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APPROVED
First Deputy Minister of Forestry
of the Republic of Belarus
_____ V. Shatravko

REPORT

On training on "Modern green technologies for application of plant-protecting agents and fertilizers in forest nurseries"

on **Contract No. BFDP/GEF/SSS/16/44/1-62/21**

dated March 29, 2021

Training of professionals engaged in forest sector, forest science, forest education and Ministry of Environmental Protection on issues related to sustainable forest management and forest use aimed to promote forest ecosystems resilience and conservation under climate change

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Minsk 2021

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EXECUTIVE SUMMARY

The general goal of the activity was to organize and hold a training workshop "Modern green technologies for application of plant-protecting agents and fertilizers in forest nurseries" on April 15–16, 2021. The target group of participants included forestry professionals, i.e., heads of forest nurseries, forest regeneration engineers and forest pathologists.

The workshop agenda comprised 20 hours split into the following key topics:

1) Main diseases of planting stock in forest nurseries (species composition, extension and harmfulness);

2) Main damaging agents of seedlings in forest nurseries of Belarus;

3) Modern system and technology for the protection of nursery stock against the incidence of pests and diseases. Measures to prevent the importation of pathogens and pests on plant seeds and purchased nursery stock. Basics of integrated control of pests and diseases of nursery stock;

4) Application of pest and disease management agents for nursery stock in forest nurseries. Main requirements to application of plant-protecting agents in the Republic of Belarus. Main pesticides (fungicides, insecticides, herbicides) certified for use in forest enterprises;

5) Safety and health in the use of plant-protecting agents and fertilizers;

6) Training of forest nursery workers on planning, treatment, fertilizing, watering and control of pests and diseases in order to promote survivability of ball-rooted seedlings and successful establishment of forest plantations (at the premises of Republican Breeding and Seed Production Centre (RBSPC));

7) Fertilizing and growth-promotion of nursery stock in forest nurseries.

The invited instructors were lecturers of Belarusian State Technological University: Vadim Nosnikov (associate professor, PhD (Agriculture), head of department), Marina Romanenko (senior lecturer, PhD (Agriculture)), Vassiliy Yarmolovich (associate professor, PhD (Biology)), Alexander Sazonov (group leader, RUE "Belgosles", senior lecturer of Forest Protection and Wood Science Department), Mikhail Asmolovskiy (associate professor, PhD (Engineering)), Alexander Ovsey (head of research department, RBSPC).

The workshop agenda was circulated among forestry enterprises (Appendix A) to identify the target group of forestry professionals who would sign up for the training.

The workshop audience included 22 participants (See Appendix B for the list of participants), among them workers of forestry enterprises, State Production Associations, the Ministry of Forestry and the republican Breeding and Seed Production Center (only for practical training).

The agenda included field training on application of fertilizers and growth-promotion agents for nursery stock in forest nurseries. The practical training was held at the premises of the Republican Breeding and Seed Production Center under the Ministry of Forestry (Shchomyslitsa agro-town, Minsk district).

The workshop kit consisted of an information brochure with key lecture notes, an instruction manual on specialized tools for application of plant-protecting agents,

workshop agenda, a participant's badge, a pen, a certificate of participation and a BSTU promo bag (Figure 1).

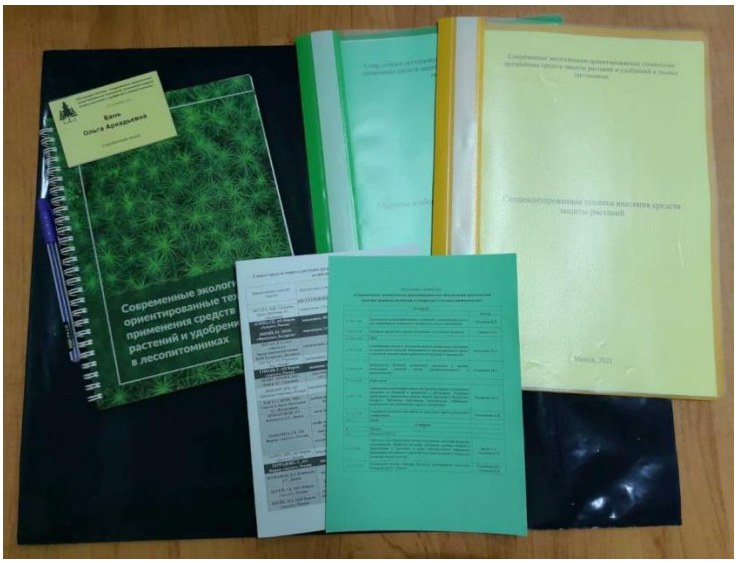

Figure 1 – Workshop participant's kit and handouts

1. The lecture "**Main diseases of coniferous planting stock in forest nurseries, their species composition, extension and harmfulness**" was dedicated to the extension and harmfulness aof plant diseases in forest nurseries, causes of infectious damping off, and symptoms of infestation of coniferous and deciduous sprouts and seedlings in protected grounds. It also focused on the causes of needle dieback, pine-leaf cast, rust diseases of needles. It was emphasized that the measures on protection of seedlings and planting stock should be integrated into the technology for their growing. The lecture dwelled upon such issues as monitoring, prevention and elimination of diseases and damage of coniferous and deciduous saplings and seedlings in forest nurseries by biological agents.

2. The lecture "**Main damaging agents of seedlings in forest nurseries of Belarus**" listed main pests of planting stock in forest nurseries. Special focus was made on rhizophagous pests, i.e., chestnut cockchafer, common cockchafer, European mole cricket. The lecture gave a detailed description of their biology, distribution, flight seasons and morphology, monitoring activities in forest nurseries.

3. The lecture "**Modern system and technology for the protection of nursery stock against the incidence of pests and diseases. Measures to prevent the importation of pathogens and pests on plant seeds and purchased nursery stock. Basics of integrated control of pests and diseases of nursery stock**" touched upon the structure of forest protection measures in forest nurseries, including forest health monitoring, cultural, chemical and biological control practices. The lecture involved the issue of plant quarantine of forest tree species which aims to prevent importation and exportation of quarantined plants and other damaging agents to and from the territory of Belarus.

4. The lecture "**Application of pest and disease management agents for**

nursery stock in forest nurseries. Main requirements to application of plant-protecting agents in the Republic of Belarus. Main pesticides (fungicides, insecticides, herbicides) certified for use in forest enterprises" dwelled upon the forest certification requirements to the safety of chemical plant-protecting agents used by the forestry enterprises of the Republic of Belarus. FSC policy prohibits the application of fungicides, insecticides and other plant-protecting agents classified as highly hazardous.

5. During the lecture "**Fertilizing and growth-promotion of nursery stock in forest nurseries**" the participants were introduced to the classification of mineral and organic fertilizers, physiological aspects of plant nutrition and how physical and chemical properties of soil affect the nutrition capacity of nursery stock by macro- and microelements. Special attention was given to antagonism and synergism of fertilizer elements in forest nurseries.

The lecture touched upon various diagnostic techniques to determine the lack of nutrients in the soil of forest nurseries, benefits and drawbacks of each technique, application details of organic fertilizers and ways of making compost in Belarus and foreign countries, as well as application of extended fertilizers.

The participants were informed about the current classification of growth-promotion agents, their effect on plants, growth-promotion agents certified for use in the Republic of Belarus.

6. The lecture "**Safety and health in the use of plant-protecting agents and fertilizers**" provided a detailed description of health and safety regulations for the use of pesticides, as well as first aid to intoxication victims.

During practical training the participants were shown equipment for making substrates from mineral fertilizers with a special focus on making mineral fertilizer substrates for growing ball-rooted planting stock (Figure 2). The participants studied the system of supplementary fertilizing in greenhouses and nursery fields. The practical training included measurements of nutrient proportion by indirect study methods both in the substrate and soil solution to highlight their applicability for ongoing monitoring of the mineral status of ball-rooted seedlings.

Figure 2 – Demonstration of equipment for making substrates from mineral fertilizers

The lectures and practical training were met with great interest. The workshop participants actively discussed green technologies for application of plant-protecting agents, fertilizers and growth-promotion agents for the nursery stock in forest nurseries.

All participants demonstrated great motivation and active involvement in the workshop activities. Their positive feedback makes it possible to expect higher quality of nursery stock grown by green technology for application of plant-protecting agents and fertilizers.

In the wrap-up meeting the participants were awarded certificates of participation.

Figure 3 – Award of certificates of participation

The training workshop was given attention of print media (Belarusian Forest Newspaper, Issue 17 dated April 29, 2021) and social media (VKontakte, Instagram, Facebook). The report on BSTU website was hash tagged as #GEF.

Handouts have been made up into a teaching manual "Modern green technologies for application of plant-protecting agents and fertilizers in forest nurseries" designed for students of the Forestry study program, forest nursery workers, forest pathologists and forest regeneration engineers as a practical guide. The teaching manual has received several positive reviews (A.N. Smirnov, D.Sc. (Biology), professor, Department of Plant Protection, Russian State Agrarrian University – Moscow Timiryazev Agricultural Academy; Department of Forestry Studies, Gomel State University named after Francysk Skaryna; S.V. Panteleyev, PhD (Biology), senior researcher, Unit of Genome Studies and Bioinformatics, Forest Research Institute of Belarus NAS). The teaching manual will be approved by Educational and Methodological Association on Nature Management and Forestry for study program 1–75 01 01 Forestry. After the teaching manual receives the stamp of approval by the Ministry of Education, it will be circulated to all forestry enterprises that have forest nurseries.

The following information not included in the handouts was e-mailed to

78 forestry enterprises:

- Recommended measures to prevent the most common diseases and to protect nursery stock in forest nurseries;
- Recommended measures to protect nursery stock in forest nurseries against soil-inhabiting pests, instructions on specialized techniques for application of plant-protecting agents;
- List of plant-protecting agents included in the State Register and certified for forestry uses in the Republic of Belarus;
- FSC pesticides policy FSC-POL-30-001 V3-0 EN Draft translation;
- FSC highly hazardous pesticides FSC-POL-30-001a RU;
- Video «Technology for growing ball-rooted nursery stock» https://youtu.be/Q7JWMOmbXBc;
- Video «Methods of water regime control and nutrition supply of plants» https://youtu.be/Z7IXKVcqYLM;
- Video «Egedal – fertilizer distributing machine (to be installed on a cultivator)» https://youtu.be/ALt3u8jbIcE.

INTRODUCTION

The GEF-funded "Belarusian Forestry Development Project" includes the project activity "Training of forestry professionals on the issues related to sustainable forest management aimed to promote forest ecosystem resilience and biodiversity conservation in the context of climate change".

Green and safe pesticides are being used in the Republic of Belarus in order to prevent dieback of nursery stock in forest nurseries. Greater emphasis is placed on preventive measures and biological control of pests and diseases.

One of the most reliable and efficient methods of afforestation and reforestation is planting of young trees. Cultural practices of forest planting in the Republic of Belarus are implemented in forest nurseries where planting stock, primarily, saplings and ball-rooted seedlings are grown.

Expansion of coniferous plantations is a priority task of forest nurseries in Belarus. The wood of aboriginal species, in particular, pine and spruce is highly valuable due to its outstanding strength, hardness, decay resistance and ease of processing. The wood of conifers is widely used by many industries as timber (stakes, logs, boards, lumber cants, mine props) as well as for the production of paper, cardboard, wood-based boards, fuel, etc.

Growing of planting stock in forest nurseries presents many challenges induced by pest attacks and diseases. Young trees, in particular, seedlings have weak ground tissues for a quite long period of time. High infection background and considerable weakening of plants by negative external factors as well as wrong cultural practices lead to local epiphytoties. Pests and diseases cause large-scale dieback of seedlings and reduce the number of planting stock pieces which produces a negative effect on the efficiency and cost-benefit of forestry enterprises.

Chapter 1

MAIN DISEASES OF PLANTING STOCK IN FOREST NURSERIES (species composition, extension and harmfulness)

M.O. Ramanenka, senior lecturer, **Department of Forest Protection and Wood Science, Belarusian State Technological University, PhD (Agriculture)**

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INFECTIOUS DAMPING OFF AND ROOT ROT

Pythium spp., Fusarium spp., Rhizoctonia spp., Alternaria spp.

Damping off and root rot appear as damping-off of seeds and germinants in soil, rotting of young rootlets, damping-off and dying of non-woody seedlings. The diseases affect mainly coniferous (pine, spruce, larch), while maple, linden, elm, poplar and other deciduous are less susceptible to them. Damping-off commonly affects 1-3-month-old seedlings. The disease is caused by various fungi that are mainly present in the soil or occasionally on the seeds.

Symptoms of the disease are not directly dependent on the causal agent. The symptoms may occur at the following stages: pre-emergence, post-emergence and root rot without damping-off. All the forms have a clearly focused (grouped) area of damage.

Pre-emergence damping-off kills germinants in the soil. The germinating ability of seeds is greatly weakened, sprouts are randomly distributed, seedlings occur in small patches, some of them demonstrate loss of vigour. Rotting occurs during seed germination. Damped-off seeds and dead germinants can be found in the soil.

Post-emergence damping-off can become obvious when the sprouts come out of the ground and become one month old until they lignify. The diseased lower stems become weak, stunted, chlorotic, turn brown and decay. The tops of diseased stems very often stay in seed caps as the plant tissue wilts. The roots of the diseased plants decay, the seedlings can be easily pulled out of the soil, the root tips are white and thin (Figure 4).

Figure 4 – Damped-off seedlings. Photo by V.A. Yarmolovich

Root rot symptoms become obvious on 1–3-month old shoots when damping-off is declining. The woody stem becomes resistant to damping-off causal agents and does not decay. However, the rootlets are affected by pathogens, begin to rot and the plant dries out without damping off (Figure 5). When the shoots are pulled out of the soil, the bark and cortex of the central root are easily stripped away to expose the cambium.

Figure 5 – Root rot of seedlings without damping off. Photo by M.O. Ramanenka

Table 1 describes pathogens and conditions noted to favour damping off organisms.

Table 1 – Conditions noted to favour damping off organisms

Pathogen	Temperature	Air humidity	Soil acidity	Cultural practices
Pythium spp.	10−25 °C	high	ρH about 5.5	- high sowing density; - high N fertilization; - excess of irrigation.
Fusarium spp. *Alternaria* spp.	25−35 °C	medium	ρH 7 and above	
Rhizoctonia spp.	20−35 °C	–	–	

Control is based on certain cultural practices aimed to make the plants more disease-resistant. Chemical and biological control options include seed dressing prior to sowing and treatment of soil with fungicides in areas where damping off was previously registered (Table 2).

Table 2 – Main damping-off control options

Cultural practices	Chemical control	Biological control
- Soil drainage; - Maintaining soil pH between 5 and 5.5; - Control of depth, density and dates of sowing; - Bare fallowing and timely removal of weeds; - Solarisation of soil during vegetative season by using plastic UV-resistant 40-120 micron film; - Reusable containers should be carefully cleaned; - Fertilization by potassium-rich fertilizers	Preventive treatment of plants during the growing season with approved systemic fungicides	- **BREVISIN**; - **TRIKHODERMIN**; - Mycorhization of seeds by *Lacearía* sp. fungi

Chemical and biological control options used in forest nurseries include seed dressing prior to sowing and soil fumigation after the first symptoms. The treatment is done on the affected area and 50 cm beyond. Overall treatment of soil with fungicides has proved cost-ineffective.

DIPLODIA PINEA

Sphaeropsis sapinea

Diplodia blight affects the needles and causes drying out or produces deformation of side and apex shoots of young pines, including pine seedlings in forest nurseries. Very often the disease kills pines in forest nurseries.

Symptoms and favourable conditions. Spores of the causal agents attack the current-year shoots. The dispersion starts in early may and can go on until September-October. The incubation period may last between several days and 2–3 weeks. Then the affected tissue on the shoots starts to turn brown and die. The

infected shoots wilt, the needles dry out. They become weak and very often curl (Figure 6).

Figure 6 – Pine shoots infected with Diplodia blight. Photo by V.A. Yarmolovich

Resin drops may appear on the infected shoots. In the first ten days of July the fungus produces its first spores as small (1 mm), dark-brown to coal-black, pimple-like fruiting bodies (pycnidia) that break through tissue at the base of infected needles (Figure 7).

Figure 7 – Pycnidia of *Sphaeropsis sapinea.* Photo by V.A. Yarmolovich

In the late July-August most affected shoots die and become straw-yellow, the dispersion of conidia becomes large-scale, especially during wet periods. During September-November the fruiting bodies (pycnidia) appear on shoots and needles moving upwards the initial infection centre.

The following conditions favour the disease (Table 3).

Table 3 – Favourable conditions to Diplodia blight in forest nurseries

Temperature	Air	Other factors
10 to 35 °C	70–80%	- plants in stressed condition by abiotic and other factors; - poor nutrition, nitrogen deficit.

Control of Diplodia pinea includes the following options (Table 4).

Table 4 – Main control options of Diplodia blight

Cultural practices	Chemical	Biological
- foliar dressing by nitrogen fertilizers; - removal of Diplodia infected plants.	Preventive treatment of plants during the growing season with approved systemic fungicides.	**BETAPROTEKTIN** **FRUTIN**

Basically, chemical and biological control strategies must be aimed to prevent the disease.

PHOMA BLIGHT OF CONIFERS

Phoma spp.

The Phoma blight affected needles start to go golden brown. Then the needles become brown, necrotic, finally die and drop prematurely. At the initial stage the plant growth diminishes, then the seedlings die. Plants that are 2 years old and older can die only partly, i.e., the current year shoots with the needles.

Symptoms and favourable conditions. Weakened seedlings are especially susceptible to attack. However, as Phoma progresses, even strong plants can become colonized.

