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SUPPORT OF THE FLORA OF THE SPA THERAPEUTIC LANDSCAPE

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Abstract

The developed method of supporting the growth and vitality of cultivated forest trees, ornamental shrubs, grassy areas and flora in spa parks, forest parks and spa forest stands consists in the application of ectomycorrhizal, or endomycorrhizal fungi, which can utilize a much larger volume of soil with the help of extramatrical hyphae than the root hairs of non-mycorrhizal plants alone. Resistance to phytopathogenic fungi is significantly reduced by a lack of moisture (during summer droughts). Therefore, the addition of biochar, natural polysaccharides based on carrageenan, alginate or xanthan, humic substances, peat and crushed bork (preferably disintegrated using hydrodynamic cavitation) and a porous inorganic carrier significantly contributes to the protection of the flora. In ongoing symbiosis between plants and added mycorrhizal fungi, there is mutual influence of nutrient exchange between the mycorrhizal fungus and the host plant, and these physiological processes are mainly manifested in nutrient cycling in ecosystems. The increased vitality of plants contributes to the creation of a pleasant, healthy environment in spa forests, forest parks and gardens.

Keywords

Mycorrhizal fungi, biochar, hydrocolloids, vitality of plants, spa therapeutic landscape

1 INTRODUCTION

A complete spa treatment includes not only its own healing and regeneration procedures, its important part is also a stay in a certain natural environment, in which there is a synergy of hygienic, environmental and aesthetic prerequisites. When evaluating the therapeutic effect, it is not possible to separate the positive effects of mineral water or other healing sources (gases or peloids) from the synergistic effects of the natural environment of the spa place as a whole, therefore the term spa therapeutic landscape is mainly associated with parks and forests falling within the heritage-protected area of the spa place. Healthy flora, together with a suitable urban planning solution, helps the healing process during a therapeutic stay in the spa environment not only by its effect on the creation of a healthy atmosphere with the content of health-promoting substances, but also by a positive effect on the psyche and aesthetic perceptions of patients and visitors to the spa premises.

The maintenance of healthy spa flora has recently become increasingly difficult for many reasons, but mainly due to the lack of moisture and the increased occurrence of phytopathogenic fungi. Due to the influence of snowdrifts, especially in the summer season, not only the spa forests, especially the Norway spruce, are damaged, but also the grassy areas with the corresponding growth of ornamental trees and shrubs in the spa parks, the irrigation of which must be paid increasing attention.

2 MYCORRHIZAL SYMBIOSES

Mycorrhizal symbiosis is defined as a mutualistic relationship between the roots of higher plants and soil fungi. Mycorrhizal fungi can use extramatrical hyphae to utilize a much larger volume of soil than the root hairs of transplanted plants alone, resulting in significantly higher uptake of water and mineral nutrients by mycorrhizal than non-mycorrhizal roots (Real, 1991). Mycorrhizal fungi mainly obtain carbon from plants in the form of sugars, which serve as a source of energy. During mycorrhizae, plants are willing to provide up to 20 percent of all the carbon produced by photosynthesis. Their reward is nutrients and water, which the fungi obtain from places inaccessible to the roots of the plants themselves.

The whole range of extant mycorrhizal fungi is divided into many categories not only according to the way in which they associate with the host plant, but also according to the types of plants with which they form mycorrhizal symbioses.

The main types of mycorrhizal symbioses are

1. Ectomycorrhiza
2. Endomycorrhiza
   a) arbuscular mycorrhiza
   b) ericoid mycorrhiza
   c) orchidoid mycorrhiza

2.1 Ectomycorrhiza

Ectomycorrhizal fungi create a so-called hyphal sheath around the root, the fibers also enter between the cells of the primary cortex, but not inside the cells. The morphology of the roots changes – short roots are formed. The network of mycelia increases the volume of the substrate many times over. Most ectomycorrhizal fungi develop above-ground reproductive fruiting bodies (fungi) at the base of mycorrhizal trees. Ectomycorrhiza occurs in all coniferous trees, from deciduous trees to oak, beech, linden, hornbeam, birch, willow, etc.

