POLLUTION

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NEEDLE CAST DISEASES IN THE ENVIRONMENTAL CONDITIONS OF THE SURGUT REGION IN KHANTY-MANSIYSKY AUTONOMOUS OKRUG – YUGRA

Research article

Abstract

Conifers are widely represented by Scots pine (*Pinus sylvestris* L.) and Siberian pine (*Pinus sibirica* Du Tour) on the territory of the Khanty-Mansiysky Autonomous Okrug – Yugra. In the conditions of the North plants are largely effected by infectious diseases; the needle cast diseases are the most harmful. The pine is stricken by Lophodermium needle cast (Cyclaneusma), snow blights (Phacidium needle cast), or pine facidiosis and gray blights (Hypodermella needle cast), the causative agents of the disease are fungi of the Ascomycota phylum, class Euascomycetes, order Phacidiales. It was found that the degree of development of these infectious needle cast diseases as well as damage intensity to a plant depend on the plantations composition (phytocenosis) and on the plants age.

Keywords: needle cast, infectious diseases, pathogens, phytocenosis, Siberian pine, Scots pine.

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БОЛЕЗНИ ТИПА ШЮТТЕ В УСЛОВИЯХ СУРГУТСКОГО РАЙОНА ХАНТЫ-МАНСИЙСКОГО АВТОНОМНОГО ОКРУГА – ЮГРЫ

Научная статья

Аннотация

На территории Ханты-Мансийского автономного округа – Югры хвойные породы широко представлены сосной обыкновенной (*Pinus sylvestris* L.) и сосной сибирской (*Pinus sibirica* Du Tour). В условиях севера растения в значительной степени поражаются инфекционными болезнями, наиболее вредоносными являются болезни типа шютте. На сосне встречается обыкновенное шютте, снежное шютте, или фацидиоз сосны и серое шютте. Возбудители болезни – грибы отдела Ascomycota, класса Euascomycetes, порядка Phacidiales. Установлено, что степень развития инфекционных болезней типа шютте и интенсивность поражения растений зависят от состава насаждений (фитоценоза) и возраста растений.

Ключевые слова: шютте, инфекционные болезни, возбудители болезни, фитоценоз, сосна сибирская, сосна обыкновенная.

1. Introduction

The woody vegetation of the Khanty-Mansiysky Autonomous Okrug – Yugra is widely represented by Scots pine (*Pinus sylvestris L.*) and Siberian pine (*Pinus sibirica* Du Tour). In the conditions of a sharply continental climate the plants are affected by the needle cast diseases, which reduce their decorative effect and vitality [1]. Annual supervision of the green plantations condition allows to timely establish the causes of a disease, identify the extent and intensity of plant damage, and take measures to protect plants from infectious diseases.

The aim of this study was to establish the etiology of damage to *Pinus sylvestris* and *P. sibirica* needles, to assess the severity of the needle cast diseases in Surgut region, depending on the type of green plantation and plants age.

2. Methods

Forest pathological examination of green plantations was carried out on the territory of Surgut region: Surgut and its surroundings, Yugan village. A geobotanical survey of urban tree plantations with introduction of Siberian pine and Scots pine as wall as a forest on the territory of Yugan village was carried out according to the method E.N. Andreeva technique [2]. The damage evaluation to the needles was carried out visually against a four-point scale: 1 – up to 25% of needles are effected; 2 – 25-50% of needles needles are effected; 3 – 50-75% of needles needles are effected; 4 – more than 75% of the needles needles are effected. Determination of plant diseases and identification of pathogens - according to the technique of E.S. Sokolova [3]. The spread of diseases and the intensity of plant damage were calculated using the equation of A.E. Chumakov [4].

3. Results and discussion

This detailed survey of the green plantations found that on the territory of Surgut region the pines (*Pinus sylvestris* and *P. sibirica*) are effected by Lophodermium needle cast, the causative agents of this disease are *Lophodermium pinastri* Chev. (marsupial stage of the fungus) and *Leptostroma pinastri Desm.* (conidial stage); snow blights, or pine facidiosis, the causative agent of the disease is *Phacidium infestans Karst.* fungus, and gray blights with the causative agent of the disease is *Hypodermella sulcigena (Rostr.) Tub.* fungus. (= *Lophodermella sulcigena (Rostr.) Hohn.)*. The fungi are representatives of the *Ascomycota* phylum, *Euascomycetes* class, *Phacidiales* order [5].

