Advanced Studies in Biology, Vol. 16, 2024, no. 1, 53 - 61
HIKARI Ltd, www.m-hikari.com
https://doi.org/10.12988/asb.2024.91875

Biology of Flowering and Fruiting of Some Woody Plants Spread in the North-Eastern Part of the Greater Caucasus in the Conditions *in ex situ* and *in situ*

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Abstract

In the conducted research, the characteristics of flowering, fruiting and seed production of trees and shrubs distributed in the north-eastern part of the Greater Caucasus (Azerbaijan) were comparatively studied in the conditions of in ex situ and in situ. The tree and shrub plants studied during the study were divided into 4 groups according to the flowering and its finish process: early-starting and early-finishing (EE), early-starting and medium-finishing (EM), medium-starting and medium-finishing (MM), late-starting and late-finishing (LL). The results of phenological observations have shown that there is no direct correlation between the duration of flowering and the life of a flower. Depending on the individual biological characteristics of plants was determined that compared to opened flowers the retention of fruits formed in ex situ conditions varied from 1.8-6.4%, and in situ conditions varied from 3.1-68.6%. As a result of research became clear that depending on the species the plants studied in natural conditions have 5-10% higher fruit storage capacity compared to the cultivated conditions. The results of the experimental work showed that because research materials are more favorable from an environmental point of view the process of flowering and fruiting in natural conditions was higher relative to cultural conditions. The results of the conducted

research showed that the plants studied in ex situ conditions give normal flowering and fruiting, so their gene pool can be preserved and used in greening works.

Keywords: introduction, flowering, fruiting, ex situ, in situ, flower, fruit

The reproductive period is one of the most important stages in the ontogenesis of plants. Knowledge of flowering and fruiting biology is of particular interest in newly introduced plants. Successful flowering and fruiting are very important signs of adaptation of introduced plants to new conditions.

Entering the flowering phase is closely related to the individual biological characteristics of plants, environmental factors of the environment where they grow [1,2, 4, 6, 11, 15] . Flowering and fruiting issues of introduced trees and shrubs have been studied by many authors [3, 5, 14] .

According to these authors, the completion of the complete cycle of development during the vegetation period of newly introduced plants in *ex situ* conditions means the successful adaptation of the introducers.

A comparative study of the rhythm of development in the area where the introducers were introduced and where they naturally grow allows to understand in which direction the exotic is adapted to the new conditions, at the same time to reveal the reasons for the lack of adaptation and to find ways to increase the reproductive activity [7-8, 10, 12-13] .

Flowering and fruiting characteristics of the dendroflora of the northeastern part of the Greater Caucasus (Azerbaijan) in *ex situ* and *in situ* conditions have not been comparatively studied. In order to study such issues, by us were carried out scientific-research works, studied the flowering phase, fruiting and seed production of tree and shrub species distributed in the north-eastern part of the Greater Caucasus *in ex situ* and *in situ* conditions.

Materials and methods

The research material was 26 species (Acer campestre L., A.laetum C.A.Mey., Berberis vulgaris L., Carpinus orientalis Mill., Cotinus coggygria Scop., Cotoneaster melanocarpus Fisch. ex Blytt, Cydonia oblonga Mill., Euonymus europaea L., Lonicera caprifolium L., L.iberica Bieb., L.xylosteum L., Mespilus germanica L., Pistacia mutica Fisch. et Mey; Pterocarya pterocarpa (Michx.) Kunth ex I.Iljinsk., Pyracantha coccinea (L.) M.Roem., Sorbus torminalis (L.) Grantz, Viburnum lantana L., V. opulus L. Ulmus carpinifolia Rupp. ex Suckow Carpinus betulus L. Cornus mas L., Salix caprea L Ligustrum vulgare L., Punica granatum L., Tilia begoniifolia Stev., T.cordata Mill.)of woody plants belonging to 14 families and 19 genera. The experiments were carried out in the conditions of Absheron (Central Botanical

Garden) on old (old) and newly introduced trees and shrubs growing naturally in the northeastern part of the Greater Caucasus.