2.2 Endomycorrhiza

Endomycorrhizae are formed by different groups of fungi depending on whether they are orchid, ericoid or vesiculo-arbuscular (according to the new terminology, only arbuscular) type of mycorrhizae. The subfungi of endomycorrhizal fungi are located inside the cells of the root, grow into the surrounding soil and do not form a fungal mantle around the root, nor do they change the shape of the root and its morphology. Microscopic spores with a diameter of about 0.2 mm mediate the reproduction of fungi in the soil. Endomycorrhizal fungi do not form above-ground fruiting bodies, so their presence in the soil can only be detected with the help of a microscope.

2.2.a Arbuscular mycorrhiza

Arbuscular mycorrhiza (Ferrol & Lanfranco, 2020) is the most widespread type of mycorrhiza in nature, which occurs in 80 to 95% of plant species important from the point of view of agriculture, forestry and horticulture (Buil et al., 2022). This type of mycorrhiza is characterized by the growth of hyphae in inter- and intracellular spaces and the formation of rich extramatrical mycelium. Within the cells, peculiar bush-like formations called arbuscules and vesicle-like formations called vesicles are formed. Arbuscules are usually formed in intracellular spaces, while vesicles are formed in both intra- and intercellular spaces. Short-lived arbuscules are the site of intense nutrient exchange between the host plant and the endomycorrhizal fungus. Vesicles perform a storage function. The fungi form an extensive network of mycelium that extends beyond the rhizosphere of the roots, allowing the host plant to obtain nutrients from a significantly larger volume of soil (Abdalla et al.,2023).

2.2.b Ericoid mycorrhiza

Ericoid mycorrhiza is formed in plants with fine roots without root hairs, found in bogs, bogs and moors, i.e. in places with a low content of mineral nutrients. Ericoid fungi can be beneficial for making mineral nutrients available, they can persist in a certain location for a very long time, 10 to 20 years, without their plant hosts. This fact is apparently the reason for the rapid uptake of ericoid plants when they are introduced to the given location.

2.2.c Orchidoid mycorrhiza

Orchidoid mycorrhiza is found in members of the Orchidaceae family, where the root system of orchids is made up of strong, sparsely branched or completely unbranched roots. The orchidoid symbiosis is of fundamental importance for the life cycle of the plant, where the extra-root mycelium of the fungi receives nutrients from the soil solution and passes them on to the host plant.

3 PRACTICAL USE OF PLANT MYCORRHIZATION

The specificity of mycorrhizal symbionts is very important for practical application. Mycorrhiza is specific for some plants, non-specific for others. Non-specific mycorrhiza is more widespread, for example some trees, such as poplars, alders, willows or yews, use both ecto- and endomycorrhiza for their growth, while the fact that endomycorrhizal fungi form a symbiosis with the roots of 80 to 95% of plant species is important for practical use including grasses, flowers, ornamental shrubs, agricultural crops, fruit trees, etc., while ectomycorrhiza is specific for conifers and certain types of deciduous trees such as oak, beech, poplar, alder, linden, hornbeam, birch, willow, etc.

Based on the above findings, it can be concluded that arbuscular endomycorrhiza is the most suitable for practice. However, for its practical use, the fact that cultivation of these fungi in artificial media has not yet been successful is a certain problem. For this reason, the appropriate mycelium of endomycorrhizal fungi, e.g. the genus *Glomus* (more recently *Funneliformis*), *Gigaspora, Acaulospora, Claroideoglomus, Rhizophagus, Sclerocystis* and *Diversisporales*, is grown on a host plant, e.g. maize or clover, cultivated hydroponically in a mixture of perlite and sand after the addition of spores or inocula of cultivated endomycorrhizal fungi. The formed mycelium in the form of a substrate with fragments of the roots of the host plant with hyphae and spores of endomycorrhizal fungi is used as an addition to the planting material. The germinating spore grows into one or more germination sacs and forms a mycelium that is able to penetrate the host plant's root cells.

Despite its narrow specificity, the application of ectomycorrhiza is very important especially when planting conifers. Unlike endomycorrhizal fungi, ectomycorrhizal fungi can be cultivated in artificial soils in culture flasks or in fermenters. Biomass of these mushrooms (e.g. *Boletus, Paxillus, Suillus, Laccaria, Russula, Cortinarius, Lactarius, Entoloma, Hebeloma, Lepista, Gymnopilus, Crucibulum, Agaricus, Hypholoma, Macrolepiota, Morchella, Pisolithus, Rhizopogon, Scleroderma* and *Sparassis*) is prepared by cultivation under aerobic conditions in wort liquid medium or in potato-soy broth at 15 to 25 ^{0}C for 14 days in the dark. Cultivated biomass is used directly in the form of cultivation medium with grown biomass, or it is previously converted into a dry form in a spray dryer or by lyophilization. In Fig. 1 is a culture of ectomycorrhizal fungi grown in an Erlenmeyer flask.

