

The road to an environmental friendly wax protection of conifer seedlings



Photo: A.B. Eriksen, UiO



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PROTECTION AGAINST PINE WEEVIL



Photo: Claes Hellqvist, SLU

- **Pine weevil** (*Hylobius abietis*) an serious economically destructive insect pest in the forest.
- **Insecticides**, the main protection method since 1940s and it start with DDT. An effective insecticide, but an adverse problem for the environment, wildlife birds, bees, agricultural animals and humans.
- **Need** for an insecticide-free protection method for the conifer seedlings?
- **In the 1990s**, a new idea to an insecticide free method came to the Research Center, NORSK HYDRO:
- **Wax cover around the stem of the conifer seedlings.**



Photo: A. B. Eriksen, UiO

The start of the wax protection idea

- **Co-operation** with Norsk Hydro and Stora Enso Skog AB in 1992
- **Norsk Hydro** produced the wax «Bugstop»
- **Sjögränd Nursery** produced conifer seedlings
- **A waxing machine** was developed and placed at Sjögränd Nursery
- **The protection effect of wax** against pine weevils was tested in field experiments in the forest
- **Claes Hellqvist** at SLU, designed the field experiments. Evaluated the protection effect against pine weevil. Compared controls, wax and insecticide treated plants.

Field experiments with different wax types



Bugstop 93 (soft wax)

(Photo Claes Hellqvist, SLU)

- **Experiments from 1995 to 2000:**
- The field experiments showed that wax protected the seedlings.
- The pine weevil attacks decreased:
Damaged seedling from 49 to 28% and
dead seedlings from 41 to 16 %.
- **Wax treatment could also damage the seedlings. Giving necrotic dark colour to the inner bark at the stem base.**
- High temperature in the field, melt the soft wax (Bugstop 93).
Low molecular compounds migrated into the stem and the cambium, which damaged the seedlings.

Problems to solve

- Develop wax types not harming the seedlings
- Develop wax types melting at higher temperatures
- The seedlings protecting period for 2 years



Photo: A.B. Eriksen, UiO

Norsk Wax A/S start in 2000

Co-operation Norsk Wax, Stora Enso Skog, SLU and University of Oslo



Photo: A.B. Eriksen, UiO

Wax: Bugstop 00,93,97and 98 (white)

Light level: sun exposed and shadow

Growth medium: soil with and without white perlite cover

Watering: every week and every 2. week

Replicates: 9; Treatment: 48

A new problem: The white wax, Bugstop 98, friendly for the plants, but cracks!

Stem growth without wax cracking

Increasing the wax plasticity by using environmentally and plant friendly compounds

Bugv98



New type C



Photo:28.04.2010, A. B. Eriksen, UiO

Stem growth: high 25 cm (114 %), diameter 3,4 mm (126%)

Spruce seedlings with New type C wax

Temperature regimes; **A.** 23 °C - 8 °C; **B.** 19 °C - 13 °C; **C.** 30 °C - 18 °C .



Photo A.B.Eriksen, UiO.

- New type C wax :**
- 1. No negative effect on plant growth**
 - 2. No serious wax cracking after «2 years growth»**
 - 3. Field experiment, good protection against pine weevil**

EU-project: WeevilSTOP

1. Development of a cost-effective and sustainable insecticide-free plant protection method against pine weevil
Hylobius abietis
2. Development of an automatically waxing machine



Long-term growth experiments

Wax – plant interactions

The experiments are designed to examine a great range of wax thicknesses and heights to uncover the limits of:

- **what the plants can tolerate**
 - Heights of the wax: 0-100 % of plant height
 - Thickness of the wax: thin wax layer and up to 200 % increase in thickness
- **what the wax can endure** (plastic deformation or cracking)
 - Stretching as the plant stem diameter increases
 - How long does the wax cover the stem? Two years or longer?

