Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2020, 10(6), 196-202, doi: 10.15421/2020_282

ORIGINAL ARTICLE

The most vulnerable fungal diseases of trees and shrubs in Aktobe city

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Received: 23.10.2020. Accepted: 22.11.2020

The article presents the results of identification of fungal diseases among the trees and shrubs in Aktobe City (Kazakhstan). The most common diseases were powdery mildew, rust, spots, and leaf curl. Three species of fungal diseases were identified in genus *Ulmus*, two species – in genus *Acer*, four species in *Populus*, two species in genus *Fraxinus,* and the genera *Salix, Rosa, Malus, Padus,* and *Crataegus* had one fungi species each. The study revealed an uneven distribution of the identified fungal diseases. We determined that there were fewer types of fungal diseases in the gardens and parks than in the suburbs. We also registered a decrease in powdery mildew together with increase of the leave rust in urban environments. The regularity in reducing the number of fungal diseases toward the city center from periphery was defined.
Key words*:* fungal diseases, powdery mildew, rust, spots, leaf curl.

Introduction

In the beginning of the XXI century, the humanity realized the importance of woody vegetation in urban area and began to consider it as a factor of environmental safety that ensures sustainable development of humankind (Civitello et al., 2015; Crooks, 2002; Fedorov, Poleschuk, 1981; Hantsch et al., 2014; Setiawan et al., 2014; Stenlid et al., 2011). Activation of important functions of woody plants depends on the intensity of growth of seedlings grown (Holdenrieder et al., 2004; Jactel et al., 2009; Keesing et al., 2006; Vacher et al., 2008), and it can be determined by abiotic and biotic factors. The fungi as pathogens of trees and shrubs are widespread and activate their pathogenic properties during meso- and microevolution (Eroshenko, Shevchenko, 2020; Fedorov, Poleschuk, 1981; Isikov, 2014; Shikhova, Polyakova, 2011; Sokolova, Kolganikhina, 2009). When assessing the anthropogenic impact, it is necessary to consider some natural factors that cause the symptoms similar to anthropogenic anomalies. Therefore, it is necessary to take into account the possibility of fungal diseases, pests, weather conditions of the previous year, and the composition of pollutants (Kovyazin et al., 2015; Makarova et al., 2015; Makarova, Makarov, 2017; Yasinskaya, 2018).
The aim of our research was to determine the fungal diseases in the parks and gardens of Aktobe City as the environmental indicators of urban system.

Methods

Microscopic method of identification of fungi was used to examine the affected plant tissue and spores of the pathogen. We registered the color, shape of spores in fungi and the presence of fruit bodies. We also determined the location and type of pathogen in the plant tissues. If a colorless or slightly colored fruit body was found, we used colored paint to determine whether it was an infectious or non-infectious disease. For this purpose, a preparation stained with acidic potassium from living tissues was examined under a microscope.

Results

Three fungal species were identified in the genus *Ulmus*, two species – in the genus maple (*Acer*), four species - in poplar (*Populus*), two species – in the genus Ash (*Fraxinus*). One species was registered in genera *Salix, Rosa, Malus, Padus* and *Crataegus* (Table 1).

Table 1. Distribution of fungal diseases among the trees and shrubs in Aktobe.

Species	Powdery mildew	Rust	Leaf spot	Septoria spot	Leaf curl
Ulmus scabra	+	-	-	-	-
Ulmus laevis	+	-	-	-	-
Ulmus pinnato-ramosa	-	-	-	-	+
Acer negundo	+	-	+	-	-
Salix acutifolia	+	-	-	-	-
Malus kirghisorum	-	+	-	-	-
Rosa glabrifolia	-	+	-	-	-
Crataegus altaica	-	-	-	+	-
Fraxinus pennsylvanica	+	-	+	-	-
Populus nigra	+	+	+	-	-
Populus laurifolia	-	+	-	-	-
Padus avium	-	-	+	-	-

+ the disease was determined, - the disease was not registered

Decease characteristics

White powder

A pale white powder coating appears on the surface of the leaves affected by the disease. The surface of the young shoots of the affected tree is covered with a white or pale coating, a powdery coating. The powdery coating is showered with damaged flower spikelets and calyces, petal petals and flower gums. A favorable environment for the spread of the disease is created by a decrease in turgor pressure, high temperature and average humidity on plants in the second half of the growing season (Figs 1, 2).

