JOINT INFLUENCE OF *PRATYLENCHUS PENETRANS* (NEMATODA) AND *GLOMUS FASCICULATUM* (PHYCOMYCETA) ON THE ONTOGENY OF *PHASEOLUS VULGARIS*[1]

A. P. Elliott, G. W. Bird, and G. R. Safir

Respectively, Assistant Professor, Department of Plant Pathology and Physiology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061; Professor, Department of Entomology, and Associate Professor, Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824, U.S.A.

Accepted:

24.IV.1984

Aceptado:

ABSTRACT

Elliott, A. P., G. W. Bird, and G. R. Safir. 1984. Joint influence of *Pratylenchus penetrans* (Nematoda) and *Glomus fasciculatum* (Phycomyceta) on the ontogeny of *Phaseolus vulgaris*. Nematropica 14:111-119.

The joint influence of *Pratylenchus penetrans* and *Glomus fasciculatum* on the ontogeny of *Phaseolus vulgaris* (navy beans) was examined under greenhouse conditions. Root colonization by *G. fasciculatum* was less in the presence of *P. penetrans* than in its absence. Population densities of *P. penetrans* were initially (prior to 600 cumulative degree days at a base of 10C [DD_{10}]) lower in plants exposed to only *P. penetrans* than in plants grown in the presence of both organisms. After 600 DD_{10}, nematode population densities were greater in plants exposed to both *P. penetrans* and *G. fasciculatum* than in those grown only in the presence of the nematode. In addition, the reproductive rate of *G. fasciculatum* was reduced in the presence of *P. penetrans*. Plant growth and yield were reduced in the presence of *P. penetrans*, and increased in the presence of *G. fasciculatum*.

Additional key words: root-lesion nematode, dry beans, vesicular-arbuscular mycorrhizae.

RESUMEN

Elliott, A. P., G. W. Bird y G. R. Safir. 1984. Influencia conjunta de *Pratylenchus penetrans* (Nematoda) y *Glomus fasciculatum* (Phycomyceta) en la ontogenia del *Phaseolus vulgaris*. Nematropica 14:111-119.

La influencia conjunta de *Pratylenchus penetrans* y *Glomus fasciculatum* en la ontogenia del *Phaseolus vulgaris* (frijol blanco) fue examinada bajo condiciones de invernadero. La colonización de las raices del frijol por *G. fasciculatum* fue menor en presencia de *P. penetrans* que en su ausencia. La densidad de las poblaciones de *P. penetrans* fueron inicialmente [inferior a 600 grados días acumulativos a base de 10C (DD_{10})] más bajas en plantas expuestas solamente a *P. penetrans* que en plantas creciendo en presencia de ambos organismos. Por encima de 600 DD_{10}, las densidades fueron mayores en plantas expuestas a ambos *P. penetrans* y *G. fasciculatum* que aquellas creciendo sólo en presencia del nematodo. En adición la proporción de re-

producción de *G. fasciculatum* fue reducida en presencia de *P. penetrans*. El crecimiento de la planta y los rendimientos fueron reducidos en presencia de *P. penetrans* y aumentaron en presencia de *G. fasciculatum*.
Palabras claves adicionales: nematodo de las lesiones, frijol blanco, micorriza visicular arboscular.

INTRODUCTION

Vesicular-arbuscular (VA) mycorrhizal fungi (Phycomyceta) and the root-lesion nematode (*Pratylenchus penetrans* Filipjev & Schuurmans Stekhoven, 1941) are commonly found in soils associated with dry bean (*Phaseolus vulgaris* L.) production in Michigan (5). VA mycorrhizal-nematode interactions have been studied by a number of researchers (2,

