



ANNOSUS ROOT ROT

CAUSED BY
HETEROBASIDION ANNOSUM

by *GASTON LaFLAMME*

QUEBEC REGION — INFORMATION LEAFLET LFC 27



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COVER PAGE:

Photo 1

Characteristic circle of dead trees (as described by Hortic) in a red pine plantation that indicates the presence of *Heterobasidion annosum*.

Photo: R. Blais

Photo 2

Well-developed fruiting bodies of *Heterobasidion annosum* fungi on a stump thought to be the infection centre.

Photo: C. Moffet

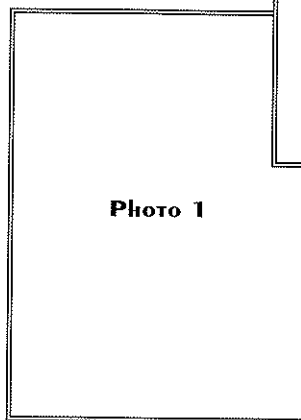
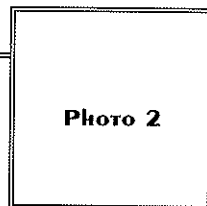


Photo 2



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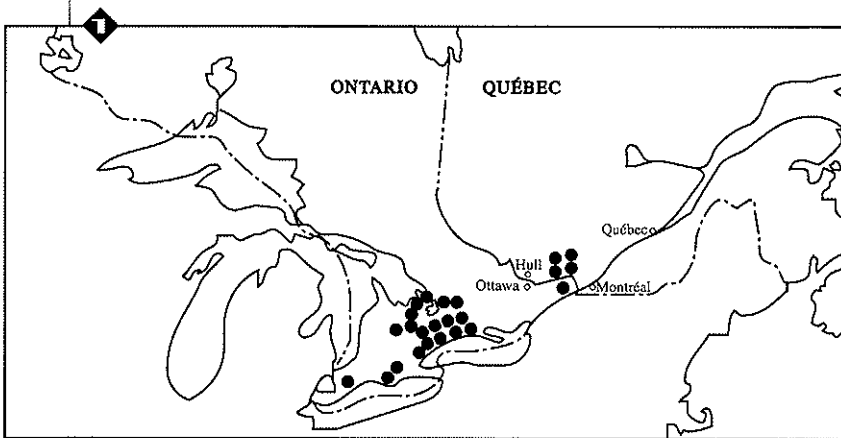
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INTRODUCTION

ANNOSUS ROOT ROT, found on all continents, is caused by the fungus *Heterobasidion annosum* (Fr.) Bref. (*Fomes annosus* [Fr.] Karst.), a member of the Polyporaceae family. Polypores are easily identified by their characteristic fruiting bodies growing on tree trunks and causing wood decay and discolouration. However, *H. annosum* and its associated disease are less well known because in Quebec, the fungus was discovered only recently, i.e. in 1989, in a red pine (*Pinus resinosa* Ait.) plantation (Laflamme and Blais 1993). Nevertheless, since *H. annosum* causes extensive damage in forests around the world, it is considered to be one of the most destructive pathogens in evergreen forests.

The disease was first identified by the German researcher Robert Hartig (1874), the pioneer of forest pathology. Hartig (1900) demonstrated that the disease is transmitted from tree to tree by root contact, creating characteristic «circles of mortality».

The research on the disease made a great leap forward half a century later. In 1951, the English pathologist John Rishbeth discovered that the fungus becomes established in a stand by spores that colonize freshly cut stumps. The discovery of this key element in the propagation of the disease finally made it possible to develop methods aimed at controlling the introduction of the disease in forests through the treatment of stumps. Various chemical products were then tested and Rishbeth (1963) was the first to use biological control in his experiments, with promising results.



Location of annosus root rot caused by *Heterobasidion annosum* in Ontario in 1988 (Whitney 1988) and Québec in 1993.

In Eastern Canada, the disease was first found on red pine. It was in Ontario, in two plantations that had been thinned approximately ten years earlier (Hord and Quirke 1955). After 1955, the disease was reported in several other places in Ontario, including the Larose Forest near the Québec-Ontario border (Figure 1).

