SILAVA   LATVIJAS VALSTS MEŽI

Improving seed production from forest seed orchards in the Baltic Sea region countries – establishment, management, flowering stimulation and protection

Meža koku sēklu plantāciju apsaimniekošana Baltijas jūras reģiona valstīs – ierīkošana, kopšana, atzarošana, aizsardzība un ražības veicināšana

April 5, 2013 / Riga, Latvia   2013. gada 5. aprīlis / Rīga, Latvija

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9:00 **Opening of the conference**
Martins Gaigals

9:10 **Seed orchards in Latvia: present and future**
[*Sēklu plantācijas Latvijā: šodien un nākotnē*]
Guntis Grandans, Laima Zvejniece

9:30 **Seed orchards in Estonia: past, present and future**
[*Sēklu plantācijas Igaunijā: pagātne, tagadne un nākotne*]
Aivo Vares, Esko Krinal

9:50 **Pruning of seed orchards in Lithuania**
[Vainagu veidošana sēklu plantācijās Lietuvā]
Vidmantas Verbyla (**Remigijus Bakys**)

10:10 **Revised seed orchard strategy in Poland**
[Atjaunotā Polijas sēklu plantāciju stratēģija]
Jan Kowalczyk, Jerzyna Przypaśniak and Marak Rzońca

10:30 Discussion

10:50 Coffee break

11:10 **Management of seed orchards in Germany**
[Sēklu plantāciju apsaimniekošana Vācijā]
Volker Schneck, Dagmar Schneck

11:40 **Basic principles of developing forest tree seed orchards in Sweden**
[Meža sēklu plantāciju attīstības pamatprincipi Zviedrijā]
Curt Almqvist

11:55 Discussion

12:10 **Starting seed orchards of other conifer species. Why?**
[Sēklu plantāciju ierīkošanas citām skuju koku sugām. Kādēļ?]
Bo Nilsson

12:30 **Birch seed orchards in Finland**
[Bērza sēklu plantācijas Somijā]
Sirkku Pöykkö

12:50 Discussion

13:05 Lunch

14:00 **Forest insect outbreaks in Sweden 1971-2012 – monitoring and control**
[Meža kukaiņu masu savairošanās Zviedrijā 1971.-2012. – monitorings un kontrole]
Åle Lindelöw

14:20 **Insect damage in Norway spruce (*Picea abies* L. (Karst.)) seed orchards: introduction to solutions**
[Kukaiņu bojājumi parastās egles sēklu plantācijās: iesējamie risinājumi (ievads)]
Tiina Ylioja

14:45 **Pest management in Swedish spruce seed orchards**
[Kaitēkļu kontrole egles sēklu plantācijās Zviedrijā]
Olle Rosenberg, Jan Weslien

15:10 **Managing cone and seed insects with semiochemicals**
[Čiekuru un sēklu kaitēkļu ķīmiska kontrole]
Olle Anderbrant *et al.* (Anderbrant O., Wang H.-L., Svensson G.P., Jakobsson J., Jirle E.V., Rosenberg O., Weslien J., Liblikas I., Millar J.G., Löfstedt C.)

15:30 Discussion

16:00 Coffee break

16:15 **Methods to stimulate flowering and seed production in spruce seed orchards**
[Ziedēšanas un sēklu ražas stimulēšanas metodes parastās egles sēklu plantācijās]
Curt Almqvist

16:40 **Practical experience from seed orchard management**
[Sēklu plantāciju apsaimniekošanas praktiskā pieredze]
Staffan Nilsson, Bo Nilsson

17:00 **Genetic variability of the breeding population of pine (*Pinus sylvestris* L.) in seed orchards from Susz**
[Parastās priedes sēklu plantācijas Susz selekcijas populācijas ģenētiskā daudzveidība]
Paweł Przybyslski, Małgorzata Borys, Jolanta Bieniek

17:15 **Closing discussion; end of the conference**

POSTERS

Genetic diversity of Norway spruce (*Picea abies* (L.) Karst.) seed orchard progenies in Latvia
Aris Jansons, Angelika Voronova-Petrova, Dainis Rungis, Krista Kanberga-Silina, Baiba Dzerina

Genetic diversity in Scots pine (*Pinus sylvestris* L.) seed orchards in Latvia and factors affecting it
Aris Jansons, Imants Baumanis, Dainis Rungis, Una Neimane

Factors determining formation of lammas shoots in young stands of Scots pine in Latvia
Aris Jansons, Oskars Krisans, Liga Purina, Juris Rieksts-Riekstins

