

The pome fruit (*Malinae* Rev.) collections of the National dendrological park “Sofiyivka” of NAS of Ukraine

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Abstract. The plant collections of the NDP “Sofiyivka” of NAS of Ukraine including accessions of the subtribe *Malinae* Rev., formerly the subfamily *Maloideae* C. Weber (*Rosaceae* Juss.), are the objects for research in the field of plant introduction and phytodiversity protection. Because of the significant number of park's holiday-makers, which are not always careful about plants, the posttraumatic regenerative ability of plants is of particular importance for adaptation and periods of the highest regenerative activity could be favourable for vegetative reproduction, including microcloning. Thus, *Malinae* of the "Sofiyivka" might be useful for germplasm conservation and utilization in the breeding programs.

1 Introduction

The National dendrological park “Sofiyivka” of NAS of Ukraine is situated in the Central-Dnipro elevated region of Podilsk-Prydniprovsk area of the Forest-Steppe Zone of Ukraine. The area is characterized by temperate-continental climate with unstable humidification and considerable temperature fluctuations. It is quite an old park [1] that will celebrate its 225th anniversary in 2021. Import of exotic trees and shrubs and planting them in “Sofiyivka” began in the late 18th – first half of the 19th century, almost from the first days of the park’s foundation. However, it was mainly ornamental plants to please the eye of the owner and his guests, although there were also fruit and vegetable plants. Systematic import of plants for scientific research was started in 1899 under the guidance and participation of Vasyl Pashkevych, Professor of the Main School of Horticulture (now Uman National University of Horticulture). The park had been under the responsibility of the mentioned School from 1859 to 1929. A significant increase of plant collections, their study and breeding of the most promising accessions for their implementation in the park compositions began after the transfer of “Sofiyivka” to the NAS of Ukraine in 1955.

The introduced tree and shrub collections of “Sofiyivka” has been included in the National Heritage Tree and Shrub Register by order of the Cabinet of Ministers of Ukraine

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№ 73 from February 11, 2004 [2]. It is currently numbered 2130 species and infraspecific taxa. A significant proportion of these collections are plants belonging to the subtribe Malinae Rev., formerly the subfamily Maloideae C. Weber (Rosaceae Juss.). The apple (*Malus* spp.) and pear (*Pyrus* spp.) are among the essential Malinae genera. However, the popularity of some species of *Amelanchier* Medik, *Crataegus* L. and *Sorbus* L. are increasing in Ukraine. Furthermore, the scientists of “Sofiyivka” pay great attention to the preservation of biotic diversity of these plants, as well as issues belonging to landscape design and architecture, and the history of gardening. They explore the physiology, genetics and breeding of these plants both to improve their genotypes and to develop ways of their reproduction and implementation in horticulture and garden design.

The plant collections of “Sofiyivka” are the objects for research in the field of plant introduction and phytodiversity protection, and the study of the features of the reproductive biology of strange plants in *ex situ* conditions. Besides, they perform scientific, cognitive and recreational functions. As a result of the conducted research, the classification of the studied genera Malinae was updated. The phylogenetic relationships of their cultivated representatives with the wild ones have been refined, taking into account the published data on molecular biology studies [3].

2 Material and methods

The *Malus* spp. collection consists of approximately 60 species and infraspecific taxa, including 40 taxonomic units of ornamental crabapples. The *Pyrus* spp. collection covers more than 60 species and about ten intraspecific taxa, without seedlings of their breeding. Over the past decades, the quantitative composition of juneberry (*Amelanchier*), hawthorn (*Crataegus*) and mountain ash (*Sorbus*) collections has increased significantly. Herewith the *Amelanchier* collection abundance has risen to 19 accessions, mainly due to an increase in the number of species. However, in the collections of *Crataegus* (27 accessions) and *Sorbus* (38 accessions), the number of cultivars increased.

Because of the significant number of park’s holiday-makers, which are not always careful about plants, the posttraumatic regenerative ability of individual plants to restore damaged parts and also the regenerative capacity of population structures is of particular importance [4]. To estimate regeneration ability notchings (10–12 mm long, 1.5–2.0 mm wide) (Fig. 1) was made using a special cutter on one-year-old shoots of the previous year plants studied every decade from March till October. It is essential to notch into the cambium (Fig. 1a). The wounds covered with transparent scotch-tape to avoid infection and withering. The overgrowth of the wound was observed every decade with the help of a magnifying glass. A 9-point scale was used to compare results. The intensity of callus genesis was estimated at 1 point if callus formation did not occur or its surface was less than 5% of the wound (Fig. 1b). Objects with callus areas equal to 87.5–100% were estimated at 9 points (Fig. 1c). Regeneration coefficient was calculated in units of regeneration coefficient (urc) according to O. A. Opalko’s formula [4]:

$$R = \frac{S^2}{n_1 + n_2},$$

where R—regeneration coefficient, urc; S—intensity of callus genesis, points; n1—number of days after notching was made to the appearance of the first signs of callus; n2—number of days after notching was made to the completion or termination of callus development.

