NEW TECHNOLOGY OF WOOD FUMIGATION AGAINST BARK BEETLE

FIRST TRIAL RESULTS - EDN PRODUCT USED FOR FOREST PROTECTION IN CZECH REPUBLIC

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In the last two years Draslovka a.s., VÚRV, v.v.i. (Crop Research Institute), and ČZU (Czech University of Life Sciences) have been conducting experiments with a new fumigation substance and formulation (BLUEFUME - stabilized hydrogen cyanide, and EDN) and their application to soil, seed and plant commodities, including construction, packaging and semi-processed (harvested) wood for quarantine purposes. The research was supported by the Ministry of Agriculture project (NAZV) and is currently being supported by the Ministry of Education (TACR). Of the two gases, BLUEFUME and EDN, the latter showed to be best suitable for the treatment of wooden logs (based on the chemical properties and preliminary tests in commercial conditions). In a research collaboration with the Archdiocese of Prague (Forestry administration), experimental fumigations - first in Europe - were performed in the Archdiocese forests in the first half of 2017. In the experiments, logs not yet debarked were treated with EDN under a tarp directly in the forest. The results of the initial tests of EDN fumigation performed on naturally infested conifer logs are optimistic. They have shown a high (100%) efficacy against several species of bark beetles (Ips sp., Pityogenes sp., Hylurgops sp.) and inhibition of the pest transfer from the wood after only a several-hour treatment. It is therefore interesting to ask the question whether it would be possible to use this product to decrease the negative effects of bark beetle calamities.

BARK BEETLE CALAMITY PROBLEM

The causes and consequences of bark beetle calamities are well known. The wide avalanche-like spread of the bark beetle in the recent years has been threatening the essence of forestry and has brought immense financial losses to forest owners. A timely detection of the bark-beetle-infested trees and the fastest possible treatment of such wood remain the alpha and omega in the uneasy situation of changing natural conditions and lack of workforce. Each owner shall assess the effectiveness of the individual procedures, invested costs and their impact on the real protection of the forest. At this point, it is necessary to emphasize the term "efficient treatment" (eradication of bark beetles). It is up to the owner as to what he considers to be proper treatment. The number and types of defensive measures, systematic checks and mainly the systematic detection of the infected trees by an experienced forester can all be thwarted by an ineffective treatment. It is suitable to process the pupae-and-beetle-infested wood by harvesters or is it better to haul the logs while the bark peels off massively? When is it advisable to remove the wood and when is it only transferring the problem? Do we have the human capacity?

Is there available a rapid and efficient treatment that would also preserve the ecological requirements? A brief - and thus a very simplified - overview of the possible treatments that are and are not available to the foresters is given in the following paragraph.

ALTERNATIVES TO WOOD TREATMENT IN FORESTS

Is it possible to treat harvested wood directly in the forest and kill the pest rapidly in order to prevent its transfer, re-infestation and spread? Only with great difficulty! The following paragraphs give an overview of the currently available methods, their advantages and technological limitations.

▪ Removal (transport) or mechanical treatment: manual debarking using a scraper is limited by the stage of larvae. Mechanical debarking using a chainsaw tool is highly effective and can be used during the whole developmental cycle of the bark beetles. However, major limiting factors of such mechanical treatment are productivity and lack of human resources.

▪ Chemical treatment using POR spray and insecticidal nets: Even though products for surface treatment of wood (bark) against the bark beetle by spraying are registered at present, the methods are time-consuming and difficult when it comes to transport of the liquid as well as handling the wood. The disadvantage of spraying is that it affects non-target

insect species (e.g. the sprayed liquid gets transferred to the vicinity of the treated trees due to wind). Insecticidal nets acting on contact present an alternative chemical protection. The major problem of spraying and especially of the nets is the fact that they do not kill the bark beetle inside the wood; the beetle can thus fly out during further handling (scraping treated bark), transfer and attack other tree.

