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**Diagnosis**
Brown spots covered by compact, yellow mycelium form on cotyledons. The seedcoat bursts from mycelial growth and fungal fruiting bodies form that have a lateral stalk, a pale-gray, wavy surface, and a pale-brown, gill-bearing hymenophore. The tissues of affected acorns are destroyed.

**Damage**
Reduces germination power

**Distribution**
European part of Russia, southern Urals, Far East

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**Pathogen**
*Stereum hirsutum* (Willd: Fr) S.F. Gray

**Hosts**
Species of oak (*Quercus*)

**Diagnosis**
Cotyledons turn brown and lose their structure. Yellow, chamois-like pellicles develop between the seedcoat and cotyledon surface. Fruiting bodies form on the outer seed surface as thin, hairy, leather-like pileuses with a gray upper part and a smooth, yellow hymenophore.

**Damage**
Reduces germination power

**Distribution**
European part of Russia, southern Urals, Far East

**Class/Order: Ascomycetes, Microascales**

**Pathogen**
*Ceratocystis roboris* Georg. et Teod. and *C. valachicum* Georg. et Teod.

**Hosts**
Species of oak (*Quercus*)

**Diagnosis**
Black spots develop near the base of acorns; cotyledons become soft and the outer seedcoat turns black. Conidia form, more often in coremia, on affected acorns. Perithecia develop after the acorns die. Perithecia are pear-like, black, with long necks.

**Damage**
Reduces germination power and withers seedlings

**Distribution**
Southern area of European part of Russia

## Diseases of Needles and Leaves

***Needle Diseases***

### Lophodermium Needle Casts

**Class/Order: Ascomycetes, Phacidales**

**Pathogen**
*Lophodermium seditiosum* Mint., Stal., et Mill. and L. *pinastri* Chev.

**Hosts**
Primarily species of pine, including Scots (*P. sylvestris*), white *(P. strobus)*, jack *(P. banksiana)*, Siberian *(P. sibirica)*, and mountain *(P. pumila)*

**Diagnosis**

The first symptoms of *L. seditiosum* infection appear in late October and early November. Yellow spots form on infected parts of needles, usually in the lower part of the crown in early stages of disease development. The first external symptoms of disease in seedling nurseries are found 3-9 days after snowmelt. Infected needles die and turn red-brown (**Fig. 1**). Lophodermium needle casts usually have uniform distribution over the forest areas. On a single tree, the disease spreads from bottom to top. Killed needles on 1-year-old plants remain attached to the stem for a year before they are cast. Damaged needles of 3-year-old plants usually are cast during the first growing season. Pycnidia develop on diseased needles from mid-April until mid-May. Apothecia are formed in June-July.

Pycnidia on single needles are oval-elongate, but on twin needles are round to elongate and are 300-500 μ, often linked. Conidia are 1-celled, colorless, cylindrical, 6-8 μ. Apothecia that develop beneath the epidermal layer are gray, often connected, elongate, sharpened. Apothecia are 901-1281 x 435-554 μ. They open longitudinally during maturation; the color of the split margins is blue-gray or dirty-green. Epidermal cells are absent under the base of apothecia when viewed on a transverse cutting. Transverse lines on the needles are absent or rare. Asci are colorless and wide, 126-184 x 11-14 μ. Ascospores are thread-like, 90-115 x 3 μ.

The first visible symptoms of *L. pinastri* infection of pine seedlings appear usually in May, approximately 1 month after snowmelt during storage of seedlings in the heeling beds or soon after seedling planting. Needles die and turn red in the lower part of plants. Pycnidia form on affected needles in June and July or are absent. As a rule, fruit bodies form only on cast needles. Transverse lines on the needles develop usually at the end of summer or beginning of the next year after infection, shortly before apothecia develop. Transverse lines and apothecia do not form on needles of growing seedlings.

Pycnidia are dark-gray or black, round, 300-400 μ. When mature, they open as a longitudinal split; conidia are 1-celled, colorless, cylindrical, 4.5 x 6.25 μ. The base of apothecia is immersed in the epidermis; apothecia are black, oval or ellipse-elongate, 825-1099 x 432-563 μ. Fruit bodies open during maturation as longitudinal splits. The split margins are red- or dark-brown. There are usually 5 or more epidermal cells under the base of the apothecium on transverse cutting. Transverse lines on needles (especially paired) are black, numerous, and distinct. Asci are colorless, wide, 90-148 x 10-12 μ. Ascospores are thread-like, 90-115 x 3 μ.

Figure 1.—Pine (*Pinus sibirica*) needles affected by *Lophodermium seditiosum.*

**Biology**
Lophodermium needle casts of seedlings in nurseries and green-houses, saplings, understory trees, and forest plantations less than 5 years old are caused primarily by *L. seditiosum*. Occasionally, *L. pinastri* is found on seedlings in nurseries and greenhouses. Understory trees and forest plantations 6-14 years old are damaged by both species of fungi at the same time. Pines more than 15 years old are infected only by *L. pinastri.*

Sources of *L. seditiosum* inoculum are diseased plants in nurseries, pine plantations, and understory trees. Both healthy and weak plants are affected. Ascospores mature and spread in June and July. Needle penetration occurs from late July to late September or early October. Intensity of disease development depends on the quantity of precipitation from June to August and air temperature during July and August; however, moisture is the primary factor in disease development.

Pine plantations and understory 15 years old and older are the sources of *L. pinastri* inoculum. Apothecia form on dead needles on the ground during the year after they drop. The most active period for ascospore release and needle penetration is July and August, but these can occur in May. Seedlings subjected to infection may have been weakened by unfavorable growing conditions, infection by other diseases, and mechanical injuries.

**Damage**
Nursery seedlings and forest plantations less than 5 years old sustain the greatest damage. Damage to pine seedlings in Russian nurseries ranges from 30-100 percent. Needle casts reduce productivity of pine plantations as well as the health of standard planting material in the nursery.

**Distribution**
Throughout Russia

**Control**
Observation
Survey for the appearance and distribution of disease in spring just after snowmelt and again during the second half of summer and early autumn.

Cultural
- Choose location of new nurseries carefully, e.g., at least 200 m from existing pine forests or plantations.
- Rotate pine with other conifers in nursery beds at intervals of 2 years or more.
- Select seed sources from resistant plantations.
- Use appropriate and agrotechnical methods for establishing and maintaining seedlings.

Chemical
- Protect 1-3-year-old seedlings with systemic fungicides (BAYMEB, Benomyl, Bavistin, Daconil, Benlate, Topsin M) or protective fungicides (Zineb, sulphur).

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**Pathogen**
*Lophodermium macrosporum* (Hart.) Rehm.