Seed orchards in Estonia: past, present and future

Aivo Vares, Esko Krinal (Aivo.Vares@rmk.ee)

The selection of forest trees of the economically more important species (Scots pine, Norway spruce, silver birch) has been ongoing in Estonia since 1959, when the first plus trees of Scots pine were identified in the forest stands. The selection of Norway spruce plus trees began in 1963, the first plus trees of silver birch were selected in the beginning of the 1970s. By 1976, 424 pine plus trees, 200 spruce plus trees, and 26 birch plus trees had been selected. The grafts were harvested from the selected plus trees and first generation seed orchards were established using plants obtained by grafting. The first seed orchards were created in 1963 and during the next 20 years the majority of today's seed-providing Scots pine and Norway spruce seed orchards were established. A total 113,000 pine and 38,000 spruce trees were grafted during that time. From the seed orchards established at that time, there are 150 ha of pine seed orchards and 30 ha of spruce seed orchards that are actively managed at present. Unfortunately, no major silver birch seed orchards were established in the years 1960–2000. It was only in the 2000s when approximately 4 ha of silver birch seed orchards and one greenhouse seed orchard (with an area of 1,000 m^2) were established.

In 2003, the Estonian forest seed management development plan until 2030 was prepared. It analysed the state and needs of the seed management sector and set concrete objectives for improving the situation. The development plan was aimed at establishing new seed orchards every year in such volumes that would be sufficient to supply Estonian nurseries with seeds from seed orchards. To reach this objective, there should be at least 170 ha of pine seed orchards, 70 ha of spruce seed orchards, and 4 ha of birch seed orchards (incl. one greenhouse seed orchard) in Estonia.

As of the end of 2012, there were 200 ha of seed-producing seed orchards and 60 ha of young seed orchards in Estonia. Seed-producing pine seed orchards covered 165 ha and seed-producing spruce seed orchards covered 32.8 ha. Currently, there are 402 pine clones and 175 spruce clones growing in different seed orchards. The pine and spruce clones growing in seed-producing seed orchards are used for the establishment of new seed orchards. The authority responsible for the establishment and management of all state-owned seed orchards is the State Forest Management Centre. In 2001–2012, the average annual output of seed orchards was 1.3 kg/ha for Scots pine (1.8 kg/ha in the seed year) and 5.9 kg/ha for Norway spruce (34.2 kg/ha in the seed year). During that period, the seed productivity was considerable in six years for the pine (2002, 2004, 2005, 2007, 2008, 2012) and in two years for the spruce (2001, 2007).

In 2011, a Scots pine and Norway spruce progeny test project was initiated. The most important activities under the first stage of the project are to obtain initial material (plus trees from the stand, clones from seed orchards) and to test their progeny. Progeny test plantations include plants grown from the seeds of clones growing in the seed orchards and of plus trees selected from the stand: 300 seed orchard clones and 150 new plus trees for Scots pine, 150 seed orchard clones and 300 new plus trees for Norway spruce. The plantations will have a total of 45,000 pine and 45,000 spruce plants. From every new plus tree (450 trees in total) it is also intended to get 20 grafted plants, in order to grow them in a seed orchard (9,000 grafted plants in total). On the basis of the information received as a result of the first stage of progeny tests, 10–15 % of the superior clones will be selected, which will enable to establish 1.5 generation seed orchards in Estonia.

Pruning of seed orchards in Lithuania

Vidmantas Verbyla (V.Verbyla@amvmt.lt)

Presently forest seed orchards in Lithuania are the most important form of seed farming. In Lithuania it is accepted, that 70 % of planted forests should originate from seeds, collected in seed orchards. To achieve this goal, state forest enterprises at the moment are using 449.7 ha of seed orchards. In the upcoming 10 years, 303.7 ha of additional seed orchards of improved genetic quality are planned to be established. Starting from 1990, there were established in Lithuania conifer seed orchards of second generation only. Deciduous tree breeding in Lithuania took place later than conifers, and this is the main reason of second generation deciduous seed orchards establishment since 2013 and this is achieved for silver birch and black alder. For the establishment of seed orchards of other most important in silviculture deciduous tree species, additional evaluation of seed trials is necessary in the future.

Albeit considered as the source of most valuable seed production, seed farming in the orchards faces certain difficulties, particularly expensive and often complicated collection of seeds from growing trees. The most effective way to overcome this problem is pruning of tree crowns.

