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CLIMATE CHANGE IMPACT ON SEASONAL OF WOODY PLANTS GROWTH IN CITY OF KYIV

N.O. Oleksiychenko, *ScD in Agricultural*
N.Yu. Breus, *postgraduate**
National University of Life and Environmental Sciences of Ukraine

Having analyzed the climate changes in the area of Kyiv for the period of the research 2009–2013 and based of comparative analysis of seasonal development of beautiful flowering shrubs, our own observations and data of other authors, the dynamic for 60 years in flowering phases of the species which are the most common in landscape gardening was revealed. The substantial impact of climate changes to flowering phases of woody plants was proved.

Introduction. According to official data of the international program LIFE launched by the European Commission as "the financial instrument for the environment" and coordinated by the Environment Directorate-General, the issue of impact of global climate changes to Europe's flora is a challenge [15]. According to the latest studies, approximately 2080 plant species (more than a half) of European flora are assessed those that could be threatened by substantial changes in vegetative growth that are featured by significant shifts, prolongations or reductions of phenological phases (namely flowering). This effect is the most evident in mountainous and the Mediterranean regions [16].

The climate changes in Ukraine are mostly synchronized with global ones, although based on the conclusions of the international group of UN experts currently the country does not belong to the countries which are the most vulnerable to global dynamic. However, according to the experts' observations, further intensive growth of average annual temperature may result in change of the majority of natural and climatic landscape of the country [1].

Based on numerous hydrometeorological features and data the national specialists-climatologists came to the conclusion that the features of new climate started forming in Ukraine for the last 10–25 years. The analysis of changes of average annual temperature for more than 100 years allows to establish that the global warming is evident within the last decades and becomes more intensive every year. The following data can be used for demonstration – the average annual temperature in the city of Kyiv in some periods was as follows: 1881–1960 – 7.1 °C; 1961–1990 – 7.7 °C; 1991–2013 – 8.6 °C. The winters have become not so cold and with less snow and the summers have become significantly hotter. However, there are different and rather controversial data and conclusions with regard to this issue. Sometimes there are rapid changes of

*Scientific supervisor – Doctor of Agricultural science, Professor N.O.Oleksiychenko

temperature up to 10–12°C per day. Usually, in such periods one can observe atmospheric disturbance and natural phenomena such as heavy falls of rain, thunder storms, hailstorms, high wind, massive storms etc. [7].March 2013 can serve as an example of such natural phenomena, since in that month the amount of precipitations exceeded the average norm for more than three times (pursuant to official data, the amount of precipitation was 305% compared to the normal one) [5].

According to the scientists [12, 2, 14 etc.], if the tendency to global warming preserves, it will cause changes of weather, the warming will disturb steady functioning of ecological systems, affect natural resources as well as sanitary and other conditions of people's life and will have influence on various elements of living. Thus, while using woody plants as main components for improvement of urban landscapes, one cannot ignore the fact that their seasonal biorhythms directly depend on climate changes. In this respect it should be noted that during many decades seasonal development of woody plants are studied by the leading scientists. In particular, the works of Rubtsov L.I. (1952), Mysnyk G.Ye. (1976), Kolisnychenko O.M. (2004), etc. should be mentioned.

Taking into account that Ukraine is one of the world regions vulnerable to ongoing climate changes, the main task of the conducted research was to reveal how phenological phases of beautiful flowering shrubs depend on climate indexes in the area of Kyiv.

Materials and methods of research. The beautiful flowering shrubs which are the most common in landscape gardening in the city of Kyiv were chosen as an object of the research. The meteorological date for the period 2009–2013 stated at the official website of International Meteorological Station [11] were used for analysis of climate changes and obtaining data regarding the amount of effective temperatures for the flowering phases of the examined species. Phenological observations for the period 2009–2013 were conducted based on the method of Bulygin M.E [3] and statistical plant biomentrics were calculation based on the approach of Zaytsev G.M. [6]. The information was processed by means of the MS "Excel".

