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Mycobiota and Resistance to Diseases of Trees and Shrubs Used in the Greening of Urban Ecosystems

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The presented work is devoted to the assessment of the mycobiota of trees and shrubs used in landscaping large cities of the Republic of Azerbaijan, according to their species composition and resistance to diseases caused by fungi. It turned out that 143 species of fungi are involved in the formation of the mycobiota of trees used in the landscaping of Azerbaijan. Of these, 58.5% are Ascomycota, 28.0% are Basidiomycota, and 7.6% are Mucormycota. 85.7% of the fungi involved in the formation of the general mycobiota of trees and shrubs are potentially pathogenic, causing 50 diseases in plants, the prevalence of which is 0.7-24.5%.

Keywords: Landscaping; Mycobiota; Phytopathogens; Publication Dissemination; Shrubs; Trees; Urban Ecosystems.

In modern times, the development of civilization has reached a global level, which has led to a change in the attitude of man to the environment. Large-scale adverse natural and anthropogenic changes in the environment for the functioning of the biosphere are today's realities[1]. In such conditions, the risk of irreversible environmental problems also increases, which in its turn, reveals the protection of humanity as an important task. Thus, mutagenic and concorogenic substances, highly toxic components and radioactive products are the main sources of pollution and degradation of urbanized areas. This is due to the high level of technical-technological, transport and energy equipment of modern settlements of people[2]. All this leads to the realization of trends that lead to the increase of environmental insecurity, diseases and deaths. Taking care of all these is one of the main tasks that concern humanity today, more precisely, it is the first one. Considering this point of view, one of the important components of the ecological systems of big cities is the greening of that environment. Because greening is one of the conditions that

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determine the normal conditions for maximally revealing the physical and psychological health of people, as well as their creative activity[3]. It is no coincidence that greening is considered one of the main elements of the ecological structure of urbanized areas. So, green plants absorb carbon dioxide from the air and enrich it with oxygen, on the other side, green plants help regulate the temperature of the city air, create air currents, increase air humidity, and plays an important role in the processes, more precisely, green plants are irreplaceable in solving environmental problems caused by human activity today[4]. For this reason, the greening of cities in any country, especially those that are large in terms of territory and population, is one of the most urgent issues[5,6]. Hundreds of species of trees, shrubs and grasses are currently used to solve this problem. However, the factors affecting the biological productivity of these plants prevent their activities from being performed properly, and among the reasons for this, the pathologies recorded in those plants also occupy an important place, and fungi play a serious role among the causes of these pathologies[7,8]. In order to solve these issues, to prepare countermeasures for the prevention of diseases, it is important to first determine the species composition of its causative agent.

For this reason, the purpose of the presented work was dedicated to the evaluation to the fungal diseases resistance of studied plants and fungal species involved in the formation of the mycobiota of trees and shrubs used in the greening of large cities of Azerbaijan.

MATERIAL AND METHODS

The researches were conducted in the streets and avenues, parks and gardens of the cities of Baku, Ganja and Sumgayit of the Republic of Azerbaijan, and samples were taken from the vegetative and generative organs of trees used in greening, as well as some bushes, which are believed to be fungi, and analyzed according to the known mycological methods relevant to the set goal. Sampling was also carried out by seasons, and in total, about 1000 samples were taken during the research.

During the removal of fungi from the studied tree and shrub plants to the pure culture were used medium such as agarized malt juice (AMJ), rice (RA), starch (SA) and potato (PA) agars, agarized Czapek and Czapek-Dox[9]. The preparation of media, sterilization and pouring into Petri dishes was carried out according to known methods[10].

The identification of fungi was carried out according to the determinants drawn up based on their cultural-morphological and physiological characteristics[11,16].

The frequency of use of plants in urban greening was calculated based on the following formula:

$$N = n/s$$

N -is the frequency of use (units/ha), n- is the number of specific tree species found in the studied street, avenue, park, etc. (units), s is the area of the research area (ha). The frequency of occurrence of fungi in the samples taken, as well as the pathogenic activity of diseases caused by pathogenic cultures, was determined by the following formula:

$$P= (n/N)x100$$

P- the frequency of occurrence of fungi in the samples (or the prevalence of the disease caused by the pathogen - in %), n – the number of detected fungi (the number of plant individuals infected with the disease in the studied area, un.), N- the total number of samples (the total number of sampled plant species).