There are no commonly accepted methods of seed orchards pruning in Lithuanian forest state enterprises, mainly because lacking of practical experience. Majority of foresters in Lithuania agrees only with low intensity (top shearing) tree crown pruning, but there are many of those, that are against any pruning. The main argument against pruning is diminished seed yield and the life of the orchard itself. Nevertheless, majority of seed orchards are pruning of relatively various level of intensity, depending on species of the trees. Several old seed orchards of conifers are not pruned anymore.

To achieve more pronounced flowering, fruiting, quality of seeds and to lower the expenses of seed farming, we suggest more intense pruning in seed orchards is required disregarding tree species. Such pruning consists of: 1) top shearing of the crowns; 2) side shearing of the crowns and 3) crown thinning (renewal).

The height of Scots pine should be reduced then trees reaching 1.3-1.5 m by removing the top shoot every 2-3 years. For Norway spruce, top shoots should be removed when trees achieve 3-5 m in the mast years, usually every 3-7 years. Deciduous trees should be shortened after they grow up to 3-5 m; such pruning, however, should not exceed more than 1/3 of existing crown.

Side shearing is important regardless the tree species grown in the seed orchard. Such pruning helps to maintain desirable size of the crown. Usually 1-to-2 year old shoots are removed at the same time as top shearing. If side shearing is accomplished in good time, it helps to escape snowbreaks and windfalls.

Crown thinning is effective only for tree species evenly fruiting in the whole crown. If trees are fruiting only in the outer surface of the crown, thinning is of little effect. Primarily old, fading, unproductive braches, growing to undesirable directions are removed; thick, skeletal shoots are rarely pruned.

Revised seed orchard strategy in Poland

Jan Kowalczyk, Jerzyna Przypaśniak and Marak Rzońca (j.kowalczyk@ibles.waw.pl)

In Poland, forest tree breeding is conducted in two parallel methods. The first method is based on the seed stands selection and utilisation of the seeds from these stands (population selection). The basic importance of population selection is maintained which should satisfy 60% of the needs for seed. Low-intensity breeding (improvement) provides a small gain, but were consistent with the principles of sustainable forest management closer to nature and protect genetic diversity in forests stands. In parallel, either the plus tree selection as second method is conducted. It resulting establishing seed orchards (SO): vegetative and generative. In Poland often generative seed orchard are established as objects combining production of improved seeds with genetic testing (Kowalczyk 2008). According the internal register of State Forest there exists 96 – generative on 667 ha for 14 forest tree species and 174 – vegetative on 1234 ha for 18 forest tree species at present time in Poland. Most of them use open pollination progenies from trees phenotypically selected in forests. All generative seed orchard are designed in spacing 5 x 5 m, vegetative are designed 6 x 6 m. Until 2005 no crown pruning has been applied. Nowadays crown pruning is applied on selected youngest SO. The first thinning is planned after 10–15 years. Seed orchards in Poland are fully funded by the State Forests. Supervision over the SO leads IBL. All existing SO are the first generation. Some of the them where after genetic thinning where the worst clones were eliminated from SO based on breeding value. Despite the fact that Poland has a large number of SO, seed production from plantations in period from 1990 to 2010 on average did not exceed 5%. This was due to availability of cheap and easy to obtain seeds from seed stands, reduction the use of seeds resulting by transfer rules, limited up to 20% share of the seeds of SO in afforestation and forest regeneration in last program for years 1991-2010 (Matras at all 1993), and the itself organization of seeds distribution.

The new tree breeding program emphasis on better use of seed orchards in Poland. It was assumed that in the next few years, the use of SO seeds will grow nearly 10 times up to 40% (Chałupka at all 2011). To achieve this ambitious goal the following actions were taken:

1) education and popularization of the use of seeds from the SO among foresters (seminars, articles in forestry newspapers);
2) creation a series of demonstration plots comparing seed stands and SO;
3) survey among SO managers.

Survey indicate the strengths and weaknesses of SO in Poland and suggest actions to be taken to better utilization of SO potential. The proposed actions are mostly organizational and directed to improve both the seed distribution system and delineation regions of seeds utilisation for each SO.

The planed task on seed orchard management include:

1) verification and categorization of SO (the verification of the plantation on the ground in terms of their suitability for forest management and potential using);
2) redefine the seed regions for SO;
3) improve seed distribution system (based on Internet application) and closer connection it with a large containerized nursery as well as preparing offer for international seed market;

We hope that measures already taken and planned will allow for better use of SO in Poland. Long term tree breeding and seed orchards interface and depend on each other. Seed orchards is the efficient method to deploy progress of tree breeding into forests.

