



VOL. 6 ISSUE 1, JULY 2025

ISSN 2563-1497

International Mycorrhiza Society

<http://mycorrhizas.org/>

Twitter/Instagram: [@mycorrhiza_ims](#)

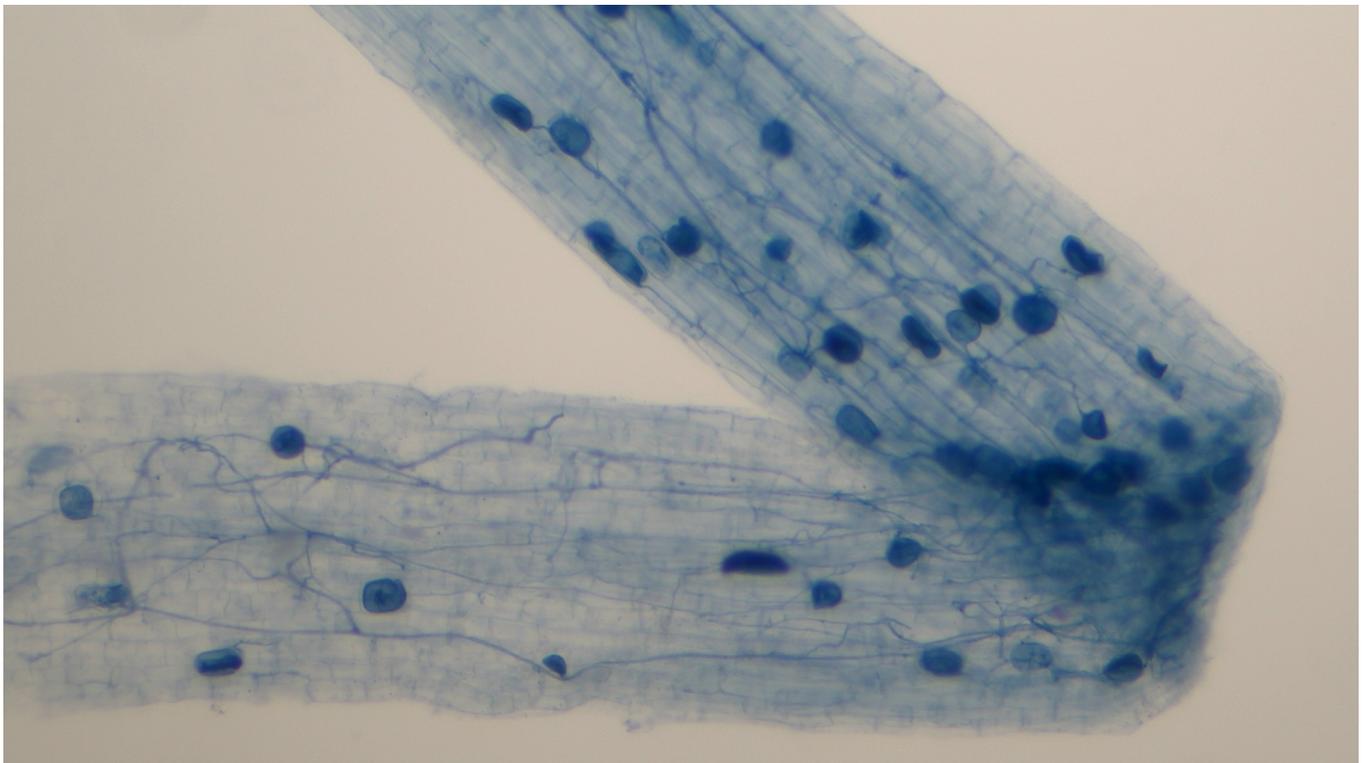
IMS Newsletter

Indexed in Latindex

The International Mycorrhiza Society quarterly e-newsletter

Stained root of *Hamadryas kingii* Hook.f., collected in Tarn Mount, Magallanes, Chile.

Photo by: Constanza Martínez & Jenny Ramírez.



ICOM | **Cairns**
2026 | **Australia**

icom2026.org



Editor-in-Chief: César Marín

Contents:

• Message from the President's Desk.....	3
• Editorial.....	5
• Top 10 papers.....	9
• ICOM12 meeting report.....	10
• Research commentaries.....	18
• YouTube interviews.....	22
• Tools.....	23
• Events.....	24
• IMS Executive.....	26

IMS Newsletter Editorial Board

Editor-in-Chief

César Marín – Center for Research and Innovation for Climate Change, Santo Tomás University, Chile

E-mail: cmarind@santotomas.cl

Topic Editors

- *Ecology* – Justine Karst, University of Alberta, Canada
- *Evolution* – Jason Hoeksema, University of Mississippi, US
- *Molecular biology* – Jonathan Plett, Western Sydney University, Australia
- *Applications* – Pedro M. Antunes, Algoma University, Canada

Editorial Office

- *Managing Editor* – Rosario Iacono, Helmholtz Centre for Environmental Research, UFZ, Germany
- *Editorial Assistant* – Melissa Davie

Message from the President's Desk

We are one year away from the 20th anniversary of the IMS and from ICOM2026! Jonathan Plett, Stephanie Watts-Fawkes and their team are making excellent progress on putting together a wonderful conference for us in Cairns, Australia. The ICOM2026 website is now live:

<https://icom2026.org/>



In July, the IMS released its new website (<https://mycorrhizas.org/>) and logo. The logo represents the society's mission to facilitate mycorrhizal research and commitment to inclusivity, collaboration, and environmental sustainability on a global scale. On our website, we showcase award winners from ICOM12, archive past newsletters, and provide information on past and future conferences. For each past conference, we have posted searchable program abstracts. Thanks to everyone for sharing pictures of mycorrhizal fungi with us. They have made the website beautiful.



We are pleased to announce that the New Phytologist Foundation is giving the IMS funding to support travel of six early-career researchers to upcoming ICOMs. The travel award will be offered through an open call before each ICOM. An awards committee will select a winner from each continent. More details will be provided closer to ICOM2026. For now, thank you very much to the New Phytologist Foundation for helping ECRs get to the conference!



New Phytologist
Foundation

I would like to welcome Roxane Bergeron to the Board as our new secretary. Roxane is a MSc student at Algoma University, Canada. I am deeply appreciative of her help keeping us organized and scheduled.



Roxane Bergeron

6 pm MDT

[https://ualberta-ca.zoom.us/j/96205104367?](https://ualberta-ca.zoom.us/j/96205104367?pwd=Uh5X4X3oBymdyDTwSOHbBgDuYxfOGw.1)
pwd=Uh5X4X3oBymdyDTwSOHbBgDuYxf
oGw.1
Meeting ID: 962 0510 4367; Passcode:
383959

Thank you!

Justine Karst, IMS President

Please mark **September 17, 2025**, on your calendars. We invite you to attend our annual members' meeting. There will be two sessions to accommodate time zones across the world: 9 am and 6 pm Mountain Daylight Time. I will be hosting the meeting from Edmonton, Canada and will be joined by several Board members. We will provide updates on ICOM2026, Board activities and finances, and leave time for questions from you.

Zoom links:

9 am MDT

[https://ualberta-ca.zoom.us/j/92647858750?](https://ualberta-ca.zoom.us/j/92647858750?pwd=bGdjzNSIEOqOG3B3B3T4bA2bOM6yuh.1)
pwd=bGdjzNSIEOqOG3B3B3T4bA2bOM6y
uh.1

Meeting ID: 926 4785 8750; Passcode:
376184

16th Editorial of the IMS Newsletter

César Marín ^{1, 2*}

¹Center for Research and Innovation for Climate Change, Santo Tomás University, Chile.

²Amsterdam Institute for Life and Environment (A-LIFE), Section Systems Ecology, Vrije Universiteit Amsterdam, the Netherlands. *E-mail: cmarind@santotomas.cl

We are entering – with some delay– the 5th year of the International Mycorrhiza Society (IMS) Newsletter. In this Editorial, I reflect on five-year trends of the Top 10 mycorrhizal research papers provide updates on new members of our team; and as usual, a summary of the content in the current issue.