Plants are most likely to become infected by fungus spores (conidia). The invasion starts from terminal buds and then progresses down the stem (Figure 8). Alternatively, soilborne Phoma spores can infect needles (Figure 9). Overhead irrigation or rain splash may result in excessive soil collar buildup around young seedling stems. Phoma can invade seedlings from soil collars, usually through the lower needles. Plants can also be infected through wounds made by soil tillage tools with spores on them.

Figure 8 – *Phoma* blight of spruce. Photo by M.O. Ramanenka

Figure 9 – *Phoma* blight infected pine. Photo by M.O. Ramanenka

In the later vegetation period Phoma produces numerous black fruiting bodies (pycnidia) on dead needles and stems. The fungus spreads its spores in late summer, however, the greater part is dispersed in early spring after the fungus has survived the winter. In many cases, no picnidia are produced which makes diagnosing difficult. Samples of infected plants then undergo a laboratory study.

The following conditions have been noted to favour the disease (Table 5).

Table 5 – Phoma favourable conditions

Temperature	Air	Other factors
10 to 35 °C, 22-24°C optimum	about 100%	- heavy rainfall; - plants weakened by abiotic or other factors; - poor nutrition, nitrogen deficit

Control of Phoma blight includes the following options (Table 6).

Table 6 – Main control options of Phoma blight

Cultural practices	Chemical	Biological	Selection
- rotation and bare fallowing of lands, timely weed cutting; - removal of badly infected seedlings; - soil drainage; - soil pH between 5 and 5,5; - sterilization of reusable containers; - combined fertilization.	Preventive treatment of plants during the growing season with approved systemic fungicides	- use of *Trichoderma* fungi-based biologicals; - seed mycorhization by *Lacearía* sp. fungi	Use of genetically superior seedlings.

GRAY MOLD OF SEEDLINGS

Botrytis cinerea

Grey mold often affects young conifers in moist and frosty environments. It can also occur after excessive fertilization or chemical treatment. More rarely it develops on seedlings in controlled environment, i.e., cooling greenhouses. Typical signs of the disease are grey mycelium and conidia on seedlings.

Symptoms and favourable conditions. The disease causes dying and decay of the above-ground parts and roots of the plants.

The soft and moist tissues of seedlings are easily invaded by fungus sclerotia and die. In excessively moist environments the seedlings can often get enveloped by dense mycelium filaments (Figure 10). However, the mycelium can easily be destroyed by sunlight and wind.

Figure 10 – *Botrytis cinerea* conidia on pine seedling. Photo by S.A. Prakhodskiy

In severe weather conditions, especially in autumn, the infected seedlings become covered by rugged, first grayish-white, then black sclerotia of 2–7 mm. They are resistant to low temperature in winter and enter the mycelium in the following spring season. The disease is characterized by a focal location – the affected

seedlings often grow in groups about 0,5 m in diameter.

Gray mold is commonly found on coniferous seedlings grown in greenhouses with wrong irrigation and air supply, as well as in over-dense plantations (Table 7).

Table 7 – Favourable conditions for gray mold in forest nurseries and storage areas of planting stock

Temperature	Light	Air	Influencing factors	Additional condtions
8 to 26 °C.	Insufficient light can favour gray mold and development of fungus sclerotia.	> 90%, high moisture periods over 12 hours.	- highly dense plantations; - excessive irrigation; - nigh N fertilization; - misuse of pesticides; - mechanical wounds.	- weak or damaged seedlings; - wet or dirty seedlings; - poor lighting in dense plantations; - wrong prechilling of seedlings.

Control of gray mold includes the following options (Table 8).

Table 8 – Main control options of gray mold

Cultural practices	Chemical	Biological
- proper density of plantations; - reasonable fertilization; - lower air humidity (ensure air supply); - lower oxygen supply to storage areas.	Preventive treatment of plants during the growing season with approved systemic fungicides.	Use of *Trichoderma* fungi-based biologicals.

LARCH NEEDLE CAST OR MERIA DISEASE

Meria laricis

Larch needle cast is a widely distributed disease. It causes discoloration and browning of larch needles. It weakens and stunts the plants and, in case of severe infection, can kill them.

Symptoms and favourable conditions. The plants get infected by conidia dwelling on the fallen needles of the previous year. Mycelium which develops from growing conidia enters the tissue of young needles. As the disease spreads, the needles become discolored, brown, die and fall. The disease progresses from the needles of the ground part to the top of the seedling. The fungus develops throughout the vegetation period. The infected needles die after 15–25 days. Under favourable conditions the fungus may cause complete needle fall in late July-early August (Figure 11).

Figure 11 – Larch needle dieback caused by *Meria laricis.* Photo by M.O. Ramanenka

First symptoms are visible in late May–early June on second-year seedlings, in July on first-year seedlings. The needle tips become light-green, and then get reddish-brown.

The needles become dry, tufts of conidiophores bearing white spore masses grow out through the stomata on the lower surface of the infected needles (Figure 12).

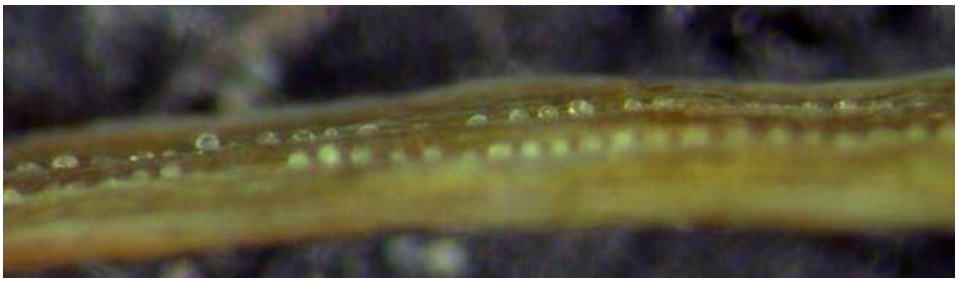


Figure 12 –*Meria laricis* conidia on the infected needles. Photo by Thomas L.Cech.

During periods of high humidity, the spores can survive for several months. However, in dry seasons they lose their germinating ability. There can be 3 to 4 waves of spore germination throughout the growing season, especially after heavy rainfall. The fungus mycelium survives winters on the fallen needles.

Favourable conditions for larch needle cast are given in Table 9.

Table 9 – Favourable conditions for larch needle cast

Temperature	Air
0 to 25°C, optimum 17–20°C	> 90%

Control of *Meria laricis* in forest nurseries includes the following options (Table 10).

Table 10 – Main control options of larch needle cast

Cultural practices	Chemical
- avoid locating nurseries in the vicinity of larch trees; - avoid high humidity; - remove fallen needles.	*Kapta*-, copper- or sulphur-based fungicides.

LOPHODERMIUM NEEDLE CAST

Lophodermium seditiosum

Pine needle cast is caused by *Lophodermium seditiosum*. Small yellow spots or bands appear on the infected needles; later, needles turn brown and fall. This disease may be very damaging on one- to three-year-old planting stock.

Symptoms and favourable conditions. Needle infection can run throughout the growing season; most commonly it starts in the third ten days of July and goes on until late August. The fungus spores infect the needles and enter them. Yellow spots develop on the needles (most commonly needle tips). The fungus survives winter in needle tissue. In spring it spreads over the needles. As the green pigment disappears and tissues die, the infected needles turn reddish-brown (Figure 13).

Figure 13 – First symptoms of infection by *Lophodermium pinastri*. Photo by M.O. Ramanenka

In early summer the fungus fruiting bodies known as ascocarps develop on the affected needles. The ascocarps are oval-shaped spots which are 0,5–2,0 mm long and 0,3–1 mm wide (Figure 14). The ascospores in the fruiting bodies germinate in late July – early August. The ascocarps open and release the ascospores at temperatures above 15ºC. In wet conditions the spore release may last until late September.

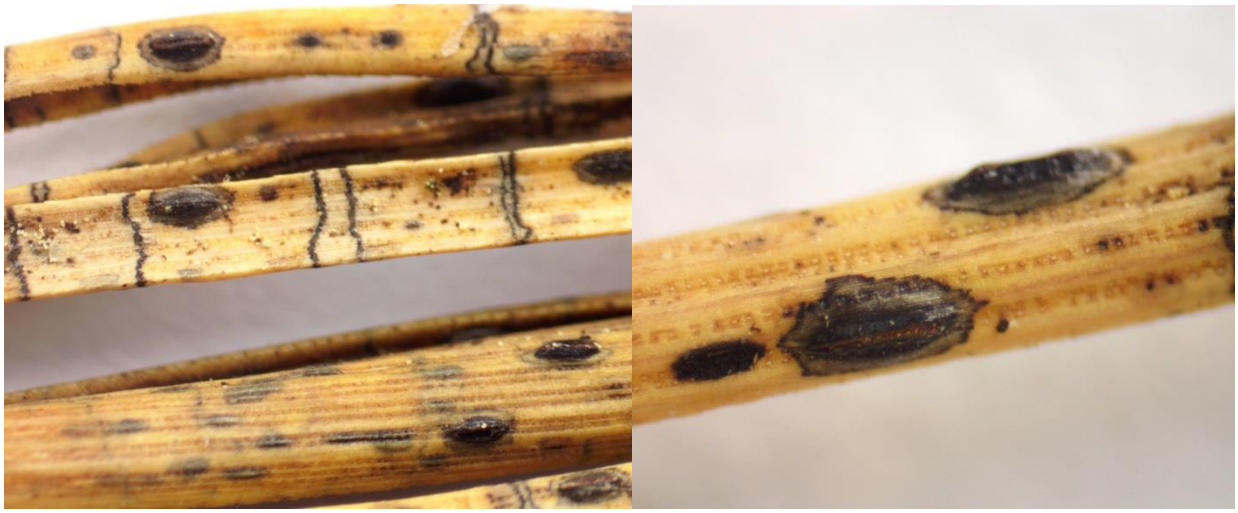


Figure 14 – Fruiting bodies of *Lophodermium seditiosum.* Photo by M.O. Ramanenka

Weather conditions greatly influence the disease cycle, development of fruiting bodies and spore release. Under long-term average annual conditions of the growing season, the first symptoms (yellow spots) appear on the needles of two-year-old seedlings in autumn (October–November) (Table 11).

Table 11 – Favourable conditions for pine needle cast in forest nurseries

Temperature	Air	Influencing factors
15 to 28 °C	> 90%	- weed vegetation; - wrong cultural practices.

Table 12 describes ***control options*** for pine needle cast. When seedlings are dug out of the ground, they should be carefully inspected; the seedlings with more than 25 % of affected needles should be removed.

Table 12 – Main control options for pine needle cast

Cultural practices	Chemical	Biological
- rotation and bare fallowing of lands; - timely weed cutting; – combined fertilization.	Preventive treatment of plants during the growing season with approved systemic fungicides.	**BREVISIN**

SNOW BLIGHT

Phacidium infestans

Infected pine needles become yellow and die. Seedlings younger than 5-6 years are most susceptible to pine snow blight.

Symptoms and favourable conditions. The plants are infected by spores in autumn and the infection lasts until the first snows of winter. In winter, the needles develop olive-green spots which then turn yellow. Needles under porous, loose snow cover create highly favourable conditions for fungus development. As the snow

melts, the mycelium becomes weblike, then gets thicker and forms light-grey films that are easily blown off by the wind. In spring the infected needles become red-brown, dry, but do not fall, remaining on the plant for a long time (Figure 15).

Figure 15 – Seedlings infected by *Phacidium infestans*. Photo by M.O. Ramanenka

In late summer, the affected needles become greyish. Dark-fruiting bodies (apothecia) are formed as small brownish-black spots more or less evenly distributed along the needles (Figure 16).

In early autumn the apothecia become more conspicuous. They appear as dark-grey spots of 0,6 to 1,2 mm in diameter.

Figure 16 – Fruiting bodies of *Phacidium infestans*. Photo by V.A. Yarmolovich

In excessively moist conditions, the mature fruiting bodies open and release spores. The dispersion of spores depends on weather conditions. It is favoured by

warm moist periods; most typically it starts in late September – early October and terminates during frost periods. Mid-October is the most favourable period for spore liberation and dispersion. In dry autumns, the spores are dispersed in November during drizzling rainy periods (Table 13).

Table 13 – Favourable conditions for snow blight

Temperature	Air	Influencing factors
approx. 0°C	about 100%	- thick snow cover; - long snow-melting period in spring.

Control of pine snow blight includes the following options (Table 14):

Table 14 – Main control options of pine snow blight

Cultural practices	Chemical	Biological	Genetic
- rotation and bare fallowing of lands, timely weed cutting - increased potassium fertilization; - removal of badly infected seedlings; - mulching of snow surface by fragmented peat or ash.	Preventive treatment of plants during the growing season with approved systemic fungicides.	**BREVISIN**	Use of genetically superior seedlings.

RUSTS

Coleosporium spp., *Melampsoridium* spp., *Melampsora* spp., *Chrysomyxa* spp., *Gymnosporangium* spp.

Many rusts infect nursery trees but only a few are of economic importance. The causal agents are rust fungi which generally have a complicated disease cycle that requires two host species (Figure 17, Table 15).

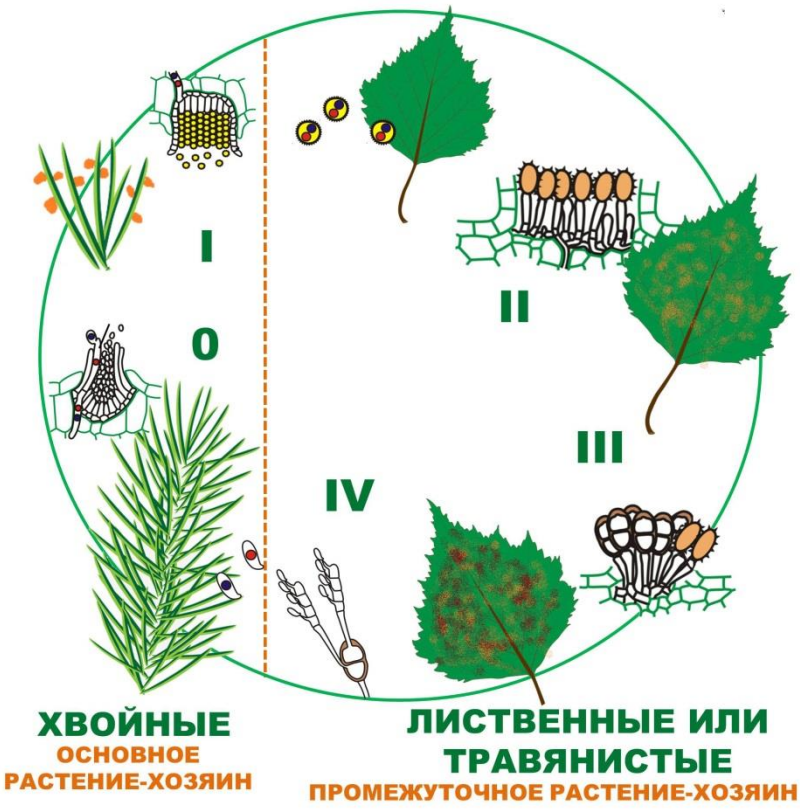


Figure 17 – Disease cycle of rust fungi. By M.O. Ramanenka

Table 15 – Main rust fungi

PRIMARY HOST	ALTERNATE HOST	LATIN NAME
Pine	Coltsfoot, Sow-thistle, Bell-flower, Cow-wheat	*Coleosporium tussilaginis* *C. sonchiarvensis* *C. campanulae* *C. melampyri*
Larch	Birch Poplar, Aspen Willow	*Melampsoridium betulinum* *Melampsora larici-populia*, *M. larici-salicina*
Spruce (full cycle)	Ledum	*Chrysomyxa ledi*
Juniper	Pear, mountain ash	*Gymnosporangium confusum*, *G. juniperinum*, *G. sabinae*

COLEOSPORIUM NEEDLE RUST

Coleosporium spp.

The symptoms become visible in late April–early May. The needles become covered with yellow-orange pustules (1 to 3 mm long, 0,4 to 0,6 mm wide) on both the lower and the upper sides (Figure 18). The tissue around the pustules turns yellow and dies, the needles become multicoloured. Heavy attacks may produce more than 10 pustules on one needle. The needles rarely die completely, however, the progress of disease may lead to lower growth increment.

Figure 18 – Coleosporium pine needle rust. Photos by M.O. Ramanenka, V.A. Yarmolovich

Common alternate hosts are coltsfoot, bell-flower and other grassy plants (Figure 19).

Figure 19 – *Coleosporium* fungi on alternate hosts: coltsfoot and bell-flower. Photo by M.O. Ramanenka

Control options. Removal of alternate host – coltsfoot (weeding, mowing, herbicide treatment) in forest nurseries and adjacent areas. Removal of badly infected pine trees (more than 50% of affected needles).

LEAF RUST

Melampsoridium spp. *и Melampsora* spp.

Leaf rust symptoms become visible on poplar and aspen leaves in June and July. The leaves become covered with numerous yellow-orange powder pustules. Heavy attacks can completely cover the bottom side of the leaf (Figure 20). During the summer, the pustules open and release spores which infect the leaves. The disease progresses throughout the growing season. The affected leaves die prematurely and fall. In late growing season, brown and black pustules appear on the fallen leaves where they stay for the winter period. In spring, the fungus attacks young leaves of trees or growing parts of alternate hosts.

Figure 20 – Pustules of *Melampsora* on poplar and willow leaves. Photos by M.O. Ramanenka

POWDERY MILDEW

Microsphaera spp., Uncinula spp. и др.