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Management of seed orchards in Germany

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Seed orchards are a common tool for the effective production of high valuable forest seeds in Germany. First seed orchards were established in the 1950's. The approval of seed orchards is in the responsibility of the authorities of the Federal states (Laender). A national list of forest reproductive material was prepared and is updated periodically by the Federal Office of Agriculture and Food. This list contains amongst others information about seed orchards for the 26 species and one genus which are under the German act for forest reproductive material. Today 250 seed orchards are established for 26 of these species. One-fifth is seed orchards with Scots pine. These orchards occupy about 200 ha. Norway spruce, European larch and black alder have a larger number of seed orchards. The average area of an orchard is around 2 ha.

The management is carried out by the owner of the orchards. Most of the orchards are public owned (state forest enterprises). Recommendations for management are given by the forest research institutes or other authorities of the Federal States. These institutions check the condition of the orchards periodically. Minimum requirements for seed orchards are formulated in the German law about forest reproductive material in accordance with the EU directive 1999/105/EC on the marketing of forest reproductive material. It is recommended that the minimum number of clones or families within a seed orchard has to be 40 for major species and 20 for minor species. A lower number of clones are possible for older seed orchards or such in the category "tested". Up to now all seed orchards are established with grafted clones.

The amount of seeds harvested in the orchards varies highly between years and depends on the importance of respective tree species and the current seed set. Between 2004 and 2012 on average 1.1 % of harvested seeds came from seed orchards with large differences between species. Excluding beech and oaks the percentage is 5.6 %. The range is from 100 % for hybrid larch to less than 10 % for two-thirds of the species. But interest is increasing for harvesting seeds in seed orchards as well as for establishing new orchards in the last years.

The number of seed orchards in the category "tested" has increased in the last two decades significantly. Almost all of these orchards were approved as "tested" after comparative testing of their offspring. Offspring of different Scots pine seed orchards showed superiority in height growth compared to a control seed lot (selected stand) between 6.5 to 14.5 % after ten years. In an older test with volume growth of Scots pine seed orchard offspring was up to 20 % higher compared to the test average. Also for hybrid larch superiority of reproductive material from seed orchards is considerably (20-30 % height growth, 50-80 % volume growth).

Basic principles of developing forest tree seed orchards in Sweden

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The use of improved plant breeding stock is an effective way to increase wood production and thereby long-term harvest potential in Swedish forests. Today, forest owners are very aware of, and are very willing to use, improved plant breeding stock, but greater utilization is limited by the supply of improved seeds.

The Swedish forest land owners are in a joint effort working with the establishment of the third batch of seed orchards. The program are designed to give full seed supply for the whole country for Scots pine and Norway spruce. The orchard establishment is synchronized with the progress in the breeding populations. That means that at the same time as the breeders have make selections for a new breeding generation they also do the selections of clones to be used in a new seed orchard for that area. In this way the seed orchards in production phase will be as close to the breeding front as possible.

An analysis of seed supply shows that the primary shortage involves seeds of Norway spruce. Not until around 2030 will supply meet needs throughout the country with the current ambition on seed orchard management. In short term, the supply of Norway spruce seeds can be significantly improved with relatively simple and well known methods. Seed production can be increased at low marginal cost through more intensive orchard management, stimulation of flowering and control of seed-destroying insects.

Starting seed orchards of other conifer species. Why?

(Utilization perspectives for orchards start-ups to obtain highly valuable wood (larch, Douglas fir))

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Tree species division today. Enough or important to change to be prepared for…?

Threat pictures (examples**):**
Fungis - Insects - Wild animals
Climate change: Storms - Rain- and snowfalls - Flooding - Frost - Drought
Other Market and more Restrictions

With regard to this threats there are **many reasons to plan for changing the tree species division! What to think about when you have to use the right choice?**

For the site: Right tree species and provenances and preferably with different species in stands near each other.
Product demands – today and expected
Enviroment demands
Laws and Certifications

Examples of two suitable tree species: Hybrid larch (*Larix eurolepis*) and Douglasspruce (*Pseudotsuga menziesii*)
Description of why and choice of provenance
How to start up more breeding and orchards

Birch seed orchards in Finland

Sirkku Pöykkö (sirkku.poykko@metla.fi)

Forest insect outbreaks in Sweden 1971-2012 – monitoring and control

Åle Lindelöw (ake.lindelow@slu.se)

Insect damage in Norway spruce (*Picea abies* L. (Karst.)) seed orchards: introduction to solutions

Tiina Ylioja (tiina.ylioja@metla.fi)

Deficit of seed from Norway spruce seed orchards has continued for a decade in Finland. Cone years occur seldom and considerable amount of the crop is lost due to damage by cone and seed insects.