**Host**
Norway spruce (*Picea abies*)

**Diagnosis**
Needles on previous-year shoots turn brown in May. Long, black apothecia form on lower surface of needles during summer. Asci are mace-shaped, 100 x 15-21 µ.

**Damage**
Weakens and can kill seedlings in understory and forest plantations

**Distribution**
European part of Russia, Urals, Siberia

**Pathogen**
*Lophodermium juniperinum* (Fr.) De Not.

**Host**
Ground cedar (*Juniperus communis*)

**Diagnosis**
Previous-year needles turn yellow or red-brown at the beginning of summer (**Fig. 2**). Prominent, black apothecia about 2 mm long form on the upper surface of needles in midsummer. Asci are mace-shaped, wide, 70-90 x 9-12 μ. Ascospores are thread-like, colorless, 65-75 x 1-2 μ.

**Damage**
Weakens trees and sometimes causes dieback

**Distribution**
European part of Russia, Urals

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**Pathogen**
*Lophodermium nervisequium* (D.C.) Rehm.

**Hosts**
Species of fir (*Abies*), including Nordmann (*A. nordmanniana*), silver (*A. alba*), and Siberian (*A. sibirica*).

Figure 2.—Ground cedar (*Juniperus communis*) affected by *Lophodermium juniperinum.*

**Diagnosis**
Needles turn brown at the end of summer. Pycnidia form on the lower surface of needles as tiny black marks. Elliptical black apothecia, 1-1.5 mm long, form in needles later. Asci are mace-shaped, 70-100 x 15-20 μ. Ascospores are oblong-clavate, slightly curved, colorless, 1-celled, 50-60 x 2-2.5 μ.

**Damage**
Weakens trees in young stands and can cause partial dieback

**Distribution**
Southeastern area of European part of Russia, Urals, Siberia

## Snow Blight

**Pathogen**
*Phacidium infestans* Karst.

**Hosts**
Scotch pine (*Pinus sylvestris*), Siberian stone pine (*P. sibirica*), mountain pine (*P. pumila*), Norway spruce (*Picea abies*), Siberian black spruce (*P. obovata*), and ground cedar (*Juniperus communis*)

**Diagnosis**
The first symptoms of disease appear in January when temperature inside the snow layer ranges from 0-5°C. The foliage is pale-green, and an ephemeral and cobwebby mycelium forms on the needles at this time. In February, needles have a marbled appearance with specific alternation of green, yellow, and brown spots. Active development of exterior mycelium begins in March when the temperature inside the snow layer reaches to +0.5°C. Needles beneath the snow are killed.

Mycelium spreads from diseased needles and during the period of snowmelt develops into white and gray pellicles, which are important diagnostic features. The pellicles are short-lived and only dirty-white pieces of mycelium remain on the seedlings and soil. Diseased needles die during the first several days after snowmelt and become bright-red or orange. At this time groups of infected seedlings are clearly noticeable in comparison with the green color of healthy plants. Soon after snowmelt, diseased needle color lightens and primordia of apothecia develop on them. The apothecia are small, dark blurred spots. During summer, infected needles become gray, and apothecia resemble dark hillocks. At the beginning of autumn, needles turn a distinct ashy color. Fragile apothecia open and burst through the needle epidermis, forming star-shaped openings. The gray-pink round hymenial layer is visible at this time. Asci are widely clavate with a distinct thick cover and they contain ellipsoid, rarely egg-shaped ascospores. Asci are 72-140 x 12-25 μ; spores are 11-28 x 5-9 μ.

**Biology**
Ascospores mature and spread after the apothecia open. The most active period occurs under warm, moist conditions after heavy precipitation and higher than mean annual air temperature. Spore dispersal usually is from late September through October. Major spore dissemination occurs in mid-October. The most favorable conditions for this process and needle infection are periods of snow followed by snow melt. Spore spread ends before permanent snow cover is established. Typical mid-October weather patterns, alternating rain and snowfall, result in heavy precipitation and high humidity. Spore loading on the needles is well established when snow cover is permanent. Ascospores germinate on and penetrate needles. Fungal development inside leaf tissue begins after snow cover is established. The most important factor in this process is the temperature under the snow cover. Conditions for pathogen development are most favorable when high snow cover lies on unfrozen soil that remains slushy during the winter and the temperature inside the snow layer is 0° and above.

The saprophytic phase of fungus development begins after snowmelt and continues through the vegetative growth period. Fungal fruit bodies form and mature throughout the year. The parasitic phase of the fungus begins with apothecia opening and continues up to snowmelt. In Russia, depending on climate conditions, there are three types of fungal development during the parasitic phase: European, Siberian, and Intermediate. In the European type, the spores spread in autumn and disease develops during the winter. The European type develops in regions with wet autumns, relatively mild winters, and high snow cover. With the Siberian type, sporulation, penetration, and infection of healthy needles occur simultaneously in the snow layer cavities and in the snow "greenhouses" that have relatively high humidity and temperature during spring snowmelt. The

Figure 3.—Pine (*Pinus sylvestris*) understory in cutting area showing symptoms of snow blight (*Phacidium infestans*).

Siberian type occurs under conditions of continental climate with cold dry autumns, harsh winters, and warm springs. The Intermediate type is similar to the other types depending on weather changes.

**Damage**
Damages seedlings in nurseries, forest plantations, and pine understory. Snow blight is most prevalent on planted and natural seedlings, and on pine plantation understory during winters with a deep snow layer. Annual mortality of nursery seedlings ranges from 25-40 percent. Snow blight also hinders successful artificial regeneration in clearcut areas where annual mortality ranges from 50-60 percent (**Fig. 3**).

**Distribution**
European part of Russia, Urals, Siberia, Far East

**Control**
Observation
- Survey for snow-blight loci during the first 2 - 3 days after snowmelt; mycelial patches are visible at this time; repeat observations in September-October.

Prevention and Cultural
- Establish new tree nurseries at least 200 meters from adjacent forest stands and plantations.
- During spring, collect and burn all diseased seedlings.
- Do not use snow blight-infected seedlings for reforestation.

Chemical
- In nurseries and pine plantations, apply protective fungicides (colloid sulfur) and systemic fungicides (Benomyl, Benlate, Daconil, Bavistin, Derosal, BAYMEB).

**Meria Needle Blight**

**Class/Order: Deuteromycetes, Hyphomycetales**

**Pathogen**
*Meria laricis* Vuill.

**Hosts**
Species of larch (*Larix*), including European or common (*L. decidua*), Siberian (*L. sibirica*), Sukachev (*L. sukaczewii*), and Dahurian (*L. dahurica*)

**Diagnosis**
The first symptoms of infection occur 10-14 days after new needles emerge. Small brown spots develop on the upper surface of the needle and enlarge to include the entire needle. Damaged needles are red-brown and slightly twisted (**Fig. 4**). At this time, the pathogen produces colorless conidia in clusters along stomata lines on the lower surface of the needle. Conidia develop on conidiophores that emerge from stomata, and spore clusters appear as sand on the needle.