The flowering and fruiting biology of the thos species was studied according to the methodology of G.G. Kaper [9], but phenological observations to the methodology Zaitsev G.N [16].

Results and their dıscussion

The results of the phenological observations showed that *Cornus mas* (10,03), *Ulmus carpinifolia* (13.03), *Salix caprea* (14.03), and *Carpinus betulus* (25.03) were the fastest(March) blooming among the research plants.

Among the new introduced species during the research period, it was observed that the 5-year-old *Lonicera xylosteum L*. entered the first flowering phase. The first flowering was solitary.

İn most of the studied plants flowering occurred after leafing. İn the species Ulmus carpinifolia Rupp. ex Suckow, Cornus mas L. first are formed the flowering then the leaves. In species of Carpinus betulus L. the flower and leaf bud opened simultaneously.

The trees and shrubs studied during the research were divided into several groups according to the beginning and end of flowering:

1. Those start flowering early and finish early (EE) (13.03-30.03)-*Ulmus carpinifolia* Rupp. ex Suckow;

2. Those who start flowering early and finish in the middle period (EM) (10.03-15.04)- *Carpinus betulus* L. *Cornus mas* L., *Salix caprea* L.;

3. Flowering starts in the middle period and ends in the middle period (MM) (10.04-20.05)-*Acer campestre* L., *A.laetum* C.A.Mey., *Berberis vulgaris* L., *Carpinus orientalis* Mill., *Cotinus coggygria* Scop., *Cotoneaster melanocarpus* Fisch. ex Blytt, *Cydonia oblonga* Mill., *Euonymus europaea* L., *Lonicera caprifolium* L., *L.iberica* Bieb., *L.xylosteum* L., *Mespilus germanica* L., *Pistacia mutica* Fisch. et Mey; *Pterocarya pterocarpa* (Michx.) Kunth ex I.Iljinsk., *Pyracantha coccinea* (L.) M.Roem., *Sorbus torminalis* (L.) Grantz, *Viburnum lantana* L., *V. opulus* L.

4. Those start blooming late and finish late (LL) (22.05.-01.08)- *Ligustrum vu*lgare L., *Punica granatum* L., *Tilia begoniifolia* Stev., *T.cordata* Mill.

Most of the studied species were included in the group that begins flowering in the middle period and ends in the middle period (MM).The duration of flowering in these plant species varied from 10 to 32 days.

Ulmus carpinifolia among the studied species in the dry subtropical climate of Absheron, belonged to the group of EE. In this species, the duration of flowering in *ex situ* conditions was 17 days, and *in situ* conditions 18 days. In *Ulmus carpinifolia*, fruit formed shortly after flowering, ripening in late April and early May.

Species Ligustrum vulgare, Punica granatum, Tilia begoniifolia, T.cordata belonged to the group of LL (table 1.). Late entry into the flowering phase depended on the biological characteristics of the studied species as well as the temperature conditions during the flowering period.

Table 1. Flowering of some tree and shrub plants spread in the northeastern part of the Greater Caucasus under conditions of *ex situ* and *in situ*

№	*Spacies*	*ex situ*				*in situ*			
		Flowering			The life of a flower (day)	Flowering			The life of a flower (day)
		Star-ting	Ending	Duration of continua-tion		Starting	Ending	Duration of continua-tion	
1	2	3	4	5	6	7	8	9	10
1.	*Acer campestre*	23.04	13.05	20	10-12	25.04	18.05	23	11-12
2.	*A. laetum*	22.04	12.05	20	10-12	24.04	15.05	21	11-12
3.	*Berberis vulgaris*	2.05	12.05	10	6-8	9.05	21.05	12	8-10
4.	*Carpinus betulus*	25.03	13.04	18	10-12	10.04	26.04	16	11-12
5.	*C.orientalis*	4.04	23.04	19	10-12	19.04	6.04	17	11-13
6.	*Cornus mas*	10.03	7.04	28	14-16	16.03	10.04	25	15-16
7.	*Cotinus coggygria*	8.05	18.05	10	8-11	14.05	25.05	11	10.12
8.	*Cotoneaster melanocarpus*	28.04	10.05	12	9-10	5.05	18.05	13	10-11
9.	*Cydonia oblonga*	29.04	12.05	13	9-10	4.05	15.05	11	10-12
10.	*Euonymus europaea*	6.05	16.05	10	7-8	13.05	24.05	11	8-9
11.	*Ligustum vulgare*	23.05	10.06	18	10-12	6.06	27.06	21	12-14
12.	*Lonicera caprifolium*	14.04	16.05	32	14-16	23.04	23.05	30	15-16
13.	*L.iberica*	11.05	23.05	12	8-9	19.05	1.06	13	9-10
14.	*L.xylosteum*	9.05	22.05	13	12-14	14.05	29.05	15	13-14
15.	*Mespilus germanica*	2.05	13.05	11	10-11	12.05	25.05	13	10-12
16.	*Pistacia mutica*	20.04	6.05	16	6-11	25.04	10.05	15	5-12
17.	*Pterocarya pterocarpa*	19.04	6.05	17	9-11	27.04	15.05	18	10-12