Long-term experiment at the Phytotron



The experiment started December 2012.

| | |
|-------------------------|--|
| 3 seedling size: | 20, 25 and 28 cm |
| 3 wax thickness: | 1, 2 and 3 layer |
| 6 wax height: | 10, 15, 20 cm, 30, 40, 50 % of plant height |



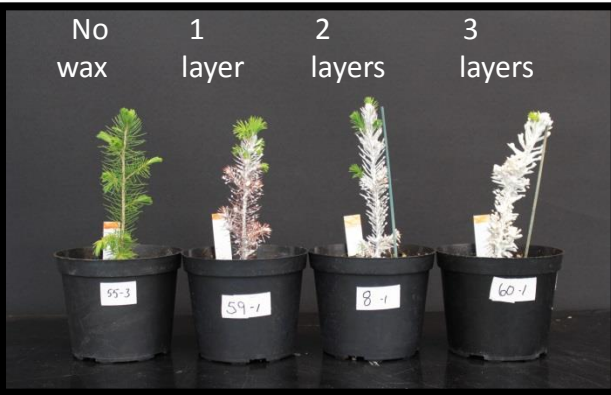
Photos: A. Vollsnes, UiO

The experiment finished March 2013

Long-term experiment at the Phytotron

Wax qualities – plant tolerance

Small plants (20 cm)



Medium plants (25 cm)



Large plants (28 cm)



20 cm wax height, 1 to 3 layer wax on 20 cm high plants.

60 % wax cover no growth reduction

**Growth period:
4 months**

Root growth capacity experiment

RGC



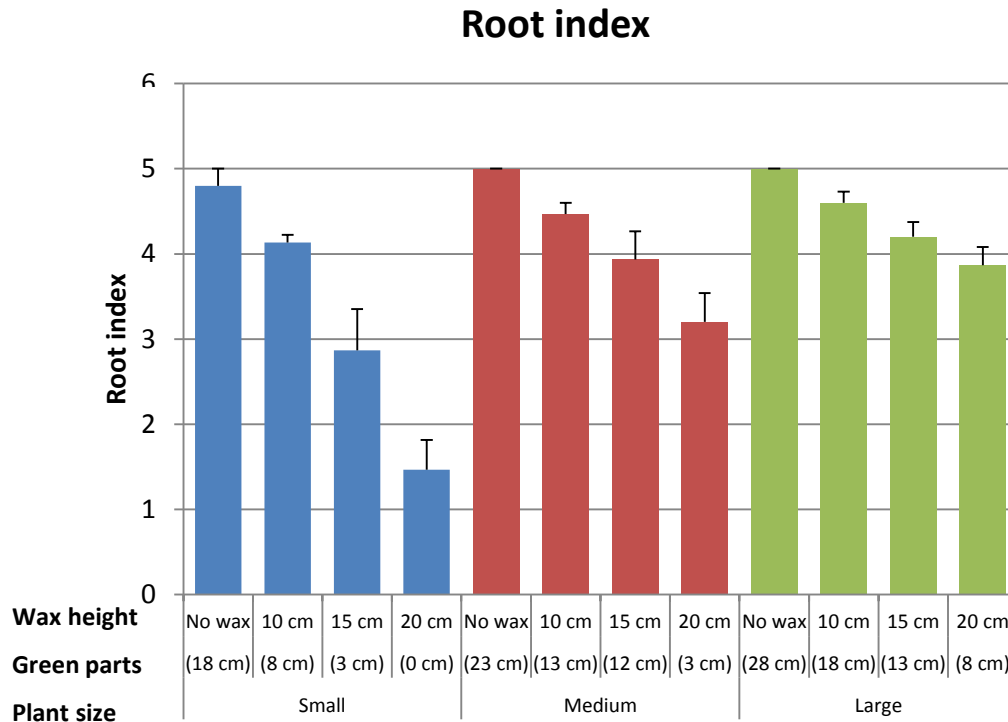
Start 2012



Five weeks
later

- Three plant sizes
- Six heights of wax cover
- Three thicknesses of wax cover
- 5 replicates of all combinations and totally 285 plants