When the quality of cone corps was assessed during cone years from 11 - 15 Finnish seed orchards, the insect damage was low in 1989 but in 1995 more than 90% of the inspected cones was damaged by insects and in 2000 the level of insect damage ranged from 30 to 80%. In 2006 the insect damage was lower 10 – 30% but cone crop was severely infected by cone rusts.

The most severe and common insect damage is caused by spruce seed moth *Cydia strobilella* (Lepid., Tortricidae) and coneworm *Dioryctria abietella* (Lepid., Pyralidae). Cone maggot *Strobilomyia anthracina* (Dipt., Anthomyiidae) can be very abundant locally. Damage by cone loopers (*Eupithecia abietaria* and *E. analoga*) looks similar than the damage of coneworm. The abundance of spermatophages *Plemeliella abietina* (Dipt., Cecidomyiidae), and *Megastigmus strobilobius* (Hym., Torymidae) varies a lot from year to year.

Chemical control against above mentioned insects is challenging: multiple interacting species are targeted and larvae live protected inside the cones and cones are located in the upper canopy. In 2007 insecticides that had e.g. abamectin, spinosad, diflubenzuron and esfenvalerate as active ingredients were tested in Finland, Sweden and Norway, but at that time none of them proved efficient against the two major pests. *Bacillus thuringiensis* var. *aizawai* x *kurstaki* sprayed during flowering works against cone worm and cone loopers but it is not yet used in Finland. New studies in chemical control are needed for efficient insecticides and methods to evaluate the need and timing of their application.

Directive 2009/128/EC and new national legislation on plant protection demands integrated pest management approach starting from 2014. Forest seed producers lack those tactics. Therefore, in 2006 Nordic collaborative research on monitoring of *D. abietella* and *C. strobilella* with pheromone traps was started.

The first generation seed orchards established in the 1970’s are still in production phase. In most of them grafts are tall and terrain not level, thus the canopies are not easily accessed for spraying against insects. New seed orchards have been established after 2000. The goal of research is to have IPM strategies for cone and seed insects by the time they reach production phase.

Pest management in Swedish spruce seed orchards

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Insects hamper seed production in Swedish spruce seed orchards by feeding on cones and/or seeds, and are one important reason why there is a substantial lack of genetically improved spruce seedlings for reforestation. There are mainly four pest insects that cause severe damage. Three species of Lepidoptera- *Dioryctria abietella* Den et Schiff. (Pyralidae), *Eupithecia abietaria* Götze (Geometridae) and *Cydia strobilella* (L.) (Tortricidae), and one species of Diptera- *Strobilomyia anthracina* Czerny (Anthomyiidae). We have evaluated the efficacy of conventionally sprayed or injected insecticides to reduce insect damage.

Spraying of the biological insecticide *Bacillus thuringiensis* var. *Kurstaki* x *Aizawai*, targeted against lepidopteran species, during late flowering was found to reduce damage by *D. abietella* and *E. abietaria*. Spraying of the insecticide acetamiprid was found to reduce damage by *D. abietella* and *E. abietaria* somewhat and spraying of alpha-cypermethrin reduced damage by *D. abietella* and *S. anthracina*. No treatment reduced damage by *C. strobilella,* which probably was due to the feeding behavior of the larva. Injections of systemic insecticides and the flower stimulating hormone gibberellin resulted in damage reduction from *D. abietella* and *E. abietaria* and increased cone crop. Injection of insecticide directly into the tree stems is more expensive compared to conventional spraying, but cost efficiency increases as it is possible to increase cone crop at the same time. Injections also minimize possible negative effects by insecticides on the surrounding environment.