Research results. For the period of research 2009–2011 the inventory of beautiful flowering shrubs was performed in 100 parks of the city of Kyiv. It was revealed that plants in the city areas of public use are represented by 20 species of beautiful flowering shrubs which is only 6.7 % of the total number of species of this group of plants present in the collection funds of botanical gardens in the city of Kyiv [14]. Among the examined plants in the city parks the most common are only 9: Chaenomeles maulei (Mast.) C.K. Schneid., Philadelphus coronarius L.Maxim., Viburnum opulus L., Forsythia suspensa (Thunb.) Vahl., Syringa vulgaris L., Spiraea x billardii Dippel, Spiraea japonica L., Spiraea vanhouttei (Briot) Zabel, Cornus mas L. The time and character of flowering of the shrubs often determine their place in the landscapes of gardens and parks. It is impossible to arrange the composition of plants without clear knowledge of flowering periods and their duration. In order to be able to determine duration of decorative nature of plants in the city of Kyiv by virtue of beautiful flowering shrubs and to make any suggestions with regard to the extension of range of this group of plants for use in the city parks, it is necessary to have reliable data on the flowering periods of species available in the city of Kyiv. Before providing grounds showing the dependence of phenological phases of beautiful flowering shrubs on climatic indexes, in our opinion it is necessary to understand to what extent the climate changes can be traced in the city of Kyiv for the period of our research (Fig.1)

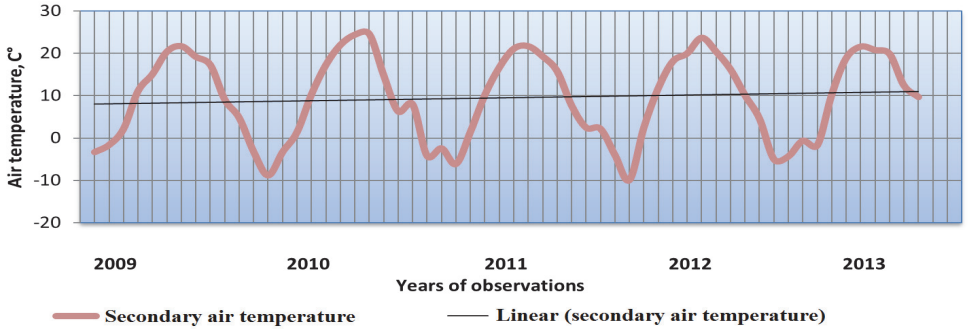


Fig.1. Changes in air temperature in the area of Kyiv for the period 2009–2013

It should be noted that according to statistical calculations, the trend line (linear, as shown on the Fig.1) for average annual temperature is described by equation = 0.0512x + 7.9949, approximation accuracy R^2 = 0.0074.The above-mentioned graph of change of temperature in the area of Kyiv for the period 2009-2013 explicitly shows the increase of average monthly temperatures during last five years. In the course of further research it was established that this dynamic appears first of all in spring and causes shifts of phenophases to earlier period (Fig.2).

During analysis of the obtained information it is necessary to pay attention to the fact that the beginning of flowering phases of the examined objects for the period 2009–2013 may considerably fluctuate (table 1). It is supported by the high coefficient of variation especially for early-spring species (for example, for Cornus mas L. It is 22.5%, for Forsythia suspensa (Thunb.) Vahl. – 15.8%) which are the most sensitive to temperature environment while their flowering periods can remain stable. First of all, it is related to the fact that