Root growth capacity



Root index 5: >31 new roots
 Root index 4: 11-30 new roots
 Root index 3: 6-10 new roots
 Root index 2: 1-5 new roots

Root index is reduced as wax height increases

The green parts collecting energy for root growth are covered in wax

With 8 cm or more of the shoot above wax, the root index is 4 or 5 (60 % wax cover)

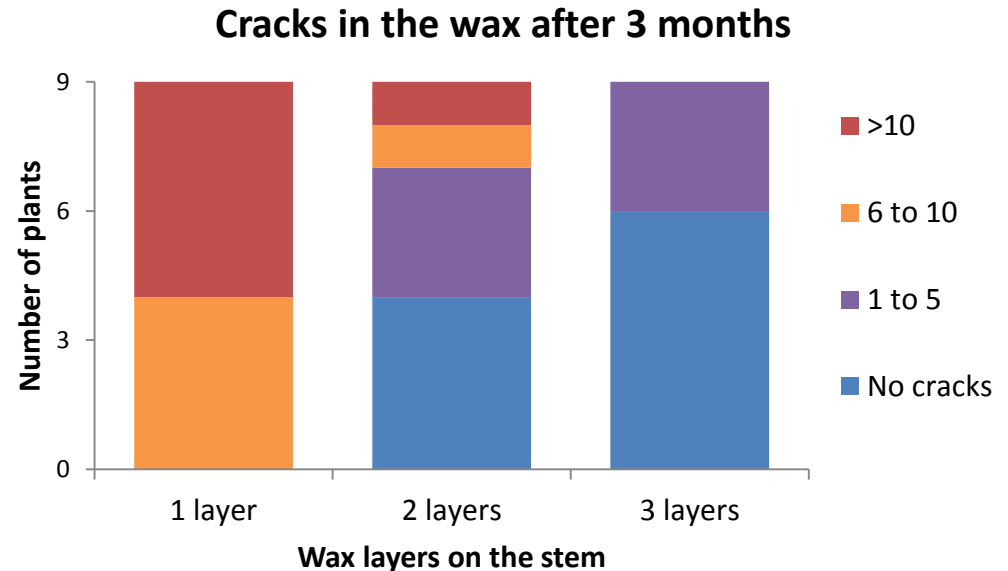
Long-term growth experiment

Plant – wax cracking

- Stem diameter increased 190-230 % during the experiment
- No flexible and plastic wax: expect at least 66-70 % of the stem to be free of wax at harvest
- Many of the plants given two or three layers of wax had less than 5 cracks and therefore most of the stem still covered by wax after 3 months