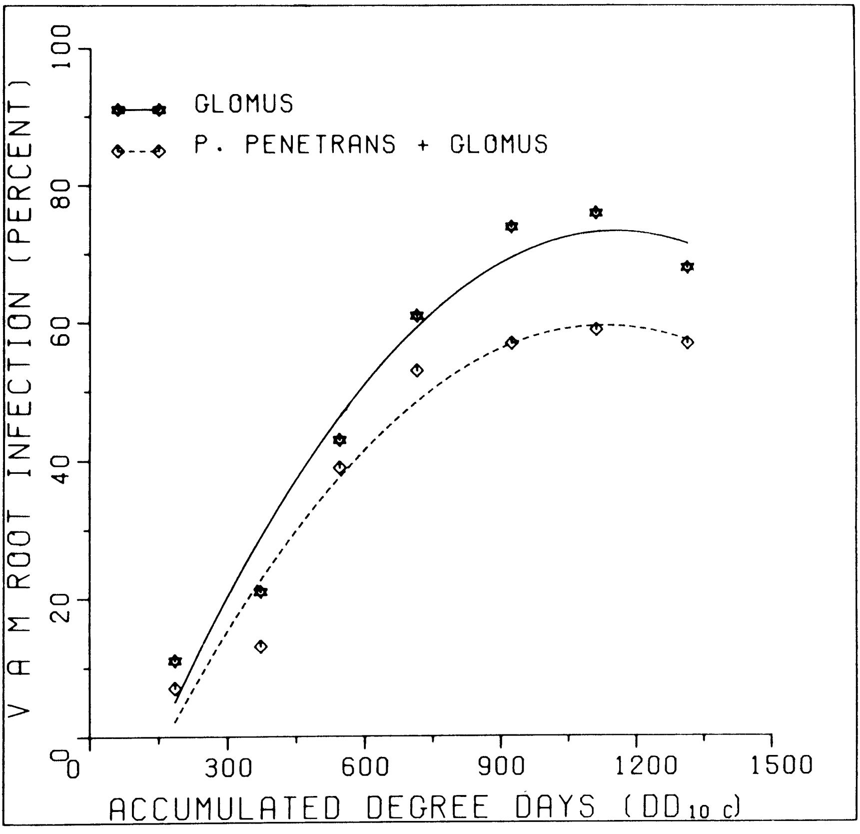

Fig. 1. Joint influence of *Glomus fasciculatum* and *Pratylenchus penetrans* on vesicular-arbuscular mycorrhizal colonization of *Phaseolus vulgaris*.

7, 10, 16, 17, 19, 20). Although the results of these studies vary, there is increasing evidence that under a number of environmental conditions, the detrimental influence of plant-parasitic nematodes can be at least partially alleviated by the presence of an endomycorrhizal association (11, 21). The objective of this investigation was to evaluate the impact of *P. penetrans* on *P. vulgaris* cv 'Sanilac' in the presence and absence of the VA mycorrizal fungus *Glomus fasciculatum* sensu Gerdemann, 1974.

MATERIALS AND METHODS

A randomized-design greenhouse study consisting of 4 replicates of 4 treatments was used to evaluate the joint influence of *G. fasciculatum* and *P. penetrans* on the ontogeny of *P. vulgaris*. The 4 treatments included: (i) an initial nematode population density of 300 *P. penetrans*

