-arbuscular mycorrhizal fungi) decreased significantly after 27 mo storage. The rate of decrease in MIP was greater in the upper 60 cm of the pile. These data suggest that the quality of stored topsoil as a growth medium for plants requiring VA mycorrhizae can deteriorate rapidly under semi-arid conditions in the West.

1137 TOMMERUP, I. C.; ABBOTT, L. K. **Prolonged survival and viability of VA mycorrhizal hyphae after root death.** *Soil Biology & Biochemistry* (1981) 13 (5) 431-433 [En, 10 ref.] Dep. of Soil Sci. and Plant Nutrition, Univ. of Western Australia, Nedlands, Western Australia 6009.

Subterranean clover root fragments infected with vesicular arbuscular mycorrhizae (VAM) were dried to a matric water potential of -50 MPa and stored for 6 months. When these dead root fragments were subsequently incubated in steamed soil for 4 weeks, new hyphae arose from roots containing *Glomus monosporus*, *G. fasciculatus* and *Gigaspora calospora*, but not from roots containing *Acaulospora laevis* or *Glomus caledonius*. The new hyphal growth was initiated from the original VAM hyphae in the dead root cortex, and formed new mycorrhizal infections in clover seedlings.

1138 ABERCH, S.M.; FORTIN, J.A. Germination of zygospores of *Endogone incrassata*. Mycologia 74(5): 861-864. 1982.

1139 GLENN, M.G. Pre-infection growth of Vam fungi. Phytopathology 72(8): 1135-36 1982 Abst.

Pre-infection growth patterns of Glomus mosseae and Gigaspora gigantea were observed when resting spores were germinated on minimal salts agar without roots, near elongating roots of compatible hosts Nicotiana tabacum and Allium cepa, and near elongating roots of non-hosts Brassica campestris and B. napus. In the absence of roots, germ tubes were sparsely branched. Presence of a host or non-host root tip stimulated many hyphal branches. With hosts, contact and penetration usually followed. Responses to Brassica root tips ranged from stubby branches oriented both toward and away from roots, to contact and penetration. Compared to hyphal branches stimulated by hosts, those due to Brassica arose closer to the root, and often senesced before making contact. Even though young and vigorous hyphae penetrated Brassica roots there was never any post-penetration flush of hyphal growth, and functional symbioses never developed.

*1140 GLENN, M.G. In situ observation of VA mycorrhizal infection. Phytopathology 72(7) 929, 1982. Abst.

VA mycorrhizal resting spores germinate on water agar and produce a network of exploratory hyphae. Hyphae branch in respon to nearby root tips, make contact, form appressoria, and penetrate the root surface. Seedlings of Nicotiana tabacum, Brassica campestris or B. napus, and spores of Glomus mosseae or Gigaspora gigantea were placed in proximity on slides thinly coated with water agar. Slides were covered with dialysis membrane and incubated on filter paper in 15 cm petri plates under cool white lights. Plates were inclined 30° with a pool of Hepper's nutrient solution in the bottom. Mycorrhizae deve oped on the slide when hyphae encountered elongating roots, an could be monitored at 12-30x without opening the plates. Slid were removed for high power examination after 2-3 weeks. Afte living mycorrhizae were observed at 100-400x, the slide was fixed in gluteraldehyde and OsO_4. Excised segments were prepared for SEM or embedded and sectioned. Mycorrhizae stained black with Os and were easily located.

1141 GRAHAM, J. H. **Effect of citrus root exudates on germination of chlamydospores of the vesicular-arbuscular mycorrhizal fungus, *Glomus epigaeum*.** *Mycologia* (1982) 74 (5) 831-835 [En, 7 ref., 2 fig., 1 tab.] Univ. Florida, Agric. Res. Education Cent., Lake Alfred, USA.

Opt. temp. for germination of surface-sterilized chlamydospores on water agar was 25°C. After 7 days' exposure of spores to root exudates their germination was increased from < 10% (distilled water control) to up to 27%. Germ tube length of exudate-treated spores was >4 times greater than that of untreated spores. Root exudates stimulated germ tube branching. The results indicate that the exudates could affect root colonization and VAM formation.

*1142 KROPP, B.R. Rotten wood as mycorrhizal inoculum for containerized western hemlock Can. Journal For. Res. 12:428-430 (1982).

1143 MILLER-WIDEMAN, M.A.; WATRUD, L.S. Sporulation of Gigaspora margarita on root cultures of tomato. Phytopathology 72(7):929. 1982. Abst.

Use of pre-germinated spores of Gigaspora margarita on agar root cultures of tomato routinely resulted in successful mycorrhizal infections on more than 50% of the plates which were inoculated. Penetration into the root, vesicle formation, arbuscule production and new spore formation were reproducibly observed and are described.

1144 SYLVIA, D.M.; SCHENCK, N.C. Effect of post-colonization treatments of sporulation of vesicular-arbuscular mycorrizal fungi. Phytopathology 72: 950. 1982. Abst.

Availability of spores is a limiting factor in mycorrhizal research. Our objective was to find treatments to stimulate sporulation in pot culture. Glomus mosseae, G. clarum and Gigaspora margarita were grown on Paspalum notatum in the greenhouse. During the logarithmic phase of root colonization five pots/species were exposed to one of six treatments: shoots removed (pruned), water withheld 9 days (drought), exposed to 5 C for 4 days in the dark (cold/dark), sprayed with paraquat at 69g a.i./ha, soil drenched with P_2O_5 at 500 ppm/pot, or soil drenched with ethazole at 12.5 ppm/pot. On an average, spores/g soil at 18 wk for G. mosseae and G margarita (soil pH 6.5) increased 99 40, or 24 percent in response to P_2O_5, drought, or paraquat; and decreased 4, 9, or 48 percent with pruning, cold/dark, or ethazole treatments, respectively, when compared to the no treatment control. Spore numbers for G. clarum (soil pH 4.5) were not affected by P_2O_5 or drought but were suppressed by pruning, drought, cold/dark, and paraquat treatments.

1145 YOUNG, J.L. Survival of endomycorrhizal spores/propagules during long-term air-dry storage. Agronomy Abstracts 1982. p.199.

Some remnants of vescicular-arbuscular mycorrhiza (VAM) in a broad range of soil types have proven capable of germinating and colonizing roots of biossay plants (Kalo=Lotus corniculatus Sudan grass=Sorghum vulgare sudanensis) after 2 to > 28 years storage in soils, air dried and k kept at room temperature (<20 to > 35°C). Stored materials represented a spectrum of soil and climatic conditionsmainly in Oregon and Washington, but included some samples from ash flows of Mt. Shasta, a calcareous blackland Vertisol from.

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Texas, and an acidic sandy soil from Florida. Extent of root colonization in bioassay plants resulting from "stored" propagules sometimes exceeded that from fresh stock-culture spores or soils. The durability of such VAM spores/propagules in the stored soils contrasts with apparent fragility of specimen Gigaspora gigantea and margarita spores that were allowed to air dry <1 hour on a watch glass in the absence of soil. Range of spore types that still appeared viable despite aging, rigors of soil processing, and long-time air-dry storage included representatives of Acaulospora, Gigaspora, Glomus and Sclerocystis species. The results are of interest in relation to devising stable VAM preparations for experimental work and for potential commercial packaging and use, a la rhizobia inocula.

1146 BAGYARAJ, D. J.; MANJUNATH, A. **Selection of a suitable host for mass production of VA mycorrhizal inoculum.** *Plant and Soil* (1980) 55 (3) 495-498 [En, 8 ref., 2 tab.] Univ. Agric. Sci., GKVK Campus, Bangalore, India.

Of 8 grasses tested, guinea grass (*Panicum maximum*) proved the best host since it was more susceptible to infection and also supported higher spore production by *Glomus fasciculatus*.

1147 DANIELS, B. A.; TRAPPE, J. M. **Factors affecting spore germination of the vesicular-arbuscular mycorrhizal fungus, *Glomus epigaeus*.** *Mycologia* (1980) 72 (3) 457-471 [En, 23 ref., 6 fig., 4 tab.] Oregon State Univ., Corvallis, USA.

Soil moisture, temp. and, to a lesser degree, pH, influenced germination of these spores, whereas levels of soil fertility and spore density had little or no effect. Max. germination occurred in soil at moisture levels at or above field capacity, at 18-25°C and pH 6-8. No germination occurred in autoclaved forest, dune and agricultural soils, or in gamma-irradiated or steamed Chehalis silt loam. Germination was 65-80% in most nonsterile soils and in both autoclaved and nonsterilized kaolin and activated charcoal. It was similar in nonsterile Chehalis soil containing nonmycorrhizal, ectomycorrhizal or vesicular-arbuscular mycorrhizal hosts. *Glomus mosseae* and *Gigaspora gigantea* also germinated readily in nonsterile soil. Max. germination of spores seems closely related to conditions that are opt. for growth of many host plants.

1148 DANIELS, B. A.; MENGE, J. A. **Secondary sporocarp formation by *Glomus epigaeus*, a vesicular-arbuscular mycorrhizal fungus, in long-term storage.** *Mycologia* (1980) 72 (6) 1235-1238 [En, 5 ref., 2 fig.] Univ. California, Riverside, USA.

Sporocarps stored for > 5 months under refrigeration (10°C) formed secondary sporocarps, growth of which reached a max. 2-3 weeks after they were first discernible. When the spores in these structures were examined microscopically, 88.7% appeared to be viable compared with 28.6% of the older stored spores. In germination tests 72.1% of spores from the new sporophores germinated compared with 15.5% from the old. It is suggested that the production of secondary sporocarps may be an adaptation to increase survival before individual spores become incapable of germination during prolonged storage.

1149 MILLER, R. M. **Effects of topsoil storage during surface mining on the viability of VA mycorrhiza.** *Soil Science* (1980) 129 (4) 253-257 [En, 21 ref.] Department of Biology, Illinois State University, Normal, Illinois 61761, USA.

Storing topsoil for 3 years was shown to reduce substantially the levels of viable inocula relative to levels in adjacent, undisturbed prairie soils. The detrimental effect of storage on VA mycorrhiza is associated with the loss of viability of mycorrhizal fragments occurring in the stored soil. Data are also presented supporting an interaction between infected root segments and roots of uninfected plants as a major means of spreading mycorrhiza in these soils.†

1150 POWELL, C. L. **Effect of phosphate fertilisers on the production of mycorrhizal inoculum in soil.** *New Zealand Journal of Agricultural Research* (1980) 23 (2) 219-223 [En, 22 ref., 4 tab.] Ruakura Soil Pl. Res. Sta., Minist. Agric. Fisheries, Hamilton, New Zealand.

