THE EFFECT OF SLASH BURNING ON THE COMMENCEMENT OF MYCORRHIZAL ASSOCIATION

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SELOSTUS:

KULOTUKSEN VAIKUTUS MYKORITSAINFEKTION ALKAMISEEN

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Introduction

Broadcast burning of slash is today a common silvicultural practice in northern Europe. Its principal objects are to destroy the slash and ground vegetation and to reduce the thickness of the raw humus layer, thus rendering reforestation work easier and improving conditions for reproduction. Burning radically changes the physical, chemical, and biological properties of forest soils, e.g. the temperature and moisture conditions, the pH, the solubility of plant nutrients, and the microbial and animal life. Although there is plenty of practical experience available on the silvicultural benefits of broadcast burning (e.g. WRETLIND 1932, BORG 1936, BLOMGREN 1952, SIRÉN 1952, WIBECK 1959), its detailed effects on different site factors are still poorly known.

Mycorrhizal fungi are permanent associates of trees of the northern coniferous forests and probably necessary to their healthy growth. Therefore, the effect of slash burning on mycorrhizal fungi and the formation of mycorrhizae is of great silvicultural importance. Since forest fires are known to cause radical changes in the fungal population of forest soil (MOSER 1949), changes in mycorrhizal conditions are also to be expected.

Practical experience has indicated, it is true, that natural reproduction takes place easily on burned areas; accordingly, complete extermination of mycorrhizal fungi by fire is not likely. Absence of appropriate fungi, however, has sometimes been suspected to be one of the reasons for the difficulty experienced in reforesting severely burned areas. It is self-evident that the high temperature of burning kills a high proportion of the soil fungal population. The severity of such an effect is determined by the extent of heat penetration, which, in turn, depends on the amount and quality of the slash, on the weather conditions during burning, and on the moisture and porosity of the soil. UGGLA (1957) has shown that during burning the temperature of the soil itself rises relatively little. Thus, for instance, the temperature at the ground surface could be + 400—500 °C but at a depth of 3 cm in moist humus only + 20°. In most cases, however, the temperature at 3 cm depth rose to + 40—60° and even at 5 cm depth sometimes to + 40°, which is well above the tolerance of the vegetative mycelia of mycorrhizal fungi (MIKOLA 1948).

Burning can also change the pH of the surface soil very much. Since ectotrophic mycorrhizal fungi have rather narrow pH requirements (MODESS 1941) burning can render the pH of forest humus unfavorable for a normal mycorrhizal population.

The purpose of the following experiment was to study whether there are any differences in the commencement and early development of mycorrhizal infection between burned and unburned areas.

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This brief note represents part of the series of studies on tree mycorrhizae which have been conducted at the Department of Silviculture, University of Helsinki, with a grant under United States Public Law No. 480, 83rd Congress.

Experiments

The study was conducted at the Forestry Field Station of the University of Helsinki, in Central Finland. Clear cutting was done in the winter of 1960—61 and slash was burned on May 31, 1961. The soil was rocky moraine, corresponding to a medium site quality (*Vaccinium* type of the Finnish classification). Before cutting there had been an old stunted spruce stand and the ground had been covered by a dense carpet of *Hylocomium* moss. Three experimental plots were selected, viz:

a. A heavily burned area where most of the humus layer had also been burned (Plot 1)

b. A slightly burned area where only the slash and living vegetation was burned but the humus layer itself was left (Plot 2)

c. Unburned soil at the edge of the cutting area (Plot 3).

The differences in the severity of burning depended on differences in the amounts of slash. The pH values below indicate that Plot 1 was really heavily burned and had received a strong ash fertilization.

	June 13	Aug. 16	Oct. 1
Plot 1	6.4	6.2	5.9
Plot 2	5.1	5.1	4.8
Plot 3	4.8	4.9	4.9

Two weeks after the burning (June 13), pine seeds were sown in 20 patches on each plot. On the burned plots the patches were prepared by removing the loose ash; on the unburned plot the humus layer was removed from the patches, because otherwise the young seedlings would have succumbed to competing ground vegetation.

