WRP Technical Note VN-RS-4.2
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Mycorrhizae in Bottomland Hardwood (BLH) Wetland Forests

PURPOSE: This technical note describes the distribution of mycorrhizae in several BLH wetland forests of the Southeast and their potential importance in restoration of BLH wetland forests from agricultural lands.

BACKGROUND: Conversion of BLH wetland forests to agriculture is a primary cause of wetland loss in the southeastern United States (Figure 1). Restoration of BLH in abandoned agricultural fields, however, has had limited success. Low survival rates of planted trees are a consequence of several environmental factors such as water stress and herbivory. However, pilot studies of growth of seedlings inoculated with mycorrhizae native to BLH wetland forests suggest that disturbance of the soil microflora, including mycorrhizae, by agricultural practices may contribute to poor seedling survival rates.

Figure 1. Below-ground processes are poorly understood in BLH wetland forests of the southeastern United States

Mycorrhizae are formed by a symbiotic relationship between soil fungi and plant roots: plants benefit from the nutrients and moisture taken up from the soil by the fungi and the fungi benefit from sugars produced by the plant. Most terrestrial plants are mycorrhizal. The two most common types of mycorrhizae are ectomycorrhizae (EM) and endomycorrhizae, also called vesicular-arbuscular mycorrhizae (VAM). The EM fungi are mainly Basidiomycetes, familiar as the mushroom-forming fungi. The VAM fungi are Zygomycetes, most of which form microscopic underground spores. The majority of plant species are colonized by VAM fungi. EM colonization is almost exclusively limited to woody species, although many woody species are also colonized by VAM fungi. Both EM and VAM are present in bottomland hardwood forests, although the dominance of one or the other type appears to depend primarily on tree species. For example, EM are common associates with oaks (*Quercus* spp.) and hickories (*Carya* spp.). VAM commonly occur with maples (*Acer* spp.), ash (*Fraxinus* spp.), and sweetgum (*Liquidambar styraciflua*). EM tend to be more sensitive to flooding, while some VAM infection is present even in permanently flooded soils.

Mycorrhizae are important in the functioning of forest ecosystems and play a critical role in plant water uptake, nutrient acquisition, and prevention of feeder root disease. The mutually beneficial relationship between the fungi and plants can be disrupted, however, by disturbance of the vegetation or soils. The fungi can be killed with removal of the host plants, increased soil temperatures, desiccation, and application of chemicals such as fungicides used in agriculture. Once the fungi are lost, reestablishment of the vegetation can be limited. Inoculation of seedlings with mycorrhizae may increase survival and growth, particularly on stressful sites.

Limited research has been done on mycorrhizae in wetlands. Many questions must be answered to understand the role of mycorrhizae in BLH wetland forests and potential inoculation requirements to increase BLH restoration success. The study results presented here are the initial characterizations of EM mycorrhizae in southeastern BLH wetland forests. Additional studies are under way at WES to investigate effects of native mycorrhizal inoculation on growth and survival of seedlings in agriculture fields that were once BLH wetland forests.

METHODS: EM colonization of Nuttall oak (*Quercus nuttallii*), water oak (*Q. nigra*), willow oak (*Q. phellos*), and water hickory (*Carya aquatica*) was characterized from June to August 1995 at mature BLH wetland forests in Arkansas, South Carolina, and two sites in Mississippi. Fine root samples were collected from three trees growing at high and low microtopographic sites for a total of six trees of each species at each site. Washed roots from individual trees were examined microscopically for EM colonization on root tips. Mycorrhizal fungi isolated from EM-colonized root tips collected from Nuttall oak and water hickory were identified to species.

Depth of EM colonization was investigated in 4- × 30-cm soil cores. Five soil cores were taken at high and low microtopographic sites for a total of ten cores at each of the four sites. Roots were collected from 5-cm-deep increments from each core and examined for EM colonization.

RESULTS AND DISCUSSION: EM colonization of roots occurred at all BLH wetland forests that were sampled. All sampled tree species had high rates of colonization (> 70 percent of root tips) at all sites (Figure 2).