A reflection on the Top 10 mycorrhizal papers

According to a questionnaire sent to IMS members, among all sections of the Newsletter, the ‘Top 10’ mycorrhizal research papers was the most highly ranked by 73% of respondents. The Top 10 is a collective effort which nevertheless is under the subjectivity of the voting panel. Over the past 15 issues of the IMS Newsletter, a panel of between 12–17 scientists from around the world and at different career stages, selected a total of 150 Top 10 papers, from a pool of 2560 papers published between September 2019 and August 2024. To compile such a list, I search terms like “mycorrhiza”, “ectomycorrhizal”, “arbuscular”, and “mycorrhizal” in Google Scholar, ensuring that the selected records include only Web of Science-indexed articles. I also search articles in the published issues of *Mycorrhiza*, *New Phytologist*, *Fungal Ecology*, *Symbiosis*, *Soil Biology and Biochemistry*, *Applied Soil Ecology*, *Plant and Soil*, *Rhizosphere*, *Science* and in *Nature* journals (includes *The ISME Journal*), *PNAS* journals, *Cell* journals (includes *Trends in Plant Science*), *Plant Physiology*, and *G3*. Based on this search, I obtain between 473 and 546 papers per year, albeit surely much

more mycorrhizal research is being published worldwide every year. These are very exciting numbers and news for our very niche field!

I evaluated the 150 papers making up the Top 10 lists to explore how these papers were assessed in the wider literature and to identify trends in the types of top-ranked studies. First, it should be noted that many of the Top 10 papers have hundreds of citations. Of the 45 papers ranked in the top three positions across the issues, 19 surpassed 100 citations (at the writing of this Editorial). Articles by Delgado-Baquerizo et al. (2020) in *Nature Ecology & Evolution*; Genre et al. (2020) in *Nature Reviews Microbiology*; Soudzilovskaia et al. (2020) in *New Phytologist*; Miyauchi et al. (2020) in *Nature Communications*; Carmona et al. (2021) in *Nature*; and Jiang et al. (2021) in *New Phytologist*, had greater than 200 Web of Science citations. I checked the Web of Science for the five most cited articles from 2020 to 2024 and compared them to our 45 Top 3 articles and found that only five papers appeared on both lists, indicating that our panel does not necessarily vote for the most cited papers, which tend to be general reviews. Instead, the panel highly ranks original research.

I also split the 150 papers by mycorrhizal type (**Fig. 1**), area of study (**Fig. 2**), and type of study (**Fig. 3**). Regarding mycorrhizal type (**Fig. 1**), most of the Top 10 papers focus on arbuscular mycorrhizal fungi (AMF), although a sizeable proportion of papers—usually ecological ones—investigate two or more mycorrhizal types simultaneously.

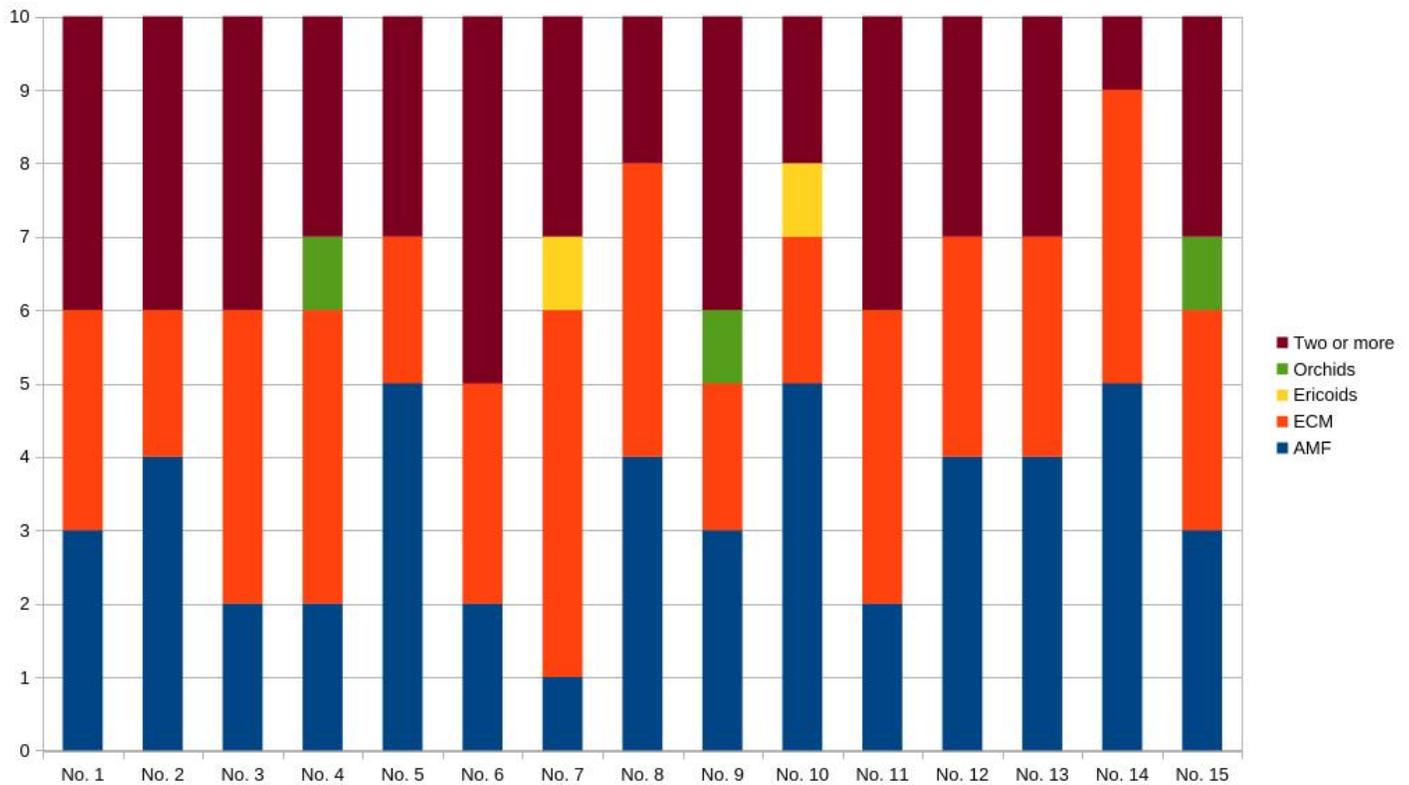


Figure 1. Distribution of mycorrhizal types of the Top 10 mycorrhizal research papers across the IMS Newsletters (No. 1 = March 2020; No. 15 = December 2024). AMF: arbuscular mycorrhizas; ECM: ectomycorrhizas.

Papers with an ecological focus made up the highest proportion of the Top 10 papers, followed by studies in molecular biology (**Fig. 2**). Studies on evolution and applications of mycorrhizal research were scarce in the Top 10. (Fig. 2). I wonder whether this trend reflects a bias in the voting panel, a bias in the field of mycorrhizal research, or both.

Finally, I split the 150 papers by publication type (**Fig. 3**): lab or greenhouse experiment, field studies, review, methods, or meta-analysis/ data mining. In this case, there is no clear dominance of any category, albeit lab/greenhouse experiments and field studies combined make up most of the Top 10 papers.