The seedlings were sampled seven times during the summer, the first time one month after sowing and then at two-week intervals (the last sampling on Oct. 1). At each sampling 30 seedlings were removed from each plot; the roots of 20 of these were examined immediately under a binocular microscope (5—20 x

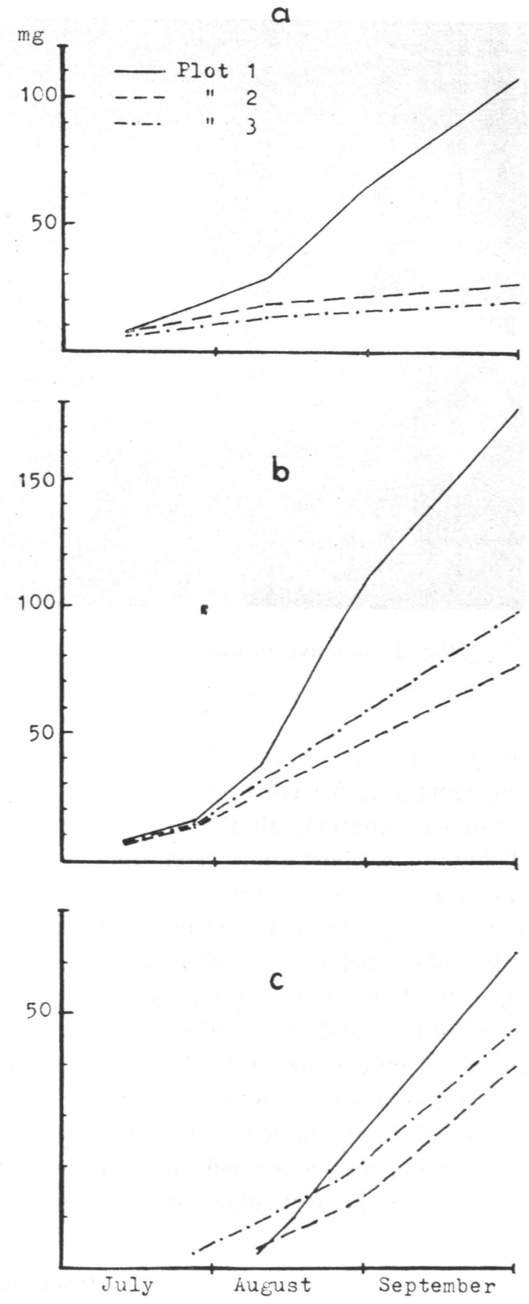

Fig. 1. Development of seedlings. a. Dry weight of the shoot. b. Number of short root tips. c. Number of tips of dichotomous short roots.

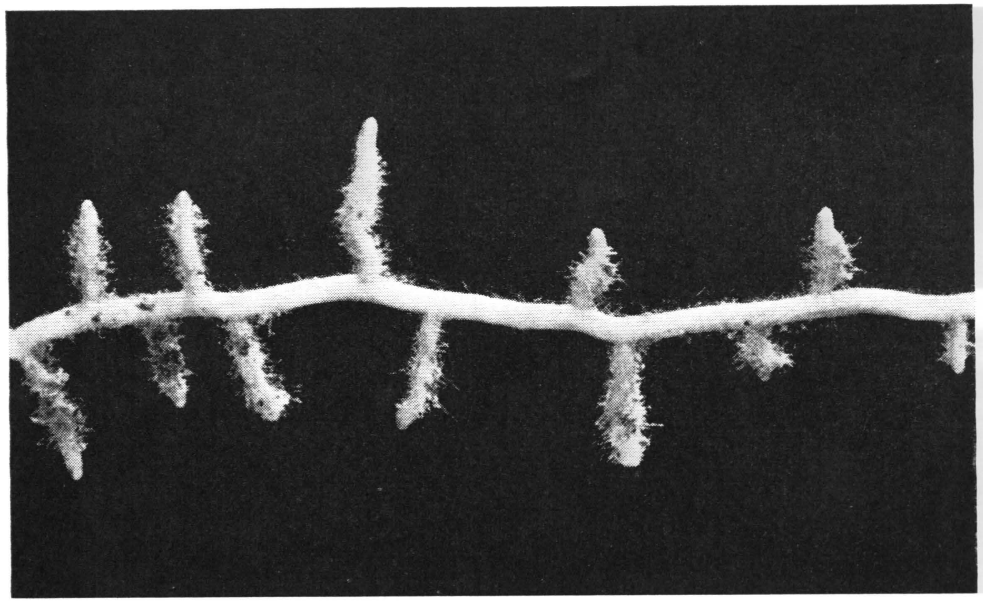

Fig. 2. Non-mycorrhizal short root with numerous root hairs. Plot 1, Aug. 16.

magnification), 5 seedlings were dried at room temperature, and the roots of the remaining 5 were preserved in fixative for later microscopic examination.