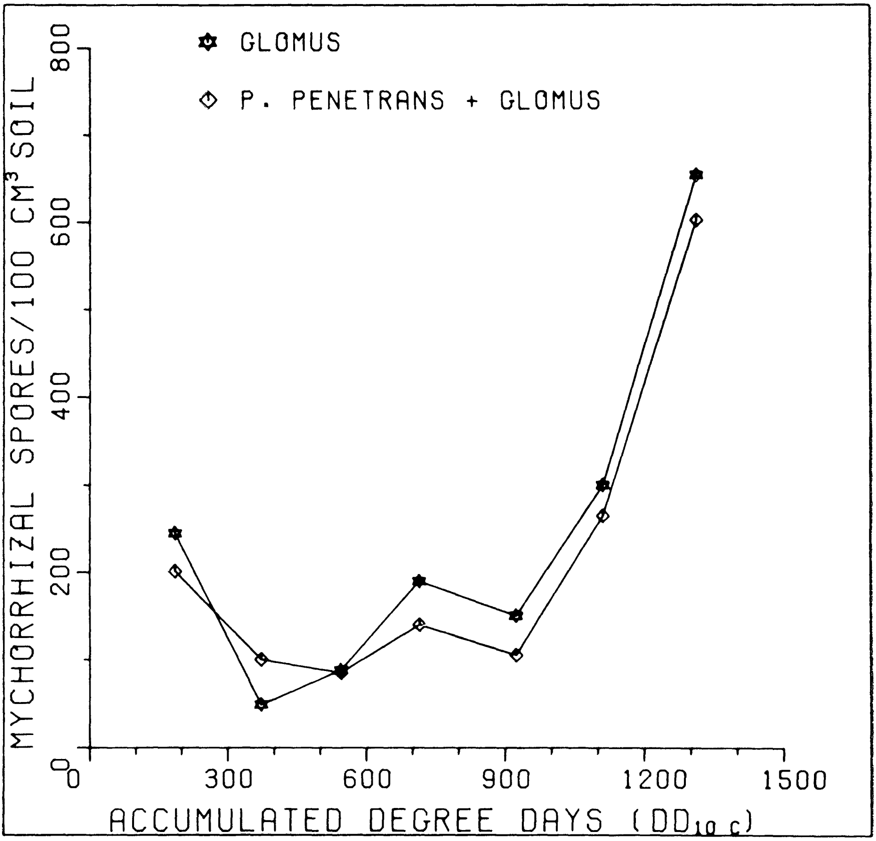

Fig. 2. Influence of *Pratylenchus penetrans* on spore density of *Glomus fasciculatum*.

per 100 cm^3 soil, (ii) 1000 spores of *G. fasciculatum* per 100 cm^3 soil, (iii) 300 *P. penetrans* plus 1000 spores of *G. fasciculatum* per 100 cm^3 soil, and (iv) a control where the plants were grown in the absence of these two organisms. One hundred and twelve 23.7-cm-diameter clay pots were filled with 3000 cm^3 of soil containing the desired densities of *P. penetrans* and *G. fasciculatum*, obtained by mixing steam-sterilized sandy clay loam soil with *P. penetrans*-infested soil and soil containing spores of *G. fasciculatum*. Three navy bean seeds were planted in the soil in each pot. The plants were thinned to one seedling per pot after germination, watered daily, and maintained at 30 ± 5.5 C under greenhouse conditions for 98 days.

Four replicates of each of the treatments were analyzed every 14 days. Plant growth measurements, including leaf area, shoot fresh weight, and root area, were recorded throughout this experimental period. Relative

