

Supplementary Materials

**Ectomycorrhizal fungi modulate biochemical response against powdery mildew disease in
Quercus robur L.**

Figure S1. *Scleroderma citrinum* ectomycorrhizae observed on roots of *Quercus robur* in the ECM-C treatment



Figure S2. Phylogenetic tree generated from a maximum likelihood (ML) analysis based on ITS sequence data showing the position of *Scleroderma citrinum* in relation to its closely related *Scleroderma* species. ML bootstrap support values greater than 70% are indicated above or below branches. The specimen sequenced in this study is shown in bold. *Suillus lariciphilus* (CAL CD 13-003) is included as an outgroup. Scale bar indicates expected number of substitutions per site.

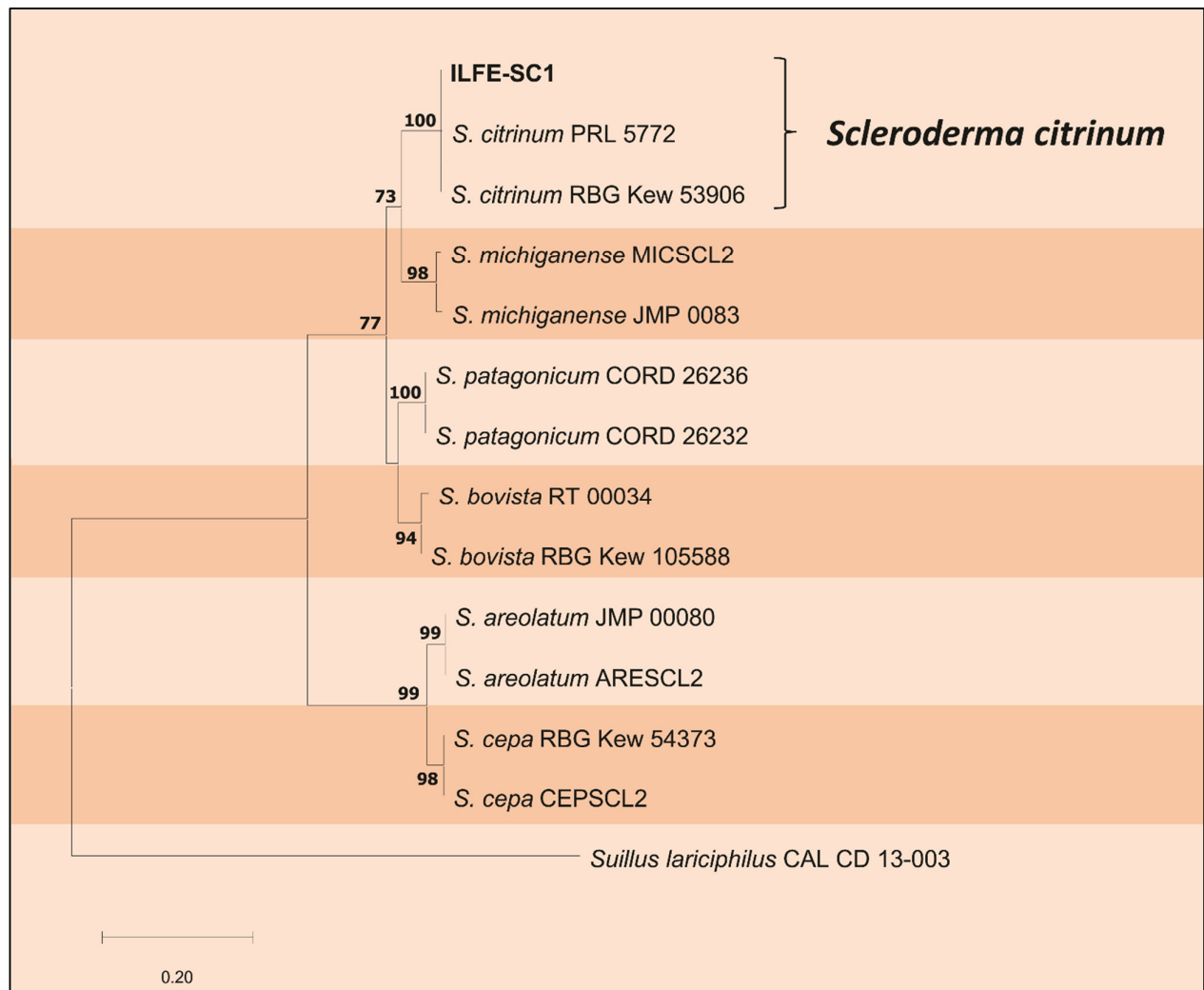


Figure S3. Phylogenetic tree generated from a maximum likelihood analysis (ML) based on ITS sequence data of the *Quercus robur* powdery mildews showing the position of *Erysiphe alphitoides* in relation to closely related *Erysiphe quercicola*. ML bootstrap support values greater than 70% are indicated on branches. The type specimens are marked with an asterisk. The specimen sequenced in this study is shown in bold. *Erysiphe paeoniae* (AB257437) is included as an outgroup. Scale bar indicates expected number of substitutions per site.

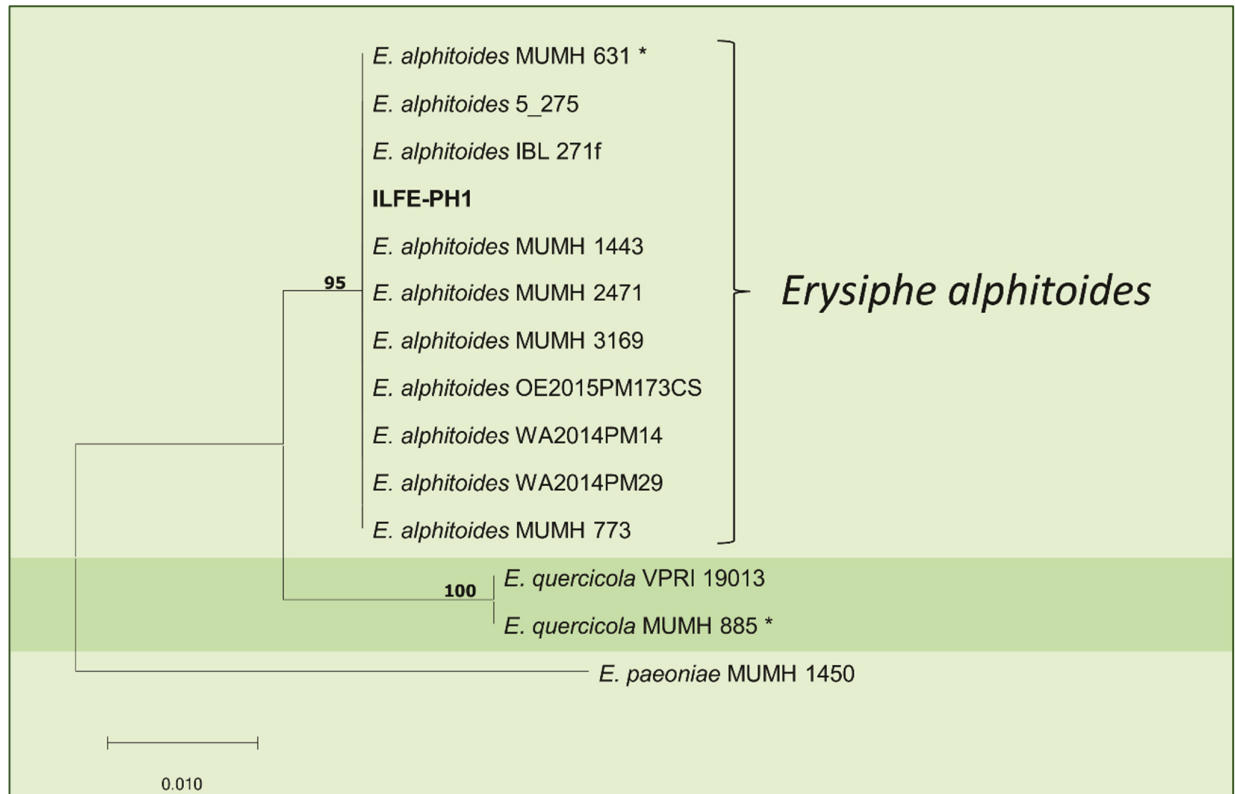


Table S1. Sequences used in the phylogenetic analyses of *Scleroderma* species.