The regeneration calculated coefficients could be used to estimate regenerative potentials for calendar dates and development phases of the studied plant and / or population or any taxonomic unit [4, 5].

The obtained data has not only general biological significance but also could be applied for the adaptability estimation of the first and foremost introduced tree and shrub populations to the milieu of alien plant species introduction conditions. The use of ornamental plants in landscape compositions, in particular, the planning of the distance of plants from the pedestrian zone to the places of mass visit must be conducted with consideration for non-morphogenic regeneration coefficients [6]. The success of the vegetative propagation of the garden plants [7] as well as the effectiveness of the technological operations planning for garden care depends on their regenerative potentials. Since morphogenic and non-morphogenic regeneration are interrelated [5, 8].

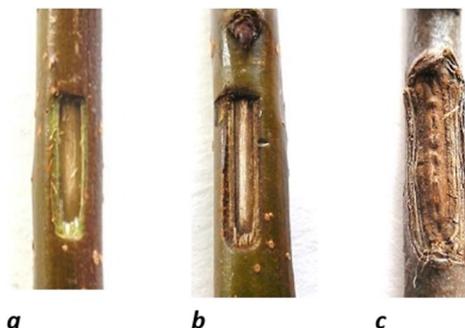


Fig. 1. Estimation of the wound overgrowing: a—wound made with manual cutter; b—the surface of callus occupies less than 5% of the wound (1 point); c—the surface of callus occupies 87.5–100% of the wound (9 points).

It is well known that stimuli of regeneration induced by natural traumatic stress are similar to irritation occurring in the process of propagation by cutting as well as in a result of any artificial injury to the plant. Such technique contributed to the prediction of the periods of highest regenerative ability for the establishment of optimal terms of micropropagation beginning (with greater or lesser approximation) [5].

3 Results and discussion

The results obtained during the experiments were combined as the average generic indicators for the studied accessions for all the years of research in order to be able to compare the regenerative potencies of different genera. The higher rates of more domesticated *Malus* spp. and *Pyrus* spp. than the closer to the wild plants *Amelanchier* spp., *Crataegus* spp. and *Sorbus* spp. were somewhat unexpected (Table 1).

The variation of the average generic indicators of regeneration coefficients of *Amelanchier* genus was similar to their dynamics in the genus *Crataegus* but in all *Crataegus* spp. the period of relative stabilization preceded the period of second rise wave of regeneration coefficients. Similar dynamics were observed in the genus *Sorbus*, but the relative decrease period of the common posttraumatic regenerative coefficient characteristic of *Amelanchier*, *Crataegus* and *Malus* was not identified. A comparison of the rates and intensity of wound growing of *Malus* and *Pyrus* genera also showed a rapid increase in regeneration coefficients in late April – early May in most species. However, in pears, the difference between regeneration coefficients of individual species was more significant. The period of its relative decline was observed only in individual species. In particular, *P. communis* in the third decade of April fell to 1.23 urc, and until the third decade of August, it remained almost at the same level (about 1.5–1.9 urc). The second wave of increase in the regeneration coefficient of this species was quite high (5.33–6.51 urc).

Table 1. Dynamics of posttraumatic regeneration coefficients of Malinae collection

Genera	Regeneration coefficients, urc/calendar date				
	regeneration rise	relative decrease	secondary increase	relative stabilization	autumn damping
<i>Amelanchier</i>	5.91–6.72/ C.04–A.05	1.98–2.75/ A.05–C.05	4.23–5.67/ B.06–B.07	3.34–4.14/ B.06–C.07	1.58–0.03/ B.09–A.10
<i>Crataegus</i>	3.52–7.39/ A.05–C.05	1.11–2.68/ A.06–A.07	5.84–6.76/ B.08	2.54–3.51/ B.07–B.08	1.33–0.01/ B.09–A.10
<i>Malus</i>	5.37–8.97/ C.04–A.05	4.25–2.33/ C.05–A.06	5.05–7.39/ B.07–C.07	4.05–4.12/ A.08–C.08	2.29–0.06/ C.09–A.10
<i>Pyrus</i>	7.42–8.36/ C.05–A.06	missing	6.84–7.76/ C.07–B.08	4.53–5.19/ A.05–B.06	2.10–0.26/ C.08–B.10
<i>Sorbus</i>	3.67–4.08/ C.04–B.05	missing	2.5–5.02/ C.07–B.08	2.18–2.27/ A.06–A.07	1.12–0.01/ B.09–C.09