Powdery mildew is a common disease of many tree and shrub species. The causal agents are many *Erisyphaceae* fungi that are obligate parasites. However each fungus has its own specific host, e.g., *Microsphaera alphitoides* fungus (causal agent of oak mildew) does not attack birch, poplar, maple, etc.

Oak mildew is caused by *Microsphaera alphitoides* Griff. et Maubl. English oak, especially its late-shooting species, is highly susceptible to the disease (Figure 21).

Maple is affected by *Uncinula aceris Sacc* fungus; willow and poplar by *U. salicis Wint.*; birch by *M. betulae Magn.* (Figure 22).

Symptoms and favourable conditions. Infection of first-year seedlings of oak and other plants starts in June by spores from the fallen leaves and ground surface.

First symptoms become visible in the second ten days of June–early July. A grey-white mycelium develops, forming patches, which grow and finally cover both upper and lower surface of the leaves. The mycelium produces conidia which, together with mycelium, form the characteristic powdery coating on the affected leaves. Young shoots may become affected by the disease as well.

Figure 21 – Oak leaves affected by *Microsphaera alphitoides.* Photo by M.O. Ramanenka

Figure 22 – Maple leaves affected by *Uncinula aceris*. Photo by M.O. Ramanenka

During summer, the fungus can produce several generations of spores which are dispersed from plant to plant.

In late summer, the spore development ceases. The coating on the leaves becomes felty. The leaves are distorted, with dark-brown spots on them. The fungus starts to form fruiting bodies (black spherical cleistothecia) 0,10 to 0,15 mm in diameter. The fungus survives the winter on the fallen leaves and the ground surface.

Table 16 describes favourable conditions for powdery mildew.

Table 16 – Favourable conditions for powdery mildew

Temperature	Air	Light	Cultural practices
Infection – 8–10 °C Development – 20–30°C	76 to 96%	high	High N fertilization

Control of powdery mildew in forest nurseries includes the following options (Table 17).

Table 17 – Main control options of powdery mildew

Cultural practices	Chemical	Genetic
- sowing of acorns in autumn or early spring; - balanced fertilization; - removal of fallen leaves; - addition cultivation (tillage) of soil.	Preventive treatment of plants during the growing season with approved systemic fungicides.	Selection of acorn of early English oak.

LEAF SPOT ON LINDEN

Cercospora microsora

The disease causes numerous round- or irregularly-shaped dark-brown 4-mm spots with light-coloured core.

Symptoms and favourable conditions. Heavily affected linden leaves (Figure 20) become almost completely covered by the brown spots. The affected leaves dry and prematurely fall. In summer, the underside of the leaves becomes covered with fungus conidia. They transmit the disease throughout the summer season. Then pathogen dwells on the fallen leaves lying on the ground, forming spores that affect young leaves in spring.

The following conditions favour the disease (Table 23).

Figure 23 – Affected leaves. Photo by M.O. Ramanenka

Table 18 – Favourable conditions for leaf spot

Temperature	Air
10 to 35 °C, optimum 22–24°C	Medium

Control includes the following options (Table 19):

Table 19 – Control options of leaf spot on linden leaves

Cultural practices	Chemical
- removal of badly affected trees and fallen leaves; - fertilization.	Preventive treatment of plants during the growing season with approved systemic fungicides.

Chapter 2

MAIN DAMAGING AGENTS OF SEEDLINGS IN FOREST NURSERIES OF BELARUS

European mole cricket – *Gryllotalpa gryllotalpa* L.

Taxonomy: order: Orthoptera, family: Gryllotalpidae.

Adults are big insects (30–50 mm), dark brown (Figure 24), cylindrical-bodied, with shovel-like forelegs powerful and highly developed for burrowing. The mole crickets are widely distributed and are highly destructive for nursery plants as they can cause extensive damage to young trees and shrubs.

Figure 24 – Adult *Gryllotalpa gryllotalpa.* Photo by V.A. Yarmolovich

Nymphs and adults overwinter in soil to a depth of 30 cm to 1 m. In spring, mole crickets burrow through the soil forming horizontal tunnels a few cm below the surface. AT night, adults may come to the surface.

Females lay their eggs in specially dug brood chambers to a depth of 10–20 cm. One egg clutch may contain 300–350 eggs. The nymphs then stay in the chamber for 20–30 days tended by the female and later leave to feed and develop independently below the surface. The insects develop one generation of young in a year. The mole crickets are omnivorous, they feed on plant roots, soil invertebrates, as well as humus. They damage plants by feeding on roots and digging under the plants when burrowing their tunnels. Control options are given in Table 18.

Table 20 – *Gryllotalpa gryllotalpa* control in forest nurseries

Cultural control	Chemical control
- Soil cultivation to destroy nests; - At the end of vegetation period, making 70cm deep traps with dung or compost to attract mole crickets for overwintering; opening the traps when first frosts occur.	Soil treatment with diazinon-based granulated insecticides during sowing and planting.

Click beetles – Elateridae

Taxonomy: order: Coleoptera, family: Elateridae.

Click beetles are represented by numerous species, the most common being **lined click beetle (*Agriotes lineatus* L.)**, **dark elaterid beetle (*A. obscurus* L.)**, **common click beetle (*A. sputator* L.)**, **elaterid beetle (*Selatosomus latus* Fabricius)**, **snapping beetle (*S. aeneus* L.)**, **fetid smelling click beetle (*Agrypnus murinus* L.)**, **black click beetle (*Athous niger* L.).** Click beetles are widely distributed. They attack root systems of various forest, ornamental, fruit-bearing, berry and other plants. They also feed on crop seeds.

Click beetles have dark-brown elongated body, small head and short legs, all legs have five members. Most click beetles range between 6 and 18 mm. Click beetles have a spine attached to the underside of the prothorax and fits in to a notch in the underside of the mesothorax. By snapping a spinelike structure into a groove on the underside of the thorax (beneath the pronotum), click beetles that find themselves on their backs can flip suddenly into the air. Their larvae are called wireworms, they have three pairs of short legs, slender, cylindrical, elongated bodies, highly sclerotized, rust-coloured, yellow-brown or reddish-brown. The ninth abdominal segment of their body is often divided into pair outgrowths (urogomphs). The term wireworm comes from their physical resemblance to rusty wires.

Larvae and adults overwinter in the soil. In spring, females feed on blossoming plants and then lay between 50 and 200 eggs into the surface soil. Hatching larvae take 3–4 years to develop and feed on roots and organic particles interspersed in the soil. They often feed on crop seeds and sprouts causing them to die. Adult click beetles cause little damage. Main control options are given in Table 21.

Table 21 – Click beetle control in forest nurseries

Cultural practices	Chemical control
- soil cultivation, weed control; - liming of acidic soils to prevent larvae development; - early sowing of seeds (in nurseries) at the optimum seed level.	- treatment of soils densely populated by wireworms with allowed granulated insecticides during sowing or planting; - roots of saplings should be dipped into insecticide-peat mixture (8g vallar or terradox per 1 l of "mixture").

Cockchafers (May beetles) – *Melolontha* spp.

Taxonomy: order: Coleoptera, family: Scarabaeidae.

Chestnut cockchafer (*Melolontha hippocastani* F.) is commonly distributed, **common cockchafer (*M. melolontha* L.)** is widely distributed, thermophilic (Figure 25). Both species attack roots of many coniferous and deciduous forest trees as well as fruit trees. They cause extensive damage in nurseries and young plantations. Chestnut cockchafer can also attack roots of some field and vegetable crops.

Figure 25 – Chestnut cockchafer *Melolontha melolontha*. Photo by M.O. Ramanenka

Chestnut cockchafer adults are 20–22 mm long, oval-shaped, elytra are chestnut-brown, thorax and abdomen are black. The male antennae have 7 lamellae while the female has 6 lamellae. The pygidium (the abdomen end) is long and flat. Common cockchafer adults are larger (up to 31 mm), the pygidium is rather dull. Larvae can be as long as 60 mm, creamy white, C-shaped, have three pairs of legs (Figure 26). Larvae and adults of both species overwinter in the soil. The beetles come out to the surface in late April – May. Beetles fly for about one month. They feed on young foliage of many trees and particularly like birch and oak. After mating, females deposit clusters of 25–30 eggs each into the soil to a depth of 15–30 cm. One female can lay about 70 eggs. Larvae feed on roots and take 3–4 years to develop. They overwinter in the earth at depths between 1 and 1,5 m. They work their way to the surface only in spring. Larvae of the final instar are highly voracious feeders. Large numbers of larvae can cause young trees to die. Larvae pupate in mid-summer in the places where they feed. Adult beetles appear one month later, they stay in the soil where they overwinter. The life cycle of cockchafer takes 4–5 years.

Figure 26 – Cockchafer larva. Photo by I.M. Mityushev

Main control options are given in Table 22.

Table 22 – Control of cockchafers

Cultural practices	Chemical control
- thorough care of young plantations, soil plowing so that larvae are killed by agricultural tools and eaten by birds; - creation of a second deciduous storey in pine forests; - for farm households: hand picking of beetles and spraying of beetle feeding spots (mainly on birch) by allowed insecticides.	- if large numbers of cockchafer larvae are detected, the soil should be laid fallow for 2 years or treated by insecticides before sowing and plowing; - roots of coniferous and deciduous plantings should be dipped in the insecticide-peat mixture ("mixture"),

Thorough inspection of soil to detect **chestnut cockchafer (*Melolontha melolontha* L.)** and other soil-inhabiting insects should be done by soil sampling. This is done during autumn inventory of forest plantations within the range of cockchafer damage as well as during project planning of forest plantations within the same area. The damaged areas are inspected by stations: forest plantations 1–3 years old, 4–6 years old, 7–10, 11–15, 16–20, over 20 years old, glades, open stands, cutting sites. Forest types and growth conditions are registered.

Census of chestnut cockchafer is done by soil sampling, i.e., digging of holes as large as 1x1 m (1m^2) or 0,5x0,5 m (0,25 m^2) and as deep as the larvae can be found. The holes are evenly distributed across the inspected area according to the following procedure. At first, about 10-15 holes are dug and the total number of cockchafers is calculated. At the end, absolute and relative density of cockchafer population is determined. If the number of cockchafers is small (average density is less than 1 individual/m^2), the required accuracy of census can hardly be achieved. So, a minimum number of holes is dug, i.e., 10 holes of 1x1 m or 16 holes of 0,5x0,5 m. The survey data are used to make a map of cockchafer invasion with the indication of density (low, medium, high), phenological calendar of the pest, life cycles and years of flight, areas of additional feeding, years of peak damage to crops and plantations. To determine the required control practices and make a map of soil inhabitation by cockchafer larvae, it is recommended to use a plan of sequential sampling made for three density levels: low – less than 1 individual/m^2, medium – 1,0–2,9 individual/m^2, high – over 3.0 individual/m^2.

The condition of forest plantations within the cockchafer damage range is assessed by establishing sampling plots with minimum 200 trees of the following categories: 1 – healthy, 2 – weakened, 3 – drying, 4 – dead. Categories 2–4 are divided into damage-free and those affected by cockchafers, other insect pests (by species), mice, moose, diseases (by types), anthropogenic factors (by types), abiotic factors, other factors. The inventory results are expressed in absolute (individuals) and relative (%) values to identify survival ability and preservation of forest plantations.

Hemlock scale – *Nuculaspis abietis* Schrank

Taxonomy: order: Homoptera, family: Diaspididae. The insect attacks spruce, pine, fir, juniper and black spruce.

Larvae of the second instar overwinter on needles. In spring (April-May) they develop into adult insects. Females are oval-shaped, 1,7–2,3 mm long, black in the centre, exuviae central, gray at margins. Female scale is oval, dark gray, about 3 mm long. Females remain non-mobile and deposit about 70 eggs under the scales. The hatched larvae are mobile (so called ‘crawlers); about 0,25 mm long, yellow. Crawlers can move to adjacent twigs, then settle on needles and start secreting a scale. As hemlock scales feed on needles, they develop chlorotic spots causing needle desiccation and drop. High density of hemlock scales results in general weakening of trees. The insect develops one annual generation a year. Coniferous can be attacked by other hemlock scale species, e.g., **white pine scale (*Leucaspis pusilla* Löw)** that has white elongated oval scale. Control options are described below (Table 23).

Table 23 – Hemlock scale control

Cultural practices	Chemical control
- inspection of planting stock; - removal of highly infested and drying branches.	Spraying of conifers during hatching of crawlers (May-June) by organophosphate insecticides and synthetic pyrethroids.

Aphids – Aphidoidea

Taxonomy: order: Homoptera, hyperfamily: Aphidoidea.

Apple trees and some other Rosaceae family trees are attacked by **green apple aphid (*Aphis pomi* DeGeer)**, linden – by **linden aphid (*Eucallipterus tiliae* L.)**, oak – by **giant oak aphid (*Stomaphis quercus* L.)** and **oak phylloxera (*Phylloxera quercus* Boyer de Fonscolombe)**, elm – by **elm cockscomb gall aphid (*Colopha compressa* Koch)** и **elm-currant aphid (*Eriosoma ulmi* L.)**, poplar –by **poplar spiral gall aphid (*Pemphigus* spp.**) that forms galls on leaf stalks.

Aphids are small insects (Figure 27), between 0,5 and 0,7 mm long. Their bodies are oval, egg-shaped, light- or dark-green, yellow, reddish, gray or black. The presence of cornicles, siphunculae, hairs is a characteristic morphological feature of aphids. They have a pair of cornicles (siphunculi), abdominal tubes on the dorsal surface of their fifth abdominal segment and a tail-like protrusion called a cauda above their rectal apertures.

Figure 27 – Aphids on pine saplings. Photo by M.O. Ramanenka

The life cycle of aphids alternates between different generations, i.e. parthenogenesis (the offspring are only females) and holocyclic (the offspring are males and females). By their development cycle, all aphids can be divided into monoecious (single-host) and heteroecious (host-alternating). The overwintering eggs of single-host aphids that hatch in the spring result in females, called fundatrices (stem mothers). These give rise to the colonies of aphids that reproduce asexually by parthenogenesis and have genetically identical winged and non-winged female progeny. Winged stem mothers fly to adjacent plants and form new parthenogenetic colonies. In autumn, aphids reproduce sexually and lay eggs that hatch winged males and non-winged females. After mating, females lay eggs that overwinter and hatch new colony of stem mothers in spring. Host-alternating aphids change host plants during their life cycle. Bisexual generations develop on primary host, most typically woody plant. Fertile eggs also overwinter on primary host. The eggs hatch stem mothers that produce colonies of 2–3 parthenogenetic generations. Then aphids produce winged female that fly to secondary host (most typically herbs) and produce several generations of heteroecious aphids. In autumn the winged aphids come back to their primary host. Feeding of aphids causes plant deformations, discolouring and drying of plant parts, some aphid species make galls. Besides, aphids produce honeydew (a sweet excretory product) that attracts ants. Ant feed on honeydew and guard aphids from predators. Honeydew creates a favourable environment for saprophytic sooty fungi that impair the decorative effect of plants. Control options are given in Table 24.

Table 24 – Aphids control in forest nurseries

Cultural practices	Chemical control
- weed control to eliminate additional feed supplies of aphids; - nectar plants in forest nurseries attract insect eaters that attack aphids; - imago and larvae of ladybug and golden-eyed fly may act as biological control agents.	Spraying by allowed insecticides once aphid colonies have been detected.

Adelges – Adelgidae

Taxonomy: order: Homoptera, family: Adelgidae.

There are host-alternating (two-year life cycle on two conifer species) and single-host or non-migrating species of adelges. The most common host-alternating species include **spruce pineapple gall adelges (*Sacchiphantes viridis* Ratzeburg)** and **larch adelges (*Adelges laricis* Vallot)** (hosting on different species of spruce and larch), **spruce fir adelges (*Aphrastia pectinatae* Cholodkovsky)** (on spruce and fir), **silver fir adelges (*Dreyfusia nordmannianae* Eckstein)** (on Caucasian fir and Oriental spruce), etc.; single-host species include **spruce gall adelges (*Sacchiphantes abietis* L.)**, **pine adelges (*Pineus pini* L.)** and **Weymouth pine adelges (*P. strobi* Hartig)** (on pine), **spruce gall adelges (*Adelges tardus* Dreyfus)** (on different spruce species), etc.

Adelges are small insects, 1–2 mm, most typically black, greyish or red-brown. Their bodies are covered with white waxy secretion. They suck sap from bark and needles and colonize only coniferous attacking young, vigorous trees. Stem mothers of spruce pineapple gall adelges and green-winged adelges appear in towards the end of the first decade of May. Their bodies are covered with white waxy secretion. They are host-alternating and have a two-year life cycle. In the first year, the colonies of stem mothers make cone-like 3,5 cm galls on spruce. The affected sprouts usually die over the next year. In May, stem mother deposits over 300 eggs inside the gall. The eggs hatch larvae within a couple of weeks. In August, the nymphs fly to larch and lay about 10 eggs each on the needles. The larvae attach themselves to new larch needles and overwinter. In spring they develop into false stem mothers. In July, adult female moves to spruce where it lay eggs that produce males and females. The stem mother lays one egg that will develop into the future fundatrice (stem mother). Adelges weaken and inhibit young trees, badly affect their decorative qualities. The insects make large cone-like galls on spruces (Figure 28).

Figure 28 – Spruce pineapple gall adelges. Photo by M.O. Romanenko

Figure 29 – Spruce pineapple gall adelges. Photo by I.M. Mityushev

Adelges cause neeedles die-off. Large colonies of single-host adelges may cause death of young plants. Main control options are given in Table 25.