Specimen no. ¹	Identity	Tissue type	Host	Location	ITS ² GenBank Accession number
ILFE-SC1	<i>Scleroderma citrinum</i>	ectomycorrhizal root tip	<i>Quercus robur</i>	Serbia	ON239799
PRL 5772	<i>S. citrinum</i>	basidiome	-	USA	GQ166907
RBG Kew K(M) 53906	<i>S. citrinum</i>	-	-	England	EU784414
MICSCL2	<i>S. michiganense</i>	basidiome	-	USA	FM213347
JMP0083	<i>S. michiganense</i>	-	<i>Castanea dentata</i>	USA	EU819441
CORD26236	<i>S. patagonicum</i>	-	-	Argentina	HQ688788
CORD26232	<i>S. patagonicum</i>	-	-	Argentina	HQ688789
RT00034	<i>S. bovista</i>	-	<i>C. dentata</i>	USA	EU819517
RBG Kew 105588	<i>S. bovista</i>	-	-	England	EU784409
JMP 00080	<i>S. areolatum</i>	ectomycorrhizal root tip	<i>C. dentata</i>	USA	EU819438
ARESCL2	<i>S. areolatum</i>	basidiome	-	USA	FM213352
RBG Kew 54373	<i>S. cepa</i>	-	-	England	EU784412
CEPSCL2	<i>S. cepa</i>	basidiome	-	Spain	FM213354
CALCD13-003	<i>Suillus lariciphilus</i>	-	<i>Larix griffithii</i>	India	NR_153246

¹ A sequence obtained in this study is shown in bold² ITS: Internal Transcribed Spacer

Dash indicates the data not available.

Table S2. Sequences used in the phylogenetic analyses of *Erysiphe* species.

Specimen no. ^{1,2}	Identity	Host	Location	ITS ³ GenBank Accession number
<i>MUMH 631</i>	<i>Erysiphe alphitoides</i>	<i>Quercus robur</i>	Switzerland	AB292708
5_275	<i>E. alphitoides</i>	<i>Q. robur</i>	UK	KY660888
IBL 271f	<i>E. alphitoides</i>	<i>Q. robur</i>	Poland	KY346982
ILFE-PH1	<i>E. alphitoides</i>	<i>Q. robur</i>	Serbia	OM007976
MUMH 1443	<i>E. alphitoides</i>	<i>Q. robur</i>	Switzerland	AB257431
MUMH 2471	<i>E. alphitoides</i>	<i>Q. robur</i>	Argentina	AB292699
MUMH 3169	<i>E. alphitoides</i>	<i>Q. robur</i>	Argentina	AB292702
OE2015PM173C S	<i>E. alphitoides</i>	<i>Q. robur</i>	UK	KY653183
WA2014PM29	<i>E. alphitoides</i>	<i>Q. robur</i>	UK	KP641999
WA2014PM14	<i>E. alphitoides</i>	<i>Q. robur</i>	UK	KP641984
MUMH 773	<i>E. alphitoides</i>	<i>Q. robur</i>	Lithuania	AB292710
VPRI 19013	<i>E. quercicola</i>	<i>Q. robur</i>	Australia	AB295454
<i>MUMH 885</i>	<i>E. quercicola</i>	<i>Q. phillyraeoides</i>	Japan	AB193591
MUMH 1450	<i>E. paeoniae</i>	<i>Paeonia wittmanniana</i>	Switzerland	AB257437

¹ Sequences morphologically related to the type specimens are shown in italic.

² A sequence obtained in this study is shown in bold.





³ ITS: Internal Transcribed Spacer

ILFE: Collection of Microorganisms of the Institute of Lowland Forestry and Environment, University of Novi Sad, Serbia; MUCC: Culture Collection of Murdoch University, Perth, Australia; MUMH: Mie University Mycological Herbarium; IBL: Forest Research Institute, Warsaw.

Table S3. Disease index scale for powdery mildew

Score	Description
0	Absent.
1	Low – Individual pustules up to 0.5 cm in diameter, limited mycelium development and sporulation.
2	Medium – Individual pustules are merging and reaching up to 1 cm in diameter.
3	High – Pustules merging and covering more than 75% of leaf area, dense mycelial development, and abundant sporulation.