- Thermal / microwave treatment: In-depth treatment of wood by heat or microwave radiation is possible in a sawmill but not in the forest.
- Fumigation: Fumigation (gaseous) insecticides present a single rapid solution applicable directly in the forest; their small molecules relatively quickly penetrate the whole profile of the wood (logs) and instantaneously kill all developmental stages of the pest (i.e. eggs, larvae, pupae and adults). Most fumigation technologies target the organisms under a tarp (i.e. there is no

"drift" to the surrounding vegetation with negative effects on non-target organisms and beneficial insects). Methyl bromide was used worldwide in its gaseous form for in-depth wood protection. However, the EU has banned its use as it destroys the ozonosphere. After the methyl bromide ban it seemed almost impossible to find an equally effective replacement. It is extremely difficult and expensive to create new chemical products and application technologies that would allow efficient protection of wood and commodities these days. However, a promising active substance has appeared recently. The first practical experience is the subject of this article. The fumigation method allows quick treatment of large amounts of bark-beetle-infested wood providing high efficacy against all its developmental stages and eliminating the risk of transfer and repeated attack during subsequent handling. But it does not provide residual protection. However, the designed technology of EDN use targets the organisms under a tarp (i.e. there is no "drift" to the surrounding vegetation with negative effects on non-target organisms and beneficial insects).

USED PRODUCT EDN (ETHANEDINITRILE) - CHARACTERISTICS

EDN (Ethanedinitrile) has the potential to be beneficial as a multifunctional fumigant in a variety of applications: soil, grain, wood, against a variety of pests: insects, nematodes, fungi (molds) and for devitalization of grain (export/import). Preliminary studies have shown that EDN exhibits high toxicity against all stages of the tested insect species: it is at least as effective as methyl bromide. One advantage is that EDN penetrates wood faster than methyl bromide. EDN works quickly: EDN exposure is 10 - 24 hours. EDN, similar to methyl bromide, instantly kills all the pest developmental stages (eggs, larvae, pupae and adults). For comparison, fumigation using hydrogen phosphide requires a ten-day treatment and is thus not suitable for a quick treatment of commodities and wood before export. EDN is an environmentally friendly product. The main decomposition process occurs already in the course of the treatment and therefore, EDN concentration at the end of the fumigation reaches single grams per cubic meter, an amount that can be rapidly and safely ventilated without any problems. The remaining ventilated EDN reacts with humidity and decomposes spontaneously and rapidly. The final products of EDN decomposition are non-toxic substances carbon dioxide, ammonia and water. EDN does not deplete the ozonosphere. Decomposition of the active substance (EDN) is quick and does not leave any EDN residues in the wood.

VALIDATION AND INITIAL TRIAL

Description of treated wood

On 18 May 2017 treatment of harvested wood infested with the bark beetle was performed in the forest in the vicinity of Libeř village. The logs in the pile were not yet debarked and comprised two kinds of trees: Norway spruce (Pices abies) 4 m long and Scots pine (Pinus sylvestris) 4 m long. The diameter of the logs was from 15 to 40 cm. In total, the harvested wood pile contained 80 m^3 of wood with "loading factor" 62 %. The stored pile was 12.5 x 4 x 2.5 meters and when covered with a tarp, the treated area was 130 m^3. The tarp was also placed under the pile so as to reduce the product losses by leakage into the soil.

Used procedure (methodology) for treatment of logs by means of EDN fumigation under a tarp in validation study

1. The infested wood (preferably logs) was piled on a prepared tarp placed on a transport place or handling area. (Note. Bark-beetle-infested wood should not be processed using a technology that causes the bark containing the pupa and beetle to fall off!)

2. The pile was covered with a tarp which was then weighed down with sandbags and was thus connected to the bottom tarp. Local leaks in the tarp were prevented by using a duct tape.

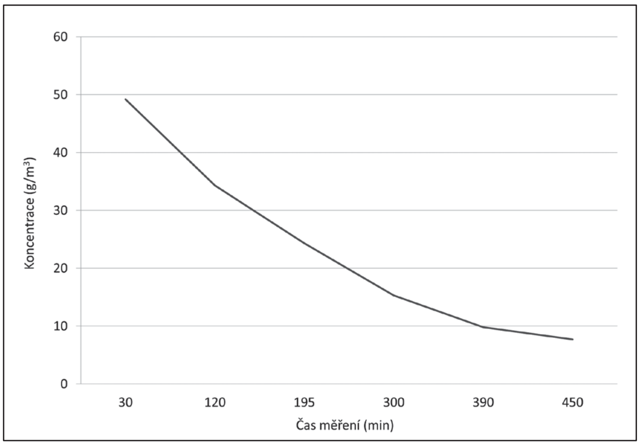

Chart 1: EDN concentration (g/m^3) progress during treatment. (A - right side)

