Bois et Forêts des Tropiques – ISSN : L-0006-579X
Volume 357 – 3e trimestre – octobre 2023 – p. 3-4

Plant-Plant Interdependence and Mutualism Interactions in Heterogeneous Ecosystems still hide a lot of secrets

Heterogeneous ecosystems, such as tropical forests, serve as vital reservoirs of biodiversity, harboring a myriad of plant species. Within these ecosystems, plants not only interact with their environment and other living beings such as fungi and bacteria, but also engage in intricate relationships with one another. Plant-plant interactions play a crucial role in shaping the structure, dynamics, and resilience of these ecosystems. These interactions encompass various aspects, the most important is the cooperative and mutualistic relationships. In this editorial, we explore the significance of these mutualistic interactions and highlight the pressing need for further research to unlock their full potential.

Plant species can facilitate each other's growth through interactions such as nurse-plant relationships. Certain plant species act as nurse plants by providing shade, shelter, or improved microclimatic conditions for the establishment and growth of other plants. This facilitation allows less competitive or more sensitive species to thrive in challenging or disturbed environments. The nurse plants create a more favorable environment by reducing competition, protecting against herbivory, or enhancing water availability. In forest ecosystems, whether they are deciduous forests (Bartkowicz and Paluch, 2019) or tropical forests (Ntawuhiganayo *et al.*, 2020), there is a fascinating phenomenon where shade-intolerant plant species play a crucial role. These species form a canopy that offers shade and protection for shade-tolerant plant species. The shade-intolerant plants benefit from the increased competition for light, while the shade-tolerant plants benefit from reduced light intensity and lower temperatures. This mutualistic interaction allows both types of plants to coexist and thrive. Understanding these interactions can help us to identify and to utilize the potential of nurse plants to restore degraded ecosystems or to enhance biodiversity conservation efforts. Additionally, further research is needed to explore the specific mechanisms and ecological implications of these facilitative interactions, particularly in different ecosystems and under changing environmental conditions.

Belowground interactions between plant roots can play a crucial role in nutrient acquisition and plant growth. Some plant species form mycorrhizal associations where fungal hyphae extend the nutrient-absorbing capacity of roots, benefiting both plants involved. In addition, certain plants have been shown to share nutrients through mycorrhizal hyphae, allowing them to support each other in nutrient-limited conditions. Recently, it was found that the healthy neighboring plants connected through the common mycorrhizal networks showed increased disease resistance and the activation of various defensive enzymes and genes (Jung *et al.*, 2012). Furthermore, some studies draw parallels between the fungal mycelia of mycorrhizae, which facilitate communication between trees in a forest, and social networks or neural networks (Gorzelak *et al.*, 2015). This suggests that the mycorrhizal networks can serve as an underground communication conduit, allowing plants to transfer disease resistance and defense signals to neighboring plants before they are attacked. Exploring the intricate networks of mycorrhizal associations and root provides opportunities to enhance sustainable agricultural practices, ecological restoration efforts, and plant community management.