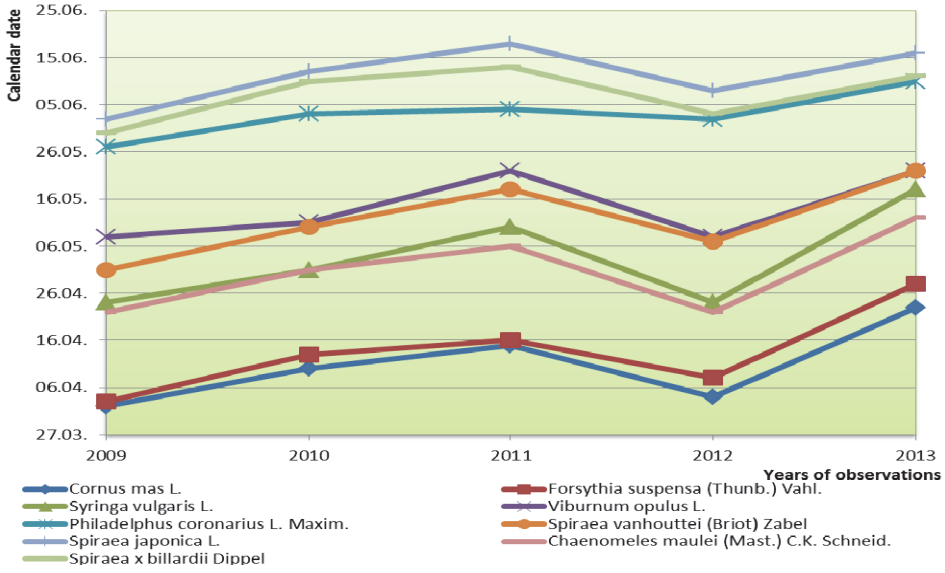
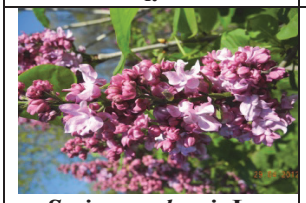
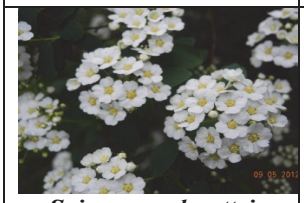


Fig.2. Beginning of the flowering phase of shrubs, research in 2009–2013

Table. Beginning of flowering phenophase of species of beautiful flowering shrubs among plants in the area of Kyiv

Species	Data of our own observations 2009-2013				Average value of beginning of flowering phase (Rubtsov L.I., 1952)	Average value of beginning of flowering phase (Kolisnichenko O.M., 2004)
	Average value of beginning of flowering phase	Mean square deviation	Variation coefficient, %	Amount of effective temperatures (average value), °C		
 ***Cornus mas* L.**	**10.IV**	7.6262	22,5	180±21	**17.IV**	**14.IV**
 ***Forsythia suspensa* (Thunb.) Vahl.**	**13.IV**	8.4522	15,8	203±18	**27.IV**	**16.IV**
 ***Syringa vulgaris* L.**	**3.V**	9.3723	15,5	380±15	**12.V**	**10.V**
 ***Viburnum opulus* L.**	**14.V**	6.4621	7,5	537±15	**22.V**	**24.V**
 ***Physocarpus opulifolius* (L.) Maxim.**	**3.VI**	4.4721	2,2	965±12	**11.VI**	**4.VI**

Species	Data of our own observations 2009-2013				Average value of beginning of flowering phase (Rubtsov L.I., 1952)	Average value of beginning of flowering phase (Kolisnichenko O.M., 2004)
	Average value of beginning of flowering phase	Mean square deviation	Variation coefficient, %	Amount of effective temperatures (average value), °C		
 ***Spiraea vanhouttei* (Briot) Zabel**	**11.V**	7.5525	7,3	484±18	**18.V**	**18.V**
 ***Spiraea japonica* L.**	**11.VI**	5.7410	5,9	1128±6	-	**18.VI**
 ***Chaenomeles maulei* (Mast.) C.K. Schneid.**	**30.IV**	7.8383	16,3	350±11	**3.V**	**6.V**
 ***Spiraea x billardii* Dippel**	**7.VI**	5.3066	6,3	1034±8	-	**13.VI**

calendar days of beginning of phenophases are not fixed and cannot be treated as a constant unlike the amount of effective temperatures. It is known that physiological processes in plant tissues begin at the temperature +5° C and become active at +10° C and higher. Temperatures within which the active physiological processes take place are called effective. The amount of effective temperatures (or thermal constants) is a constant for beginning of one or another phase of each particular species. It is known that the respective phase of plant development begins when this index reaches the certain value provided that other factors are in optimum. The average index value of

the beginning of flowering phase for each species is specified in the table below.