**Biology**
Mycelium of the pathogen overwinters in cast needles, which are the source of infection in spring. Damage is most prominent on seedlings growing in one location for 2 years. The disease spreads and kills needles in the lower, middle, and finally upper part of the plants. The time between conidia penetration into needles and new spore formation is 10-14 days.

Disease development depends on the summer weather. Temperature does not significantly influence pathogen development; mycelium growth occurs at 5°-30°C; the optimum temperature is 18°-20°C. Intensity of spore dispersal depends on moisture or quantity of precipitation; dry weather suppresses disease development while damp weather during the first part of the growth period favors the disease.

**Control**
Observation
- Survey for disease appearance and spread within 10-14 days after needles have expanded; repeat observations in midsummer.

Cultural
- Establish new nurseries at least 100 m from forest stands or plantations.
- Establish current-year seedling beds some distance from beds where seedlings from previous years are growing.
- Collect and burn cast damaged needles in autumn and early spring to remove potential sources of overwintering fungus.

Figure 4.—Current-year larch (*Larix decidua*) seedlings affected by larch needle cast (*Meria laricis*).

• Use greenhouses to protect seedlings from primary infection.

Chemical
• Apply fungicides to fallen needles (e.g., colloid sulfur) to exterminate the inoculum source.
• Apply preventive fungicides on foliage of seedlings and young plantations during the growing season.
• Use systemic fungicides (BAYMEB, Topsin M, Daconil, Bavistin, and Derosal) and protective fungicides (colloid sulfur, Zineb, Poliram, Policarbacin, Metiram).

## Brown Felt Blight

**Class/Order: Ascomycetes, Sphaeriales**

**Pathogen**
*Herpotrichia juniperi* (Duby) Petr.

**Hosts**
Species of pine (*Pinus*), spruce (*Picea*), fir (*Abies*), and cedar (*Juniperus*)

**Diagnosis**
Needles are encased in thick, dark-brown mycelium after snowmelt. Felt-like mats of mycelium overgrow needles and twigs (**Fig. 5**). Felts develop while branches are beneath the snow. Perithecia are formed at the beginning of autumn. They are nearly globose or pear-shaped, 200-300 μ in diameter, and covered with long brown hairs at the base. Asci are elongate, 72-100 x 10-12 μ. Ascospores are spindle-shaped, colorless, 1- to 4-celled, 15-30 x 6-12 μ.

**Damage**
Kills seedlings in nurseries, weakens understory in forest plantations, and promotes branch breakage by snow

**Distribution**
Northwestern area of European part of Russia, middle Urals, Siberia

## Rhizosphaera Needle Casts

**Class/Order: Deuteromycetes, Sphaeropsidales**

**Pathogen**
*Rhizosphaera pini* (Corda.) Maubl.

**Hosts**
Species of fir (*Abies*), including Nordmann *(A. nordmanniana)*, silver *(A. alba)*, and Siberian *(A. sibirica)*

**Diagnosis**
Single yellow spots develop on infected needles, which turn brown by the end of summer (**Fig. 6**). Pycnidia chains develop on infected needles along the midrib, appearing as minute black spheres about 100 μ in diameter. Conidia are egg-shaped, colorless, 1-celled, 16-23 x 7.5 μ.

**Damage**
Weakens and can kill young trees and fir plantations under forest canopy

**Distribution**
Southeastern area of European part of Russia, Urals, Siberia

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**Pathogen**
*Rhizosphaera kalkhoffii* Bubak.

**Host**
Norway spruce (*Picea abies*)

Figure 5.—Fir (*Abies sibirica*) understory tree affected by *Herpotrichia juniperi*.

**Diagnosis**

Yellow spots on 1-year-old needles develop in summer or autumn. Spots merge gradually. Infected needles turn brown. After overwintering, round, black pycnidia, 80-150 μ in diameter, form on lower surfaces of needles. Conidia are oval, colorless, 1-celled, 7-10 x 3-5 μ.

**Damage**

Causes weakening and dieback of seedlings and young plantations

**Distribution**

Northwestern area of European part of Russia

**Control**

- Control is required in nurseries and plantations only in cases of significant injury.

Cultural

- Cull and burn infected plants in nurseries and plantations in the spring.
- Remove forest logging residues (near nurseries and plantations) that may serve as a source of inoculum.

Chemical

- Protect nurseries and plantations with Bordeaux mixture.

Figure 6.—Fir (*Abies sibirica*) needles affected by *Rhizosphaera pini*.

## Needle Rusts of Pine

**Class/Order: Basidiomycetes, Uredinales**

**Pathogen**
*Coleosporium* spp.

**Hosts**
Species of pine (*Pinus*), including Scots *(P. sylvestris),* Swiss mountain *(P. montana),* and Austrian *(P. nigra)*

**Diagnosis**
Aecia develop on the needles in late spring or beginning of summer. Aecia form as lines on the both sides of needles. Aecial blisters are orange, later white, about 3 mm long. Aeciospores, connected inside aecia like chains, are orange, oval or elongate, with thorny spore walls, 16-26 x 26-57 µ. After aeciospore dispersion, aecia covers remain on needles for some time but eventually disappear, leaving brown spots on the needles.

**Biology**
The pathogen is a macrocyclic rust. In summer, aeciospores are produced within aecia on needles. Aeciospores infect the leaves of alternate hosts, primarily herbaceous plants such as *Tussilago farfara, Senecio nemorensis, S. jacaea, Sonchus arvensis*, and species from the genus *Inula*. The uredinial stage develops in yellow pustules during summer on leaves of these plants. Urediniospores from the pustules cause repeating cycles of infection on leaves of the same herbaceous species. The telial stage develops on the same leaves and telia overwinter on the dead leaves. Teliospores germinate in the spring, producing basidia with basidiospores that infect needles. Infection is heaviest on well-lighted portions of the crown and in warmer areas within stands.

**Damage**
Weakens plant and causes growth loss

**Distribution**
European part of Russia, Urals, Siberia, Far East

**Control**

Prevention

- Remove alternate host plants.

Chemical

- Apply Bordeaux mixture to foliage.

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**Pathogen**

*Chrysomyxa ledi* (Alb. et Schw.) de Bary.

**Hosts**

Norway spruce *(Picea abies)* and Siberian black spruce *(P. obovata)*

**Diagnosis**

Aecia develop on the lower surface of needles as 2 lines. They are orange, blister-like, and no more than 2 mm long and 3 mm high (**Fig. 7**). Aeciospores are elliptical, yellow, 19-30 x 15-21 μ.