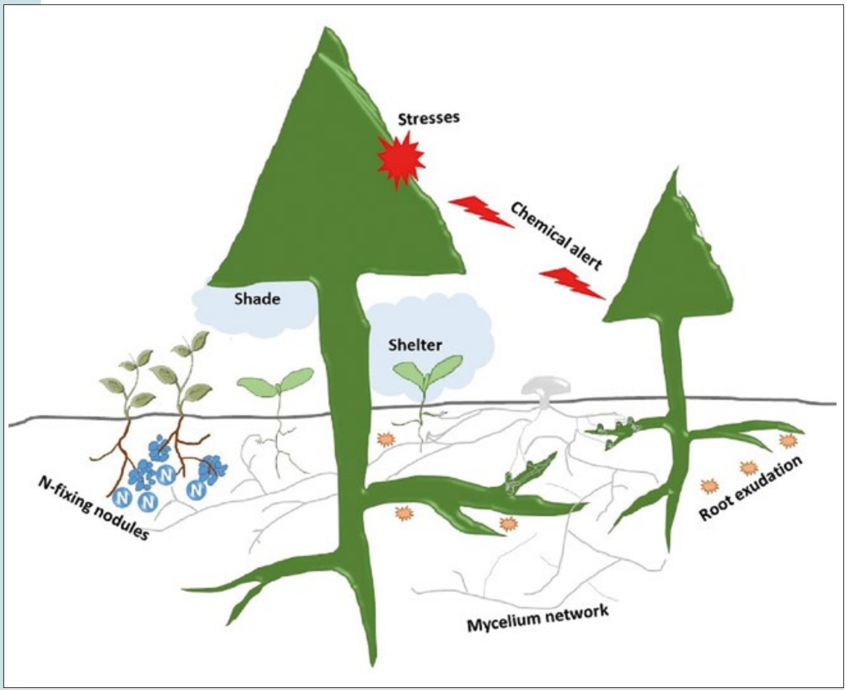

Figure 1.
Schematic representation of key mutualistic plant interactions in a heterogeneous ecosystem.

In addition, plant species can interact in ways that promote nutrient cycling within ecosystems. They can form specialized root systems that enhance nutrient uptake and make nutrients accessible to neighboring plants. For instance, in nitrogen-limited environments, such as tropical rainforests, symbiotic nitrogen-fixing trees can efficiently capture and convert atmospheric nitrogen into usable forms through specialized root nodules (Menge and Chazdon, 2016). By doing so, they create a local nitrogen source that can benefit neighboring non-nitrogen-fixing plants. This mutualistic interaction allows nitrogen-fixing and non-nitrogen-fixing plants to coexist and thrive by increasing nitrogen availability. Furthermore, this beneficial plant-plant association can occur over time; the passage of a nitrogen-fixing plants from one plot, forms a nitrogen-rich microenvironment for the subsequent crop. This sequential association allows plants to benefit from the nitrogen released by the preceding species. This type of beneficial plant-plant relationship has long been utilized by humans in the form of crop rotation. However, in complex and natural ecosystems such as tropical and mediterranean forests, the investigation of such associations is often overlooked, despite their potential significant role in maintaining biodiversity and the functioning of natural ecosystems.

Although allelopathy can lead to adverse effects on nearby plants, it also offers the potential for mutually beneficial interactions in certain cases. Some plant species release chemicals that suppress the growth of competing plants but have a positive effect on the growth of other plant species. This can create a mutualistic relationship where the allelopathic plant provides a competitive advantage to the beneficiary plant. One example is the *Juglans nigra* tree, which produces the juglone[1]. It is toxic to many plant species and can inhibit their growth or even cause their death. However, there are certain plant species, such as the *Asimina triloba*, that are allelopathically tolerant to juglone (Mosquera-Losada and Prabhu, 2019). These tolerant plants can thrive in the presence of *J. nigra* trees and may even benefit from the suppression of competing plants, allowing them to occupy niches that would otherwise be occupied by other species. This demonstrates how allelopathy can influence plant interactions and shape the composition of plant communities. Chemical Signaling can play another role in plant cooperation, in certain cases, plant species may cooperate to defend against herbivores or environmental stresses. They can emit chemical signals that alert neighboring plants to the presence of herbivores, triggering defense mechanisms in those plants. For example, in temperate forests, *Betula pubescens* are known to release methyl jasmonate when attacked by herbivores. Methyl jasmonate is a signaling molecule that can induce defensive responses in neighboring plants, even of different species. When the nearby plants sense the methyl jasmonate, they activate their own chemical defenses, making them less susceptible to herbivore damage (Benevenuto *et al.*, 2020). Further research in this field is essential to unravel the intricacies of these interactions, identify key chemical compounds involved, and assess their ecological consequences in diverse ecosystems. By unraveling the mechanisms and ecological implications of allelopathy and chemical signaling, we can gain a deeper understanding of plant community dynamics and potentially apply this knowledge to enhance biodiversity conservation efforts and sustainable agricultural practices.