Mycorrhizal inocula (*Glomus tenuis* or *Gigaspora margarita*) were prepared in 2 soils by growing white clover host plants with various phosphate fertilizers applied at 0-2.8 g/pot. Infectivity of the inocula was subsequently assessed using white clover as a test plant. Superphosphate generally reduced inoculum infectivity despite greatly increased host root growth. Chatham Rise and Christmas Island 'C' grade rock phosphates had little overall effect on inoculum density despite greatly increased root growth in soil fertilized with the former.

1151 RIVES, C. S.; BAJWA, M. I.; LIBERTA, A. E.; MILLER, R. M. **Effects of topsoil storage during surface mining of the viability of VA mycorrhiza.** *Soil Science* (1980) 129 (4) 253-257 [En, 21 ref., 4 tab.] Illinois State Univ., Normal, Ill., USA.

Storing topsoil for 3 yr substantially reduced the level of vesicular-arbuscular mycorrhizal inoculum, compared with that in adjacent undisturbed prairies soils. The effect was associated with loss of viability of mycorrhizal fragments and not with numbers of *Glomus fasciculatus* spores. An interaction between infected root segments and roots of uninfected plants appears to be important in spreading mycorrhiza in these soils.

1152 ROSS, J. P. **Effect of nontreated field soil on sporulation of vesicular-arbuscular mycorrhizal fungi associated with soybean.** *Phytopathology* (1980) 70 (12) 1200-1205 [En, 12 ref., 3 fig., 3 tab.] USDA, North Carolina State Univ., Raleigh, USA.

Cultures of *Glomus macrocarpus* var. *geosporus* or *Gigaspora gigantea* were established on soybean plants growing in steamed or fumigated soil or sand amended with various amounts of nontreated soil, or organic matter extracted from nontreated soil. Spore counts were made after 3-4 months and expressed as the number/g root. Amendments of 1 and 5% nontreated soil to steamed soil reduced *Glomus* sporulation almost 3 and 6-fold, respectively, compared with sporulation in steamed soil. Av. chlamydospore size of *Glomus* was significantly less in soil amended with nontreated soil compared with that in steamed soil and was positively correlated with spore numbers. Additions of 5% nontreated soil decreased azygospore production of *G. gigantea* by 93%. Separation of cultures of *Glomus* in steamed soil from nontreated soil by means of a polycarbonate membrane (pore size 0.2 μm) prevented sporulation suppression. Soybean seedling roots grown in nontreated soil for 1 week did not transmit the sporulation suppressor when transplanted without soil into steamed soil. Organic matter extracted from nontreated soil manifested sporulation suppression similar to that of nontreated soil; the suppressive activity was eliminated when organic matter was heated for 15 min at 65-75°C. Additions of small amounts of nontreated soil or organic matter to *Glomus* cultures in quartz sand induced 2-3 and 7-8 fold increases in sporulation, respectively, over that obtained when the additions had been steamed. Additions of cultures of actinomycetes isolated from nonsterile soil to cultures of *Glomus* or *Gigaspora* in steamed soil had little or no effect on sporulation. Additions of 4.6% by vol. of nonfumigated soils, of 4 different classifications, to soil in plots which had been fumigated with methyl bromide also caused significant reductions in sporulation of mycorrhizal fungi. A clay soil induced a greater reduction of total *Glomus* sporulation than the 3 loam soils. The results explain in part why infection and sporulation on soybean roots in the field are only a fraction of those found in experiments with sterile soils.

1153 HEPPER, C. M. **Germination and growth of *Glomus caledonius* spores: the effects of inhibitors and nutrients.** *Soil Biology & Biochemistry* (1979) 11 (3) 269-277 [En, 36 ref., 4 fig., 6 tab.] Rothamsted Exp. Sta., Harpenden, Herts., UK.

Spores of this vesicular-arbuscular mycorrhizal endophyte readily germinated in the absence of soil or host roots. Hyphal growth was improved by incorporation of nutrients in the medium or by addition of pieces of cotyledon, but still depended on the spore reserves. The responses of ungerminated and pregerminated spores to inhibitors of protein and nucleic acid synthesis resembled those of saprophytic fungi more than other obligate biotrophs.

1154 LUEDDERS, V. D.; CARLING, D. E.; BROWN, M. F. **Effect of soybean plant growth on spore production by *Glomus mosseae*.** *Plant and Soil* (1979) 53 (3) 393-397 [En,

13 ref.] USDA, SEA, AR, Dep. of Agron., Missouri Univ., Columbia, MO 65211, USA.

Plants of 2 soyabean cv. infected with *G. mosseae* were physiologically stressed by top removal and were harvested at 7 2-wk intervals. Removing tops stopped root growth, stimulated branching and delayed plant growth stages by c 2 wk, but did not affect spore production. Spore numbers were significantly related only to time of harvest. Pot variation in spore number was not significantly correlated with infection percentage or root dry wt. Harvest, cv. and cutting effects were highly significant for root and shoot wt. and root:shoot ratios.

1155 MERTZ, S. M., JR.; HEITHAUS, J. J., III; BUSH, R. L. **Mass production of axenic spores of the endomycorrhizal fungus *Gigaspora margarita*. *Transactions of the British Mycological Society* (1979) 72 (1) 167-169** [En, 10 ref., 2 tab.] Monsanto Agric. Products Co., St. Louis, Miss., USA.

Soil containing large numbers of mature spores of *G. margarita* was collected in late Nov. and stored at 4°C. Five US gal. lots of the soil were decanted and wet sieved with cold water; the spore fraction was collected between 425 and 250 µm sieves. Some debris was removed by decanting or vacuum aspiration of the surface of the water and spores were separated from most of the remaining debris by using discontinuous 30% (w/v) aqueous sucrose gradients, followed by centrifugation. Up to 10 000 spores/man-day could be recovered by these means and 99.9% of the accompanying debris removed. Spores were surface-sterilized by 2 10-min treatments in 1% (w/v) chloramine T, 5 min of each treatment being *in vacuo*, or by storing for at least 1 week in the dark at 4° in a filter-sterilized solution of 200 p.p.m. streptomycin and 100 p.p.m. gentamycin. It was important to keep the spores chilled to maintain the state of dormancy and prevent germination before use. Spores stored in antibiotic solution for 1 yr at 4° remained viable and lost none of their ability to germinate.

*1156 WOODHEAD, S.H.; KENNEY. D.S. VA mycorrhizal fungi starter cultures. Phytopathology 69:(9): 1049. 1979. Abst.

Vesicular-arbuscular mycorrhizal fungi are propagated in pot cultures on the roots of living plants. Through the cooperation of researchers at various universities throughout the United States, twenty-three isolates representing fifteen species of these fungi are being maintained by Abbott Laboratories on various host plants. These hosts are rotated to reduce root pathogen build-up. The plants are maintained in a healthy condition for three to four months and then harvested. A soil sample is wet sieved and checked for spore number and contamination by other mycorrhizal species. The cultures are stored at cool temperatures until use. As a service to investigators interested in endomycorrhizal research, Abbott Laboratories is distributing starter cultures of these fungi for a modest fee. The starter cultures consist of living fungal spores of a single species, root tissue of the previous host and soil.

1157 DANIELS, B.A.: DUFF, D.M. Variation in germination and spore morphology among four isolates of Glomus mosseae. Mycologia 70(6): 1261-1267. 1978.

1158 MENGE, J. A.; JOHNSON, E. L. V. **Commercial production of mycorrhizal inoculum may benefit citrus growers. *Citrograph* (1978) 63 (6) 139-143** [En, 16 ref., 2 fig., 1 pl.] California University, Riverside, California, USA.

Some of the beneficial effects of vesicular-arbuscular mycorrhizal fungi on citrus are discussed, including greatly increased growth in fumigated or sterilized soils, associated with enhanced mineral uptake. A proposed scheme for the commercial production of pathogen-free mycorrhizal inoculum is outlined.

1159 DANIELS, B. A.; GRAHAM, S.O. Effects of nutrition and soil extracts on germination of Glomus mosseae spores. Mycologia (1976) 68(1) 108-116 Washington State Univ., Pullman, Wash., USA.

The effect of nutrient level on germination of G. (Endogone) mosseae spores is described, and the effects of soil factors, various commercial agars and spore age on germination are clarified.

1160 GREEN, N.E.; GRAHAM, S.O.; SCHENCK, N.C. The influence of pH on the germination of vesicular-arbuscular mycorrhizal spores. Mycologia (1976) 68 (4) 929-934.

Studies showed that germination of Glomus mosseae spores is favoured by neutral to alkaline conditions especially at lower temperatures, while that of Gigaspora coralloidea and G. heterogama spores is favoured by acid conditions. The K ion conc. was not influential since substitution of NaOH for KOH produced similar results. The results are consistent with the environments from which the 3 spp. were originally derived. It is suggested that manipulating soil pH may increase the beneficial effects of endomycorrhiza on crop plants.

1161 HEPPER, C. M.; SMITH, G.A. Observations on the germination of Endogone spores. Transactions of the British Mycological Society (1976) 66(2) 189-194.

Although reliable germination of E. spores has previously been difficult to achieve it was possible to obtain >90% yields of germinated E. mosseae spores on distilled water agar. Zn and Mn at the concs. present in many commercially available agars could completely inhibit spore germination. Spores from freshly harvested sporocarps germinated slowly; this was improved by storing the sporocarps at 6°C for several weeks. The germination of some spore sources was improved by the addition of nicotinic acid or thiamine HCl to the agar.

1162 TRAPPE, J.M.; MASER, C. Germination of spores of Glomus macrocarpus (Endogonaceae) after passage through a rodent digestive tract. Mycologia (1976) 68(2) 433-436 USDA For. Sci. Lab., Corvallis, Ore., USA.

The viability of these spores [Endogone macrocarpa] after passage through the digestive tract of a vole was demostrated confirming the suggestion that mycophagy is the only probable method of dispersal for spores formed in sporocarps of Endogonaceae.

1163 CRUSH, J. R.; PATTISON, A. C. **Preliminary results on the production of vesicular-arbuscular mycorrhizal inoculum by freeze drying.** 485-493 [En, 10 ref.] Rothamsted Exp. Sta., Harpenden, Herts AL5 2JQ, UK.

In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp.485 - 493. 1975.