**Biology**

Aecia produce chains of aeciospores that are disseminated by wind and infect leaves of the alternate host, *Ledum palustre*. The uredinial and telial stages develop on the leaves of *L. palustre*. Telia overwinter and germinate in the spring, producing basidia with basidiospores that infect needles. The rate of infection increases in stands where crowns are open and well insolated e.g., low-density stands or along forest edges and roads.

**Damage**

Affects spruce needles in young and mature stands and can cause massive needle loss, resulting in weakening and death of understory trees. Needle damage can reach 100 percent in an epiphytotic year.

**Distribution**

Northwestern area of European part of Russia, Urals, Siberia, Far East

**Control**

- Application of Bordeaux mixture is recommended in nurseries when seedling infection is heavy.

Figure 7.—Needle rust of spruce (*Picea abies*) caused by *Chrysomyxa ledi*.

## Powdery Mildews

**Class/Order: Ascomycetes/Erysiphales**

Many deciduous trees and shrubs are affected. The most common powdery mildews and hosts in Russia are listed in Table 1.

**Diagnosis**
The primary symptom of infection is the formation in late spring and early summer of a powdery growth on the upper surfaces of leaves or other tender plant parts **(Fig. 8).** The powdery growth is white, gray, or brown, and consists of superficial mycelium and conidial sporulation. Appearance

**Table 1.—Species of fungi causing powdery mildew, their hosts, and distribution of disease occurrence**

| Pathogen | Hosts | Distribution |
|---|---|---|
| *Microsphaera alphitoides* Griff. et Maubl. | *Quercus* | European part of Russia, Urals, Siberia, Far East |
| *M. betulae* Magn. | *Betula* | European part of Russia, Urals, Siberia, Far East |
| *M. berberidis* Lev. | *Berberis* | European part of Russia |
| *M. penicillata* (Wallr.) Lev. | *Alnus, Rhamnus, Syringa, Viburnum* | European part of Russia |
| *M. lonicera* Wint. | *Lonicera* | European part of Russia, Southern and Middle Urals, Far East |
| *M. syringae* (Schwein.)Magnus | *Syringa* | European part of Russia |
| *M. vanbruntiana* Gerard. | *Sambucus* | European part of Russia, Urals, Siberia, Far East |
| *M. viburni* (Duby) Blum. | *Viburnum* | European part of Russia |
| *M. grossulariae* (Wallr.) Lev. | *Ribes* | European part of Russia |
| *Uncinula aceris* Sacc. | *Acer* | European part of Russia, Southern and Middle Urals, Siberia, Far East |
| *U. salicis* Wint. | *Populus, Salix* | European part of Russia, Urals, Siberia, Far East |
| *U. fraxini* Miyake | *Fraxinus* | Far East |
| *U. clandestina* Schroet. | *Ulmus* | European part of Russia, Far East |
| *Phyllactinia suffulta* (Rabh.) Sacc. | *Alnus, Betulae, Corylus, Fraxinus, Sorbus, Fagus, Ulmus* | European part of Russia, Urals, Siberia, Far East |
| *Podosphaera oxyacanthae* de Bary | *Crataegus, Padus, Sorbus* | European part of Russia, Urals, Siberia, Far East |
| *Trichocladia caraganae* Magn. | *Caragana arborescens* | European part of Russia |
| *T. euonymi* Neger. | *Euonymus* | European part of Russia, Urals |
| *Sphaerotheca pannosa* (Wallr.) Lev | *Rosa* | European part of Russia, Urals, Far East |

Figure 8.—Floodplain oak stands (*Quercus robur*) affected by *Microsphaera alphitoides.*

differs considerably with the pathogen species. It can be inconspicuous and cobwebby, well-developed and mealy, compact and wadding-like, or felt-like. In late summer, numerous cleistothecia are produced on or in the mycelial mat. They are yellow-brown or black spheres with special appendages that differ in position, form, structure, and length depending on the fungal species. This is a diagnostic feature. The number of asci that develop in the cleistothecia also depends on the pathogen.

**Biology**
As obligate parasitic fungi, some species are restricted to certain plant species, e.g., *Microsphaera alphitoides,* and *M. palczenskii*, while others can infect plants from different botanical families, e.g., *Phyllactinia suffulta,* and *Podosphaera oxyacanthae* (Table 1). Species from the genera *Microsphaera, Phyllactinia, Podosphaera,* and *Uncinula* are sensitive to humidity but tolerate a wide range of temperatures.

**Damage**
In forest nurseries, these diseases cause premature defoliation and weaken seedlings. Affected seedlings become misshapen and are not used for standard planting material. Both plant growth in young plantations and plantation productivity are reduced, as are the decorative and protective properties of trees and shrubs in urban settings.

**Control**
Cultural
- Sow seeds in nurseries as early as possible.
- Eliminate stump sprouts (source of inoculum) near nurseries.
- Fertilize (NPK complex), especially with phosphorus, to speed leaf maturation and shorten the period of disease susceptibility.
- Create plantations of mixed tree species to reduce disease spread.

Chemical
- Apply BAYMEB and colloid sulfur.

**Leaf Spots**

**Class/Order: Ascomycetes, Phacidiales**

**Pathogen**
*Rhytisma acerinum* (Pers.) Fr. (anamorph: *Melasmia acerina* Zev.)

**Hosts**
Species of maple (*Acer*)

**Diagnosis**
Spots develop on leaves in summer. The infected tissue turns yellow and numerous small, black stromata develop within the spots on upper leaf surfaces. Large convex, black, shiny, stromata coalesce with small ones within the spot. Stromata are surrounded by yellow-green margins. Conidia are produced on the stromata. After overwintering, apothecia develop in the stromata and asci with ascospores mature during the summer. Asci are mace-shaped on a pedicle, 120-130 x 9-10 μ. Ascospores are sticky, thread-like, 52 x 80 x 1.5-3 μ.

**Distribution**
European part of Russia, Urals, Far East

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**Pathogen**
*Rhytisma punctatum* (Pers.) Fr. (anamorph: *Melasmia punctata* Sacc.)

**Hosts**
Species of maple (*Acer*)

**Diagnosis**
Small, yellow spots develop on leaves in summer, and conidophores and spores develop on them. Later, small, dotted, shiny stromata develop within the spots. Apothecia form within the stroma. Asci are wide, 120-130 x 9-10 μ. Ascospores are thread-like, colorless, 60-80 x 1.5-3 μ.

**Distribution**
European part of Russia, Urals, Far East

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**Pathogen**
*Rhytisma salicinum* (Pers.) Fr. (anamorph: *Melasmia salicina* Lev.)

**Hosts**
Species of willow (*Salix*)

**Diagnosis**
Yellow spots develop on leaves in summer. Later, a convex, black, shiny stroma, 0.5-2 cm in diameter, forms (**Fig. 9**). Apothecia form, ripen during spring, and emerge from the stroma. The hymenium is yellow. Asci are wide, 120-150 x 10-15 μ. Ascospores are colorless, thread-like, 60-100 x 1.5-3 μ.