In this issue

As always, please find on page 9 the Top 10 mycorrhizal research papers of the last four months (papers published between

September and December, 2024). The first place article was published by Adrien Anckaert on *Current Biology*, and investigated how *Bacillus velezensis* colonized the whole mycelial network more efficiently than roots, and how it uses such hyphae for soil invasion and colonize new plants. The second place article was a Tansley review published by Rebecca A. Bunn and co-authors in *New Phytologist*, where they discuss evolutionary (biological market models) and physiological (carbon surplus hypothesis) frameworks, as models that have been used to understand what determines carbon plants to mycorrhizal fungi. Please also find an interview about it, in the [YouTube channel](#) of the South American Mycorrhizal Research Network (@whatwearereading6719). An article published in *New Phytologist* by Tessa Camenzind and co-authors, was ranked third. They discuss how arbuscular mycorrhizal (AM) fungal life-history

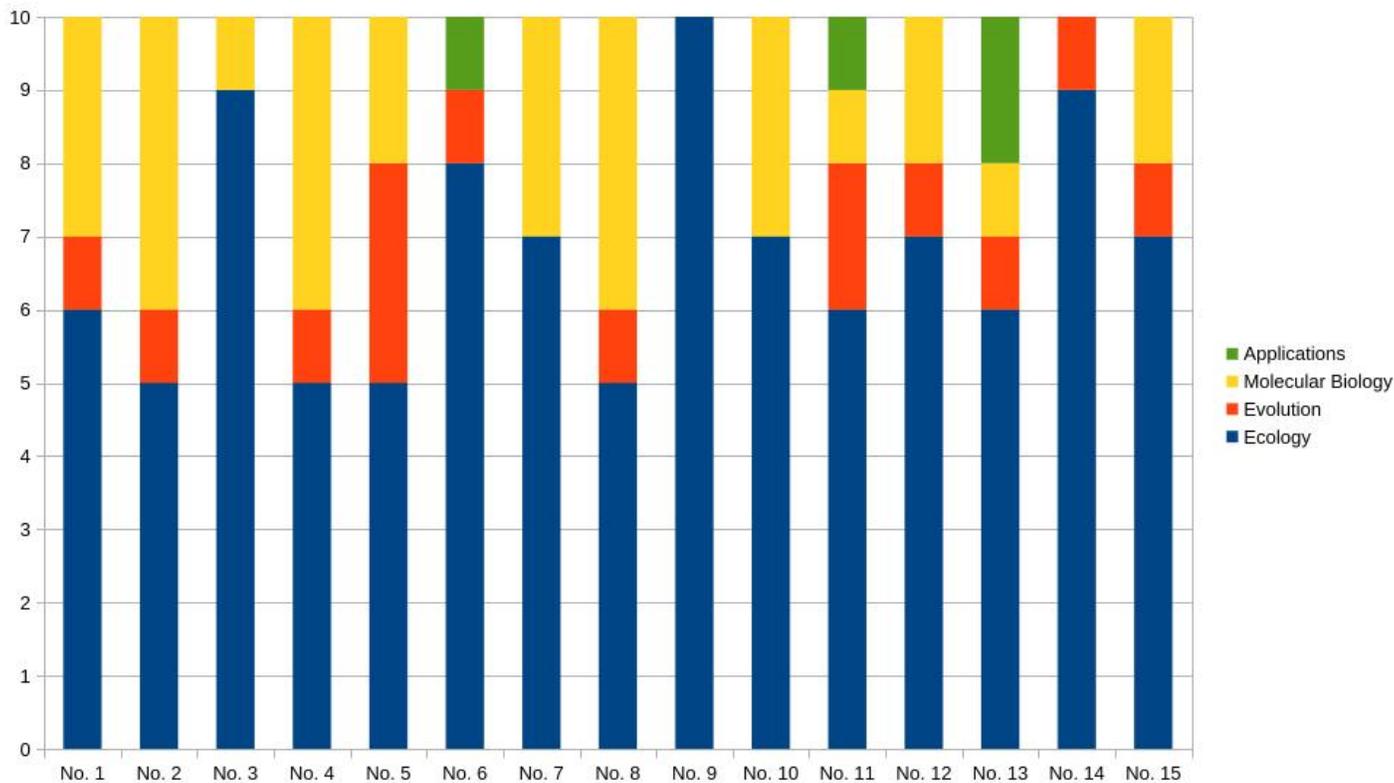


Figure 2. Distribution of study areas of the Top 10 mycorrhizal research papers across the IMS Newsletters (No. 1 = March 2020; No. 15 = December 2024).

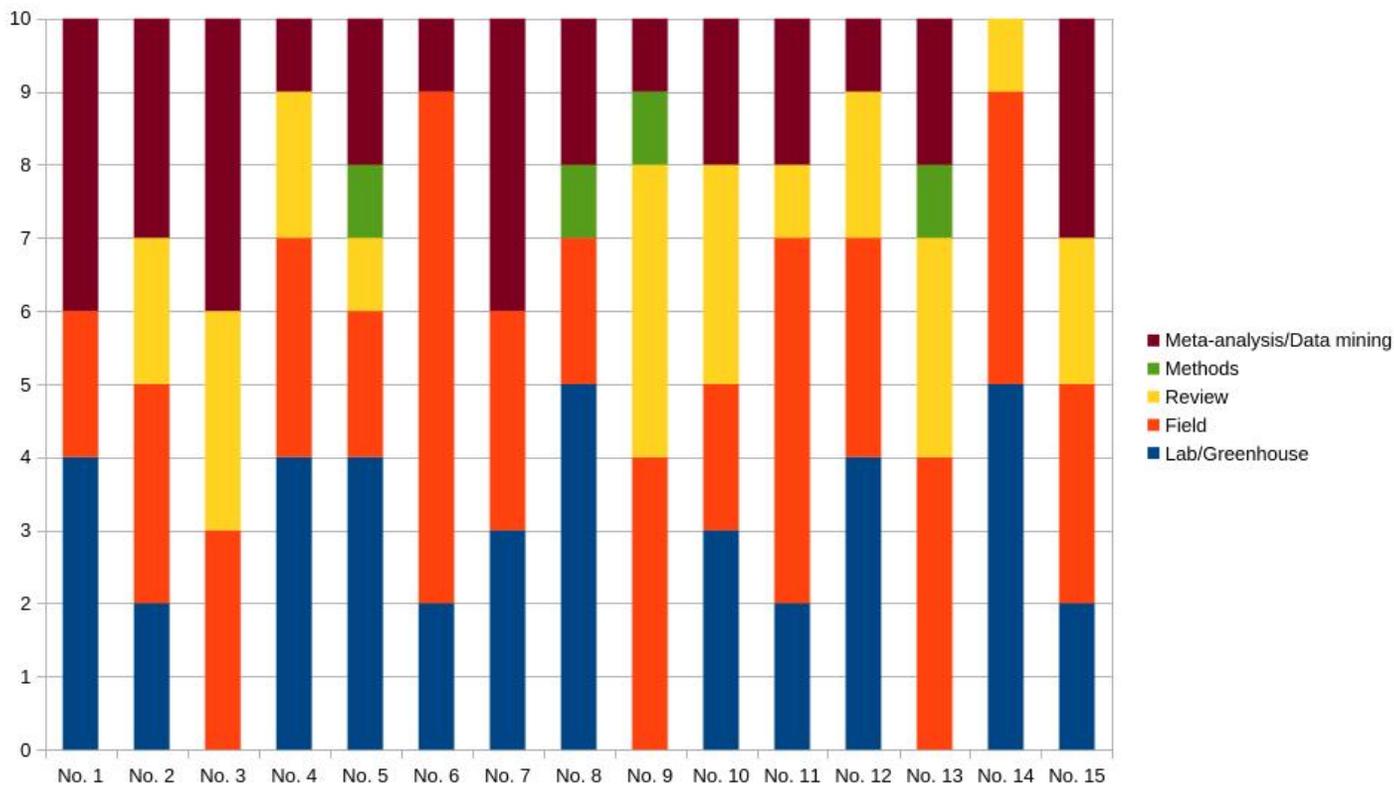


Figure 3. Distribution of publication type of the Top 10 mycorrhizal research papers across the IMS Newsletters (No. 1 = March 2020; No. 15 = December 2024).

theories often focus on differential investment into intraradical vs. extraradical structures among AM fungal taxa, and its implications for plant benefits. They expand such theories by integrating a mycocentric economics- and resource-based life-history framework.

This 16th issue of the IMS Newsletter includes one meeting report, one short article, and one YouTube interviews. The meeting report led by Sarah A. Cuprewich and co-authors details the topics and themes, advances, methods, takeaways, and future research directions discussed during our 12th International Conference on Mycorrhizas (ICOM) held in Manchester, United Kingdom, on 4-9 August 2024. This meeting report reflects equal contributions from a combination of early career and senior researchers whose research crosses a variety of disciplines. Please also find a short article by Nicholas Medina and co-authors on a project on fungal phenology aimed “to know if the timing of fungal reproduction matches the production patterns and species shifts happening underground”. One YouTube interview conducted by César Marín with Prof. Matthias C. Rillig (Freie Universität Berlin), about his recent *New Phytologist* paper entitled “Concurrent common fungal networks formed by different guilds of fungi” (Rillig et al. 2025).