Fig. 1. Powder mildew and its ascospores on the leaves of a black poplar (a), 750 magnification (b)

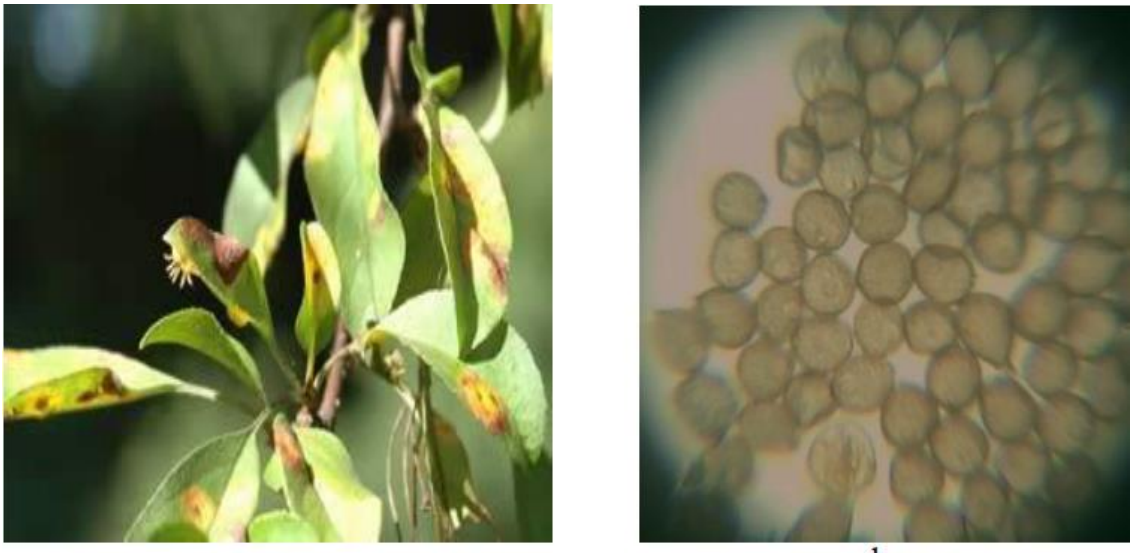
This type of disease is transmitted by the white powdery fungus. The mycelium of the pathogen is located on plant top, forming a very dense white body. Spores of the fungus resemble white flour, which is sown during mass education.

a b

Fig. 2. Powdery mildew and its ascospores on the leaves of the Siberian violet-willow (a), 750 magnification (b)

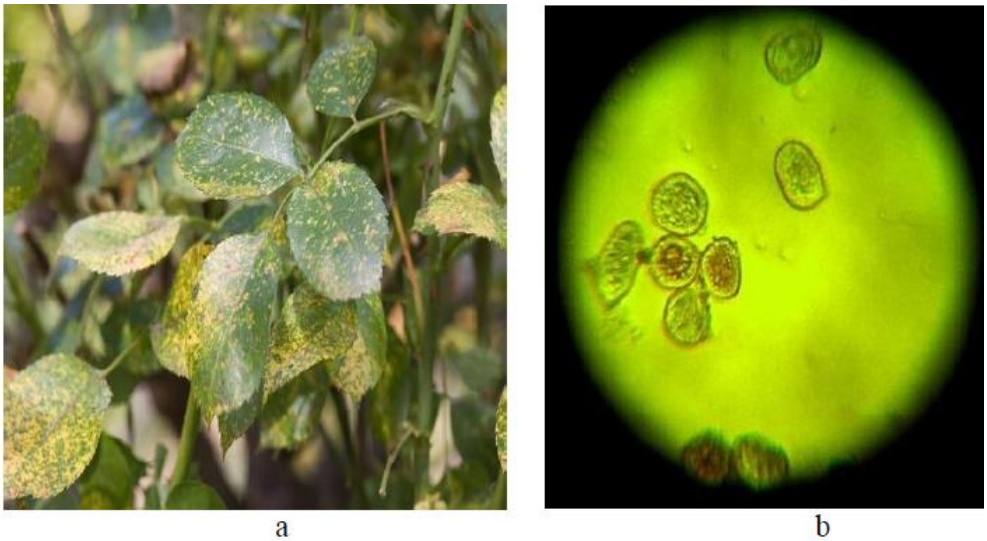
Rust

Rust is caused by the rust fungus. Most often, leaves are affected, less often trunks and spines can be damaged. A characteristic feature of this disease is the rupture of damaged integumentary tissues. Fungal spores are yellow, orange or dark brown color (Figs 3, 4).



a b

Fig. 3. Rust and its urediniospores in the leaves of the apple tree (a), 750 magnification(b)



a b

Fig. 4. Rust and its urediniospores on the leaves of the multiflora rose; 750 magnification (b)