Table 25 – Control of spruce pineapple gall adelges

Cultural practices	Chemical control
- distance separation of spruce and larch plantations; - cutting of gall-bearing twigs.	Spraying to kill the overwintered larvae in autumn, hatching larvae (late May – June) or nymphs and winged adelges appearing from galls (August) by organophosphates.

Pine bark bug – *Aradus cinnamomeus* Panzer

Taxonomy: order: Hemiptera, family: Aradidae.

The pine bark bug attacks common pine, yellow pine, jack pine, Siberian pine, larch. It is a widely distributed insect.

The bodies are ashy-brown, flat, 3,5–5,0 mm. Female can appear as short-winged and long-winged. Long-winged females have two pairs of well-developed wings that enable them to fly. Short-winged females have rather short elytra and rudimentary wings, which prevents them from flying. Males are smaller than females, their bodies are more slender. Primary wings are well developed, secondary wings are absent, males are not able to fly. It is long-winged females of pine bark beetles that ensure colonization.

Fourth-instar nymphs and adults overwinter in ground litter around tree stems and in the lower stem bark. In early spring they move upwards the pine stems. Adult beetles feed and mate under the bark. Eggs are deposited under the bark scales after 6–10 days. One female is able to lay 16–28 eggs. Larvae are actively hatched in late May – early June. Larvae start feeding after 5–7 days and continue so until winter.

The pine bark beetle infestations occur rather slowly; they attack pine trees as soon as they develop scaly bark (5–6 years), the peak infestation happens in 15–18-year-old forests. In 20–25-year-old forest stands the colonies are less numerous and almost disappear in 30-year-old forests. Pine bark beetles can be recognized by

presence of silvery-white spots under the bark which gradually turn yellow and brown. Heavy attacks are indicated by large spots covering the whole stem and pitch tubes under the bark. The pitch tubes than cause the bark to crack and the pitch comes outside. The needles turn yellow, the growth slows down, the twigs become short and brush-like, the crown often dies off. The infested trees are highly susceptible to secondary borers. Control options are given in Table 26.

Table 26 – Control of pine bark beetles

Cultural practices	Chemical control
- creation of dense pine and mixed plantations containing birch, oak and shrubs; - inspection of planting stock coming from forest nurseries; - attraction of insect-eating birds.	Spraying by insecticides during vegetation period.

Spruce spider mite – *Oligonychus ununguis* Jacobi

Taxonomy: class: Arachnida, family: Tetranychidae.

Adult spruce spider mites are oval-shaped, 0,3–0,4 mm, greenish, red or black, with 4 pairs of legs. They attack spruce, pine, fir, juniper, thuya and other conifers, particularly young trees. Eggs overwinter at needle bottoms, sprouts and last-year growth. In May, they hatch larvae that suck on needles for 2–3 weeks and develop into adults that continue feeding. One female can lay 40–50 eggs on needle bottoms or needles. The infested needles become chlorotic, large infestations are indicated by thin greyish webs. The needles turn brown and drop. Spruce spider mite infestations badly affect decorative qualities of trees, the trees lose their vigour and are colonized by borers. Large trees suffer from needle die-off in the lower part of the stem. The mites can develop over 4-6 generations in a year. They are easily distributed on planting stock, tools and clothes of nursery workers as well as on their webs by air.

Table 27 gives control options for spruce spider mite.

Table 27 – Control of spruce spider mite

Cultural practices	Chemical control
Inspection of planting stock in nurseries and during planting.	Spraying of coniferous trees by specific organophosphate acaricides or insectoacaricides and neonicotinoids.

Cottonwood leaf beetle – *Chrysomela populi* L.

Taxonomy: order: Coleoptera, family: Chrysomelidae.

Cottonwood leaf beetle is a 10–12 mm beetle, evenly convex (Figure 30). Elytra are brick-red to yellow-brown, with slender black markings on their wingcovers. Bodies are blue-black, head and scutellum dark. First-instar nymphs are grey-white. Scutellum, head and legs are dark brown. Adult nymphs are grey-white to light-green with black glossy markings, black scutellum and dark warts. Second and third thorax segments have white spots on both sides. Legs are stumpy. Pupa is free, rather short, grey-white with symmetrical black marks, the body end is pointed. Eggs

are elongated, oval-shaped, yellow to orange-red. Cottonwood leaf beetle attacks poplar, ash, willow which it seriously defoliates. The adults overwinter on the grouold in forest litter. Flight is in early spring, depending on location and can start in March in southern regions as soon as leaves appear. The beetles live and mate on leaves.

Figure 30 – Cottonwood leaf beetle – *Chrysomela populi* L. Photo by M.O. Romanenko

Females lay eggs on the underside of leaves, each cluster containing 20–30 eggs, and are able to deposit several hundreds of eggs. Larvae hatch after 1–2 weeks, they start feeding on leaves and skeletonize them. After three weeks, the pendent larvae pupate. The pupaption lasts for approx. 10 days. Young adult perforate leaves and lay the second generation which completely develops by September in Central Europe. In most favourable conditions, i.e., southern regions, the insects may produce three generations. The pests cause considerable damage in forest nurseries. Apart from cottonwood leaf beetle, ornamental trees and shrubs may be attacked by **aspen leaf beetle (*Melasoma tremulae* Fabricius)**, **alder leaf beetle (*Agelastica alni* L.)**, **elm leaf beetle (*Xanthogaleruca luteola* Müller)** and some other species (Figures 31, 32).

Figure 31 – Alder leaf beetle *Agelastica alni* L.. Photo by M.O. Romanenko

Figure 32 – Poplar leaf beetle larvae. Photo by I.M. Mityushev

Control options of leaf beetles are given in Table 28.

Table 28 – Control of leaf beetles

Cultural practices	Chemical control
Hand picking of beetles and larvae on small areas.	Treatment by allowed insecticides.

Chapter 3

FERTILIZING AND GROWTH-PROMOTION OF NURSERY STOCK IN FOREST NURSERIES

Vadim Nosnikov, associate professor, PhD (Agriculture), Head of Department, Belarusian State Technological University

Fertilization is important for growing of nursery stock for it compensates for the lack of nutrients.

When growing the nursery stock in forest nurseries, soils are depleted of nutrients. Growing of first-year pine seedlings depletes 30 kg/ha of N 63, P_2O_5 – 18, K_2O – 30. A growing cycle of second-year pine seedlings depletes 58 kg/ha of N 148, P_2O_5 – 38, K_2O, of spruce – 30 kg/ha of N 74, P_2O_5 – 31, K_2O. First-year seedlings of English oak require 37 kg/ha of N 55, P_2O_5 – 23, K_2O (V.S. Pobedov). These values correspond to the minimum required annual mineral fertilization of nursery fields. It should be understood that only about 40–50% of the applied fertilizers is extracted by the plants.

Nutrients are depleted not only by nursery stock, but are washed out into the deeper ground layers. Being strongly bound to the ionic complexes of soil, part of them becomes inaccessible or turns into unavailable state. Wrong rotation of crops requires organic fertilization, otherwise the soils will become depleted and degrade.

Application of fertilizers is governed by several fundamental laws.

The Liebig's law of the minimum states that ***growth is dictated not by total resources available, but by the scarcest resource***. So, balanced mineral nutrition is essential for plants.

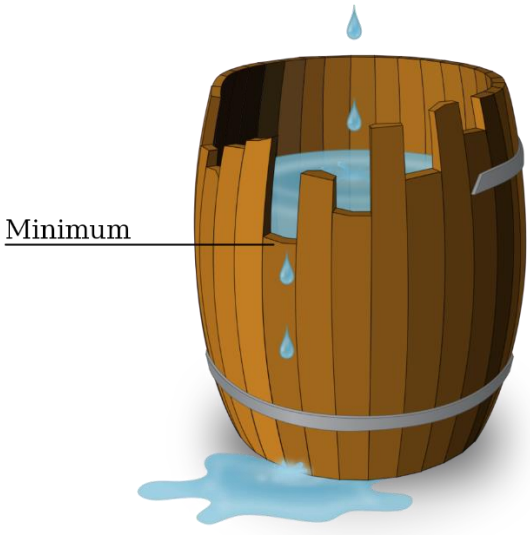


Figure 33 – Liebig's barrel.

The Shelford’s law of tolerance states that an organism's success is based on a complex set of conditions and that each organism has a certain minimum, maximum, and optimum environmental factor or combination of factors that determine success.

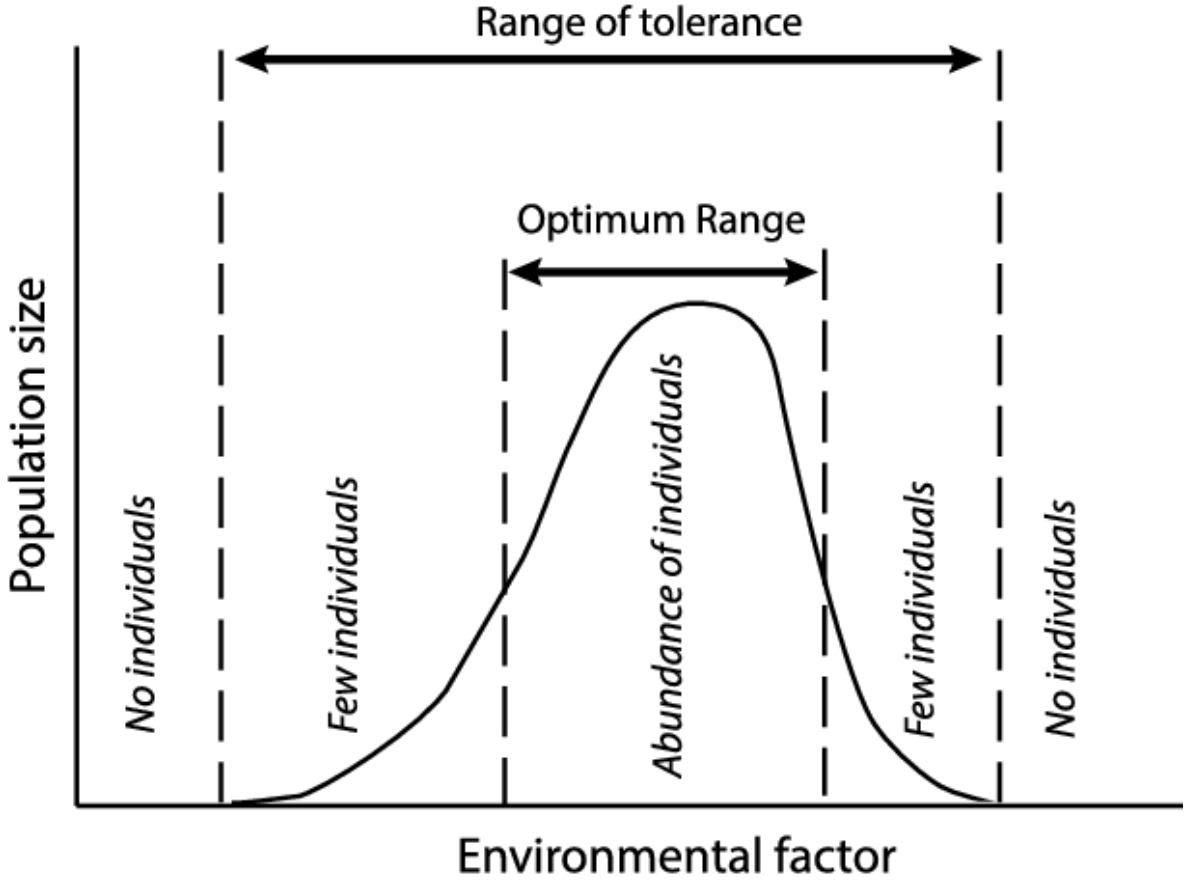


Figure 31 – Graphical representation of Shelford's Law of Tolerance.

The main conclusion from the law is that excess of fertilizers can slow down the growth of seedlings or even cause them to die.

All fertilizer elements can be grouped as necessary (N, P, S, K, Ca, Mg and Fe) and useful (Na, Si, Co, Se, Al).

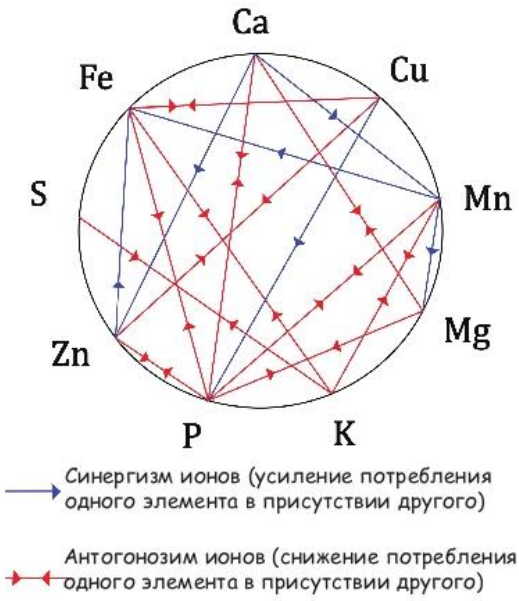
By content and extraction by the plants, all fertilizer elements can be divided into macroelements or basic elements (N, P, K) and microelements (Mn, Cu, Zn, B, Mo, Cl). There are also secondary elements (Ca, Mg, S), which are less needed by the plants than the basic elements, but more required than microelements.

The most essential chemical qualities of soil are pH level (acid/basic) and cation-exchange capacity (capacity of a soil to hold exchangeable cations of nutrients).

Such factors as pH level and moisture content of soil can affect the solubility of fertilizers or the capacity of plants to absorb the fertilizer elements. Lack of microelements (Cu, Zn, Mn, Fe, B, etc.) is noted in soils with high pH level. High acidity or alkalinity has a negative effect on phosphorus availability. Low pH

increases the extraction of aluminum and manganese which can produce a toxic effect. Acidity can have different effects in mineral and organic soils. Maximum extraction of fertilizer elements has been registered in mineral soil at pH 6,0–6,5, in organic soil at pH 5,0–5,5.

For plants to be supplied necessary nutrition, interaction of fertilizer elements is highly important. The excess of certain elements results in the lack of other elements and produces a negative effect on plant productivity (antagonism of elements). Excess of nitrogen leads to lack of potassium; excess of potassium results in the lack of nitrogen; abundant sulphur results in insufficient molybdenum; excess of calcium causes shortage of potassium, sulphur, boron, manganese, zinc. Copper and zinc, iron and manganese, zinc and iron are antagonistic ions. It is known that certain elements in the soil can induce higher extraction of other elements by plants (synergism of elements), e.g., calcium and boron, zinc and iron, manganese and magnesium, etc.



Synergism of ions (increased consumption of elements caused by the presence of other elements)

Antagonism of ions (lower consumption of elements caused by the presence of other elements)

Figure 34 – Interaction of mineral fertilizer elements.

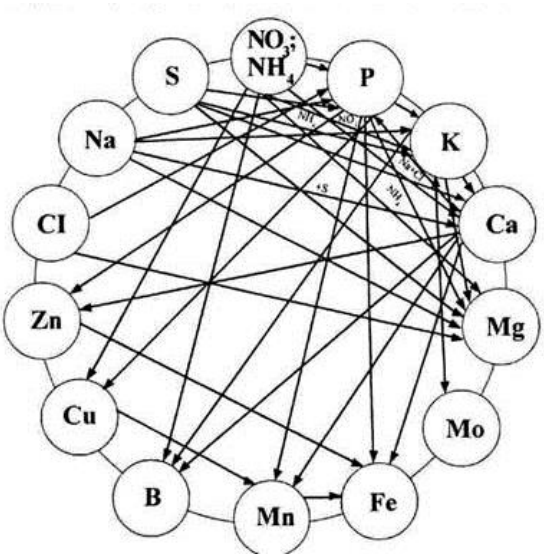


Figure 35 – Antagonism of ions under the condition of excessive nutrients

These interactions of fertilizer elements can serve as a basis for some recommendations on mineral fertilizer applications.

Nitrogen fertilizers should be applied during the growing season, the established required amount shall be divided into parts, fertilization should continue from mid-May to late June and should start 3–4 weeks after seed germination. Nitrogen fertilizer should contain ammonium ion (NH_4^+) and nitrate ion (NO_3^-), however, the content of nitrate ion should not exceed 50%.

Effect of nitrogen ions on fertilizer elements adsorption

Antagonism of ions (NH_4^+ is adsorbed faster than …)

Synergism of ions (cations adsorption), higher by 30%

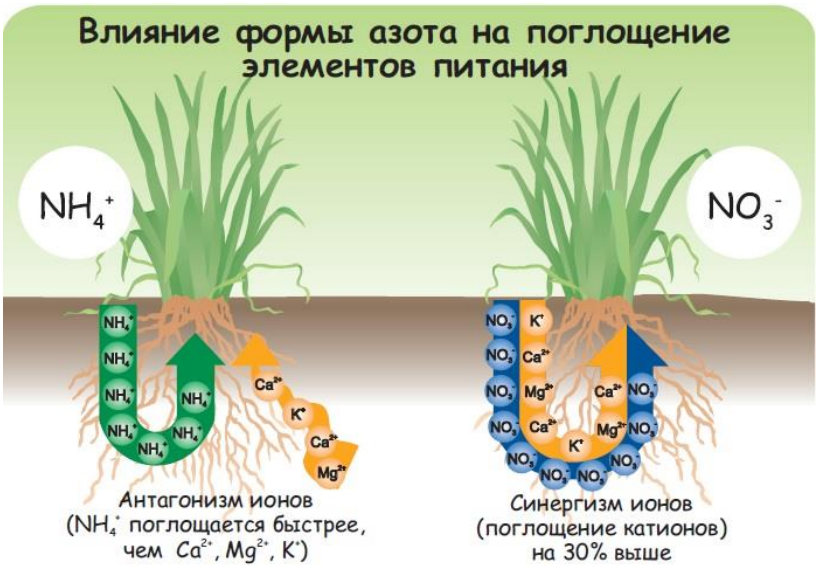


Figure 36 – Effect of nitrogen ions on fertilizer elements adsorption

Phosphorus and potassium fertilizers should be applied in autumn of in spring, two weeks prior to lime application. Fertilization should not be combined with liming, as exothermal reactions can decrease its efficiency. The Table below can serve to make combinations of fertilizers.