As always, IMS Seminars, Tools, and Events are also highlighted.

References

- Carmona, C. P., Bueno, C. G., Toussaint, A., Träger, S., Díaz, S., Moora, M., ... & Tamm, R. (2021). Fine-root traits in the global spectrum of plant form and function. *Nature*, 597(7878), 683-687. <https://doi.org/10.1038/s41586-021-03871-y>
- Delgado-Baquerizo, M., Reich, P. B., Trivedi, C., Eldridge, D. J., Abades, S., Alfaro, F. D., ... & Singh, B. K. (2020). Multiple elements of soil biodiversity drive ecosystem functions across biomes. *Nature Ecology & Evolution*, 4(2), 210-220. <https://doi.org/10.1038/s41559-019-1084-y>
- Genre, A., Lanfranco, L., Perotto, S., & Bonfante, P. (2020). Unique and common traits in mycorrhizal symbioses. *Nature Reviews Microbiology*, 18(11), 649-660. <https://doi.org/10.1038/s41579-020-0402-3>
- Jiang, F., Zhang, L., Zhou, J., George, T. S., & Feng, G. (2021). Arbuscular mycorrhizal fungi enhance mineralisation of organic phosphorus by carrying bacteria along their extraradical hyphae. *New Phytologist*, 230(1), 304-315. <https://doi.org/10.1111/nph.17081>

- Miyauchi, S., Kiss, E., Kuo, A., Drula, E., Kohler, A., Sánchez-García, M., ... & Martin, F. M. (2020). Large-scale genome sequencing of mycorrhizal fungi provides insights into the early evolution of symbiotic traits. *Nature Communications*, 11(1), 5125. <https://doi.org/10.1038/s41467-020-18795-w>
- Rillig, M. C., Lehmann, A., Mounts, I. R., & Bock, B. M. (2025). Concurrent common fungal networks formed by different guilds of fungi. *New Phytologist*, 246(1), 33. <https://doi.org/10.1111/nph.20418>
- Soudzilovskaia, N. A., Vaessen, S., Barcelo, M., He, J., Rahimlou, S., Abarenkov, K., ... & Tedersoo, L. (2020). FungalRoot: global online database of plant mycorrhizal associations. *New Phytologist*, 227(3), 955-966. <https://doi.org/10.1111/nph.16569>



Top 10 papers on mycorrhizal research*

1. Anckaert, A., Declerck, S., Poussart, L. A., Lambert, S., Helmus, C., Boubsi, F., ... Ongena, M. (2024). The biology and chemistry of a mutualism between a soil bacterium and a mycorrhizal fungus. *Current Biology*, 34(21), 4934–4950. <https://doi.org/10.1016/j.cub.2024.09.019>
2. Bunn, R. A., Corrêa, A., Joshi, J., Kaiser, C., Lekberg, Y., Prescott, C. E., ... Karst, J. (2024). What determines transfer of carbon from plants to mycorrhizal fungi? *New Phytologist*, 244(4), 1199–1215. <http://doi.org/10.1111/nph.20145>
3. Camenzind, T., Aguilar-Trigueros, C. A., Heuck, M. K., Maerowitz-McMahan, S., Rillig, M. C., Cornwell, W. K., & Powell, J. R. (2024). Progressing beyond colonization strategies to understand arbuscular mycorrhizal fungal life history. *New Phytologist*, 244(3), 752–759. <https://doi.org/10.1111/nph.20090>
4. Koziol, L., Lubin, T., & Bever, J. D. (2024). An assessment of twenty-three mycorrhizal inoculants reveals limited viability of AM fungi, pathogen contamination, and negative microbial effect on crop growth for commercial products. *Applied Soil Ecology*, 202, 105559. <https://doi.org/10.1016/j.apsoil.2024.105559>
5. Cortese, A. M., & Horton, T. R. (2024). Ectomycorrhizal tree islands in arbuscular mycorrhizal forests: Hotspots of fungal inoculum important for seedling establishment of historically dominant trees. *Journal of Ecology*, 112(11), 2680–2694. <https://doi.org/10.1111/1365-2745.14417>
6. Clemmensen, K. E., Michelsen, A., Finlay, R. D., & Lindahl, B. D. (2024). The balance between accumulation and loss of soil organic matter in subarctic forest is related to ratios of saprotrophic, ecto- and ericoid mycorrhizal fungal guilds. *Fungal Ecology*, 71, 101359. <https://doi.org/10.1016/j.funeco.2024.101359>
7. Willing, C. E., Wan, J., Yeam, J. J., Cessna, A. M., & Peay, K. G. (2024). Arbuscular mycorrhizal fungi equalize differences in plant fitness and facilitate plant species coexistence through niche differentiation. *Nature Ecology & Evolution*, 8(11), 2058–2071. <https://doi.org/10.1038/s41559-024-02526-1>
8. Liu, X., Yu, K., Liu, H., Phillips, R. P., He, P., Liang, X., ... Ye, Q. (2024). Contrasting drought tolerance traits of woody plants is associated with mycorrhizal types at the global scale. *New Phytologist*, 244(5), 2024–2035. <https://doi.org/10.1111/nph.20097>
9. Audisio, M., Muhr, J., & Polle, A. (2024). Ectomycorrhizal fungi of Douglas-fir retain newly assimilated carbon derived from neighboring European beech. *New Phytologist*, 243(5), 1980–1990. <https://doi.org/10.1111/nph.19943>
10. Mony, C., Vannier, N., Burel, F., Ernoult, A., & Vandenkoornhuysen, P. (2024). The root microlandscape of arbuscular mycorrhizal fungi. *New Phytologist*, 244(2), 394–406. <https://doi.org/10.1111/nph.20048>

*Selected from 136 Web of Science articles published between September – December, 2024 by: Bala Chaudhary, Pedro M. Antunes, Jan Jansa, Joseph Birch, Justine Karst, Francis Martin, Rebecca Bunn, Annegret Kohler, Camille Truong, Nancy Collins Johnson, Vasilis Kokkoris, Luke Florence, Judith Lundberg-Felten, and César Marín.

Meeting reports

ICOM 12: An especially collaborative, critical, and creative conference

Summary of the 12th International Conference on Mycorrhizas (ICOM) held in Manchester, UK on 4-9 August 2024.

Sarah A. Cuprewich^{1*}, André Geremia Parise^{2,3}, Ana Vanessa Aguilar⁴

¹Environmental Studies Department, Dartmouth College, Hanover, NH, United States. ²School of Biological Sciences, University of Reading, Reading, United Kingdom. ³School of Agriculture, Policy and Development, University of Reading, Reading, United Kingdom. ⁴Crop Science Research Center, Scuola Superiore Sant'Anna, Pisa, Italy.

E-mail : sarah.a.cuprewich.gr@dartmouth.edu

Introduction

The 12th International Conference on Mycorrhiza (ICOM) meeting at Manchester (UK) was the first in-person IMS conference since 2019 and attendees made good use of the knowledge, collegiality, and inspiration that was flowing throughout the week. Although it would be impossible to capture the palpable excitement and energy in the air, here we hope to summarize the scientific highlights of the conference and spark future research directions.

As displayed in our word cloud of talk and poster presentation titles (**Fig. 1**), arbuscular mycorrhizal (AM) fungi had an outsized representation at this conference. While much exciting research in the realms of ecto-, ericoid, orchid, and other types of mycorrhizas was presented at ICOM 12, this meeting report is biased toward AM fungi for this reason. However, we hope to see some change regarding this in future ICOM's.

Impactful science of ICOM 12

The bar was set high at previous meetings, but the science of ICOM 12 was particularly impactful, especially for early career researchers and trainees.

Many new and timely refinements of old ideas were shared in an accessible and vibrant manner. Here we will summarize some of several of the impactful workshops, sessions, and keynote presentations that have remained with us long after the conference ended.

