

THE EFFECT OF BIOBARRIER® ON MYCORRHIZAE IN OAK AND SWEETGUM

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Abstract. The effect of Biobarrier® herbicide-impregnated barrier fabric (Reemay, Inc., P.O. Box 511, Old Hickory, TN 37138-3651) on mycorrhizae occurrence was assessed on established pin oak (*Quercus palustris*) and sweetgum (*Liquidambar styraciflua*) trees. Trenches were dug through 24 tree root systems, and in 12 of the root systems, trenches were lined with Biobarrier. Seventeen months later roots were collected from within and adjacent to the trenches. Microscopic examination revealed that ectomycorrhizae occurred on roots of all 12 oak trees, regardless of the presence or absence of the barrier fabric. Similarly, roots from all sweetgum trees, except for 1 control tree (no barrier fabric), had vesicular endomycorrhizae.

Key Words. Trifluralin; Biobarrier®; mycorrhizae; Fagaceae, Hamamelidaceae.

Prevention of tree root growth in urban landscapes is sometimes necessary to minimize damage to hardscape infrastructure such as sidewalks, pavements, buried sewer pipes, etc. (Wagar and Barker 1983; Knight et al. 1992; Coder 1998). Similarly, tree root barriers can assist in reducing transmission of diseases that occur via root grafts (e.g., oak wilt and Dutch elm disease) (Bruhn 1995; Agrios 1997). Gilman (1996) found that Biobarrier®, a polypropylene fabric containing herbicide (trifluralin)-impregnated nodules was effective at preventing tree roots from growing into trenches for 3 years. Recently completed tests of several in-ground barrier materials indicate that Biobarrier was among the best at preventing tree roots from growing into trenches (B. Rao, The Davey Tree Institute, unpublished data).

Biobarrier was first introduced in 1989 by Reemay, Inc., following several years of government-sponsored studies on methods to prevent roots from growing into underground waste storage containers (Van Voris et al. 1988). The product works by releasing trifluralin from nodules in the fabric as a vapor, so that roots growing only in close proximity (< 3 cm [1.2 in.]) to the fabric are affected (Zimmerman 1993). The product is guaranteed to be effective for 15 years, but the dose of herbicide emitted, as well as its longevity, is markedly affected by soil condi-

tions, especially temperature. One application of Biobarrier might therefore remain effective, i.e., actively emitting herbicide, for up to 100 years under cool soil conditions (10°C [50°F]) or only a few years under hot soil conditions (e.g., 40°C [104°F]) (Van Voris et al. 1988; Coder 1998).

Sweetgum (*Liquidambar styraciflua*) develops endomycorrhizae, and pin oak (*Quercus palustris*) develops ectomycorrhizal and endomycorrhizal associations (Watson et al. 1990; Alexopoulos et al. 1996). Several herbicides, including trifluralin, have been shown to negatively impact both types of mycorrhizae, but data are sometimes contradictory (Trappe et al. 1994). Industry concerns about the possible reduction of mycorrhizal roots, and in turn tree vitality, in response to herbicide-impregnated barrier fabrics prompted us to conduct this study. We evaluated the effects of trenching with and without Biobarrier on the presence or absence of naturally occurring endo- and ectomycorrhizae in established sweetgum and pin oak.

METHODS

Test Site

Trees were grown at the Davey Tree Research Station in Shalersville, Ohio (USDA cold hardiness zone 5b) in a well-drained, Ravenna silt loam soil. Soil temperature data were not collected at the Ohio test site, but the 7-year average in soils underlying grass near The Morton Arboretum in Lisle, Illinois (Zone 5a), was approximately 15°C (59°F) with a winter low of 2°C (37°F) and a summer high of 28°C (83°F) (P. Kelsey, The Morton Arboretum, personal communication). Based on those temperatures, nodules within the barrier fabric would be expected to have been actively releasing trifluralin for the duration of the study (see Coder 1988).