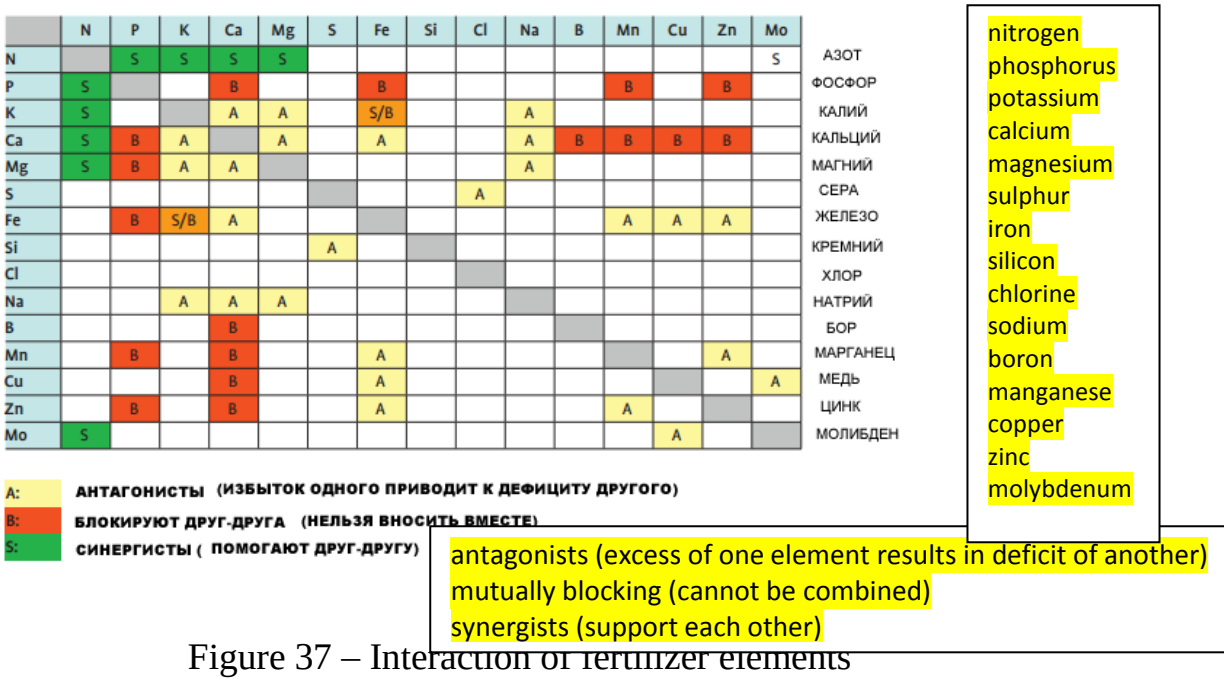


Figure 37 – Interaction of fertilizer elements

It is understood that when fertilizers are applied, areas of high concentration are formed around the fertilizer pills. The high concentration can cause damage to plants, especially at the emergence stage. So, pre-sowing or main fertilizer application should be at least two weeks prior to seed sowing.

The need for nutrients in forest nurseries should be evaluated separately for each species, its feed requirements and age.

The need can be established by monitoring of soil nutritional capacity, primarily, the presence of available forms, humus content and pH level.

Other factors affecting the plant growth should also be considered, i.e., preceding production cycles, nutrients wash-out into deeper ground layers, binding of nutrients, etc.

One of the simplest, but less accurate methods is a visual inspection of plant appearance to establish lack of nutrients.

Visual inspection for the lack of nitrogen reveals yellowing of old leaves as nitrogen moves to younger parts of the plant:

Figure 38 – Lack of nitrogen in plants

The lack of phosphorus causes young needles to turn red. Discoloration of old needles is caused by low temperatures or more intense UV radiation. The leaves of deciduous trees turn discolored from light-yellow to purple.

Figure 39 – Lack of phosphorus in plants

Potassium deficit can be noted by shortened needles and yellow (occasionally purple) leaves.

The lack of iron causes young needles to go yellow, while nitrogen deficit discoloures old leaves and needles.

Figure 40 – Lack of iron in needles

Copper deficit makes needles turn spiral:

Figure 41 – Lack of copper in needles. Photo by M.O. Ramanenka

More accurate results can be obtained by the analysis of selected ground samples (taken from 10–15 spots at 20 cm depth) after the production cycles. Sample selection is done by special techniques. The more samples are selected, the more

accurate the results are. Crop rotation fields often change their boundaries, so it is difficult to monitor the removal and introduction of fertilizer elements.

The analysis can be done in mobile or stationary laboratories of various research or educational institutions. Methodology can involve precise analytic techniques or spectroscopy which allow fast and accurate large-scale evaluation of soil qualities. “Belgosles” enterprise is in charge of such investigations for forestry purposes.

The results make it possible to establish different groups of soils.

Table 31 – Soil groups by acidity

Group	Acidity	pH в KCl
II	strongly acid	4,1–4,5
III	medium acid	4,6–5,2
IV	subacid	5,3–6,4
V	neutral and near neutral	6,5–7,4

Table 30 – Soil groups by humus containing capacity

Group	Sufficiency	Humus content, %
I	very low	<1,00
II	low	1,01–2,0
III	medium	2,01–3,0
IV	high	3,01–4,0

Table 31 – Soil groups by potassium sufficiency level

Group	Sufficiency	K2O content, mg per 100 g of soil
I	very low	<3,00
II	Low	3,01–6,00
III	Medium	6,01–12,00
IV	High	12,01–13,50

Table 32 – Soil groups by phosphorus sufficiency level

Group	Sufficiency	P2O5 content, mg per 100 g of soil
I	very low	<3,00
II	low	3,01–6,00
III	medium	6,01–13,00
V	high	> 15,50

Table 33 – Application rates of mineral fertilizers by active substance

Group of sufficiency	Soil		
	sandy and sandy-loam		
	Pine	spruce, larch	deciduous
Nitrogen fertilizers			
I	55	60	40
II	45	50	30
III	25	30	20
IV	only supplementary fertilizing		
Phosphorous fertilizers			
I	140	130	145
II	110	100	115
III	60	50	65
IV	20	20	20
Potassium fertilizers			
I	100	80	80
II	75	55	55
III	35	30	30
IV	20	20	20

The required amount of mineral fertilizer (H, kg/ha) is calculated by the formula: $H=R \cdot 100 / P$, where R is the fertilizer rate by active ingredient, kg/ha; P is the proportion of active ingredient, %.

The proportion of fertilizer elements in soils and growing medium can be determined by indirect methods. For instance, the test method of soil solution conductivity (EC) allows determination of gross nutrient in soil by means of conductivity meter. The pH level of soil solution can be determined as well. The following methods of EC determination prove to be most efficient for practical use:

Dilution 1:2.

The method is suitable for all types of cells, excluding small-volume ones. This method also cannot be used to analyze growing medium containing extended fertilizers because it causes disintegration of fertilizer granules and the analysis cannot be considered as accurate. It is the most common method by which one portion of growing medium is diluted by 2 portions of distilled water (Figure 42).

The mixture of growing medium and soil solution is filtered and squeezed. The resulting solution is analyzed.

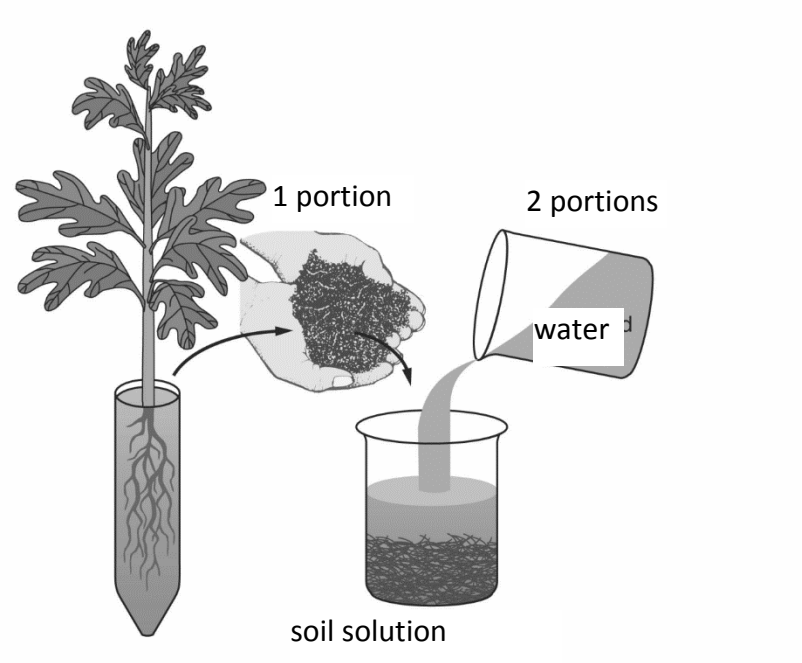


Figure 42 – Dilution 1:2 (by Thomas D. Landis, R. Kasten)

The obtained sample can be analyzed for EC and pH values as well as the presence of macro- and microelements.

As peat has strong water-retaining capacity, the dilution 1:2 method requires much growing medium to obtain necessary amount of soil solution. So, some cell with nursery stock have to be removed. The amount of distilled water should be increased to 5 portions per 1 portion of peat growing medium. However, it should be remembered that the results obtained by the dilution 1:5 and the dilution 1:2 cannot be compared.

Flushing method. In this method, the soil solution in the cell medium is replaced by distilled water. It is well adapted for any container, except for small- or large-sized heavy-to-move containers. The method is also suitable for growing media containing extended fertilizers because the fertilizer granules are not disintegrated as distinct from the dilution 1:2 (1:5) method.

The method involves two stages. First, containers are generously filled with water and are left for two hours. Then, the cell is filled up with distilled water until 100 ml of drainage water can be collected (Figure 41). A measuring glass must be put under the cell prior to watering. The water is poured slowly so that the water does not touch the cell walls.

The obtained results can be compared against the index scale (see Table 34) to evaluate fertilization needs.

Table 34 – EC index, mCm/cm, based on nutrient sufficiency level (by Thomas D. Landis, R. Kasten)

Level of sufficiency	Dilution 1:2	Flushing
Absent	below 0,25	below 1,00
Low	0,30–0,75	1,00–2,50
Optimal	0,75–1,50	1,00–6,00
High	1,50–2,50	6,00–8,00
Dangerous	above 2,50	above 8,00

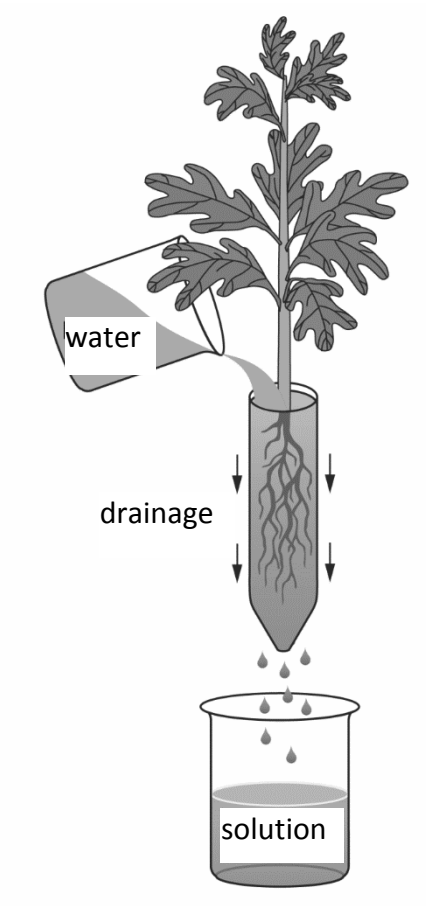


Figure 43 – Flushing method (by Thomas D. Landis, R. Kasten)

However, we should remember the words by the outstanding scientist D.M. Pryanishnikov, the author of nutrient cycle concept, who said that 'it is plants, not fields, that must be fertilized'.

The most efficient technique is the analysis of nutrient content in the plant. Plant samples are collected and analyzed by laboratory equipment. The key point is the "reference" seedling that will serve as a control sample for comparing the nutrient content of other samples. In Belarus, this technique is expected to be developed in the long run.

Both conventional and specialized mineral fertilizers can be applied in forest nurseries.

Main application and supplementary fertilizing should be done by solid fertilizers, such as ammonium nitrate, carbamide, concentrated superphosphate, and complex fertilizers, i.e., ammophoska. Foliar dressing requires liquid fertilizers or soluble solid fertilizers. Soil application by Egedal cultivator works well for coniferous species.

Application of mineral fertilizers influences the soil acidity. It must remain within the pH KCl 4,0–5,5 for conifers and pH 5,0–6.0 for deciduous. Soil can be acidified by ammonium sulphate, ammonium chloride, ammonium nitrate, carbamide, ammonium bicarbonate, superphosphate, ammophos, potassium chloride and potassium sulphate.

Controlled release fertilizers (CRF) or extended fertilizers are new generation of fertilizers. The most widespread is Osmocote, however its license expires at the

Republican Breeding and Seed Production Center. There is also a 180-day Bazakot fertilizer.

Figure 44 – Extended fertilizer Osmocote and its action time by types

The controlled release fertilizers are special granulated fertilizers with an established time period for release of active ingredients which depends on soil temperature. The granules are covered with wax, resin, or more commonly, polymer.

Figure 45 – Time periods of active ingredient release

The duration of the fertilizer action depends on the granule cover and its thickness. The manufacturers establish its for the soil temperature of 21°C. As the temperature rises, the release time is reduced.

Extended fertilizers can safely be used during sowing, no supplementary fertilization is required afterwards.

Organic fertilizers are capable of producing the yield promotion effect for several years. They are environmentally friendly and nitrate-free.

The most common raw material for organic fertilizers is manure which can be applied in its pure form only with some restrictions. Therefore, composting is a basic way of applying manure.

Compost (*Ger*. Kompost, *It.* composta, *Lat*. compositus - composite) is an organic fertilizer obtained from decomposition of organic animal or plant material into a humus-like material. Composting involves biodegradation of various organic materials by microorganisms, decomposers and detritophags.

Commonly, the raw material for compost can be defined as "green" or "brown". Green material is rich in nitrogen, brown material contains much carbon. The optimum carbon-nitrogen proportion is 25–30:1. Freshly cut grass has 15:1 proportion, dry fallen leaves – 50:1. Mixing of equal shares of grass and leaves will produce an optimum compost mixture.

The quality of compost can be assessed by the following five criteria groups:

– maturity,

– impurities,

– microelements,

– pathogen,

– organic pollutants.

Maturity is an important criterion of the compost quality assessment. Non-mature compost mixtures negatively affect plants. Maturity is an essential quality of compost. If compost mixture is not mature, the term "compost" should not be used.

Maturity is assessed by the following three criteria:

– C:N proportion,

– oxygen consumption,

– germination and growth rate of plants.

Compost can be defined as mature if it meets two requirements:

– C:N proportion <25;

– oxygen consumption <150 mg O2/kg/hour.

Organic fertilizers have some distinctive features. They can be produced on site from animal waste or secondary products. However, the technological process of making the organic fertilizers is rather complicated because the application of organic fertilizers requires huge quantity which can amount to dozens of tons per 1 ha.

The application of organic fertilizers can be made more efficient by making concentrated organic fertilizers, such as bio-humus and bio-fertilizers.

Figure 46 – Bio-fertilizers

Bio-humus has the highest potential in forest nurseries. Bio-humus is produced by organic waste decomposition by red Californian redworm. The worm is able to decompose all types of animal manure, bird manure, food waste, wastewater sludge, and waste from fish and meat industries.

Bio-humus has extremely high water-resistance which determines the soil structure and creates an optimal soil solution medium. The bio-humus elements dissolve slowly in the soil, so plants can absorb them for a prolonged period of time.

Green manure is a special, very important sort of organic fertilizers.

Green manure consists of quickly-growing plants which are grown for further ploughing under the ground to create a source of organic elements and nitrogen for plants and soil microorganisms.

Green manure is grown for the following purposes:

– enriching of soil with organic elements and nitrogen; green manure can fully replace conventional manure (3 kg of green manure replace 1–1,5 kg of conventional manure);

– enriching of soil with phosphorus, potassium, calcium;

– improvement of soil structure, physical and physicochemical qualities (lower acidity, higher adsorption capacity, higher water capacity, etc.); during rotting, green manure makes soil more porous and water-saturated;

– increased activity of useful microflora;

– the ground surface is shadowed and protected from intensive sun radiation;

– green manure protects soil from wash-off and blow-off;

– inhibition of weed plants;

– some green manure has phytosanitary action by preventing certain diseases of main crops;

– pest control on main crop; a certain proportion of pests is distracted by green manure;

– green manure plants with bright blossom attract useful insects;

– green manure can be used for compost mixtures, it can accelerate decomposition, increase the proportion of useful nutrients and greatly improve the composition.

Green manure efficiency greatly depends on the age of plants. Yong fresh plants are rich in nitrogen, quickly decompose in the soil. However, large masses of vegetation should not be ploughed under the ground to avoid acidification. Degradation of older plants is slower, but they are richer in nutrients.