**Distribution**
European part of Russia, Urals, Siberia, Far East

**Class/Order: Ascomycetes, Dothideales**

**Pathogen**
*Dothidella betulina* (Fr.) Sacc.

**Hosts**
Species of birch (*Betula*)

**Diagnosis**
In summer, numerous small, black, convex stromata develop on the upper leaf surfaces (**Fig. 10**). They are round or irregular. Spherical pseudothecia with several loculi form after the leaves drop. Asci in loculi are cylindrical, 38-70 x 10-12.5 μ. Ascospores are elliptical, 2-celled with unequal cells, greenish, 10-14 x 5 μ.

**Distribution**
European part of Russia, Urals, Far East

Figure 9.—Tar spot of willow (*Salix caprea*) caused by *Rhytisma salicinum.*

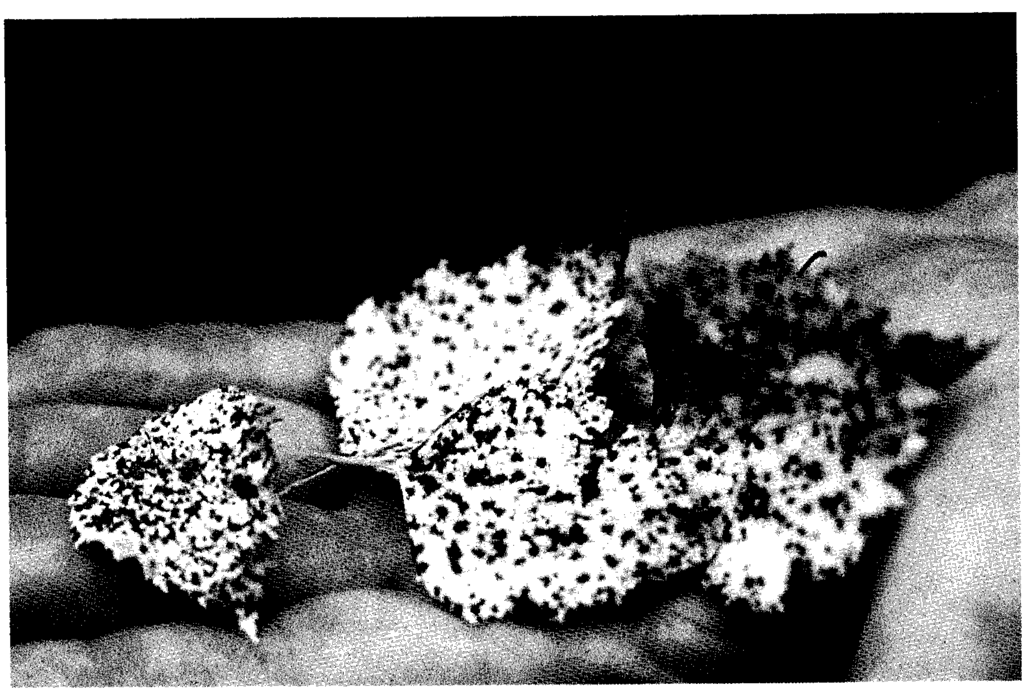

Figure 10.—Leaf spot of birch (*Betula pendula*) caused by *Dothidella betulina.*

**Pathogen**
*Dothidella ulmi* (Duv.) Wint. (anamorph: *Piggotia astroidea* Berk. et Br.)

**Hosts**
Species of elm (*Ulmus*)

**Diagnosis**
Grayish-black, roundish, convex stromata, 2-3 mm in diameter, develop on leaves in summer. Spherical pseudothecia form inside the stroma with the outlet opening on the stroma surface. Asci are cylindrical, on short pedicles, 60-70 x 8-9 μ. Ascospores are elongate, egg-shaped, greenish, 2-celled, with unequal cells, 10-12.5 x 4.5 μ.

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**Pathogen**
*Venturia tremulae* Aderh. (anamorph: *Pollacia radiosa* (Lib.) Bald. et Cif.)

**Host**
Species of poplar (*Populus*), including white *(P. alba)* and black *(P. nigra)*

**Diagnosis**
The first infections occur in early summer on leaf blades, and round violet-brown spots of various sizes form. Later, the brown surface turns olive and velvety with the formation of a layer of conidiophores and conidia. Infected young shoots turn black and wither bending like a hook. Conidia are oval-elliptical, light-olive, with 2 unequal sized cells, 17-26 x 7-11 μ.

**Biology**
Overwinters as mycelium on fallen leaves and shoots blighted the previous season. Conidiophores and conidia develop from mycelium; conidia are the primary inocula. Incubation period is 10-14 days; thus, several generations of conidia can form during the summer and cause secondary infections of leaves and young shoots. Disease development depends on the weather conditions, primarily humidity. Wet weather and timely rains promote conidia germination and infection. Infection can occur over a temperature range of 13-35°C. The most favorable conditions for the pathogen are created during the first part of the vegetative growth period when the quantity of precipitation (and humidity) is high and young foliage is most susceptible to infection.

**Damage**
Causes leaf and terminal shoot blight (and sometimes dieback) and reduces height growth. Damage occurs primarily in nurseries but weakening and dieback of young poplar can occur in natural stands. Poplar stands in urban areas lose aesthetic quality. Seedling infection in nurseries often reaches 100 percent. Defoliation on infected seedlings can reach 30-50 percent by mid-August.

**Distribution**
European part of Russia, Urals, Siberia, Far East

**Control**
Cultural
- Isolate mother tree plantations and transplant beds of *P. alba* from mature stands.
- Plow under fallen leaves and shoots during autumn or early spring.

Chemical
- Apply (DNOC) fungicide before new foliage expands.
- Apply several fungicides (sulfur and Thiram) during the vegetative growth period

**Class/Order: Ascomycetes, Taphrinales**

**Pathogen**
*Taphrina aurea* Fr.

**Hosts**
Species of poplar (*Populus)*, including black *(P. nigra)* and Bolle's *(P. pyramidalis)*

**Diagnosis**
Large spots form on leaves as round swellings in summer. A golden-yellow hymenium develops on the lower surface. The cells under the asci are elongate. Asci are cylindrical or widened at the base, 50-98 x 15-25 μ. Ascospores are spherical, 4 μ.

**Distribution**
European part of Russia

**Pathogen**
*Taphrina polyspora* Johans.

**Host**
Tartarian maple (*Acer tatarica*)

**Diagnosis**
Infected areas on the leaf are swollen and become irregularly shaped brown spots. Later, they turn black and burst. The hymenium develops on the upper surface of spots. There are no cells under the asci. Asci are wide, cylindrical, rounded at the top, 33-47 x 12-17 μ. Ascospores are spherical, 3-4 μ.

