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Full Length Research Paper

Soil temperatures during prescribed burning and the occurrence of *Rhizina undulata* Fr.

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***Rhizina undulata* is a postfire fungus. The ascospores germinate after heating over 35°C. The prescribed burning of one forest compartment was done in the purpose to investigate the effects of forest fire to atmosphere at Hyytiälä Forestry Field Station in Southern Finland. The soil temperature measurements were one part of that research. One year after burning, the ascocarps of *R. undulata* appeared offering the possibility to use temperature data for studying the ecology of the species. The soil temperature was measured with 21 iButton sensors. Before and during the burning, all sensors were at 7 cm depth in the burned area. After burning, 10 sensors were moved to the unburned control area. The ascocarps were inventoried from 40 systematically located 10 m^2 plots. On average 6 ascocarps were found in one plot. Ascocarps were present on 75% of plots. Most ascocarps were found on spots for seeding with bare mineral soil visible. The fungus has not killed germlings of pine but 43% of planted seedlings were dead. The temperature during the burning reached 35°C in 10 points. In 4 points, the temperature was over 60°C, which could be too high temperature for spores to survive. It seems that the ascospores could exist in the soil in 2 to 10 cm depth if they can germinate. The temperatures after burning did not reach 35°C in 7 cm depth. More measurements are needed to show if the temperature in the surface of burned area reached critical point after burning.**

Key words: Postfire fungus, forest fire, ascocarps.

INTRODUCTION

Rhizina undulata is a postfire root rot pathogen occurring circumpolarily in Eurasian Taiga forest, Central Europe, Japan, Northern America and South Africa (CMI descriptions 489, 1993; Cha et al., 2009). The ascospores require a temperature over 35°C for germination (Jalaluddin, 1967a). The ascospores can survive years in the soil waiting for forest fire and high enough temperatures for germination (Jalaluddin, 1967). On the other hand, too high temperatures can kill the spores. The fungus grows in coniferous roots in acidic soil and it can kill living big trees near the fire place (Jalaluddin, 1967; Cha et al., 2009).

R. undulata has been shown to be homothallic (Vasiliauskas and Stenlid, 2001). It has at least 14 vegetative compatibility groups (Lygis et al., 2005).

In Finland, *R. undulata* damages seemed to increase in 1960’s (Laine, 1968). After that the areas of prescribed burning collapsed and nowadays it is not anymore an important pathogen, but it is ecologically interesting. It could have important role to kill trees after biodiversity burnings.

Fire protection is nowadays efficient and although the annual number of forest fires has varied between 100 and 3000 per year, the total burned area has been only 100 to 1600 ha/year (Finnish Statistical Yearbook of Forestry, 2010). Due to continental climate and far distances the big fires are still common in Russia. In history, prescribed burning has had different aims. First the forest was burned to cultivate rye, turnip and oats. This forest destroying way came to an end in the beginning of 1900’s. After that prescribed burning was used in clear cuts for preparing soil easier to seed new forest. In the period, 1953 to 1966; the burned clear cut area annually exceeded 10000 ha in Finland (Yearbook