In the course of the research, all experiments were performed at least 4 times and the obtained results were processed statistically[17], and in all cases the data corresponding to the formula m/M = Pd" 0.05 (here, M is the mean indicator, m is the mean squared deviation, P is the Student's criterion)were considered honest and included in the dissertation..

RESULTS AND DISCUSSION

Based on the observations and verified literature data, the total number of tree and shrub species used in the greening of Baku, Ganja and Sumgayit cities is around 150. The use of these trees in urban greening is not the same, and for this reason, the frequency of their use in urban greening was specified first. It became clear that they can be broadly divided into 3 groups: dominants, frequently and rare one used (tab. 1). As it can be seen, 10% of the tree and shrub species used in Baku city are dominant, 40.7% are frequently used, and 49.3% are rarely used.

Examples of the dominant species in the studied cities of Azerbaijan are mainly *Platanus orientalis, Cupressus sempervirens, Pinus eldarica, Sophora japonica, Olea europaea, Rosa alba, Buxus sempervirens, Nerium oleander etc. Robinia pseudoacacia, Populus L., Morus alba, Horse chestnut, Tilia caucasica, Eriobotrya japonica, Evonymus japonica, Juniperus communis, Syringa vulqaris, Ligustrina vulgare* and others can be mentioned among the frequently encountered ones. It should be noted that the dominance of trees and shrub can vary by city, so although the *Sophora japonica* and the *Olea europaea* are dominant in the greenery of Baku, in Ganja these plants are considered rare and random.

It is known that trees and shrubs contain enough elements to form the food of other living things, and for this reason they are also characterized as one of the feeding places of other living things. Fungi are of special interest among these creatures. Thus, fungi included in the heterotrophic block of any ecosystem have a strong enzyme system, and due to this, they have different nutritional relationships with other living things, including plants. Manifestations of the result of these relations include various pathologies, which result in changes in both the general appearance (more precisely, decorativeness) and biological activity of plants. It can be noted with regret that this change is characterized in most cases in a negative way. Prevention of this is currently one of the topical directions of a number of scientific fields, including microbiology and mycology. The initial stage of research in this direction consists in clarifying the organisms living in the mentioned plants (in our case, the species composition of fungi). It was considered appropriate to clarify this issue during the research. It became clear that the trees and bushes involved in the greening of the city of Ganja are also characterized as one of the habitats of fungi. 143 species was involved in the formation of their mycobiota in the studies conducted during 2012-2022, and the quantitative indicators of their taxonomic structure are given in tab. 2. They all belong to the kingdom of true fungi (Mycota).

Table 1. The frequency of use of trees and shrubs in the greening of large cities of Azerbaijan

	Dominant species (more than 10 units/ha)	Commonly used ones (1-10 units/ha)	Rare ones (less than 1 unit/ha)
		Gymnosperms	
Baku	3	7	9
Ganja	3	5	7
Sumgayit	2	4	5
		Angiosperms	
Baku	15	60	70
Ganja	12	52	64
Sumgayit	10	48	54
		Total	
Baku	18	67	79
Ganja	15	57	71
Sumgayit	12	52	59

Table 2. Taxonomic structure of fungi involved in the greening of city

Kingdom	Division	Class	Order	Familiy	Genus(species)
Mycota	3	8	17	32	50(143)