IN THE AUTUMN OF 1967, A spore sampling operation in New Brunswick (Redfern and Van Sickle 1968) revealed, on the one hand, that viable airborne spores from *H. annosum* were present in the air, although the disease had not yet been identified in New Brunswick forests and, on the other hand, that *H. annosum* spores can travel great distances. In fact, the closest source of infection was over 110 km away, in Maine.

In 1970, a similar operation was carried out in Quebec (Martineau and Lavallée 1970), with negative results. Nevertheless, in 1982, because of the proliferation of the disease in the nearby Larose Forest, the forest pathology committee of the ministère des Ressources Naturelles du Québec (secteur Forêts) recommended that foresters begin treating stumps with borax after thinnings. In 1985, a monitoring program was set up in the province and, in September 1989, the first case of annosum root rot in Quebec was discovered approximately 40 km from the Larose Forest (Laflamme and Blais 1993).

HOSTS

The disease is found in over 170 species of conifers and hardwoods worldwide. Although the extent of the damage varies from species to species, the greatest damage occurs in conifers.

In Eastern Canada, red pine is the most affected species. In fact, reports have indicated that the disease is introduced into a plantation through red pine stumps,

and the situation seems to be the same in the northeastern United States. Aside from pines, other species growing near red pines infected with *H. annosum* have also been found to be infected with the fungus, but these species generally do not serve as entry sites and are not given preventive treatment.

FUNGUS

The fungus was traditionally called *Fomes annosus* (Fr.) Karsten, but was renamed *H. annosum* due to progress in the classification of fungi. *H. annosum* reproduces sexually by forming a fruiting body or conk, which in turn produces basidiospores that propagate the fungus and thus the disease.

Well-developed fruiting bodies of *Heterobasidion annosum* fungi on a stump thought to be the infection centre.

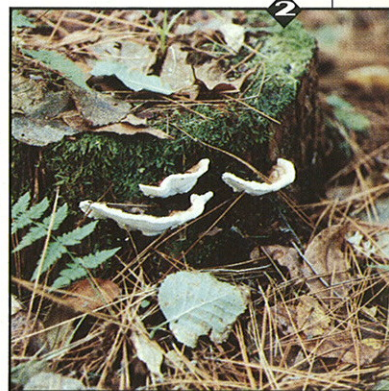


Photo : C. Moffet

THE DISEASE CAN BE DETECTED BY THE PRESENCE OF THE FUNGUS' CHARACTERISTIC FRUITING BODIES (FIGURE 2). THE UPPER SURFACE OF THE CONK IS EMBOSSED AND RANGES IN COLOUR FROM BUFF OR TAN OVER MOST OF ITS SURFACE, TO BLACK NEAR THE JUNCTION WITH THE TREE, TO WHITE ON THE MARGIN. ITS LOWER SPORE-BEARING FACE (HYMENIUM) IS WHITE AND POROUS. CONKS ARE GENERALLY 10 CM WIDE BUT CAN REACH 20 CM. IMMATURE FRUITING BODIES ARE TINY, I.E 1 TO 2 CM IN SIZE; THEY CONSIST OF SMALL, WHITE POROUS PUSTULES FOUND ON THE BARK OF TREES, AT THE SAME LEVEL AS THE LITTER (FIGURE 3), AND SOMETIMES IN THE LITTER ITSELF. FRUITING BODIES CAN USUALLY BE OBSERVED IN AUTUMN, BETWEEN SEPTEMBER AND THE FIRST FROSTS. AFTERWARDS, FRUITING BODIES BLACKEN AND DISINTEGRATE THE FOLLOWING YEAR. HOWEVER, THEY HAVE OCCASIONALLY BEEN REPORTED AS EARLY AS JULY, BUT THIS SITUATION IS DUE TO THE CLIMATIC CONDITIONS OF CERTAIN COOL AND WET SUMMERS.



Photo : C. Moffet

Fruiting bodies of *Heterobasidion annosum* revealed by removing the layer of organic matter around the base of the trunk.