The common needle cast revealed through a change in the needles color, their necrosis and premature abscission. The first signs of the disease are observed in late May - early June. Effected needles, in the tissues of which the mycelium of the fungus begins to develop, are being covered with small gray- or yellow-brown spots and then turn completely yellow [6]. In June numerous small black dots (pycnidia) of the fungus appear on the infected needles. In pycnidia, thin, cylindrical summer spores of the fungus (conidia) develop en masse. In the third decade of August apothecia of the fungus are formed under the epidermis of the dead needles (Fig. 1). The hymenial layer of the apothecia consists of clavate bursae and filamentous paraphysis with hooked-bent ends (Fig. 2).

Figure 1 – Apothecia of L. pinastri on pine needles

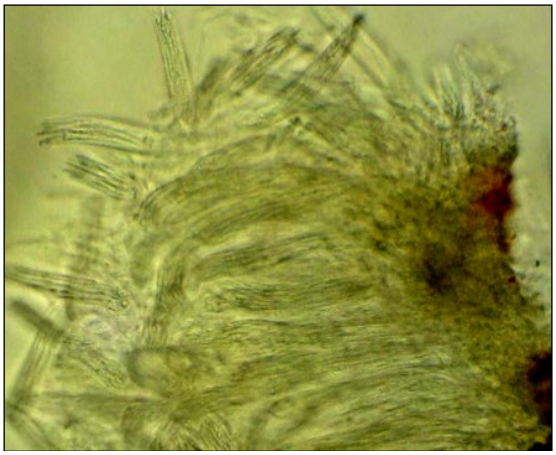

Figure 2 – Gymnial layer of apothecia

Thin black transverse lines are formed between the apothecia, which is a characteristic diagnostic sign of this disease. When ripe, the apothecia open with a longitudinal slit, bordered by gray-brown lips, from which the ascospores of the fungus emerge. Maturation and dispersal of ascospores of the fungus occur from the end of the third decade of July to the end of September (early October). Apothecia overwinter on effected needles. Spring ascospores are the source of primary infection of the plants.

The disease equally occurs both in Scots pine and Siberian pine, in various types of plantations and various plants ages. However, it poses the greatest danger to young crops where epiphytoties provided occurrence of favorable conditions for the pathogen development.

Snow blights has been observed on the needles of the pine. The causative agent of facidiosis developes under the snow cover. In the third decade of April (after the snow melts), whitish-gray films, consisting of the fungus mycelium, appear on the infected plants. In the second decade of May, the effected needles brighten, die off and become clearly visible on the green background of healthy plants. Rudiments of apothecia appear on the affected needles in the form of small, dark, slightly vague spots, which at the beginning of June take the form of clearly visible dark tubercles. In the hymenial layer of the fruiting bodies (apothecia), club-shaped bursae (asci) with ascospores are formed. In the first decade of September the needles acquire a characteristic ash color and become brittle and fragile. At the first frost the apothecia open tearing the epidermis of the needles with star-shaped lobes (Fig. 3). Ascospores are actively thrown out of the bags and fall on healthy needles infecting them. After formation of the snow cover the development of the fungus begins inside the needles tissues. In spring, when the temperature rises under the snow, an active growth of the surface mycelium is observed, which causes massive infection of healthy needles. Seedlings and needles of the young undergrowth lower branches under the snow cover completely die from facidiosis.

Gray blights disease is observed on the pine needles along with the above types of the needle casts (Fig. 4). The disease causes necrosis of the needles upper part: at first it turns yellow becoming brown-violet later. The affected needles part is sharply separated from the healthy part by a brown stripe up to 2 mm wide. In summer an imperfect stage of the fungus, pycnidia, develops on the affected part of the needles, which look like small black dots. Spores (conidia) of the fungus are formed in pycnidia.