**Distribution**
European part of Russia

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**Pathogen**
*Taphrina ulmi* Johans.

**Host**
European white elm (*Ulmus laevis*)

**Diagnosis**
Infected areas on leaves are slightly swollen, irregularly shaped spots. They are initially yellow and later turn gray-brown or black. The hymeniun develops on the upper surface of spots. The cells under asci are wide. Asci vary from cylindrical to egg-shaped, rounded at the top, 12-20 x 8-10 μ. Ascospores are spherical, 3.5 μ.

**Distribution**
European part of Russia

**Class/Order: Deuteromycetes, Hyphomycetales**

**Pathogen**
*Cercospora coryli* Mont.

**Hosts**
Species of hazel (*Corylus*)

**Diagnosis**
Small, irregularly shaped, red-brown spots with a light center form on leaves. They may coalesce. The pathogen sporulates on the spots. Conidia are cylindrical, light-olive, 2- to 3-celled, 30-45 x 3-4.5 μ.

**Distribution**
European part of Russia

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**Pathogen**
*Cercospora fraxini* Sacc.

**Hosts**
Species of ash (*Fraxinus),* including European *(F. excelsior)* and green *(F. viridis)*

**Diagnosis**
Irregularly shaped or angular, brown or nearly black spots, 2-4 mm in diameter, form on leaves. Clusters of conidiophores develop on the lower surface of leaves. Conidia are spindle-shaped, pale olive, and 1-celled at the beginning of development; later, they become 2- to 6-celled, 26-65 x 4.4-6.5 μ.

**Distribution**
European part of Russia

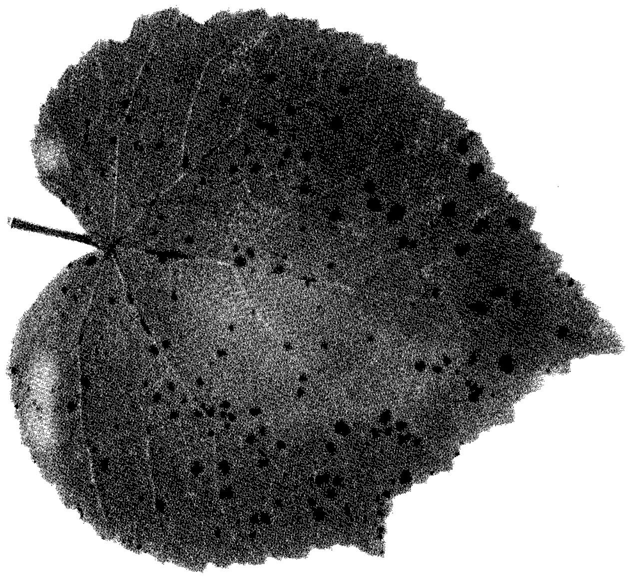

Figure 11.—Leaf spot of lime (*Tilia cordata*) caused by *Cercospora microsora.*

**Pathogen**
*Cercospora microsora* Sacc.

**Hosts**
Species of lime (*Tilia* spp.)

**Diagnosis**
Dark-brown spots with light centers form on leaves in early July **(Fig. 11)**. They are round or irregularly shaped, 2-3 mm in diameter. Conidiophores and conidia develop on the surface of the spots. Conidia are spindle-shaped, slightly curved, pale olive, 4- to 9-celled, 20-100 x 3-4 µ.

**Distribution**
European part of Russia, Urals, Siberia, Far East

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**Pathogen**
*Cercospora salicina* Ell. et Ev.

**Hosts**
Species of willow (*Salix*)

**Diagnosis**
Irregularly shaped, nearly black, often coalesced spots form on leaves, making the foliage seem dirty-black. Sporodochia form on both surfaces of the spots. Conidia are clavate shaped, slender, colorless or brown, 25-40 x 2-2.5 µ.

**Distribution**
European part of Russia, Urals, Siberia

**Class/Order: Deuteromycetes, Melanconiales**

**Pathogen**
*Colletotrichella periclymeni* (Desm.) v. Hoehn.

**Hosts**
Species of honeysuckle (*Lonicera*)

**Diagnosis**
Spots are round, often coalesced, olive-brown with light centers, often with a dark narrow border. Sporodochia are formed on the upper surface of spots. Conidia are elongate spindle- or sickle-shaped, colorless, 17-31 x 6.5-10 µ.

**Distribution**
European part of Russia, Urals, Siberia

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**Pathogen**
*Coryneum foliicola* Fckl.

**Hosts**
Species of hawthorne (*Crataegus*)

**Diagnosis**
Spots are round or irregularly shaped when coalesced, and red-brown or brown. Sporodochia are formed on upper surface of spots. Conidia, formed on slender pedicles, are elongate-elliptical, 4-celled, olive, 12-18 x 5.5-7 µ.

**Distribution**
European part of Russia, Urals, Siberia

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**Pathogen**
*Cylindrosporium ulmi* (Fr.) Vassil.

**Hosts**
Species of elm (*Ulmus*)

**Diagnosis**
Spots are small, round or irregularly shaped, and may be coalesced. They are yellow initially and then turn brown. Sporodochia form on lower surface of spots and are slightly convex and yellow-brown. Conidia are colorless, cylindrical, widened at the top or spindle-shaped, curved or straight, 2- to 5-celled, 28-60 x 3.5-8 µ.

**Distribution**
European part of Russia, Urals, Siberia, Far East

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**Pathogen**
*Gloeosporium coryli* (Desm.) Sacc.

**Hosts**
Species of hazel (*Corylus*)

**Diagnosis**
Spots are round, red- to dark-brown. Small, dark, flat, cushion-like sporodochia (acervuli) are formed on both surfaces of spots. Conidia are cylindrical, with spherical ends, colorless, 1-celled, 7-15 x 5-7 µ.