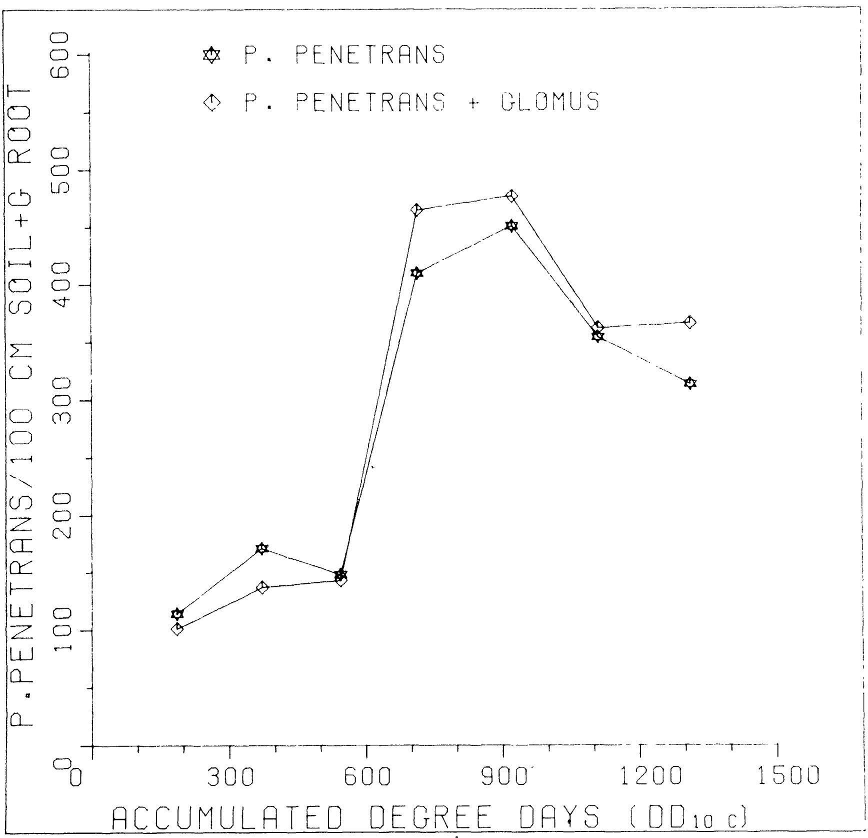

Fig. 3. Influence of *Glomus fasciculatum* on population dynamics of *Pratylenchus penetrans*.

estimates of leaf and root areas were estimated by optical scanning. Individual leaves and root segments were passed through a Lambda leaf area meter, Model LI3000®. Shoot systems were oven-dried at 30 ± 5 C, and leaf area ratios (6) were calculated (leaf area ratio = leaf area/plant dry weight). Soil and root samples were taken for nematode analysis, and *P. penetrans* densities estimated microscopically from 100 cm^3 of soil and 1.0 g of root tissue (3, 9). VA mycorrhizal root colonization was determined using root staining (acid fuchsin) and microscopic observation procedures. Estimates were made from 1.0-g root tissue samples. Soil samples were analyzed for spores of *G. fasciculatum* using a modified centrifugation-flotation technique (9).

RESULTS

VA mycorrhizal root colonization by *G. fasciculatum* increased

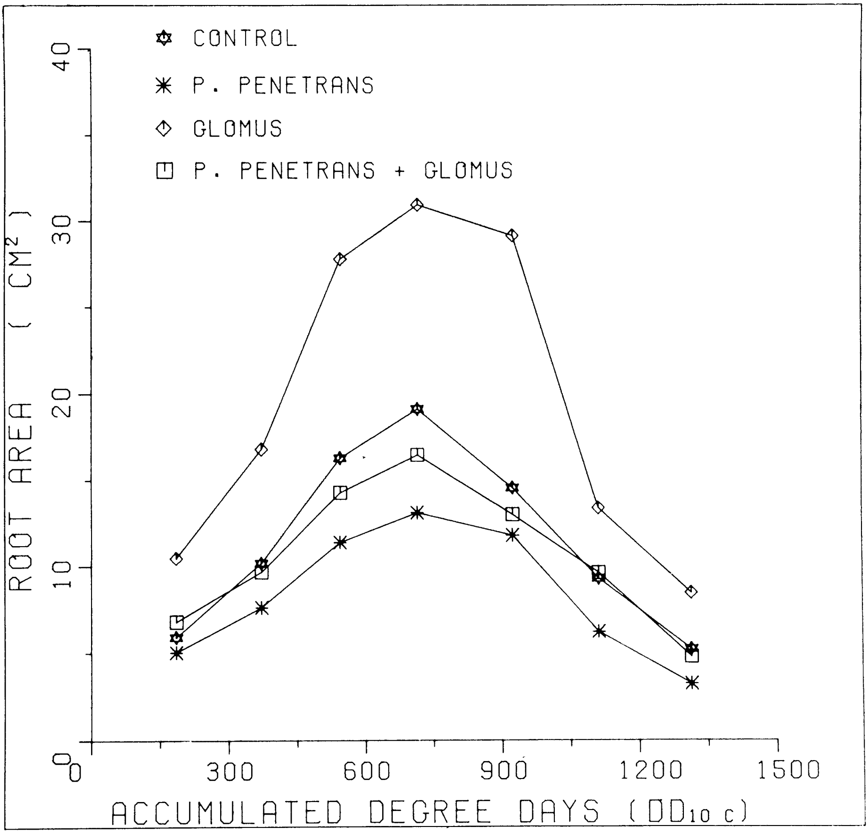

Fig. 4. Influence of *Pratylenchus penetrans* and *Glomus fasciculatum* on root area of *Phaseolus vulgaris*.

