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Editorial

Chemical Ecology in Forests

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There is a competitive and coordinated relationship among organisms which depends on their chemical connections. Chemical relationships are an important way for organisms to interact with each other. Various levels of organisms and those without a nutritional relationship are linked by chemicals, forming a vast network of chemical information. It can be said that the relationship between organisms is actually a chemical relationship. Forest ecosystems, which have a complex structure and diverse chemical relationships, encompass the majority of woody plants and animals worldwide. Chemical ecology is an important aspect of the exploration of forest ecosystems.

Plants can sense and recognize coexisting species of the same or different species, thereby adjusting their growth, reproduction, and defense strategies. Throughout its life cycle, a plant can interact directly or indirectly with its plant neighbors, thereby influencing the plant population and community structure. Agroforestry is an effective method to improve plant productivity by rationally regulating the interspecific relationships between plants. Zhao et al. conducted a comparative analysis of the growth indicators of *Camptotheca acuminata* (*C. acuminata*) cultivated in monoculture and intercropping systems, revealing a significantly higher growth rate for *C. acuminata* in the intercropping system compared to that in the monoculture system [1], and the soil properties in the mixed planting system were significantly improved. The authors believe that this positive effect is probably due to plant allelopathy. Using mass spectrometry, it was found that in *C. acuminata* rhizosphere soil exists taxanes, a class of allelochemicals unique to *Taxus chinensis* var. *mairei*. Allelopathy may be one of the important factors in promoting the growth of *C. acuminata* seedlings by interplanting *Taxus chinensis* var. *mairei*, which is an important chemical link in the interactions between plant species [1].

Plant allelopathy is a natural ecological phenomenon. When plants are ingested by animals and infected by microorganisms, plants often respond by synthesizing and releasing allelochemicals. Plants adjust their biomass distribution by recognizing information from neighboring species to decide whether to adopt chemical defense strategies. Hong et al. established a mixed forest of *Larix olgensis* and *Fraxinus mandshurica*, and found that intercropping significantly increased the content of secondary metabolites (phenolic compounds) in *Larix olgensis*, thereby enhancing its chemical defense ability [2]. The allelomic effect of *Fraxinus mandshurica* on *Larix olgensis* was found to be related to the mixing ratio, and the chemical defense ability of high-proportionally mixed forests was effective [2]. Secondary metabolites are the result of long-term evolutionary interactions between plants

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and their living environment, affecting the color, odor, and taste of the plant. Phenolic compounds can inhibit the digestion and utilization of food by herbivorous insects, thus affecting insect activity. Phenolic compounds are an important indicator for plants to resist pests, and they play a crucial role in the process of plant resistance to pests [2].

Allelochemicals can regulate forest biodiversity, productivity, and sustainability. A comprehensive understanding of allelochemicals can offer novel insights into the sustainable development of forest ecosystems. Xu et al. described allelopathy in forest ecosystems from three levels: forest, plantation, and understory vegetation [3]. Meanwhile, the author also summarized the main categories of allelochemicals in forest ecosystems and proposed that the identification of allelochemicals requires accurate information on the quantity, quality, and temporal and spatial dynamics of allelochemicals, otherwise it will be difficult to accurately understand the functional significance of allelopathic plant–plant interactions in forests [3]. The authors emphasize that allelochemicals can change the consequences of underground ecological interactions, and suitable mixed tree species can enhance their growth through underground chemical interactions [3]. Allelochemicals and signaling chemicals work synergistically to affect the coexistence, diversity, and community structure of forest plants. The proper use of kinship identification between plants can even help forest regeneration.

In addition to interactions between plants, plants also produce endogenous chemical signals to regulate their own growth. Plant hormones are active substances produced by plant cells in response to specific environmental signals and can regulate plant physiological responses. Zhong et al. comprehensively analyzed the mechanisms for seed dormancy release and germination in *Bretschneidera sinensis* Hemsl, revealing that the ratio of GA3 (gibberellin A3)/ABA (abscisic acid) in seeds plays a pivotal role in determining seed dormancy release and germination, and also revealing that seed germination requires the interaction of hormones [4]. Additionally, the author points out that seeds can break their dormancy and stimulate germination by increasing the level of soluble sugars, which provide energy for seed dormancy to germination [4]. The increased soluble sugar levels can also promote the removal of ROS (reactive oxygen species), protecting the seeds from oxidative stress [4].

Chemical herbicides are often used in plantation cultivation, and the application of herbicides can be toxic to plants, so chemical controls must be used carefully. Herbicides have a lower selectivity for eucalyptus plantations, which may cause losses in early tree development and lead to a loss in productivity. Indaziflam herbicide is one of the herbicides that is relatively safe for crops. Little is known about the tolerance of indaziflam herbicide in *Eucalyptus* plantations. Maciel et al. evaluated the persistent effects of indaziflam herbicide and its impact on plant growth [5]. The results show that the content of chlorophyll a and b, the rate of electron transport, height, and stem mass of plants in soil contaminated by indaziflam herbicide residues were all lower [5]. Indaziflam herbicide was applied to eucalyptus plants, and it was found that indaziflam herbicide could be leached to a depth of 30 cm in the soil [5]. Residues of indaziflam herbicide in the soil inhibit the growth of *Eucalyptus Clone*.

The mechanism by which organisms perceive information chemicals is an important subject of study in chemoecology. Plants can respond to their surroundings by producing chemical signaling substances, and they can also share these chemical signals with other plants. This “communication”, dominated by chemicals, can change the microenvironment for plant growth, regulate nutrient supply, and even affect plant yield.

