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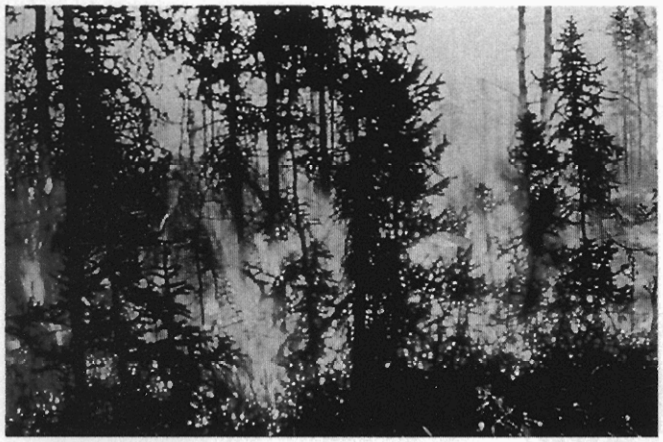

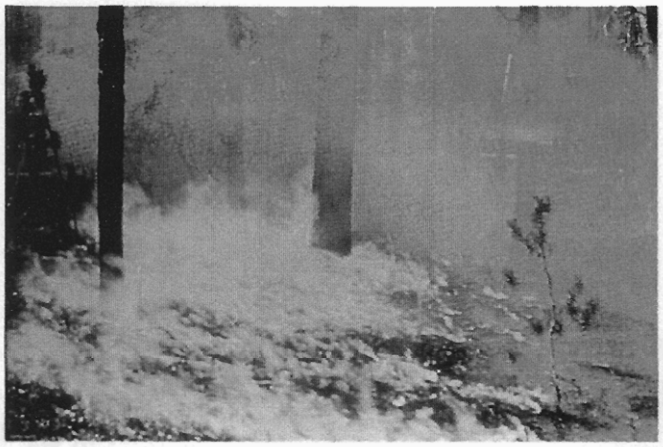

Forest fire risk and management

Proceedings of the European School of Climatology and Natural Hazards course

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EFFECTS OF FIRE ON MYCORRHIZAL FUNGI IN MEDITERRANEAN - TYPE ECOSYSTEMS

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ABSTRACT

Mycorrhizal fungi are ubiquitous in soil and their beneficial effects on the growth of plants have been extensively documented. Little is known about mycorrhizas in the soils of Mediterranean - type ecosystems, which are generally poor in nutrients. Fire is a significant factor in these ecosystems and plants have evolutionary developed specific adaptations to it. By living below ground, mycorrhizal fungi may be less affected by fire than plants, since changes in the temperature of soil at a depth of 5 cm below the surface are likely to be small. It has been shown that mycorrhizal infection of plant roots was subsequently reduced by soil temperatures greater than 50°C. This was partly attributed to loss of hyphae present in the upper soil horizon which is exposed to higher temperatures. Other workers have suggested that ectomycorrhizal fungi that are usually present in the upper soil horizons are likely to be affected more by fire than vesicular - arbuscular (VA) mycorrhizal fungi, which prevail in the underlying mineral soil layers. On the other hand, VA mycorrhizal fungi may be less affected by the destruction of above ground phytomass by fire, since they are capable of forming mycorrhizas with more plant species than ectomycorrhizal fungi. Fire may therefore modify the occurrence of different mycorrhizal types. This possibility needs to be investigated in relation to the post - fire succession of the community. There are indications that the early post - fire pioneer plants are mostly VA mycorrhizal.

EFFECTS OF FIRE ON MYCORRHIZAL FUNGI IN MEDITERRANEAN-TYPE ECOSYSTEMS.

1. INTRODUCTION

Plant growth is severely constrained by the limited availability of nutrients in the soils of Mediterranean-type ecosystems (MTE). To cope with this adverse situation, plants have developed strategies such as increased efficiency of nutrient uptake which in most cases is achieved by means of specialized root systems. One abundant type of specialized root is the mycorrhiza. This review examines the potential role of mycorrhizas in nutrient cycling after fire in MTE as well as the effects of fire on the mycorrhizal status of the soil and its subsequent recolonization by plants.

2. MYCORRHIZAS IN MEDITERRANEAN-TYPE ECOSYSTEMS

Mycorrhiza is the term used to describe the symbiosis between a plant root and a fungus in soil. There are several types of mycorrhizas but in general they consist of three main components, the root of the host plant itself, the hyphae which grow inside or between the cells of the root and the external mycelium ramifying through the soil. This external mycelium acts as an extension of the root , exploiting a greater volume of soil beyond the nutrient depletion zone of the root. After mycorrhiza formation, the plant often benefits from improved nutrition, particularly of phosphorus, as a result of which its growth is stimulated. At the same time the plant supplies the fungus with the carbohydrates which are essential for its growth. Mycorrhizas are ubiquitous geographically and may occur in most plants[1,2].

