Spruce cull pieces left on cutting areas can increase aerial spread of *Heterobasidion* – preliminary results from field trials in southern Finland

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Abstract

The fruiting of *Heterobasidion* on cull pieces and stumps of Norway spruce on logging areas was investigated. Cull pieces showing butt rot were left on three clear-cut areas and on one thinning area. They were also transported to four mature unmanaged forest sites with a dense tree cover. During the succeeding 3–4 years the cull pieces were annually investigated for fruit bodies of *Heterobasidion*, and the actively sporulating area of the fruit bodies was determined. Root bases of spruce stumps in the logging areas were dug out and sporulating fruit bodies found on the stumps were also measured.

Immediately after cutting, *Heterobasidion* sp. was isolated from 76 % of the cull pieces; 85 % of the isolates were identified as *H. parviporum* and 15 % as *H. annosum s.s.* Fruit bodies developed on 395 cull pieces, i.e. 19 % of all 2077 initially rotten cull pieces. Fruit body formation was significantly affected by several characteristics of the cull pieces and various environmental factors. It was favoured by increasing cull piece diameter and advancement of decay but restricted by the presence of *Stereum sanguinolentum*-type rot. End-to-end soil contact of the cull piece also favoured fruit body formation compared to partial or no soil contact. The between-site differences were significant but could not be explained by differences of tree cover. At the end of the investigation period the average sporulating area of *Heterobasidion* per cull piece was higher than the average sporulating area per stump at three out of four managed sites. Hence, leaving cull pieces with butt rot in southern Finland can considerably increase local production of *Heterobasidion* spores.

Introduction

Present forestry guidelines in Finland recommend increasing the amount of decaying wood in managed forests in order to ensure biodiversity. In particular, the amount of high diameter decaying wood is deficient in managed forests. This deficiency could be met by leaving in the forest cull pieces of trees that are damaged by butt rot. As *Heterobasidion parviporum* Niemelä & Korhonen and *H. annosum* (Fr.) Bres. *s.s.* are the most common fungi causing butt rot of Norway spruce [*Picea abies* (L.) Karsten] in many parts of Europe, a large proportion of decayed cull pieces of spruce are inhabited by these fungi. Such logging residues can promote fruiting and spore production by *Heterobasidion*. Schütt and Schuck (1979) showed that *Heterobasidion* sporocarps can appear already one year after logging but their frequency is highest and size greatest generally 3–4 years after logging. However, it is not known whether the amount of sporocarps occurring on logging residues could significantly increase local spore production. Neither is it known whether *H. parviporum* and *H. annosum* show differences in sporocarp production on logging residues.

Our aim was to compare the spore production by *Heterobasidion* on cull pieces and stumps of Norway spruce in the same logging area, assuming that the quantity of spore production is related to the actively sporulating pore layers of the fruit bodies. Aerial spread of *Heterobasidion* is believed to take place mainly by basidiospores, conidia having probably a minor significance in contributing to the air spora of *Heterobasidion* (Redfern & Stenlid, 1998). Additionally, we investigated the effect of various factors on sporocarp production in a field trial lasting for 4 years at eight different locations. Here we publish preliminary results.

Material and Methods

Field sites

Two managed field sites are situated in Bromarv (southwestern Finland), one in Hausjärvi (southern Finland) and one in Vehkasalo (southeastern Finland). Norway spruce was the dominating tree species on all sites. The size of the managed sites varied between 2.8 and 5.6 hectares. Logging was performed in August 2000 (Vehkasalo and Bromarv A) or August 2001 (Bromarv B and Hausjärvi). As judged from the stumps, 30–41 % of the trees suffered from butt rot. The cull pieces were left by the harvester close to the stumps from which they originated and so their distribution on the logging areas conforms to the distribution of butt rot in the stand.

The unmanaged sites are in Siuntio, Mäntsälä, Sipoo (southern Finland) and Ylämaa (southeastern Finland). They are mature over 100 years old spruce stands with closed canopy. Cull pieces were transported to the unmanaged sites from Bromarv in December 2001 (one site) and April 2002 (three sites) and placed on a ca. one-hectare area at each site.