Green manure should be ploughed under the ground during flower-bud formation before blossoming. The plants should be buried at 12-15 cm in light soils.

Green manure is made of either all vegetation mass available (green parts and roots) or only some parts of it. There are three forms of green manure: ***complete, mowing, after-grass***.

Complete green manure involves ploughing of all vegetation mass.

Mowing green manure is made of the plants grown in other locations. The mowing harvest is then moved to the field to be fertilized and ploughed under the ground. The emergency field is planted with perennial grasses (most commonly lupine) which is then mowed and moved to the neighbouring field for fertilization. The first mowing harvest is used for fertilization of winter crops, the second for winter ploughing. In gardens, the mowing harvest from interrrow spacings is used to fertilize circles around tree trunks. The fertilizing capacity of mowing green manure is similar to conventional manure. The mowing green manure can be used for composting. It is piled together with corn stovers, cotton stems, river or pond mud, excrements, etc. and left for composting.

After-grass green manure is obtained after the green part of grass has been cut. Roots and stubbles and other after-grass remnants are ploughed under the ground. The cut aboveground vegetation mass can be used for composting.

All growth-promotion agents can be classified into the following groups:

– natural substances and compounds (organic substances that can slow down or promote the growth), also known as phytohormones;

– synthesized agents.

Phytohormones differ in their action and can be classified as:

- auxins;
- ethylene;
- cytokinins;
- growth inhibitors;
- gibberellins;
- brassinosteroids.

Auxins are applied to promote the growth of stem, roots and leaves. Gibberellins are aimed to boost the growth of seeds and fruits.

Cytokinins should be preferred to encourage cell growth and bud formation on whole plants and separate tissues. Cytokinins promote layering capacity and prevent ageing of leaves.

Application of ethylene promotes female flowers which can be useful for selection.

Brassinosteroids are phytohormones that are present in plant cell. They are responsible for immune system of plants, especially in stressed conditions, i.e., drought, temperature drop, high soil moisture, abnormal acidity of soil.

Synthetic growth-promotion agents are products of auxin synthesis. Synthetic substances are able to regulate all physiological processes faster than natural ones. Application of synthetic growth-promoters requires more precise rationing.

The growth-promotion agents are used for other purposes as well.

Retardants inhibit the stem growth. The stems become shortened and incrassate, the plant becomes more resistant to damping-off. Retardants encourage lateral shoots and root system.

Morphactins slow down seed germination and inhibit growth of shoots.

The main growth-promotion agents authorized for forestry purposes are Stimpo, Peat Oxidate, Epin Extra.

Figure 47 – Growth-promotion agents

Chapter 4

MODERN ENVIRONMENTALLY-FRIENDLY PLANT-PROTECTING AGENTS AND FERTILIZERS CERTIFIED FOR APPLICATION ON FOREST TREE SPECIES

M.O. Ramanenka, senior lecturer, **Department of Forest Protection and Wood Science, Belarusian State Technological University, PhD (Agriculture)**

FSC strives to identify the best feasible approach to reduce the use of chemical pesticides in FSC-certified forests and plantations, and to prevent, minimize and mitigate the related environmental and social impacts.

The revised FSC pesticides policy is based on the following main considerations:

1. highly hazardous pesticides (HHPs) are identified and categorized as prohibited, highly restricted or restricted according to their hazard;
2. where integrated pest management (IPM) identifies the need to use a permitted chemical pesticide as a measure of last resort, an environmental and social risk assessment (ESRA) is conducted at different levels to identify the nature and degree of risk together with the measures for mitigation, and the monitoring requirements
3. The Policy highlights the importance of repairing and compensating for any damage to environmental values and human health and of monitoring both the use of pesticides and the impact of the Policy itself.

Environmental and social risk assessment (ESRA) implies a process to predict, assess and review the likely or actual environmental and social effects of a well-defined action, evaluate alternatives, and design appropriate mitigation, management and monitoring measures. In the context of the FSC Pesticides Policy, it relates to chemical pesticide use.

Highly hazardous pesticide (HHP) are chemical pesticides that are acknowledged to present particularly high levels of acute or chronic hazards to health and environment according to internationally accepted classification systems, or are listed in relevant binding international agreements or conventions, or contain dioxins, or heavy metals. The FSC policy distinguishes the following groups of HHPs:

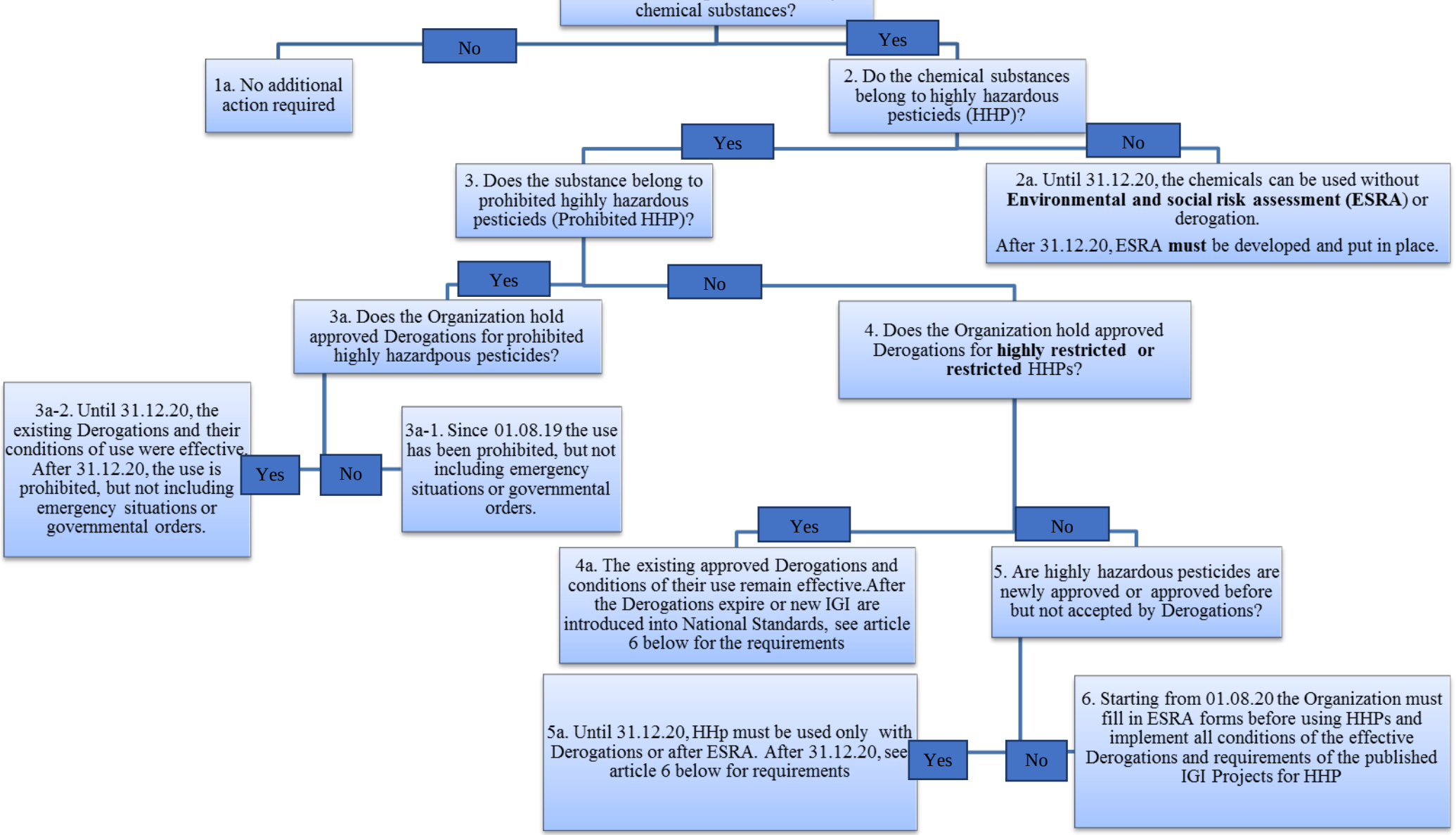
- FSC prohibited HHPs: are chemical pesticides that are:
  - listed or recommended for listing under Annex A (elimination) of the Stockholm Convention on Persistent Organic Pollutants or Annex III of the Rotterdam Convention on the Prior Informed Consent Procedure, or listed under the Montreal Protocol on Substances that Deplete the Ozone Layer or
  - acutely toxic and that can induce cancer (carcinogenic and likely to be carcinogenic) or
  - contain dioxins or
  - contain heavy metals.

- FSC highly restricted HHPs: chemical pesticide presenting **two or three** out of the following hazards:
    - acute toxicity,
    - chronic toxicity and
    - environmental toxicity.
- FSC restricted HHPs: chemical pesticide presenting **one** out of three of the following hazards:
    - acute toxicity,
    - chronic toxicity and
    - environmental toxicity.

The FSC steps to reduce and eliminate the use of chemical pesticides, and to minimize associated risks to human health and the environment, are to:

1. Identify highly hazardous pesticides (HHPs) according to their short and long-term toxicity characteristics;
2. Prioritize these characteristics and categorize the HHPs into three hazard-based lists: Prohibited HHPs, Highly Restricted HHPs and Restricted HHPs.
3. Regulate the use of HHPs in each list according to the risk they pose to human health and the environment.
4. Repair and compensate for damage to environmental values and human health caused by inadequate development or implementation of environmental and social risk assessment.
5. Monitor the use of pesticides and the impact of the FSC Pesticides Policy.

Prioritization of characteristics and categorization of HHPs are aimed to prohibit or restrict their use according to the risk they pose to human health and the environment (see Figure 1).


chemical substances?
No
Yes
1a. No additional action required
2. Do the chemical substances belong to highly hazardous pesticieds (HHP)?
Yes
No
3. Does the substance belong to prohibited hgihly hazardous pesticieds (Prohibited HHP)?
2a. Until 31.12.20, the chemicals can be used without **Environmental and social risk assessment (ESRA)** or derogation.
After 31.12.20, ESRA **must** be developed and put in place.
Yes
No
3a. Does the Organization hold approved Derogations for prohibited highly hazardpous pesticides?
4. Does the Organization hold approved Derogations for **highly restricted or restricted** HHPs?
3a-2. Until 31.12.20, the existing Derogations and their conditions of use were effective. After 31.12.20, the use is prohibited, but not including emergency situations or governmental orders.
Yes
No
3a-1. Since 01.08.19 the use has been prohibited, but not including emergency situations or governmental orders.
Yes
No
4a. The existing approved Derogations and conditions of their use remain effective.After the Derogations expire or new IGI are introduced into National Standards, see article 6 below for the requirements
5. Are highly hazardous pesticides are newly approved or approved before but not accepted by Derogations?
5a. Until 31.12.20, HHp must be used only with Derogations or after ESRA. After 31.12.20, see article 6 below for requirements
Yes
No
6. Starting from 01.08.20 the Organization must fill in ESRA forms before using HHPs and implement all conditions of the effective Derogations and requirements of the published IGI Projects for HHP

Chapter 5

MODERN SYSTEM AND TECHNOLOGY FOR THE PROTECTION OF NURSERY STOCK AGAINST THE INCIDENCE OF PESTS AND DISEASES. MEASURES TO PREVENT THE IMPORTATION OF PATHOGENS AND PESTS ON PLANT SEEDS AND PURCHASED NURSERY STOCK

V.A. Yarmolovich, Dean of Forestry Faculty, **Belarusian State Technological University, PhD (Biology), Associate Professor**

The system of protection measures in forest nurseries includes the following main actions:

1) forest health monitoring;
2) forest management (cultural) practices;
3) physical and mechanical practices;
4) chemical control;
5) biological control;
6) integrated control;
7) plant quarantine.

Forest health monitoring must be duly arranged in forest nurseries. Guidelines for forest health monitoring, including, forest nurseries, are laid down in "Procedure for forest protection practices in forest". Forest health monitoring is the responsibility of the forest nursery director, forest protection engineer and forest regeneration engineer. They carry out regular inspections of crops (plantations) of cultivated plants. If infestation is detected, the experts determine the affected area, type of pest or disease, level of damage (visual inspection), species and age of plants so that they can prescribe control measures (if required).

Detailed inspection of the incidence of plant diseases in forest nurseries is carried out throughout the year, three times per season, i.e., after melting of snow, 1–3 weeks after first sprouts appear and in late September–October.

Forest health monitoring in forest nurseries is done all the year round (more often during the growing season) and is combined with planting, care, transplanting or lifting of planting material.

Should a disease be difficult to identify in the field (atypical symptoms or early stage), samples of affected plant tissue are collected to do laboratory studies.

Forest management (cultural) practices. Up-to-date and proper forest management (cultural) practices can prevent many plant diseases and make chemical and biological control more effective.

Protection of young nursery trees against pests and diseases is primarily based on strict observance of cultural practices and techniques for each individual tree species.

New sites (particularly, permanent) of forest nurseries should be established on flat areas, sandy-loam and light loamy soils without stagnant water. Wet and swampy grounds are bad for forest nurseries. Top soil must be at least 25–30 cm thick, contain more than 2% of humus and have soil acidity of min. 4,5–5.

To prevent soil from becoming poor and plants from getting weak, areas of nursery stock planting should be fertilized annually. Mineral and organic fertilizers should be applied according to the existing industry regulations. Laboratory analysis of soils and planting stock for macro- and microelements is recommended. Acidic soils (pH<5.0) should be limed, application rates depend on the acidity of soil. When using peat as substrate or mulching material, it should be checked for pathogens, especially if it is delivered to the forest nursery by a new supplier.

Watering of plants during drought periods prevents them from drying, weakening and infestation by pathogens. On open grounds, irrigation can be less frequent, but more ample to ensure wetting of the whole root layer. Water should not be from open water sources, in particular, stagnant reservoirs. The water should be filtered prior to irrigation to eliminate attacks of pathogen fungi.

Weed cutting must be done on a regular basis. Weeds can inhibit and weaken seedlings, be a source of infection or intermediate hosts for some rust fungi. In forest nurseries, grass on unweeded and adjacent areas must be regularly mowed. Cut weedage should not be piled and stored close to seeding section of the nursery or in interrrow spaces.

Application of herbicides in nursery sections must be done in strict compliance with the existing industry regulations in order to prevent chemical burns, dieback or weakening of plants.

Optimal temperature and moisture conditions must be maintained for each tree species grown in greenhouses. The greenhouses must be regularly ventilated to prevent mould, rot and other diseases.

When transferring plants to transplanting section, adequate measures should be taken to prevent drying and damage of root systems, bending of roots.

When being lifted, planting stock should be carefully sorted; affected, damaged or stunted plants should be removed.

Intermediate hosts of rust fungi, i.e., willow, coltsfoot, juniper, etc., must be removed on the areas around the forest nursery (at a distance of 200–250 m).

In seeding sections, crumbling peat or ash should be spread on the snow surface in early spring after the winters of deep snow cover.

Physical and mechanical practices used in forest nurseries include clean-up and burning of fallen leaves in autumn because many pathogens (powdery mildew, rust, spot, scab, etc.) may overwinter on the leaves. Besides, badly affected and dry plants should be

removed, their infected parts are cut off and destroyed, web tubes of insect pests are removed.

Chemical protection agents of tree species prove to be economically feasible in forest nurseries. Seedlings are highly susceptible to pest attacks and intensive technology of nursery stock growing. Application of chemical protection agents is simple due to small size of plants being treated. It should be kept in mind that a forest nursery is classified as forest, therefore, it has to comply with FSC requirements. Plants can be treated only by the chemicals that are listed in the National Register of Plant Protection Agents, Pesticides and Fertilizers and that are allowed for use in the Republic of Belarus and not included in the FSC list of highly hazardous chemicals.

Coniferous seed must be disinfected with special pre-sowing seed dressing agent in order to prevent damping-off, mould and soil-inhabiting pests. The pre-sowing treatment is highly economical (minimum consumption of chemicals) and environmentally friendly. Pre-sowing fungicidal treatment prevent mould fungi infection during seed germination. The fungicides create a pathogen-free area around the sprouts and have a long-term fungicidal and antimycotic effect on pathogen microflora.

Water should be added during seed dressing. Small amount of water is added to the fungicidal agent (10 ml per 1 kg of seeds or 1 ml per 100 g of seeds) to ensure better soaking. Seed dressing (disinfection) can be done immediately or long before sowing.

Beforehand-treated seeds must be stored in a cool, well-ventilated place. If seeds are stored more than 6 months, laboratory germination analysis should be done prior to sowing.

In the event of first signs of sprout damping-off, soil in and around the affected area should be disinfected by fungicides. The application of fungicides must be as thorough as possible to ensure their even distribution across the soil surface. Fungicide must penetrate the root area; soil must be wet at all times because roots are not able to absorb protection agents in dry soils. Before disinfection, the ground must be carefully loosened to prevent its wash-off by disinfecting agent. The consumption rate of the working solution is 3–5 l per 1 m^2 of ground. Sandy and sandy-loam soils are easily soaked by water, so the consumption rate can be increased to 5 l. Clay-loam and loam soils require only 3 l of working solution for the fungicide to penetrate the root layer. Optimal air temperature is 10–27°C, treatment should be done in dry weather.

A second fungicidal disinfection is done 7–10 days later. All-over fungicidal treatment (throughout the sown area) can be done only on protected grounds as it is not economically feasible on open grounds.

Above-ground parts of plants can be protected against pests and diseases by two- to four-time spraying of aqueous solutions of fungicides, insecticides and biopreparations. Hand-held or powered spraying machines are used. The most advanced method is drone spraying, however, this innovative method is still a pilot forestry project.

