Symbiosis, 9 (1990) 93–96
Balaban Publishers, Philadelphia/Rehovot

Fungal Biomass in the Mycorrhizae in Relation to Sporophore Yield in a Fertilized and an Unfertilized (*Pinus taeda*) Stand*

A.M. MARKKOLA, W.G. CIBULA* and H. VÄRE

Department of Botany, University of Oulu, Linnanmaa, SF-90570 OULU, Finland
**Earth Resources Lab., John C. Stennis Space Center, MS 39529, USA.*

Abstract

The relationship between fungal biomass in the mycorrhizae measured in terms of glucosamine content and the yield of sporophores of mycorrhizal fungi was studied in one fertilized and one unfertilized loblolly pine (*Pinus taeda*) plantation in Mississippi, USA. The correlation between glucosamine and the total biomass of sporophores in the subplots was significant in the fertilized stand ($r = 0.616$, $p < 0.001$).

Introduction

Sporophore biomass production in ectomycorrhizal fungi has been used as an estimate for changes in the forest ecosystems, although it does not necessarily represent the status of the mycorrhizal symbiosis in the roots. The aim here was to determine the intensity of mycorrhizal involvement in the roots of mature loblolly pines by analyzing the glucosamine (chitin) content of the fine roots. The fungal biomass in the roots was then compared with the sporophore production of the mycorrhizal fungi. Determination of glucosamine has been used earlier in young pine seedlings (Plassard et al., 1983), but no attempts have been made to assess chemically the fungal biomass in the roots of mature trees.

Material and Methods

The stands of loblolly pine (*Pinus taeda* L.) concerned are located near Gulfport, Mississippi, where the soils are fine upland sandy loams originally low in N and P.

*Reviewed

The pine seedlings were row planted at spacings of about 3×3 m in 1960, and each study site consisted of 144 such subplots. One of the sites was dressed with 4483 kg/ha of a fertilizer (10% N; 5% P; 5% K) in 1961 (Cibula and Ovrebo 1989).

Spores of ectomycorrhizal fungi were recorded weekly during the summer of 1984, the average dry weight of each species being multiplied by the number of sporophores in order to estimate the biomass.

Root samples for mycorrhizal investigations were collected from a depth of 0–20 cm in August 1984 with a 2 cm wide soil borer. Seven subsamples taken from each subplot were pooled into one sample and the cores washed on two 2 mm sieves. All pine roots with a diameter of less than 2 mm were collected under a dissection microscope from random subsamples, dried at 50°C and weighed.

Samples of 15 ± 5 mg pulverized roots were weighed for hydrolyzation in screw-cap tubes in 2 ml 6 N HCl at 80°C for 16 h, and their glucosamine content was determined (Wieckowska 1968) using glucosamine hydrochloride as a standard.

Results

Two thirds of the subplots were occupied by mycorrhizal fungi in both loblolly pine stands, the total number of mycorrhizal taxa and the biomass of the ten dominant species being higher in the fertilized plot (Table 1). *Russula vesicatoria*, *Suillus decipiens*

Table 1. Sporophore data from *Pinus taeda* stands

	Fertilized stand	Unfertilized stand
Percentage of subplots occupied by mycorrhizal fungi	66	65
Total number of mycorrhizal species	23	17
Total number of sporophores	647	1244
Total biomass of sporophores of ten major species (g dry wt.)	980	550

and *Cantharellus cibarius* alone produced about 80% of the total biomass, *R. vesicatoria* occurring only in the fertilized stand. The amount of glucosamine per soil volume correlated positively with both the total biomass and the total number of sporophores as well as with the biomass of *Russula vesicatoria* and *Suillus decipiens* in the subplots of the fertilized stand, but no such correlations were found in the unfertilized stand (Table 2). The amount of glucosamine was on average 1.27 mg/g root DW in the fertilized stand and 1.58 in the unfertilized one.

