Phytomonitoring of woody plants in the urban agglomeration

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Abstract. Phytomonitoring including mycological studies with information about plant pathogens, etc., is required to develop strategic directions for maintaining green spaces in urban agglomeration. Mycological analysis of the aerial part and roots of urban tree plants can be used to determine the composition and structures of microbial-plant associations in visually healthy and affected plants. The relevance of these works is due to rapid development of diseases and pests and their active distribution in close proximity to city residents. In coniferous and deciduous plants with symptomatic lesions (Picea abies (L.) H. Karst., Pinus spp., Quercus robur L., Tilia spp.), the species diversity of micromycetes in the phylloplane and rhizosphere decreased by 21–38% compared to visually healthy plants. It was suggested using the following micromycetes as marker organisms for assessing the soil fungistasis of artificial bicenoses and the state of coniferous trees: Dicoccum sp., Fusarium moniliforme J. Sheld., Fusarium culmorum. Perennial urban plants require improvement of the above-ground part using foliar fertilizers and phytostimulants, bioprotection tools, humates, mycorrhizal preparations, destructors of organic compounds of roots and adjacent lawns. The prospects of phytomonitoring of old-growing trees were emphasized. Reconstruction and enhancement of their resistance to aggressive environments require complex works.

1. Introduction

Moscow agglomeration includes satellite cities closely located to the Moscow Ring Road (within a radius of 15 km) as well as cities having a "specialization" scientific cluster, industrial parks, etc. Geographical boundaries of Moscow agglomeration cover the vegetation of public gardens, boulevards, yard and street plantings, and lawns. They exist under anthropogenic pressure. The influence of aggressive conditions of the urbanized environment is leveled by agrotechnical measures: soil loosening, fertilization, moderate watering, preventing mechanical damage to roots and branches.

In the green areas of Moscow and satellite cities, active development of infectious diseases of woody plants occurs regularly. They cannot be treated by agrotechnical methods. These diseases are as follows: infectious drying of linden branches (thyrostomosis, Thyrostroma compactum (Sacc.) Hoehn.), Dutch elm disease (graphism, Ophiostoma ulmi (Buisman) Nannf.), etc.. Under the influence of various harmful factors, green plantings weaken and suffer from pathogens and pests. During the entomo-phytopathological examination of young plantings, 18% of plants had water shoots; among infectious diseases, 32% are due to branch drying (thyrostomosis, etc.), 77% are damaged by leaf-eating insects, 20% - by sucking insects (including ticks) [1]. Entomo-phytopathological monitoring of planting material, soil and substrates is mandatory for newly created landscape gardening areas and street plantings within the urban agglomeration. Phytosanitary monitoring involves the use of modern methods
to identify and account for the number of pests, structure of artificial biocenosis and abundance of its individual components taking into account weather conditions and cultivation methods [2].

Collection and analysis of multi-year information are relevant for growing and keeping trees. Therefore, phytosanitary monitoring of plants, including old 150-year old trees, should be carried out at all stages of their development and growth. Right decisions and balanced practical actions begin with systematic, scientifically grounded on-site surveys (visual diagnostics) in combination with instrumental techniques and scientific analysis.

To carry out phytosanitary monitoring, an integrated approach accompanied by data grouping is required:

- meteorological - information about the climate, including data from regions. This information has several levels: average long-term indicators, retrospective assessment of main indicators of previous years and the current year. The following weather conditions (climatic) have the greatest value in phytomonitoring: air temperature (minimum/maximum, °C), soil temperature (°C), precipitation (mm), relative air humidity (%);
- agrotechnical - data on the species composition of plantings, growth characteristics, location, phenology of the plant and its reaction to external factors. The following agrotechnical indicators have the greatest value: soil-agrochemical conditions (mechanical composition, particle size distribution, moisture and air permeability, organic matter content, pH, acidity, alkalinity), elements of mineral nutrition; ecological and biological features of growth, plant development and longevity associated with vital processes (thermal regime, insolation, medium reaction, soil microorganisms, moisture and soil aeration, the ratio of macro and microelements in the substrate);
- biocenotic - data on plant pests and pathogens (biology, phenology), structure and species composition of phytophages, entomophages, entomopathogenic microorganisms, etc. This unit of phytosanitary monitoring is extremely important for developing common strategic directions: control, protection and planting.