Mycorrhizal inoculum in the form of sievings survived 1- or 2-stage lyophilization; infected roots only survived 2-stage lyophilization. Pelleting white clover seed with inoculum showed some success, but sowing white clover or red clover seed above pelleted inoculum gave better results.

1164 MOSSE, BARBARA and CHRISTINE HEPPER. (Rothamsted Exp. Stn., Harpenden, Herts, Engl., UK.) Vesicular-arbuscular mycorrhizal infections in root organ cultures. PHYSIOL PLANT PATHOL 5(3): 215-224. illus. 1975. [In Engl. with Engl. summ.]--Vesicular-arbuscular mycorrhizal infections, similar to those formed in plants with leaves, were established for the 1st time in clover root organ cultures. These infections are most easily established in roots grown on a modified White's agar medium but they can also form in liquid culture. The pH of the medium is a critical factor determining the initiation and spread of infection. White's medium inhibited spore germination and growing roots did not relieve this inhibition. Pre-germinated spores were therefore used as inoculum. The possible value of root organ cultures for the study of root: endophyte interactions is discussed in relation to studies of some obligate fungi.

*1165 SELIVANOV, I.A. [Endogone fungi in culture and methods for their investigation.] Endogenovye griby v kul'ture i metody ikh izucheniya. Uch. Zap. Perm. Gos. Ped. Inst. (1975) No.142, 96-110. Referativnyi Zhurnal Biologiya 1976. 7V 274.

A review of methods for culturing endophytic Endogonaceae and for inoculating higher plants.

1166 WARCUP, J.H. A culturalable *Endogone* with eucalypts. *In*: Endomycorrhizas (Ed. by F.E. Sanders, B. Mosse, and B. Tinker) Academic Press, London. pp.53-63 (1975).

*1167 MOSSE, B. Growth of *Endogone* mycorrhiza in agar medium. Rothamsted Exp. Sta. Report 1971: 93. 1972.

1168 ROBINSON, R.K. The production by roots of *Calluna vulgaris* of a factor inhibitory to growth of some mycorrhizal fungi. J. Ecol., 60:219-224. 1972.

*1169 PARK, J.Y. Preparation of mycorrhizal grain spawn and its feasibility in artificial inoculation *In*: Hacskaylo, E., ed. 1971. Mycorrhizae. Proceedings of the First North American Conference on Mycorrhizae held at University of Illinois, April 1969. Misc. Publ. USDA Forest Serv. 1189 (239-240).

*1170 PHILLIPS, J.M.; MOSSE, B. The establishment of *Endogone* mycorrhiza in agar media. Rothamsted Exp. Sta. Report, Part I, 1970:88. 1971.

1171 ALLEN, M. F.; MOORE, T. S., JR.; CHRISTENSEN, M. **Phytohormone changes in *Bouteloua gracilis* infected by vesicular-arbuscular mycorrhizae. II. Altered levels of gibberellin-like substances and abscisic acid in the host plant.** *Canadian Journal of Botany* (1982) 60 (4) 468-471 [En, fr, 16 ref., 1 graph, 2 tab. See *RPP 59*, 4953] Univ. Wyoming, Laramie, Wyo., USA.

In studies using the barley half-seed bioassay and UV detection of peaks from a liquid chromatograph column, infection by mycorrhizal fungi resulted in significantly increased activity of gibberellin-like substances in the leaves and reduced activity in the roots. Abscisic acid concentration decreased in leaves of infected plants, but was unchanged in roots.

1172 BAREA, J. M.; AZCÓN-AGUILAR, C. **Production of plant growth-regulating substances by the vesicular-arbuscular mycorrhizal fungus *Glomus mosseae*.** *Applied and Environmental Microbiology* (1982) 43 (4) 810-813 [En, 17 ref., 4 fig.] Est. Exp. Zaidin, Cons. Sup. Invest. Cient., Granada, Spain.

Spores were axenically germinated in water and the resultant mycelial growth was assayed by standard procedures for extracting plant hormones from microbial cultures. Paper partition chromatography and specific bioassays were used to separate and identify plant growth-regulating substances. *G. mosseae* synthesized at least 2 gibberellin-like substances, one with R_f corresponding in position to authentic gibberellic acid, and 4 substances with the properties of cytokinins.

1173 BEILBY, J. P.; KIDBY, D. K. **The early synthesis of RNA, protein, and some associated metabolic events in germinating vesicular-arbuscular mycorrhizal fungal spores of *Glomus caledonius*.** *Canadian Journal of Microbiology* (1982) 28 (6) 623-628 [En, fr, 21 ref., 3 fig., 3 tab.] Univ. Western Australia, Nedlands, Australia.

A comparison of the kinetics of [1-^{14}C]leucine and [2-^{14}C]uracil incorporated into germinating spores of *G. caledonius* showed that RNA and protein synthesis had begun by 35 min after imbibition of water. Protein synthesis was essential for spore germination and cycloheximide-sensitive protein synthesis occurred after the onset of germination. Early RNA synthesis was not affected by cycloheximide. Within 35 min of imbibition the tricarboxylic acid cycle, gluconeogenesis and most amino acid biosynthetic pathways were operating.

1174 CAPACCIO, L. C. M.; CALLOW, J. A. **The enzymes of polyphosphate metabolism in vesicular-arbuscular mycorrhizas.** *New Phytologist* (1982) 91 (1) 81-91 [En, 12 ref., 6 fig., 1 tab.] Dep. Pl. Sci., Univ. Leeds, UK.

The enzymes were studied in mycorrhizal and non-mycorrhizal onion roots and in external and internal hyphae of *Glomus mosseae*. Polyphosphate kinase activity was detected in extracts of external hyphae and mycorrhizal roots. Exopolyphosphatase activity was detected in both mycorrhizal and non-mycorrhizal roots, but activity was 134% greater in the former, as was endopolyphosphatase activity. Polyphosphatases were detected in extracts of internal, but not external hyphae. The results are discussed in relation to potential mechanisms of P translocation and transfer in VA mycorrhizas. A new technique for isolating the internal hyphae and associated vesicles and arbuscules from mycorrhizal onion roots is described.

*1175 FEDOROVA, L. N.; DROZDOVA, T. N. [The effect of different sources of carbon nutrition on the milk-coagulating activity of a mycorrhizal fungus.] [*Russula decolorans*]. *Mikologiya i Fitopatologiya* (1982) 16 (2) 133-138 [Ru, 7 ref., 3 graphs, 2 tab.] Komarov Bot. Inst., Leningrad, USSR.

*1176 GIANINAZZI-PEARSON, V. [Mycorrhizas. III. Physiology of endomycorrhizas and prospects offered by their use.] Les mycorhizes. III. Physiologie des endomycorhizes et perspectives offertes par leur utilisation. *Comptes Rendus des Séances de l'Académie d'Agriculture de France* (1982) 68 (5) 380-389 [Fr, 29 ref., 3 tab.] Station d'Amélioration des Plantes, INRA, Dijon, France.

In work on endomycorrhizas on Ericaceae and vesicular-arbuscular (VA) mycorrhizas physiological processes that were improved as a result of infection, and the effect of VA mycorrhizas and the assimilable phosphorus content of the soil on soybean yield were studied.

*1177 GIANINAZZI-PEARSON, V. Physiology of endomycorrhiza and prospects for their use. Physiologie des endomycorrhizes et perspectives offertes par leur utilisation. Comptes Rendus des Séances de l'Académie d'Agriculture de France. 68(5):380-389. 1982.

1178 KOSKE, R. E. **Evidence for a volatile attractant from plant roots affecting germ tubes of a VA mycorrhizal fungus.** *Transactions of the British Mycological Society* (1982) 79 (2) 305-310 [En, 23 ref., 3 fig., 1 tab.] Univ. Rhode Island, Kingston, USA.

Germ-tubes from *Gigaspora gigantea* spores grew vertically or horizontally through the air to contact roots of bean (*Phaseolus vulgaris*) and maize plants situated up to 11 mm away from the spore. Up to 86% of the spores produced aerial germ tubes that were attracted to roots, apparently in response to a volatile attractant released by the roots. Initial contact between roots and germ-tubes was made as early as 5 days after a test began, with max. success after 10-24 days. Bean plants in the preflowering and pod maturation stages attracted germ tubes. Mycorrhizas were not formed under the experimental conditions.

1179 KUCEY, R. M. N.* and E. A. PAUL. (Agric. Can. Research Station, Lethbridge, Alberta, Can. T1J 4B1.) SOIL BIOL BIOCHEM 14(4): 407-412. 1982. **Carbon flow, photosynthesis and nitrogen fixation in mycorrhizal and nodulated faba beans (*Vicia faba*).**—C flows to vesicular-arbuscular mycorrhizal fungi and rhizobial symbionts of 4-5 wk old faba beans. *V. faba* L. were measured by determining the distribution of $^{14}CO_2$-C fixed by aboveground plant parts. Mycorrhizal fungi of both nodulated and non-nodulated hosts utilized ~ 4% of the C fixed by their hosts. Nodules utilized 6% of the C fixed by non-mycorrhizal hosts and 12% of the C fixed by mycorrhizal hosts. Measured rates of CO_2 fixation for symbiotic beans were higher than for non-symbiotic beans. Nodulated root systems of mycorrhizal beans fixed more $^{15}N_2$ than nodulated root systems of non-mycorrhizal plants. An increase in nodule biomass for plants infected with both rhizobia and mycorrhizal fungi was the major factor increasing N_2 fixation rates.

1180 MARX, C.; DEXHEIMER, J. **Enzymatic studies on the metabolism of vesicular-arbuscular mycorrhizas. IV. Ultracytoenzymological evidence (ATPase) for active transfer processes in the host-arbuscule interface.** *New Phytologist* (1982) 90 (1) 37-45 [En, 44 ref., 3 pl. See *RPP 58*, 2555] Lab. Bot., Univ. Nancy, France.

Ultrastructural localization of ATPase activities was identical in mycorrhizas of onion and *Acer pseudoplatanus*. DES-sensitive ATPase activity was detected within the fungal vacuole. Development of the mycorrhizal fungus within root cells modified the distribution of DES-sensitive plasmalemma-bound ATPase activity of the host. This became concentrated around the finer arbuscule branches and appeared to be a specialization of the invaginated host membrane which occurred when arbuscule structure was favourable for nutrient exchange.

1181 NEMEC, S.; GUY, G. **Carbohydrate status of mycorrhizal and nonmycorrhizal citrus rootstocks.** *Journal of the American Society for Horticultural Science* (1982) 107 (2) 177-180 [En, 20 ref., 4 tab.] USDA, Orlando, Fla., USA.