Spiniger meinelkella, asexual fructification produced from pure culture of *Heterobasidion annosum*, as seen under a microscope.

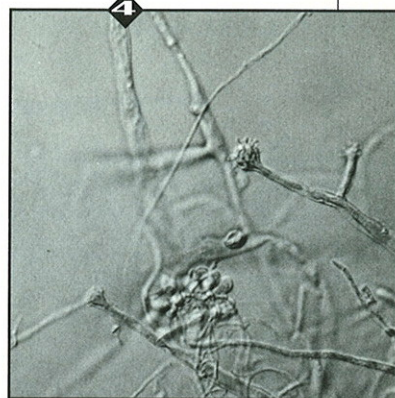


Photo : G. Laffamme

THE FUNGUS ALSO REPRODUCES ASEXUALLY; THIS TYPE OF REPRODUCTION GENERALLY OCCURS IN THE LABORATORY ON ISOLATES IN PURE CULTURE. THE FUNGUS FORMS CHARACTERISTIC CONIDIA (FIGURE 4), AND THE ASEXUAL FORM OF THE FUNGUS IS CALLED *Spiniger meinelkella* (Olson) Stalpers.

RECENT RESEARCH SUGGESTS THAT THERE ARE SEVERAL BIOLOGICAL SPECIES OF *H. ANNOSUM*. IN NORTH AMERICA, THE PRELIMINARY FINDINGS POINT TO TWO SPECIES (CHASE ET AL. 1989): THE «P» GROUP, WHICH IS FOUND MOST OFTEN ON PINE (*Pinus* spp.) BUT MAY ALSO INFECT OTHER CONIFERS, AND THE «S» GROUP, WHICH ATTACKS ONLY SPRUCE (*Picea* spp.) IN EUROPE, A THIRD SPECIES EXISTS: THE «F» GROUP, WHICH IS OBSERVED ON FIRS (*Abies* spp.) ONLY IN THE MEDITERRANEAN REGION (KORHONEN, PERSONAL COMMUNICATION). SINCE THE FUNGUS WAS FOUND PRIMARILY ON RED PINE IN QUEBEC, THE «P» GROUP IS VERY LIKELY THE ONE PRESENT. HOWEVER, SPECIFIC TESTS MUST BE CARRIED OUT TO CONFIRM THIS ASSERTION.

DISEASE

THE SPORES OF THE FUNGUS ARE CAPABLE OF TRAVELLING LONG DISTANCES. IN NEW BRUNSWICK, AS WE SAW BEFORE, REDFERN AND VAN SICKLE (1968) COLLECTED VIABLE SPORES OF THE FUNGUS MORE THAN 110 KM FROM THE NEAREST SOURCE OF INFECTION. RISHBETH (1959) FOUND VIABLE SPORES OVER THE OCEAN MORE THAN 300 KM FROM THE CLOSEST POSSIBLE SOURCE OF INFECTION. THUS, AFTER BEING TRANSPORTED BY THE WIND, THE BASIDIOSPORES OF THE FUNGUS SETTLE ON THE SURFACE OF FRESHLY CUT STUMPS AND GERMINATE THERE (FIGURE 5).

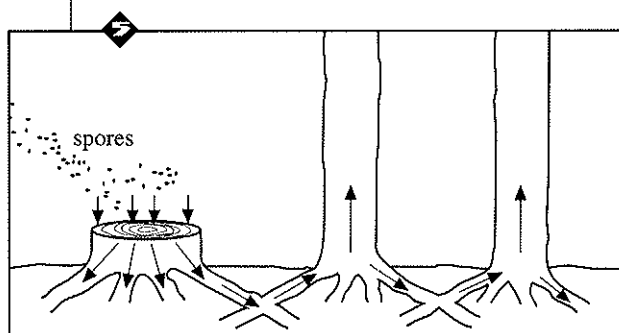


Illustration of the development of *Heterobasidion annosum* in a plantation, from the colonization of a stump to the infection of adjacent trees.