throughout the first 900 accumulative degree days at a base of 10 C (DD_{10} = 900) of the experimental period. The relationship between VA mycorrhizal root colonization and cumulative degree days was expressed as a second degree polynomial (Fig. 1). VA mycorrhizal root colonization was less in plants infected with *P. penetrans,* compared to mycorrhizal plants grown in the absence of this nematode. *G. fasciculatum* spore density declined, remained at a low density until 900 DD_{10}, and then increased (Fig. 2). The presence of *P. penetrans* had no detectable impact on the spore density of *G. fasciculatum.*

During the first 600 DD_{10}, population densities of *P. penetrans* were higher in plants infected with only *P. penetrans* compared to nematode population densities associated with plants grown in the presence of both organisms (Fig. 3), although differences were not statistically significant (P = 0.05). After 600 DD_{10}, population densities of *P. penetrans* were higher in plants infected with both *P. penetrans* and *G. fasciculatum.* Maxima in nematode population densities were observed at 343 and 715 DD_{10}, and remained relatively constant until 900 DD_{10}. This was followed by a slight decline in population densities of *P. penetrans.*

The root area of *P. vulgaris* was lowest in plants infected with *P. penetrans,* and highest in those colonized with *G. fasciculatum* (Fig. 4). Root area increased through 715 DD_{10}, and then decreased for the remainder of the experiment. Plant leaf area ratios fluctuated throughout the growth period. These were generally greatest in plants infected with *P. penetrans* and lowest in plants colonized with *G. fasciculatum.* Dry bean yield was significantly (P = 0.05) increased in plants colonized with *G. fasciculatum* and decreased in plants infected with *P. penetrans* (Fig. 5). There was no significant (P = 0.05) difference between dry bean yield of control plants and plants colonized with both *G. fasciculatum* and *P. penetrans.*

DISCUSSION

Colonization of *P. vulgaris* by *G. fasciculatum* resulted in increased plant growth and bean yield. The adverse effects of *P. penetrans* on growth and yield of dry beans was reduced in the presence of VA mycorrhizal colonization of *P. vulgaris* by *G. fasciculatum.* The mode of action and the function of the fungus in interactions with *P. penetrans* and navy beans is not known. Population densities of *P. penetrans* were not significantly different in plants infected with both *P. penetrans* and *G. fasciculatum.* The increased plant tolerance to *P. penetrans,* therefore, did not appear to be directly related to nematode population densities. Although a significant amount of additional research is needed, the presence of certain species of VA mycorrhizal fungi in navy bean production systems can be considered as beneficial. Maintenance of optimum densities of selected VA mycorrhizal fungi may be desirable in future nematode management strategies in navy bean production. The influence of agricultural chemicals on mycorrhizal associations should be considered in development of nematode control strategies (1, 4, 14, 15). The value of VA mycorrhizal fungi as a future component of an integrated nematode management strategy for navy bean production systems will most likely vary with different nematode and VA mycorrhizal fungi species. The nature of the indigenous species must be determined and the impact of introducing other species evaluated. Relationships between mycorrhizae and nematodes may not always result in beneficial effects on plants. Where the beneficial mycorrhizal species are not in-

