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INTRODUCTION AND COMPARATIVE CHARACTERISTIC OF *MALUS SIEVERSII* VARIETY CLONES OF THE DZHUNGARIAN POPULATION

Malus sieversii is a mountain-steppe and valley tree species widespread in the mountains of southeast Kazakhstan. The aim of this work is to study the structure of variability and intraspecific differentiation of Malus sieversii (Ledeb.) M. Roem. based on a complex of morphological features of generative organs and the characteristics of the seasonal rhythm of apple trees in natural and introduction conditions. Malus sieversii is a mountain-steppe and valley tree species widespread in the mountains of southeast Kazakhstan. The introduction collection of Malus sieversii's forms growing in the Main Botanical Garden of Almaty (GBS) is a source of global genetic resources. According to the research data, the intraspecific variability of the studied apple tree forms was characterized by heterogeneous morphometric parameters of the generative organs. The studied apple trees are distinguished by heterogeneous morphometric parameters. Large-flowered forms were observed both in natural populations and in GBS. In the conditions of the Dzungarian Alatau, the large sizes of flowers were characteristic of the forms in the gorges of Pikhtovaya and Mushabay. Among the variety clones the sample TP-19 selected in the Pikhtovaya distinguished itself by the large size of the corollas.

Kew words: flowering of the apple tree, flowering period, generative organs, Malus sieversii forms.

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Жоңғар популяциясының Сиверс алмасының сорт-клондарының жерсіндірілген және салыстырмалы сипаттамасы

Сиверс алма ағашы – Қазақстанның оңтүстік-шығысындағы тауларда кең таралған ағаштың таулы-дала және алқаптық түрі. Жабайы алма ормандарының табиғи (in-situ) ареалдарының тозуы, сондай-ақ табиғи популяцияларының қайта қалпына келуінің төмен болуы жағдайында Сиверс алмасының жерсіндірілген коллекциясы әлемдік маңызы бар генетикалық ресурстардың көзі болып табылады. Бұл жұмыстың мақсаты – табиғи және интродукция жағдайында Malus sieversii (Ledeb.) M. Roem түрінің өзгергіштік құрылымын және түрішілік дифференциациясын алманың генеративті мүшелерінің морфологиялық ерекшеліктері мен маусымдық ырғағы негізінде зерттеу. Сиверс алма ағашы (Malus Sieversii (Ledeb.) Roem.) – Қазақстанның оңтүстік-шығыс тауларында кең таралған таулы-дала белдеуінде және алқаптарда өсетін ағаштар. Алматы қаласының Бас Ботаникалық бағындағы Сиверс алмасының жерсіндірілген коллекциясы әлемдік генетикалық ресурстардың көзі болып табылады. Зерттеу нәтижесі бойынша зерттелген алма ағашы формаларының түрішілік өзгергіштігі генеративті мүшелердің гетерогенді морфометриялық параметрлерімен ерекшеленді. Ірі гүлді формалар табиғи популяцияларда да, GBS-де де байқалды. Жоңғар Алатауы жағдайында Пихтовая және Мушабай шатқалдарындағы формаларға үлкен гүл өлшемдері тән болды. Жерсіндірілген коллекцияда Пихтовая шатқалынан іріктелген ТП-19 сорт-клонының күлте жапырақтары үлкен өлшемдерімен ерекшеленді.

Түйін сөздер: Malus sieversii формалары, генеративті мүшелері, гүлдеу кезеңі, алманың гүлдері, сорт-клон.

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Интродукционная и сравнительная характеристика сорт-клонов яблони Сиверса джунгарской популяции

Яблоня Сиверса – горно-степной и долинный вид дерева, широко распространенный в горах юго-востока Казахстана. В условиях деградирования естественных ареалов (in-situ) диких яблоневых лесов, а также низкого возобновления в природе, интродукционная коллекция яблони Сиверса является источником генетических ресурсов, имеющих мировое значение. Цель данной работы – изучение структуры изменчивости и внутривидовой дифференциации Malus sieversii (Ledeb.) M. Roem. на основе комплекса морфологических признаков генеративных органов и особенностей сезонной ритмики деревьев яблони в природных и интродукционных условиях. Яблоня Сиверса (Malus Sieversii (Ledeb.) Roem.) – горно-степной и долинный вид дерева, широко распространенный в горах юго-востока Казахстана. Интродукционная коллекция форм яблони Сиверса, произрастающей в главном ботаническом саду г. Алматы, является источником генетических ресурсов, имеющих мировое значение. Согласно данным исследования, внутривидовая изменчивость изученных форм яблони характеризовалась неоднородными морфометрическими показателями генеративных органов. Крупноцветковые формы наблюдались как в природных популяциях, так и в ГБС. В условиях Джунгарского Алатау крупные размеры цветков были свойственны формам в ущельях Пихтовая и Мушабай. Из сорт-клонов отличился крупными размерами венчиков ТП-19, отобранный в Пихтовой.