The biological importance of mycorrhizas has been extensively documented[1]. Little is known about the role of mycorrhizas in MTE although the great majority of plants in these ecosystems appear to be mycorrhizal[3,4]. The availability of phosphorus is a significant factor limiting productivity in Mediterranean-type ecosystems[5,6]. It is likely that mycorrhizas in these ecosystems are important for the establishment and maintenance of plants, acting as specialized roots ramifying through greater volumes of soil and translocating nutrients to plants at a much faster rate than roots alone[3].

3. INTERACTIONS BETWEEN MYCORRHIZAS AND FIRE IN MEDITERRANEAN-TYPE ECOSYSTEMS

Fire is a significant factor and a strong selective force in MTE as indicated by the fact that dominant species of plants in these ecosystems have developed several adaptations to fire[7,8,9]. The effects of fire on the biogeochemical cycles and availability of nutrients have been studied extensively. Thus fire may cause ash deposition or volatilization of nutrients, surface runoff, erosion, dissolution of ions, leaching of ions out of the root zone and influence also the microbial activity and uptake of nutrients by plants[6]. Effects of fire on the fate of phosphorus in soil may be important from the mycorrhizal point of view since mycorrhizas play a significant role in translocating phosphorus from the soil to the plant. Data in the literature regarding the effects of fire on the availability of phosphorus in soil is quite contradictory ranging from large increases to large decreases of available phosphorus[6]. DeBano & Klopatek[10] suggested that large amounts of phosphorus may be lost from litter during fires in pinyon-juniper woodlands and that increases in available soil phosphorus may also occur.

At any rate, what becomes obvious from the literature is that fire puts the ecosystem under stress regarding the nutrient status of the soil. Even in cases where great quantities of nutrients become available to plant roots following burning, there is always a danger that nutrients will be lost with erosion if they are not taken up rapidly and efficiently by the recovering plants[11]. Formation of mycorrhizas may be one way of rapid and efficient uptake of nutrients from the soil as was mentioned previously. It seems reasonable to assume that the outcome of such a beneficial role of mycorrhizas in the regeneration of vegetation after burning will depend on whether mycorrhizal fungi themselves survive fires and whether plants growing immediately after fire are mycorrhizal. These two issues are discussed below.

Little is known about the effect of fire on the mycorrhizal propagules in soil. During a fire, the increase in temperature of soil at a depth of 5 cm is likely to be small compared to that in temperature of the surface[6]. It has been suggested that mycorrhizal fungi may be less affected than their hosts by fire since they live at depths of soil in which temperature is considerably lower than that of the surface[4]. This view is shared by Dhillion *et al.*[12] and Gibson & Hetrick[13] but not Klopatek *et al.* [14] who found a positive correlation between the reduction in mycorrhizal infection of the roots and temperature of soil as a result of fire.

Mycorrhizal propagules were only slightly affected by temperatures up to 50 °C but a substantial decrease in viable propagules occurred when temperatures reached 60 °C. The authors concluded that regeneration of vegetation following fire is likely to be influenced by the availability of active mycorrhizal propagules.

Evidence on the mycorrhizal status of plants growing in burned MTE is sparse. Recently, Puppi & Tartaglini[4] conducted a study of mycorrhizal types in three Mediterranean communities affected by fire and found that nonmycorhizal species were rare. The distribution of mycorrhizal types in the two burned communities was similar and differed from the distribution of the third unburned community. Thus in the burned areas vesicular-arbuscular (VA) mycorrhizal species were dominant in terms of percent plant cover whereas in the unburned area ectomycorrhizal species dominated. Ectomycorrhizal fungi prevail in the litter layers and therefore may be affected more by fire than VA mycorrhizal fungi which are more frequent in the mineral soil layers. Furthermore, VA mycorrhizal fungi may be less affected by the destruction of their hosts than ectomycorrhizal fungi since they are capable of forming mycorrhizas with many more species of plants than ectomycorrhizal fungi. Fire may therefore modify the occurrence of different mycorrhizal types just as it modifies the floristic composition of the vegetation. The relationship between these two modifications needs to be investigated.

4. CONCLUSIONS

Little work has been done on mycorrhizas in the fire prone MTE of the Mediterranean basin and particularly the MTE of Greece. From the little information available it seems possible that mycorrhizal fungi may contribute significantly to the resilience of communities after burning by being themselves less susceptible to fire than their hosts and able to colonize roots of pioneer plants following a fire. Formation of mycorrhizas may be advantageous due to the more efficient use of nutrients released by fire and the prevention of substantial losses of nutrients by erosion and leaching in the absence of living plant roots after fire. The relationship between mycorrhizal fungi and plants is so close that a much better insight on the effects of fire on vegetation in MTE is to be expected when the above possibilities have been thoroughly investigated. A research programme is currently under way, aiming to study the effects of fire on nutrient cycles in the MTE of Greece. Our aim is to study the role of mycorrhizas in the uptake of phosphorus within the framework of this programme.

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