The climate-forming ability of *Magnoliaceae* Juss. family in urban landscapes phytocenosis

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Abstract. The climate-forming ability of phytocenoses was evaluated on the basis of phenotyping of the representatives of *Magnoliaceae* Juss. in urban landscapes. The influence of deciduous representatives of the *Magnoliaceae* Juss. family in the environment shaping by the normalized difference vegetation index, foliage projective cover and photosynthetic potential is analyzed. The evaluation of plants allowed us to determine the stress-resistant species for restoration of urban landscapes of the capital of Ukraine and other metropolitan areas. The most promising species of trees to reduce the urban thermal effect are *M. acuminata* and *M. denudata*.

Keywords: *plant phenotyping, urban ecosystems, climate change, Magnoliaceae Juss., urban heat island.*

Various climate forecasts show that the main trends of climate change in the future are related to rising temperatures and decreasing rainfall, that is, to increasing aridity region. Environmental changes are becoming stable and, for the most part, negatively oriented, such as global climate change, fantastically rapid (from an evolutionary point of view) transformation of plant conditions, active degradation of phyto- and agrocenoses due to man-made pressure.

Urbanization of regions, accompanied by urban development, also contributes to a significant increase in the pressure on natural ecosystems and the deterioration of the environmental situation. Predicted climate change can have a significant impact on agriculture, the growth and development of human society. The consequences for some regions can be very serious, but urban ecosystems are the most vulnerable today.

The urban environment differs significantly from the natural conditions in which the ecological and physiological features of the plants were formed and inherited. The main potential negative effects of climate change that can occur in Ukrainian cities include: heat stress, floods, area decline and depletion of the species composition of urban green spaces. In these circumstances, there is a problem of intensification of adaptive strategies of urban ecosystems. Its practical solution requires the development of methods for assessing adaptive strategies of urbocenoses and predicting their ecological equilibrium and resistance to unfavorable environmental factors, taking into account the adaptation and integral physiological parameters of plant functional status.

The objective determination of adaptive potential can be based on plant phenotyping. Plant phenotyping is a methodology based on plant phenomics, which allows combining various physiological, morphometric and biochemical processes to characterize the responses of genetic resources to the environment, and improve breeding and plant management. The methodology of the new field of plant phenomenology is a multivariate study of a complex of plant traits related to the processes of plant growth and development, structural rearrangements, physiological reactions of tolerance, resistance, environmental plasticity and productivity. The peculiarity of phenotyping is that the use of methods of nondestructive analysis, data management and modeling has emerged as a cutting-edge technology technology for the study of plant growth and development in response to the influence of various environmental factors and to characterize specific plant species in certain conditions for the selection of species with high adaptation potential [1].

Therefore, the implementation of such technologies is crucial for sustainable urbocenosis in urban environment, while determining the margins of adaptive variability and stability of species, to form a system of phenotyping of climate-forming ability of plants.

Urban Heat Island (UHI) is one of the latest and growing threats to urban areas. UHI is a phenomenon of growing the urban temperatures compatison to surrounding countryside. UHI affects many millions of people around the world and have huge implications for the health and well-being of people living in urban areas. Increased anthropogenic heat production are the main causes of UHI [2].

According to the "Scientific Centre for Aerospace Research of the Earth" (Institute of Geological Sciences of the National Academy of Sciences of Ukraine), from 2003 to 2011 the surface temperature in some areas of Kiev increased by 7-10 °C [3]. Monitoring of the thermal field of the city of Kyiv in 1984-2014 showed a significant influence of the level of landscaping and density of urban buildings on the formation and characteristics of thermal fields in urban areas. The minimum surface temperature inherent in park / forest areas is due to natural evaporation and no artificial cover, while abnormally high temperatures are observed over large interchanges and main avenues [4].

Monitoring of the O. Fomin Botanical Garden (Taras Shevchenko National University of Kyiv) was conducted using an unmanned aerial vehicle (UAV) survey data and satellite imagery. High spatial resolution visual maps - the normalized difference vegetation index (NDVI) map, the digital altitude model, the object height map and the Botanical Garden thermal map were created. The data obtained, in particular area, height, volume and photosynthetic potential, were used to evaluate individual tree species in reducing the effect of the UHI [5].

One of the ways to improve the greening of Kyiv city is to expand the diversity of ornamental plants in green areas, optimize the species composition of tree plantations by introducing new ornamental, climate-forming and tolerant to anthropogenic (including heat stress) species and forms of plants.