Workshop on natural selection in the AM symbiosis

This workshop was unique in that it was a delicious serving of theoretical biology that was largely absent the rest of the week. The speakers provided unique and interesting ideas that could revolutionize the field of evolutionary biology of symbiosis. This workshop started with a primer on the tripartite interactions between interactors (i.e., phenotypic variation), replicators (i.e., units of inheritance), and manifestors of adaptation, when defining natural selection. The speakers then delved into various potential units of selection that may be pushing forward evolution in the AM fungi symbiosis. On one end of the spectrum, individual fungal nuclei could act as units of selection. Nuclear dynamics in AM symbioses are incredibly distinctive among the

Molecular biology advances

The plentiful technological and analytical advancements in the realm of molecular biology were on display in many sessions throughout the conference. For example, the *Molecular Biology & Physiology* session showcased interesting research projects that used creative approaches, like microfluidic chips to study hyphal behavior, to produce novel results and conclusions. The development of these innovative methods may lead us to understand more than we ever thought possible about this plant-fungal mutualism, and may continue to reveal more plants that associate with mycorrhizal fungi than ever before. Additionally, the workshop on AM fungal sequencing highlighted the ever-changing molecular sequencing landscape and suggested some best practices to help move the field forward. While much progress has been made, especially over the last decade, it is remarkable that there are still no universally accepted methods for amplicon sequencing of AM fungi in environmental samples. This is clearly an avenue for interesting future research and methodological advancement. Likewise, a suggestion for a new best practice emerged from this session: we need to adapt methodology from other microbial ecologists. Similar to how bacteria researchers include mock communities, whose members and relative abundances are known, on sequencing runs, those sequencing AM fungi should also create mock communities to include on all sequencing runs. This methodological approach could revolutionize how we report results and analyze sequence-generated data in mycorrhizal ecology studies. Lastly, we found it impressive that this collaborative development on an international scale is essential to maximize impact on research and conservation policies, especially when linked to biogeographical distributions of AM fungi.

Sustainability applications and climate mitigation

A recurring theme was the critical role of AM fungi in climate change mitigation and resilience, particularly in soil carbon storage. This highlights their central role in soil biogeochemical cycles, plant communities, and interactions with other organisms, such as insects, opening avenues for further research into ecological interactions. Regarding sustainable agriculture, studies are increasingly integrating AM fungal research with social, economic, and agricultural sciences. This underscores the need for multidisciplinary teams to address complex interactions. However, there is a noticeable lack of long-term field experiments under real-world conditions to directly observe the cumulative impacts of AM fungi on agroecosystems. Such studies could inform agricultural practices and policy-making with a broader, long-term perspective.

Keynote talks inspired future research directions

Each keynote speaker showcased foundational and interesting developments in the field of mycorrhizas, but a few keynote addresses were especially impactful. The keynote on continent-scale aerial dispersal of mycorrhizal fungi highlighted the importance of studying the macroecology of these small organisms, especially as our planet becomes increasingly connected and warmer in the Anthropocene. Quantifying mycorrhizal dispersal in the environment is a critical step to understanding their biogeographic patterns and can contribute to assessing population-level genetic patterns. Another impactful keynote discussed the role of mycoheterotrophy in common mycorrhizal networks. This talk reinforced the importance of considering mycorrhizal fungi on a parasitism-

mutualism nutritional continuum and their plant hosts on an autotroph-mycoheterotroph continuum. With this added complexity, we may be able to better quantify these relationships throughout the life of the mutualism and add much needed context to orchid mycorrhizal systems.

Applied mycorrhizal science advances

In these sections, the practical application of mycorrhizas in agricultural and ecological systems is explored, highlighting their effectiveness in ecological restoration and soil conservation. Arbuscular mycorrhizal fungi use (and regulation), control, and maintenance are key strategies for transitioning to sustainable agriculture, enhancing agroecosystem stability, and increasing production. Additionally, AM fungi play a crucial role in mitigating climate change by affecting carbon sequestration in soils, while improving resilience through enhanced soil structure, functionality, microbiota, and crop development. These benefits also increase crop tolerance to biotic and abiotic stresses, such as drought and contamination. In ecological restoration, studies focus on recovering degraded and contaminated soils and regenerating vegetation in environments impacted by pollutants like heavy metals or microplastics.

Research on crop inoculation highlights the importance of germplasm banks, *in vitro* cultures, and technologies that optimize inoculum production and persistence in soils. Identifying strains adapted to specific crops and regions is crucial for ensuring compatibility with different agricultural practices. Advances in metabarcoding have also facilitated the identification of AM fungal strains and the monitoring of fungal conservation in forest ecosystems.

While most studies focus on cereals like rice, wheat, and maize, research has also explored

perennial crops like vineyards, olive trees, and cacao. Additionally, AM fungi have been studied in the context of berry cultivation, truffle production, and grassland management. The impact of AMF on the nutraceutical composition of cereals and fruits has shown improvements in metabolomic profiles, although in some soil restoration cases, contaminants have been translocated to food. Future research should explore further the nutritional benefits of AMF in crops.

Integrated agricultural practices, such as organic amendments, crop rotation, cover crops, and reduced tillage, enhance mycorrhizal colonization and spore density in the soil compared to conventional systems. These practices promote the distribution and persistence of natural or commercial inocula but do not significantly affect AM fungal diversity. Tailored solutions are needed based on environmental, edaphic, and agronomic factors. Further research should focus on interactions between AM fungi and other soil microorganisms, particularly plant growth-promoting rhizobacteria (PGPR) and pathogens under stress.

Several studies have highlighted the negative effects of conventional practices and agrochemical use on soils and AM fungi communities. These practices disrupt microbial communities, favoring pathogen proliferation and reducing fungal ecosystem functions. Additionally, more molecular and genetic understanding is needed to select AM fungal strains that are highly efficient across crops and regions. Most studies have been limited to controlled conditions, making it difficult to apply findings to real-world scenarios. Large-scale studies are necessary to assess the impact of management practices on mycorrhizal communities.

Studies have also focused on transferring knowledge of mycorrhizal structures across disciplines to raise awareness of soil microorganisms' vital role. Advancing knowledge transfer to farmers, supporting policies for AM fungal use in sustainable agriculture, and fostering collaboration among biologists, agronomists, economists, and policymakers are essential to facilitate the adoption of AM-based technologies.

Arbuscular mycorrhizas are a crucial tool for advancing sustainable agriculture, promoting food security, soil conservation, and climate change mitigation. To facilitate their large-scale adoption, further applied research, technology transfer, and policy development are needed.

Exciting new methods and paradigms

This conference introduced us to many new methods and theoretical frameworks from which to approach the science of mycorrhizas, certainly too many to fully recount here. Below is a selection of some new methods and paradigms that excited us and show promise in moving the field forward.

Including the hyphosphere in mycorrhiza research

The importance of considering the entirety of the hyphosphere in mycorrhizal research was a frequent topic during the conference. This represents an exciting new way to think about mycorrhizas; instead of solely focusing on plant-fungus relationships, future work will include the microbiota that accompanies and influences the functioning of these systems. We learned that plant-AM-bacteria tripartite symbioses and/or cooperation are likely important but we're just scratching the surface of fully quantifying these interactions (Wang et al., 2023). We also learned that the hyphosphere community can be a factor in natural selection and may even act as a unit of

selection with the host plant, which are both critical evolutionary considerations. Among the most innovative ideas, it was fascinating to reflect on the complex, dynamic, and adaptive interactions between plants and their underground microbiomes. By applying ecological and evolutionary principles, these interactions can lead to the development of more resilient systems, with potential applications in agricultural systems.

Advances in trait-based ecology

Trait-based ecology of mycorrhizas is a promising approach to link biodiversity to environmental functions (Chaudhary et al., 2022; Antunes et al., 2025). Many presentations discussed the utility of traits and introduced us to novel traits that go beyond morphology that may impact mycorrhizal functioning in the ecosystem. Examples of some traits that may help us better quantify mycorrhizal function and biology include: considering ecological interactions and role in networks as a trait, self-reparative capabilities of hyphae after an injury and hyphal exploration types, and fungal biomass allocation (hyphae vs. spores; hyphae in soil vs. roots) as a trait. The experimental application of advanced microscopic and robotic tools to characterize fungal spores in high detail was particularly noteworthy. Advanced microscopy imaging not only allows for more precise studies but also serves as an invaluable resource for scientific communication, enhancing understanding of soil life and complexity. Growth of this field is critical to quantifying the dispersal and function of various species, and integrating these traits with molecular tools provides an overall more comprehensive understanding of AM fungi.

