UREA project 1 March – 31 May 2020
Final report

1. Objectives of the project

The Finnish Safety and Chemicals Agency collects the sales volumes data on plant protection products on an annual basis, and the EU also uses the figures to calculate harmonised risk indicators (HRI 1 and HRI 2). The purpose of the harmonised risk indicators is to measure the achievement of the targets set out in the framework directive on the sustainable use of pesticides (2009/128/EC) in the Member States. The aim of the framework directive is to reduce the risks to health and the environment arising from the use of plant protection products.

To implement the framework directive, each Member State must prepare a National Action Plan for sustainable use (NAP) setting out the targets and actions to reduce the risks arising from the use of plant protection products. Based on HRI 1, the overall risk caused by the use of plant protection products appears to have increased in Finland during the monitoring period 2011–2017. The indicator comprises the sales volumes of four categories of plant protection products. Because of weighting factors and sales volumes, category 2 has the highest impact on the indicator (88–96%). Most of the active substances contained in plant protection products are listed in category 2 and in this particular category, urea is the substance with the highest sales volumes. Urea accounts for between 43% and 70% of the total sales in the category. The increase in the indicator is solely due to an increase in urea sales, whereas the sales of other substances have decreased compared with the baseline period 2011–2013.

Urea is used to prevent root rot in forests. Under the Forest Damages Prevention Act (1087/2013), forest owners must carry out the preventive measures in conifer-dominated forests in connection with summer harvesting. Unlike most other plant protection products, urea has not been developed to destroy the organisms to be prevented. However, it causes eutrophication and damages ground vegetation. Increasing use of urea means that there is a worrying trend with regard to the sales of plant protection products under HRI 1 and the risks arising from them. It was thus decided to prepare a report on the use of urea as a plant protection product in Finland so that the EU could get a clearer picture of the use of urea in Finland's forestry sector.

The purpose of the UREA project was to

- examine the use of urea as a plant protection product in the forestry sector
- compare the amounts of urea used as a plant protection product with the use of urea as a fertiliser in the forestry sector
- examine why the biocontrol products based on *Phlebiopsis gigantea* are not used to prevent root rot in Finland as extensively as urea

Finnish Safety and Chemicals Agency (Tukes)

Helsinki
PO Box 66 (Opastinsilta 12 B)
FI-00521 Helsinki

Tampere
Yliopistonkatu 38
FI-33100 Tampere

Rovaniemi
Valtakatu 2
FI-96100 Rovaniemi

Telephone switchboard
+358 29 5052 000
www.tukes.fi
kirjaamo@tukes.fi

Business ID 1021277-9

- examine whether the advantages and disadvantages of urea have been studied, and
- to examine whether urea can be replaced with other methods.

One purpose of the project was also to implement the National Action Plan in Finland.

2. Parties and cooperation

Funding for the UREA project came from the Ministry of Agriculture and Forestry, which was represented in the project cooperation group by Tove Jern and Tatu Torniainen. The Finnish Safety and Chemicals Agency was represented in the project by Kaija Kallio-Mannila, Marja Suonpää and Emilia Hämäläinen (project worker). The Natural Resources Institute Finland was represented in the project by Tuula Piri and Jarkko Hantula. The following persons were also members of the cooperation group: Lea Jylhä (Central Union of Agricultural Producers and Forest Owners), Maija Rantamäki and Mariela Marinova-Todorova (Finnish Forest Industries), and Lauri Hyytiäinen and Simo Jaakkola (Association of Finnish Forestry and Earthmoving Contractors).

3. Findings

3.1 Methods and materials

The report was produced on the basis of interviews with experts and literature published on the topic. Both Finnish and Swedish experts were interviewed for the report.

The Finnish experts were asked the following questions, which were discussed at the cooperation meeting on 7 April 2020:

- How would you describe Finland's harvester stock?
    - Describe the way in which harvesters are used to spread urea and *Phlebiopsis gigantea*. How well suited are they for the work?
    - How old are the harvesters, how many of them will be replaced in the next few years and will there be changes to the machines?
    - In your view, what is the accuracy of the stump treatment? Do large amounts of the plant protection product miss the stumps with the currently used application methods?
- Urea is the most commonly used substance to prevent root rot. Why is *Phlebiopsis gigantea* so rarely used? Could it be used more extensively? What are the obstacles to its use?
- Why is urea the most commonly used substance to prevent root rot?
- Do weather, climate or climate change have an impact on which plant protection product is used to prevent root rot?
- Are there effective alternatives to urea?