On examination, all the short root tips were counted and the tips of the dichotomous short roots separately. Dichotomous branching of short roots is taken as an index of mycorrhizal infection. True, dichotomous branching does not indicate the commencement of infection, but infection, of course, usually takes place before branching; branching without infection is also possible. On the other hand, the early stages of infection can be detected only by microscopic examination, and the number of dichotomous short roots is a good index of the degree of mycorrhizal infection of the whole root system.

Large number of single and dichotomous short roots were mounted in paraffin, sectioned, and stained. Thus the mycorrhizal structure of the dichotomous short roots was confirmed, and unbranched short roots of early samples were examined with particular care for signs of incipient infection.

Results

As is shown in Fig. 1, in the first summer the seedlings grew much better on the heavily burned Plot 1 than on the others, probably owing to the ash fertilization. The rapid growth on Plot 1 continued in September, while the

Fig. 3. Longitudinal section of the basal part of a short root. Early stage of mycorrhizal (probably ectendotrophic) infection. Plot 1, July 26.

weight increase of the seedlings on Plots 2 and 3 was negligible after the middle of August. Root growth was also best on Plot 1, the number of short root tips being twice as great at the end of growing season as on the other plots.

Dichotomous branching of short roots first began on the unburned Plot 3. At the first sampling on July 12 no dichotomous short roots were found; on July 26, however, they were present on Plot 3, 3 tips per seedling on the average, but on the burned plots dichotomous short roots were not found before the third sampling on Aug. 9. Thereafter the branching continued similarly on all the plots, the number of tips of dichotomous short roots at the end of the growing season being greatest on Plot 1. The number of dichotomous roots, when expressed as a percentage of the total number of short roots, however, was smaller on Plot 1 than on Plots 2 and 3.

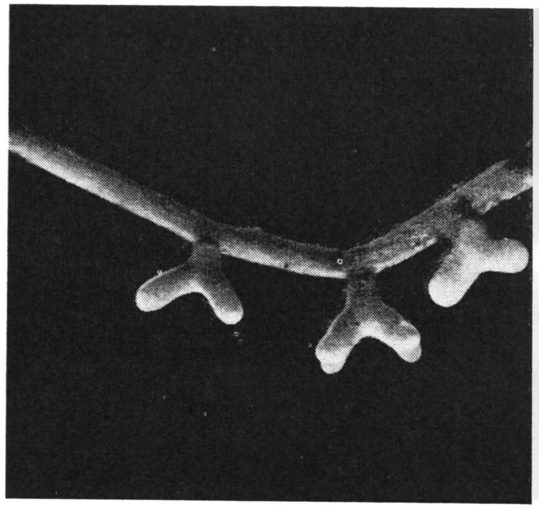

Fig. 4. Typical dichotomous pine mycorrhizae in late summer. Plot 1, Aug. 30.

Microscopic examination of the first samples (July 12) revealed no signs of fungal infection.

On July 26, the dichotomous short roots of Plot 3 were typical ectotrophic mycorrhizae, as were also some of the unbranched short roots from the same plot. Most of the short roots of Plots 1 and 2 that were examined were still non-mycorrhizal; some short roots with incipient infection, however, were found on both plots (Fig. 3).

In later samples all the dichotomous short roots examined were mycorrhizal. The predominant type was a light-colored ectotrophic mycorrhiza with mantle and Hartig net (Fig. 5). On the heavily burned Plot 1 an ectendotrophic mycorrhiza without mantle and with coarse intracellular hyphae was also present (Fig. 6). This type, which is common in many Finnish nurseries but rare in natural forest soils, was found in pine seedlings on some other burned areas too.

