COMPARISON OF DIFFERENT ELECTRONIC DEVICES FOR DETECTING HETEROBASIDION ROOT ROT

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Abstract
Root rot caused by Heterobasidion spp. is one of the most important pathogens in Norway spruce (Picea abies (L.) Karst.) stands in Latvia. It is estimated that in Latvia on average 22.9% of Norway spruce stumps are infected with Heterobasidion spp. The aim of this study was to compare four different electronic devices for Heterobasidion root rot detection in Norway spruce. In the autumn of 2009, in a sample plot located in the forests of Kalsnava district 27 trees were used to compare the possibility of instruments to detect root rot. The results show that IML-RESI F400 accuracy for detecting root rot in Norway spruce is high and the instrument is usable for detecting root rot, but additional accumulators are needed for large sample plots. Rotfinder’s accuracy for detecting root rot varies from probe to probe taken from one tree. Conditiometer AS-1 and Arbo-Sonic decay detector show slightly higher average values for infected trees, but the difference for both instruments between healthy and decayed trees is not significant, thus leaving the usage of instruments questionable.

Key words: Electronic devices, Root rot, Heterobasidion, Picea abies.

Introduction
Root rot caused by Heterobasidion spp. is one of the most important pathogens in Norway spruce (Picea abies (L.) Karst.) stands in Latvia. It is estimated that in Latvia on average 22.9% (Gaitnieks et al., 2007) of Norway spruce stumps are infected with Heterobasidion spp.

In order to prepare long term management and, if possible, recovery scenarios for infected stands it is important to identify rot in its early stage. In the world several methods are available for instrumental root rot detection. Greig (1998) in his paper mentions 12 instruments that can be used for rot detection, but Catena (2003) divides them in five categories. The oldest method mentioned is the percussion of the trunk with a hammer for interpretation of the produced sound pattern. This method is described as quick and very cost-effective, but the results depend on the operator’s experience. Sampling tree tissue with Pressler auger, visual assessment and, if needed, measuring samples for fractural resistance with fractometer is mentioned as a second most common method (Matthec and Breloer, 1994).

In the third category instruments which are used to insert probes in the tissue of the tree e. g., portable compression meter (Barrett et al., 1987), decay detecting drill (Seaby, 1990) and resistograph are included. The fourth category is associated with devices which use sound or ultrasound, including arbosonic decay detector and Sylvatest (Nicolotti and Miglietta, 1998). The last category contains instruments that use radioisotopes for rot detection (Catena, 2003), such as radar systems (Hruska et al., 1999)

In Latvia a study using digital root rot detection instruments was realized in 2004,- resistometer ‘Conditiometer AS-1’ was tested for its ability to detect root rot. The authors of this study concluded that the electrical resistance of wood is influenced by ambient temperature and tree diameter (Gaitnieks et al., 2004).

The aim of this study is to compare four different electronic devices for Heterobasidion root rot detection in Norway spruce.

Materials and Methods
The material for this study was obtained in the autumn of 2009 from a stand managed by ‘State Forest Service Forest Research Station’. The stand is located in the Eastern part of Latvia, Kalsnava district with a total area of 5.4 ha and the sample plot area 0.84 ha (70×120 m).

<table>
<thead>
<tr>
<th>Instrument Description</th>
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<tbody>
<tr>
<td>Instrument Parameter Unit of measurement</td>
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<tr>
<td>IML-RESI F400</td>
</tr>
<tr>
<td>Conditiometer AS-1</td>
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<tr>
<td>Rotfinder</td>
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<td>Arbo-Sonic decay detector</td>
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For this study 27 trees (12 without root rot and 15 without root rot) were chosen from the previous studies to compare the root rot detection ability of different electronic instruments shown in Table 1. Instruments were tested in 65 years old Norway spruce (80%) and Silver birch (Betula pendula Roth.) (20%) mixed stand in Oxalidosa turf. mel. forest type.

In selected trees Heterobasidion spp. was detected in laboratory by examining bore cores for the presence of conidiophores (Swedjemark, 1995) earlier that year. After this study all 27 trees were cut down and inspected once more for Heterobasidion spp. presence. Information about Heterobasidion spp. presence was used to evaluate the possibility of instruments to detect root rot.

At the beginning of the study diameters at the base of the stump and breast (1.3 m from the base of the stump) height were measured with a calliper. The first instrument tested was IML-RESI F400. Before each measurement strips of waxed paper were fixed on the measurement recording device. For each tree two holes (one at the stump height, another at the breast height of the tree) were drilled and the instrument automatically fixed the relative resistance graph of timber on waxed paper strips. Later in the laboratory the paper strips were examined to detect root rot cavities and the depth at which the rot occurs was recorded into MS Excel worksheet. Results were then compared with the previously obtained results.