Plant protection in forest nurseries starts when first symptoms of diseases become visible or during the periods of extensive dispersal of fungi spores.

Nursery plant protection against disease is usually done by large- to medium-drop spraying, consumption rate of working solution is 400–600 l/ha. The most common strength of working solutions used for spraying of above-ground plant parts is 0,1% (1 ml of chemical per 1 l of water).

Systemic fungicides can be combined with complex fertilizers (ammophos, nitrophos, etc.). The fertilizer is dissolved in water, then the fungicide is added.

Settings of the spraying machine and flow adjustment of the working solution must be checked prior to spraying. This can be done on a small trial area. The spraying container is filled with the amount of pure (pesticide-free) water required for the chosen area and spraying is performed until all the water is spent. The consumption is assessed by the treated area. If the consumption is too low or too high, necessary adjustments are made on the spraying machine (see instruction manual) or the speed of the machine is adjusted.

The working solution can be prepared in the spraying container or a separate container. The protective agent must be fully dissolved by water. The working solution must be spent during the same day. The remaining fungicides are given to the special storage place. Their in-use shelf life should not exceed one year, as their efficiency gets lower.

Biological plant protection is rather complicated and can be done only by highly-skilled professionals. The storage period of biologicals is relatively short and their efficiency is lower than that of chemicals. However, biologicals are much more environmentally friendly. The National Register of Plant Protection Agents lusts the biological that are certified for use.

Microbiological technology is a most advanced way of increasing the efficiency of nursery stock growing and reforestation. The most promising technique is growing of forest seedlings with the use of vegetative-microbial systems, primarily, mycorrhiza which is the symbiotic association of the root of a higher plant with a fungus. Mycorrhizae are very common in nature. Mycotrophy (plants get nutrition supply from mycorrhiza) is highly essential for plants because the symbiotic association with fungi promotes growth and development of plants. Due to the integral action of mycorrhizal preparations the pathogen microflora is inhibited; root nutrition and water metabolism are improved because the extensive mycelium makes the absorption surface bigger; mineral elements become available; organic residues are decomposed. Trees in symbiotic fungi-free environments are not able to create a proper mycorrhizal association; they often develop physiological defects and development disorder, suffer from diseases and die.

Mycorrhizal substances are widely produced in neighbouring countries. For instance, Poland has three mycorrhizal laboratories that annually produce over 50,000 l

of biologicals containing ectomycorrhizal fungi for forestry purposes. About 10 million of seedlings annually get vaccinated by *H. crustuliniforme* based biological made in Poland. In Belarus such biologicals are still under development.

Integrated control of pests and diseases is a combination of protection techniques and protective agents with natural controllers of pest populations to keep them under economic threshold of harmfulness. It is rather difficult to arrange efficient integral control in forest nurseries. Most commonly, it involves well-balanced combination of chemical and biological pesticides.

Plant quarantine is defined as the legal enforcement of the measures aimed to prevent the introduction and/or spreading of quarantine pests. Plant quarantine helps to protect flora resources of a country and to control plant pests. National Inspection on Seed-farming, Plant Quarantine and Protection is a governmental body in charge of external and domestic plant quarantine in Belarus.

External plant quarantine is a set of regulations aimed to prevent the import and export of quarantined plants and plant pests. The external plant quarantine inspection is done at the customs.

In Belarus, seeds and planting stock of tree species are rarely purchased from abroad. However, if it occurs, the plant quarantine inspection is first done at the customs and then on arrival.

Domestic plant quarantine is a set of regulations aimed to prevent spreading of quarantined plants within a country, timely detection, localization and eradication of focal areas of quarantined plants. Planting stock is rather seldom moved from one forest nursery to another. If seeds are transferred between nurseries, phytopathological and entomological inspection is done upon arrival.

The incoming planting stock must be carefully checked for symptoms of diseases or pests listed in the Eurasian Economic Union Register of Quarantine Plants.

Chapter 6

SAFETY AND HEALTH IN THE USE OF PLANT-PROTECTING AGENTS AND FERTILIZERS

M.O. Ramanenka, senior lecturer, **Department of Forest Protection and Wood Science, Belarusian State Technological University, PhD (Agriculture)**

General health and safety regulations

Persons under 18 years of age are not allowed to work with pesticides and agrochemicals. Persons with **medical contraindications**, pregnant or breastfeeding women are not allowed. Women cannot do work connected with transportation, loading and unloading of pesticides

All personnel dealing with application, transportation, storage and trading of pesticides and agrochemicals shall be allowed for work only after health check-up, training and safety knowledge assessment.

Any work with pesticides of hazard classes I and II and application of restricted-use pesticides shall be done by workers with special training.

Places for rest and meals shall be located windward, at least 200 m away from the border of the pesticide-treated areas. Drinking water, a wash-stand, soap, individual towels and a first-aid kit must be available to workers in the places for meals and rest.

All personnel involved in the use of chemicals must be provided free-of-charge proper personal protection equipment to prevent inhalation, skin absorption and ingestion of agrochemicals.

All workers must have individual **personal protective equipment**, i.e., protective clothing, safety shoes, respiratory protection (half-faced or full-faced), goggles, protective gloves. Respiratory protection must be supplied with spare filter boxes and canisters.

Personal protective equipment must be carefully selected in terms of physical-chemical properties and hazard class of substances, labour conditions and individual sizes of workers.

Application of moderately hazardous, low-volatile sprays requires the use of anti-dust (aerosol) respirators.

Universal anti-gas respirators with spare filters and industrial gas masks with spare filter boxes shall be used to prevent inhalation of volatile substances and pesticides of hazard classes I and II. Anti-gas canister shall be used when working with phosphorus, chlorine and other organic substances.

Shall the respirators with the spare canister not be provided, the works must be done in industrial gas masks with proper filter boxes and aerosol filters.

Fumigation of rooms by hazardous substances requires gas masks to be worn.

Responsible workers must complete a passport for each gas mask box or respirator filter canister, indicating the conditions of use (substance name, mode of application, and hours of use).

Used canisters, filters and boxes must be duly replaced upon the expiry of service period and at the first sign of pesticide odor smelt through the mask. Used canisters, boxes and filters must be duly disposed of in specially designated places.

Low-hazardous and moderately hazardous powdered substances require special clothing with protective properties marking to be worn.

When working with substances of hazard classes I and II and pesticide solutions, the workers must wear special clothes made of blended prepared fabric and additional skin-protection equipment, i.e., apron, membrane protective sleeves.

During fumigation and subsequent degasation of closed rooms, sowing stock, food, package and raw materials, protective clothing must include **overalls with membrane vinyl coating and obligatory underwear**.

Hand protection from concentrated emulsions, pastes, solutions and other liquid agrochemicals must include rubber, latex, butyl rubber and other gloves of similar protective and hygiene properties. Medical rubber gloves are not allowed.

Goggles shall be worn to protect eyes.

Personal protective clothing must be washed after use. It must be taken off as follows: with your protective gloves on, wash them with some decontaminating solution (3–5%-solution of soda ash, lime milk), then rinse with water; take off your boots, overall, googles and respiratory protection; wash your protective gloves with decontaminating solution and rinse with water; take off the gloves. Face rubber pieces and external surfaces of filter boxes and canisters must be brush-washed with soap-soda solution (25 g of soap + 5 g of soda ash per 1 liter of water), then rinsed with water and air-dried. Face pieces of respiratory protection must be sanitized with a cotton-wool ball soaked with 0.5%-solution of potassium permanganate or alcohol.

Every day protective clothing must be dusted with a vacuum cleaner, by shaking or beating after use. The clean clothing should be left under some roof or outdoors for 8–12 hours for airing and drying.

Apart from mechanical cleaning of protective clothing from pesticides and agrochemicals, the clothes shall be regularly washed and sanitized when getting dirty, as often as every 6 working shifts.

The workers who have not been given personal protective equipment and who work in the environments hazardous to health have the right to refuse to perform any work until the protective equipment is provided.

Workers shall not be under the influence of alcohol, drugs or other intoxicants at work. Abuse of alcohol, drugs or other intoxicants during the working hours is not allowed.

Smoking must be allowed only in designated smoking areas.

The worker is obliged:

– to observe the internal code of labour conduct, work and rest schedule, work discipline (rest and meals are allowed only in designated places);

– to timely inform the supervisor about the lack of personal protective equipment;

– to know and observe health and safety regulations, to maintain fire safety at the workplace;

– to be familiar with evacuation maps, to know procedures in case of fire, properties of flammable substances, ways of fire extinguishing;

– to know where fire extinguishers and fire alarms are located, not to block access to fire extinguishers and to be able to use them;

– to know first aid regulations and to be able to give the first aid to accident victims; to know procedures for electric shock treatment;

– to inform their supervisor about mishandling of equipment, violations of occupational safety; malfunction of equipment or facilities; any hazards; any work accidents; detected failures of equipment, tools, PPE accessories; their health deterioration, incl. acute health problems. The workers are allowed to continue their work once the above listed limitations have been eliminated;

– to work on properly functioning equipment and to use properly operating tools only for the purposes specified;

– to know the design of the equipment and to observe operation and maintenance rules;

– to know and observe personal hygiene: to soap-wash hands before meals and rest, not to use flammable substances (gasoline, kerosene, acetone, etc.) for hand-washing.

Persons violating the above rules are duly liable in accordance with the law.

Safety before work

Make sure you have all required personal protective equipment and accessories.

Inorganic saltpeter must not be transported with other mineral fertilizers or pesticides if their contact can cause spontaneous inflammation.

Containers for liquid fertilizers must have vacuum-tight hatches with vent and safety valves and be duly labeled or marked.

Pouring of liquid mineral fertilizer from one container into another must be done with a gas line hook-up. The stoppers (valves, faucets) must be loosened smoothly, without jerking or hitting them with metal.

Transportation of ammonium-containing fertilizers, preparation of solutions or mixtures and application of fertilizers are not allowed at night time.

Special-purpose transportation vehicles must be used only for the purposes specified. Other cargoes must not be transported together with pesticides of agrochemicals. Only authorized staff is allowed on the transportation vehicles.

All vehicles must be wet-cleaned and sanitized after work.

Should a traffic accident happen during transportation of mineral fertilizers, all necessary actions must be taken to remove or neutralize spillages. Potential toxic or environmental hazards must be reported to the supervisor, local hygiene and epidemiology authorities, other inspectorate bodies. Transportation vehicles must be equipped with necessary tools to remove spillages and prevent contamination of the area.

Agrochemicals must be stored in specially designated agrochemical depots.

The storage area must be divided into several zones:

– agrochemicals storage;

– seed dressing area, dressed seeds room, solution-filling station;

– depot for machines, apparatus and vehicles used for application of pesticides and agrochemicals;

– storage of packing containers, sewage cleaning facilities;

– maintenance and repair area;

– staff amenities/administration.

The distance between administrative/amenities buildings and storage premises must be minimum 50 m.

The storage areas for granular fertilizers and pesticides must have the following zoning:

– storage and delivery of granular and packaged mineral fertilizers;

– storage of drinking water and food; dining room, room for rest; PPE room;

– area for cleaning, dusting and disinfection of protective clothing, safety shoes and other PPE;

– special cloakrooms for changing and storage of everyday clothes;

– sanitary and amenities rooms.

No forage must be stored in the storage area.

Non-packed fertilizers (potassium fertilizes, superphosphates) shall be stored in bulk in separate reservoirs as high as max. 2 m for compacting fertilizers, max. 3 m for non-compacting fertilizers.

Packed mineral fertilizers and pesticides must be piled on pallets or on storage shelves. If contained in bags, metal drums, barrels (minimum 5 l), cardboard and polymer cartons, boxes, flasks, the piles of fertilizers can be placed in three tiers. If stored on shelves, the piles should be higher. The minimum distance between the wall and the goods must be 0,8 m; between the beams and the goods – 1 m; between the light and the goods – 0,5 m; between the floor and the lower shelf – 0,8 m.

All agrochemicals transferred to and from the storehouse must have a manufacturer's certificate listing specification of goods, safety requirements for transportation, storage and application. Each package must have application label or marking.

Pesticides must be delivered from the storehouse in factory packaging. Small amounts can be placed in other type of packaging that will ensure safety. Pesticides cannot be packed in paper, fabric bags or food containers.

Loading and unloading operations in agrochemicals storehouses, cleaning and sanitation of package and transport vehicles must be mechanized. Mechanized means (**fork trucks, electric trucks, forklifts, hoists**, etc.) must be selected according to the product type (packed, in bulk).

Cleaning of the storehouse must be done when necessary, at least twice a week. Storehouses of more than 50 t capacity must be equipped with dusting and cleaning machines, air and wastewater must be cleaned from pesticides and agrochemicals.

At storehouses, disinfection agents, i.e., bleach powder, soda ash and other designated agents must be used to neutralize pesticides and agrochemicals.

Before the operations, the storehouse rooms must be ventilated for 30 minutes. Should there be no technical ventilation system, the loading and unloading rooms must be given a free flow of air.

Unpurified wastewater from storehouses must not be discharged into the drainage structures and surface water bodies. First aid regulations in case of intoxication by pesticides and agrochemicals must be listed in the product instruction.

Safety during work

Areas under pesticide treatment must be demarcated by hazard-warning plates, each of them being located within visible range from the nearest ones. The plates must

contrast with the background. The plate can be removed only upon the expiration of the safety interval. Economic entities in charge must duly inform the local population about the time and place of operations through mass media, 4–5 days prior to the works.

Chemical control cannot be carried out in sanitary protection zones, i.e., less than 300 m between the treated area and a water body. If necessary, medium- or low-toxic pesticides must be applied in sanitary protection zones. Ground equipment must be used.

Aerial treatment is not allowed on areas located closer than 1,000 m from population centres and water supply sources or areas located closer than 2,000 m from fishery water bodies.

Soil fumigation cannot be done by persistent pesticides of hygiene groups I and II.

Landing strips and working sites (for preparation of working solutions, filling of ground equipment with solutions, seed dressing, preparation of baits, sanitation of vehicles and equipment) must be located at least 200 m away from residential, production and public buildings, livestock and poultry farms, water sources, wildlife habitats and at least 2,000 m away from fishery water bodies.

Working sites must have a hard-surface floor (concrete floor) to enable sanitation. Temporary rammed earth is allowed. After the treatment has been completed, the sites must be disinfected, ploughed or dug.

Preparation of working solutions and mixtures of pesticides, filling of dusting and spraying equipment must be mechanized and carried out on specially equipped sites or stationary filling stations.

Working solutions of pesticides must not be prepared in indoor premises and passages. If greenhouse facilities have no stations for working solutions preparation, designated rooms must be equipped.

Soil application of pesticides must be done only by special machinery and equipment.

In hot weather (+28°C and above) all operations must be done in the early morning and evening, provided there is no upward wind.

Spraying by ground equipment is not allowed at the wind speed more than 3 m/sec. Air sprayers can be used at the wind speed below 3 m/sec (mist spraying) and below 4 m/sec (large-drop spraying). Boom tractor sprayers are used at the wind speed below 4 m/sec (mist spraying) and below 5 m/sec (large-drop spraying). Aerial dusting can be done at the wind speed below 2 m/sec, air spraying – at the wind speed below 3 m/sec (mist spraying) and below 4 m/sec (large-drop spraying).

Before the application of pesticides, dusting and spraying equipment must be checked for normal operation by using inert powders and water:

– liquid level indicator must be checked to avoid overfilling of the spraying equipment;

– filling must be done by closed method, through seal tight tubes;

– dusting equipment must be filled with the power takeoff shaft off;

– junctions and tips can be unfastened for cleaning only if there is no pressure in the system.

During manual application of pesticides in greenhouses, the workers must be located at minimum 10 m from each other. Spray cones must not be pointed towards people, electric engineering installations and communications.

Hand-held equipment (backpack or barrow) must be filled in the working solution room. Filters must be used when pouring the working solutions into the spray tanks.

Fumigation and humid disinfection must be carried out mainly in stationary premises.

24-hour security must be provided throughout the fumigation. Security guards must be equipped with gas masks and have perceived a labour safety briefing.

Fumigation is not allowed in buildings located closer than 200 m away from residential buildings and production facilities with permanent human presence and closer than 100m away from railway lines and highways.

It is forbidden to make an open fire, to take meals and to smoke in the area under fumigation. The area must be rounded with warning signs and safety instructions.

Degasation of premises must be carried out in a timely manner by balanced ventilation system or aeration of the rooms through open doors and windows.

If the fumigating agents contain heavier-than-air vapour, basement rooms must be heavily ventilated upon the completion of the fumigation.

During degasation, the indoor temperature must be raised by 2–3 degrees for the period of the operations by closing all doors and windows for 12–16 hours. The rooms must then be aerated until the fumigant odour is not smelt.

Degasation adequacy must be checked by modern control methods as prescribed by approved guidelines. After degasation has been completed, the fumigating agent content shall not exceed ambient air standard. The treated rooms must be kept closed 2 hours prior to the degasation adequacy check.

If fumigation involves treatment of any stored products (in cornhouses or chambers), the treatment time shall be extended. Fumigation time must be established in terms of the fumigant residues in the products. The fumigated products should be sold only after they have been examined for pesticide residues.

If premises (empty storehouses, grain depots, barn yard, farms) are to be treated by spraying agents, they must be sealed and cleaned mechanically. Feeders and water troughs at farms and barn yards, other stationary equipment must be sealed with film to prevent ingress of spraying agents.

Fumigation of greenhouses and soil must be supervised by a plant protection expert. The area under fumigation must be marked with “Do not enter! Gas!” sign.

Fumigation must be done by a crew divided into teams of three workers (the number of teams depends on the cubic space). Fumigation cannot be done by one worker at temperature below 10°C and above 25°C.