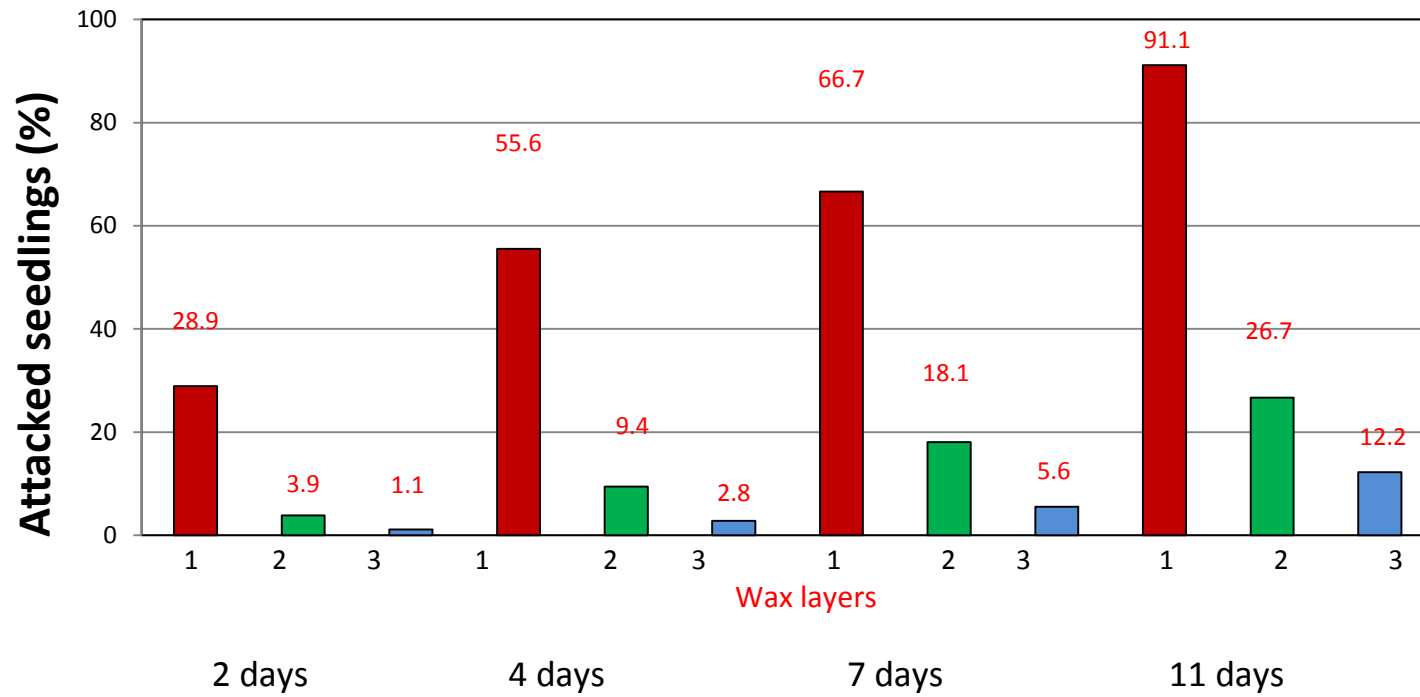


3 layer wax



Effect of wax layers on attacked seedlings by pine weevils

Experiments at SLU



Four pine weevils and one seedling

Photo A.B.Eriksen, UiO.

“OECD Guidelines for Testing Chemicals, Collembolan reproduction test in soil”



Photos: S. Sengupta, UiO.

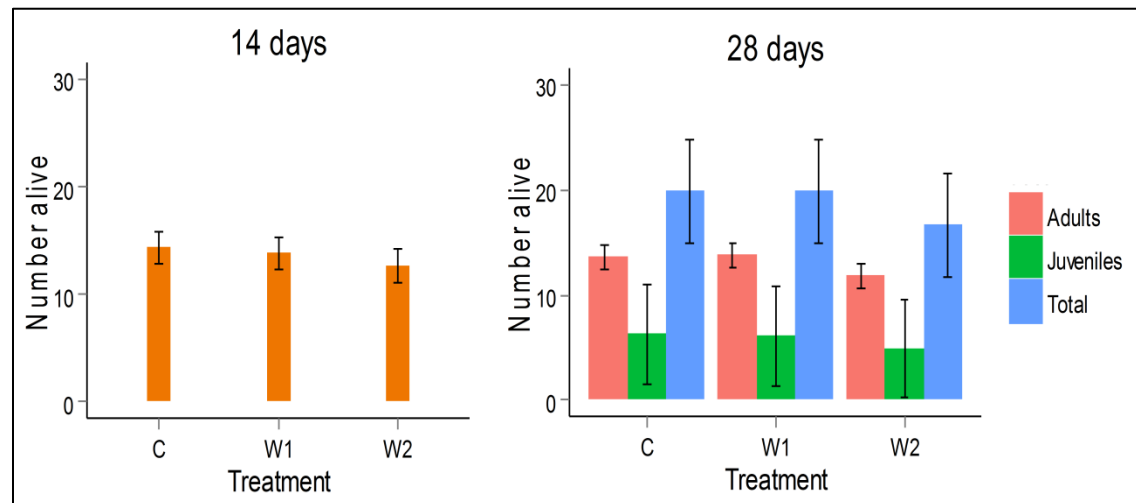
Spring tail (*Folsomia quadrioculata*) used as a model organism in the experiments.