**Distribution**
European part of Russia, Urals, Siberia

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**Pathogen**
*Gloeosporium betulinum* West. (syn. *Discula betulina* West. Arx)

**Hosts**
Species of birch (*Betula*)

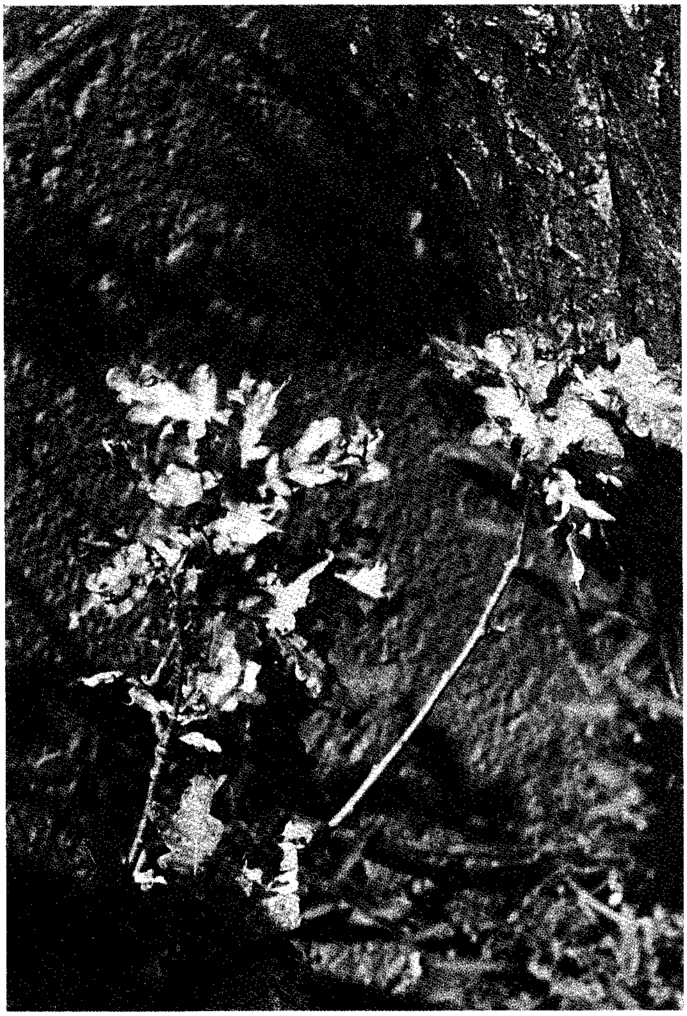

Figure 12.—Leaf spot of oak (*Quercus robur*) caused by *Gloeosporium quercinum*.

**Diagnosis**
Spots are round, about 10 mm in diameter, olive- to red-brown, with indefinite margins. Flat, yellow acervuli form on the underside of spots. Conidia are cylindrical, sometimes spindle-shaped, colorless, 1-celled, 7-15 x 0.5-2 μ.

**Distribution**
European part of Russia, Urals, Siberia, Far East

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**Pathogen**
*Gloeosporium quercinum* West. (teliomorph: *Gnomonia quercina* Kleb.) (syn. *Discula umbrinella* (Berk. & Broome) Sutton)

**Host**
Pedunculate oak (*Quercus robur*)

**Diagnosis**
Round or irregular shaped spots, 2-4 mm in diameter, develop on infected leaves in early July. Spots often occur on shoots. They are yellow-green and later turn brown (**Fig. 12**). Yellow-brown, cushion-like acervuli form on the lower surface of spots. There are two types of conidia: macroconidia are oval, egg-shaped, colorless, 1-celled, 10-18 x 4-6 μ; microsporidia are stick-like, 4-8.5 x 1-1.5 μ.

**Distribution**
European part of Russia, Urals

**Pathogen**
*Gloeosporium tiliae* Oudem.

**Host**
Little leaf lime (*Tilia cordata*)

**Diagnosis**
Spots form on leaves and sometimes shoots and flower perianth. They are creamy or rusty, with a dark-brown edge, 4-8 mm in diameter. Spots often occur on shoots and perianths. Small, dark-brown or brown sporodochia form on both leaf surfaces. There are two types of conidia: macroconidia are oval, egg-shaped, colorless, 1-celled, 10-18 x 4-6 µ; microconidia are stick-like, 4-8.5 x 1-1.5 µ.

**Distribution**
European part of Russia, Urals

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**Pathogen**
*Gloeosporium tremulae* (Lib.) Pass.

**Hosts**
Species of poplar (*Populus*), including European aspen *(P. tremula)* and white poplar *(P. alba*)

**Diagnosis**
Spots are large, gray-brown or gray-green surrounded by brown tissue, and lighter at the center (**Fig. 13**). Numerous small, black, flat, cushion-like acervuli, often coalesced, form on the upper surface of leaves. Conidia are cylindrical, curved, colorless, 1-celled, 10-15 x 1.5-2 µ.

**Distribution**
European part of Russia

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**Pathogen**
*Pestalotia breviseta* Sacc.

Figure 13.—Leaf spot of trembling aspen (*Populus tremula*) caused by *Gloeosporium tremulae* showing numerous, black sporodochia of fungus.

**Hosts**
Species of apple *(Malus)* and pear *(Pyrus)*

**Diagnosis**
Leaf spots are gray and vary in shape and size. Cushion-like sporodochia form on the upper surfaces of black spots in clusters. Conidia are spindle-shaped, 5 celled, with 3 appendages, 8-10 x 1 µ.

**Distribution**
European part of Russia

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**Pathogen**
*Marssonina populi* Kleb.

**Hosts**
Species of poplar (*Populus*), especially balsam poplar hybrid (*P. tacamahaca*)

**Diagnosis**
Spots appear on leaves from late May to early June. Spots are brown, round, about 4-5 mm in diameter, and gradually coalesce. They can cover the entire leaf surface. The central part of the spot is dotted with yellow-white sporodochia. Conidia are egg-shaped, elongate to pear-shaped, sometime curved. They are 1-celled initially but later 2-celled with the upper cell wider than the basal cell, colorless, 15-29 x 5-10 µ.

**Biology**
Source of inoculum in the spring is fallen infected leaves. Conidia from sporodochia initiate the repeating cycle of disease during summer. Pathogen incubation is about 3-5 days, so incidence of infected trees and degree of crown damage increase quickly. Primary infection occurs on lower branches nearest the conidia on overwintering fallen leaves. Infection spreads to the middle and upper branches of the crown. Wet weather (or high humidity) and moderate temperatures (13-18°C) intensify disease development.

**Damage**
Causes premature defoliation. By midsummer, susceptible species of poplar lose 50-80 percent of their foliage. Successive seasons of infection and leaf loss can cause a decrease in growth and vigor. Damage is most severe in nurseries.

**Distribution**
European part of Russia, Urals, Siberia, Far East

**Control**
Cultural
- Isolate newly created poplar nurseries and plantations from mature stands.
- Gather and burn infected fallen leaves in autumn.

Chemical
- Apply fungicide (DNOC) to fallen leaves in spring before or soon after new leaves emerge.
- Apply Bordeaux mixture to foliage during growth stages.

**Class/Order: Deuteromycetes, Sphaeropsidales**

**Pathogen**
*Asteroma padi* Grev.

**Host**
Bird cherry (*Padus avium*)

**Diagnosis**
Large spots form on both surfaces of leaf. Brown-violet spots form among branching, fan-like hyphae. Brown pycnidia are inconspicuous, embedded in the leaf tissue in groups. Conidia are elongate, egg-shaped, colorless, 1-celled, 12-18 x 3-4 µ.