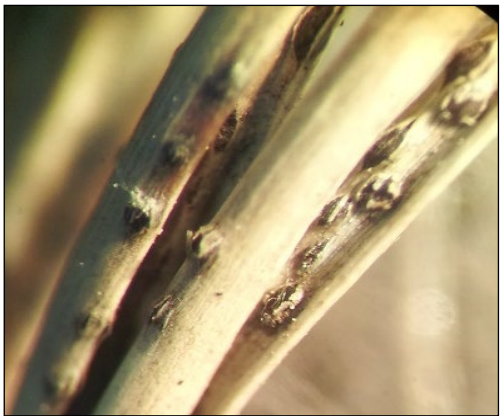

Figure 3 – Tears of the needle epidermis with star-shaped lobes

Figure 4 – Affected needles of Scots pine

Over time the affected needles become ash-gray with formation of submerged, black, elongated, leathery, somewhat convex apothecia. Bags with ascospores are located In the hymenial layer of the apothecia. They infect the needles in summer. The development of the disease is facilitated by rainy and cold weather. Pines weakened by Siberian Hermes are affected more often.

It has been found that the degree of development of infectious diseases such as needle cast and the plant damage intensity depend on the composition of the plantations (phytocenosis) and the pine age.

Geobotanical surveys of vegetation with the participation of Scots pine and Siberian pine were carried out on 7 test sites located in the territory of Surgut region (near Yugan village): spruce-pine-birch sedge forest (No. 1), willow forb-gramineous meadow (No. 2), gramineous meadow (No. 3); and on the territory of the city of Surgut – in the park "Za Saimoy": birch-cedar-pine subshrub-sphagnum forest (No. 4); in the public garden "32 Mikrorayon": birch-cedar-pine wild rosemary-sphagnum forest (No. 5), plantations of Scots pine in the public garden "Centralny" near the Monument to Soldiers-Internationalists (No. 6) and Siberian pine plantations near the historical and cultural center "Old Surgut "(No. 7).

Phytocenosis No. 1. A Spruce-pine-birch sedge forest located on the territory of Surgut Region near Yugan village. The tree layer is polydominant, 17-20 m high, composed mainly of *Picea obovata* Ledeb., *Pinus sylvestris*, *Betula pubescens* Ehrh.,

Populus tremula L., with a small occurance of *Pinus sibirica*. The forest proportion formula is 2Po2Psy3B2Pt+PsDT, crown density 0.5. Undergrowth 2–5 m in height of medium density, unevenly distributed, represented by the same species as the tree layer: the undergrowth proportion formula is 3Psi2Po2Psy2B1Pt. The shrub layer 3–5 m high is formed by *Sorbus sibirica* Hedl., projective cover is 10%. The shrub layer is poorly developed, mainly at near-stem elevations and consists of a few species of *Ledum palustre* L., *Vaccinium vitis-idaea* L., *Vaccinium myrtillus* L. (total projective cover (TPC) up to 10%). The herbaceous layer has a total projective cover of up to 60%. It contains *Carex globularis* L. – 30%, *Equisetum pratense* Ehrh. – 7%, *Equisetum sylvaticum* L. – 8%, *Oxalis acetosella* L. – 1%, *Maianthemum bifolium* (L.) FW Schmidt –1%, *Luzula pilosa* (L.) Willd <1%.

Phytocenosis No. 2. A willow forb-gramineous meadow is located near Yugan village, Surgut region. It borders with a dark coniferous shrub-green moss forest, thus this community contains undergrowth of Pinus sibirica, 30-50 cm high. The shrub layer is formed by *Salix viminalis* L., 3.5 m high, the projective cover is 15%. The herbaceous layer is well developed; the total projective cover is 90%. Domination of *Deschampsia cespitosa* (L.) P. Beauv. – 21%, *Chamerion angustifolium* (L.) Holub. – 15%, *Trifolium pratense* L. – 10%, *Carex acuta* L. – 10%, *Trifolium repens* – 8% is observed, other species are represented by an average abundance of *Plantago major* L. s. l. – 5%, *Carex globularis* – 5%, *Ranunculus repens* L. – 5%, *Tanacetum vulgare* L. – 3%, *Tussilago farfara* L. – 3%, *Potentilla anserina* L. – 5%, *Cirsium arvense* (L.) Scop. – 5%. *Dactylorhiza hebridensis* (Wilmott) Aver. is obsessed in small quantities (<1%).