Trenching and Barrier Placement

Twelve 24-year-old old oak and twelve 24-year-old sweetgum trees (dbh between 18 and 38 cm [7 and 15 in.]) were growing in an established plot of 4 rows of 6 trees each. Trees were spaced 4.7 m (15 ft) apart

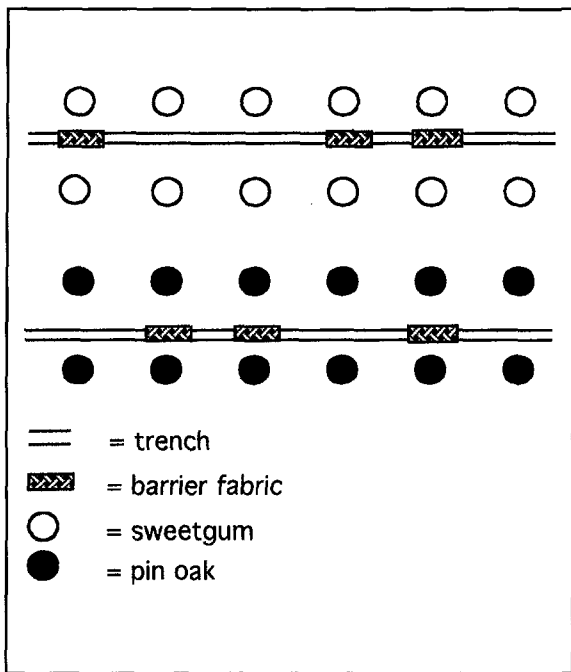


Figure 1. Diagram of study plot showing tree, trench, and Biobarrier placement. The 12 treated trees are opposite the 6 areas of trench containing the barrier fabric, and the remaining 12 trees provided controls. Spacing details are provided in the text.

and trees of 1 species were planted in adjacent rows. One trench was dug between the adjacent rows of each species using a mechanical trencher in June 1996. Each trench was 50 cm (20 in.) deep by 20 cm (8 in.) wide and was positioned 1.5 m (5 ft) from 1 row of trees and 3 m (10 ft) from the adjacent row (Figure 1). The trenches were placed at different distances from the trees in order to assess the possible importance of distance between trench and trunk on root growth effects.

The barrier fabric treatment consisted of lining both sides of a trench with 50-cm (19.5-in.) long strips of Biobarrier (Figure 2) and positioning the center of the barrier fabric to coincide with the target tree's trunk. The trenched area in front of control trees received no barrier fabric (Figure 1). All trenches were backfilled with soil taken from the trench after removing any visible roots.

Root Sampling

Seventeen months later, in November 1997, roots were collected from within the trenches by excavating sections of the trench approximately 20 cm long x 20 cm wide x 61 cm deep (8 x 8 x 24 in.) that were lined with barrier fabric (treated trees), or, in the case of control trees, areas without barrier fabric. Care was taken and additional digging was done when necessary to ensure that the roots being collected originated from the target tree. Control root samples were taken from soil within the trenches, while samples from treated trees came from soil adjacent to the tree side of the trench because no roots were found inside barrier-lined areas of the trenches. Approximately 30 g (1.1 oz) of roots were excised and placed in a moist bag and kept at 10°C (50°F) until further evaluation (approximately 2 to 3 days). Each bag was considered a sample and consisted of several large roots ranging in diameter from 1 to 1.5 cm (0.4 to 0.6 in.) along with accompanying secondary and fine roots.

Mycorrhizae Detection

All root samples were first washed in tap water to remove soil particles and other debris. Sweetgum roots were expected to be endomycorrhizal and showed no evidence of ectomycorrhizae, and so were processed according to Brundrett et al. (1994). Briefly, washed roots were fixed in formalinacetic acidalcohol

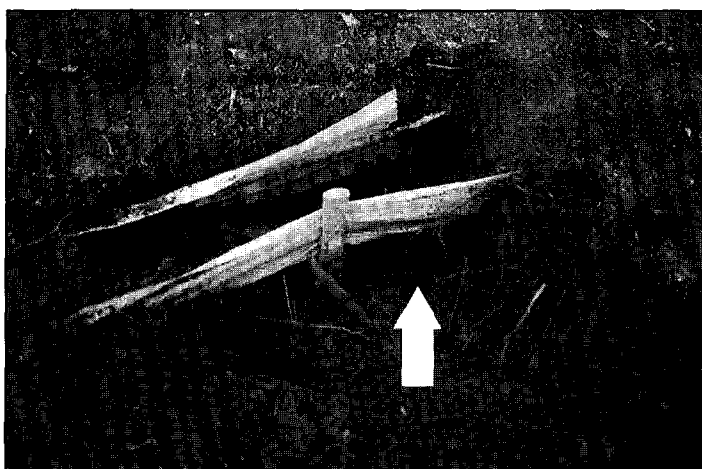


Figure 2. Trench lined with Biobarrier showing roots (arrow) that grew to the barrier fabric but not into the trench. Roots are visible on the tree side of the barrier, and the target tree stands approximately 1.5 m (5 ft) away from the barrier.