THE SURFACE OF A FRESHLY CUT STUMP IS SELECTIVE FOR A NUMBER OF MICROORGANISMS, INCLUDING *H. ANNOSUM*. THEREFORE, SOON AFTER FELLING, IT MUST COLONIZE THE SURFACE OF THE STUMP BEFORE OTHER MICROORGANISMS MOVE IN. THIS WINDOW OF OPPORTUNITY VARIES AND, ACCORDING TO RESEARCH DONE ON VARIOUS HOSTS IN DIFFERENT CLIMATES, CAN RANGE FROM A FEW DAYS TO THREE OR FOUR

WEEKS. HOWEVER, INFECTION RARELY OCCURS MORE THAN TWO WEEKS AFTER FELLING (HODGES 1969).

THE MYCELIUM OF *H. ANNOSUM* DEVELOPS AS A SAPROPHYTE IN THE STUMP AND GRADUALLY DECOMPOSES IT IN THE SAME WAY AS OTHER WOOD-ROTTING FUNGI. IT THEN PROGRESSES DOWN INTO THE ROOTS, SPREADING ITS INFECTION AREA. THIS AREA, WHICH WAS AT FIRST CONFINED TO THE STUMP SURFACE, EXPANDS AND AFTER A WHILE REACHES 1 TO 2 M IN DIAMETER. PROBLEMS BEGIN TO OCCUR WHEN THE *H. ANNOSUM* COMES INTO CONTACT WITH THE ROOTS OF A LIVING CONIFER: IT CAN INFECT THE TREE, EITHER KILLING IT OR CAUSING BUTT ROT, DEPENDING ON THE SPECIES. THE FUNGUS WILL CONTINUE TO COLONIZE NEARBY TREES (FIGURE 5), PROGRESSING AT A RATE ESTIMATED TO BE LESS THAN 1 M A YEAR. HARTIG'S PHRASE «CIRCLES OF MORTALITY» REFERS TO THIS EXPANSION FROM THE INITIAL INFECTION CENTRE IN A STAND TO A WIDENING CIRCLE OF DESTRUCTION.

THEREFORE, THE DISEASE SPREADS FAIRLY SLOWLY FROM A CENTRAL POINT; UNFORTUNATELY, THINNING OPERATIONS IN A PLANTATION CREATE LARGE NUMBERS OF POTENTIAL INFECTION SITES. HOWEVER, THE MOST PERNICIOUS ASPECT OF THIS DISEASE IS THAT THE FUNGUS CAN SURVIVE FOR LONG PERIODS OF TIME IN STUMPS. FOR EXAMPLE, GREIG AND PRAIT (1976) OBSERVED *H. ANNOSUM* LIVING IN STUMPS FOR PERIODS OF UP TO 62 YEARS AND THIS IS NOT THE ABSOLUTE MAXIMUM LENGTH OF TIME. REFORESTATION OF THESE SITES IS A PROBLEM IN SUCH A SITUATION BECAUSE SEEDLINGS ARE OFTEN QUICKLY KILLED BY THE DISEASE.

DETECTION OF DISEASE

The first step in detecting the disease in thinned red pine plantations is to look for dead trees or trees whose entire crown shows signs of dieback, such as reddened or small needles or a crown with sparse foliage (see cover page). A cruise line is therefore carried out, preferably in September, October or November.

The next step is to look on and around the base of these trees and on nearby stumps for the characteristic fruiting bodies, which are signs of the disease. Although the fruiting bodies may be readily apparent (Figure 2), they are usually hidden by a layer of litter that must be removed with a weeder or another tool (Figures 3 and 6). Furthermore, fruiting bodies may be present only in their immature form, visible only as white porous pustules. Since there are several species of

Cultivator used to remove organic matter concealing fruiting bodies of *Heterobasidion annosum*.



Photo : C. Moffet

Polyporaceae, it is recommended that a sample of the fruiting bodies be taken to the diagnostic laboratory of the Ministère des Ressources Naturelles du Québec (Secteur Forêts) for identification.

DAMAGE CAUSED BY *H. ANNOSUM*

Since annosus root rot has only recently been discovered in Québec, the damage observed in the province from the disease has been very limited so far (Figure 1). In fact, as this disease usually follows thinnings, it is understandable that it has not been observed to any great degree in the past, since our red pine plantations are still relatively young. However, many plantations are now old enough to require

thinning, which will make them susceptible to the disease.