Behavioral ecology of fungi

The study of fungal behavior is on the rise, partly due to methodological advances like the microfluidic chip to study behavior of hyphae

(Richter et al., 2024). The new adaptation of this technology can allow us to study how the hyphae of symbiotic fungi behave and grow on a cellular level, which is a largely unexplored field of mycorrhizal science.

Assessing biofertilizer utility

Biofertilizer application has been on the rise globally, with farmers searching for sustainable solutions to their agricultural challenges. However, the conference emphasized that the development and evaluation of biofertilizers under field conditions, along with their limitations in real-world applications (Koziol et al., 2024), remain critical for the sustainable scaling of these technologies to industrial levels and their practical use by farmers.

The nature of mycorrhizal research

Transformative research seems to stem from inclusive, internationally collaborative networks that prioritize less-studied geographic regions. This global perspective is crucial for advancing the understanding and application of AM fungi. This is furthered by pioneering organizations like the Society for the Protection of Underground Networks (SPUN), which are addressing research gaps in underrepresented regions and promoting global awareness of mycorrhizal fungi. Such initiatives emphasize the importance of diverse and multidisciplinary approaches to ecological relationships.

Main takeaways

Due to the exciting developments in methodology, novel and interesting results, and carefully thought out conclusions, we took many lessons away from ICOM 12. Our overall takeaway is that there is more to learn about mycorrhizas than we ever imagined! Here we will summarize just a few of our main takeaways of the conference.

1. Building scientific collaborations and partnerships, both locally and globally, plays a crucial role in engaging broader communities in promoting soil biodiversity awareness.

2. It is of utmost importance to be critical and impartial when interpreting results. Instead of fitting results into expected paradigms, explore alternative hypotheses and different interpretations with an open mind. This is how we can ensure we produce sound science while fostering a creative and collegial research environment.

3. We need to learn how to sit with uncertainty in our methodology and use that to power methodological advances. As a trainee or early career researcher, it can be especially frustrating to learn that methods are not well-established. And that's okay! Identify these areas and become excited to contribute to moving these fields forward using tools such as robotics and high-resolution microscopy. These advanced methods will not only enhance research precision but also serve as powerful ways to connect with an audience for science outreach.

4. Oversimplification of our study systems can help lead to some discoveries, but there is always a point at which it is more beneficial to add complexity back into the system. Ensuring an appropriate level of complexity can make our results more applicable to management and sustainability goals.

5. Identify key research gaps and do what you can to fill them. We are facing many complex, wicked problems around the world which we must solve one step at a time. Take a macroscopic view of these problems and find your approach to solving a small piece.

6. The importance of interdisciplinarity cannot be overstated. Connecting mycorrhizal research with fields like sociology, economics, and agriculture shows promise to promote, for example, sustainable farming practices.

7. Significant gaps remain in underrepresented areas for soil sampling and ecological function analysis, including biogeographical-specific conditions. Efforts should focus on organizing and systematizing diverse datasets to develop open-access distribution maps, enabling better understanding of diversity patterns and prioritization of zones for conservation.

Future research directions and outstanding questions

Given the exciting discussions, workshops, sessions, and meetings held during ICOM 12, and all that was learned there, we believe there are several complementary and promising directions for future research on mycorrhizas. Below, we outline six key areas of development, each accompanied by outstanding questions that merit further investigation:

1. The development of best practices for AM fungi amplicon sequencing.

a. Will further development of AM fungi amplicon sequencing methodology uncover different or unexpected global biogeographical patterns?

b. How can we best promote the collaborative development of international AMF-specific molecular databases, focusing on underrepresented regions to enhance global inclusivity?

2. Natural selection and multilevel selection in AM fungi.

a. How will a better understanding of AM natural selection inform our understanding of their ecology and biogeography?

b. What are the units of natural selection in AM fungi?

3. Continuing our thoughtful and critical dialogue around CMNs.

a. What is the role and extent of CMNs?

b. How can we acquire more data to substantiate this debate?

c. What are some other fields of mycorrhizal research that may benefit from a careful critique?

4. Expanding AM-plant research to include the hyphosphere community.

a. How can we leverage hyphosphere research to lead to a better understanding of the content-dependencies in AM fungi-plant interactions?

b. What might we discover about mycorrhizas when we consider all the communities of microorganisms in the hyphosphere?

c. What will be uncovered when we investigate “new” ecological interactions between AM fungi and other microorganisms (e.g., endophytic fungi) or macroorganisms (e.g., insects) in soil?

5. Advancing the study of fungal traits.

a. There is a need for a comprehensive assessment of fungal traits and their functions. How can we accomplish this goal?

b. How many fungal trait databases exist and how can we harmonize these efforts?

6. Methodological and technological innovations.

a. How can we integrate advanced microscopy and robotics tools with molecular methods to characterize AM fungal spores and better understand their ecological role(s)?

b. What are ways that we can explore the vast potential of advanced molecular techniques that go beyond amplicon sequencing, like rDNA metabarcoding and metatranscriptomics, to characterize AMF communities and uncover their metabolic and ecological functions?

c. How can we best design field experiments to mimic real-world conditions in order to assess the impact of AM fungi in agroecosystems managed sustainably considering diverse crops, growing regions, and over multiple growing seasons?

By having these questions in mind to guide our future research on mycorrhizal symbioses, we may advance the field by addressing the knowledge gaps identified here and discussed at length during ICOM 12. We already look forward to ICOM 13 in Cairns, Australia to share and discuss what will be achieved in the next two years!

Acknowledgements

We would like to thank César Marín for his invitation to contribute to this meeting report and for providing guidance along the way. We also wish to thank Bala Chaudhary for her helpful comments.

References

- Antunes, P. M., Stürmer, S. L., Bever, J. D., Chagnon, P. L., Chaudhary, V. B., Deveautour, C., ... & Zhang, H. (2025). Enhancing consistency in arbuscular mycorrhizal trait-based research to improve predictions of function. *Mycorrhiza*, 35(2), 14. <https://doi.org/10.1007/s00572-025-01187-7>
- Chaudhary, V. B., Rillig, M. C., van der Heijden, M. G. A., van Groenigen, J. W., & Aguilar-Trigueros, C. A. (2022). What are mycorrhizal traits? *Trends in Ecology & Evolution*, 37(7), 573–581. <https://doi.org/10.1016/j.tree.2022.04.003>
- Johnson, N. C., & Marín, C. (2025). Functional team selection as a framework for local adaptation in plants and their belowground microbiomes. *The ISME Journal*. Early View. DOI: <https://doi.org/10.1093/ismejo/wraf137>
- Karst, J., Jones, M. D., & Hoeksema, J. D. (2023). Positive citation bias and overinterpreted results lead to misinformation on common mycorrhizal networks in forests. *Nature Ecology & Evolution*, 7, 501–511. <https://doi.org/10.1038/s41559-023-01986-1>
- Koziol, L., McKenna, T. P., & Bever, J. D. (2024). Meta-analysis reveals globally sourced commercial mycorrhizal inoculants fall short. *New Phytologist*, 246(3), 821–827. <https://doi.org/10.1111/nph.20278>
- Richter, F., Calonne-Salmon, M., van der Heijden, M. G. A., Declerck, S., & Stanley, C. E. (2024). AMF-SporeChip provides new insights into arbuscular mycorrhizal fungal asymbiotic hyphal growth dynamics at the cellular level. *Lab on a Chip*, 24(10), 1930–1946. <https://doi.org/10.1039/D3LC00859B>
- Terry, V., Kokkoris, V., Villeneuve-Laroche, M., Turcu, B., Chapman, K., Cornell, C., Zheng, Z., Stefani, F., & Corradi, N. (2023). Mycorrhizal response of *Solanum tuberosum* to homokaryotic versus dikaryotic arbuscular mycorrhizal fungi. *Mycorrhiza*, 33, 333–344. <https://doi.org/10.1007/s00572-023-01123-7>

- Wang, L., Zhang, L., George, T. S., & Feng, G. (2023). A core microbiome in the hyphosphere of arbuscular mycorrhizal fungi has functional significance in organic phosphorus mineralization. *New Phytologist*, 238(3), 859–873. <https://doi.org/10.1111/nph.18642>

Research commentaries

Fun(gal) phenology: Journeying through life histories and community niches

Nicholas Medina^{1*}, Kelsey Patrick², Peter Kennedy³, M. Luke McCormack¹

¹Center for Tree Science, The Morton Arboretum, Lisle, IL, United States. ²Department of Biological Sciences, University of Illinois Chicago, Chicago, IL, United States. ³Department of Plant and Microbial Biology, University of Minnesota, Minneapolis, MN, United States.