**Distribution**
European part of Russia, Urals, Siberia

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**Pathogen**
*Asteroma tiliae* Rud.

**Host**
Little leaf lime (*Tilia cordata*)

**Diagnosis**
Large spots, brown-violet or nearly black, form on the upper surface of leaf. Heavily branched mycelial fans form on the surface of the spot.

**Distribution**
European part of Russia, Urals, Siberia

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**Pathogen**
*Phyllosticta coryli* West.

**Hosts**
Species of hazel (*Corylus*)

**Diagnosis**
Spots are large, irregular shaped, brown with lighter brown center. Pycnidia form on both surfaces of spots embedded in leaf tissue. They later break through the tissue. Pycnidia are spherical with a flat top, 100-150 μ in diameter. Conidia are colorless, ellipsoidal, with 2 drops of oil, 1-celled, 7-8 x 2-3.5 μ.

**Distribution**
European part of Russia

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**Pathogen**
*Phyllosticta fraxini* Ell. et Mart.

**Host**
European ash (*Fraxinus excelsior*)

**Diagnosis**
Spots are round, 5-10 mm in diameter, brown, surrounded by dark-red margins. Brown pycnidia about 150 μ in diameter form on the upper surface of leaf. Conidia are elongate, elliptical, colorless, with 1-2 drops of oil, 7-9 x 2.5-3 μ.

**Distribution**
European part of Russia

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**Pathogen**
*Phyllosticta populina* Sacc.

**Hosts**
Species of poplar (*Populus*)

**Diagnosis**
Leaf spots are angular, white, with a black border, 1-3 mm in diameter. Pycnidia form on the upper surface of spots, are spherical, and black. Conidia are egg-shaped or elliptical, 1-celled, olive, 6-8 x 3-3.5 μ.

**Distribution**
European part of Russia, Urals, Siberia

**Pathogen**
*Septoria betulae* Pass. non (Lib.) West.

**Hosts**
Species of birch (*Betula*)

**Diagnosis**
Spots form on both surfaces of leaf. They are irregularly-shaped or round, brown or light-brown, and coalesce. Pycnidia about 100 μ in diameter form on the lower surface of leaf. Conidia are thread-like, colorless, with 1 to several septa, 30-60 x 1.5-2 μ.

**Distribution**
European part of Russia, Urals, Siberia

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**Pathogen**
*Septoria populi* Desm.

**Hosts**
Species of poplar (*Populus*)

**Diagnosis**
White necrotic spots are 2-3 mm in diameter, surrounded by dark margins. Pycnidia develop on dead tissues as black dots, 112-240 μ in diameter. Conidia are cylindrical, curved, colorless, 2-celled, 30-45 x 3 μ.

**Distribution**
European part of Russia, Urals, Siberia

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**Pathogen**
*Septoria quercicola* (Desm.) Sacc.

**Hosts**
Species of oak (*Quercus*)

**Diagnosis**
Small white spots, 1-3 mm in diameter, form on both surfaces of leaves, and are surrounded by wide dark margins. Pycnidia are scattered and black. Conidia are thread-like, curved, colorless, 40-60 x 1.5 μ.

**Distribution**
European part of Russia

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**Pathogen**
*Septoria xylostei* Sacc. et West.

**Host**
Honeysuckle (*Lonicera tatarica*)

**Diagnosis**
Spots form on both surfaces of leaves. They are gray-white, surrounded by black margins. Black pycnidia, about 130 μ in diameter, are embedded in the leaf tissue. Conidia are thread-like, curved, colorless, 40-60 x 1.5 μ.

**Distribution**
European part of Russia, Urals, Siberia

**Damage**
Heavy infection causes premature yellowing of foliage and defoliation. Infections in successive years weaken trees. Leaf spots cause considerably more damage in nurseries. Damage can reach 40-100 percent. In urban areas, decorative properties of trees and stands can be reduced.

**Table 2.—Leaf rust pathogens, host tree species, alternate host, and distribution of disease**

| Pathogen | Host | Alternate host plant | Distribution |
|---|---|---|---|
| *Melampsora allii-populina* Kleb. | *Populus nigra* | *Allium, Arum elongatum* | European part of Russia, Urals, Siberia, Far East |
| *M. pinitorqua* Rostr. | *Populus tremulae, P.alba* | *Pinus sylvestris* | European part of Russia, Far East, Siberia |
| *Melampsoridium betulae* Arth. | *Betula* (sometimes alternate host plant is absent) | *Larix* | European part of Russia, Urals, Siberia, Far East |

**Control**

Cultural

- Establish new nurseries as far as possible from forest stands with the same woody species.
- Remove fallen leaves as a source of inoculum in nurseries and urban stands during autumn.

Chemical

- Apply fungicide (DNOC) in early spring.
- Apply Bordeaux mixture during vegetative growth period.

## Leaf Rusts

**Class/Order: Basidiomycetes/Uredinales**

Rust fungi infect numerous deciduous woody species. The most common pathogens, hosts, and areas of distribution in Russia are listed in Table 2.

**Diagnosis**

Uredinia are formed in summer on the leaves of the deciduous woody species as yellow-orange pustules that rupture the epidermal layer. Initially single and then numerous, they coalesce and often cover the entire leaf surface (**Fig. 14**). Urediniospores are oval, oblong, or spherical, with a wart-like sporewall. Size of urediniospore depends on the pathogen species and ranges from 11-30 x 11-18 µ. In late summer, telia form on leaves of the same woody species between cuticle and epidermis. They are crust-like, 1-1.5 mm diam, initially yellow-brown and later dark-brown. Telia can be single or in groups but often are coalesced and cover the entire leaf. Teliospores are prismatic or irregularly prismatic, round at both ends, 30-60 x 6-14 µ. Teliospore walls are light-brown, 1-1.5 µ thick.

**Biology**

Basidiospores form on telia in spring and infect alternate hosts for heteroecious macrocyclic rusts. Aecia form on the alternate host. Aecia produce aeciospores at the beginning of summer and infect the primary host. Uredinia containing urediniospores develop on infected leaves of the primary host and cause repeating (secondary) infection cycles during summer. Optimal conditions for uredinia formation are high humidity and moderate or high temperatures. Teliospores form on the leaves in late summer. They overwinter on fallen leaves then produce basidia with basidiospores in spring. Basidiospores infect emerging leaves or needles of alternate host plants. Teliospore germination and basidiospore production is most intense during warm and humid springs.

**Damage**

Rusts cause leaves to wither and prematurely drop, reducing tree growth. The infection of young shoots delays their development and results in damage from early autumn frosts. Most damage occurs in nurseries, particularly where seedlings are overstocked. Severe infection in urban stands significantly decreases aesthetics and protective functions of trees.