    - Is it possible to stop using plant protection products in the prevention of root rot? Are there any other methods to prevent root rot? Could they be used or are they already used to support the prevention of root rot in addition to plant protection products? Does Finland have separate forest IPM instructions or practices?
- In Sweden, *Phlebiopsis gigantea* is the only method used to prevent root rot. How would you describe the root rot situation in Sweden? How does it compare with the situation in Finland?
- How large is the difference between the amounts of urea used as a fertiliser in the forestry sector and the amounts used as a plant protection product?
- Do you have any information about the carbon footprints of urea and *Phlebiopsis gigantea*? Does the carbon footprint have any impact on the selection of the plant protection product?

The questions put to the Swedish experts were sent by email to the following parties: Swedish Chemicals Agency, Swedish Forest Agency, LRF Forestry, Swedish Association of Forestry Contractors, and Jan Stenlid and Jonas Rönnberg (both from the Swedish University of Agricultural Sciences).

Responses were received from the following persons: Camilla Thorin (Swedish Chemicals Agency), Magnus Thor (Skogsforsk), Jan Stenlid and Jonas Rönnberg.

- Användningen av urea som växtskyddsmedel är förbudet i Sverige.
    - Vad var orsakerna till förbudet?
    - När trädde förbudet i kraft?
- Kan urea fortfarande användas som växtskyddsmedel i vissa undantagsfall i Sverige?
- Hur har kostnaderna för stubbehandling ändrats sedan användningen av urea upphörde?
- Vad tänker skogsägarna / entreprenörerna om ureaförbudet (t.ex. bekostnader, effekten och användarvänligheten av pergamentsvamp)?
- Finns det några speciella anpassningar i svenska skogsmaskiner för att använda pergamentsvamp?
- Hurdan är rottickasituationen i Sverige?
- Vad uppskattar ni är de årliga ekonomiska förlusterna orsakade av rotticka?
- Använder ni urea som kvävegödselmedel i skogsbruket i Sverige? Vilka applikationsmängder rekommenderas?
- Vilka är kraven enligt svensk lag för stubbehandling?
- Vilka andra riktlinjer bestämmer hur man utför stubbehandlingen?
- Hur många pergamentsvamp-leverantörer och produkter finns det på den svenska marknaden?
- Påverkar FSC-certifikatet eller något annat certifikat stubbehandlingen på något sätt?
- Har Sverige IPM-riktlinjer för skogsbruk?
- Vilka icke-kemiska metoder används i Sverige för att kontrollera rotticka?

3.2 Findings

Using urea as a plant protection product in the forestry sector

Root rot is caused by *Heterobasidion* species. *Heterobasidion annosum* and *H. parviporum* are the species occurring in Finland and they mainly infect Scots pine and Norwegian spruce (Piri et al. 2019). Root rot infection reduces the annual volume increment of trees, weakens timber quality and increases wind falls (Oliva et al. 2010, Piri et al. 2019). Under the Forest Damages Prevention Act (1087/2013), the parties carrying out the harvesting must take measures to prevent root rot in connection with intermediate and regeneration felling in peatlands and in areas with mineral soil where there is a risk of root rot spread, in the period between the beginning of May and the end of November. In connection with regeneration felling, preventive measures are only required if the regeneration is carried out using tree species sensitive to root rot. The requirement does not apply to pine forests in peatlands. As the spores of root rot land on freshly cut stumps, root rot can be effectively prevented by means of stump treatment. Southern and central Finland are the areas with the highest risk of root rot in Finland. In Kainuu and northern Ostrobothnia, *H. annosum* is rare even though Scots pine is a common tree species in these areas. However, *H. parviporum* is widespread in both regions (Müller et al. 2018). Other wood-decay fungi are still more common in northern Finland but the spread of *Heterobasidion* species should be a concern because of such developments as climate change and more frequent harvesting (Müller et al. 2018).

Both urea products and a biocontrol product using spores of *Phlebiopsis gigantea* as an active substance are used for stump treatment. The impact mechanism of urea is based on an increase in the stump pH, which prevents the spread of spores of root rot (Johansson et al. 2002). A biocontrol product based on *Phlebiopsis gigantea* was the most common method to prevent root rot in Finland until about twenty years ago. This is because early urea products caused corrosion in harvesters. After the introduction of a urea product containing an anti-corrosion agent, urea has gradually become the most widely used stump treatment substance in Finland. The active substance contents of urea products are now lower than in the past. The active substance contents have been at their present levels (an average of 325 g/l) for the past 12–15 years. The sales and use of urea have increased at the same rate as felling volumes even though there is annual variation in felling. An increase in the size of areas considered as risk areas has also boosted the use of urea products. There are significant economic incentives for stump treatment in healthy forests where the infection pressure is high (Honkaniemi et al. 2019).