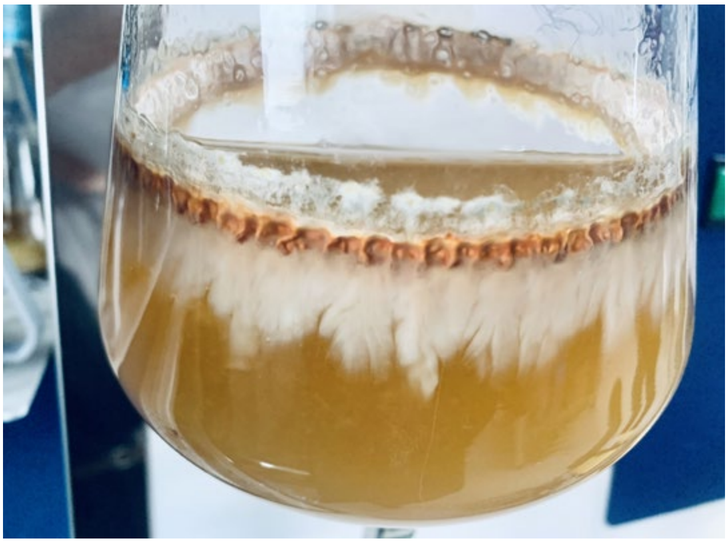

Figure 1. Cultivation of an ectomycorrhizal fungus in an Erlenmayer flask

During the actual planting of trees intended for cultivation on a given location, these plants are inoculated with ecto- or endomycorrhizal fungi either already in the forest nursery, or during the actual planting of the given trees.

4 THE PREPARATION TO SUPPORT THE FLORA OF THE SPA LANDSCAPE

At the workplace of the Institute of Spa and Balneology, public research institution, was in cooperation with Tesoro Spin off, Ltd. (spin off company at the University of Chemistry and Technology Prague) developed a preparation to support the flora of the spa therapeutic landscape, registered at the Industrial Property Office as Utility Model No. 37120 (2023) (Marek et al., 2023). Using this product, mycorrhizal fungi are more effectively fixed near the roots of cultivated plants under the influence of the addition of hydrocolloids in the form of a fixing gel and also biochar, humic substances, perlite or other porous material, peat and crushed bork, preferably disintegrated using hydrodynamic cavitation (Krchov et al., 2018).

Using the product according to the technical solution, containing hydrogel with biochar and other components, is very simple. Before planting, a bundle of planting material or individual trees or shrubs is immersed in a preparation that very easily adheres to the roots of these trees intended for planting (Fig. 2). Wrapping the roots with a fixing gel prevents the plants from drying out, which helps maintain high-quality planting material after extraction in nurseries and during transport, or even storage before actual planting.