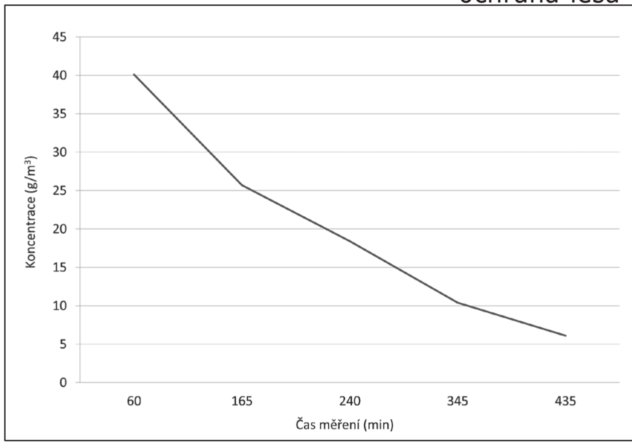

Chart 2: EDN concentration (g/m^3) progress during treatment. (B - left side)

3. A metal cylinder containing the fumigation product – EDN – was brought (manufacturer Lučební závody Draslovka a.s. Kolín).
4. Application and monitoring tubes were inserted in the prepared holes in the tarp; the space between the tubes and the tarp was then sealed and the required dose of the product was applied.
5. Fumigation exposure of wood by EDN product under a tarp is 10 - 24 hours. EDN concentration was monitored during the fumigation.
6. The tarp was removed and the remaining undecomposed gas was ventilated from under the tarp and from the wood (desorption).

Product application, concentration measurement, treatment duration and wood samples

The wood was treated with EDN product. Total amount of the applied product was 6.5 kg with the initial required dose of 50 g/m^3. The application began on 18 May 2017 at 10:45 am. The product was applied from two sites on the right and left side of the pile at about 60 cm above ground. After the product had been applied, measurement of product concentration inside the treated space started; the measurement took place at sampling sites. The concentration was monitored using Lumasense INNOVA 1412i device, which measured the concentration alternately on the right and on the left side in regular intervals. The duration of the treatment was set to 7 hours 45 minutes. After this time, the remaining product was ventilated. The treatment was aimed at the European spruce bark beetle (Ips typographus). For this purpose, the wood selected for the treatment was specifically used as a natural trap for this pest, which is a common forestry practice. Before the pile was prepared, 6 pcs of spruce logs 4 m long and 25-30 cm in diameter were selected; the logs showed signs of bark beetle infestation. Three spruce logs were randomly placed in the pile and three logs were left as untreated control. After the treatment and ventilation, these logs were removed from the pile and together with the control logs they were cut into four one-meter-long pieces. The samples were then transported to a warehouse and wrapped in a mesh, which prevented the hatching bark beetles from escaping. Subsequently, the hatched insects were checked in regular one-month intervals.

EDN concentration measurement results

EDN concentration was measured during the fumigation. The highest concentration was recorded at the beginning of the treatment at sampling site on the right. The concentration there reached 49.2 g/m^3. Charts 1A, B show the progress and changes of the product concentration during the treatment. In the course of the treatment the achieved CT-product was 158.5 g*hr/m^3 at the right sampling site and 119.5 g*hr/m^3 at the left sampling site.

Results of EDN biological efficacy against bark beetle

A total of four checks of hatching of bark beetles were performed. The last check was performed on 20 September 2017. (a) Treated wood samples: The check found no bark beetles (i.e. 0 pcs of pests from all EDN treated parts under a tarp). (b) Non-treated wood samples: In the control non-treated samples the total of five bark beetles were found: 1. European spruce bark beetle (Ips typographus) (total number of adults found in the checks was 224 pcs), 2. Spruce wood engraver (Pityogenes chalcographus) (611 pcs), 3. Lesser spruce shoot beetle (Hylurgops palliatus) (11 pcs), 4. Dryocoetes hectographus (2 pcs), 5. Dryocoetes cf. autographus) (24 pcs).

CONCLUSION

The first experimental use of EDN in a forest applied to wood fumigated under a tarp showed 100% efficacy against all the present bark beetle species, including the European spruce bark beetle (Ips typographus).

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