The black Dn mycorrhizae of *Cenococcum graniforme* were met with for the first time on Aug. 9 on Plots 1 and 2. At the end of the season they were common on all the plots.

Discussion

In the above experiment mycorrhizal infection took place on the unburned area earlier than on the burned ones. The difference of time was relatively short, perhaps 1—2 weeks. Accordingly, although burning kills mycorrhizal fungi, this fact can not seriously harm the development of seedlings; on the contrary, the favorable influence of burning was more distinct, at least in the above experiment.

As was mentioned previously, during slash burning the soil layer with detrimentally high temperature is very thin, only a few centimeters (Uggla 1957). Nevertheless, a high proportion of mycorrhizal fungi may be destroyed, because in the northern forests tree mycorrhizae are concentrated in a very thin surface layer (Mikola & Laiho 1962). Some mycorrhizae, however, are situated deeper, at depths of as much as 1—2 meters, and from there the fungi are able to infect roots and to spread back to the surface layer. Thus, it was interesting to note that on Plot 1 the first dichotomous short roots were formed at a depth

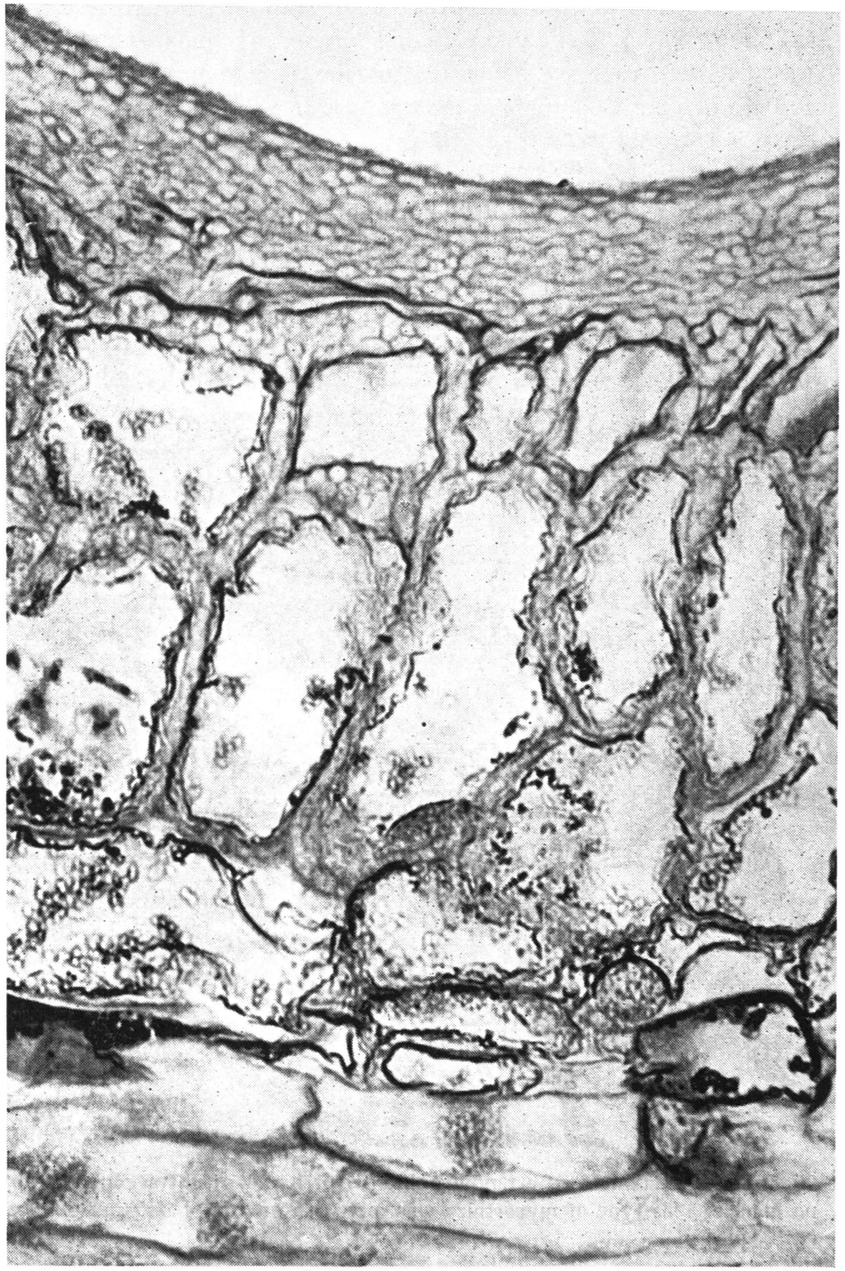

Fig. 5. Longitudinal section of a typical ectotrophic mycorrhiza with mantle and Hartig net. Plot 1, Aug. 30.