Note. A—first decade; B—second decade; C—the third decade

The rhythms of seasonal development and their association with meteorological conditions of the introduction region have been defined for most species of these genera. While analyzing the dependence of indicators of regeneration coefficients variability on meteorological conditions, the tendency of higher dependence of regenerative potential on temperature fluctuations than on precipitation or hydrothermal coefficient had been warranted [9] for most species of all genera studied. In particular, the correlation coefficient of regeneration coefficients with air temperature fluctuations reached $r=0.73...0.80$ with fluctuations in years and genotypes up to $r=0.39...0.89$. It indicates a direct (increasing) linear dependence. Correlation coefficients between regeneration capacity and precipitation also showed direct linear dependence, but with low and mostly insignificant levels ($r=0.09...0.31$). The authors also studied the techniques of seed reproduction and vegetative propagation. The germination percentages of *Malus* and *Pyrus* accessions seeds-stratification were satisfactory [10]. The germination percentage of *Amelanchier* seeds was significantly lower with all methods of seed treatment. *Sorbus* seeds sprouted even worse, and the germination capacity of *Crataegus* seeds did not exceed 5-7% [11]. Plants of all genera studied are allogamous. Therefore, the seed progeny of outcrossing plants is always segregating, and cultivar desirable characteristics cannot be maintained by seed propagation. However, the new plant that grows from the scion or bud will be exactly like the plant it came from.

Consequently, methods of vegetative propagation are used for the production of valuable, expensive genotypes and rare individuals, but there are several disadvantages of asexual propagation. The most significant of them is the loss of biodiversity. Some disease can spread faster in a uniform stand. The classical method is propagation by stem cuttings, but also by stem sections, root sections, sprouts and rarely by leafy stem cuttings [7]. The root sucker’s method was an efficient way of *Amelanchier* propagation; however, the multiplication coefficient was only 2.7–5.7. Using different variants of stem cuttings in different *Amelanchier* genotypes ensured successful rooting in 1–20% cuttings; the grafting has achieved from 41.7 to 75.0% success.

The study of the various methods of *Crataegus* vegetative propagation showed complete superiority of budding (about 90% success). The percentages of *Malus* and *Pyrus* grafting and budding were sufficiently significant (more than 90% success). However, the compatibility of meristematic activity zones on an anatomical level was different, when grafting had been done by simple copulation and summer budding. In particular, in the grafting area by spring copulation method, the remains of callus were much more significant and were better fusion compared with summer budding.

It was suggested that the index of regenerative ability indirectly confirmed the level of environmental adaptation of the investigated plants. Periods of the highest regenerative activity could be favourable for vegetative reproduction, including microcloning. A result of studying the mechanism of regeneration processes *in vitro* of *Malinae* genera plants, and also possibilities of their microcloning, the protocols of micropropagation was developed. The protocol revealed beginning from the selection of explants, techniques of their introduction on nutrient mediums, proliferation, rizogenesis and their adaptation to unsterile *ex vitro* condition.

The representatives of *Malinae* are among the ornamental plants undervalued in Ukraine. They could be used in the landscape design of city green space to increase its attractiveness, and make a better quality of life and more sustainable space. The following cultivars deserve to be distributed among *Amelanchier* accessions: *A. grandiflora* Rehd. ‘Autumn Brilliance’ and *A. canadensis* (L.) Medic. ‘Prince William’, as well as species of *A. sinica* (C. K. Schneid.) Chun and *A. asiatica* (Siebold & Zucc.) Endl. ex Walp. Some cultivars are quite interesting for research, namely *Crataegus* spp. (*C. crus-galli* L., *C. monogyna* Jacq. and *C. pringlei* Sarg.), the ornamental crabapples (*M. floribunda* Sieb., *M. halliana* Koehne, *M. sieboldii* (Regel) Borkh.), cultivars of *M. ×purpurea* (‘Ola’, ‘Royalty’ and ‘Selkirk’), *M. coronaria* ‘Red Tip’, and interspecific hybrid ‘Oekonomierat Echtermeyer’. Both *Pyrus* spp. (*P. calleriana* i *P. salicifolia*) and cultivars of *Sorbus aucuparia* L. (‘Autumn Spire’ ‘Pendula’ and ‘Rubinovaja’) are promising for gardening.

4 Conclusion

According to the mentioned data, the pome fruit (*Malinae*) collections of the “Sofiyivka” park along with collections of other plants are used as objects of botanical investigations. They might be useful for germplasm conservation and utilization in the breeding programs.

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