Ключевые слова: формы Malus sieversii, генеративные органы, период цветения, цветки яблони, сорт-клон.

Introduction

There are several traditional ways to preserve phytocenotic diversity: – protecting the species and populations in natural conditions by growing them in reserves and national parks; – conservation in cultural conditions by perfecting the propagation methods, creating the introductive populations as well as widespread introduction into landscaping or production. An important direction of preservation of general phyto-diversity, rare and economically valuable plant species is their artificial reservation by cultivation in botanical gardens [1; 2].

In Almaty in the Main botanical garden (MBG) as well as in the laboratory for the protection of the gene pool and the introduction of wild fruit plants named after A. Dzhangaliyev has got a collection of wild fruit plants of Kazakhstan (more than 1000 specimens) including the unique *Malus sieversii* gene pool [3].

Malus sieversii is a mountain-steppe and valley tree species widespread in the mountains of south-east Kazakhstan. In natural conditions it is a large tree up to 14 m high with a wide spreading crown. Flowers are in umbrella-shaped inflorescences by 3-7, pinkish or pink, 5-11 cm in diameter; a calyx is grey and pubescent; hypanthia and pedicels are thick and pubescent [4; 5]. *Malus sieversii* blossoms in the middle of May and bears fruit in August-September.

A unique (*ex-situ*) introductive collection created by Academician A. Dzhangaliyev gave rise to the gene pool preservation of wild *Malus sieversii* in cultivated conditions and the allocation of promising forms for various practical purposes according to the results of introduction [6].

In conditions of degradation of natural habitats (*in-situ*) of wild apple forests, as well as their low regeneration in nature, the collection *Malus sieversii* is a source of genetic resources of global importance [7-13].

The study of wild-fruit apple tree includes the followings: – expeditionary and introductive surveys with the selection of the most valuable wild forms and their subsequent placement in collections in the territory of the MBG; – identification of some laws of their development; – determination of morphological parameters of flowering of individual trees and the most valuable forms of apple trees by ecological and morphological features. Agrotechnical measures in the introduction garden satisfy to requirements and recommendations of agrotechnical care for gardens [14-16].

The purpose of this work is to study the structure of variability and intraspecific differentiation of *Malus sieversii* based on a complex of morphologi-

cal features of generative organs and features of seasonal rhythm of the trees in natural and introductive conditions.

Objects and methods of investigation

The objects of our research are new apple variety-clones of the Dzungarian population (variety clones TM-1, TM-2, TM-5, TM-7, TM-8, TM-9 were selected in the Mushabay gorge; variety-clones TP-19 – TP-25 were selected in the Pikhtovoye gorge) and forms currently growing in the gorges Pikhtovaya (FP), Mushabay (FM) and Krutoye (FK) of the Dzungarian Alatau.

The studied plants have been of artificial (variety clones) and natural origin (seed, shootings). The location of the trees in natural populations has been marked by a GPS navigator (Table 1). Phenological phases of development and morphological features of generative organs were also investigated.

Table 1 – Characteristics of the sampling site of Malus sieversii

Populations	Location	Altitude of explored location, m above the sea level	Geographical coordinates
Introduction collection MBG	The Main Botanical Garden of Almaty	877-892	N43°13′12″ E76°54′54″
Forms of a wild apple tree in the Pikhtovaya gorge, Dzhungarskiy Alatau	Along the Mushabay water divide on the left bank of the river of Terekty	1124-1140	N45°24′01.3″ E80°23′17.0″– N45°24′13.4″ E80°23′46.9″
Forms of a wild apple tree in the Mushabay gorge, Dzungar Alatau	Along the Mushabay water divide between the rivers of Soldatskaya and Pikhtovaya	1131-1149	N45°23′56.0″ E80°23′14.1″– 45°24′47.9″ E80°23′13.0″
Forms of a wild apple tree in the Mushabay gorge, Dzungar Alatau	South of the Zhunzhurek settlement on the right bank of the Lepsa river	1488-1512	N45°33′21.8″ E80°43′48.5″– N45°33′22.4″ E80°44′02.4″

Conventional techniques were used during the research implementation [17; 18; 19]. Statistics data were calculated for each parameter [20; 21]. Mathematical analysis of the results was carried out using Microsoft Excel software.