According to observations in Europe (Delatour 1972), annosus root rot causes two types of damage in trees of thinning age:

1 Death of tree

The fungus infects and kills the roots and then progresses up to the root

CROWN AND INTO THE CAMBIUM, CAUSING THE DEATH OF THE TREE SOON AFTERWARDS. THE FUNGUS IS NOT ABLE TO TRAVEL FURTHER UP THE TREE BECAUSE OF INHIBITORS PRESENT IN THE TRUNK. THIS BEHAVIOUR IS FOUND IN RED PINE.

2 Rot

THE FUNGUS ROTS THE CORE OF THE ROOTS WITHOUT NECESSARILY KILLING THEM AND THEN PROGRESSES TO THE BASE OF THE TRUNK. ALTHOUGH THE DISEASE DOES NOT KILL THE TREE DIRECTLY, THIS ATTACK AT THE BASE OF THE TREE MAKES IT MORE SUS-

CEPTIBLE TO BREAKS, AND STANDS WITH A HIGH PERCENTAGE OF INFECTED TREES ARE MORE PRONE TO WINDTHROW. CONTRARY TO THE PREVIOUS CASE, THE DISEASE SHOWS NO EASILY DETECTABLE SYMPTOMS EXCEPT IN VERY ADVANCED STAGES, WHEN FRUITING BODIES APPEAR ON THE TRUNK OF THE TREE DESPITE THE FACT IT IS STILL ALIVE. IN EUROPE, THIS BEHAVIOUR IS FOUND MAINLY IN SPRUCE (*Picea* spp.).

IN SEEDLINGS, THE DISEASE CAN CAUSE DEATH RELATIVELY QUICKLY, EVEN IN SPECIES IN WHICH CORE ROT OCCURS ONLY IN OLDER TREES.

CONTROL METHODS

A ERADICATION

ONCE *H. annosum* HAS INFECTED A STAND, IT IS VERY DIFFICULT TO ERADICATE BECAUSE THE FUNGUS CAN SURVIVE FOR DECADES IN THE ROOTS OF STUMPS LEFT AFTER FELLING. THE ONLY EFFECTIVE WAY OF ELIMINATING THE DISEASE IS TO REMOVE THE INFECTED STUMPS AND DESTROY THEM. THE INFECTED STUMPS AND SURROUNDING ORGANIC MATTER HAVE TO BE DUG OUT AND TRANSPORTED TO A DISPOSAL SITE, WHICH REQUIRES HEAVY MACHINERY (HYDRAULIC SHOVEL OR BULLDOZER).

THIS METHOD IS STILL ECONOMICALLY FEASIBLE IN QUEBEC BECAUSE THE DISEASE IS FAIRLY RECENT AND RELATIVELY LIMITED GEOGRAPHICALLY SPEAKING. THE OBJECTIVE OF THIS TREATMENT IS TO ERADICATE EXISTING POCKETS OF INFECTION WHILE THEY ARE STILL SMALL, BEFORE EVEN MORE EXPENSIVE TREATMENTS ARE REQUIRED. FOR EXAMPLE, IN ENGLAND, A BULLDOZER WAS REQUIRED TO REMOVE ALL THE STUMPS FROM

badly infected sites (GREIG 1984). THIS EXPENSIVE TREATMENT DID NOT ERADICATE THE DISEASE, BUT WAS ONLY AIMED AT REDUCING ITS IMPACT ON THE NEW PLANTATION. THIS IS THE TYPE OF SITUATION THAT MUST BE AVOIDED HERE IN QUEBEC.

B SUBSTITUTION

ANOTHER WAY TO REHABILITATE SITES INFECTED WITH *H. annosum* IS TO REFOREST THEM WITH SPECIES THAT ARE LESS SUSCEPTIBLE TO THE DISEASE, SUCH AS HARDWOODS. HOWEVER, NO VALID RECOMMENDATIONS ON REPLACEMENT SPECIES CAN BE MADE AT THIS TIME BECAUSE OF THE LACK OF INFORMATION AVAILABLE. FURTHERMORE, IT IS NOT ALWAYS POSSIBLE TO FIND ANOTHER SPECIES SUITED TO THE SITE. HOWEVER, WITH A BETTER KNOWLEDGE OF THE «S» AND «P» GROUPS OF *H. annosum*, WE

may be able to reforest some pine plantations with conifers that are better adapted to the site and less prone to the «P» variety of the fungus.