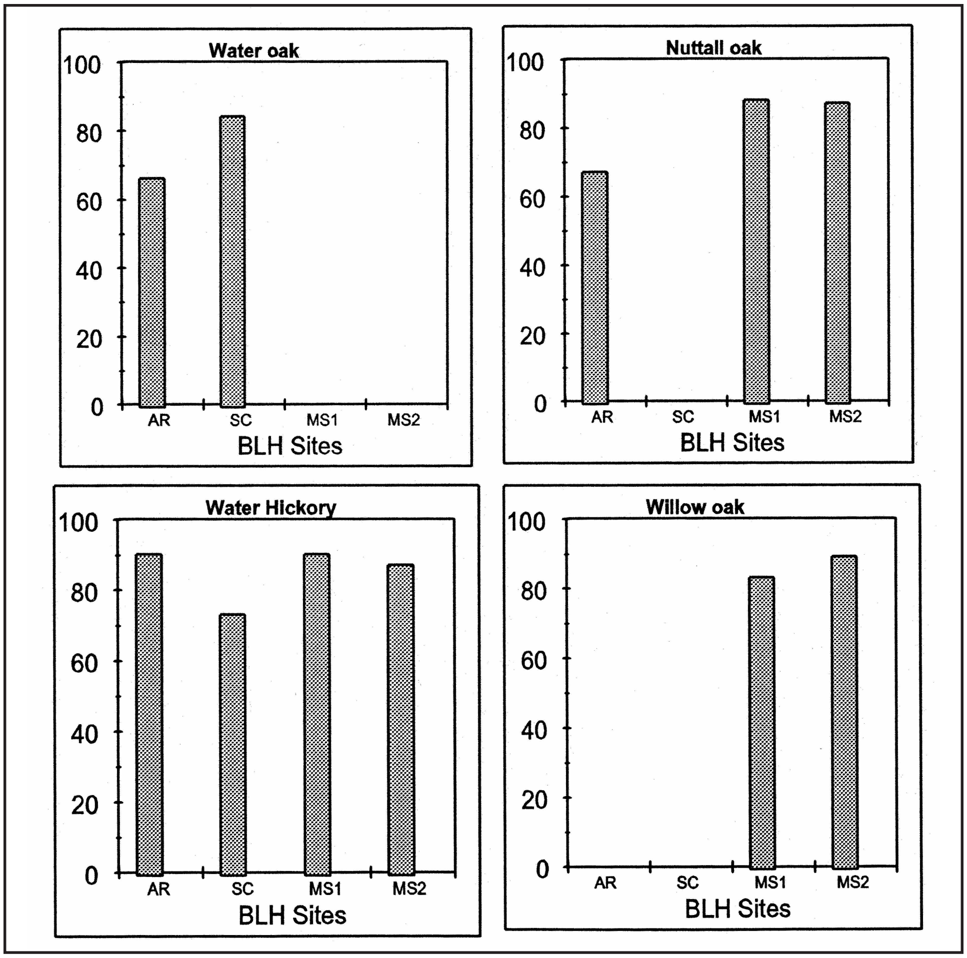

Figure 2. Ectomycorrhizae colonization of common bottomland hardwood oak tree species at four locations: Cache River, AR; Coosawhatchie River, SC; Delta National Forest, MS (MS1); and Lake George, MS (MS2)

A total of 48 ectomycorrhizal fungal species were identified on Nuttall oak and water hickory (Table 1). Generally, more fungal EM species were found on Nuttall oak than water hickory. Wet areas had more fungal species than dry areas. There was very little overlap in ectomychorrhizal species composition between trees in wet and dry areas within the same site or across sites. Only three fungal species occurred on both tree species and four fungal species occurred at more than one site. These results indicate that richness of fungal species is very high in these BLH wetland forests.

EM fungi were evenly distributed throughout the BLH wetland forests. The sampling sites had been dry for more than two months at the time of sampling. As a consequence, high and low microtopographic sites differed only slightly in soil moisture content (silty-clay to clay soil textures with range of 22–37 percent weight/weight soil moisture at 0- to 5-cm soil depth). No significant differences in root tip colonization were found between microtopographic sites. Soil moistures were uniform, and soils were apparently aerated at depths up to 30 cm. Although root tips were concentrated in the upper 5 cm of the soil, the proportion of EM colonized root tips was consistent with depth at all sites.

Table 1. Ectomycorrhizal species richness on two tree species under two moisture conditions at four mature bottomland hardwood forests in the southeastern United States[1]

Site Location	Nuttall Oak Wet	Nuttall Oak Dry	Nuttall Oak Tree Total	Water Hickory Wet	Water Hickory Dry	Water Hickory Tree Total	Site Total
MS1	8	4	11 (1)	2	ns	2 (ns)	12 (1)
MS2	8	7	12 (3)	1	1	2 (0)	13 (1)
SC	7	3	9 (1)	7	ns	7 (ns)	14 (2)
AR	5	2	6 (1)	5	6	10 (1)	15 (1)
Moisture Total	24[2] (2)	13 (2)	35 (3,2)[3]	12 (1)	7 (0)	19 (1,1)[3]	48 (3,4)[3]

[1] Numbers in parentheses indicate the number of species in common across each condition.
[2] Totals reflect numbers of species and may not be additive because a species may occur in more than two sites.
[3] The first number in parentheses is the total number of shared species across moisture gradients; the second number is the total number of shared species across all sites.

CONCLUSIONS: EM fungi are abundant in BLH wetland forests and are associated with tree species commonly targeted for restoration of agriculture fields. Presence of EM fungi in these wetland forests indicates that they are tolerant of flooding. The large number of fungal species that have little overlap among tree species suggests that several fungal species may perform ecologically similar roles in the symbiotic relationship with the host tree. This indicates that the development of the mycorrhizal inoculum for plantings to be used in restoration projects should involve only a limited number of species. If the common mycorrhizal fungi or fungi that exhibit desirable characteristics can be easily cultured, commercial inoculation of large numbers of seedlings will be economically feasible. Further investigations into effects of inoculation with these EM on tree seedling growth and survival are under way at WES.

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> Davis, M. M., and Shearer, J. (1999). "Mycorrhizae in bottomland hardwood (BLH) wetland forests." *WRP Technical Notes Collection* (TN WRP VN-RS-4.2). U.S. Army Engineer Research and Development Center, Vicksburg, MS. *www.wes.army.mil/el/wrp*