Collection of morphometric characteristics of the features of each sample was carried out in the field conditions using a vernier caliper with an accuracy of 1 mm during the 2017-2019 period.

Results and discussion

Depending on the research conditions the date of the developmental phases and their duration differed for different forms of *Malus sieversii*.

While early spring the vegetation can begin in the middle of March; while late spring it can start in the middle of April. So, during the years of research, the beginning of vegetation in most forms under MBG conditions was noted at the end of March when the daytime air temperature rose above + 12ºC. Under *in-situ* conditions, it usually started at the end of April, in some years at the first decade of May.

Generative buds in apple tree start blooming simultaneously with vegetative ones.

Apple flowering in the botanical garden begins in early April, in some years at the end of the month. The earliest is the variety clone TP-23, the latest are the variety-clones TM-1 and TM-9. The duration of the period from budding to flowering is 10-12 days. Flowering lasts an average of 7-10 days depending on air temperature. With temperature increasing the flowering period decreases.

For comparative analysis the phenophases of *Malus sieversii* forms under natural conditions were also studied. So, it was noted the later flowering of the apple tree in the gorges of the Dzungarian Alatau.

Malus sieversii flowering in natural conditions began in early May, in the southern expositions and in the expositions with a sufficient level of solar insolation; at the end of the first decade of May it started in the northern expositions.

As the height of the tree growth site increases, flowering began for 2 days later per every 100 m above the sea level.

According to data of A.D. Dzhangaliyev, the temperature of the environment is one of the main factors affecting the dates of beginning and duration of inter phases periods of the apple tree [5]. The vegetation period of *Malus sieversii* in natural conditions is shorter than the vegetation period of trees growing in MBG. It can be explained by the adaptation of plants to mountain environmental conditions.

Generative organs of woody plant species, as it is known, are less dependent on environmental factors [22; 23]. The flower is less subjected to environmental changes compared to vegetative organs of the plant. During the flowering period, the apple tree has the most decorative qualities, which are formed from the features of the flower structure [24; 25].

Morphometric characteristics of the flowers of variety clones in the collection plot and selective forms of wild apple trees in natural conditions are presented in Table 2.

The mean arithmetic (M) and its error were determined, as well as the coefficient of variation (CV, %) was also determined. Almost all the studied parameters of the flowers varied.

According to Table 2, intraspecific variability of studied apple forms was characterized by heterogeneous morphometric indices of generative organs.

The coefficient of variation of the corolla values of flowers in different forms ranged from 10 to 20%; the values of the diameter of the flowers and the length of the petals varied within the "upper" norm (39 and 19%); the length of the pestles and stamens of the flowers varied within the "lower" norm (8 and 10%, respectively).

Note: these tables contain data of the forms of the Dzungarian population selected according to their economically valuable features for replenishment and fixation in the introduction collection.

In the natural population, the forms differed from the variety clones in the MBG collection by large flowers. Large-flowered forms were observed in the Pikhtovaya population. The maximum diameter of the flowering corollas was noted in the forms FP-15 and FP-16. Among the variety clones the TM-19 sample selected in the Mushabay gorge distinguished itself by the large sizes of the corollas. Also, the large sizes of the flowers were characteristic of natural forms in the gorge Mushabay. (FM-20, FM-21).

Under GBG conditions, the maximum diameter of the corollas was observed in the variety clone TM-9 (max 50.11 mm) selected in the Mushabay gorge.

The minimum flower size was noted in variety clones TP-22 and TM-7 (22.7 mm and 24.3 mm, respectively). The average width of the corollas of flowers in variety clones of Malus sieversii was 11.83 ± 0.5 mm, while the width of the corolla petals from natural populations was on average 14.72 ± 0.58.

The maximum length of the stamens was noted in the forms FK-28 and FP-14 (20.4 and 9.8 mm), under MBG conditions these were variety clones TM-1 and TM-8 (9.8 and 9.7 mm); the minimum values were in the forms FP-16, FK-25 (7.2 and 7.4 mm) from the gorges Pikhtovoye and Krutoye and the variety clones TP-20 and TP-24 (7.2 mm each) from the MBG.

The maximum pestle length was noted in the forms FK-28 and FK-24 (16.4 and 12.6 mm) from the Krutoye gorge and in the variety clones TM-9, TM-1 (10.4 and 10.2 mm) selected in the Mushabay gorge; minimum dimensions were in the forms FM-23 and FP-15 (6.9 and 7.6 mm) from the Mushabay and the Pikhtovoye gorges, and the variety clone TP-25 (7.5 mm) under MBG.