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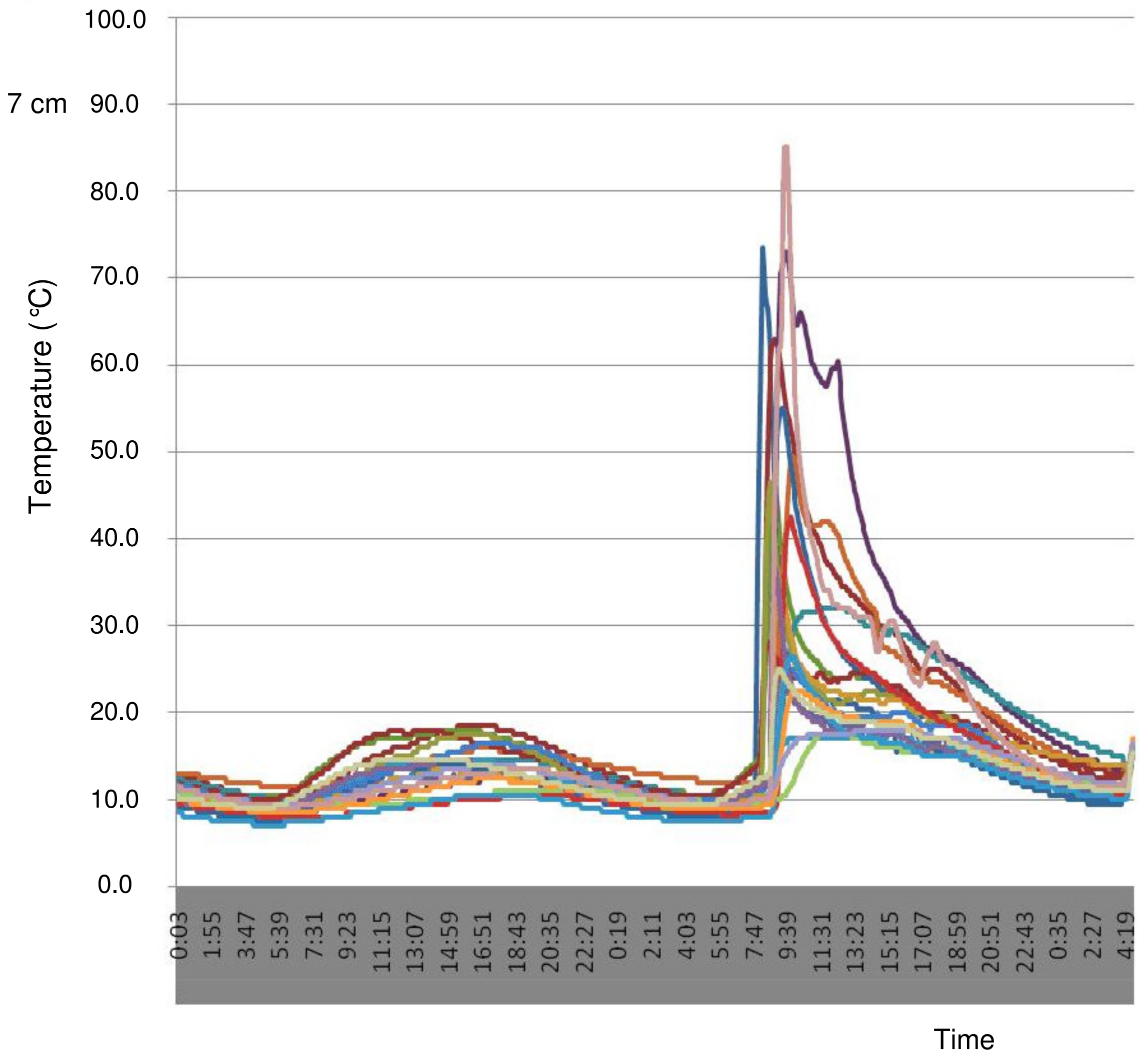

Figure 1. The soil temperatures of 21 points in 7 cm depth during the prescribed burning.

of Forest Statistics, 1988). After that machines took the role of burning in soil management; in recent years, burnings have also been done for increasing biodiversity.

The prescribed burning experiment was planned to measure the air pollutants of forest fire and carbon balance in burned area. *R. undulata* appeared one year after burning and then we decided to study the connection between occurrence of the fungus and soil temperatures during and after burning.

MATERIALS AND METHODS

The experiment area is located near the Hyytiälä Forest Station (61°51´N, 24°17'E). The 100 year old Myrtillus type spruce-pine forest was clearcut in February 2009 for the experiment. The soil of the site is medium coarse tilled and the average thickness of the organic surface layer is 7 cm. Main part of the one hectare clearcut was burned in 26th June, 2009. The slash and surface vegetation were fully burned and the thickness of the organic soil layer diminished 17%. In the beginning of June 2010 the burned area was seeded manually. The humus layer was removed with planting hoe from 30 × 30 cm spot. Pine seeds were sown manually on these spots. In addition, in the beginning of July one-year-old pot seedlings of *Pinus sylvestris* were planted on 20 × 30 m experimental plot. Occurrence of *R. undulata* was inventoried in the end of August 2010. The number of ascocarps were counted from 40 systematically located 10 m^2 plots. The ascocarps were counted separately on spots where the humus layer was removed. The ascocarps were photographed and microscoped in laboratory. Also the number of dead seedlings was observed.

The soil temperatures were measured with 21 iButton sensors at 7 cm depth systematically located in the area. The temperature measurements started before burning and half of the sensors were moved to the unburned control area after burning. During the burning the measurement interval was 4 min. After burning the temperature was measured at 1 h interval. The measurements continued over the year.