Promising in the context of climate-forming ability are representatives of the *Magnoliaceae* Juss. family. This family is one of the basal groups of flowering plants with an evolutionary history of over 100 million years. Adaptation mechanisms that have allowed *Magnoliaceae* to adapt to different climatic changes over the course of evolution have attracted the attention of scientists and suggest that certain species of this family may have a high thermoregulatory ability to shape the microclimate of the urban landscape.

The *Magnoliaceae* family unites two genera: *Magnolia* L. (about 230 species) and *Liriodendron* (2 species: *L. chinense* (Hemsl.) Sarg., *L. tulipifera* L.). Species of the genus *Magnolia* are evergreen and deciduous trees and shrubs common in North America and East Asia. The genus *Liriodendron* is represented only by deciduous trees, the natural range of *L. chinense* in Asia (south and east of China and north of Vietnam), and *L. tulipifera* in North America (east of the United States).

To determine thermoregulatory capacity, we investigated species introduced at temperate latitudes growing in the territory of O. Fomin Botanical Garden: four species of the genus *Magnolia* (*M. acuminata*, *M. kobus*, *M. denudata*, *M. soulangiana*) and one species of the genus *Liliodendron* (*L. chinense*).

The physiological state of woody plants and the prediction of their viability in urban ecosystems are assessed by the functional activity of the assimilation apparatus. The intensity of absorption and emission of CO_2 by a leaf (photosynthesis and respiration) allows estimating the physiological activity of plants during heat treatment. Photosynthetic potential is an integral indicator that reflects the efficiency of CO_2 assimilation by a whole tree. Photosynthetic potential was calculated by foliage projective cover (FPC) and normalized difference vegetation index (NDVI), which characterizes the potential photosynthetic efficiency of plants per unit area [5].

According to the data obtained, the highest photosynthesis efficiency is characterized by *M. acuminata*, the lowest – *M. soulangiana* (33.50 and 1.25 relative units, respectively) (Table 1). *M. acuminata* also has the largest FPC of 91.21 m^2 and *M. denudata* has the highest NDVI of 0.454.

Table 1 – Photosynthetic potential of the *Magnoliaceae* Juss. family

№	Spesies	Photosynthesis efficiency, Rel. units	Foliage projective cover, FPC, m^2	Normalized Difference Vegetation Index, NDVI±SE
1	*Liliodendron chinense*	12.26	34.14	0.431±0.00011
2	*Magnolia acuminata*	33.50	91.21	0.441±0.00006
3	*Magnolia kobus*	23.34	64.43	0.435±0.00012
4	*Magnolia denudata*	6.19	16.38	0.454±0.00014
5	*Magnolia soulangiana*	1.25	3.678	0.407±0.00051

Thus, analyzing the photosynthesis efficiency, NDVI, structure and crown shape of representatives of the *Magnoliaceae* Juss. family, we can conclude that the most promising species of *Magnoliaceae* from the collection of the Botanical Garden to reduce the temperature of the UHI phenomenon are *M. acuminata* and *M. denudata*. These species actively absorb CO_2 during the summer heat, creating powerful shading.

REFERENCES

1. Costa, J.M., Marques da Silva, J., Pinheiro, C., Barón, M., Mylona, P., Centritto, M., ... & Oliveira, M. M. Opportunities and limitations of crop phenotyping in southern European countries // Frontiers in plant science, 2019. 10, P. 1125.
2. Mohajerani, A., Bakaric, J., Jeffrey-Bailey, T. The urban heat island effect, its causes, and mitigation, with reference to the thermal properties of asphalt concrete // Journal of environmental management, 2017. 197, P. 522-538.
3. Stankevich, S.A., Filippovich, V.E. Infrared satellite imaging for the study of urban heat islands in Ukraine // Proceedings of 8th International Green Energy Conference (IGEC-8), Kiev: NAU, 2013. P. 219-223.
4. Filipovich, V., Mychak, A., Krylova, A. Use of satellite data in monitoring ecological condition of urban landscape. // 14th GeoConference on Informatics, Geoinformatics and Remote Sensing. Conference Proceedings, 2014. Vol. 3, P. 1061-1068.
5. Kazantsev, T.A., Futorna, O.A., Svietlova, N.B., Badanina, V.A., Taran, N.Y. Prospects of Using Unmanned Aerial Vehicle for Assessing Climate-Making Properties of Park Tree Species Using Kiev AV Fomin Botanical Garden as an Example // Journal of Automation and Information Sciences, 2018. 50(4).