Table 3. Distribution of fungi on individual trees and shrubs

Plant	Taxonomic affiliation of fungi species					
	Zygo-mycota	Ascomycota		Bazidiomycota		Total
		Tele-morph	Ana-morph	Telio-mycetes	Bazidio-mycetes	
Gymnosperms						
Pinus eldarica Medw	1	1	4	1	2	9
Cupressus sempervirens L.	1	1	3	1	2	8
Cedrus deodara Loud.	1	1	4	1	2	9
Cedrus deodara Loud.	1	2	2	1	3	9
Pinus Pallasiana Lamb	1	1	7	1	2	12
Taxus baccata L	2	2	4	1	3	12
Angiosperms						
Platanus orientalis L	1	1	7	0	5	14
Diospuros kaki Thunb.	1	1	8	0	2	12
Rosa alba L	1	3	14	1	0	19
Ulmus foliaceae Gilib	1	2	7	1	5	16
Euonymus japonicus L.	1	1	6	1	2	11
Tilia caucasica Rupr	2	1	7	1	10	21
Eriobotrya japonica Lindl	1	1	5	1	1	9
Fraxinus excelsior L.	1	1	8	0	7	17
Sophora japonica L.	1	1	5	0	3	10
Ligustrina lucidum Aitt.	2	1	7	2	1	13
Syringa vulqaris L.	1	1	8	0	2	12
Sambucus racemosa L.	1	1	4	1	0	7
Vitis vinifera L.	1	2	5	1	0	9
Aesculus hippocastanum L.	1	1	7	0	7	16
Robinia pseudoacacia L.	2	3	8	1	8	22
Salix australior Anderss.	3	2	14	0	9	28
Quercus ilex L.	1	1	9	0	7	18
Salix babylonica L.	1	2	7	0	0	10
Populus alba L.	1	2	12	0	11	26
Populus tremula L.	1	1	14	0	12	28
Laurocerasus officinalis Roem	1	2	10	1	1	15
Hippophae rhamnoides L.	1	3	9	1	0	14
Forsythia europaea Deg.	1	2	9	1	0	13
Ailanthus glandulosa Desf.	1	1	7	1	2	12
Olea europaea L.	1	1	12	1	3	16
Morus alba L.	1	1	10	1	5	18
Morus nigra L.	1	1	9	1	4	16
Others	3	4	17	2	10	37

Table 4. Pathogenic activity of mycobiota of plants involved in the greening of Ganja city

Groups of fungi according to pathological activity	The number of fungal species belonging to the corresponding group
Those with broad-spectrum activity, that is, eurytrophs	49
Those with limited activity, that is, conditional stenotrophs	27
Those with specific activity, that is, stenotrophs	9
Those belonging to the epiphytic mycobiota	18
Those whose status is unknown	12

Table 5. Diseases found in plants used in the greening of Ganja city and their causative agents, found plants

Disease	Causative agents	Host plant
Root rot	*Fomitopsis annosa, Armillariella mellea, Coniophora puteana, Phaeolus schweinizi*	*Pinus eldarica, Quercus castaneifolia, Q.ilex, Q.robur*
White stem rot	*Fomes fomentarius, Phellinus igniarus, Ph.pini, Ganoderma applanatum*	*Quercus castaneifolia, Q.ilex, Q.robur, Salix australior, White acacia, Populus alba, P.tremula, Tilia caucasica, Gleditsia caspica, Platanus orientalis*
Brown stem rot	*Fomitopsis pinicola, Ýnonotus hispidus, Laetiporus sulphureus*	*Morus alba, White acacia, Populus alba, P.tremula, Sophora japonica*
Fusariosis	*Fusarium sporotrichioides, F.bulbigenum*	*Eriobotrya japonica, Evonymus japonica*
Rust	*Coleosporium balsamea, C.senecionis, Gymnosporangium juniperinum, Melampsora populina, M.salicina*	*Salix australior, Malus orientalis, Juniperus communis, Populus alba, P.tremula,*
Brown spotting	*Phoma acicola*	*Pinus silvestris*
Necrosis	*Clitliris quercina*	*Quercus castaneifolia, Q.ilex, Q.robur*
Yellowing of conifers	*Lophodermium macrosporum*	*Cupressus sempervirens*
Staining	*Marssonina rosae*	*Rosa alba*
Grey mold rot	*Botrytis cinerea*	*Rosa alba*
Floury dew	*Podosphaera leucotricha, Microsphaera alphitoides*	*Rosa alba, Quercus castaneifolia, Q.ilex*
Ascocytosis	*Ascochyta fagi, Ascochyta sp.,*	*Rosa alba, Populus alba, P.tremula, Quercus castaneifolia, Q.ilex*
Gray spotting	*Septoria salicicola, Phyllosticta salicola*	*Salix australior*
Fruit rot	*Alternaria mali*	*Malus orientalis.*
Twisting of leaves	*Taphrina deformans*	*Persica vulgaris,Prunus divaricata, Pyrus communis*
Green mold	*Penicillium puberulum, P. divergens, P. glaucum*	*Aesculus hippocastanum, Quercus castaneifolia, Q.ilex*
Black mold	species belonging to the genus -*Alternaria, Cladosporium, Hormiscium, Aspergillus*	*Pinus silvestris, Populus alba, P.tremula, oak, Ulmus foliaceae*
Head mold	species belonging to the genus -*Rhizopus stoloniufer, Thamnidium elegans* and *Mucor.*	Coniferous and broad-leaved trees