Both urea products and products based on *Phlebiopsis gigantea* have proved effective in studies made on different tree species even though there may be differences in effectiveness between them in different situations (Wang et al. 2012, Thor & Stenlid 2005, Gunulf et al. 2012, and Gonthier 2019). According to the effectiveness tests carried out in southern Finland by the Finnish Forest Research Institute (now the Natural Resources Institute Finland) since the late 1980s, strong urea solutions (30–35%) prevent more than 90% of the root rot spore infections affecting stumps when correctly used. According to recent research, urea has proved more effective than *Phlebiopsis gigantea* when applied to small stumps in connection with thinning but there were no differences between their active substances in regeneration felling (Blomquist et al. 2020). According to the study in question, stump treatment is required in both thinning and regeneration felling

(Blomquist et al. 2020). There are no differences between the effectiveness of mechanised and manual stump treatment (Thor & Stenlid 2005).

There are currently four urea products and one *Phlebiopsis gigantea* product in the plant protection product register of the Finnish Safety and Chemicals Agency. Products containing other active substances (such as boron) have not been approved for stump treatment in Finland. Only holders of plant protection qualification may use urea products and *Phlebiopsis gigantea* products in forestry. Either the extensive qualification or the less extensive qualification, which is only intended for the forestry sector, is required.

No forest IPM instructions have been prepared for the Finnish forestry sector but the best forest management practices are contained in all forestry instructions and certificates. There are references to the IPM instructions in international certification instructions but these are applied on a national basis. The report on the root rot situation prepared before the drafting of the Forest Damages Prevention Act (1087/2013) corresponds to the planning and prevention requirements set out in the IPM instructions.

Finland's forest machine stock

There are slightly more than 2,000 harvesters and between 4,300 and 4,500 forest tractors in Finland. About 300 harvesters are replaced with new ones each year. There is not much need for more machines. The area where stump treatment is obligatory accounts for between 80% and 85% of harvesting in Finland. In this area, trees are bigger and work productivity higher than in other areas and thus the number of machines is lower in relation to harvested volumes. The areas outside the stump treatment area (Northern Ostrobothnia and Lapland) account for about 15% of the harvested volumes. Productivity in this part of Finland is lower and thus in relative terms, more machines (15–20% of the total) operate in these areas.

A large proportion of the forest machines used by contractors in Finland are replaced with new ones after 6–7 years. According to a study produced by the Natural Resources Institute Finland in 2015, the average useful life of a harvester is 6.8 years. Harvesters now in use can spread both urea and *Phlebiopsis gigantea* products. However, urea is used at 88% of all harvesting sites and *Phlebiopsis gigantea* at 12% of the sites.

Urea as an active substance

Urea has been approved as a plant protection product in the EU under the Commission directive 2008/127/EC. On that occasion, the evaluation was carried out by Greece. A re-evaluation is under way and in this process Greece again is acting as the reporting country, with Finland responsible for parallel reporting. The current approval for urea is in effect until the end of August 2020. If an administrative renewal for the active substance is granted, it will also apply to products containing urea. The administrative renewal is granted by the European Commission if the evaluation report on urea is not yet ready or the Commission proposal for approval or non-approval is not available and no vote can take place before the expiry of the authorisation for the active substance. There may also be disagreements between the Member States preventing the decision from being made quickly enough. The authorisation holder must submit the application for the renewal of the authorisation to Greece and Finland within three months of the date

on which the active substance was approved. The Finnish Safety and Chemicals Agency has reminded authorisation holders of the dates, the situation and the required information.

Sweden has given approval to one *Phlebiopsis gigantea* product with one supplier but no urea products have been approved. This means that both Finland and Sweden are highly vulnerable in this respect. In a situation where there is no approval for urea as a plant protection product, Finland would have two options: using a *Phlebiopsis gigantea* product, or 120-day authorisations by derogation in a plant protection emergency. In such situations, authorisation by derogation for using urea fertilisers could also be considered. However, a *Phlebiopsis gigantea* product intended for preventing root rot is already available on the market, which might pose problems with regard to the authorisation by derogation. The use in Finland of the biological stump treatment product containing *Pseudomonas* sp. strain DSMZ 13134 as active substance could be considered. This product was approved for use in Sweden in December 2019. Finland could also propose the removal of urea from the list of active substances and classifying it as a basic substance referred to in the Plant Protection Regulation of the EU. However, a number of matters, such as the large amounts of urea used compared with existing basic substances (such as nettle water) would have to be taken into account in this connection. The removal of urea from the list of active substances would nevertheless be a cause for concern and the smaller number of alternatives would understandably lead to problems in stump treatment, burden the timber purchasing chain with additional costs and result in a major market failure in the product markets.