(FAA) and cleared in 10% potassium hydroxide at room temperature for 2 weeks. Cleared roots were transferred to 0.05% trypan blue in lactoglycerol for 1 week, then destained overnight in 2 changes of acidified water. Twenty 1- to 2-cm (0.8-in.) long segments of fine roots were treated as subsamples of each sample and were examined microscopically for the presence of internal vesicles, arbuscules, and hyphae characteristic of endomycorrhizal fungi.

Roots from pin oak trees were expected to be mainly ectomycorrhizal and so were not examined for endomycorrhizae. A minimum of 10 root subsamples, each several centimeters long, were examined under a stereo microscope for each sample. The presence of swollen, short roots, highly branched short roots, external hyphae, and other indications of ectomycorrhizal infection were noted. If no ectomycorrhizae were detected in the 10 subsamples, additional roots were examined until none remained in the sample.

The presence or absence of mycorrhizae was analyzed for association with the barrier fabric using the Chi-square procedure. Photomicrographs were taken with a Nikon Optiphot® autoexposure system and recorded onto Fuji 100 ASA color slide film.

RESULTS

No roots were found in any trench area lined with Biobarrier, although roots were found very close, e.g., 1 cm (0.4 in.) to the barrier-lined trench. Control tree roots had grown into, and frequently across, trench

areas without Biobarrier during the 17-month period, regardless of whether the trench was dug 1.5 or 3.0 m (5 or 10 ft) from a tree's trunk.

Samples taken from the 6 treated sweetgum trees all had endomycorrhizal roots containing vesicles and hyphae (Figure 3). Samples taken from 5 of the 6 control sweetgums were also mycorrhizal, but none of the 20 root sections examined from the remaining control tree contained endomycorrhizal structures.

Swollen, highly branched short roots characteristic of ectomycorrhizae (Figure 4) were observed in all 12 pin oak root samples regardless of whether the trees were controls or treated (exposed to the barrier).

The Chi-square test added no further clarification to the findings: 100% of the treated pin oak trees developed ectomycorrhizae, as did 100% of the control pin oak trees. Likewise, 100% of treated sweetgum trees and 83% of the control sweetgums developed endomycorrhizae. Collectively, these percentages indicate that there was no association between mycorrhizae occurrence and the presence or absence of the barrier fabric.

DISCUSSION

Ecto- and endomycorrhizae formation in oak and sweetgum, respectively, appears to be unaffected by exposure to the trifluralin-containing barrier fabric, as installed in this study. The low sample and replication numbers limit our ability to quantify differences, but the results are clear in showing no difference between roots that were or were not exposed to the barrier fabric.

The findings reported are contrary to some earlier reports of the effect of trifluralin on ectomycorrhizae. One study documented severely reduced levels of ectotrophic mycorrhizae (ectomycorrhizae) in pine seedlings planted in trifluralin-treated pots (Iloba 1977b). Two other studies reported that mycorrhizal fungi are inhibited *in vitro* by the herbicide (Iloba 1977a; Kelley and South 1977). However, the latter study found that only very high concentrations of trifluralin, e.g., 80-fold greater than the recommended rate, were capable of inhibiting fungal growth. Such high concentrations of trifluralin could not have been emitted from Biobarrier (Zimmerman 1993).

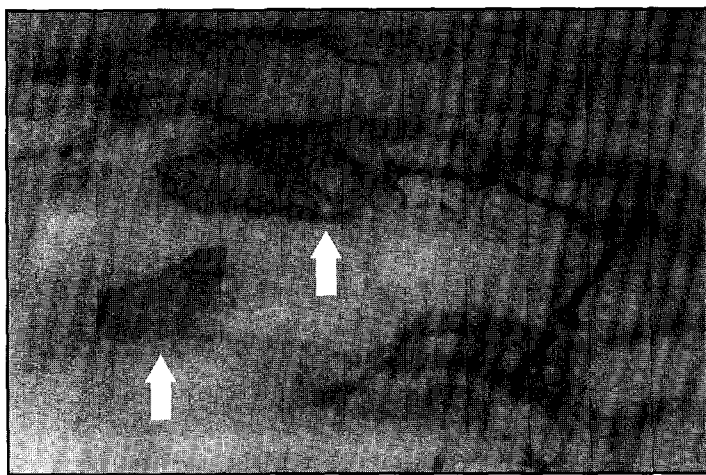


Figure 3. Root from sweetgum treated with Biobarrier. Root section was stained with trypan blue and viewed with a brightfield light microscope. Note dark-staining hyphae and vesicles (arrows) of endomycorrhizal fungal symbiont (400X).