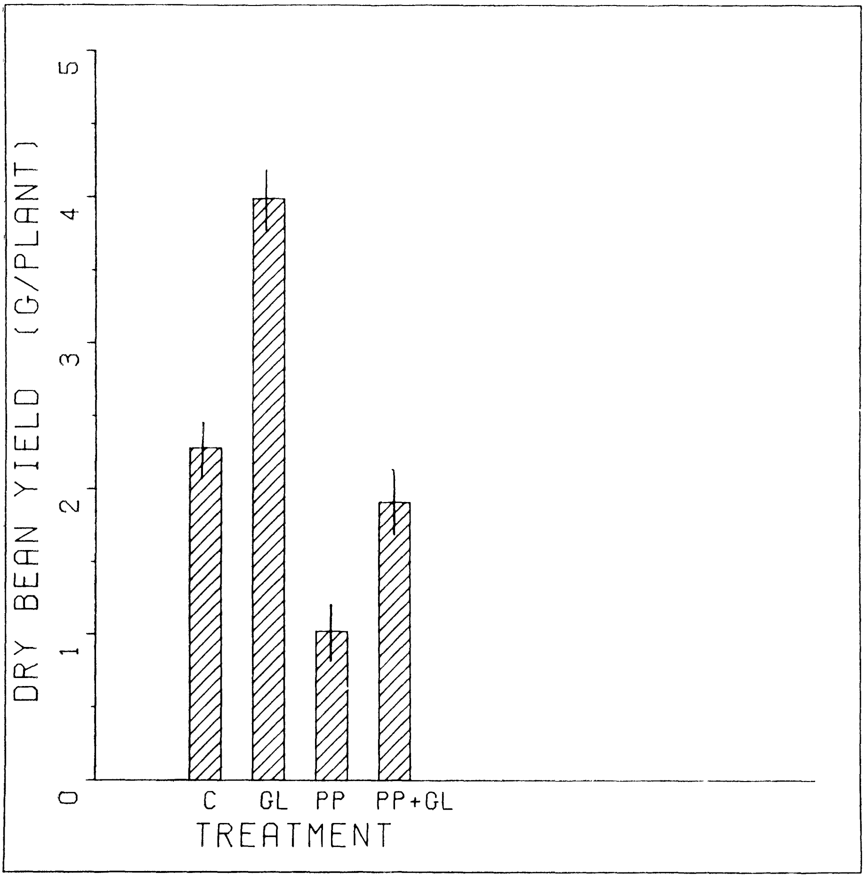

Fig. 5. Influence of *Pratylenchus penetrans* (PP) and *Glomus fasciculatum* (GL) on yield of *Phaseolus vulgaris* (C = control).

digenous, it may be possible to introduce them, and increase population densities by effective crop rotation (12, 13).