The values of the calculated average values by the diameter of the corolla were closest to the form FK-24 and variety clone TM-1; by the length of the petal – to the form FK-27 and variety clone TM-1; by the width of the petal – to the form FP-15 and variety clone TM-7; by the length of the stamens – to the form FM-23 and variety clone TM-7; by the length of the pestle – to the form FM-20 and variety clone TP-21.

It can be noted that the observed diversity of the morphological parameters of flowers suggests the seed origin of the trees in the studied population (or populations) of the Mushabay and the Pikhtovoye; while in the gorge Krutoye the flowers of apple inflorescences were smaller and had a lower level of variability due to a significant altitude above sea level, indicating that vegetative (shootings) reproduction prevailed in this population.

Observations of the flowering of variety clones in MBG and the forms in the natural population showed that flowers also varied in quality (corolla color, margins and type of petal attachment) (Table 3). Analysis of the table 3 demonstrated that in the gorges of Pikhtovoye and Mushabay the corollas of flowers of the researched forms were painted in white and pink colour.

The materials reviewed indicated that in the gorge Pikhtovoye of the Dzungarian Alatau flowers are large and the forms of apple trees in flowering are more decorative.

Table 2 – Morphometric characteristics of the flowers of the Sievers apple tree

№	Clone variety, apple tree forms	Average diameter of the corollas, мм	C_v, %	Average length of the petal, мм	C_v, %	average width of the petal, мм	C_v, %	Average length of the pestles, мм	Average length of the stamens, мм
1	2	3	4	5	6	7	8	9	10
Introduction collection MBG, Almaty									
1.	ТМ-1	32,0±0,16	1,16	16,9±0,23	2,6	11,1±0,23	2,58	9,8±0,1	10,2±0,20
2.	ТМ-2	39,4±0,19	1,16	17,5±0,72	3,96	13,3±0,67	2,19	7,6±0,21	7,60±0,18
3.	ТМ-5	24,9±0,09	0,92	13,0±0,33	1,8	12,1±0,26	2,55	7,6±0,21	7,97±0,25
4.	ТМ-7	24,3±0,20	1,98	12,2±0,35	2,55	12,1±0,35	2,62	7,4±0,15	7,60±0,17
5.	ТМ-8	26,0±0,33	3,14	14,0±0,7	3,07	9,8±0,34	2,65	9,7±0,14	9,2±0,24
6.	ТМ-9	50,11±0,62	3,06	25,01±0,19	1,20	16,2±0,84	4,30	9,7±0,14	10,4±0,14
7.	ТП-19	41,0±0,58	3,45	22,2±0,31	1,85	14,2±0,09	3,50	9,00±0,24	9,6±0,15
8.	ТП-20	37,3±0,71	4,68	16,3±0,26	3,08	11,4±0,30	2,67	7,2±0,24	7,60±0,15
9.	ТП-21	39,0±0,77	4,01	18,1±0,19	1,45	15,3±0,4	3,00	8,8±0,19	8,60±0,17
10.	ТП-22	22,7±0,26	3,08	11,1±0,17	2,02	9,2±0,23	2,58	7,6±0,21	7,60±0,15
11.	ТП-23	38,3±0,37	2,59	19,0±0,2	2,9	10,9±0,18	2,50	8,8±0,19	9,0±1,15
12.	ТП-24	28,14±0,37	2,57	14,02±0,15	2,76	13,5±0,8	4,71	7,2±0,24	7,60±0,15
13.	ТП-25	29,12±0,35	2,55	14,8±0,60	9,6	13,8±0,5	3,82	7,6±0,21	7,50±0,15
Average		**33,25±2,2**		**16,47±1,06**		**11,83±0,5**		**8,31±0,27**	
“Mushabay” gorge, Dzungarian Alatau									
14.	ФМ19	43,00±0,3	1,76	21,0±0,29	2,44	16,0±0,29	4,72	8,8±0,19	11,6±0,21
15.	ФМ20	44,4±0,21	1,49	19,2±0,39	6,51	17,7±0,14	4,54	9,7±0,14	11,2±0,24
16.	ФМ21	44,6±0,15	1,10	19,3±0,28	4,66	18,9±0,26	4,40	9,7±0,14	9,6±0,15
17.	ФМ22	42,7±0,38	2,78	15,1±0,59	12,4	11,5±0,16	4,35	7,4±0,21	10,30±0,3
18.	ФМ23	42,0±0,35	2,61	**17,4±0,29**	**5,27**	16,6±0,43	8,17	9,2±0,24	6,9±0,22