Leaf spot

This is a widespread plant disease. Spotting is transmitted by fungi, bacteria, viruses, and adverse abiotic factors. Basically, the leaves are most often damaged by spotting, sometimes the fruits and young buds an be also damaged. This type of disease is associated with the death of tissues, changes in their color and structure. Spores of the pathogen are formed after the plant was infected with a fungus. Spotting varies in color, shape, and structure. They can be black, white, brown, small, rounded, angular, dotted, or holed (Fig. 5, 6).

a b

Fig. 5. Leaf spot on the leaves of black poplar and ash-leaved maple (b)

a b

Fig. 6. Leaf spot on the leaves of the bird cherry (a); its pathogen, 750 magnification (b)

Septoria spot

Symptoms of Septoria spot are characterized by a dusty-gray, gray-brown, dark brown and chlorinated spots of different shape and different size. Cool humid weather contributed to the development of the disease. The disease reduced the assimilation leaf surface and increased the transpiration of the plant. As a result, the water balance is disturbed, the leaf were prematurely withers and dries (Fig.7).

a b

Fig. 7. Septoria spot on the leaves of the Altai hawthorn (a); its pathogen, 750 magnification (b)

Leaf curl

Occurs under the influence of various factors or is transmitted by fungi and viruses, can lead to curvature of plant organs. The type of deformation varies. Deformation of the leaves leads to their wilting, wrinkling, and the formation of blisters. Damaged saccular or foliaceous tissues cause deformation of plant fruits and seeds. When the flowers are deformed, the generative organs turn into vegetative ones or the flower is underdeveloped. There is also a curvature and thickening of the buds and stems (Fig. 8).

a b

Fig. 8. Leaf curl on the leaves of the common elm (a) and its pathogen, 750 magnification (b).

The phytopathological study of tree diseases has shown that the number of harmful mycotic diseases in the city is growing, which is coincides with Eroshenko, Shevchenko (2020), Kolganikhina, Shishkina (2011), Nguyen et al. (2016), Pautasso et al. (2005). When studying damage to tree and shrub foliage growing in Aktobe, we found that they are more common diseases that cause powdery mildew, rust and various spots (Fig. 9).