Managing cone and seed insects with semiochemicals

Anderbrant, O., Wang, H.-L[1], Svensson, G.P., Jakobsson, J., Jirle, E.V., Rosenberg, O., Weslien, J., Liblikas, I., Millar, J.G., Löfstedt, C. (Olle.Anderbrant@biol.lu.se)

Several insect species feed on spruce seeds and cause economic damage in seed orchards. In Europe, three moth species, viz. *Cydia strobilella* (Tortricidae), *Dioryctria abietella* (Pyralidae), and *Eupithecia abietaria* (Geometridae), significantly reduce the seed yield. One of the species, *C. strobilella*, is also a potential threat to regeneration of the endangered sandy spruce, *Picea mongolica*, in Inner Mongolia. Current methods to suppress these pest insects, including chemical insecticides and application of *Bacillus thuringiensis*, are not reliable or sufficient (1,2). Semiochemicals, in particular pheromones, can potentially be used for control as well as for monitoring of insects. The female produced sex pheromones have been identified for both *C. strobiella* (3,4) and *D. abietella* (5) and have been used in attempts to correlate trap catch with larval density in some Swedish spruce seed orchards. Since flowering, potential seed crop and damage vary enormously between years the data are difficult to interpret. Recently also volatiles emitted by flowers have been investigated and might be used for catching females and thus obtaining a complementary density estimate. In addition, a series of experiments to evaluate the possibility of using pheromone-mediated mating disruption for population suppression have been done. Trap catches of male *C. strobilella* and *D. abietella* in pheromone-treated areas dropped to almost zero, but so far we have not obtained reliable data indicating a reduction of the infestation in treated areas versus control areas.

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Project web page

http://www.lu.se/pheromonegroup/research/pheromones-for-managing-insects-in-spruce-seed-orchards

Acknowledgments

The research is supported by the Swedish Research Council Formas and The Swedish Tree Breeding Association.

Methods to stimulate flowering and seed production in spruce seed orchards

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Conifers of the *Pinaceae* family were first successfully induced to flower by gibberellin application in the mid-1970s, when the use of the relatively non-polar gibberellins GA_4 and GA_7 started. From that time and onwards numerous of research experiments using $GA_{4/7}$ for flowering stimulation has been performed, and generally with encouraging results. But practical use of the developed methods has been prevented because there has been no registered product available for use in seed orchards.

Together with GLOBACHEM Skogforsk and the Swedish seed orchard managers have now registered Gibb Plus Forest as a $GA_{4/7}$ product for use in flowering stimulation of conifer seed orchards. The product is approved until 2019.

Gibb Plus Forest require different application equipment compared to what commonly used by researchers and breeders. Together with the Swedish seed orchard managers Skogforsk has scanned the market and found a suitable equipment to use.

Even though $GA_{4/7}$ not is the magic wand we all are longing for and that it not give a positive result at every treatment occasion, economic calculation show good profitability.

Root pruning is a cultivation technique to induce drought stress to the orchard trees that can be used in combination with GA4/7 treatment. Girdling is another cultivation technique that should be avoided.

Practical experience from seed orchard: management

Staffan Nilsson (staffan.nilsson@sodra.com)

If we can do what we need to do when the measure/the activity gives optimal results we reach:
+ more grafts/cuttings survive
+ the crop will increase and come some years earlier

Therefor it is important;
- that the location of a seed orchard is on a suitable place,
- to follow scientist knowledge and good advises we get about seed orchards,
- to find the right person in the neighborhood who is responsible for running the orchard,
  the person must make sure that in all situations there has to be workers and machines in right time.

The presentation with a collection of photos will give you examples.

Genetic variability of the breeding population of pine (*Pinus sylvestris* L.) in seed orchards from Susz

Paweł Przybyslski, Małgorzata Borys, Jolanta Bieniek (p.przybylski@ibles.waw.pl)

The research results represent parameters of genetic variability analyzed on plus tree activity. The research was investigated using 13 isozyme markers and 2 highly variable microsatellite loci DNA: Spac 12.5 and Spag 7.14.The aim was to answer the question whether the narrow amount of maternal trees, in order to establish a seed orchard, results in restriction of genetic variability.

The research was investigated on a plant material collected from seed orchards of Scots Pine in Susz to compare strains from the same clones grown in the clone archive of forest trees in north-eastern Poland in Lomza. The plant material had been collected in early spring 2011 and was kept frozen in constant temperature of – 20 degrees Celsius until the analysis was investigated.

Laboratory examination of isozyme markers were based on testing procedure described in the work by Conkle and all. (1982) with a modification by Monchenko (1994) and Odrzykoski (2002). However, for the microsatellite DNA analysis of loci Spac 12.5 and Spag 7.14 the testing was investigated using the method described in Soranzo and all. (1998).