More than half of the real fungi recorded in the course of research belong to anamorphic fungi (58.5%), which are currently classified as sac fungi (Ascomycota). Basidiomycetes (Bazidiomycota - 33 or 28.0%), ascomycetes (telemorphs - 9 or 7.6%) and zygomycetes (Mucormycota - 7 or 5.9%) take the next places.

As for the separate distribution of fungi involved in the formation of the mycocomplex of the studied plants, it became clear that there is no clear dependence between the distribution of fungi on plants and the frequency of use of those plants for urban greening. That is, the mycocomplex of the species considered dominant due to their use in urban greening is not rich in terms of species composition. As can be seen from the table with summarized results (Fig. 3), although white acacia, willow and poplar have the richest mycobiota, they are not dominant in terms of frequency of use. Thus, southern willow, which ranks first in terms of the richness of mycobiota, belongs to the category of frequently used plants, while white poplar belongs to the category of rarely encountered plants.

As is well known, fungi constitute either epiphytic or pathogenic mycobiota of the plant it inhabits. Depending on this form of participation, between plants and fungi are formed nutritional relationships(eco-trophic adaptations).

Studying this is also important in terms of clarifying both the form of their mutual relations and the role of this relation in determining the nature of the processes occurring in the ecosystem. Therefore, the next stage of research is devoted to the clarification of these issues. It became clear that, a total of 8.4% of the 143 species recorded during the research was involved in the formation of the epiphyte mycobiota of the studied plants, that is, they belong to the true saprotrophs due to their ecolo trophic relationship. The rest are relatively pathogenic species. Thus, 10 of the recorded fungi belong to the mycobiota. A large number of pathogens and a small number of epiphytes also determines the number of biotrophs and facultatives (more precisely, polytrophs) in the eco-trophic distribution of fungi. Thus, 10.5% of registered fungi belong to biotrophs, and 81.1% to polytrophs.

It should be noted that recently, when mushrooms are characterized according to the manifestations of their eco-trophic specialization, their toxigenicity, allergenicity and opportunism[18] are among the issues in the focus of special attention in microbiological and mycological studies. During the characterization of the fungi recorded in the tree and shrub plants used in the greening of the studied cities, it became clear that, among them, there are toxigens(*Aspergillus flavus, A.fumigatus, A.ochraseus, Cladosporium herbarium, Fuzarium moniliforme, F.oxysporium, Penicilium cuslopium, P.citrinum* and oth.), allergens (*Botrytis cinerea, Monila stophila, Penicillium granulatum, Rhizobus stolonifer, T.viride* and oth.), and opportunists(*Aspergillus niger, A.terreus, A. versicolor, Candida alpicans, Pencillium expansum, P. purpurogenum, Mucor hiemails* and oth), and their quantitative indicators vary between 32.5-52.8%. In other words, fungi with the mentioned characteristics are actively involved in the formation of the mycobiota of the studied trees and shrubs, which is one of the facts that must be taken into account in terms of mycological safety.