Table 2. Coefficients of correlation between glucosamine content in the mycorrhizae and sporophore yield in a fertilized and an unfertilized *Pinus taeda* stand. GLUNH2 = glucosamine mg/dm^3 soil, SPOROP = total number of sporophores /m^2, RUSBIO = biomass of sporophores of *Russula vesicatoria* /m^2, SUIBIO = biomass of sporophores of *Suillus decipiens* /m^2, CANBIO = biomass of sporophores of *Cantharellus cibarius* /m^2, TOTBIO = biomass of sporophores of ten major species /m^2. ***P < 0.001, *P < 0.05, NS = non-significant.

Fertilized stand

	GLUNH2	SPOROP	RUSBIO	SUIBIO	CANBIO
SPOROP	0.546***				
RUSBIO	0·522***	0·414***			
SUIBIO	0·469***	0·794***	0·005 NS		
CANBIO	0.021 NS	0·250*	−0·069 NS	−0·003 NS	
TOTBIO	0.616***	0.598***	0.973***	0.230 NS	−0.008 NS

Unfertilized stand

	GLUNH2	SPOROP	SUIBIO	CANBIO
SPOROP	0.103 NS			
SUIBIO	−0.005 NS	0.346***		
CANBIO	0.102 NS	0.905***	−0.066 NS	
TOTBIO	0.075 NS	0.934***	0.645***	0.720***

Discussion

The number of mycorrhizal short roots has been found to correlate positively with the number of sporophores in single species studies (Laiho 1970, Cotter and Bills 1985), and a correlation has been thought to exist between fungal biomass and sporophore production in a forest stand with several fungal symbionts (Menge and Grand 1978, Bills et al., 1986). Similarly, earlier work on fertilized loblolly pine plantations has shown the total numbers of living mycorrhizal tips correlate well with the numbers of sporophores of all mycorrhizal fungi (Menge and Grand 1978). It has to be kept in mind, that fungal biomass measured in terms of glucosamine content consists of both active and non-active mycorrhizae (even dead ones) thus probably overestimating the functional biomass. The lack of any significant correlation between the above-ground and below-ground fungal biomasses in the present unfertilized stand may also imply that a distinct relationship of this kind occurs only in forest ecosystems dominated by a small number of species.

REFERENCES

Bills, G.F., Holtzman, G.I., and Miller, O.K. 1986. Comparison of ectomycorrhizal-basidiomycete communities in red spruce versus northern hardwood forests of West Virginia. *Can. J. Bot.* **64:** 760–768.

Cibula, W.G. and Ovrebo, C.L. 1989. Mycosociological studies of mycorrhizal fungi in two loblolly pine plots in Mississippi and some relationships with remote sensing. In: *Remote sensing for resource inventory, planning and monitoring.* Greer, J.D., ed. Proceedings of the 2nd Forest Service Remote Sensing Application Conference. Slidell, Louisiana and NSTL, Missisippi. April 11–15, 1988.

Cotter, H.V.T. and Bills, G.F. 1985. Comparison of spatial patterns of sexual and vegetative stages of *Boletinellus merulioides. Trans. Br. Mycol. Soc.* **85:** 520–524.

Laiho, O. 1970. *Paxillus involutus* as a mycorrhizal symbiont of forest trees. *Acta For. Fenn.* **106:** 1–72.

Menge, J.A. and Grand, L.F. 1978. Effect of fertilization on production of epigeous basidiocarps by mycorrhizal fungi in loblolly pine plantations. *Can. J. Bot.* **56:** 2357–2362.

Plassard, C., Mousain, D. and Salsac, L. 1983. Dosage de la chitine sur des ectomycorhizes de pin maritime (*Pinus pinaster*) a *Pisolithus tinctorius*: evaluation de la masse mycelienne et de la mycorhization. *Can. J. Bot.* **61:** 692–699.

Wieckowska, E. 1968. Oznaczanie chityny w grzybach. Summary: Determination of chitin in mushrooms. *Mikologia Stosowana* **1:** 65–71.