Carbohydrates were analyzed in orange and mandarin seedlings in the glasshouse. Seedlings inoculated with *Glomus etunicatus*, *G. mosseae* and *G. macrocarpus* grew taller or weighed more and their leaves contained greater amounts of total soluble sugar, sucrose, reducing sugars, starch and total nonstructural carbohydrate/g of tissue in a low P (9-12 p.p.m.) soil. Only the reducing sugars, fructose and glucose, increased slightly in roots of inoculated seedlings. Levels of reducing sugars were higher in leaves than in roots. Uninoculated seedlings grown in a high P soil (210 p.p.m.) were c. the same height and their leaves contained levels of total soluble and reducing sugars similar to those in inoculated rootstocks in a low P soil. These mycorrhizal fungi did not appear to mobilise sugars as a sink for photosynthate in roots.

1182 SNELLGROVE, R. C.; SPLITTSTOESSER, W. E.; STRIBLEY, D. P.; TINKER, P. B. **The distribution of carbon and the demand of the fungal symbiont in leek plants with vesicular-arbuscular mycorrhizas.** *New Phytologist* (1982) 92 (1) 75-87 [En, 27 ref., 5 fig., 3 tab.] Rothamsted Exp. Sta., Harpenden, Herts., UK.

In all 3 experiments, c. 7% more of the total fixed C was translocated from shoot to root in plants grown in partially sterilized soil inoculated with *Glomus mosseae* (M plants) compared with those in uninoculated soil (NM). When plants were harvested 214 h after labelling this could be accounted for by increased root respiration + increased loss of C to the soil but, despite this drain, M and MN plants had equal rates of C assimilation/ unit leaf area. However, shoots of M plants had a lower content of dry matter and hence higher assimilation rates expressed on a dry matter basis. Increased hydration is suggested as a mechanism whereby leaf area and hence C assimilation increases in mycorrhizal plants and which offsets the effects of the drain imposed by the mycorrhizas.

*1183 HOLLAND, A. A. Immunological relationships of *Endogone eucalypti* (ined.). *Australasian Plant Pathology* (1981) 10 (3) 47-48 [En, 5 ref., 2 tab.] Monash Univ., Clayton, Vict., Australia.

Vegetative mycelium was produced by culturing this endomycorrhizal fungus in modified Whites tissue culture medium and used to prepare antigenic suspensions and antisera. When tested for cross-reactions with members of other fungal groups, using the direct fluorescent antibody technique, *E. eucalypti* showed a relationship with the Phycomycetes and particularly with the Mucorales, supporting the morphological, taxonomic relationship of *Endogone*. The wide cross reaction of *E. eucalypti* antigens indicate that FA staining would not be applicable in estimating the penetration of hyphae in a substrate or hyphal biomass. However the use of fractionated antigens, structural protein or enzymes and suitable cross absorption of the antiserum by cross reacting antigens could possibly result in a specific antiserum and consequently highly selective FA staining.

1184 NEMEC, S.; MEREDITH, F. I. Amino acid content of leaves in mycorrhizal and non-mycorrhizal citrus rootstocks. *Annals of Botany* (1981) 47 (3) 351-358 [En, 39 ref.] USDA, Science and Education Administration, Orlando, Florida 32803, USA.

After 5 months growth in low-P sand inoculated with *Glomus etunicatus* or in sand with superphosphate at 2240 kg/ha, sour orange rootstocks were 3.1 and 3.5 times taller, respectively, than untreated controls in sand, and rough lemon citrus rootstocks were 1.8 and 2.0 times taller than controls. Total and free leaf acid contents were significantly higher in control rootstocks and were not significantly different between P and mycorrhizal treatments. Urea, ammonia and 22 amino acids were detected in all plants and control rootstocks had increased levels of citrulline, ornithine, lysine, histidine, arginine and ammonia.

1185 NORDBY, H. E.; NEMEC, S.; NAGY, S. Fatty acids and sterols associated with citrus root mycorrhizae. *Journal of Agricultural and Food Chemistry* (1981) 29 (2) 396-401 [En, 32 ref.] US Citrus and Subtropical Products Laboratory, USDA, Winter Haven, Florida 3380, USA.

Studies are reported with seed-raised rootstocks of *Citrus reticulata, C. sinensis, C. aurantium, C. limon, C. paradisi* and *Poncirus trifoliata* × *C. sinensis*. Four fatty acids were found in fibrous roots infected with the vesicular-arbuscular mycorrhizal fungi *Glomus fasciculatus, G. mosseae* or *G. etunicatus*, but not in non-infected roots. They were absent from the taproots and leaves. Mature trees contained lower levels than young seedlings. Sour orange seedlings grown in non-inoculated soil treated with triple superphosphate at 2240 kg/ha did not yield the acids and showed no increase in lipid content compared with seedlings not receiving P fertilizer.

*1186 STRULLU, D. G.; GOURRET, J.-P.; GARREC, J.-P. [Microanalysis of vacuolar granules of ectomycorrhizas, endomycorrhizas and endomycothalli.] Microanalyse des granules vacuolaires des ectomycorhizes, endomycorhizes et endomycothalles. *Physiologie Végétale* (1981) 19 (3) 367-378 [Fr, en, 46 ref., 5 fig., 1 tab.] Lab. Bot., Univ. Rennes, France.

The composition of vacuolar granules in ectomycorrhizas of *Pseudotsuga menziesii*, vesicular-arbuscular endomycorrhizas of clover and endomycothalli of *Pellia epiphylla* was studied by electron probe microanalysis. Concs. of phosphorus and calcium in these granules were always higher than in the light part of the vacuole. The phosphorus level was also higher than that of the cytoplasm.

1187 ALLEN, M. F.; MOORE, T. S., JR.; CHRISTENSEN, M. Phytohormone changes in *Bouteloua gracilis* infected by vesicular-arbuscular mycorrhizae: I. Cytokinin increases in the host plant. *Canadian Journal of Botany* (1980) 58 (3) 371-374 [En, fr, 28 ref.] Dep. of Bot., Wyoming Univ., Laramie, WY 82071, USA.

B. gracilis was grown in defined, axenic culture with and without vesicular-arbuscular mycorrhizae. Leaves and roots of mycorrhizal and non-mycorrhizal plants were harvested and assayed for cytokinin content using a soyabean callus tissue bioassay. Total cytokinin activity was 57 and 11% greater in leaves and roots, resp., in mycorrhizal than in control plants. Cytokinin activities, separated using paper chromatography with water saturated *n*-butanol as a solvent, doubled in roots and leaves at R_f values of 0.3 and 0.9 and increased 9-fold in roots at an R_f value of 0.1 with infection. This was thought to be the 1st demonstration of altered cytokinin levels in plants resulting from mycorrhizal infection.

*1188 BEILBY, J.B. Fatty acid and sterol composition of ungerminated spores of vesicular-arbuscular mycorrhizal fungus, *Acaulospora laevis*. Lipids 15:949-952 (1980).

*1189 CALLEJA, M. *et al.* 1980. Effects of phosphate deficiency on acid phosphatase activities of 3 mycorrhizal fungi. Physiologie Vegetale 18:489-504 (1980).

1190 NAGY, S.; NORDBY, H. E.; NEMEC, S. Composition of lipids in roots of six citrus cultivars infected with the vesicular-arbuscular mycorrhizal fungus, *Glomus mosseae*. *New Phytologist* (1980) 85 (3) 377-384 [En, 28 ref.] US Citrus and Subtropical Products Laboratory, Winter Haven, FL 33880, USA.

The lipid compositions of infected and non-infected fibrous roots of sweet orange, sour orange, rough lemon, Carrizo citrange, Cleopatra mandarin and Rangpur lime were studied. Infected roots of all cvs contained significantly more phospholipids and triglycerides than did their non-infected controls. Campesterol was found at higher percentages of free sterols in infected compared with non-infected roots whereas cholesterol and β-sitosterol were detected at lower levels in infected roots. Three unknown fatty acids were detected in infected roots but not in non-infected roots, and made up 46 - 52% of the fatty acids in the triglycerides, 31 - 41% in the total lipids and 7 - 20% in the phospholipids.

1191 CRESS, W. A.; THRONEBERRY, G. O.; LINDSEY, D. L. Kinetics of phosphorus absorption by mycorrhizal and nonmycorrhizal tomato roots. *Plant Physiology* (1979) 64 (3) 484-487 [En, 22 ref.] Department of Entomology and Plant Pathology, New Mexico State University, Las Cruces, New Mexico 88003, USA.

Kinetics of P absorption were investigated in mycorrhizal (*Glomus fasciculatus*) and nonmycorrhizal tomato (*Lycopersicon esculentum*) roots to determine why increased ion absorption by mycorrhizae occurs. Initial rates of absorption of ^{32}P were measured at 1 to 100 micromolar KH_2PO_4 (pH 4.6). Absorption rates of mycorrhizae were about twice those of control roots. Augustinsson-Hofstee analysis yielded two linear phases; V_{max} and K_m were calculated for each phase. In the low phase (1 to 20 micromolar), V_{max} values for the mycorrhizal and nonmycorrhizal roots were each 0.10 micromoles P per gram fresh weight per hour while K_m values were 1.6 and 3.9 micromolar KH_2PO_4, respectively. For the high phase (30 to 100 micromolar), V_{max} values for mycorrhizal and nonmycorrhizal roots were 0.32 and 0.25 micromoles P per gram fresh weight per hour and K_m values were 35 and 42 micromolar, respectively. These results indicate that at the lower phase concentrations, similar to those expected in most soil solutions, a major factor contributing to the increased uptake was an apparent greater affinity of the absorbing sites for $H_2PO_4^-$ (lower K_m).

1192 GIANINAZZI, S.; GIANINAZZI-PEARSON, V.; DEXHEIMER, J. Enzymatic studies on the metabolism of vesicular-arbuscular mycorrhiza. III. Ultrastructural localization of acid and alkaline phosphatase in onion roots infected by *Glomus mosseae* (Nicol. & Gerd.). *New Phytologist* (1979) 82 (1) 127-132 [En, 16 ref., 3 pl.] Station d'Amélioration des Plantes, INRA, BV 1540, 21034 Dijon-Cédex, France.

The ultrastructural distribution of acid and alkaline

phosphatase in 6-week-old onion roots infected by *Glomus mosseae* was studied cytochemically. Significant acid phosphatase activity was observed in the immature arbuscule branches and strong alkaline phosphatase activity in the mature arbuscular and intercellular hyphae. In the host cells neither acid nor alkaline phosphatase distribution was modified by vesicular-arbuscular mycorrhiza formation.