Measurements with Rotfinder started with an input of the current tree diameter at the breast height to the instrument before each measurement. Two probes from each tree were obtained. Rotfinder has a scale from 0 to 10. 0 means that the sample tree has no rot, but 1 to 10 means that there is a possibility that the tree is infected with rot-causing fungi. Measurement results were recorded into MS Excel worksheet and the accuracy of the instrument for each probe calculated as a relative value of correctly detected measurements from all measured trees for each probe.

Measurements of electrical resistance of wood at the breast height of the sample trees were conducted using Conditiometer AS-1. The probe was stuck in the bark as deep as possible and, while slowly pulling the probe out, lower values of the reading were recorded. The average electrical resistance (in kΩ) was calculated from four readings from each tree. The data were analysed using the regression analyses and analysis of variance.

Measurements of ultrasound propagation time at stump height were conducted using Arbo-Sonic decay detector. Before each measurement, two bark plugs on opposite sides of the trees (4.5 cm in diameter) were removed to expose xylem at the breast height. Transducers (transmitter and receiver) were pressed simultaneously against the xylem on opposing points of each tree to generate the ultrasound wave across each diameter and ultrasound propagation time readings (time per unit of distance - μsec) were recorded. Regression analysis was used to detect correlation between the diameter at breast height and the propagation time of ultrasound. Analysis of variance was used to further analyze propagation time in relation to tree diameter at stem height.

Results and Discussion

A correlation of decrease of average electrical resistance of wood with increase of tree diameter was detected in the analysis of results obtained with Conditiometer AS-1. It was also clarified that the average resistance (Figure 1) for infected trees (12.6 ± 0.7 kΩ) is slightly higher than for not infected (11.8 ± 0.6 kΩ), still, the difference between average resistance of infected and not infected trees is not significant (p=0.39>0.05). Similar results were obtained by Gaitnieks et al. in 2004.

![Figure 1. Correlation between the tree diameter and wood electrical resistance of trees (Conditiometer AS-1).](image)
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Results obtained with Arbo-Sonic decay detector indicate that the average ultrasound propagation time through wood (μsec) is in positive correlation with the increase of diameter of examined trees (Figure 2). The average propagation time for infected trees was determined to be (301 ± 53 μsec), higher than for not infected ones (241 ± 34 μsec), yet again, the difference between average propagation time of infected and not infected trees is not significant (p=0.37>0.05). The accuracy of Conditiometer AS-1 and Arbo-Sonic decay detector could be influenced by high moisture in the stand, characteristic for Oxalidosa turf. mel. forest type.

Data obtained by using Rotfinder show that in both probes not infected trees were identified correctly (Table 2). Some variation between repeated measurements exists. In the first measurement round 67% of cases from all measurements (not infected + infected) results were correct, in the second measurement round 70% were correct. Results of this study show lower accuracy levels of instrument than that obtained by Romeralo (2010) whose study’s accuracy levels ranged from 75.8% to 87.2%. To increase the accuracy of the instrument it could be recommended to increase the number of probes taken from each tree.

Data obtained from IML-RESI F400 resistance meter show that in all 24 measurement pairs measurements were 100% correct. It should be mentioned that after 48 measurements both accumulators of the instrument included in the set went empty leaving 3 trees unmeasured, thus showing that optimal number of measurements for one accumulator load is in range from 20 to 25 and, to obtain more data from sample plots, more charged accumulators are needed.

In order to evaluate the influence of different factors (moisture, ambient temperature, age, stand composition) on labor-intensity and accuracy level of root rot detection instruments in Norway spruce stands, other forest types and age groups will be tested.

Conclusions

1. Rotfinder accuracy in this study from the first probes was 67%, but from the second 70%, thus suggesting that by increasing number of probes taken, accuracy could improve.
2. Conditiometer AS-1 and Arbo-Sonic Decay Detector show slightly higher average values for infected trees, but the difference for both instruments between groups is not significant, thus leaving the usage of instruments questionable.

Table 2

<table>
<thead>
<tr>
<th>Group</th>
<th>1. probe</th>
<th>2. probe</th>
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<tbody>
<tr>
<td>Correctly detected not infected trees</td>
<td>12 (45%)</td>
<td>12 (45%)</td>
</tr>
<tr>
<td>Correctly detected infected trees</td>
<td>6 (22%)</td>
<td>7 (26%)</td>
</tr>
<tr>
<td>Uncorrectly detected infected trees</td>
<td>9 (33%)</td>
<td>8 (30%)</td>
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</table>
3. The accuracy of IML-RESI F400 for detecting root rot in Norway spruce is 100% and it can be useful for detecting root rot. We suggest the purchase of additional batteries for large sample plots.

Acknowledgements

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References