Continuation of table 2

№	Clone variety, apple tree forms	Average diameter of the corollas, мм	C_v, %	Average length of the petal, мм	C_v, %	average width of the petal, мм	C_v, %	Average length of the pestles, мм	Average length of the stamens, мм
1	2	3	4	5	6	7	8	9	10
“Pikhtovaya” gorge, Dzungarian Alatau									
19.	ФП-14	32,0±0,75	3,98	17,6±0,22	2,17	12,4±0,22	3,40	9,8±0,18	9,80±0,22
20.	**ФП-15**	**44,7**±0,23	1,48	21,86±0,24	2,92	15,0±0,37	6,66	7,6±0,22	7,60±0,22
21.	**ФП-16**	**51,4**±0,35	1,93	20,14±0,24	3,17	17,0±0,68	12,7	7,2±0,24	9,6±0,21
22.	ФП-17	34,6±0,19	1,11	15,12±0,84	11,1	12,43±0,2	2,69	9,6±0,15	9,5±0,16
23.	ФП-18	30,86±1,0	6,47	14,14±0,6	1,48	13,6±0,73	9,79	7,6±0,21	10,3±0,25
“Krutoe” gorge, Dzungarian Alatau									
24.	ФК24	40,2±0,19	1,49	17,5±0,16	2,86	12,5±0,16	4,00	9,0±0,24	12,6±0,15
25.	ФК25	34,7±0,14	1,32	17,6±0,15	2,78	16,3±0,32	6,17	7,4±0,15	7,60±0,15
26.	ФК26	31,0±0,55	5,59	17,8±0,53	9,33	11,3±0,28	7,78	9,50±0,16	9,50±0,16
27.	ФК27	42,1±0,35	2,62	18,0±0,60	10,1	12,2±0,18	3,80	8,6±0,2	8,80±0,15
28.	ФК28	35,3±0,20	1,81	20,4±0,15	2,40	16,5±0,16	3,03	20,4±0,15	16,4±0,15
29.	ФК29	34,7±0,14	1,32	17,6±0,15	2,78	16,3±0,32	6,17	7,40±0,15	7,60±0,15
30.	ФК30	40,2±0,19	1,49	17,5±0,16	2,86	12,5±0,16	4,00	9,00±0,24	12,6±0,15
Average		**39,32±1,37**		**18,07±0,49**		**14,63±0,57**		**9,29±0,71**	**10,86±0,44**

Table 3 – Qualitative traits of wild apple forms' flowers depending on populations

Populations	Corolla coloring			The edges of the petals			Petal attachment type	
	number of forms	White-pink, %	White, %	Smooth	Medium wavy, %	Strongly wavy, %	On a short claw, %	On a long claw, %
GBS	13	61,54	38,46	8,5	59,4	32,1	84,4	15,6
Pikhtovoye	30	74,3	25,7	6,7	64,7	28,6	62,9	37,1
Mushaabay	30	53,84	41,16	15,3	60,5	24,2	89,5	10,5
Krutoe	40	16,52	83,48	28,7	44,2	27,1	22,6	77,4

Thus, the materials reviewed indicated that the parameters of the apple flowers were in close connection with the origin of the population, as well as the absolute height of the tree plot.

Conclusion

The morphological characteristics of the generative organs of apple trees varied significantly by years. In the years with early spring the vegetation could begin in the middle of March; with belated spring it could start in the middle of April. So, during the years of research, the phase of vegetation occurred in March, when the air temperature rises above +12ºC. The end of the vegetation period (yellowing the leaves) for wild apple trees was noted at the beginning of the third decade of September. In 2020, despite the protracted autumn and air temperature of + 20ºC, the complete fall of leaves and the end of the growing season for studied trees were marked at the end of October.

A comparative morphological analysis of flowers allowed us to reveal the intraspecific variability of the *Malus sieversii*. The studied trees of *Malus sieversii* were distinguished by heterogeneous morphometric parameters. Large-flowered forms were observed both in natural populations and in MBS. In the conditions of the Dzungarian Alatau, the large sizes of flowers were characteristic of the forms in the gorges of Pikhtovaya and Mushabay. Among the variety clones the sample TP-19 selected in the Pikhtovaya distinguished itself by the large size of the corollas.

The average width of the corollas of flowers in variety clones of Malus sieversii was 11.83 ± 0.5 mm, while the width of the corolla petals from natural populations was on average 14.72 ± 0.58 mm. The smallest morphometric values of flower corollas were set for the variety clone TP-22. During flowering the most decorative were the variety clones with larger flowers: TM-9 and TP-19. In the gorge Krutoye the apple flowers were smaller and had a low level of variability, indicating that vegetative (shootings) reproduction prevailed in this population.

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