On the basis of the research, the narrowing of gene pool on a seed orchard has not been proved. The results are characterized by Wright fixation index: for isozymes F=0,04, for microsatellite DNA F=0,037. The investigated analysis tested $\chi 2$ of the genetic variability of isoezymes and DNA results have not proved lack of Hardy-Weinber equilibrium. For microsatellite locus Spag 7.14 it has been proved that the occurrence of numerous alleles null, hinders a statistic interpretation of the results. Alleles null significantly extend homozygousity of a tested population. Those two methods of molecular analysis were used in order to verify the correctness of seedling arrangement. The results indicate an adequate genetic sensitivity of given molecular markers to verify the correctness of seedling arrangement. For the tested object, the existence of about 31% false plants which are potentially responsible for the occurrence of majority genetic pollution on an analyzed plantation.

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Genetic diversity of Norway spruce (*Picea abies* (L.) Karst.) seed orchard progenies in Latvia

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Norway spruce is the third most widespread tree species in Latvia that occupies 537 thousand ha of forest land. Approximately 80% of its stands are regenerated using planting; therefore genetic composition of seeds for plant production has a large practical importance. Significant part of the seeds (33-45%) is obtained from seed orchards with current total area reaching 104 ha. Orchards are established based on phenotypic selections of plus trees predominantly in the region of its location. The aim of the study was to assess the possible influence from the use of seed orchard progenies on genetic diversity of young stands.

Material for the study was collected from progenies of two Norway spruce seed orchards: Remte – located in south-western part of Latvia, consisting of 50 clones, and Katvari – located in north-eastern part of Latvia, consisting of 20 clones. Random selection of 217 (for Remte) and 274 (for Katvari) progenies was done in progeny trials, where average samples of both seed orchards were represented, located in Forest research stations Auce (central part of Latvia) and Kalsnava (eastern part of Latvia) forest districts. Mature forest stands were represented by samples from randomly selected trees (with distance of 100 m) or seedlings from average seed sample of the stand. Stands were randomly chosen to represent western (3 stands, 139 trees in total), central (3 stands, 144 trees) and eastern (2 stands, 96 trees) provenance regions. DNA, extracted from the needles, was analysed with 6 nuclear SSR markers.

Results reveal that mean number of alleles per locus ranges from 10 (UAPgAG150) to 35 (EAC7H07) and no differences in this parameter between forest stands and seed orchard progenies were observed. Total number of alleles found is slightly larger, but number of effective alleles slightly smaller for seed orchard progenies in comparison to forest stands, however observed heterozygosity (Ho) did not differ between the analysed groups (Ho=0.61 and Ho=0.59 respectively). Significant differences were not detected also in values of diversity index (DI) and Shannon's Information Index (I): for the progenies of seed orchards DI=0.92 and I=2.0, for the forest stands DI=0.91 and I=1.9. Number of alleles with high frequency (≥5%), that are important for genetic stability of stand, is slightly higher for the progenies of seed orchards than for the forest stands. Differences are more pronounced in comparison with stands from the central and eastern provenance region.

It can be concluded, that the number of clones in seed orchards (20 and 50) is sufficient to avoid possible losses of genetic diversity for seed orchard progenies. Therefore use of seed orchard seeds for seedling production does not decrease the genetic diversity of young Norway spruce stands.

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Genetic diversity in Scots pine (Pinus sylvestris L.) seed orchards in Latvia and factors affecting it

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Genetic diversity has a fundamental role in species evolution and its capacity to adapt to changes in environmental conditions in long term. It can be considered as an insurance for species survival under pressure of different and changing abiotic (e.g. wind storms) and biotic (e.g. insects, fungi) influences. Therefore factors affecting genetic diversity of seed orchard crop need to be considered.

Genetic diversity level in seed orchard can be characterized by effective number of clones (N_e; Lindgren, Mullin, 1998) that is equal to actual number of clones, if all of them are unrelated and contribute equally to next generation. Usually effective number of clones is smaller than actual number due to: a) relatedness among clones; b) unequal number of ramets per clone; c) differences in flowering abundance; d) differences in flowering phenology, reducing chances to contribute to the next generation to some clones; e) differences in cone traits. Last two aspects are covered in case studies in Scots pine seed orchards in Latvia, finalized with actual comparison of genetic diversity indicators.

Flowering phenology was characterized in two Scots pine seed orchards – Dravas in the western part of Latvia (containing 65 Misa population clones), and Sāviena in the eastern region of Latvia (containing 76 Misa population clones and 86 Smiltene population clones). Phenological observations were made 6 times in the period between the 12th of May and the 3rd of June. The pine clones were categorized into 5 female flowering and 3 male flowering groups. It has been established, that significant flowering time differences occur both between populations and within populations between different clones.