*1193 LAPUKHOVA, S. M. [Internal content of vesicles of mycorrhizal fungi of wheat.] O vnutrennem soderzhimom vezikul mikoriznogo griba pshenitsy. *Botanicheskie Materialy Gerbariya Instituta Botaniki Akademii Nauk Kazakhskoĭ SSR* (1979) No.11, 86-90 [Ru, 37 ref.]

Numerous nuclei and oil globules in vesicles indicated that the vesicles were metamorphosed sporangia of zygomycetes.

1194 LÖSEL, D. M.; COOPER, K. M. **Incorporation of ^{14}C-labelled substrates by uninfected and VA mycorrhizal roots of onion.** *New Phytologist* (1979) 83 (2) 415-426 [En, 24 ref.] Department of Botany, University of Sheffield, Sheffield S10 2TN, UK.

In a pot experiment and in excised roots, VA mycorrhizal infection of onion roots with *Glomus mosseae* increased their metabolism of carbon from external sources, such as sucrose, acetate and glycerol, as well as from photosynthetic assimilate. Within 20 min of photosynthesis in $^{14}CO_2$, radioactivity was present in lipid and non-lipid, soluble and insoluble compounds in the roots. Eighteen hours after exposure to ^{14}C ceased, *c.* 30% of the radioactivity in mycorrhizal and non-mycorrhizal roots supplied with [2-^{14}C]acetate and [^{14}C]glycerol and 12 to 20% of that from [^{14}C]sucrose was in the lipid fraction, while *c.* 5% of the ^{14}C-labelled photosynthate received by the roots appeared in lipids. Mycorrhizal roots differed from uninfected roots in their significantly higher incorporation of carbon from photosynthate, sucrose and acetate into ethanol-soluble compounds and insoluble materials, from sucrose into water-soluble compounds and from acetate into lipids.

*1195 NEMEC, S.; NAGY, S.; NORDBY, H.E. Lipid analysis of Glomus Mosseae -infected and non-infected citrus roots. Phytopathology 69(5): 531. 1979. Abst.

Six citrus rootstock cultivars were inoculated with Glomus mosseae in a low-phosphorus sand in the greenhouse and fertilized monthly with a liquid 12-0-6. Noninoculated cultivars served as controls. After 140 days, roots were washed, weighed and extracted in chloroform/methanol, 2:1. Lipids were purified by Sephadex G-25 and separated by silica gel chromatography. Neutral lipids (NL) and coumarins comprised about 75-86%, glycolipids (GL) about 8-22%, and phospholipids (PL) 2-7% of the total fat soluble extracts. In general, GL were higher in controls; PL were higher in all inoculated cultivars; and no differences were present in the NL and coumarin fraction. However, among the NL, triglycerides were significantly higher in all inoculated cultivars. PL as mg/g root ranged from 1.62-3.95 in inoculated cultivars and from 0.79 to 1.56 in controls, and were significantly higher in all inoculated cultivars. In general, cholesterol, stigmasterol, and ß-sitosterol as percentages of total sterols were higher in the controls.

*1196 SWAMINATHAN, K. **Nature of the inorganic fraction of soil phosphate fed on by vesicular-arbuscular mycorrhizae of potatoes.** *Proceedings of the Indian Academy of Sciences, B* (1979) 88 (2, VI) 423-433 [En, 32 ref., 7 tab.] Central Potato Res. Inst., Simla, India.

Three latosols with good soluble phosphate fixing ability were dressed with labelled single superphosphate and potato plants grown in them, with or without inoculation with spores of endomycorrhizae. Mycorrhizal plants accumulated more phosphate, especially from the ferruginous Ootacamund soil which has the strongest affinity for phosphate. Fractional chemical and radiochemical analyses of the soils, before and after the plant culture (and other evidence), indicated that the endophyte can attack and mobilise such phosphate fractions in latosols that are least available to the plants. This was confirmed by sand culture tests where mycorrhizal and non-mycorrhizal plants were either dressed with labelled $AlPO_4$ and $FePO_4$, or fed with saturated sols. of them. In the former, uptake was much larger although the specific activities remained unchanged.

*1197 — ALLEN, M.F.; MOORE, T.S. Jr.; CHRISTENSEN, M. Physiological alterations of Bouteloua Gracilis infected by Glomus Fasciculatus, A vesicular arbuscular mycorrhizal fungus. Plant Physiol. (Suppl.) 61(4): 50. 1978. Abst.

Mycorrhizal and nonmycorrhizal seedlings of Bouteloua gracilis were grown in axenic agar cultures and greenhouse pots and compared for changes in plant biomass, morphology, water relations, and cytokinin content. Infection rates of inoculated plants averaged 75% in the agar cultures and 50% in the greenhouse pots. Mycorrhizal plants had significantly lower leaf resistance and leaf xylem tension than nonmycorrhizal plants in greenhouse pots. Root biomass increased by 150% and root branching increased significantly with mycorrhizal infection in agar culture. These changes may be due in part to altered hormone levels. Mycorrhizal plants in agar culture had significantly higher cytokinin concentrations in both leaves and roots than did nonmycorrhizal controls.

1198 CARLING, D. E.; RIEHLE, W. G.; BROWN, M. F.; JOHNSON, D. R. **Effects of a vesicular-arbuscular mycorrhizal fungus on nitrate reductase and nitrogenase activities in nodulating and non-nodulating soybeans.** *Phytopathology* (1978) 68 (11) 1590-1596 [En, 20 ref.] Departments of Plant Pathology and Agronomy, University of Missouri, Columbia, MO 65211, USA.

Nodulating and non-nodulating soybean isolines were treated with various combinations of *Glomus fasciculatus, Rhizobium japonicum* and phosphate fertilizer. Dually-infected nodulating soybean plants showed increases in total dry weight and nodule dry weight, as well as higher levels of nitrogenase and nitrate reductase activities over singly or noninfected plants. When phosphorus was substituted for mycorrhizal infection, similar growth and enzyme activity increases were observed. This suggests that VA endomycorrhizal fungi, which can assist legumes in the uptake of phosphorus, do not interact directly with nitrogen-fixing bacteria.

1199 COOPER, K. M.; LÖSEL, D. M. **Lipid physiology of vesicular-arbuscular mycorrhiza. I. Composition of lipids in roots of onion, clover and ryegrass infected with *Glomus mosseae*.** *New Phytologist* (1978) 80 (1) 143-151 [En, 36 ref.] Department of Botany, University of Sheffield, Sheffield, S10 2TN, UK.

A microscopic and biochemical comparison was made of the distribution, quantity and composition of lipid in roots of onion, clover and ryegrass infected with the VA mycorrhizal fungus, *Glomus mosseae*, in uninfected roots and in the external mycelium from infected, aseptically grown onion roots. Abundant oil-droplets were observed in the internal and external fungal mycelium, in the vesicles and chlamydospores, and adjacent to the appressoria at entry points. Mycorrhizal roots contained significantly more total lipid than uninfected roots. The mycorrhizal roots consistently contained higher levels of triglyceride than did non-mycorrhizal roots. External mycelium contained high levels of neutral lipids, especially triglyceride, diglyceride and free fatty acids. Compared with uninfected roots, mycorrhizal onion roots contained higher levels of diphosphatidyl glycerol, phosphatidyl serine, phosphatidyl ethanolamine, phosphatidyl choline, phosphatidyl glycerol, phosphatidic acid and phosphatidyl inositol. With the exception of phosphatidyl inositol and phosphatidic acid, these were all prominant components of *G.mosseae* mycelium.

1200 GIANINAZZI-PEARSON, V.; GIANINAZZI, S. **Enzymatic studies on the metabolism of vesicular-arbuscular mycorrhiza. II. Soluble alkaline phosphatase specific to mycorrhizal infection in onion roots.** *Physiological Plant Pathology* (1978) 12 (1) 45-53 [En, 19 ref., 1 pl.] Station de Physiologie Végétale, INRA, BV 1540, 21034 Dijon-Cédex, France.

The specific phosphatase was demonstrated in enzyme extracts from onion roots inoculated with *Glomus mosseae*. Maximum activity occurred whilst the infection was still young and coincided with the start of the mycorrhizal growth response, declining afterwards as plant development and infection continued. Activity was optimal in $10^{-5}M$ orthophosphate but was depressed above $10^{-4}M$. The properties of mycorrhiza-specific alkaline phosphatase were characteristic of alkaline phosphomonesterase. The possible implications of these results with respect to mechanisms involved in the assimilation of phosphorus in the VA (vesicular-arbuscular) mycorrhizal system and/or the establishment of VA mycorrhizal infection are discussed.

1201 GIANINAZZI-PEARSON, V.; GIANINAZZI, S.; DEXHEIMER, J.; BERTHEAU, Y.; ASIMI, S. **[Soluble alkaline phosphatases in a vesicular-arbuscular endomycorrhizal association.]** Les phosphatases alcalines

solubles dans l'association endomycorhizienne à vésicules et arbuscules. *Physiologie Végétale* (1978) 16 (4) 671-678 [Fr, en, 21 ref., 3 fig.] Station de Physiopathologie Végétale, INRA, Dijon, France.

When onion, tobacco and soybean roots are infected by *Glomus mosseae* or E_3 (*G* sp.) new soluble phosphatases specific to the vesicular-arbuscular (VA) mycorrhizal infection are formed. In the association onion/*G. mosseae* this enzyme activity has the properties of non-specific alkaline phosphomonoesterase and it is closely linked to the development of the infection and of the host. Activity is max. at the beginning of the mycorrhizal growth response and in the arbuscular phase of infection. There is strong evidence that these VA mycorrhiza-specific phosphatases are of fungal origin. Intense alkaline phosphatase activity has also been found in vacuoles of the intercellular and arbuscular hyphae of *G. mosseae*. The possible involvement of alkaline phosphatases in the active phosphate transport and/or transfer mechanisms in the VA mycorrhizal system is discussed.

1202 MACDONALD, R. M.; LEWIS, M. **The occurrence of some acid phosphatases and dehydrogenases in the vesicular-arbuscular mycorrhizal fungus *Glomus mosseae*.** *New Phytologist* (1978) 80 (1) 135-141 [En, 20 ref.] Department of Soil Microbiology, Rothamsted Experimental Station, Harpenden, Herts, UK.