Fig. 6. Longitudinal section of an ectendotrophic mycorrhiza with intracellular hyphae and no mantle. This type of mycorrhiza was met with on Plot 1 only. Aug. 23.

of 2—4 cm, while on the other plots dichotomous branching began near the surface. This may show the depth of detrimental heat penetration. Likewise, the authors have found that in nursely soil which has been treated with methyl bromide the first mycorrhizae appear at a depth of about 5 cm, while in untreated nursery soil mycorrhizal infection begins near the surface (LAIHO & MIKOLA 1964).

Too high a pH at soil surface may also result from heavy burning. The pH 6.4 on Plot 1 is well above the optimum of most mycorrhizal fungi and near the upper limit of their pH range, and considerably higher values, up to 9.5, have been measured immediately after burning (UGGLA 1958). This effect, however, is limited to a thin surface layer.

Controlled burning and wild fire are not quite comparable. Controlled burning is usually practised in early summer on soils with a thick layer of raw humus, while the most destructive wild fires occur during the driest season on dry soils. Thus in wild fires soil temperatures may rise more than has been recorded in controlled burnings. It is improbable, however, that even wild fires could completely exterminate the mycorrhizal fungi of forest soils.

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SELOSTUS:

KULOTUKSEN VAIKUTUS MYKORITSAINFEKTION ALKAMISEEN

Kulotus on nykyisin Suomessa ja muissa pohjoismaissa paljon käytetty metsänhoidon menetelmä, joka metsien uudistamisessa on osoittautunut monessa suhteessa edulliseksi. Kulotuksen yhteydessä lämpötila maanpinnassa nousee sangen korkeaksi, joten on odotettavissa, että maassa tapahtuu merkittäviä kemiallisia muutoksia ja maan pieneliöstö, sekä haitallinen että hyödyllinen, suureksi osaksi tuhoutuu. Hyödyllisten mikrobien kohdalla huomio kiintyy erityisesti mykoritsasieniin, jotka kangasmetsissä ovat havupuiden vakituisia symbiontteja. Tässä työssä on tutkittu kulotuksen vaikutusta mykoritsainfektion alkamiseen kylvämällä samalla metsänviljelyalalla mäntyä vahvasti palaneisiin, lievästi palaneisiin ja palamattomiin kohtiin sekä ottamalla kylvöksistä määräajoin näytteitä, joista mikroskooppisesti on seurattu mykoritsain syntyä ja kehitystä.

Kokeessa mykoritsainfektio tapahtui palamattomassa maassa aikaisemmin kuin palaneessa. Aikaero oli kuitenkin varsin pieni, 1—2 viikkoa. Taimet itse kasvoivat kulotetussa maassa paljon voimakkaammin kuin palamattomassa (Kuva 1).

Syynä mykoritsainfektion lievään viivästymiseen kulotetuilla aloilla lienee kulotuksen aikainen korkea lämpötila, joka on tuhonnut sienet maan pintakerroksesta. Kuumuuden tunkeutuminen syvemmälle on kuitenkin vähäistä, jo 5 cm:n syvyydellä maanpinnasta lämpö harvoin nousee sienille tuhoisan korkeaksi (Uggla 1957), joten mykoritsainfektio voi tapahtua juurien ennätettyä riittävän syvälle. Voimakkaassa kulotuksessa maan pintaosan pH voi myös tilapäisesti nousta mykoritsasienille haitallisen korkeaksi.

Mykoritsain kehityksen vuoksi ei siis ole syytä välttää kulotusta siellä, missä se muista syistä katsotaan tarpeelliseksi.