Based on flowering time average values for the female flowering groups “very late”, “late”, “early” and “very early” were 5%, 27%, 13% and 1%, respectively. With regard to male flowering time, the size of the medium group in both populations was very similar – 56-57%. The remaining clones were all classified as early flowering, except for one clone from the Misas population, and one from the Smiltenes population. No correlation was found between strobile abundance and either male or female flowering time. Overall, early and late flowering clones maintained their phenological characteristics in differing environments.

The same group of clones from Sāviena seed orchard was used to analyse differences in cone opening level in seed extraction that also is one of the factors affecting contribution of particular clone in total orchards seed crop. Based on sample of 20 cones per clone, significant differences were found between clones in this trait, even so the size of cones was not significantly different.

In autumn 2011, seed material was collected from 18 Misa provenance plus tree clones, located in three seed orchards: Sāviena (orchard age 23 years), Dravas (23 years) and Norupe (8 years). Cone length and diameter were measured, and full seed number per cone and 1000 seed weight were determined. 48 seeds from each seedlot were germinated and DNA extracted for genetic diversity assessment, using 6 SSR markers. Additionally, bulked seed lots were obtained from Saviena (1999, 2006) and Dravas (2010).

Results reveal, that traits characterizing cone and seed properties (including number of seeds per cone and seed weight) were statistically significantly different between clones and orchards (years), however, clone mean correlation among orchards was significant and strong (r=0.7 on average).

Genetic diversity parameters of seeds obtained from seed orchards established with identical clones were similar to each other and between seed collection years, however similarities were higher between seeds from 3 different seed orchards in one year (2011) than between seed lots from the same seed orchards in different years.

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Factors determining formation of lammas shoots in young stands of Scots pine in Latvia

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Scots pine is the most wide-spread tree species in Latvia, covering altogether 29% of the total forest area (NFI data) and represented in wide range of forest types. It is important to minimize the risks affecting both quality and survival of trees, to ensure highest value of wood and forest services provided by pine stand. Risk assessment shall consider also possible influence of changes in climatic conditions, predicted to take place relatively rapidly within the rotation period of Scots pine (100-120 years). They include rise of temperature during vegetation period and increase of its length by more than a month by the end of this century in comparison to the reference period. Response of trees to the availability of a longer period of favorable growing conditions might include increased frequency of formation of lammas shoots – additional height increment due to free growth in the second half of vegetation period, after the end of formation of predetermined height increment. Lammas growth can notably influence quality of tree, increasing probability of spike knot formation, as well as higher number of branches per whorl and/or per meter of tree stem. Therefore aim of the study was to assess the proportion of trees with lammas growth in young Scots pine stands and factors affecting it.

Data have been collected in the central part of Latvia in 122 randomly selected Scots pine stands at the age of 3-7 years at the end of year 2011 and repeatedly in 22 stands at the end of year 2012. Forest types on mineral soil with normal or increased moisture and on drained peat and mineral soil, typical for Scots pine were represented in sampling. In each stand 20 sample plots (25 m^2) were placed systematically and number of trees with and without lammas shoots was assessed. Additionally lammas shoots were also assessed and height increments of trees measured in four consecutive years (from year 2009 to year 2012) in two Scots pine open pollinated progeny trials, established in year 2005 in *Vacciniosa* forest type, also located in the central part of Latvia.

Results reveal, that on average 8.3% of trees had lammas shoots; frequency was not statistically significantly different between the years, and the correlation at stand mean level was significant and weak ($r=0.47$, $p<0.05$), indicating relative stability and limited influence of micro-environmental conditions. Results from progeny trials reveal, that trees with lammas shoot in one year are more likely to form it also in following years, and differences between families in this trait were notable – ranging from 0% to more than 40% of trees with lammas shoots. Additionally, no clear link between the length of height increment and formation of lamas shoot was detected.

No age-related trend was detected – differences in frequency of lammas shoots between stands at the age from 3 to 8 years were not statistically significant. In contrast forest type had a statistically significant (χ^2 test, $p<0.05$) influence on frequency of lammas shoots. Highest value was found in stands on fertile drained peat soils (*Myrtillosa* turf. mel.).

Meteorological data collected directly in progeny trials suggest that increased air temperature in first two weeks of August (when formation of lammas shoots is typically starting) could be involved in triggering of free growth. This implies, that higher frequency of Scots pine trees with lammas shoots could be expected in future climatic conditions and this trait has to be included in selection index

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