RESULTS AND DISCUSSION

The first ascocarp was observed in 19th July, 2010 one

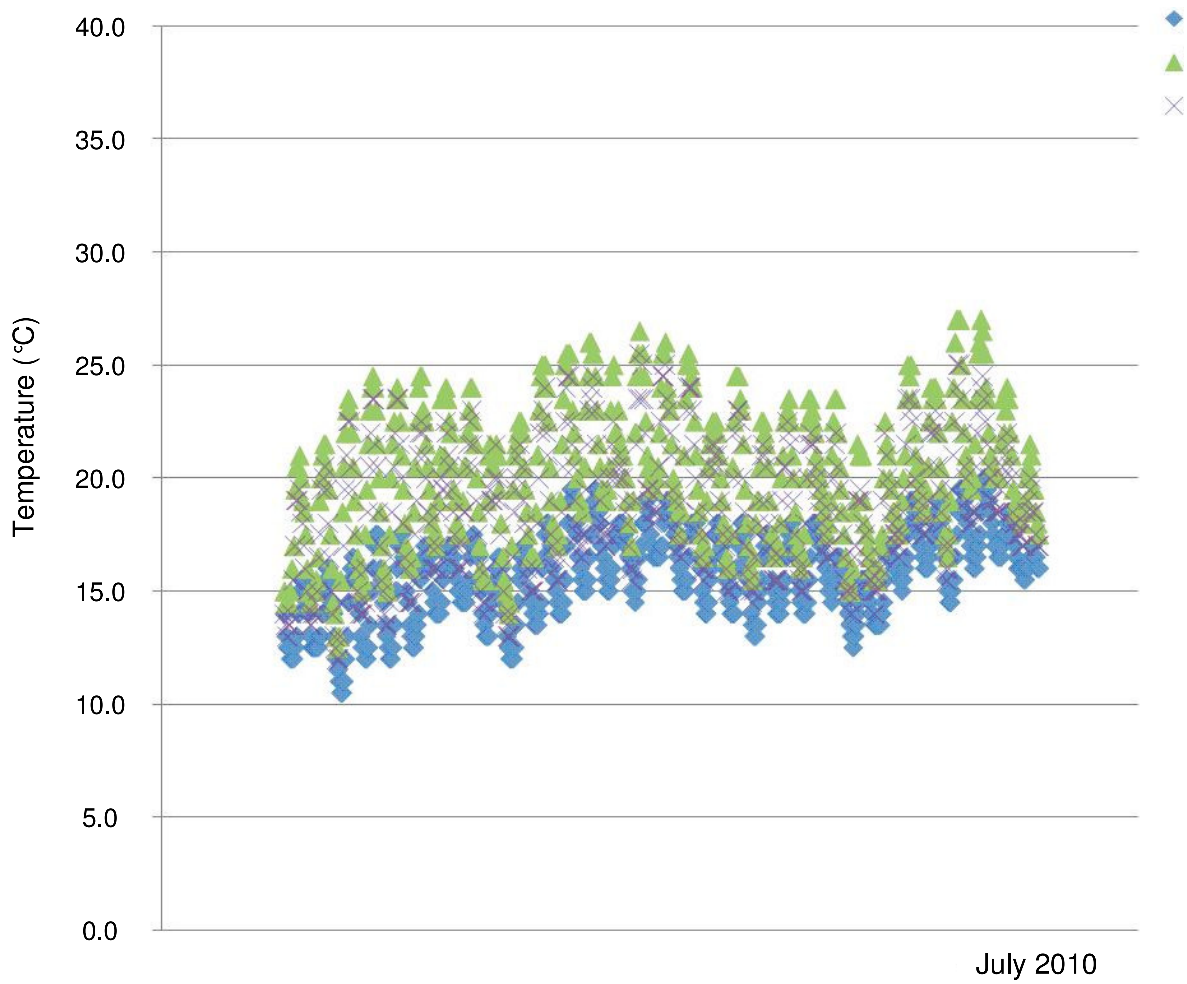

Figure 2. Soil temperatures in 7 cm depth one year after burning. B 16 and B 18 represent a burned area and Control represent an unburned area in the same clearcut.

year after burning. In the end of August the ascocarps were abundant on the whole burned area. Only one ascocarp was found outside the burned area. This one was growing on fire corridor 50 cm distance from burning edge. The ascocarps were observed on 75% of 10 m^2 plots. The mean ascocarp density was 0.6/m^2. In September the asci contents ripen ascospores ready for spreading. It seems that the ascocarps suffered from first night frosts. The ascocarps were much more common on seeding spots where the humus layer was removed and the mineral soil surface was visible. A total of 45% ascocarps were found on these spots.

Though the seeded pines have not yet suffered *R. undulata* infections, 43% of planted seedlings died due to infections or drought.

The temperatures in 7 cm depth from the surface of humus layer did not reach 35°C before and after burning. During the burning, soil temperatures rose over 35°C in 10 of 21 measuring points (Figure 1). The last of over 35°C temperature varied from 0 to 6 h. The critical 35°C is probably reached in depth 0 to 7 cm in the whole burned area. In four measuring points the temperature exceeded 60°C which could be lethal to ascospores.

The highest soil temperatures one year after burning in 7 cm depth reached 26.5°C (Figure 2). Air temperatures were at the same time over 30°C. The soil was clearly warmer in burned area, but the critical point for germination (35°C) was not reached in 7 cm depth.

The data shows that the suitable temperature for germination is present in varying depths in the same burning area. To be able to germinate, the living ascospores should be just there. The layer of suitable temperature for germination is only some centimetres thick. Earlier it has been shown that the fungus can spread 3 m outside bonfire places (Jalaluddin, 1967). The fire corridor was made so that all humus and in addition surface layer of mineral soil with roots were removed. This seems to stop spreading *R. undulata* outside the burned area. These also show us that living or dying roots are important for the *R. undulata* mycelium growth in the soil (Jalaluddin, 1967).

Further research is needed to find out if the high temperature of black soil surface after the burning can start the germination process.

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