Before fumigation, rooms must be made seal tight (all doors and window frames must be tightly closed; all panes must be in place). Upon the fumigation, doors must be locked and sealed with sealing tape or paper.

Upon fumigation, workers must enter the rooms only with their gas masks on before they start degasation. Degasation shall be carried out within the time established by the product instruction of the fumigating agent.

All disinfection operations must be carried out on specially equipped sites having waterproof coating (chemization stations), indoors or outdoors.

The site (minimum 6x12 m) must have concrete flooring and boards, with a 5–7° gradient in the direction of wastewater collector. The site must be located at chemization stations (when there are no chemization areas, the sites shall be established at pesticide storehouses or working solution stations).

Disinfection sites must be equipped with tools for remote use of washing agents, containers and mixing tools for making working solutions (there must be an adequate number of containers to carry out full disinfection of machines); room for disinfecting agents, handling tools and wiping cloths; pump-driven washing machine or hose; lidded metal container for wiping cloths; concrete pit and reservoir for wash waters.

Disinfection site must have lockers for clothes and personal protective equipment, wash sinks, towels, soap, water cooler or drinking fountain, drying frame for special clothes, shower rooms, first-aid kit.

High-pressure washing machines must be equipped with pressure meters and thermometers and their control systems.

Mineral fertilizers must be duly prepared before soil application. They must be free from clumps and foreign matter.

Pressure meters on lime-spreading mineral wagons must be carefully verified for pressure readability.

Only authorized personnel are allowed to enter pesticides and agrochemicals working areas.

All pesticides and mineral fertilizers working areas must have first aid kits.

All machines, mechanisms and apparatus for fertilization must be carefully repaired before work and checked for leak tightness. Before using liquid mineral fertilizers, all containers, pipelines, hoses, taps, nozzles and other machine elements must be carefully cleaned, washed and inspected for leakage using clean water.

Faulty equipment must not be operated. In case of serious breakdown, the equipment must be made free from fertilizers, washed and repaired at the repair station.

Mechanized loading of mineral fertilizers into machines and units must be preferred.

Manual loading of units, fertilizer distributors, plant feeders and other machines with packed fertilizers must not exceed 10 kg for one package. Mechanized loading of mineral fertilizers into plane bins must not exceed 20 kg for one bag of working mixture.

All operations of preparing, diluting and mixing of liquid mineral fertilizers must be done using specialized equipment and personal protective equipment.

Filling of machines and units with liquid mineral fertilizers must be done through the closed seal-tight piping system.

Tractors and other agricultural machinery for mineral fertilizer application must have a designated working seat. Wind direction must be taken into account when organizing work and arranging a working seat in order to prevent inhaling of mineral spraying agents.

Granulated fertilizer packaging must be cleaned from residues and brought back to the storehouse. Worn-out paper packaging must be disposed of (burned) on designated sites.

Containers in use must be used exclusively for storage and transportation of mineral fertilizers.

Glass and metal containers for mineral fertilizers must be kept in a specially designated area.

Upon the completion of works, all sites, machines (containers, boxes, pipelines), tools must be cleared from mineral residues, cleaned and hose-blown with water.

Tanks, containers, pipes and taps mounted on machines for liquid fertilizer application must be cleaned with hot water or steam. Cleansing and washing of machines and tools must be done at washing sites. Fertilizer residues must be removed from the field and brought back to the storehouse.

Upon the completion of liquid fertilizer application, special clothes and other personal protective equipment must be cleaned, washed and delivered back to the storehouse.

Operations with preservative-containing agents must be done under the supervision of an agricultural chemist or plant protection expert.

Operations with toxic pesticides must ensure maximum health safety of the workers.

Skin must be protected by chemical suits or specialized jumpsuit made of blended impregnated dustproof fabric. An apron made of rubber-proofed fabric must be worn over the chemical suit (jumpsuit).

Hand must be protected with rubber gloves, latex gloves, gauntlets, butyl-rubber gloves or other gloves preventing skin contact.

Medical rubber gloves are not allowed.

Feet must be protected with acid-resistant (solution-resistant) rubber or leather boots or shoes.

Face must be covered with a screen mask; goggles must be worn. Anti-fog film disks, pencils or liquids must be used to prevent fogging-up of goggles.

Respiratory protection must include:

– **filter-type (aerosol) respirators** when working with medium-toxic low-volatile preparations of toxic pesticides in aerosol-loaded environments (dust, smoke, fog);

– anti-gas and all-purpose respirators with proper canisters (anti-gas canister A for organophosphorus, organochlorine, pyrethroid and other organic pesticides, canister G for organomercury pesticides, canister B for acid vapour and smoke), industrial gas masks with replaceable containers.

Toxic pesticides working areas must have first aid kit with necessary means for medical aid in case of intoxication and first aid manual.

During repacking of toxic pesticides, the following safety instructions must be observed:

– it is not allowed to drink, smoke, eat, take off personal protective equipment;

– upon completion of the works and taking off special clothes, soap-wash your face and hands, rinse your mouth with water, take shower if available;

– designated places must be arranged for the workers to have meals and to take rest. The places must have wash-sinks, soap, towels, water cooler, first aid kit;

– additional breaks must be taken during one shift for the workers to have rest outside the repacking area and to temporarily take off their personal protective equipment;

– repacking of toxic pesticides from destroyed primary packaging or compacted piles must be done with ventilation on. Safety measures must be taken to prevent fire within and near the repacking area;

– spillages of toxic pesticides must be covered up with sand, the sand must then be packed;

– spillages must not be covered with flammable matter (sawdust, turf, wiping cloth);

– spillages of powdered pesticides must be removed by plastic or wooden shovels. Metal shovels are not allowed to prevent sparking.

Safety after work

After the working shift, the workers must clean their personal protective clothing. It must be taken off as follows: with your protective gloves on, wash them with some decontaminating solution (3–5%-solution of soda ash, lime milk), then rinse with water; take off your boots, overall, goggles and respiratory protection; wash your protective gloves with decontaminating solution and rinse with water; take off the gloves.

Face rubber pieces and external surfaces of filter boxes and canisters must be brush-washed with soap-soda solution (25 g of soap + 5 g of soda ash per 1 liter of water), then rinsed with water and air-dried. Face pieces of respiratory protection must be sanitized with a cotton-wool ball soaked with 0,5%-solution of potassium permanganate or alcohol.

Every day protective clothing must be dusted with a vacuum cleaner, by shaking or beating after use. The collected dust must be disposed of as prescribed by the instructions of repacking of toxic pesticides. The clean clothing should be left under some roof or outdoors for 8–12 hours for airing and drying.

Washing of personal protective clothes must be done when necessary, no less frequently than every 6 working shifts. Washing of personal protective clothing must be done at special laundries that have equipment adequate for washing and drying of special clothes and sewage sanitation in compliance with sanitary rules and regulations.

Personal protective equipment must be stored in a separate room.

Personal protective clothing cannot be stored close to toxic pesticides, taken home or used for works not related to toxic pesticides handling.

APPENDIX A

WORKSHOP AGENDA
« Modern environmentally-friendly technologies for application of plant protection agents and fertilizers in forest nurseries»

Программа семинара

«Современные экологически-ориентированные технологии применения средств защиты растений и удобрений в лесных питомниках»

15 апреля		
		Лектор
10.30-11.30	Применение высокоэффективных удобрений и стимуляторов роста при выращивании посадочного материала в лесных питомниках	Носников В.В.
11.40-12.40	Основные вредители сеянцев и саженцев в лесных питомниках Беларуси	Козел А.В.
12.50-13.20	Обед	
13.30-14.30	Современная система и технологии защиты посадочного материала от вредителей и болезней. Мероприятия по предотвращению заноса в питомник опасных видов возбудителей болезней и вредителей с семенами лесных растений и закупаемым посадочным материалом.	Ярмолович В.А.
14.40-15.40	Применение высокоэффективных препаратов в защите посадочного материала от болезней и вредителей в питомниках. Основные требования к применению средств защиты растений в Республике Беларусь. Пестициды (фунгициды, инсектициды, гербициды), разрешенные для применения в лесных питомниках.	Романенко М.О.
15.50-16.40	Возбудители болезней посадочного материала в лесных питомниках (видовой состав, распространенность и вредоносность)	Романенко М.О.
16.50-17.00	Кофе-пауза	
17.10-18.30	Обучение для сотрудников лесных питомников лесхозов вопросам планирования, обработки растений, удобрения, полива и борьбы с вредителями и болезнями в целях максимального повышения приживаемости сеянцев с закрытой корневой системой и успешного создания лесных культур	Юреня А.В.
18.30-19.20	Техника безопасности при работе со средствами защиты растений и удобрениями.	Домненкова А.В.
19.30	Ужин	
16 апреля		
8:30	Завтрак.	
9.00	Отъезд в РЛССЦ	
9:40-12:40	Обучение для сотрудников лесных питомников лесхозов вопросам планирования, обработки растений, удобрения, полива и борьбы с вредителями и болезнями в целях максимального повышения приживаемости сеянцев с закрытой корневой системой и успешного создания лесных культур	Овсей А.А. Носников В.В.
12:40-13:20	Специализированная техника для внесения средств защиты растений и удобрений.	Асмоловский М.К.
13.20	Подведение итогов семинара. Вручение сертификатов участника. Возвращение в г. Минск.	Романенко М.О. Носников В.В.

APPENDIX B

Invitation letters

Ministry of Education of the Republic of Belarus
Educational institution “Belarusian State Technological University” (BSTU)
13a Sverdlova Str., 220006 Minsk
Tel./fax: +375 17 399 46 21, 327 62 17, 327 56 20
e-mail: root@belstu.by

01.04.2021No. 08-04-16

To: Director of Forestry
Protection enterprise

Subject: training workshop

Herewith we would like to inform you about the training workshop “Modern environmentally-friendly technologies for application of plant protection agents and fertilizers in forest nurseries” for a group of 25 participants. The workshop is to be held within the “Belarusian Forestry Development Project” and is aimed to promote professional development of forest sector workers. The workshop will take place at the premises of RTC “Les” and field sites of BSTU on April 15–16, 2021. All participation costs (incl. accommodation, meals and travel to field sites) of your representative (forest regeneration engineer or head of forest nursery) will be covered by project funds. The cost of round trip between the place of residence and the workshop venue is not included. The number of participants is limited by 25 applications.

Should you be interested to take part in the event, please submit your application by e-mail (see below) until April 12,2021. The application should contain name, job position and mobile phone number of the applicant. Your participation must also be confirmed by a subsequent phone call.

Training workshop agenda is attached.

Contact person: Marina Ramanenka, tel.: +375 29 236 08 34, e-mail: romina_mo@bk.ru.

Vice-rector for academic Affairs Sergey Shetko

APPENDIX C

«Modern environmentally-friendly technologies for application of plant protection agents and fertilizers in forest nurseries»

Minsk, 2021

No.	Name, surname	Organisation	Job position
1.	Bath Olga	Starobinsky forestry enterprise	Forest health engineer
2.	Blessed Anna	Baranovichi forestry enterprise	Head of forest nursery
3.	Tambourine Alexander	Uzdensky forestry enterprise	Forest health engineer
4.	Gankova Ksenia	Starobinsky forestry enterprise	Forest nursery master
5.	Golovnev Vyacheslav	Mogilev SPFA	Lead Forestry Engineer
6.	Zozulya Pavel	Kobrin Experimental Forestry enterprise	Forest health engineer
7.	Igor Kabetov	Cherikovsky forestry enterprise	Forest health engineer
8.	Kazun Ekaterina	Slutsk forestry enterprise	Forest health engineer
9.	Kivulya Alexander	Dyatlovsky forestry enterprise	Forest health engineer
10.	Kopylova Natalia	Belynichsky forestry enterprise	Forest health engineer
11.	Alina Lastovskaya	Lida forestry enterprise	Head of forest nursery
12.	Melnikova Marina	Mogilev forestry enterprise	Head of complex for growing planting material
13.	Minaev Alexander	Liozno forestry enterprise	Head of forest nursery
14.	Rudko Alexandra	Bobruisk forestry enterprise	Seed farming engineer
15.	Trakhimchik Alexander	Shchuchinsky forestry enterprise	Head of forest nursery
16.	Shamshura Lily	Vitebsk forestry enterprise	Forest health engineer
17.	Shvets Svetlana	Vitebsk SPFA	Lead forest health engineer
18.	Shyich Ekaterina	Gantsevichi forestry enterprise	Forest health engineer
19.	Shostyr Ksenia	Luninets forestry enterprise	Head of forest nursery
20.	Yutsevich Maria	Ministry of Forestry of the Republic of Belarus	Forestry management consultant
21.	Prokhorenko Ekaterina	Buda-Koshelevsky experimental forestry enterprise	Forest health engineer
22.	Chizh Tatiana	Telekhany forestry enterprise	Forest health engineer

APPENDIX D

Mailing list

Brochure "Modern environmentally-friendly technologies for application of plant protection agents and fertilizers in forest nurseries"

	No.	Enterprise	Quantity of brochures, pcs.
Brest SPFA	1	Baranovichi forestry enterprise	1
	2	Brest forestry enterprise	1
	3	Gantsevichi forestry enterprise	1
	4	Drogichin forestry enterprise	1
	5	Ivatsevichi forestry enterprise	1
	6	Kobrin forestry experimental enterprise	1
	7	Luninets forestry enterprise	1
	8	Pinsk forestry enterprise	1
	9	Telekhany forestry enterprise	1
	Total Brest SPFA		9
Vitebsk SPFA	10	Begoml forestry enterprise	1
	11	Beshenkovichi forestry enterprise	1
	12	Bogushev forestry enterprise	1
	13	Vitebsk forestry enterprise	1
	14	Verkhnedvinsk forestry enterprise	1
	15	Glubokoe forestry experimental enterprise	1
	16	Gorodok forestry enterprise	1
	17	Disna forestry enterprise	1
	18	Lepel forestry enterprise	1
	19	Liozno forestry enterprise	1
	20	Orsha forestry enterprise	1
	21	Polotsk forestry enterprise	1
	22	Postavy forestry enterprise	1
	23	Rossony forestry enterprise	1
	24	Tolochin forestry enterprise	1
	25	Ushachi forestry enterprise	1
	26	Shumilino forestry enterprise	1
	Total Vitebsk SPFA		15
Gomel SPFA	27	Buda-Koshelevo forestry enterprise	1
	28	Gomel forestry experimental enterprise	1
	29	Zhlobin forestry enterprise	1
	30	Kalinkovichi forestry enterprise	1
	31	Miloshevichi forestry enterprise	1
	32	Mozyr forestry experimental enterprise	1
	33	Petrikov forestry enterprise	1
	34	Rechitsa forestry experimental enterprise	1
	35	Svetlogorsk forestry enterprise	1

	Total Gomel SPFA		9
Grodno SPFA	36	Volkovysk forestry enterprise	1
	37	Grodno forestry enterprise	1
	38	Dyatlovo forestry enterprise	1
	39	Ivye forestry enterprise	1
	40	Lida forestry enterprise	1
	41	Novogrudok forestry enterprise	1
	42	Ostrovets forestry enterprise	1
	43	Slonim forestry enterprise	1
	44	Smorgon forestry enterprise	1
	45	Shchuchin forestry enterprise	1
	Total Grodno SPFA		10
Minsk SPFA	46	Berezina forestry enterprise	1
	47	Borisov forestry experimental enterprise	1
	48	Vileyka forestry experimental enterprise	1
	49	Volozhin forestry enterprise	1
	50	Kletsk forestry enterprise	1
	51	Kopyl forestry experimental enterprise	1
	52	Krupsk forestry enterprise	1
	53	Logoisk forestry enterprise	1
	54	Luban forestry enterprise	1
	55	Minsk forestry enterprise	1
	56	Molodechno forestry enterprise	1
	57	Pukhovichi forestry enterprise	1
	58	Slutsk forestry enterprise	1
	59	Smolevichi forestry enterprise	1
	60	Starobin forestry enterprise	1
	61	Starye Dorogi forestry experimental enterprise	1
	62	Stolbtsy forestry enterprise	1
	63	Uzda forestry enterprise	1
	64	Cherven forestry enterprise	1
	Total Minsk SPFA		19
Mogilev SPFA:	65	Belynichi forestry enterprise	1
	66	Bobruisk forestry enterprise	1
	67	Bykhov forestry enterprise	1
	68	Gorki forestry enterprise	1
	69	Glussk forestry enterprise	1
	70	Klimovichi forestry enterprise	1
	71	Klichev forestry enterprise	1
	72	Kosyukovichi forestry enterprise	1
	73	Krasnoploye forestry enterprise	1
	74	Mogilev forestry enterprise	2
	75	Osipovichi forestry experimental enterprise	1

	76	Chaussy forestry enterprise	1
	77	Cherikov forestry enterprise	1
	Total Mogilev SPFA		14
	78	Republican Breeding and Seed Production Center	1
		TOTAL	**78**

APPENDIX E

Calculation cost of organization of training workshop “Modern environmentally-friendly technologies for application of plant protection agents and fertilizers in forest nurseries”

Item	Total, USD
1. Salary of experts:	**2 625,00**
Manager	600,00
Expert 1	300,00
Expert 2	170,00
Expert 3	270,00
Expert 4	85,00
Expert 5	200,00
Expert 6	100,00
Expert 7	300,00
Expert 8	300,00
Translator	300,00
2. Outsourced services	**1 000,00**
Accommodation, meals	890,00
Transport	110,00
3. Consumables	**1 100,00**
Training aids, handouts	1 100,00
4. Social welfare contributions	**793,00**
5. Overhead and administrative costs	**982,10**
6. Other costs	**–**
Total	**6 500,00**