Accuracy and coverage

Based on the report, the accuracy of the two stump treatment products should not be a concern. In manual harvesting, the stump treatment substance is spread by applying it on the stump by hand, or using a knapsack sprayer or a spray bottle, in which case the forest worker can adjust the accuracy of the spread and ensure that the substance is evenly applied. It should be noted, however, that nearly 100% of all industrial roundwood and energy wood harvesting in Finland is carried out by machines. The spraying nozzles of the harvester's flanges can be adjusted in accordance with the stump surface area, though this is usually done for each stand marked for harvesting and not for individual trees. However, using the adjustment option increases accuracy. When harvesters are used for stump treatment, the substance is only applied on stumps of conifer trees (and not broadleaved trees). This reduces wastage and the fertilising effect of urea. The professional skills of the forest machine operator are essential for ensuring accuracy and even spread of the substance. Willingness to minimise costs also serves as an incentive for achieving a high degree of accuracy: all misses are an additional cost item and reduce the income of the forest machine contractor.

According to an opinion issued by the Finnish Forest Research Institute in 2011, to ensure effectiveness, the urea product layer applied on stumps should correspond to a 2 mm layer of liquid on the stump surface and the surface should be evenly covered. Coverage should be at least 85% but a coverage of more than 95% increases the protective effect. In *Phlebiopsis gigantea* treatment, too, a coverage of 100% gives the best results (Berglund 2005). Thus, careful application is essential for ensuring effective stump treatment. In fact, economic profitability of

the prevention of root rot greatly depends on the quality of the stump treatment (Honkaniemi et al. 2019).

The coverage of stump treatment was supervised by the Finnish Forest Centre during the previous legislation when the prevention of root rot was still supported with Kemera funding. However, the quality of stump treatment is still supervised on an annual basis. According to the control results for 2012, the overall coverage has been good. In the controls, a total of 107 inspections were carried out during the application of the substance and in 79 cases, the process was considered successful. Comments were issued in 25 cases and in three cases, the substance was applied in an incorrect manner. The substance was applied by means of a guide plate method even though in three cases, there was no information on the method used. According to the 2019 control results published by the Finnish Forest Centre, in 52 of the 67 cases, the substance was applied in an effective manner, in 11 in a satisfactory manner and in 4 cases in an ineffective manner. Thus, the percentage of effective use of the substance has remained more or less unchanged over the years. The validity of the plant protection qualifications of the harvester operators was also checked in the inspections carried out between 2017 and 2019. It is surprising that there is still a small number of operators with no qualifications even though their proportion has decreased substantially (from 13.9% in 2017 to 4.4% in 2019). The purpose of the plant protection qualification is to ensure that the professional users of plant protection products can use the substances in a safe and responsible manner. The self-monitoring instructions for stump treatment issued by the Natural Resources Institute Finland, Finnish Forest Centre and the Ministry of Agriculture and Forestry provides clearly illustrated instructions for self-monitoring of stump treatment quality.

Using urea as a fertiliser in the forestry sector

The recommended amounts of urea fertilisers for forestry use are given in the forest management guidelines issued by Tapio. For heath forests, the recommendation is 250–430 kg/ha every 6 to 8 years and for peatland,150–200 kg/ha every 10 to 15 years. In the prevention of root rot in regeneration felling, the average consumption of the stump treatment substance is 0.39 litres/one cubic metre of harvested softwood timber or 81 l/ha (Kärhä et al. 2018). On average, one litre of treatment solution contains 325 grammes of urea. It is estimated that the use of urea in the prevention of root rot accounts for about 10% of its use as fertiliser if fertilisation is carried out in accordance with recommendations.

No exact figures on the amounts of urea used for forest fertilisation could be included in this report. According to the 2018 forest statistics, fertilised area totals 61,200 ha of which fertilisation for growth accounts for 45,800 ha and remedial fertilisation for 15,300 ha. Fertilisation for growth can be in the form of urea, ash, potassium or phosphorus, while remedial fertilisation is usually in the form of boron and ash. However, the proportion of urea cannot be determined on the basis of the statistics. According to Tapio, ash fertilisation has become more common in recent years. In practice, according to the interviews with experts, urea fertilisation is not as widespread in Finland as the recommendations suggest, and the correct figure would be about 150 kg/ha (in both heath forests and peatland).

Why is urea more commonly used in Finland than *Phlebiopsis gigantea*?

According to this report, urea is considered easier to use than *Phlebiopsis gigantea* products. Urea is also less expensive and it can be stored for long periods. The urea solution remains usable for about ten months which means that it may even

be used in the treatment period of the following year. In contrast, the *Phlebiopsis gigantea* solution must be used within 36 hours of its preparation. Any solution older than this is unusable because the spores of the *Phlebiopsis gigantea* start to sprout and may dry when on the stump surface.

The delivery of the *Phlebiopsis gigantea* product to the harvesting site is considered more difficult as the product must be stored in a cool place. To ensure the survival of the spores, the package must be kept in a refrigerator (in a temperature below +5 °C) or in a freezer. This means that unlike urea, it cannot be stored in room temperature or outdoors. Furthermore, in sub-zero temperatures, the *Phlebiopsis gigantea* solution may freeze in the hoses of the forest machine, which causes problems to the machine contractors. In contrast, the urea solution can withstand temperatures of up to -7 °C.