All sites include moderate slopes (<20 m). Healthy-looking cull pieces were left as controls on each experimental site. All the cull pieces were GPS-mapped and marked with a numbered label. Their dimensions (diameter, length), degree of ground contact (complete, one end, no contact), and bark condition (intact, partly removed, completely removed) were recorded. Altogether 2077 cull pieces with signs of decay and 441 healthy looking controls were included in the study.

All stumps on the managed sites were mapped, marked, and evaluated visually for the presence of butt rot.

Isolation and identification of Heterobasidion

At the beginning of the trials two discs, ca. 5 cm thick, were removed from one end of each cull piece. The first disc was discarded, the second was placed in a plastic bag, incubated at room temperature for 5–7 days, and thereafter stored up to one week at +4 ^{o}C until investigated under a dissecting microscope. Decay caused by *Heterobasidion* was identified from the discs on the basis of conidiophores. The fungus was isolated from conidia and the species was identified using mating tests (Mitchelson & Korhonen 1988). Other decays were visually classified into three types: *Stereum sanguinolentum* (Alb. & Schwein.) Fr. type, *Armillaria* type and unidentified type. The squared ratio between the average disc diameter and decay diameter was used as a measure of the degree of decay, i.e. proportional volume of decay in a cull piece.

Fruit body survey

In each September of the following 3–4 years after logging, randomly selected cull pieces (1/3 or 1/4 of total) were investigated and actively sporulating (white) pore layers of *Heterobasidion* fruit bodies were drawn onto a transparent that was later scanned and subjected to image analysis in order to obtain the area counts. In order to estimate the background spore production (without cull pieces) on the managed sites, a random sample of spruce stumps showing butt rot (1/3 or 1/4 of total per year) was also investigated for the presence of *Heterobasidion* fruit bodies. The root bases were dug out and active fruit bodies were measured as from cull pieces.

Statistical analyses

Statistical analyses were done using the SPSS 13.0 for Windows program (SPSS Inc. Chicago, USA).

Results and discussion

Immediately after cutting, *Heterobasidion* sp. was isolated from 76 % of the cull pieces; 85 % of the isolates were identified as *H. parviporum* and 15 % as *H. annosum.* In the course of 3–4 years after logging *Heterobasidion* fruit bodies were found on cull pieces on every experimental sites. Altogether they were found on 395 cull pieces, corresponding to 19 % of the total of 2077 cull pieces with butt rot.

During the first three years after cutting the active pore layer area of the fruit bodies increased. On two managed sites the logs were investigated during four successive years; on one site the pore layer area decreased in the fourth year from the maximum recorded in the third year, whereas on the other site the pore layer area increased also during the fourth year. Significant differences were observed between the pore layer area found on different sites. The tree cover on the sites could not explain these differences since high and low values were found both on clear-cut and unmanaged sites. In a logistic regression analysis the most significant variables explaining fruit body formation were the diameter of the cull piece and the proportional volume of decay at the time of cutting. The higher the diameter of the cull piece and the higher its decay volume, the higher was the probability of fruit body development. Also the soil contact of the cull piece and the presence of *S. sanguinolentum* type of decay were highly significant variables, but their effect was smaller than that of cull piece size and advancement of decay. Initial presence of *S. sanguinolentum* type of decay and absence of soil contact lowered the probability of fruit body development. Bark injuries on cull piece or *Heterobasidion* species causing decay did not affect the probability of fruit body formation on the cull pieces.

Fruit bodies of *Heterobasidion* were also found on seven of the initially healthy- looking control cull pieces, corresponding to 1.6 % of their total number. They have not necessarily emerged from new infections after cutting but may originate from incipient decay that was not observed during the initial investigation of the cull pieces. Hence, we consider that leaving healthy looking spruce cull pieces on cutting areas infested with *Heterobasidion* does not noteworthy support spore production by this fungus.

The sporulating fruit body area on cull pieces was highest in the last survey year 2004 on all but one of the eight experimental sites. On three out of the four managed sites the average pore layer area per cull piece exceeded that found in 2004 on stumps. At one site the average pore layer area per cull piece was half of that found on stumps in 2004. As it can be supposed that spore production is related to the actively sporulating area of fruit bodies, these data show that leaving decayed cull pieces can considerably increase local spore production by *Heterobasidion*. Hence, leaving decayed cull pieces of Norway spruce on logging sites infested by *Heterobasidion* can support the spreading of this pathogen to the next tree generation and to the surrounding forests.

References

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