The longevity of flowers and groups of flowers of the studied trees and shrubs in *ex situ* conditions was 14-16 days, and 15-16 days in *in situ*.

The results of the conducted phenological observations showed that a direct correlation between the duration of the flowering phase and the life of a flower was not observed. Thus, while the duration of flowering in *Punica granatum* is 64 days, the life of one flower varies from 8 to 12 days (table 1).

Table 1. (continued)

1	2	3	4	5	6	7	8	9	10
18.	*Punica granatum*	27.05	30.07	64	8-12	2.06	1.08	60	10-12
19.	*Pyracantha coccinea*	16.05	31.05	15	8-12	25.05	9.06	15	11-13
20.	*Salix caprea*	14.03	2.04	19	10-12	19.03	9.04	21	11-12
21.	*Sorbus torminalis*	8.05	21.05	13	6-8	16.05	30.05	14	8-10
22.	*Tilia begoniifolia*	7.06	17.06	10	8-9	14.06	25.06	11	9-10
23.	*T.cordata*	4.06	16.06	12	8-9	12.06	24.06	12	9-10
24.	*Viburnum lantana*	25.04	8.05	13	8-10	7.05	22.05	15	9-11
25.	*V.opulus*	2.05	17.05	15	8-10	12.05	29.05	17	10.12
26.	*Ulmus carpinifolia*	13.03	30.03	17	10-12	15.03	2.04	18	10-13

According to the analysis of the obtained results, it can be noted that the life of the flower does not have any dependence on the duration of flowering.This situation can be attributed to the individual biological characteristics of each plant species.

When comparing the characteristics of flowering and fruiting of the studied plants in the *ex situ* and *in situ* conditions, there was not observed difference between the duration of flowering and flower life between plants in both conditions.

It was noticed that the duration of flowering in plants growing in *ex situ* conditions is 1-6 days longer than in plants *in situ* conditions. This mainly depended on climatic factors and temperature.

İn the conducted study the number of opened flowers as calculated and compared both *in situ* and *ex situ* conditions. It was determined that this number was higher in plants in the *in situ* conditions. Depending on the bioecological characteristics of the studied plants, it was determined that the preservation of the fruits formed in ex situ conditions varied between 1.8-64% and in situ conditions between 3.1-68.6%(table 2).

Table 2. Fruit formation of the studied trees and shrubs in *ex situ* and *in situ* conditions