C PREVENTION

SINCE CONTROLLING this fungus is very expensive, it is strongly recommended that measures be taken to prevent its introduction into a stand. The current method used in several countries is to treat the stumps after felling operations.

Treatment must be administered immediately after felling, but it could be delayed for one day or more only in the event of heavy rains, when the product might be washed away.

Preventive treatments, whether chemical or biological, should be administered from mid-May or as soon as temperatures reach 8°C according to Finnish researchers, to mid-December or as soon as the ground is covered with snow.

A) Chemical treatment

The purpose of chemical treatment is to create a fungitoxic environment on the surface of the stump. Tests performed in Ontario (Myren 1981) have shown that borax (decahydrate sodium tetraborate) and sodium nitrite are both very effective in protecting the stumps against *H. annosum*. However, borax is the only product currently approved for this type of treatment, since certain doses of sodium nitrite can be toxic to animals.

The treatment consists in sprinkling powdered borax with a shaker on the surface of freshly cut stumps (at the rate

of 0.11 kg/m²) (Figure 7). The exact amount of powder to be applied need not be calculated; the surface of each stump must be completely covered with powder. To assess the quantity (Q) of borax required to treat a plantation, the following formula should be used to treat 1 ha and the result should be multiplied by the number of hectares to be treated.

$$Q (\text{kg/ha}) = ((D^2 / 4) \times 3.1416) \times 0.011 \times N / 1,000$$

WHERE

D	= AVERAGE STUMP DIAMETER
0.011	= CONCENTRATION (110 g/m ² OR 0.011 g/cm ²)
N	= NUMBER OF TREES TO BE FELLED PER HECTARE.

Example of a shaker used to treat stumps with borax to prevent infection by *Pterobotrydium annosum*.

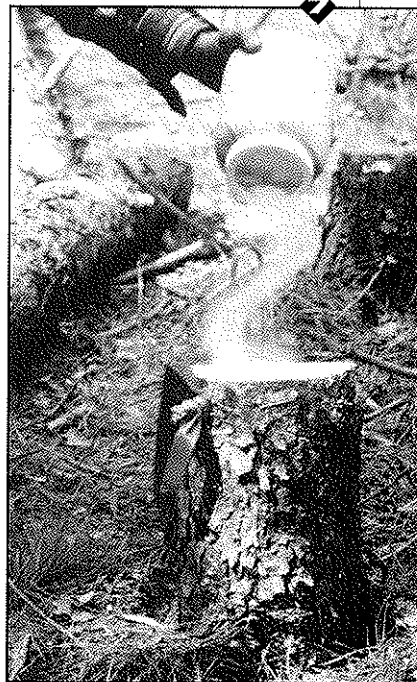


Photo : G. Laffamme

Quantity of borax required according to the number of stems to be felled and their average stump diameter for a treatment with a concentration of 110 g/m².

DIAMETER (CM)	NUMBER OF STEMS FELLED	QUANTITY OF BORAX (KG)
10	100	0.09
10	500	0.43
10	800	0.69
15	100	0.19
15	500	0.97
15	800	1.55
20	100	0.35
20	500	1.73
20	800	2.76
25	100	0.54
25	500	2.70
25	800	4.32
30	100	0.78
30	500	3.89
30	800	6.22

For example, in a plantation where 800 stems per hectare are to be felled, each having an average stump diameter of 15 cm, the quantity of borax required will be 1.6 kg/ha. Table 1 provides the quantities of borax required for various stump diameters.

Although borax can also be applied in a 10% aqueous solution, this is not recommended since it has not been tested under the conditions of our forests.