The ready-to-use urea solution can be purchased in large tanks whereas the *Phlebiopsis gigantea* solution must be mixed by the forest machine operator. Using the *Phlebiopsis gigantea* solution causes additional work and the solution is more prone to cause the harvester to malfunction. The urea solution does not require any cleaning of the harvester systems. When a *Phlebiopsis gigantea* solution is used, the equipment must be cleaned: the tank of the machine must be washed with clean water every week, while the hoses must be washed with water on a daily basis. This removes bacterial growth and prevents impurities from clogging the equipment, which would reduce the effectiveness of *Phlebiopsis gigantea*. This means more work for the machine contractor, leaves less time for productive work and creates additional costs.

There may be substantial variation in weather conditions at the start and the end of the stump treatment season and in such conditions, urea is the best and the most weather-resistant alternative. *Phlebiopsis gigantea* needs a growth temperature of +5 °C and it is best suited for warm and humid conditions. It is less effective in cool and dry conditions. Using *Phlebiopsis gigantea* is difficult in conditions where it is a few degrees below zero at night and daytime temperatures are high.

Forest owners would like to have more stumps treated with *Phlebiopsis gigantea* but few contractors offer such service. Most contractors have the capacity to use urea but not *Phlebiopsis gigantea* because the machine contractors must be able to start the stump treatment immediately when the application season starts. Quick changeover from urea to *Phlebiopsis gigantea* would be expensive and mean a great deal of work for the contractor.

Situation in Sweden

Urea is not prohibited in Sweden but no approved urea products are currently on offer in that country. This means that urea products may only be sold and used in Sweden if an authorisation by derogation is granted. The last urea product in use was removed from the register of the Swedish Chemicals Agency in 2015 and no new applications have been received since then. The urea product available on the market was rarely used during the ten years prior to its withdrawal.

In Sweden, the taxation of plant protection products is based on the content of the active substance in the product, which is the main reason why no applications have been received and urea is not used. The urea solution contains about 300–350 kg

of urea/1,000 litres of ready-to-use solution, making the product far too expensive. For comparison, a *Phlebiopsis gigantea* product only contains one kilogramme of active substance/1,000 litres of ready-to-use solution. After the withdrawal of urea from the market, there have been few changes in stump treatment costs as the prices of *Phlebiopsis gigantea* products have remained unchanged. However, there has been no monitoring of cost trends. Moreover, forest owners' opinions on the withdrawal of urea products have not been surveyed either.

In early 2020, five approved *Phlebiopsis gigantea* products were listed in the register of the Swedish Chemicals Agency but since 1 May 2020, only one product, resembling gel and producing no dust, has been listed in the register. No renewal for approval has been sought for other products. The transition period for the sales, use and storage of the products to be withdrawn will end on 31 October 2021. There is only one supplier of *Phlebiopsis gigantea* products in Sweden.

In December 2019, a new biological product was approved for use in Sweden in addition to *Phlebiopsis gigantea*. It has *Pseudomonas* sp. strain DSMZ 13134 (6,6E10 cfu/g) as active substance. No application for using the product in Finland has been submitted. A master's thesis, in which *Pseudomonas* species were tested in the prevention of root rot for the first time (Gzibovska, 2016) was the only source of information on the potential of *Pseudomonas* species in the prevention of root rot that could be obtained for this report. The thesis was written in the Swedish University of Agricultural Sciences. The strain used in Sweden was, however, approved as an active substance of plant protection products in the EU in 2014.

In Sweden, the substances are often sprayed using knapsack sprayers. Many harvesters have a small tank for the *Phlebiopsis gigantea* product and another tank for water plus a range of different technical equipment to prevent damage through freezing. Harvesters are, however, also suited for other products in addition to *Phlebiopsis gigantea*. There is practically no use of urea as a forest fertiliser in Sweden.

Root rot is a serious problem in Sweden and it has become more common, especially in southern parts of the country. The losses incurred by forest owners as a result of root rot each year total between SEK 500 and 1,000 million (about EUR 90 million) and this figure includes growth losses and lowering of timber quality. In Finland, the annual losses amount to about EUR 50 million. Stump treatment is not a statutory requirement in Sweden. Forest industry companies have their own stump treatment guidelines, while the Swedish Forest Agency has issued recommendations. Stump treatment is carried out in Götaland, Svealand and in coastal areas of Norrland. Thinning includes stump treatment when the average daily temperature exceeds +5 °C. Regeneration felling occasionally also includes stump treatment.

Sweden does not have separate integrated pest management (IPM) instructions for forests as the principles of integrated prevention have been incorporated in such instruments as forest certificates. It has been proposed that Sweden should follow the Finnish example and make stump treatment a statutory obligation. In fact, modellings and follow-up studies carried out in Sweden have shown that stump treatment brings benefits in thinning and regeneration felling (Thor et al. 2005, Thor et al. 2009). According to Rönnberg (2020), future research should produce anticipation tools so that stump treatment can be applied when the infection risk is high.