Phytocenosis No. 3. A forb-gramineous meadow borders on a dark-coniferous forb forest in the territory of Yugan village, Surgut region. This phytocenosis contains numerous undergrowth of *Pinus sibirica*, Siberian stone pine, up to 1.5 m in height (77 pcs. on 100 m^2 area). The herbaceous layer is dense, the total projective cover is 95%, consists of two sublayers: the first substage of tall grasses (up to 1.2 m high) includes *Deschampsia cespitosa* – 20%, *Elytrigia repens* (L.) Nevski – 5%, *Calamagrostis epigeios* (L.) Roth – 36%, *Cirsium arvense* – 5 %. The second sublayer (20-30 cm high) is formed by *Ranunculus repens* – 5%, *Tussilago farfara* – 3%, *Potentilla anserine* – 5%, *Trifolium pratense* - 13%, *Geum aleppicum* Jacq. – 3%.

Phytocenosis No. 4. A Birch-cedar-pine subshrub-sphagnum forest is located on the territory of Surgut in the park "Za Saimoy". The tree layer is composed of *Pinus sylvestris*, *Pinus sibirica* and *Betula pubescens*, the forest proportion formula is 5С3К2Б (5Psy3Psi2B). The height of the forest stand is 10-11 m, the density is 0.5. The undergrowth layer is formed by the same species, unevenly distributed with a projective cover of 20%, up to 3 m in height. The shrub layer is well developed, the total projective cover is 90%; *Ledum palustre* (30%) and *Vaccinium myrtillus* (35%) are prevalent; *Vaccinium vitis-idaea, Vaccinium uliginosum* are found in average abundance (10-15%), a small abundance of *Linnaea borealis* – 3% is observed. The herbaceous layer is poorly developed, represented by *Equisetum sylvaticum* (10%), *Carex globularis* (3%), *Maianthemum bifolium* (1%), *Luzula pilosa* (<1%). The moss layer contains *Sphagnum angustifolium* C.E.O. Jensen (35%), *Polytrichum commune* Hedw. (15%).

Phytocenosis No. 5. A Birch-cedar-pine wild rosemary-sphagnum forest is surveyed on the territory of a public garden in “32 Mikrorayon” of Surgut. The base of the tree layer is formed by *Pinus sylvestris*, 16 m high, with trunk diameter of 33 cm and Betula pubescens, 12-15 m high, with trunk diameter of 12-15 cm. Siberian pine is less common, the height of the trees is 10-14 m, the diameter of the trunks is 18-20 cm. Forest proportion formula: 6С2Б1К (6Psy2B1Psi). The undergrowth is not dense, in group distribution, its projective cover is 20%, the undergrowth formula is 5С4К1Б (), the height is 1-2.5 m. The shrub layer has a total projective cover of 75%, and composed of *Ledum palustre* – 40%, *Vaccinium myrtillus* –10%, *Vaccinium vitis-idaea* – 15%, *Vaccinium uliginosum* – 10%. The herbaceous layer is formed by *Carex globularis* (15%), *Oxalis acetosella* (10%), *Plantago major* (1%), *Goodyera repens* (<1%), *Lycopodium annotinum* (1%), *Chamerion angustifolium* (<1%). The moss layer (TPC 35%) is represented by *Sphagnum angustifolium* Warnst (35%), *Polytrichum commune* (1%), *Hylocomium splendens* (2%), *Pleurozium schreberi* (2%).

Phytocenosis No. 6. A Pine forest (with presentce of *Pinus sibirica*) in the park “Tsentralny” in Surgut, on the territory of the Monument to Soldiers-Internationalists. The Scots pines and Siberian pines (forest proportion formula 8C2K (8Psy2Psi)) reach a height of 15-16 m, trunk diameter – 35-40 cm, stand density – 0.7. There is no undergrowth. The herbaceous layer is well-formed; total projective cover is 70%. The grass is regularly mowed. The species grow on the site are *Trifolium repens*, *Plantago major*, *Geum aleppicum* Jacq., *Potentilla anserine*, *Festuca ovina* L., *Festuca rubra* L., *Poa annua* L., *Stellaria graminea* L., *Kadenia dubia* (Schkuhr) Lavrova & V.N. Tikhom. The phytocenosis is divided by a trail network.

Phytocenosis No. 7. Urban plantations of Siberian pine within the historical and cultural center "Old Surgut" along Energetikov street. Stand density is 0.1. The height of the trees is from 2 to 2.5 m. The grass layer with total projective cover of 80% includes the following species: *Trifolium repens*, *Plantago major*, *Taraxacum officinale* F.H. Wigg., *Trifolium pratense* L., *Calamagrostis epigeios* (L.) Roth, *Potentilla anserine*, *Festuca rubra*, *Agrostis gigantea* Roth *Prunella vulgaris* L., *Tripleurospermum inodorum* (L.) Sch. Bip., *Leontodon autumnalis* L., *Phleum pratense* L., *Ranunculus repens, Achillea millefolium* L.