In Finland, urea is preferred to borax because the latter, although it is considered very safe, can be somewhat toxic to

humans when handled. Unlike borax, urea does not form a fungitoxic barrier on the stump, but rather promotes the colonization of the stump by competing saprophytic microorganisms, thereby preventing *H. annosum* from becoming established.

The urea is applied in a 30% aqueous solution (Korhonen, personal communication) using a brush or sprayer. A dye should be added to the solution so that stumps that have been treated can easily be identified. The entire surface of the stump should be thoroughly wetted with the solution. To assess the quantity of solution to be prepared, the following formula should be used to treat 1 ha and the result should be multiplied by the number of hectares to be treated.

$$S \text{ (L/ha)} = ((D^2 / 4) \times 3.1416) \times 0.2 \times N / 1,000$$

WHERE

D = AVERAGE STUMP DIAMETER

0.2 = CONCENTRATION (2 L/m² OR 0.2 mL/cm²)

N = NUMBER OF TREES TO BE FELLED PER HECTARE.

For example, in a plantation where 800 stems per hectare are to be felled, each having an average stump diameter of 15 cm, 28 L/ha of solution will be required.

b) Biological treatment

Rishbeth (1963) was the first researcher to quite successfully experiment with biological control against *H. annosum*. He had observed that untreated stumps were often colonized by the saprophytic fungus *Phlebiopsis gigantea* (Fr.) Jöl.

(*PENIOPHORA GIGANTEA* [Fr.] MASSEE).
ONCE ESTABLISHED, THIS FUNGUS PREVENTED
H. ANNOSUM FROM INFECTING THE STUMP.
P. GIGANTEA HAS THE ADDITIONAL ADVANTAGE
OF PRODUCING LARGE QUANTITIES OF SPORES
WHEN CULTIVATED IN THE LABORATORY. LIKE
MANY OTHER WOOD-ROOTING FUNGI,
P. GIGANTEA SPREADS BY FORMING A FUNGAL
THIN AND POROUS LAYER ON THE SURFACE OF THE
SUBSTRATUM THAT THE FUNGI DECOMPOSES.
THIS FORM IS USUALLY REFERRED TO AS
RESUPINATE.

OVER THE LAST THIRTY YEARS, *P. GIGANTEA* HAS
BEEN TESTED ON VARIOUS TREE SPECIES UNDER
VARIOUS CONDITIONS. COMMERCIAL
PREPARATIONS OF *P. GIGANTEA* ARE CURRENTLY
BEING USED IN SOME COUNTRIES BUT ACCORDING
TO SIEROTA (PERSONAL COMMUNICATION),
NATIVE ISOLATES SHOULD BE USED INSTEAD OF
ADOPTING A COMMERCIAL ISOLATE FROM A
COUNTRY WITH ECOLOGICAL CONDITIONS
DIFFERENT FROM OURS.

IN QUEBEC, NO COMMERCIAL PREPARATIONS
OF THE FUNGUS CONTAINING A NATIVE ISOLATE
ARE AVAILABLE, BUT OVER TWO HUNDRED ISOLATES
ARE CURRENTLY BEING TESTED. IF A PRODUCT
BECOMES AVAILABLE, THE SPORE SOLUTION WILL
HAVE TO BE PREPARED LIKE ANY OTHER POWDER
ACCORDING TO THE PROPORTIONS INDICATED
ON THE PACKAGE. THE «S» FORMULA PROVIDED
ABOVE SHOULD BE USED TO CALCULATE THE
SOLUTION VOLUME.

AN AUTOMATIC SPRAYER MOUNTED ON A TREE
FELLER IS BEING TESTED IN FINLAND. THIS
DEVICE SHOULD MAKE IT POSSIBLE TO INOCULATE
STUMPS AUTOMATICALLY WITH THE FUNGI
P. GIGANTEA (KORHONEN, PERSONAL COMMU-
NICATION).