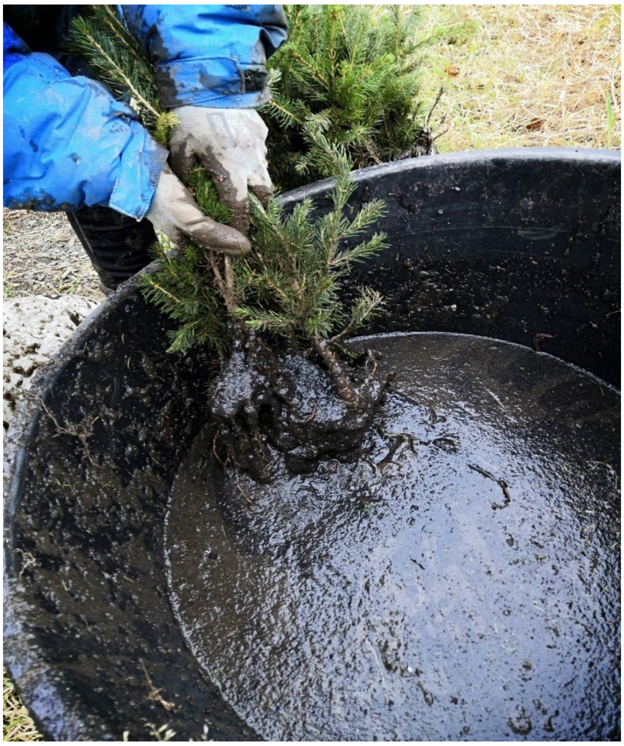

Figure 2. Inoculation of planting material by soaking in the preparation

Mycorrhization of planting material together with the addition of biochar after application of the product in question increases the vitality and resistance of planted and cultivated plants to negative environmental influences, especially to the very current attack by phytopathogenic fungi (Gianinazz-Pearson & Gianinazzi, 1988). Given that resistance to phyto-pathogenic fungi is significantly reduced in the case of a lack of moisture (during summer droughts), the application of biochar and hydrocolloids (based on alginate, carrageenan, xanthan or preferably pectates as waste secondary raw materials from pectin production) significantly contributes to protection before attacking them.

5 THE CULTIVATION OF GRASSY AREAS

The cultivation of grassy areas, flowers and ornamental shrubs in the respective spa parks is very important for the spa therapeutic landscape. To support this flora, it is advantageous to apply the preparation in question containing the mycelium of endomycorrhizal fungi in the form of a substrate with fragments of the roots of the host plant, preferably clover or maize, with hyphae and spores of cultivated endomycorrhizal fungi, with the addition of biochar, a porous inorganic material on which the endomycorrhizal fungi were grown, and the addition of peat and crushed bark, preferably disintegrated using hydrodynamic cavitation.

The added biochar, preferably obtained by charring waste wood in a retort or heat treatment of sludge from sewage treatment plants (when meeting the conditions set by the standard for the content of heavy metals and polycyclic aromatic hydro-carbons), has the ability to absorb and retain water in the soil and preserve it even during the dry season. It improves the ability to retain nutrients that are dissolved in water or trapped on the surface of biochar, binds mineral substances and, in addition, with its "prophylactic" effect, it limits the occurrence of diseases and pests attacking the roots of these plants. It brings to the soil the ability to better pass and retain air, significantly better than sand, which lightens the soil, but its grains do not have an internal porous structure (Marek et al., 2015).

To assess the influence of the individual components of the mentioned mixture, grass growth was monitored:

1. On the standard substrate itself (see Fig. 3),
2. On the same substrate with the addition of biochar (see Fig. 4),
3. On the same substrate with the addition of endomycorrhizal fungi (see Fig. 5), and
4. On the same substrate with the addition of the preparation in question, i.e. both components - biochar and endomycorrhizal fungi (see Fig. 6).

The attached images show the positive effect of the addition of biochar (Fig. 4), endomycorrhizal fungi (Fig. 5), and especially the preparation in question containing both components at the same time (Fig. 6) compared to the growth of grasses on the standard substrate alone (Fig. 3) . This procedure is particularly advantageous in the formation of grass mats, where a mixture of substrate with added endomycorrhizal fungi with fragments of host plant roots, added biochar and seed is cultivated in a layer over sand and/or perlite for easy cutting of the established mat of grasses. This result is very encouraging for the realization of the production of lawn carpets.

Figure 3. Control growth of grass on a standard substrate without the addition of endomycorrhizal fungi and without biochar

Figure 4. Grass grown on the same substrate with added biochar.

Figure 5. Grass grown on the same substrate with added endomycorrhizal fungi.

Figure 6. Grass grown on the same substrate with added endomycorrhizal fungi and biochar.

6 CONCLUSIONS

The application of the preparation to support the flora of the spa therapeutic landscape according to the technical solution supports the uptake, growth and vitality of cultivated plants together with their protection against stress factors such as lack of moisture, especially in the form of summer droughts and invasions by phytopathogenic fungi and viruses with the risk of a subsequent attack by bark beetles, especially the spruce bark beetle. For this reason, the application of the preparation in question contributes to the creation of a pleasant, healthy environment in spa forests, forest parks, spa parks and gardens. A non-negligible advantage is the low economic complexity of the preparation and application of this product, regardless of the savings potential related to the achieved protection of treated trees.

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