Microorganisms are the executors and drivers of energy flow in soil, and plants can influence the rhizosphere soil microbial community through root exudates or litter. In turn, changes in soil biological characteristics can affect the host plant and its coexisting plants. Zhong et al. established an intercropping field between *Areca catechu* L. and *Pandanus amaryllifolius* Roxb [6]. It was found that intercropping had positive effects on soil microbial homeostasis in plantations by comparing them with monoculture [6]. What is more interesting is that the authors found a special correlation between the soil’s physical

and chemical properties, enzyme activity, and microorganisms [6]. Urease and phosphatase are the key factors that regulate the abundance of the soil's microbial community. Compared with fungi, the authors suggest that bacterial communities are more sensitive to interplant relationships and that bacteria are more responsive to changes in soil environmental factors [6].

The composition of soil microbial communities affects the availability of soil nutrients. To determine the correlation between soil nutrients and microbial diversity after the introduction of other plant species, Liu et al. conducted a mixed planting experiment with the legume species *Lespedeza bicolor* Turcz. and the mulberry species *Morus alba* [7]. It was found that intercropping significantly increased the contents of C, N, and P in soil. Nitrogen-fixing plants increase the productivity of plants by increasing the availability of soil nutrients, especially nitrogen, and provide essential base metabolites for more microbial growth [7]. *Actinobacteria* has a high soil abundance due to the soil's nutrient and organic matter content. Due to the harsh environment, *Proteobacteria*, which has certain resistance in the face of extreme environment, dominates the soil [7]. By conducting 16S rRNA and ITS sequencing on soil microorganisms, the authors found that there was a significant change in diversity within the bacterial community compared to the fungal community [7]. Therefore, soil microbial communities serve as an important link between aboveground plant communities and underground ecological processes, regulating the material cycling process in forest ecosystems and the flow of energy in the soil.

Due to biological and abiotic influences, the accumulation, release, and transformation of soil nutrients often change. No matter how environmental factors change, the ecological stoichiometric value of a plant species usually remains relatively constant, which is called stoichiometric homeostasis. In order to further understand the adaptability of trees under nutrient changes, Guo et al. explored the changing rules of nutrient uptake and ecological stoichiometric homeostasis in *Pinus massoniana* plantation [8]. The authors found that there was a synergistic effect between the leaf litter and soil, and that the ecological stoichiometry and nutrient uptake of different aged trees were variable [8]. The results showed that P content decreased first and then increased with the increase in plantation age, which was different from the conventional rule of increasing accumulation of nutrients alongside an increase in the time sequence [8]. The absorption efficiency of N and P first increased and then decreased during the growth of the *Pinus massoniana* plantation [8]. The increase in nutrient element absorption promoted the growth of *Pinus massoniana*. The author believes that introducing suitable tree species and planting them with *Pinus massoniana* can achieve more effective artificial forest cultivation, which is an effective strategy to alleviate nutrient limitations [8].

The pharmacological effects of plants are derived from compounds produced by the secondary metabolism in plants. External environmental factors can regulate the production of a plant's active substances. Photosynthesis is the process by which plants produce nutrients, which is crucial for the production of secondary metabolites. Zhao et al. treated *Ginkgo biloba* with UVA to explore the molecular mechanism of the influence of light on the synthesis of flavonols, the plant's active ingredient, thereby improving the quality of *Ginkgo biloba* [9]. The results showed significant differences in flavonol content and enzyme activity in the phenylpropane pathway in plants under different intensities of UVA [9]. Moderate UVA intensity can promote enzyme activity related to the flavonoid synthesis pathway and flavonol accumulation in *Ginkgo biloba*, while excessive UVA plays an inhibitory role [9]. The authors indicate that the enhancement of the flavonoid content's medicinal value in *Ginkgo biloba* can be achieved by stimulating the expression of related enzyme genes (MYB (Gb_02997), bHLH (Gb_05320), bZIP (Gb_00122), and NAC (Gb_13200, Gb_37720)) [9].

Environmental factors can also trigger plant diseases and reduce plant quality. In Yanshan chestnut garden, there were symptoms of scorching between the leaf's margin and vein. Different from the previous reports of leaf burn disease, no pathogenic bacteria were detected in the infected plants. In order to explore the main factors leading to *Castanea*

mollissima leaf scorching and the effect of leaf scorching disease on the characteristics of the nuts, Chen et al. analyzed and compared the differences in the leaf, root, and soil nutrients, nut phenotypes, and antioxidant enzyme activities between healthy and leaf-scorched trees [10]. Leaf scorching has a significant impact on the morphology and traits of *Castanea mollissima*' nuts [10]. The correlation analysis results show that B, Zn, Mg, and Fe have a significant impact on the health of leaves [10]. The soil AK, K Fe, B, and Cu have a significant impact on the leaf's B concentration. The author believes that *Castanea mollissima* leaf scorching may be caused by the high content of B in leaves and the lack of Mg, which is related to the change in the balance of AK, B, Mg, Cu, and Fe in the soil [10]. The decrease in Mg is most likely caused by the soil's AK [10].

This Special Issue of the *Forests* journal, "Forest Chemical Ecology", covers the study of the chemical connection between organisms and their mechanisms. This Special Issue covers discussions on pesticide pollution, pest resistance, and the intrinsic causes of interspecies relationships, and provides guidance on pest control, biodiversity conservation, and the rational utilization of biological resources in forest ecosystems. The research reports contained in this Special Issue provide important insights for realizing the sustainable development of forest ecological systems.

Conflicts of Interest: The author declares no conflicts of interest.

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