RECOMMENDATIONS

GIVEN OUR CURRENT STATE OF knowledge ON ANNOSUS ROOT ROT AND QUEBEC'S CLIMATIC CONDITIONS, WE PRESENT THE FOLLOWING RECOMMENDATIONS THAT MINIMIZE THE RISK OF INFECTION AT THE LOWEST POSSIBLE COST:

- 1 THE TREATMENT MUST BE ADMINISTERED ON STUMPS BETWEEN MID-MAY AND MID-DECEMBER, IMMEDIATELY AFTER TREE FELLING.
- 2 THE ONLY PRODUCT CURRENTLY APPROVED FOR TREATING STUMPS AGAINST *H. ANNOSUM* IS BORAX; UREA AND *P. GIGANTEA* ARE STILL IN THE TESTING AND DEVELOPMENT STAGE.
- 3 THE SPECIES TO BE TREATED ARE RED PINE AND SCOTS PINE (*PINUS SYLVESTRIS* L.) (THIS EXOTIC SPECIES HAS BEEN SEVERELY DAMAGED BY THIS DISEASE IN EUROPE) AND THE TREATMENT SHOULD BE ADMINISTERED REGARDLESS OF THE LOCATION OF PLANTATIONS IN QUEBEC, GIVEN THE LONG DISTANCES THAT *H. ANNOSUM* BASIDIOSPORES CAN TRAVEL. SINCE THE STUMPS OF PINES OTHER THAN RED PINE HAVE ALSO BEEN INFECTED IN SOUTHERN ONTARIO, THIS RECOMMENDATION MAY BE EXPANDED IN THE FUTURE.
- 4 THE TREATMENT MUST BE CAREFULLY MONITORED TO ENSURE IT IS DONE PROPERLY; TESTS IN ONTARIO HAVE SHOWN THAT FAILURES ARE NOT DUE TO THE PRODUCT USED, BUT RATHER TO A CERTAIN PERCENTAGE OF STUMPS LEFT UNTREATED, OFTEN BECAUSE THEY ARE COVERED WITH BRANCHES.
- 5 AS LONG AS THE NUMBER OF INFECTED PLANTATIONS IN QUEBEC REMAINS SMALL AND SINCE PREVENTIVE BORAX TREATMENTS HAVE BEEN ADMINISTERED IN SEVERAL PLANTATIONS SINCE 1982, IT IS RECOMMENDED THAT THE DISEASE BE ERADICATED IN IDENTIFIED INFECTION CENTRES.

Should the situation change in Quebec, these recommendations will have to be revised in collaboration with the ministère des Ressources Naturelles du Québec (secteur Forêts). However, given the knowledge we have in 1994, we believe these recommendations are very realistic.

CONCLUSION

ONE CENTURY AGO, *H. ANNOSUM* ROOT ROT WAS DESCRIBED BY HARTIG (1894). THIS FOREST PATHOLOGIST DISCOVERED THAT THE DISEASE IS TRANSMITTED FROM TREE TO TREE BY ROOT CONTACT. HOWEVER, THE FORESTRY COMMUNITY HAD TO WAIT ALMOST 60 YEARS BEFORE RISHBETH (1951) DEMONSTRATED THE LINK BETWEEN THE APPEARANCE OF THE DISEASE IN A PLANTATION AND THE COLONIZATION OF FRESHLY CUT STUMPS BY *H. ANNOSUM* SPORES. THE DISEASE THUS HAD THE CHANCE TO INFECT MANY THINNED PLANTATIONS IN EUROPE AND ELSEWHERE IN THE WORLD.

IN QUÉBEC, WE ARE AT THE SAME POINT AS EUROPEAN FORESTERS WERE AT THE TURN OF THE CENTURY. MANY OF OUR RED PINE PLANTATIONS ARE NOW OLD ENOUGH TO REQUIRE A FIRST THINNING. LUCKILY, WE ARE FAIRLY FAMILIAR WITH THE EPIDEMIOLOGY OF ANNOSUS ROOT ROT, AND RESEARCHERS HAVE DEVELOPED METHODS TO PREVENT THE CONTAMINATION OF OUR PLANTATIONS, WHICH, ONCE INFECTED, ARE VERY EXPENSIVE TO TREAT. THEREFORE, WE HAVE A CHOICE TO MAKE, AND PREVENTION IS CLEARLY THE MOST EFFECTIVE AND THE LEAST COSTLY SOLUTION OFFERED TO US.

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