Short communication

Spruce tree fighting back – study of honey fungus infection

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Abstract

Buza, A. K., Divos, F., 2016. Spruce tree fighting back – study of honey fungus infection. *Folia Oecologica*, 42: 204–207.

Fungi infection is a common disease, problem for trees. Becoming fearful of the presence of fungi is obvious, although the effects of the infection are variable widely. Honey fungus (*Armillaria mellea*) is considered to be dangerous species weakening the trees. A honey fungus attacked spruce could be measured repeatedly for three years with acoustic tomography while pulling tests were performed as well. The research goes on, although the results interestingly show us the tree “fighting back”. The safety and stability of the examined spruce is very good, the conditions of the root system are – surprisingly – getting better.

Keywords

acoustic tomography, fungi attack, honey fungus, pulling test, urban tree

Introduction

Honey fungi including *Armillaria mellea* infect often both forest and agricultural crops (Cruickshank et al., 2011), while the fungi are spread on all continents except Antarctica (Westwood et al., 2012; DeLong, 1995). These are “white rot” fungi, killing the root system and often moving upward into the lower parts of the trunk (Glaeser, 2008). The tree may answer such a common infection with decline, extensive basal decay or premature withdraw (LaBonte et al., 2015; Williams et al., 1986). The attacked trees can become very dangerous and hazardous.

Researches on how fungi attacks a living tree are available numerous, for instance Bieker and colleagues (2009) examined *Trametes versicolor* infection on *Fraxinus excelsior*, Deflorio and his team (2008) measured several tree-fungi combinations to test different sonic tomography’s ability to catch the infection, while Cruichshank and colleagues (2011) studied non-lethal root infections associated with *Armillaria* root disease. The mentioned tests were performed in laboratories, or at least somehow disturbed condition, and focus of the measurement was on the beginning of the infection.

Our research begins with a tree which has already been decayed in about 63% of the cross section at 30 cm height. (The date of the infection is unknown.) As well the tree was left in its original position; no disturbance was made except the measurements themselves.

Material and methods

The tested tree

A spruce (*Picea albies*) in the botanical garden of the University of West Hungary was selected for the measurements. Honey fungus (*Armillaria mellea* s.l.) inflection was noticed on the tree, as the reason to start the research. In 2013 at the beginning of the tests the tree was 92 years old, with 20 m high, while the crown area was 30.4 m^2, the crown centre was at 12.7 m, and the trunk had 1° incline. (Fig 1.)

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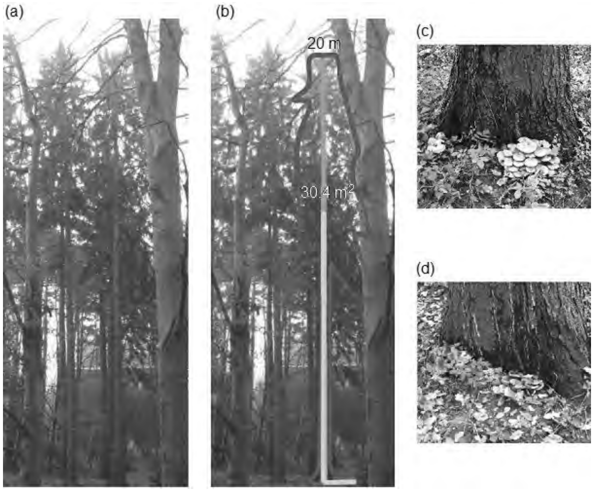

Fig. 1. The measured tree is in the botanical garden of the University of West Hungary (a) and the tree with the data (height, crown area, height of crown center, b). The fruiting bodies of honey fungus were seen in different years (c and d).

Acoustic tomography

Acoustic tomography for studying decays inside living trees is a technique used for decades (Wang, 2013). Several tests proved the correlation of tomograms with the trunks' real conditions. (Divos and Szalai, 2003; Divos et al., 2008; Wang et al., 2009; Li et al., 2011; Feng et al., 2014; Li et al., 2014).