Other field and greenhouse investigations on the effects of trifluralin support our findings. No detrimental effects could be detected on endomycorrhizae development in soybean (*Glycine max*) (Burpee et al. 1978) and citrus (*Citrus spp.*) (Nemec and Tucker 1983) when trifluralin was applied as a soil drench. Similarly, endomycorrhizae formation in sweetgum seedlings was not diminished following a pre-emergent treatment of the soil with trifluralin (South et al. 1980).

CONCLUSIONS

This is the first report, to our knowledge, indicating that Biobarrier does not apparently affect mycorrhizae formation (neither ecto- nor endomycorrhizae) in established trees. Care should be taken in extrapolating the results to other tree species, as well as other soil conditions given the impact of edaphic factors on herbicide emission. It should also be noted that other herbicides are more toxic to mycorrhizae than trifluralin (see Trappe et al. 1994) and our results should not be applied generally to similar products containing other herbicides.

LITERATURE CITED

- Alexopoulos, C.J., C.W. Mims, and M. Blackwell. 1996. *Introductory Mycology*. Wiley, New York, NY. 869 pp.
- Agrios, G.N. 1997. *Plant Pathology*, 4th ed. Academic Press, New York, NY. 633 pp.
- Bruhn, J.N. 1995. Oak wilt management in Michigan, pp 109–116. In Appel, D.N., and R.F. Billings (Eds.). *Oak Wilt Perspectives: Proceedings of the National Oak Wilt Symposium*.
- Brundrett, M., L. Melville, and L. Peterson (Eds.). 1994. *Practical Methods in Mycorrhiza Research*. Mycologue Publications, Guelph, Ontario. 161 pp.
- Burpee, L.L., and H. Cole, Jr. 1978. The influence of alachlor, trifluralin, and diazinon on the development of endogenous mycorrhizae in soybeans. *Bull. Environ. Contam. Toxicol.* 78:191–197.
- Coder, K.D. 1998. Root growth control: Managing perceptions and realities, pp 51–78. In Neely, D., and G. Watson (Eds.). *The Landscape Below Ground II: Proceedings of an International Workshop on Tree Root Development in Urban Soils*. International Society of Arboriculture, Champaign, IL. 265 pp.



(a)



(b)

Figure 4. Pin oak roots from trees treated with Biobarrier. Roots were washed and examined under a stereo microscope. (a) Swollen short roots of ectomycorrhizae (above) compared with nonmycorrhizal roots (below) from same tree (15X). (b) Highly branched, swollen short roots typical of ectomycorrhizal infection taken from a tree treated with the barrier fabric (27.5X).

- Gilman, E.F. 1996. Root barriers affect root distribution. *J. Arboric.* 22:151–154.
- Iloba, Ch. 1977a. The effect of trifluralin on the formation of ectotrophic mycorrhizae in some pine species I: toxicity to mycorrhiza-forming fungi. *Eur. J. For. Pathol.* 7:47–51.
- Iloba, Ch. 1977b. The effect of trifluralin on the formation of ectotrophic mycorrhizae in some pine species II: on the toxicity to ectotrophic mycorrhizae. *Eur. J. For. Pathol.* 7:172–177.
- Kelley, W.B., and D.B. South. 1977. *In vitro* effects of selected herbicides on growth of mycorrhizal fungi, p