Table S4. Description of the treatments-defined by percentages of powdery mildew (PM) disease intensity and percentages of colonization with ectomycorrhiza (ECM)

TREATMENT	NM-C	NM-PM	ECM-C	ECM-PM
Visual representation of infected leaves				
PM disease intensity (%) \pm STD*	0 \pm 0 ^a	93.33 \pm 3.33 ^c	0 \pm 0 ^a	42.89 \pm 1.92 ^b
ECM colonization (%) \pm STD*	0 \pm 0 ^a	0 \pm 0 ^a	62.22 \pm 4.14 ^b	58.42 \pm 6.94 ^b

*Mean values with different superscript letters are significantly different according to Fisher's LSD test ($p < 0.05$).

Table S5. A two-way ANOVA results on variable (ECM, PM, ECMxPM) effects on inspected parameters.

Parameters		ECM			PM			ECM x PM		
		<i>F</i>	<i>p</i> < .05	<i>p</i>	<i>F</i>	<i>p</i> < .05	<i>p</i>	<i>F</i>	<i>p</i> < .05	<i>p</i>
Osmolytes	Glycine betaine (GB)	8.99	*	0.01	1.10	ns	0.32	2.57	ns	0.14
	Free proline (PRO)	4.93	*	0.05	1.22	ns	0.29	32.61	*	9.76 × 10 ⁻⁵
	Total polyamine content (Pas)	1.68	ns	0.22	16.03	*	2 × 10 ⁻³	0.07	ns	0.80
	Putrescine (PUT)	1.84	ns	0.20	0.42	ns	0.53	0.01	ns	0.95
	Spermine (SPM)	0.03	ns	0.86	8.75	*	0.01	0.14	ns	0.71
	Spermidine (SPD)	4.07	ns	0.07	25.04	*	3.07 × 10 ⁻⁴	4 × 10 ⁻³	ns	0.95
Antioxidant parameters	Lipid peroxidation (MDA)	8.61	*	0.01	31.23	*	1.18 × 10 ⁻⁴	4.38	ns	0.06
	Total non-protein thiols (GSH)	4.35	ns	0.06	0.01	ns	0.93	1.30	ns	0.28
	Radical scavenger capacity (RSC) against ABTS radical (ABTS)	3.88	ns	0.07	0.93	ns	0.35	21.98	*	5.25 × 10 ⁻⁴
	Ferric reducing ability of extract/plasma (FRAP)	6.46	*	0.03	28.84	*	1.68 × 10 ⁻⁴	5.97	*	0.03
	Total phenolic content (TPC)	1.80	ns	0.20	3.05	ns	0.11	7.82	*	0.02
	Total flavonoid content (TFC)	1.38	ns	0.26	0.78	ns	0.39	0.03	ns	0.88
	Condensed tannins (CT)	0.11	ns	0.75	3.66	ns	0.08	2.70	ns	0.13
Physiologic al parameters	Relative water content (RWC)	0.03	ns	0.86	2.94	ns	0.11	1.64	ns	0.23
	Intercellular CO2 concentration (Ci)	47.40	*	1.96 × 10 ⁻⁵	48.96	*	1.44 × 10 ⁻⁵	12.82	*	4 × 10 ⁻³
	Net photosynthesis (A)	30.63	*	1.29 × 10 ⁻⁴	54.75	*	8.28 × 10 ⁻⁶	24.82	*	3.19 × 10 ⁻⁴
	Transpiration rate (E)	0.26	ns	0.62	3.48	ns	0.09	1.57	ns	0.24
	Stomatal conductance (gs)	0.96	ns	0.35	1.24	ns	0.29	1.31	ns	0.28
	Water use efficiency (WUE)	26.81	*	0.00	20.18	*	7.37 × 10 ⁻⁴	10.02	*	0.01
Mineral elements	Nitrogen content (N)	2.25	ns	0.16	0.41	ns	0.53	0.01	ns	0.94
	Carbon content (C)	3.39	*	0.09	0.04	ns	0.85	0.05	ns	0.83