The research purpose is to study prospects of phytonomonitoring of woody plants in the urban agglomeration, including mycological research, in order to make timely optimal management decisions.

2. Materials and methods
The basis of phytomonitoring data in the urban environment was made up of observations of the state of greenery (route surveys of 2014-2018) in garden and park systems in satellite cities of the megalopolis. The state of old plants was accounted by assessing categories of the state of trees used in forestry [3]. The studies assessed the spread and development of diseases, pests and non-infectious damage. Information was systematized and analyzed using MS Excell, MS Access and Internet resources.

For an instrumental analysis, at the beginning of the growing season, samples of soil and plants (branches, shoots) were taken. The general scheme of soil sampling from a depth of 0–10 cm for a mycological analysis included mixed samples from the root zone at a distance of 10–15 cm from the trunk and background samples taken above 50 cm from the trunk. Each sample was placed in an individual plastic bag. The samples were taken three times. The samples were analyzed by traditional methods used in microbiology: a wet chamber, sowing in the nutrient media. Isolated species were identified according to modern determinants of fungi [4, 5]. The terminology is used in accordance with Index Fungorum (http://www.indexfungorum.org).

3. The study of the structure of the modified lead-tin-base bronze
According to the results of phytomonitoring surveys, general signs (symptoms) of lesion were identified in a number of tree species in artificial biocenoses. For example, in conifers (Picea abies (L.) H. Karst., Pinus spp.), these are shortening needles and shoots (the current year increment), curvature and deformation of branches and trunks, staining of needles at the edges of shoots in rusty-brown color. The following symptoms were observed in deciduous species: pedunculate oak (Quercus robur L.) – deformed chlorotic leaves with small yellow spots on the edge of the central veib; cream or black shoots;
Linden species (Tilia spp.) - dark brown spots on leaves, bucket-like twisted leaves; shoots have brown round spots.

Mycological analysis of plants showed differences in the biodiversity of the microbial community: 34 filloplans and 21 microscopic fungi from the root zone were identified. In visually healthy plants, for example, *Quercus robur*, the following fungi were isolated in the aerial part: *Alternaria alternata* (Fr.) Keissl., *Aspergillus glaucus* (L.) Link, *Aureobasidium pullulans* (de Bary & Löwenthal) G. Arnaud, *Chrysosporium merdarium* ( Ehrenb. ) Jw Carmich., *Penicillium chrysogenum* Thom, *Phylosticta* sp. In the root zone, the following fungi were identified: *Aspergillus niger* Tiegh., *Cunninghamella echinulata* (Thaxt.) Thaxt. ex Blakeslee, *Cylindrocladiella parva* (P.J. Anderson) Boesew., *Fusarium solani* (Mart.) Sacc., *Mucor* sp., *Trichoderma viride* Pers. For deciduous trees with lesion symptoms (oak, linden), the following fungi were identified: *A. alternata*, *A. niger*, *Ch. merdarium*, *Fusarium sporotrichioides* Sherb., *Fusarium culmorum* (Wm.G. Sm.) Sacc., *Trichoderma virens* (J.H. Mill., Giddens & A.A. Foster) Arx [= *Gliocladium virens* J.H. Mill., Giddens & A.A. Foster.], *Micelia sterilia*.

For coniferous and deciduous plants with symptomatic lesions, species diversity of micromycetes in the phylloplan and rhizosphere decreased by 21–38%, compared with visually healthy plants. Representatives of 10 species were identified with a frequency of 6% and higher, with the maximum presence of the fungi *Fusarium oxysporum* Schltdl. and *Fusarium solani*. In the fungi observed in the root zone, the number of *Fusarium* and *Clonostachys* genera fungi was higher by 20% compared to *Fusarium*, *Alternaria*, *Aspergillus* fungi. In the root zone of all conifers (spruce, pine species), the following fungi were identified: *Clonostachys rosea* (Link) Schroers, *Sarcoscypha chlorocephala* (Berthold; Scotch pine *Pinus sylvestris* L.) Boesew., *Trichoderma virens* J.H. Mill., *Gliocladium* sp., *Mucor* sp., *Trichoderma viride* Pers., *Fusarium* sp., and *Clonostachys* sp.