The basic idea of the measure is the change in signal detection time in the presence of decay. As seen in Fig. 2, in healthy tree, in non-decayed wood the acoustic signal can travel directly through the trunk. Decays change the path of the signal and increase the time of the detection.

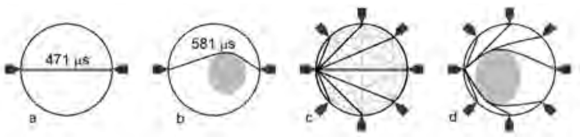

Fig. 2.
a) Acoustic or ultrasound time-of-flight (TOF) measurement on a healthy trunk.
b) TOF measurement on a decayed trunk.
c) The schematic image of a tomography with 8 receivers with the measuring paths.
d) Tomography on a decayed trunk. The travelling paths become longer. With the help of the collectable data a tomogram of the trunk can be prepared, the decay can be localized and safety estimations can be done.

(When the acoustic signal reaches the edge of wood, the end of continuous material it slows down during the penetration to the air. This is why the signal "in a roundabout way" will be the first reaching the detector. It also leads to one limit of this technique. Using acoustic tomography the measured data have information about only the healthy, the continuous part. Acoustic tomography does not "see" inside the decay (Nicolotti et al., 2003)).

The size of the decay is another limiting factor for this technique. Incipient decays like the beginning of a fungi attack (2 months after artificial infection) cannot be seen in tomograms (Deflorio et al., 2008).

However in our case the decay could be seen, measured and quantified clearly.

ArborSonic 3D Acoustic Tomograph was used for the measurements and the program ArborSonic3D 5.2. was used to estimate safety factors for the trunk's levels.

Pulling test

The pulling or winching test is well-known method to investigate the root-soil system, the root anchorage, estimate safety of trees, and evaluate stem conditions, while it can serve as calibration for measurements in real wind situations as well (Bell et al. 1991; Wessolly 1991; Peltola et al. 2000).

An inclino-type pulling test (measuring inclinations and force) developed by the University of West Hungary was used during the test, which is a tool to get information about the roots' condition. The wind load is simulated by a cable. During the test the pulling force and the inclination of the trunk at ground level are measured. As seen on Fig 3.

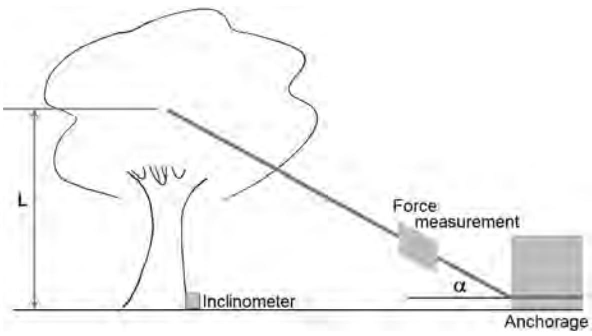

Fig. 3. The schematic picture of a pulling test. A cable is on the measured tree as close to the crown center as it is possible. The height of the cable is L.

For pulling tests which evaluates safety, the cable should be as close to the crown centre as it can be. While the inclinometer should be as close to the ground as it is possible. The anchorage should bear the force (Neild and Wood, 1999; Peltola et al., 2000).

During the measurement the inclination of the measured tree was under 0.2°. The force and the inclination were measured continuously with 1 data sec^{-1}. The used program was PullingCollect which calculated safety factors for the root system as well (Brudi and Wassenaer, 2002).

Results

Acoustic measurements were performed during the springs of 2013, 2014 and 2015. Pulling tests were achieved in 2013 and 2015 spring.

Tomograms were made in three levels, at 30, 100 and 170 cm above ground level. (Fig 4.)