Biological stump treatment is an acceptable method under the FSC certificate. Under the FSC certificate, chemical methods should not be used if alternatives are available. In addition to biological stump treatment, other non-chemical prevention methods used in Sweden include winter thinning, giving priority to mixed forests, replacing conifer trees with broadleaved trees, replacing spruce with pine (in the north), and developing more resistant varieties of spruce.

Advantages and disadvantages of urea and *Phlebiopsis gigantea*

In Finland, all plant protection products are approved by the Finnish Safety and Chemicals Agency before they are placed on the market. This means that all four approved products containing urea as active substance have been assessed in terms of the environment, human health, chemical composition and effectiveness. According to the Finnish Safety and Chemicals Agency, the products are safe to human health and the environment when used in accordance with the instructions.

Despite the fact that its effectiveness has been verified, the use of urea has been criticised for environmental and other reasons (Asiegbu et al. 2005). According to a study carried out in Sweden, the urea falling outside stumps caused irreversible damage to the vegetation around the stumps and increased the soil pH value by two units. However, the pH value returned to near-normal one year after the treatment (Westlund and Nohrsted 2000). In the same study, *Phlebiopsis gigantea* treatment was not found to impact vegetation or soil.

In the past, a buffer zone of 25 metres on the shores of water bodies was obligatory in Finland when urea was used, and this requirement was based on the estimates produced by the Finnish Environment Institute of toxicity of urea and ammonia (degradation product of urea) to aquatic organisms and the runoff of urea to water bodies. However, in 2009 and 2010, the Finnish Food Authority changed the buffer zone requirement to ten metres. The change was based on the manner in which the use of the products (one-off treatment of freshly cut stumps) impacts the risk that urea will end up in water bodies, compared to the use of plant protection products in agricultural land.

A Finnish strain of *Phlebiopsis gigantea* is used in Finland, while a Swedish strain is used in Sweden. Active spread of a single strain in forests has caused concern of the narrowing of biodiversity and other impacts of *Phlebiopsis gigantea* on the organisms of the area. There has also been concern of the possible transformation of a saprotrophic wood-decay fungus into a necrotrophic parasite. However, studies suggest that the use of *Phlebiopsis gigantea* does not have any major impact on fungus species in the test areas in which it has been used (Vainio 2008, Terhonen et al. 2013). Vasiliuskas et al. (2004) also noted that the species returned to natural state after *Phlebiopsis gigantea* treatment. However, after a 19 per cent urea treatment, the range of fungus species on the stump had become less diverse (Vasiliuskas et al. 2004). According to Suni (2011), the negative impacts of *Phlebiopsis gigantea* on the bacteria flora of the test area are gradually reversed. According to Vainio (2008), stump treatment should, however, be carried out using local *Phlebiopsis gigantea* strains so that hybrid strains can be prevented. *Phlebiopsis gigantea* may cause brown spot disease in pine saplings but the disease cannot spread even if the treatment is continued for lengthy periods (Sun 2011). Thus, the risk of *Phlebiopsis gigantea* transforming into a pathogenic organism is small.

Finnish Safety and Chemicals Agency (Tukes)

Helsinki
PO Box 66 (Opastinsilta 12 B)
FI-00521 Helsinki

Tampere
Yliopistonkatu 38
FI-33100 Tampere

Rovaniemi
Valtakatu 2
FI-96100 Rovaniemi

Telephone switchboard
+358 29 5052 000
www.tukes.fi
kirjaamo@tukes.fi

Business ID 1021277-9

Can root rot be prevented without using plant protection products?

According to the experts interviewed for this report, plant protection products are essential for preventing root rot. Finland's climate, mild winters (now a common phenomenon) and the current infection pressure mean that stump treatment will become more important in the future. Extending the stump treatment requirement to peatland is one issue under consideration in the revision of the Forest Damages Prevention Act (1087/2013) now under way.

Non-chemical prevention methods are not sufficient but they can be used alongside stump treatment. For example, ending summer harvesting would definitely reduce the risk of root rot and the need for stump treatment but it would not be a realistic alternative from an economic perspective. In continuous-cover silviculture, measures to prevent root rot must be taken on a more frequent basis and summer harvesting is not recommended from the perspective of the efforts to prevent root rot. Mild winters also reduce the protective effect of snow.

There could also be only one thinning per rotation period. The establishment of mixed forests could also prevent root rot infections because in such forests, broadleaved trees (which do not require stump treatment) could be removed in thinning. After regeneration felling, a broadleaved stand can be grown at the site. Removal of stumps can also reduce (but not prevent) root rot because the stumps and root parts can act as sources of infection for new saplings. However, stumps cannot be removed in connection with thinning. Moreover, the low energy value of rotten stumps may make their removal less attractive (Piri & Hamberg 2015).