LITERATURE CITED

1. BACKMAN, P. A., and E. M. CLARK. 1977. Effect of carbofuran and other pesticides on vesicular-arbuscular mycorrhizae in peanuts. Nematropica 7:13-17.
2. BALTRUSCHAT, H., R. A. SIKORA, and F. SCHONBECK. 1973. Effect of VA mycorrhiza *Endogone mosseae*) on the establishment of *Thielaviopsis basicola* and *Meloidogyne incognita* in tobacco. No. 0661, 2nd Int. Congr. of Pl. Path. 1973. Minn. (Abstr.).
3. BIRD, G. W. 1971. Influence of incubation solution on the rate of recovery of *Pratylenchus brachyurus* from cotton roots. J. Nematol. 3:378-385.
4. BIRD, G. W., J. R. RICH, and S. V. Glover. 1974. Increased endomycorrhizae on cotton roots in soil treated with nematicides. Phytopathology 64:48-51.
5. ELLIOTT, A. P. 1980. Ecology of *Pratylenchus penetrans* associated with navy beans (*Phaseolus vulgaris* L.). Ph.D. Dissertation, Dept. of Entomology, Michigan State Univ., E. Lansing, MI 352 pp.
6. EVANS, G. C. 1972. The quantitiative analysis of plant growth. Studies in ecology, Vol. I. Univ. of California Press, Berkeley. 736 pp.
7. FOX, J. A., and L. SPASOFF. 1972. Interaction of *Heterodera solanacearum* and *Endogone giganta* on tobacco. J. Nematol. 4:224-225. (Abstr.).
8. GRAY, L. E., and J. W. GERDEMANN. 1967. Influence of vesicular-arbuscular mycorrhizae on uptake of phosphorus-32 by *Liriodendron tulipifera* and *Liquidambar styraciflua*. Nature 213:106-107.
9. JENKINS, W. R. 1966. A rapid centrifugal-flotation technique for separating nematodes from soil. Plant Dis. Reptr. 48:692.
10. HUSSEY, R. S., and R. W. RONCADORI. 1978. Interaction of *Pratylenchus brachyurus* and *Gigaspora margarita* on cotton. J. Nematol. 10:16-20.
11. HUSSEY, R. S., and R. W. RONCADORI. 1982. Vesicular-arbuscular mycorrhizae may limit nematode activity and improve plant growth. Plant Disease 66:9-14.
12. KHAN, A. G. 1975. Mycorrhizae and their significance in plant nutrition. Biologica 42-48 (Special Supplement, April).
13. KHAN, A. G. 1975. Growth effects of vesicular-arbuscular mycorrhiza on crops in the field. Pp. 419-436 *in* Sanders, F. E., B. Mosse, and P. B. Tinker (eds.), Endomycorrhizas. Academic Press, London. 626 pp.
14. KLEINSCHMIDT, G. D., and J. W. GERDEMANN. 1972. Stunting

of citrus seedlings in fumigated nursery soils related to the absence of endomycorrhizae. Phytopathology 62:1447-1453.
15. NESHEIM, N. O., and M. B. LINN. 1969. Deleterious effects of certain fungitoxicants on the formation of mycorrhizae on corn by *Endogone fasciculatus* and corn root development. Phytopathology 59:297-300.
16. O'BANNON, J. H., R. N. NEMEC, and N. VORLES. 1979. The response of *Citrus limon* seedlings to a symbiont, *Glomus etunicatus* and a pathogen, *Radopholus similis*. J. Nematol. 11:270-275.
17. RICH, J. R., and G. W. BIRD. 1974. Association of early-season vesicular-arbuscular mycorrhizae with increased growth and development of cotton. Phytopathology 64:1421-1425.
18. RHODES, L. G. 1976. Effects of vesicular-arbuscular mycorrhizae on sulfate, calcium, and zinc uptake by onion plants. Ph.D. Thesis. Univ. of Illinois, Champaign-Urbana, Ill.
19. SCHENCK, N. C., and R. A. KINLOCH. 1974. Pathogenic fungi, parasitic nematodes, and endomycorrhizal fungi associations with soybean roots in Florida. Plant Dis. Reptr. 61:266-267.
20. SCHENCK, N. C., R. A. KINLOCH, and D. W. DICKSON. 1975. Interaction of endomycorrhizal fungi and root-knot nematodes on soybean. Pp. 607-618 *in* Sanders, F. E., B. Mosse, and P. B. Tinker (eds.), Endomycorrhizas. Academic Press, London. 626 pp.
21. SIKORA, R. A. 1979. Predisposition to *Meloidogyne* infection by the endotrophic mycorrhizae fungus *Glomus mosseae*. Pp. 399-404 *in* Lamberti, F., and C. E. Taylor (eds.), Root-knot nematode (*Meloidogyne* spp.) systematics, biology, and control. Academic Press, New York. 477 pp.
22. TINKER, P. B. 1975. Effects of vesicular-arbuscular mycorrhizas on higher plants. Symp. Soc. Exp. Biol. 29:325-349.

Received for publication:
16.XII.1983
Recibido para publicar:

---

[1]Michigan Agricultural Experiment Station Journal Article Number 11095. Research conducted by the senior author as part of a Ph.D. dissertation, and partially supported by the Michigan Dry Edible Bean Research Board.