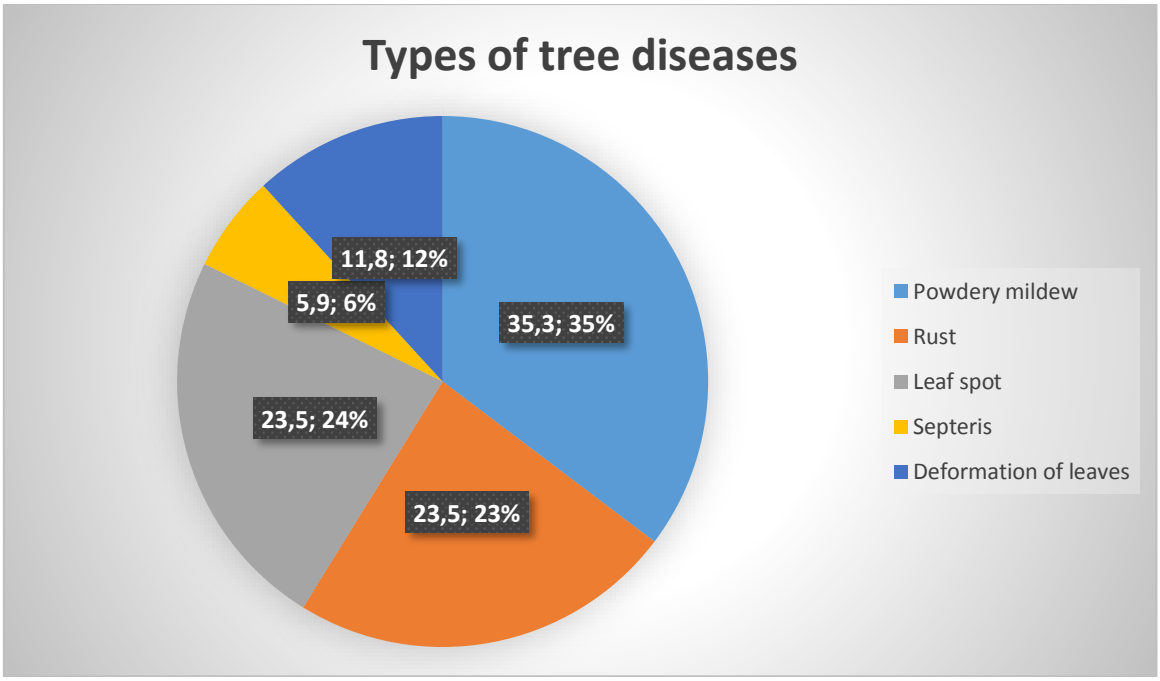


Fig. 9. Fungal diseases frequency distribution in the Aktobe dendrites

Powdery mildew appears on the leaves of trees in the first half of summer, reducing the decorative effect of the plant. The beginning of the formation of summer spores of fungi (conidia) falls on the II-III decade of June, mass formation falls on the first decade of July. A high level of development of the disease is observed in summer, when the average daily air temperature rises to +21-23 °C. Depending on weather conditions, the development of the fungus lasts 40-46 days. Powdery mildew is caused by several types of fungi: elm – *Uncinula clandestina Biv-Bern.*, maple – *Sawadaea bicornis* = *U. bicornis*; willow – *Phyllactinia guttata*, ash – *Phyllactinia suffula* and *Unculina fraxinini*, poplar – *Uncinula adunca*.

The development of rust fungus occurs intensively in warm years. Mass development of summer urediniospores occurs in the second half of summer. The following types of pathogenic rust fungi were found on trees and shrubs in Aktobe: on apple trees- *Gymnosporangium tremelloides* Hartig., poplar – *Melampsora populina* Auct., and multiflora rose – *Phragmudium*

tuberculatum J. Muehll. There were several types of spots on the leaves of the city's trees. Spots on the leaves appear in early summer, and by the end of the growing season of the plant, the development of the disease increases. The formation of fungal spores is facilitated by prolonged rain or morning dew. The air temperature, favorable for the development of most types of fungi, is about 13-20 °C.

With a large lesion of trees, early defoliation was observed, their fragility, protective and decorative properties are reduced. The pathogens of spots we determined were: in elm *Mycosphaerella linicola (Septogloeum ulmicolum)* caused brown leaf spot; in maple, *Phyllostista negundinis* caused floating spot; in ash, *Cercospora fraxini* caused brown leaf spot; in poplar, *Gloeosporium tremulae* caused gray leaf spot; in bird cherry, *Pholystigma rubrum* caused red leaf spot.

Conifers have Schutte and rust diseases. These types of diseases lead to simultaneous damage to conifers, which leads to a decrease in the decorative properties of wood and resistance to various adverse factors. The causative agent of common Schutte disease in pine is the fungus *Lophodermium pinastri* Chev. (fern stage of the fungus) and *Leptostroma pinastri* Desm. (conidian period). Young pine trees in parks are damaged by the fungus *Asteridermium pini Kleb.*

One of the reasons for the high incidence of trees in Aktobe is due to improper implementation of requirements for the care of green spaces. Among mixed trees of different ages, there was a decrease in the pathological load: among trees of the same age, certain types of pathogens that cause epiphytotic diseases were dominated, which was also reported by Kovyazin et al. (2015), Pigorev et al. (2018), Pisarenko (2003), Razinkova et al. (2013), Shikhova, Polyakova (2011), Sukhykh (2003). Before the planting the shrubs or trees, we recommend to choose the plants that are most susceptible to the local soil and climate conditions and resistant to the harmful diseases (see aslo Vacher et al., 2008).

When examining trees and shrubs, we registered that the degree of their resistance to fungal diseases varied considerably. Relatively resistant to the powdery mildew were *Betula pendula, Populus nigra, Salix triandra* and *S. pentandra*, and less resistant were *Caragana arborescens, Crataegus sanguinea, Populus tremula,* and *Rosa glabrifolia;* relatively resistant to the rust were *Populus nigra* and *P. balsamifera,* while weak resistance had *Betula pendula, Caragana arborescens, Crataegus sanguinea,* and *Sorbus sibirica.*

When planting the trees, we must bear in mind that the same type of tree can be damaged by the same type of pathogens of different tree species and vice versa. It is highely likely that such species could infect each other with the diseases if they are planted together (Hantsch et sl., 2014). Therefore, we not recommended to plant such plants together. For example, birch and cedar (both *Melampsordium betulae* (Schum.) *Artur - rust pathogen*), aspen and pine (both *Melampsora pinitorgua* (A.Br.) *Rostrup causes rust*), poplars and willows (both are subject to powdery mildew *Uncinula adunca*) can not be planted together.

Conclusion

We registered uneven distribution of the detected fungal diseases among the municipal objects. In gardens and parks, fewer species of pathogenic fungi were found on woody plants than on the outskirts of the city. As the influence of the urban environment increases, powdery mildew on tree leaves decreases, as does the number of rust-causing species. There was a pattern of decreasing species of fungi developing on leaves towards the city center.

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Citation:

Utarbaeva, N.A., Aipeisova, S., Maui, A., Kazkeev, E., Matsyura, A. (2020). The most vulnerable fungal diseases of trees and shrubs in Aktobe city. *Ukrainian Journal of Ecology, 10*(6), 196-202.