Climate impacts of urea and *Phlebiopsis gigantea*

It was concluded in the report that there is too little unambiguous information about the climate impacts of urea and for this reason, the matter could not be discussed in this report. The ammonia emissions arising from the use of urea as a plant protection product in forestry may be fairly small and it is not clear whether the calculations concerning the carbon footprint of urea and *Phlebiopsis gigantea* are comparable and how well they actually describe the carbon footprint of the products.

Not enough information on the consideration of the environmental aspects (such as the carbon footprint) in the selection of the stump treatment substance could be found for this report. However, the conclusion is that the ease of use and the price are usually the key criteria used in the selection process. At the same time, however, the interest in the use of biological stump treatment substances among forest owners may indicate interest in environmental impacts among this group.

4. Evaluation of the findings

The report provides an overview of the current use of urea as a plant protection product and the state of the prevention of root rot in Finland. The conclusion is that the risks arising from the use of urea as a plant protection product are properly managed in Finland and the prevention of root rot is well-planned and carried out in a thorough and professional manner. Preventing root rot should remain a statutory

obligation. The report also shows that fully replacing urea with other prevention methods is not possible at the moment.

Based on the report, the prevention guidelines used in Finland are more consistent than those used in Sweden. However, there are reasons to be concerned about the future of urea as an active substance and if, due to the absence of the required research findings, the approval for urea cannot be renewed, the search for alternatives should be started without delay. There is a danger that prevention costs will rise if urea is withdrawn from the market and only one *Phlebiopsis gigantea* product provided by one supplier would available.

Based on the report, it can be concluded that the harmonised risk indicator 1 (HRI 1) does not describe the actual risk arising from the use of plant protection products in Finland and that HRI 1 treats Finland unfairly compared to other EU Member States. This is because higher sales volumes of urea are the only reason why Finland's HRI 1 has risen. In Finland, urea is only used as a plant protection product to treat stumps so that root rot can be prevented, which means that when it is correctly used, there is no risk to humans, the environment or water bodies. In some EU Member States, urea is also used as a plant protection product in agriculture. In fact, statistics on the use of plant protection products in agriculture and forestry should be separated so that the risk indicator could give a more accurate picture of the risks arising from the use of plant protection products.

Finnish Safety and Chemicals Agency (Tukes)

Helsinki
PO Box 66 (Opastinsilta 12 B)
FI-00521 Helsinki

Tampere
Yliopistonkatu 38
FI-33100 Tampere

Rovaniemi
Valtakatu 2
FI-96100 Rovaniemi

Telephone switchboard
+358 29 5052 000
www.tukes.fi
kirjaamo@tukes.fi

Business ID 1021277-9

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Appendix 2. Abstract

UREA project

The Finnish Safety and Chemicals Agency collects the sales volumes data on plant protection products on an annual basis, and the EU also uses the figures to calculate harmonised risk indicators (HRI 1 and HRI 2). The purpose of the risk indicators is to measure the achievement of the targets set out in the framework directive on the sustainable use of pesticides. Based on HRI 1, the overall risk caused by the use of plant protection products appears to have increased in Finland during the monitoring period 2011–2017. The indicator comprises the sales volumes of four categories of plant protection products but because of weighting factors and sales volumes, one category has the highest impact on the indicator (88–96%). In this category, urea is the substance with the highest sales volumes as it accounts for between 43% to 70% of total sales in the category. The increase shown by the indicator is solely due to an increase in urea sales, whereas the sales of other substances have decreased compared with the baseline period 2011–2013. Urea is used to prevent root rot in forests. Under the Forest Damages Prevention Act (1087/2013), forest owners must carry out the preventive measures in conifer-dominated forests in connection with summer harvesting. Unlike most other plant protection products, urea has not been developed to destroy the organisms to be prevented but it causes eutrophication and damages ground vegetation. Increasing use of urea means that there is a worrying trend with regard to the sales of plant protection products and the risks arising from the products. One purpose of the project is to implement the National Action Plan in Finland.