As is known, some microorganisms, including fungi, have the ability to synthesize a number of biologically active substances, which have different effects on plant growth and productivity. So, this effect can manifest itself either by stimulation, weakening, or complete destruction of the plant. The organisms that cause the latter, including fungi, are generally called phytopathogens. As a rule, during the systematization of fungi corresponding to this characteristic, their morphological and physiological characteristics and specialization to the plants they use as a feeding place are taken as a basis. Correspondingly, some researchers in similar studies divide the pathogenic species of micromycetes into powdery mildew, rust and anamorphic fungi of ascomycetes. Taking into account that this division is somewhat confused, we considered it appropriate to characterize the pathogenicity activity of the pathogen in studies according to the specialization in different substrates. From the obtained results, it was clear that the fungi recorded in the studies can be divided into 5 groups, among which most of the recorded fungi with pathogenic activity have a wide range of effects. Thus, most of the plants of trees and shrubs involved in the greening of Ganja city are involved in the occurrence of one or another pathology (tab. 4), that is, they are characterized as eurytrophs.

This fact can be evaluated as a case characterized in a negative side. Because fungi characterized as eurytrophs have higher adaptation characteristics compared to stenotrophs and conventional stenotrophs, so that any environment is more suitable for at least meeting their nutritional requirements.

As is well known, fungi are in relationship with plants in various forms, including trees and shrubs, and different pathologies arise from their mutual relations, as mentioned. Although bacteria and viruses are involved in the occurrence of these pathologies, according to experts' calculations, more than 80% of the pathologies recorded in plants are the result of the activity of fungi. As a result of this activity, it is inevitable to lose the product, which is measured in millions of tons every year. Suffice it to say that every year at least 10% of the crops produced on earth are lost as a result of the activity of fungi. Taking into account the constant increase in the world's population and its occurrence within a stable area, it is worth noting that this loss is dangerous for humanity. For this reason, the need to prepare measures to combat this situation is one of the realities accepted by everyone today. As mentioned, the vast majority of fungi recorded in the course of research, more precisely 85.7%, have the ability to inhabit plants that retain their vitality to one degree or another, that is, each of these fungi has potential pathogenicity. Clarification of the extent to which this is a real source of danger was considered appropriate in research. It was clear from the obtained results that more than 80 types of fungi, whose phytopathogenicity was confirmed in one or another study, are among the fungi spreading on the studied plants, and the number of pathologies caused by them separately or together is slightly more than 50. Information about some diseases, their causative agents and host plants, recorded in the course of research and determined according to the relevant determinants, is summarized in table 5. As seen, the fungi recorded in the occurrence of the diseases observed in the course of the research are species belonging to the division Zygmycota, Ascomycota and Basidiomycota. As for, the prevalence of diseases caused by the mentioned fungi, from the obtained results, became clear that during the period of the research, there was no epidemic of any disease, and the prevalence rate of the recorded diseases varies from 0.7 to 24.5%. Among the mentioned diseases, the disease characterized by the highest indicator is the spotting disease, which is caused by more than 10 species of fungi. For example, the participation of fungi, such as *Ascochyta sp., Cercospora salicina, C.microsora, Marssonina populi, M.rosae, Phyllosticta salicola, Septoria salicicola* and oth. in the occurrence of spotting disease is one of the facts established during the conducted research. In addition, based on the obtained results (tab. 5), it can be noted that it is not appropriate to use trees such as *Salix australior* and *Populus tremula*, also *M.alba* and *M.nigra* in urban greening. For example, due to the fact that *Salix australior* and *Populus tremula* are not resistant to the diseases they cannot maintain their decorative appearance for a long time, while the fruits of *M.alba* and *M.nigra* is a favorable food source for fungi, it causes the spread of fungi, including pathogens.

CONCLUSION

Thus, the study of both angiosperms and gymnosperms trees and shrubs used in the greening of large cities of the Republic of Azerbaijan, such as Baku, Ganja, and Sumgait, showed that they are characterized as one of the habitats of both micromycetes and macromycetes. Most of the fungi recorded on the studied trees, more than 90%, are pathogenic to one or another degree , leads to the observation of various diseases. From a phytosanitary point of view, the prevalence of diseases observed is not considered very high and this is also confirmed by the absence of epiphytoty of any of the diseases recorded during the years of research. The fact that most of the recorded fungi are prone to pathogenicity to one or another degree, predominate eurytrophs , specific weight of toxigens, allergens, and opportunist is quite high, allows us to note the important of problem, and always kept in mind and take porifalctic measures aimed at eliminating these situations. The obtained results can serve as base data for measures to be prepared in this direction.

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Conflict of Interest

There are no conflict of interest.

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