*E-mail: nmedina@mortonarb.org

We all probably have times of year when we love to forage for mushrooms. However, when thinking about ecosystem ecology, we would love to know if the timing of fungal reproduction matches the production patterns and species shifts happening underground. Most studies have analyzed fungal phenology using aboveground mushroom surveys, but with high-throughput sequencing methods and compiled databases, we now have greater taxonomic and functional resolution to characterize mycorrhizal fungal hyphae and roots living in soils. Broadly, these community details are critical to understanding how trees and forests acclimate to intra- and inter-annual regime shifts in nutrient availability, supporting their future success (Hawkins et al., 2023). Our project on mycorrhizal phenology, MycoPhen, gets at this question by sampling soils and tree roots monthly over multiple years to understand community changes in mycorrhizal fungi. The project was initiated in 2023 and will wrap up in 2025. Here, we share some insights on the project adventure to date, while deferring some results to future reporting.

Using botanical collections

The Morton Arboretum in Illinois, United States has an herbarium of preserved plant specimens, as

well as a collection of living trees on the grounds. Here, we make use of a subset of 100-year-old areas across the 690-hectare grounds now maintained for continuous monitoring and data collection (Midgley & Sims, 2020). These single-species stands are a legacy of trial timber plantings that now are leveraged for well-controlled studies which isolate effects of tree species on many forest processes: from aboveground greening to belowground fine root production, and of course, mycorrhizal fungal community dynamics.

Mycorrhizal dynamics

So far in the project, we've found that ectomycorrhizal fungal communities show different compositions and relative abundances intra-annually, suggesting that sampling more than once per season is needed to best characterize the different compositions of soil ectomycorrhizal fungal communities. This finding is relevant as some globally abundant taxa appear to become absent in some parts of the year, such as *Wilcoxina* in spring under deciduous stands, and *Russula* in autumn under evergreen tree stands. It also appears that temporal effects are more common than effects of host tree leaf habit



Russula mushroom (left) and *Cenococcum* root tip (right) from under a *Picea abies* stand at The Morton Arboretum in Illinois, United States. **Photo credit:** Marvin Lo and Claire Kaliski.

(e.g., deciduous versus evergreen) for several genera and exploration types. In root tip data, *Cenococcum*, which is typically present year-round, shows some pulses during summer when other species are experiencing drought. Taking a broader perspective, our findings and multi-year phenology study might be seen as a temporal analog to similar efforts to understand mycorrhizal fungal communities at broader spatial scales, such as global efforts led by fungal conservation groups including the Society for the Protection of Underground Networks (SPUN), which has similarly helped uncovered new species from underrepresented tropical ecosystems, also in the *Russula* genus (Manz et al., 2021). The arboretum harbours approximately 4,000 tree species, and a series of planted monodominant tree stands, from which a diverse subset of ten plots are included in the current study. From this work, we are synthesizing a discussion that integrates previous studies of tree non-structural carbohydrate

phenology as well as preliminary data on fine root phenology, to ultimately link the synchronicity of above- and belowground forest tree growth. Here, we are interested in how the distribution of carbohydrates in a tree coincides with carbon allocation to roots and mycorrhizal fungi, as well as the influence of fine root production phenology on mycorrhizal fungal production, which additional projects at the arboretum are also addressing.

Now in 2025, we are sequencing another batch of 1,000 samples of roots and soils from year two of our study, to analyze inter-annual effects. We are also comparing arbuscular mycorrhizal with ectomycorrhizal fungal dynamics, which initially show that arbuscular mycorrhizal fungi have stronger responses than ectomycorrhizal fungi to changes in soil microclimate and environmental conditions. We have also teamed up with outside collaborators to draft upcoming reviews of ectomycorrhizal fungal phenology, as well as urban mycorrhizal fungi as an understudied topic, and we are excited and looking forward to contributing novel knowledge to the field.

Piecing together a temporal story with different methods

This project invokes multiple strategies for robust scientific research. To triangulate patterns of mycorrhizal fungal production, we are using qPCR, minirhizotron image analyses, and relative abundance metrics from sequencing. While these are all ideally methods that produce similar data, they each have their own limitations. For example, qPCR was done using fungal-specific primers, so it gives us a sense of total fungal DNA production. We know, however, that DNA is relatively stable on its own, and that approximately 60% of DNA in soil can be relics, or not indicative of immediately living cells (Carini et al., 2016). This is similarly relevant to sequencing data, which also gives abundances relative to each identified fungal species. To get total fungal production, we could also look at something like biomass, although in-growth bags may also have some bias toward certain species (Janowski & Leski, 2023; Hendricks et al., 2006).



Minirhizotron image, taken using a CID camera and visualized with US NIH ImageJ software, showing late-season autumn fungal hyphal structures (red box) under *Pinus strobus* in 2021 at The Morton Arboretum in Illinois, United States.

Using mini-rhizotron images, we can actually see fungal biomass, primarily mycorrhizal, although it focuses on medium- to long-distance and rhizomorphic (i.e., more hydrophobic) ectomycorrhizal fungi (Lilleskov et al., 2011).

From an ecosystem perspective, this is useful if most mycorrhizal fungal biomass comes from a few taxa with longer-distance growth forms. However, in cases where the mycorrhizal community includes many taxa with less extensive exploration strategies and is reasonably diverse, as is often the case in ecology (Matthews & Whittaker, 2015), we must interpret these visual estimates carefully. Still, the image analysis provides a clear estimate of when fungal biomass is increasing and decreasing throughout the year, making it a useful way to answer our question of understanding relative phenology under various host trees.

Finally, we are also differentiating between mycorrhizal fungal communities in different parts of the rhizosphere, namely fine roots and soils. Comparing fine root and soil communities will help better distinguish functional community differences by hyphal production and exploration types, and also indicate stronger or weaker associations with host tree root phenology. By considering fine root communities, we can also consider which genera might be more persistent or resilient to variable growing conditions than others. Integrating each of these unique datasets together now provides us with an exciting opportunity to uncover scientific truth about mycorrhizal dynamics.

Science is a social endeavor

This project has also been the product of strong collaborative teamwork, spanning The Morton Arboretum, the University of Illinois-Chicago, and the University of Minnesota. Following mycology's reputation of welcoming 'amateur' scientific

contributions, the contributions to academic scientific research that are regularly made by retired volunteers and high school interns at local cultural institutions like Morton are noteworthy. While there is an education arm, the population served is not centered on undergraduate or graduate students, but expanded to learners of all ages, both formal and informal. This provides opportunities to engage with folks from a variety of backgrounds. The collaborative work of lab research assistants, interns, undergraduates, and volunteers have really helped make this research happen and have helped keep days lively.