The occurrence of acid phosphatase, glutamate dehydrogenase, succinate dehydrogenase, glyceraldehyde-3-phosphate dehydrogenase, glucose-6-phosphate dehydrogenase and NADH and NADPH diaphorases in *Glomus mosseae* (yellow vacuolate *Endogone* spore type) was demonstrated cytochemically. Acid phosphatase was found in lysing and growing fungal structures. It was inferred that the fungus possesses an Embden-Meyerhof-Parnas system, a tricarboxylic acid cycle and a hexose monophosphate shunt.

1203 RATNAYAKE, M.; LEONARD, R. T.; MENGE, J. A. **Root exudation in relation to supply of phosphorus and its possible relevance to mycorrhizal formation.** *New Phytologist* (1978) 81 (3) 543-552 [En, 29 ref.] Dep. of Plant Sciences, Univ. of California, Riverside, 92521, USA.

The mechanism responsible for inhibition of mycorrhizal establishment in *Sorghum vulgare* and *Citrus aurantium* under high levels of soil P was studied. Plants were grown on loamy sand (4.5 ppm P) receiving superphosphate at 0, 6, 28, 56, 228 and 556 ppm P. The percentage P content of root tissue was correlated with the amount of P added to the soil. Root exudation (net leakage of soluble amino acids and reducing sugars during 17 h) was significantly higher with 0-28 ppm P than with 56-556 ppm P. The amount of exudation was correlated with a P-induced decrease in phospholipid levels and associated changes in permeability properties of root membranes, rather than with changes in the root content of sugars and amino N. It is proposed that P inhibition of mycorrhizal symbiosis may be associated with a membrane-mediated decrease in root exudation.

*1204 SAGINA, I. I. **[Amino acid composition of mycorrhizal plants of maize.]** In *Mikoriza i drugie formy konsertivnnykh otnoshenii v prirode.* Perm', USSR. (1977) 46-50 [Ru] From *Referativnyĭ Zhurnal* (1978) 6.55.143.

Active penetration of fungal mycorrhiza into maize roots decreased contents of free amino acids in leaves and the mycorrhiza; it was associated with utilization of amino acids for active synthesis of proteins in both the symbionts. The amount of amino acids in all plant parts increased at the moment of lysis of the fungus. The transport of amino acids from the roots to the shoots was more intensive in mycorrhizal plants than in non-mycorrhizal ones. There were quantitative changes in amino acids of mycorrhizal plants during growth period, but the composition of amino acids was not changed.

1205 WATRUD, L.S.; HEITHAUS, J.J.; III JAWORSKI, E.G. Evidence for production of inhibitor by the vesicular-arbuscular-mycorrhizal fungus Gigaspora margarita. Mycologia 70:821-28. 1978.

Inoculation of spores of Gigaspora margarita on agar medium containing activated charcoal resulted in an increased rate of hyphal growth. Circular patterns simulated by hyphal growth from groups of centrally plated spores following germination permitted assessment of "colony" diam. Pretreatment of spores or water with activated charcoal did not enhance fungal growth. These results suggest that an inhibitor of fungal growth is produced or released during and/or after germination.

1206 WATRUD, L. S.; HEITHAUSE, J. J., III; JAWORSKI, E. G. **Geotropism in the endomycorrhizal fungus *Gigaspora margarita*.** *Mycologia* (1978) 70 (2) 449-452 [En, 8 ref., 4 fig.] Monsanto Agric. Products Co., St. Louis, Mo., USA.

Gravity appears to induce bi-directional growth from germinating spores of this phycomycetous endomycorrhizal fungus. Germ tubes grow upward and secondary branched hyphae grow downward. Echinulate vesicle clusters are produced on the branched hyphae.

1207 HO,I. Phytosterols in root systems of mycorrhizal and nonmycorrhizal Zea mays L. Lloydia 90: 476-478. 1977.

Root systems of Zea mays L. inoculated respectively with four species of vesicular-arbuscular mycorrhizal fungi or uninoculated were compared for content of free phytosterols. Mycorrhizal root systems, including inseparable fungal elements, contained significantly greater concentrations of total sterols, cholesterol, and campesterol than nonmycorrhizal root systems; but concentrations of stigmasterol and B-sitosterol did not differ between treatments. No significant differences were detected among the four mycorrhizal fungus treatments.

1208 GIANINAZZI-PEARSON, V.; GIANINAZZI, S. Enzymatic studies on the metabolism of vesicular-arbuscular mycorrhiza 1. Effect of mycorrhiza formation and phosphorus nutrition on soluble phosphate activities in onion roots. Physiologie Végétale (1976) 14 (4) 833-841.

Levels of soluble acid phosphatase activity of 10-week-old onions were not significantly altered by vesicular-arbuscular mycorrhiza or by adding soluble P to the soil. Root alkaline phosphatase activity was significantly reduced only in plants supplied with available P during growth. Analyses of the soluble phosphatases after gel electrophoresis revealed differences in the enzymes involved in the P metabolism of roots supplied with available P and those provided with P by the mycorrhiza; a new enzyme band with an activity at pH 4 and 8.5 was specific to the mycorrhizal infection.

1209 SCHOKNECHT, J. D.; HATTINGH, M. J. **X-ray microanalysis of elements in cells of VA mycorrhizal and nonmycorrhizal onions.** *Mycologia* (1976) 68 (2) 296-303 [En, 6 ref., 3 pl.] Indiana State University, Terre Haute, Indiana 47809, USA.

Segments of onion roots containing the vesicular-arbuscular (VA) mycorrhizal fungi *Glomus fasciculatus* and *G. mosseae* were examined. Cells containing arbuscules had considerable amounts of P, in contrast to those lacking arbuscules. Other elements (S, Cl, K and Ca) were present in both types of cell and in cells from non-mycorrhizal controls.

*1210 BELLANDO, M. {Some biochemical aspects of mycorrhiza.} Su alcuni aspetti biochimici della micorrizia. Giornale Botanico Italiano (1975) 109 (3) 145-158.

In ectotrophic mycorrhizia the plant usually depends on the fungus for uptake of salts, in particular phosphates, supplying in return carbohydrates transformed by the mycobiont into alcohols and sugars that the host connot utilize. The symbiosis favours the synthesis of aminoacids and proteins. In endotrophic mycorrhizia, in particular in *Orchis* spp., the process is tilted in favour of the host, such that the external aspects at least suggest parasitism.

1211 BEVEGE, D. I.; BOWEN, G. D.; SKINNER, M. F. **Comparative carbohydrate physiology of ecto- and endomycorrhizas.** 149-174 [En, 24 ref.] Div. of Soils, CSIRO, Glen Osmond, S.A., Australia 5064.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp. 149 - 174. 1975.

The fate of ^{14}C-labelled photosynthate in endomycorrhizal subterranean clover was compared with that in endomycorrhizal *Araucaria cunninghamii* and ectomycorrhizal *Pinus radiata*. In subterranean clover infected with *Endogone mosseae*, only 6 and 12%, resp. of measured activity was located in the soluble carbohydrate pools of mycorrhizas and uninfected roots, whereas incorporation into metal-precipitated and polysaccharide fractions together accounted for 90 and 76%, resp. Storage of carbohydrates in VA mycorrhizas appeared to be small; trehalose, mannitol and other polyols were not found, but some storage occurred as glycogen. In subterranean clover, where infection was deliberately restricted to a localized part of the root system, activity/unit wt. of hyphae was nearly 4 times and total activity 24% of that of subtending roots. The extramatrical *E. mosseae* hyphae were only 1% of the total wt. of the plant, but infection resulted in a 150% increase in plant growth. The greater translocation of ^{14}C assimilate to the roots of mycorrhizal plants was due to greater amounts of root in the mycorrhizal system, rather than large fungal sinks. It is suggested that sucrose and glucose are the principal sugars transferred.

1212 BOWEN, G. D.; BEVEGE, D. I.; MOSSE, B. **Phosphate physiology of vesicular-arbuscular mycorrhizas.** 241-260 [En, 24 ref.] Div. of Soils, CSIRO, Glen Osmond, S.A., Australia 5064.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp.

Mycorrhizal roots of subterranean clover cv. Bacchus Marsh inoculated with *Endogone mosseae* took up more than twice as much phosphate as roots from non-mycorrhizal plants. Differences in uptake between mycorrhizal and non-mycorrhizal roots on the same plant were much smaller. Phosphate uptake was high in young uninfected root tips and decreased sharply with distance from the apex, except where mycorrhizal infection occurred. Microautoradiographs showed that uptake by hyphae outside the root was a primary cause of the increased phosphate-absorbing power of mycorrhizas. Phosphate was translocated to arbuscules and vesicles inside the plant and thence to the higher plant. Phosphate was not translocated preferentially towards mycorrhizas or stored in them.

1213 HO, I.; TRAPPE, J.M. Nitrate reducing capacity of two vesicular-arbuscular mycorrhizal fungi. Mycologia (1975) 67 (4) 886-888.
Evidence is presented that Glomus macrocarpus [Endogone macrocarpa] and G.[E] mosseae reduce nitrate to nitrite and therefore presumably possess the nitrate reductase enzyme system. Thus these widely distributed VA mycorrhizal fungi assume increased symbiotic effectiveness in terms of N assimilation and translocation to the host.

1214 LEWIS, D. H. **Comparative aspects of the carbon nutrition of mycorrhizas.** 119-148 [En, 110 ref.] Dep. of Bot., Sheffield Univ., Sheffield S10 2TN, UK.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp. 119 - 148. 1975.

The classification and nomenclature of mycorrhizas are discussed. The C nutrition of mycorrhizal associations is discussed with reference to physical sources of C for mycorrhizal fungi, the direction of net flux of carbohydrate in mycorrhizas, the chemical nature of major C sources for mycorrhizal fungi, maintenance of biotrophy and 2-way transport of C.

1215 LING-LEE, M.; CHILVERS, G. A.; ASHFORD, A. E. **Polyphosphate granules in three different kinds of tree mycorrhiza.** *New Phytologist* (1975) 75 (3) 551-554 [En, 11 ref., 1 pl.] Australian National University, Canberra, Australia.

Using cytochemical techniques, granules containing polyphosphate were detected in sheath, intercellular and intracellular hyphae of *Arbutus unedo* ectendomycorrhizas and in hyphae and vesicles of *Liquidambar styraciflua* endomycorrhyzas.

1216 PEARSON, V.; TINKER, P. B. **Measurement of phosphorus fluxes in the external hyphae of endomycorrhizas.** 277-287 [En, 9 ref.] Dep. of Pl. Sci., Leeds Univ., Leeds LS2 9JT, UK.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp. 277 - 287. 1975.