Evaluation of the phytopathological state of the plants revealed a various degree of spread of diseases and the intensity of damage to the plants in phytocenoses of Surgut region (Table 1).

Table 1 – The degree of distribution (P, %) of pine needle cast and the intensity of plant damage (R,%) in various phytocenoses

Phytocenosis	Infecting agent	P, %	R, %
Phytocoenosis No. 1. Spruce-pine-birch sedge forest	*Phacidium infestans*	33.1	16.4
	Hupoderella sulcigen	17.2	8.3
	Lophodermium pinastri	43.7	21.7
Phytocenosis No. 2. Willow forb-gramineous meadow	*Phacidium infestans*	12.1	5.3
	Hupoderella sulcigen	2.7	1.2
	Lophodermium pinastri	56.1	23.3
Phytocoenosis No. 3. forb-gramineous meadow	*Phacidium infestans*	43.6	15.5
	Lophodermium pinastri	38.1	16.5
Phytocenosis No. 4. Birch-cedar-pine subshrub-sphagnum forest	*Phacidium infestans*	20.1	12.1
	Hupoderella sulcigen	32.1	21.1
	Lophodermium pinastri	48.1	26.2
Phytocenosis No. 5. Birch-cedar-pine wild rosemary-sphagnum forest	*Phacidium infestans*	30.1	10.2
	Hupoderella sulcigen	20.2	12.5
	Lophodermium pinastri	50.3	20.2
Phytocenosis No. 6. Scots pine plantations (Monument to Soldiers-Internationalists)	*Hupoderella sulcigen*	54.5	27.3
	Lophodermium pinastri	27.3	11.4
Phytocenosis No. 7. Urban plantings of Siberian pine (Historical and cultural center “Old Surgut")	*Hupoderella sulcigen*	60.6	34.1
	Lophodermium pinastri	30.3	20.1

In forest phytocenoses (phytocenoses No. 1-5), common needle cast has a significant degree of distribution (from 43.7 to 50.3%) and it is gray blights (from 54.5 to 60.6%) in urban (phytocenoses No. 6-7). The intensity of damage to plants in the region is average (from 1.2 to 34.1%), the highest degree of damage to pine needles (34.1%) by gray blights was found in the Historical and Cultural Center "Old Surgut", which may be related to the age of the plants. The greatest degree of distribution and the intensity of plant damage was revealed in the plantings of Siberian pine, whose age is less than 15 years (Table 2).

Table 2 – Average degree of spread (P,%) and plant damage (R,%) depending on the pine age

№ No.	Disease name	Plant age, years	P, %	R, %
1	Common needle cast	‹ 15	73.5	65.8
		› 15	26.5	34.2
2	Gray bights	‹ 15	70.6	55.1
		› 15	29.4	54.9
3	Snow blights	‹ 15	66.7	55.2
		› 15	33.3	44.8

It is observed that the acidity of the cell sap, for the plants less than 15 years old is 3.96, for the plants over 15 years old is 4.37, significantly affects the degree of the disease. Thus the degree of distribution of all types of needle cast from 66.7 to 73.5% is observed in young stands (less than 15 years old); the degree of the disease distribution is 2-3 times lower (26.5-33. 3%) in more mature plants (over 15 years old). The intensity of plant damage in the pine forests of the Surgut region is 2-3 points.

4. Conclusion

The needle cast diseases are widespread in the green plantations of Surgut region. The diseases lead to early fall of needles, decrease of plant resistance to pests, and, in case of severe damage, the plants death. The intensity of the disease development is within 2-3 points (average). The spread of diseases depends on the type of phytocenosis and the age of the pine. To reduce the disease harmfulness in the territory of the region it is necessary to timely survey the condition of wood plantations and take preventive measures, which include creation of the mixed unequal-age plantations as the most resistant to the diseases; qualitative planting material should be used for such artificial plantations, without the signs of diseases; revealed focuses of the diseases should be liquidated by means of sanitary fellings or pesticides.

Conflict of Interest **Конфликт интересов**

None declared. Не указан.

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