References

- Carini, P., Marsden, P. J., Leff, J. W., Morgan, E. E., Strickland, M. S., & Fierer, N. (2016). Relic DNA is abundant in soil and obscures estimates of soil microbial diversity. *Nature Microbiology*, 2, 16242. <https://doi.org/10.1038/nmicrobiol.2016.242>
- Hawkins, H.-J., Cargill, R. I. M., Van Nuland, M. E., Hagen, S. C., Field, K. J., Sheldrake, M., Soudzilovskaia, N. A., & Kiers, E. T. (2023). Mycorrhizal mycelium as a global carbon pool. *Current Biology*, 33(11), R560–R573. <https://doi.org/10.1016/j.cub.2023.02.027>
- Hendricks, J. J., Mitchell, R. J., Kuehn, K. A., Pecot, S. D., & Sims, S. E. (2006). Measuring external mycelia production of ectomycorrhizal fungi in the field: The soil matrix matters. *New Phytologist*, 171(1), 179–186. <https://doi.org/10.1111/j.1469-8137.2006.01742.x>
- Janowski, D., & Leski, T. (2023). Methods for identifying and measuring the diversity of ectomycorrhizal fungi. *Forestry: An International Journal of Forest Research*, 96(5), 639–652. <https://doi.org/10.1093/forestry/cpad017>
- Lilleskov, E. A., Hobbie, E. A., & Horton, T. R. (2011). Conservation of ectomycorrhizal fungi: Exploring the linkages between functional and taxonomic responses to anthropogenic N deposition. *Fungal Ecology*, 4(2), 174–183. <https://doi.org/10.1016/j.funeco.2010.09.008>
- Manz, C., Adamčík, S., Looney, B. P., Corrales, A., Ovrebo, C., Adamčíková, K., Hofmann, T. A., Hampe, F., & Piepenbring, M. (2021). Four new species of *Russula* subsection *Roseinae* from tropical montane forests in Western Panama. *PLOS ONE*, 16(10), e0257616. <https://doi.org/10.1371/journal.pone.0257616>
- Matthews, T. J., & Whittaker, R. J. (2015). Review: On the species abundance distribution in applied ecology and biodiversity management. *Journal of Applied Ecology*, 52(2), 443–454. <https://doi.org/10.1111/1365-2664.12380>
- Midgley, M. G., & Sims, R. S. (2020). Mycorrhizal association better predicts tree effects on soil than leaf habit. *Frontiers in Forests and Global Change*, 3, 74. <https://doi.org/10.3389/ffgc.2020.00074>

YouTube interviews*

- Matthias C. Rillig on concurrent common fungal networks

Prof. César Marín (Universidad Santo Tomás, Chile) interviews Prof. Matthias C. Rillig (Freie Universität Berlin, Germany) about different definitions and ways a fungal network can be 'common' across plants, emphasizing that not only mycorrhizal fungi might be able to form them but also other fungal guilds.

Interview: <https://southmycorrhizas.org/reading/march-2025/>

Study: Rillig, M. C., Lehmann, A., Mounts, I. R., & Bock, B. M. (2025). Concurrent common fungal networks formed by different guilds of fungi. *New Phytologist*, 246(1), 33. <https://doi.org/10.1111/nph.20418>



* Section by: South American Mycorrhizal Research Network

Contact/Join us: <https://southmycorrhizas.org/join/>

For further YouTube interviews in mycorrhizal and mycorrhizal-adjacent topics, seminars, and workshops, check our YouTube channel: [@whatwearereading6719](https://www.youtube.com/@whatwearereading6719)

<https://www.youtube.com/@whatwearereading6719>

Tools

- New fungal primers for Mucoromycotinian AMF

Seeliger et al. (2024) modified existing 'AM' 18S rRNA primers which co-amplify Glomeromycota-AMF (G-AMF) and Mucoromycotina-AMF (M-AMF) to reduce bias against Mucoromycotina, and compared them against a new 'FRE' primer set which selectively amplifies Mucoromycotina. In an experimental setup, the authors found no significant effect of either Nitrogen-addition or wheat variety on G-AMF or M-AMF diversity or community composition when using the existing AM-primers. In contrast, using the new FRE-primers, N-addition was shown to reduce M-AMF diversity and altered community composition.

Study: Seeliger, M., Hilton, S., Muscatt, G., Walker, C., Bass, D., Albornoz, F., ... & Bending, G. D. (2024). New fungal primers reveal the diversity of Mucoromycotinian arbuscular mycorrhizal fungi and their response to nitrogen application. *Environmental Microbiome*, 19(1), 71. <https://doi.org/10.1186/s40793-024-00617-x>

- Cold storage to promote AMF germination/colonization from hyphal propagules

Liu et al. (2024) conducted an experiment with two storage temperatures (25°C and 4°C), to test germination success from AMF propagules. They showed that the germination rate remained unchanged after storage for 0 and 1 month at 25°C, but decreased rapidly after storage for 3 months. In contrast, the germination rates of spores, hyphae and root fragments were significantly higher under cold storage compared to those at 25°C.

Study: Liu, X., Ye, G., Feng, Z., Zhou, Y., Qin, Y., Yao, Q., & Zhu, H. (2024). Cold storage promotes germination and colonization of arbuscular mycorrhizal fungal hyphae as propagules. *Frontiers in Plant Science*, 15, 1450829. <https://doi.org/10.3389/fpls.2024.1450829>

Click for previous Tools: [Vol1_I1](#) (p. 11), [Vol1_I2](#) (p. 15), [Vol1_I3](#) (p. 16), [Vol2_I1](#) (p. 19), [Vol2_I2](#) (p. 15), [Vol2_I3](#) (p. 15), [Vol3_I1](#) (p. 16), [Vol3_I2](#) (p. 17), [Vol3_I3](#) (p. 26), [Vol4_I1](#) (p. 19), [Vol4_I2](#) (p. 23), [Vol4_I3](#) (p. 34), [Vol5_I1](#) (p. 21), [Vol5_I2](#) (p. 29), and [Vol5_I3](#) (p. 44).

Events

ICOM13: <https://icom2026.org/>

The 13th International Conference on Mycorrhiza (ICOM13) will take place in the Cairns Convention Centre, Cairns, Queensland, Australia, July 12-17, 2026.

The theme for ICOM2026 is: “Mycorrhizas in a changing world: challenges, opportunities and solutions.”



ICOM

2026

Cairns
Australia

Events

4th Global Soil Biodiversity Conference: <https://globalsoilbiodiversity2026.org/>

The 4th Global Soil Biodiversity Conference will take place in the Victoria Conference Centre, Victoria, British Columbia, Canada from April 12 to 15, 2026. Deadline for **Abstract submissions** has been extended until August 15, 2025, 23:59 PDT.



**CALL FOR
ABSTRACTS**

4TH GLOBAL SOIL BIODIVERSITY
CONFERENCE
(GSB 2026)

APRIL 12–15, 2026 VICTORIA, BC

DEADLINE: Extended to August 15, 2025, 23:59 PDT

[GLOBALSOILBIODIVERSITY2026.ORG/ABSTRACTS](https://globalsoilbiodiversity2026.org/abstracts)

International Mycorrhiza Society Executive

- **President:** Justine Karst, University of Alberta, Canada (karst@ualberta.ca).
- **Vice-President:** Jan Jansa, Institute of Microbiology, Czech Academy of Sciences, Czechia (jansa@biomed.cas.cz).
- **Past President:** Marcel G.A. van der Heijden, Agroscope & University of Zurich, Switzerland (marcel.vanderheijden@agroscope.admin.ch).

Board

- César Marín – Editor-in-Chief of IMS Newsletter, Santo Tomás University, Chile (cmarind@santotomas.cl).
- Pedro M. Antunes – Director, Algoma University, Canada (pedro.antunes@algotmau.ca).
- Jonathan Plett – ICOM13 Lead Organizer, Western Sydney University, Australia (J.Plett@westernsydney.edu.au).
- Franck Stefani – Treasurer, Agriculture and Agri-Food Canada, Canada (franck.stefani@agr.gc.ca).
- Patricia Silva-Flores – Director of Communications, Catholic University of Maule, Chile (psilva@ucm.cl).
- Roxane Bergeron, Secretary, Algoma University, Canada (rbergeron@algotmau.ca).

ICOM13 will be organised in July 2026 in Cairns, Australia, by Prof. Jonathan Plett (Western Sidney University) and his colleagues.

IMS – INTERNATIONAL MYCORRHIZA SOCIETY
60 RUE LORD-AYLMER
GATINEAU QC J9H 3R7 CANADA