External hyphae of mycorrhizal seedlings of white clover were grown in petri dishes divided by a 6 mm high partition, with soil agar on 1 side and tap water agar on the other. A sterile seedling was transferred to the soil agar and inoculated with pregerminated spores of *Glomus mosseae*. After 1-2 months, the roots showed normal VA infections; hyphae ramified through the soil agar and later grew over into the water agar. Hyphae crossing the partition were counted and their diam. measured. Lanolin was spread on to the partition to form a barrier to diffusion around the hyphae. ^{32}P was added to the water agar and its appearance in the clover shoots was detected with a specially designed β-ray counter. There was a steady increase of ^{32}P in the shoots during the 6 days after exposure, but the shoots only contained c. 5% of the ^{32}P in digests of the whole plant and surrounding agar. Retention of ^{32}P in roots and hyphae may have been due to low transpiration rates under petri dish conditions. The phosphate flux in the hyphae was calculated as 0.3-1.0 $\times$ 10^{-9} moles/cm^{2}s, compared with the previously calculated value of 3.8 $\times$ 10^{-8} moles/cm^{2}s for entry point hyphae.

1217 WOOLHOUSE, H. W. **Membrane structure and transport problems considered in relation to phosphorus and carbohydrate movements and the regulation of endotrophic mycorrhizal associations.** 209-239 [En, 48 ref.] Dep. of Pl. Sci., Leeds Univ., Leeds LS2 9JT, UK.
In: Sanders, F.E.; Mosse, B.; Tinker, P.B. (Eds.) Endomycorrhizas. Proceedings of a symposium held at the University of Leeds, 22-25 July 1974. London, Academic Press. pp. 209 - 239. 1975.

Transport problems in endomycorrhizas are discussed with reference to the mechanism of movement of phosphate from the soil sol. into fungal cytoplasm and from there to the host cell cytoplasm; the mechanism of movement of carbohydrates from host cell cytoplasm to the fungal cytoplasm; and the mechanism by which the conc. of available phosphate regulates the extent of fungal penetration of the host, the growth of the fungus within the host and hence the subsequent movement of carbohydrates from host to fungus.

*1218 HEPPER, C.M.; MOSSE, B. Trehalose and mannitol in VA-mycorrhiza. Rothamsted Exp. Sta. Report, 1972:81. 1973.

*1219 PROTSENKO, M. A. **[Electron microscope study of the localization of acid phosphatase in pea mycorrhizal cells digesting the fungus.]** *Doklady Akademii Nauk SSSR* (1973) 211 (1) 213-215 [Ru] Institut Biokhimii Im. A.N. Bakha, Akademii Nauk SSSR, Moscow.

*1220 GRAY, L.E. Physiology of vesicular-arbuscular mycorrhizae *In:* Hacskaylo, E., ed. 1971. Mycorrhizae. Proceedings of the First North American Conference on Mycorrhizae held at University of Illinois, April 1969. Misc. Publ. USDA Forest Serv. 1189 (145-150).

A review with 29 references, which concludes that vesicular-arbuscular mycorrhizae (those formed by aseptate fungi) can increase plant growth by increasing the nutrient absorption of the roots and by increasing the utilization of less available forms of P. Little is known of the effect of mycorrhizae on plants growing in fertile soils.

*1221 DAVIS, E.A.; YOUNG, J.L. Isolation and subculture of VA-mycorrhizal fungi from high fertility soils. Agronomy Abstracts 1982. p.185. Ubiquitous endomycorrhizal fungi may help plant survival and growth under adverse growing conditions, e.g. low soil fertility. However, many fungal isolates capable of providing benefit where P is deficient become "ineffective" when introduced into agricultural/horticultural systems where liberal amounts of fertilizer/amendments are used. As a possible remedy we seek to discover, isolate, and subculture vesicular-arbuscular mycorrhizal (VAM) fungal species adapted to, or tolerant of, more intesively managed field situations. Samples collected from well-fertilized Ag. Exp. Station fields cropped with various wheat, triticale, rye, and hop cultivars have shown as much as 20% root colonization by VAM fungi; averages are closer to 8%, but several with low colonization have extensive external hyphae. In addition, feeder roots from older, liberally-fertilized private hops yards (Bray P > 100 ppm) in the Willamette Valley also have substantial VAM colonization. The isolation and identification of such higher-fertility-tolerant species will aid in the selection of VAM fungal isolates that may still benefit plants despite intensive management practices.

1222 NELSEN, C. E.; SAFIR, G. R. **The water relations of well-watered, mycorrhizal, and non-mycorrhizal onion plants.** *Journal of the American Society for Horticultural Science* (1982) 107 (2) 271-274 [En, 19 ref.] Michigan State University, East Lansing, MI 48824, USA.

Mycorrhizal (*Glomus etunicatus*) onion plants, cv. Downing Yellow Globe, had higher leaf water potentials, transpiration rates and hydraulic conductivities, and lower leaf resistances than did non-mycorrhizal plants grown in low soil P conditions. When non-mycorrhizal plants were grown under high soil P conditions (with an addition of 50 p.p.m. P), the 4 parameters were not different from those of mycorrhizal plants. The magnitude of the effect of mycorrhizal fungi on the water relations of the host may, in part, be a function of P nutrition. The differences in leaf water potentials, transpiration rates and leaf resistances are considered to be the result of the differences found in hydraulic conductivities.

*1223 PUPPI, G. **[Use of vesicular-arbuscular mycorrhizas in the reclamation of sand dunes, eroded soils, waste tips and mines.]** L'uso delle micorrhize vescicolari-arbuscolari nel recupero di terreni sabbiosi, erosi, di discarica e di miniera [a review]. *Micologia Italiana* (1982) 11 (2) 5-10 [It, en, 20 ref.] Istituto dell'Orto Botanico, Rome, Italy.

*1224 SANDS, R.; FISCUS, E.L.; REID, C.P.P. Hydraulic properties of pine and bean roots with varying degrees of suberization, vascular differentiation and mycorrhizal infection. Aust. J. Plant Physiol., 1982 9 559-569. The hydraulic behaviour of root systems of loblolly pine seedlings conformed to the model of Fiscus (1975) and Dalton et al. (1975). The average hydraulic conductance per unit of root surface area was 1.4 x 10-6 cm s-1 bar-1. The hydraulic conductance of various parts of pine root systems was determined using roots severing experiments. The average hydraulic conductance of brown (older suberized) roots was 7.55 x10-7 cm s -1 bar-1, and that of white (newly regenerated unsuberized roots was 1.95x10-6 cm s-1 bar-1. Hydraulic conductance was independent of the amount of mycorrhizal infection. The mean maximum exudation rate from detopped seedlings at zero hydrostatic pressure difference was 1.31x 10-7 cm s-1. Axial conductance of nutrient solution by roots of bean plants and loblolly pine seedlings was measured at 25°C. Bean vessels and pine tracheids conducted at 0.4 and 0.55 times idealized Poiseuille conductance. Bean roots with differentiated vessels had 8 times more axial conductance per unit area of stele than pine roots, and 6.5 times more axial conductance than bean roots with undifferentiated vessels. Change in axial conductance of bean roots with temperature was completely explained by change in viscosity of the solution. Axial resistance was negligible in the experiments where the hydraulic conductance of whole root systems was measured.

*1225 McCOOL, P.M. Induced pathogenicity of the vesicular-arbuscular mycorrhizal fungus, *Glomus fasciculatus*, on tomato subjected to environmental stress. Phytopathology 71(2):240. 1981. Abstr. Seven species of vesicular-arbuscular mycorrhizal fungi were evaluated for their effects on the growth of five crop species in the greenhouse. Transplants of each host were grown in 15 cm pots filled with spore-infested (0.3 spores/g), autoclaved sandy soil having 69 ppm phosphorus and pH of 5.7. Growth parameters for both the fungi and hosts were monitored at 45, 60, 90, and 120 days (fie plants/treatment/date). *Glomus epigaeus*, *G. etunicatus*, and *G. mosseae* provided a 50, 50, and 200% growth increase, respectively, in citrus after 120 days. *Glomus etunicatus* and *G. fasciculatus* increased tomato yields 200 and 300% respectively. These two species caused earlier bloom and larger flower in chrysanthemum. Peach responded well to each species in all growth parameters, whereas, podocarpus did not. Root colonization and sporulation of the mycorrhizal fungi were of little value in predicting plant response. Ranking of host response to fungal species varied with time emphasizing the need for serial monitoring.

*1226 McGRAW, A.-C; SCHENCK, N.C. Host-specificity of vesicular-arbuscular mycorrhizal fungi on 5 crop species. Phytopathology 71(2):241. 1981. Abstr.

Tomato seedlings were incoulated with soil containing the mycorrhizal fungus, *Glomus fasciculatus* while control seedlings received no inoculum. Three weeks after inoculation, the plants were subjected to .30 ppm ozone once weekly for a period of 5 weeks while controls received only filtered air. Plants were harvested twice weekly and analyzed for mycorrhizal infection and total dry weights. When the experiment was run during conditions of optimal temperature, light and daylenght, ozone eliminated the beneficial growth response due to the mycorrhizal fungus. However, when environmental conditions were sub-optimal, mycorrhizal control plants were smaller than the non-mycorrhizal controls. The growth of mycorrhizal plants exposed to ozone was further reduced as compared to non-mycorrhizal controls. Growth depression in mycorrhizal control plants under conditions of environmental stress may result from an alteration of the symbiosis in favor of pathogenicity.

*1227 NELSEN, C.E.; SAFIR, G.R. Water movement in vesicular-arbuscular mycorrhizal onion (Allium cepa) 72nd Annual Meeting of the American Phytopathological Society and the Canadian Phytopathological Society. Aug. 24-28. 1980. Phytopathology 71(2):245. 1981. Abstract.

Onion plants (Allium cepa L.), with and without the mycorrhizal fungus Glomus fasciculatus, were grown under low phosphorus conditions (9ppm P. Bray P-1 extractable) in the growth chamber. One half of the non-mycorrhizal (NM) plants were

fertilized with P to increase the growth to levels similar to that of the mycorrhizal (MYC) plants. Transpiration rates of MYC and fertilized NM onions were similar (1.0 and 0.9 gm dm-2 hr-1) under well-watered conditions; the rates of non-fertilized NM plants were about 50% lower (0.5 gm dm-2 hr-1). Leaf water potentials of the MYC and fertilized NM onions were equal (-3.5 and -3.2 bars), while potentials of the non-fertilized NM plants were significantly lower (-6.7 bars). Calculated hydraulic conductances (x10-7 cm bar-1 s-1) were: MYC= 4.6, fertilized NM=4.5, and non-fertilized =1.1. Stomatal resistances (s cm-1) were: MYC= 3.2, fertilized NM=3.6, and non-fertilized= 9.9.