Parties

Finnish Safety and Chemicals Agency (Tukes)

Helsinki
PO Box 66 (Opastinsilta 12 B)
FI-00521 Helsinki

Tampere
Yliopistonkatu 38
FI-33100 Tampere

Rovaniemi
Valtakatu 2
FI-96100 Rovaniemi

Telephone switchboard
+358 29 5052 000
www.tukes.fi
kirjaamo@tukes.fi

Business ID 1021277-9

Finnish Safety and Chemicals Agency Kaija Kallio-Mannila, Marja Suonpää and Emilia Hämäläinen (project worker)

Ministry of Agriculture and Forestry: Tove Jern and Tatu Torniainen

Natural Resources Institute Finland: Tuula Piri and Jarkko Hantula

Central Union of Agricultural Producers and Forest Owners: Lea Jylhä

Finnish Forest Industries: Maija Rantamäki and Mariela Marinova-Todorova

Association of Finnish Forestry and Earthmoving Contractors: Lauri Hyytiäinen and Simo Jaakkola

Coordinators

Emilia Hämäläinen (project worker, plant protection products)

Kaija Kallio-Mannila (Head of Unit, Plant Protection Products)

Tiina Putkonen (Deputy Director General, Chemicals)

Budget

Ministry of Agriculture and Forestry: EUR 16,000

Finnish Safety and Chemicals Agency EUR 5,000

Total EUR 21,000

Technical description

The project was carried out by interviewing experts and studying literature. Interviews with experts were carried out in a cooperation group and in this manner information could also be obtained from a wider group of experts and end users. Answers to questions on the situation in Sweden were received from the Swedish Chemicals Agency, Skogforsk and the Swedish University of Agricultural Sciences.

Objectives

The objective of the project was to examine the use of urea as a plant protection product in forestry, compare the amounts of urea used as a plant protection product with the use of urea as a fertiliser in the forestry sector, examine why the biocontrol product based on *Phlebiopsis gigantea* used in Sweden to prevent root rot is not widely used in Finland, examine whether the advantages and disadvantages of urea have been studied, and find out whether urea could be replaced with other methods.

Key findings

The sales and use of urea have increased at the same rate as felling volumes and the areas considered as risk areas. There are significant economic incentives to use stump treatment in healthy forests where the infection pressure is high. Stump treatment is required in both thinning and regeneration felling, and both urea and *Phlebiopsis gigantea* products are effective against root rot. According to the report, accuracy in stump treatment is high and the results are of even quality, which has an impact on the preventive effect. According to this report, urea is considered easier to use than *Phlebiopsis gigantea* products. Urea is also less

expensive, it can withstand sub-zero temperatures and it can be stored for long periods.

A re-evaluation for the use of urea as an active substance is under way and the work is carried out by Greece and Finland. The current approval for urea is in effect until the end of August 2020. Removal of urea from the list of active substances would be extremely worrying and the reduction in the number of alternatives would cause problems in stump treatment. It is estimated that the use of urea in the prevention of root rot accounts for about 10% of its use as a fertiliser if the fertilisation is carried out in accordance with recommendations.

Urea is not prohibited in Sweden but no approved urea products are currently on offer in that country. In Sweden, the taxation of chemical plant protection products is based on the content of the active substance in the product, which is the main reason why no applications have been received and urea is not used. Prevention of root rot is not a statutory obligation in Sweden and the disease is widespread. In Finland, all plant protection products are approved by the Finnish Safety and Chemicals Agency before they are placed on the market, which means that according to the agency, all urea products used in Finland are safe to human health and the environment when used in accordance with the instructions. According to the experts interviewed for this report, plant protection products are essential for preventing root rot. Finland's climate, mild winters (now a common phenomenon) and the current infection pressure mean that stump treatment will become more important in the future.

Evaluation of the findings

The report provides an overview of the current use of urea as a plant protection product and the state of the prevention of root rot in Finland. The conclusion is that the risks arising from the use of urea as a plant protection product are properly managed in Finland and the prevention of root rot is well-planned and carried out in a thorough and professional manner.

Based on the report, the prevention guidelines used in Finland are more consistent that those used in Sweden. However, there are reasons to be concerned about the future of urea as an active substance and if, due to the absence of the required research findings, the approval for urea cannot be renewed, the search for alternatives should be started without delay.

Based on the report, it can be concluded that the harmonised risk indicator 1 (HRI 1) does not describe the actual risk arising from the use of plant protection products in Finland and that HRI 1 treats Finland unfairly compared to other EU Member States. This is because higher sales volumes of urea are the only reason why Finland's HRI 1 has risen. In Finland, urea is only used as a plant protection product to prevent root rot, which means that when it is used in accordance with instructions, there is no risk to humans, the environment or water bodies. In some EU Member States, urea is also used as a plant protection product in agriculture. In fact, statistics on the use of plant protection products in agriculture and forestry should be separated so that the risk indicator could give a more accurate picture of the risks arising from the use of plant protection products.

Publications

No publication on the UREA project will be produced because the project was of short duration and preparing a report was the main purpose of the work. The

project ends with a final report, which can be used as a basis for well-justified practical proposals and instructions for preventing root rot.

Finnish Safety and Chemicals Agency (Tukes)

Helsinki
PO Box 66 (Opastinsilta 12 B)
FI-00521 Helsinki

Tampere
Yliopistonkatu 38
FI-33100 Tampere

Rovaniemi
Valtakatu 2
FI-96100 Rovaniemi

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