№	Spacies	Number of flowers on the plant	The number of fruits		Fruit ripening time	Number of flowers on the plant	The number of fruits		Fruit ripening time
			un	%			un	%	
		ex situ				*in situ*			
1.	*Acer campestre*	26625	15840	59,5	25.09	27812	16951	61	26.10
2.	*A. laetum*	25536	14550	57	18.10	26072	15718	60	22.10
3.	*Berberis vulgaris*	248	75	30	22.09	1458	467	32	26.09
4.	*Carpinus betulus*	18025	11556	64	25.09	21716	14896	68,6	28.09
5.	*C.orientalis*	8789	3465	39,4	6.10	10136	4145	40,9	10.10
6.	*Cornus mas*	655	45	6,3	12.09	802	78	9,7	15.09
7.	*Cotinus coggygria*	12936	232	1,8	19.09	13178	467	3,5	25.09
8.	*Cotoneaster melanocarpus*	1310	652	49,8	16.09	1485	726	48,9	20.09
9.	*Cydonia oblonga*	296	53	17,6	6.12	401	89	22.2	10.12
10.	*Euonymus europaea*	1356	67	4,9	20.10	1879	91	4,8	23.10
11.	*Lonicera caprifolium*	972	207	21,3	18.08	1149	305	26,5	24.08
12.	*L.iberica*	860	292	34	26.10	1012	411	40,6	30.10
13.	*L.xylosteum*	4625	713	15	20.10	5128	935	18	25.10
14.	*Mespilus germanica*	387	194	50	30.11	564	310	55	2.12
15.	*Pistacia mutica*	2585	470	18	30.08	3135	726	23,2	6.09
16.	*Punica granatum*	1172	121	10	27.11	1367	214	15,7	5.12
17.	*Pyracantha coccinea*	2257	1236	54,8	12.09	2292	1302	56,8	18.09
18.	*Sorbus torminalis*	945	215	22,8	5.10	1248	371	29,7	10.10
19.	*Tilia begoniifolia*	440	165	37,5	6.09	11879	4570	38,5	7.09
20.	*T.cordata*	2860	997	34,9	10.09	5462	2018	36,9	11.09
21.	*Viburnum lantana*	1840	124	6,7	7.09	2916	244	8,4	15.09
22.	*V.opulus*	2625	64	2,4	12.09	5937	978	16.5	17.09

Among these plants, the highest fruit storage capacity were found in the species *Carpinus betulus* (64-68,6%), *Acer campestre* (59,5-61%), the least in the species *Cotinus coggygria* (1,8-3,5%), *Viburnum opulus* L. (2,4-16,5%) (table 2).

Flowering and fruiting characteristics of the studied plants in the conditions in *ex situ* compared to *in situ* the lowest indicators were in the species *Viburnum opulus* and the highest in *Carpinus betulus*.

Plants under natural conditions depending on the species had 5-10% higher fruit storage capacity compared to cultivated conditions. Natural conditions have more favorable environmental factors for normal flowering and fruiting of plants. Since the studied plants grow naturally in the northeastern regions of the Greater Caucasus, the climate of the Absheron peninsula, where they were introduced, makes a difference between these regions. As a result of this differences in flowering and fruiting phases in the studied tree and shrub plants can be considered as a normal situation.

According to fruit ripening, the plants studied in ex situ and in situ conditions can be divided into 3 groups:

1. Fruits that ripen early (May)-*Ulmus carpinifolia*;

2. Those fruits ripen in the middle period (September-October) – *Acer campestre, A.laetum, Carpinus betulus, C.orientalis, Cornus mas Cotoneaster melanocarpus, Lonicera caprifolium, L.iberica, L.xylosteum, Pistacia mutica, Pterocarya pterocarpa, Pyracantha coccinea, Tilia begoniifolia, T.cordata, Viburnum lantana, V.opulus.*

3. Those fruits ripen late (November-December)-*Cydonia oblonga, Mespilus germanica, Punica granatum.*

When comparing the fruiting characteristics of plants under cultivated and natural growing conditions, it was determined that under in situ conditions, depending on the relief spead of plant the ripening of the fruit is delayed by 10-15 days. Determining the time of fruit ripening of trees and shrubs have both scientific and great practical importance in greening fields in introduction works.

As a result of the phenological observations made during the study, it was found that the average period between fruit set and their ripening in trees and shrubs studied in ex situ conditions varies between 120-130 days.

Conclusion

While studying the characteristics of flowering and fruiting of the studied plants in both ex situ and in situ conditions, it was found that the tree and shrub plants spread in the north-eastern part of the Greater Caucasus bloom and bear fruit normally in both conditions (cultivated and natural). Taking into account the normal flowering and fruiting characteristics of these naturally growing plants, it is possible to preserve the gene pool in ex situ conditions and use them in greening works.

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Received: June 9, 2024; Published: June 27, 2024