1228 BAGYARAJ, D. J.; MANJUNATH, A.; MOHAN, R. **Root length in relation to endomycorrhizal infection in grasses.** *Mysore Journal of Agricultural Sciences* (1980) 14 (3) 318-320 [En, 4 ref.] Dep. of Agric. Microbiol., Univ. of Agric. Sci., GKVK, Bangalore 560 065, Karnataka, India.

The root segments between 3-4 cm and between 8-9 cm were found infected 45 days after inoculation while the lowest 1-cm root segment was not infected. The infection increased with time and, 75 days after inoculation, there was no significant difference in percentage infection among the different root segments. The mycorrhizal infection spread to deeper layers by the mycelial growth through the root.

1229 HEAP, A. J.; NEWMAN, E. I. **Links between roots by hyphae of vesicular-arbuscular mycorrhizas.** *New Phytologist* (1980) 85 (2) 169-171 [En, 8 ref.] Department of Botany, The University, Bristol BS8 1UG, UK.

Using a buried slide technique, hyphal connections are shown to exist between different roots on one plant, *Lolium perenne*, and between two roots of different species *L. perenne* and *Plantago lanceolata*. These two species are commonly found together in permanent pasture.

1230 TISDALL, J. M.; OADES, J. M. **Stabilization of soil aggregates by the root systems of ryegrass.** *Australian Journal of Soil Research* (1979) 17 (3) 429-441 [En, 27 ref.] Dep. of Soil Sci., Waite Agric. Res. Inst., Adelaide Univ., Glen Osmond, S. A. Australia 5064.

The root system of perennial ryegrass was more efficient than that of white clover in stabilizing aggregates of Lemos loam because the ryegrass supported a larger population of vesicular-arbuscular mycorrhizal hyphae in the soil. Electron micrographs showed that the hyphae were covered with a layer of amorphous material to which clay particles were attached.

1231 CHRISTIE, P.; NEWMAN, E. I.; CAMPBELL, R. **The influence of neighbouring grassland plants on each others' endomycorrhizas and root-surface microorganisms.** *Soil Biology & Biochemistry* (1978) 10 (6) 521-527 [En, 23 ref.] Botany Department, The University, Bristol BS8 1UG, UK.

In three glasshouse experiments the grassland plants *Anthoxanthum odoratum*, *Lolium perenne*, *Plantago lanceolata* and *Trifolium repens* were grown in pots of grassland soil, in monocultures and in various two-species mixtures. Mixed-species and single-species swards were also sown in a garden bed, and in a permanent pasture *P. lanceolata* individuals whose surrounding vegetation had been removed were compared with control plants. The abundance of root-surface bacteria and fungi, and of internal mycorrhizal infection were measured by direct observation of randomly-selected root segments. The abundance of all three microbial groups on a given "host" species was often significantly altered by the presence of other plant species. Bacteria were usually changed in the same direction as fungi, but proportionately less. Mycorrhizas were usually changed less than the other two groups and not always in the same direction. In the pot experiments, when growth in a mixture resulted in a plant being larger and having higher nutrient

1232 MOJALLALI, H.; WEED, S. B. **Weathering of micas by mycorrhizal soybean plants.** *Soil Science Society of America Journal* (1978) 42 (2) 367-372 [En, 32 ref.] North Carolina Agricultural Experiment Station, Raleigh, NC 27607, USA.

Two biotites, a phlogopite, and a muscovite, ground to yield sandsize flakes, were used as sources of K for soybeans grown in pot culture with and without vesicular-arbuscular mycorrhizal association. On the low-fertility soil used, effects of the mycorrhizae were most pronounced in terms of P uptake. Plants in noninoculated pots were stunted and P deficient; no K deficiency was observed in these plants. Plants grown in inoculated soil were larger and did not exhibit P deficiency symptoms; they were, however, K deficient. When P deficiency was corrected, there was no difference in plant growth attributable to K source, though the micas differed markedly in their abilities to supply soluble K. The mycorrhizae appeared to accelerate weathering of the biotites and the phlogopite, but no effect was observed on the muscovite. Electron microprobe analysis showed extensive removal of K and some removal of Al from edges of the readily weathered biotite flakes subjected to biological weathering.P

1233 SUTTON, J. C.; SHEPPARD, B. R. **Aggregation of sand-dune soil by endomycorrhizal fungi.** *Canadian Journal of Botany* (1976) 54 (3/4) 326-333 [En, fr] Department of Environmental Biology, Ontario Agricultural College, University of Guelph, Ontario N1G 2W1, Canada.

The mycorrhizal fungus *Glomus* in association with bean hosts (*Phaseolus vulgaris* L.) was the dominant factor in the aggregation of sand particles in sterilized dune soil artificially inoculated either with *Glomus*, or with *Glomus* and a soil extract containing miscellaneous microorganisms. The weight of sand adhered to roots harvested from dried soil was about 3 times greater in mycorrhizal than in nonmycorrhizal roots. The weight of sand aggregates per kilogram dried soil from among roots of senescent beans was 10 g in nonmycorrhizal plants but 54 g in mycorrhizal plants. The fungitoxicant benomyl prevented mycorrhizal development and markedly restricted sand aggregation on and among roots of beans grown in soil inoculated with *Glomus*. A soil extract enhanced mycorrhizal development, the amount of sand adhered to mycorrhizal roots, and the extent of sand aggregation among mycorrhizal roots. Based on microscopic observations, the major mechanism linking sand grains in aggregates was the binding of sand to extensive *Glomus* mycelia.

*1234 BULAVSKAYA, E.S.; KHRUSHCHEVA, E.P. {Microflora of mycorrhizal roots of maize plants.} Mikroflora kornei mikoriznykh rastenii kukuruzy. Trudy Gor'kov. Golovn. S.-Kh. Inst. (1975) 65, 47-50. 2

Qualitative and quantitative differences in the composition of fungi, bacteria and cellulose decomposing micro-organisms in mycorrhizal and non-mycorrhizal roots of maize are indicated. Spp. of fungi associated with mycorrhizal roots are described.

*1235 UHLIG, S.K. Investigations on drought resistance of mycorrhiza-forming fungi. (Germ). Zentralbl. Bakt. Parasitenk. Infekt. Hyg., Abt. 2, 127:124-133. 1972.

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JALALI, B.L.
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JANOS, D.P.
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JARRELL, W.M.
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MOONEY, H.A.
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MOORE, T.S. JR.
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MORANDI, D.
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TIMMER, J.W.
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TING, I.P.
0900

TINKER, P.B.
0103 0104 0105 0308 0370 0432 0433
0557 0636 0653 0669 0719 0720 0756
0779 0782 0784 0813 0827 0844 0866
0912 0944 1182 1216

TISDALL, J.M.
1230

TOMMERUP, I.C.
0551 0556 0928 0929 1137

TOMMERUP, I.N.
0531

TONPKINS, C.M.
0111

TOTH, D.
0532

TOTH, R.
0450 0532

TRAPPE, J.M.
0027 0189 0203 0204 0234 0256 0272
0287 0290 0304 0334 0359 0378 0403
0421 0858 0930 0988 1147 1162 1213

TRINICK, M.J.
0179 0497

TROUVELOT, A.
0933

TRUONG, B.
0713

TSERLING, G.I.
0114

TU, C.C.
1000

TUCKER, D.P.H.
0852

TUPAS, G.L.
0353

TZEAN, S.S.
0048 0266

UHLIG, S.K.
1234

UK, ROTHAMSTED
0012 0061 0136

USA, UNIVERSITY OF KENTU
0077

USHER, M.B.
1007

VAIL, W.J.
0894

VALDES, M.
0472

VANDERPLOEG, J.F.
0386

VARMA, A.K.
0218 0232 0461

VEGH, I.
1011

VENKATARAMANAN, M.N.
0062 0205

VENUGOPAL, N.
0676

VERBERNE, N.J.
0611

VERKADE, S.D.
0641

VERMA, B.C.
0749 0808

VERSCHOYLE, M.J.S.
0563

VOGEL, W.G.
0197

VOIGT, G.K.
0134

VOVLAS, N.
1056

VOZZO, J.A.
0135 0387 0406

VURCKHARDT, E.
0594

WAGNER, C.A.
0233

WAGNER, D.
0284

WAIDYANATHA, U.P.
0267 0750

WAITE AGRICULTURAL RESEA
0089

WALKER, C.
0206 0234 0235 0291

WALKER, G.D.
0479

WALKER, J.E.
0658

WALKER, N.A.
0543

WALLACE, L.L.
0620 0671

WAN, Z.L.
0721

WANI, S.P.
0760

WARCUP, J.H.
1166

WARNER, A.
0470 0607 0906 0942

WARNOCK, A.J.
1007

WATRUD, L.S.
1143 1205 1206

WEAVER, D.J.
1108

WEED, S.B.
1232

WEHUNT, E.J.
1108

WEIJMAN, A.C.M.
0292

WEIR, R.G.
0723

WHITE, J.A.
0480 0491

WHITNEY, R.D.
0418

WHITTINGHAM, J.
0621

WICK, R.L.
1008

WICKLOW, D.T.
0919

WILD, A.
0581 0709 0710 0740

WILD, J.A.
0827

WILDE, S.A.
0033 0137

WILHELM, J.M.
0388

WILHELM, S.
0388

WILLIAMS, S.E.
0293 0354 0853

WOJAHN, K.E.
1099

WOLLUM, A.G.
0853

WONG, J.Y.
0147

WOODHEAD, S.H.
1156

WOOLHOUSE, H.W.
1217

WRIGHT, S.E.
0194

YAKOBI, L.M.
0654

YODER, J.F.
0629

YODER, W.A.
0894

YOGARATNAM, N.
0750

YOST, R.S.
0013 0622 0672 0751 0752

YOUNG, J.L.
0558 1145 1221

YOUNGBERG, C.T.
0661

YOUNUS, M.
0215

YOUSAF, M.
0215

ZAAG, P. VANDER
0752

ZAIDI, A.A.
0328

ZAK, J.C.
0207 0443

ZAMBOLIN, L.
0615 1031

ZANDSTRA, B.H.
0673 0916

ZATSEPINA, V.M.
0392

ZENTMYER, G.A.
0767 1074

ZORRILLA, R.A.
1050