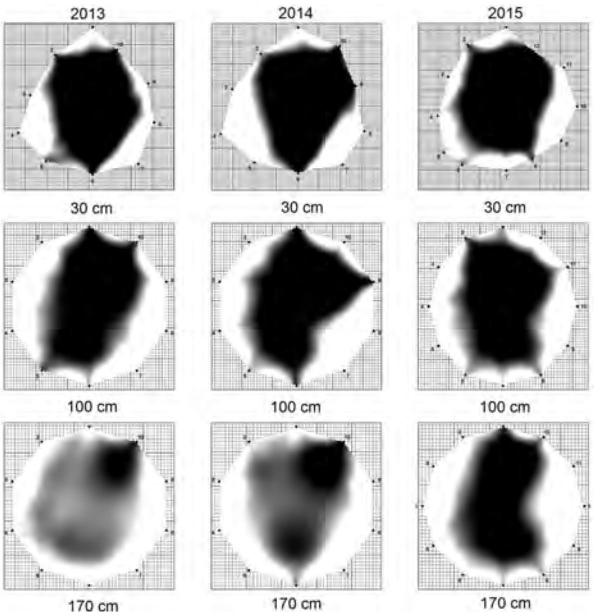

Fig. 4. Acoustic tomograms (white color refers to healthy wood while grey and black refer to decayed areas).

The measurements showed the spruce was "fighting" against the infection. The tree grew in each year, the change in circumference was between 3 and 7 cm, while the diameter widened with 0.5 to 2 cm.

At 30 cm height the decay decreased and the safety increased during the years. (The stem growth was faster than the extent of the decay). At 100 cm height the change in the decay was small while the safety factor rose. At 170 cm height the decay spread and the safety dropped off. The data of the measurements are summarized in Table 1. The tree is still in good conditions. (Safety factors are calculated for 120 km h^{-1} wind gusts. Usually 150% safety factor is accepted for a tree to be safe).

High produce of resin could also be observed on the tree.

Discussion

Three years are long time – even in the life of a tree – while three years do not let us make final conclusions. The examined tree "defends" itself against the infection; compartmentalization of decay could be observed (Shigo, 1984). The change seems to be slow at 30 cm while the decay doubled at 170 cm height.

As honey fungus usually attacks from the soil and the roots (Glaeser, 2008), it is not surprising that the lowest level lost the most material while the defense worked for more time. The defense may be so effective in the living tissues to stop the infection in radial direction. The observed situation might be a balance but there were not enough measurements to decide it.

The longitudinal direction forecasts are not very encouraging. The infection could grow faster than the trunk. The safety decreased. The tree is in good condition at the moment but a break at this level or even higher may happen in a few years.

The measure will continue, the conditions will be monitored. The practical advice in this situation is to measure more often, in every half or quarter year.

Table 1. The measured decays and the calculated safety factors (SF) with their change to the data from 2013. The decay decreased and the safety increased at 30 cm high. The decay increased a little while the safety increased also at 100 cm high. At 170 cm the decay increase was followed by decrease in safety. For the root system the pulling test showed increasing safety. Note: the growth of the trunk's diameter was 0.5–2 cm $year^{-1}$.

	2013	2014	2015
Acoustic tomography			
30 cm			
Decayed area (%)	63	61.00	61.00
Change from 2013 (%)	0	–3.17	–3.17
SF for trunk level (%)	586	616.00	617.00
Change from 2013 (%)	0	5.12	5.29
100 cm			
Decayed area (%)	52	55.00	53.00
Change from 2013 (%)	0	5.77	1.92
SF for trunk level (%)	392	483.00	501.00
Change from 2013 (%)	0	23.21	27.81
170 cm			
Decayed area (%)	23	42.00	46.00
Change from 2013 (%)	0	82.61	100.00
SF for trunk level (%)	488	475.00	411.00
Change from 2013 (%)	0	–2.66	–15.78
Pulling test			
SF for root system (%)	302		347.00
Change from 2013 (%)	0		14.90

Conclusion

A honey fungus infected spruce was examined for three years. Even as the fungus is considered to be a dangerous one the tree is still in fair condition both for trunk breaking and tipping.

Acoustic tomography and pulling tests were done in the springs of 2013, 2014 and 2015. The acoustic tomogram shows 5–30% change in the decay at 30 and 100 cm from ground while the decayed area doubled at 170 cm height.

The pulling test showed the root system to stay in good condition, the safety increased.

The tree is in good condition to let it stay at the botanical garden. The measure will go on for more years with more often examinations.

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Received October 21, 2015
Accepted December 10, 2015