The animals were reared in small boxes with 0,4 g soil.

Treatments: C : Control, wax free

W1: 1,3 mg wax/box

W2: 10 mg wax/box

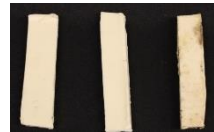
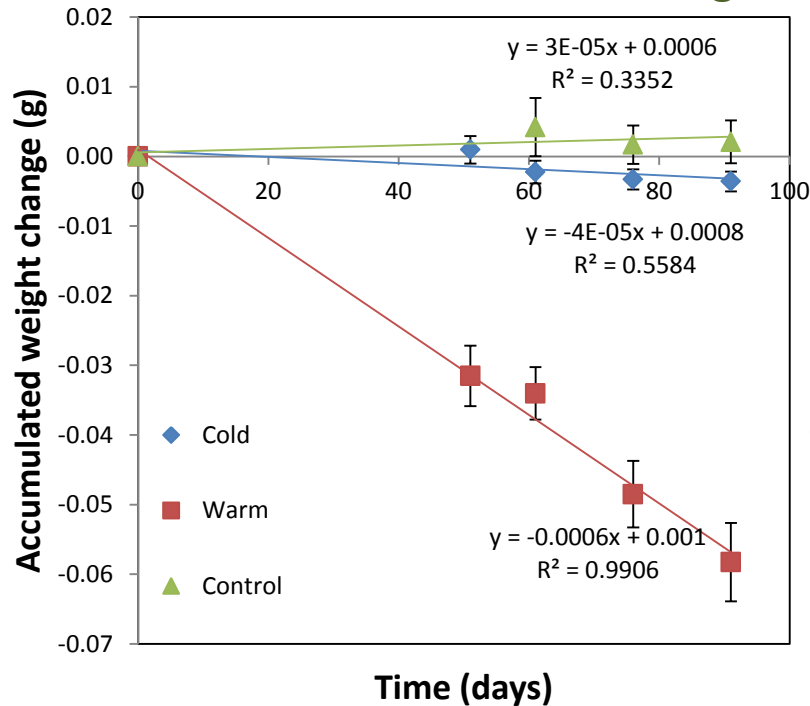


No difference in growth and reproduction of the animals in the boxes with wax mixed soil and the control boxes. No significant differences in the number of adult and juvenile animals.

Wax degradation

- A long protection period puts strong emphasis on the wax quality
- Important parameters are plasticity, elasticity, low cracking and degradation
- Continuous wax layer from root neck, stem base and up stem are needed
- At transplanting the root neck and stem base are covered with soil and the wax should provide long-term covering. Pine weevil girdling of this part will result in dying seedlings.

Wax degradation in soil



Wax sticks (20 x100x10 mm) covered in trays with soil with a water content of 60 to 70 %. 6 trays were placed in each dark rooms at 20C and 8C for 604 days .

The degradation loss was significantly higher at 20 C than 8C and it is a slow process. The was loss at 20 C was 0,164 % of the wax stick after 79 days.

Wax biodegradability

The inherent biodegradability of the wax was compared with paraffin and bees wax. Two OECD tests:301d (Ready Biodegradability, closed bottle test (UiO) and 302b(Zahn-Wellens/EMPA test). The decomposition is measured by the consumption of oxygen or production of carbon dioxide.

Norsk wax found that the degradation of wax, paraffin and bees wax levelled out after 70 days and reached reached 57+3 %, 92+5% and 69+5%. Inherent Biodegradable.

Results from the EU-project WeevilSTOP:

- 1. An environmentally friendly spruce seedling protection method against pine weevils. Protection of the spruce seedlings (1-2 years plug plants) for 2 years**
- 2. Wax thickness from 1mm to 1,4 mm**
- 3. Wax height larger than 10 cm, up to 15 cm**
- 4. 60 % of the plants can be covered by wax without reducing the plant growth**
- 5. A prototype for automatized waxing system for spruce seedlings is constructed.**



Photo: A.B.Eriksen, UiO.

Thanks for your attention!