15. In Marx, D.H. (Ed.). Abstracts of the Proceedings of the Third North American Conference on Mycorrhizae. Knight, P.R., D.J. Eakes, C.H. Gilliam, and J.A. Raeder. 1992. Root control techniques for the urban landscape. Proceedings of the Southern Nurserymen's Association Research Conference Annual Report 37:3940.
- Nemec, S., and D. Tucker. 1983. Effects of herbicides on endomycorrhizal fungi in Florida citrus (*Citrus* spp.) soils. *Weed Sci.* 31:427-431.
- South, D.B., D.H. Gjerstad, and S.J. Campbell. 1980. Comparison of methyl bromide and herbicide effects on endomycorrhizal formation, seedling production and weed control in sweetgum beds. *Eur. J. For. Pathol.* 10:371-377.
- Trappe, J.M., R. Molina, and M. Castellano. 1994. Reactions of mycorrhizal fungi and mycorrhiza formation to pesticides. *Annu. Rev. Phytopathol.* 22:331-359.
- Van Voris, P., D.A. Cataldo, C.E. Cowan, N.R. Gordon, J.F. Cline, F.G. Burton, and W.E. Skeins. 1988. Long-term controlled release of herbicides: Root growth inhibition, pp 223-240. In Cross, B., and H.B. Scher (Eds.). *Pesticide Formulations, Innovations and Developments*. American Chemical Society Symposium Series 371.
- Watson, G.W., K.G. von der Heide-Spravka, and V.K. Howe. 1990. Ecological significance of endo-/ectomycorrhizae in the oak sub-genus *Erythrolanus*. *J. Arboric.* 14:107-116.
- Wagar, J.A., and P.A. Barker. 1983. Tree root damage to sidewalks and curbs. *J. Arboric.* 9:177-181.
- Zimmerman, L. 1993. A new herbicide delivery system. *Plasticulture* 99:310.

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Résumé. Les effets d'une membrane Biobarrier® imprégnée d'herbicide sur le développement des mycorrhizes et l'inhibition de la croissance racinaire ont été étudiés sur des chênes des marais (*Quercus palustris*) et des copalmes d'Amérique (*Liquidambar styraciflua*) plantés en situation réelle. Des tranchées ont été creusées au travers du système racinaire de 24 arbres et le Biobarrier installé dans la moitié de ces tranchées. Sept mois plus tard, des échantillons de racines ont été récoltés ; leur examen microscopique a révélé que les ectomycorrhizes étaient présentes en quantités similaires pour les chênes sans membrane et ceux du groupe-témoin. De façon similaire, tous les copalmes sauf un du groupe-témoin avaient des endomycorrhizes vésiculaires. Malgré l'effet négligeable sur les mycorrhizes, la croissance racinaire a été entièrement arrêtée dans toutes les tranchées avec membrane. Ces résultats suggèrent que ni les ectos ou les endomycorrhizes ne sont affectées par la membrane Biobarrier® en situation réelle sur le terrain.

Zusammenfassung. Bei *Quercus palustris* und *Liquidambar* wurde der Einfluß von herbizidimprägnierten Wurzelbarrieren, Biobarrier®, untersucht. Es wurden durch 24 Wurzelsysteme Gräben gezogen und in 12 davon Biobarrier eingebaut. Siebzehn Monate später wurden Wurzelproben entnommen und die mikroskopische Untersuchung ergab, daß Ektomycorrhiza bei behandelten und unbehandelten Bäumen in gleichem Maße vorhanden war. Ähnlich dazu enthielten alle *Liquidambar* bis auf einen vesticuläres Endomycor-rhiza. Ungeachtet des zu vernachlässigenden Effekts von Mycorrhizza wurde in allen behandelten Gräben das Wurzelwachstum beschränkt. Diese Ergebnisse verdeutlichen, daß in Feldversuchen weder Ekto- und Endomycorrhiza durch Biobarrier Beeinflusst werden.

Resumen. Se examinó el efecto de una barrera geotextil impregnada de herbicida Biobarrier® sobre la inhibición del desarrollo de las micorrizas y el crecimiento de las raíces en árboles de encino (*Quercus palustris*) y liquidámbar (*Liquidambar styraciflua*). Se abrieron zanjas a través de 24 sistemas de raíces de los árboles y se instaló el Biobarrier en la mitad de las zanjas. Diecisiete meses mas tarde se tomaron muestras de las raíces y su examen reveló que las ectomicorrizas estaban presentes a niveles similares en el control y en los árboles tratados. Similarmente, todos los liquidámbar, excepto uno de control, contenían raíces con endomicorrizas. Con todo y el efecto mínimo sobre las micorrizas, el crecimiento de las raíces fue completamente contrarrestado en todas las zanjas con geotextil. Estos resultados sugieren que ni las ectomicorrizas ni las endomicorrizas son afectadas con Biobarrier en condiciones de campo.