The differences in the composition of fungi in the root zone were established. The following states were identified for the (visual damage symptoms): Norway spruce - *Cylindrocladiella parva* (P.J. Anderson) Boesew., *Fusarium gibbosum* Appel & Wollenw., *Gliocladium simplicium* (J.A. Mey.) B.J. Wiley & E.G. Simmons, species of the genus *Penicillium*, *Verticillium albo-atrum* Reinke & Berthold; Scotch pine - *Fusarium sambucinum* Fuckel, *Gliocladium* sp.; for plants of the 3-4th categories (damage symptoms), the following states for identified: Norway spruce - *Coniothyrium* sp., *Dicoccum* sp., *Fusarium moniliforme* J. Sheld.; Scotch pine - *Fusarium culmorum*. For urban green spaces, it is important to preserve soil fungistasis, i.e. the action of the biological component of the soil in order to limit the mycelial growth of fungi and inhibit the germination of resting forms of pathogens. Therefore, it is useful to consider fungi communities that characterize the state of the 1-2nd and 3-4th categories as markers of the state of the tree and soil fungistasis of artificial bionoses.

It is useful to supplement the data of phytomonitoring with information on the mycology of plant parts and soil. At the same time, natural processes are accompanied by succession of dominant representatives in the microbial community. For example, in the zone of the root system of woody plants, the succession of complex of micromycetes or destroyer organisms, including phytopathogens (*Fusarium*, *Pythium*, etc.) capable of invading roots of weak plants is initiated. Then they are replaced by saprotrophic fungi (*Mucor, Penicillium, Aspergillus*) which are able to absorb available substances – mono- and oligosaccharum, hemicellulose; then, they are replaced by cellulolytic micromycetes (*Trichoderma, Dematium, Cladosporium*, *Alternaria, Ceratocystis, Cunninghamella*) and lignin-destroying fungi In the urban environment, agrotechnical measures (loosening, mulching, fertilizing) affect the development cycles of living organisms and infectious processes, formation of resistance to host plants.

Particular attention should be paid to the problem of old (150 years and older) for which the results of phytomonitoring must be accompanied by comprehensive works to reduce the overcrowding of the upper soil layers by loosening and pitting, removing weeds and lawn grass near the trunk; introduction of structural elements (sand, peat, clay, expanded clay, coarse material); mulching; removal of rotten root patches; seasonal use of potassium humate, fungicides, morphoregulators and biological preparations with active destructive organisms, etc.

It is necessary to say about the seasonality of "critical periods" of plant growth (the survival rate after
transplantation, flowering, fruiting) during which the risk of disturbances in plant development, weakening vitality and loss of decorativeness is high. The following measures can be used: watering, use of foliar fertilizers, macro, micro and chelated fertilizers. Biological activity of the soil microflora can be suppressed (changed) by applying complex mineral fertilizers which worsens the soil structure, increases humus mineralization and leaches calcium, magnesium and mobile organic substances.

Therefore, it is important to observe calendar dates for maintenance works. Phytomonitoring (visual diagnostics of planting conditions) is important for plant protection, prediction of the development of pests and assessment of the effectiveness of seasonal methods for protection and maintenance of green areas. In case of danger of development of diseases and pests, their active distribution in the human environment according to the official “List of pesticides and agrochemicals which can be used in the Russian Federation” [6], there is a limited range of pesticides with regard to environmental safety requirements which can be used in urban areas. Therefore, maintenance of plant immunity, creation of optimal conditions for their growth is crucial when designing, creating and keeping urban greenery.

4. Conclusion

The relevance of phytomonitoring of woody plants in the urban agglomeration is associated with rapid formation of foci of diseases and pests and their active distribution in close proximity to humans which affects their health, performance, and physical endurance, etc. The development of pathogens is a predictor of events, reflects changes in abiotic factors and the influence of human activities. For perennial urban plantings, given the importance of work on their reconstruction and increasing resistance to aggressive environments, it is important to carry out seasonal works to improve aerial parts of plants using foliar top dressings with fertilizers and phytostimulants, treatment of roots with bio-protectors, humates, mycorrhizal preparations, destructors of organic compounds, etc.

References

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