The obtained results of phenological observations and examination of average annual temperature in the area of Kyiv for the period 2009–2013 give an opportunity to determine that temperature fluctuations cause substantial shift of phenological dates of flowering of beautiful flowering shrubs. In particular, having compared the obtained data with the data specified by Rubtsov L.I. in 1952 (observations were conducted on the basis of plants in the M. M. Gryshko National Botanical Garden of the Academy of Sciences of Ukraine) it can be traced that taking into account average value of beginning of flowering phase Forsythia suspensa (Thunb.) Vahl.,the plant starts flowering two weeks earlier and Syringa vulgaris L. – 9 days earlier. At the same time, having compared the obtained data with the data specified by Kolisnichenko O.M. in 2004 (the observations were conducted on the basis of the collection fund of the A.V. Fomin Botanical Garden), variation of data is not so evident. First of all, it is related to periods of conducted observations – during 32 years at the turn of XX–XXI century when fluctuations of climate towards warming were already noticeable. According to analysis of the obtained data, it may be concluded that climatic indexes of the area of Kyiv essentially influence on the beginning of phenological phase of flowering of beautiful flowering shrubs which are used for landscape gardening in the city of Kyiv (see the table). Furthermore, as a result of natural anomalies that can be observed in the city of Kyiv in the last years one can observe untypical for repetition the flowering phases of some species of woody plants. For example, in 2010 the flowering of Forsythia suspensa (Thunb.) Vahl. was recorded on 12 December; in 2011 the repeated flowering of Kerria, Kolkwitzia and some species of magnolia was recorded, namely at the beginning of August in the M. M. Gryshko National Botanical Garden of the Academy of Sciences of Ukraine; flowering of Aesculus hippocastanum L. in autumn in last few years. Such anomalies in vegetative cycle of plants increase the risks of damages to plants due to low temperatures and possibly, their loss. That's why peculiarities of changes in climate conditions in the area of Kyiv should be taken into account during improvement of criteria of selection of plants and agricultural techniques of their growing that will facilitate in prevention of negative effects of weather conditions at the present stage.

Conclusions

1. Based on numerous hydrometeorological features and data, national specialists-climatologists point out that for the last 10-25 years the features of new climate started forming in Ukraine.
2. Global climate changes have significant impact on plant life. It leads to the shift of phenological phases of vegetative development of plants, changes of genetic composition of plant life, change of species composition of alien species due to weakening of adaptive capability of native flora. The most vulnerable are woody plants as those that have the longest life cycle.
3. According to the results of the inventory in 100 parks of the city of Kyiv for the period 2009–2011, the plants in the city areas of public use are represented by 20 species of beautiful flowering shrubs among which the most common are only 9 species.
4. According to the revealed dependence of beginning of the flowering phase of beautiful flowering shrubs on climatic indexes in the area of Kyiv, due to warming of climate the essential shifts of phenological phase of beginning of flowering to more earlier stage are observed in the area of research, while the amount of effective temperatures remains constant for each particular species.

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АНОТАЦІЯ

Олексійченко Н.О., Бреус Н.Ю. *Вплив кліматичних змін на сезонність розвитку декоративних деревних рослин у Києві // Біоресурси і природокористування. – 2015. – 7, № 1–2. – С. 123–129.*

Проаналізовано кліматичні зміни в районі м. Києва за період 2009–2013 рр. Виявлено динаміку настання фаз цвітіння у найпоширеніших в озелененні видів за останні 60 років на основі порівняльного аналізу сезонного розвитку красивоквітучих деревних кущів за власними спостереженнями та даними інших авторів. Доведено суттєвий вплив кліматичних змін на фази цвітіння декоративних деревних видів.

АННОТАЦИЯ

Алексейченко Н.А., Бреус Н.Ю. *Влияние климатических изменений на сезонность развития декоративных древесных растений в Киеве // Биоресурсы и природопользование. – 2015. – 7, № 1–2. – Р. 123–129.*

Проанализированы изменения климата в районе г. Киева за период 2009–2013 гг. Выявлена динамика наступления фаз цветения у наиболее распространенных в озеленении видов за последние 60 лет на основе сравнительного анализа сезонного развития красивоцветущих древесных кустарников по собственным наблюдениям и данным других авторов. Доказано существенное влияние климатических изменений на фазы цветения декоративных древесных видов.