In this editorial, we have highlighted the fascinating and complex nature of beneficial plant-plant interactions. These interactions hold tremendous potential, yet our understanding of their underlying mechanisms remains limited. The nature, triggers, outcomes, and environmental factors influencing these interactions are still poorly understood, hampering their practical application in various agricultural and reforestation systems. Nonetheless, these interactions serve as vital threads that intertwine and shape the diverse fabric of heterogeneous ecosystems. Recognizing the significance of plant-plant interactions and their implications, it is crucial to invest in further research. By delving into these intricate relationships, we can unlock the secrets that lie within, fostering a deeper appreciation for the interconnectedness and complexity of life within forests and other natural landscapes.

Belkacem El Amrani[2]

[2] Member of the Editorial Committee of the journal
Bois et Forêts des Tropiques
University of Sidi Mohamed Ben Abdellah
1002 - 66, Al-Wafaa Retail, Road Sefrou
Cp 30060, Fez
Morocco

Auteur correspondant / Corresponding author:
Belkacem EL AMRANI – elamranibelkacem@gmail.com

ORCID : https://orcid.org/0000-0002-8969-199X

References

Bartkowicz L., Paluch J., 2019. Co-occurrence of shade-tolerant and light-adapted tree species in uneven-aged deciduous forests of southern Poland. European Journal of Forest Research, 138 (1): 15-30. https://doi.org/10.1007/s10342-018-1149-5

Benevenuto R. F., Seldal T., Moe S. R., Rodriguez-Saona C., Hegland S. J., 2020. Neighborhood Effects of Herbivore-Induced Plant Resistance Vary Along an Elevational Gradient. Frontiers in Ecology and Evolution, 8: 117. https://doi.org/10.3389/fevo.2020.00117

Gorzelak M. A., Asay A. K., Pickles B. J., Simard S. W., 2015. Inter-plant communication through mycorrhizal networks mediates complex adaptive behaviour in plant communities. AoB Plants, 7: plv050. https://doi.org/10.1093/aobpla/plv050

Jung S. C., Martinez-Medina A., Lopez-Raez J. A., Pozo M. J., 2012. Mycorrhiza-Induced Resistance and Priming of Plant Defenses. Journal of Chemical Ecology, 38 (6): 651-664. https://doi.org/10.1007/s10886-012-0134-6

Menge D. N. L., Chazdon R. L., 2016. Higher survival drives the success of nitrogen-fixing trees through succession in Costa Rican rainforests. New Phytologist, 209 (3): 965-977. https://doi.org/10.1111/nph.13734

Mosquera-Losada M. R., Prabhu R. (Eds.), 2019. Agroforestry for sustainable agriculture (1st edition). Burleigh Dodds Science Publishing, 542 p. https://doi.org/10.1201/9780429275500

Ntawuhiganayo E. B., Uwizeye F. K., Zibera E., Dusenge M. E., Ziegler C., Ntirugulirwa B., Nsabimana D., Wallin G., Uddling J., 2020. Traits controlling shade tolerance in tropical montane trees. Tree Physiology, 40 (2): 183-197. https://doi.org/10.1093/treephys/tpz119

[1] Juglone is an organic compound with the molecular formula $C_{10}H_6O_3$.

Doi : 10.19182/bft2023.357.a37293 – Droit d'auteur © 2023, Bois et Forêts des Tropiques – © Cirad – Date de soumission : 9 juin 2023 ; date d'acceptation : 8 septembre 2023 ; date de publication : 1er octobre 2023.

Citer l'article / To cite the article

El Amrani B., 2023. Editorial: The Plant-Plant Interdependence and Mutualism Interactions in Heterogeneous Ecosystems, hides yet a lot of secrets. Bois et Forêts des Tropiques, 357: 3-4. Doi : https://doi.org/10.19182/bft2023.357.a37293