MACLURA POMIFERA: GROWING OF PLANTING MATERIAL AND ITS USE IN THE NATIONAL ECONOMY

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The ornamental and medicinal properties of *Maclura pomifera* (habitus, beautiful foliage, fruits) make it one of the promising taxa for use in alternative medicine and landscape design [2, 5-7, 9]. It is used in various compositions in the form of single-stem plantings, hedges, and protective strips.

In European countries, the fruits of this cultivar are used to make medicines, and in folk medicine, a tincture is used to treat joint pain and rheumatism. The wood is used to make furniture, the leaves are used as food for silkworms, and the bark and roots are used to make a valuable dye [8]. As of 2020, there was virtually no demand for planting material for this valuable medicinal and ornamental plant.

Relevance. The insufficient amount of planting material of *M. pomifera (Rafin.) Scheid* in the nurseries of our country is due to the low awareness of specialists regarding effective methods of propagation of this plant and the lack of information about adaptive capabilities in the areas of its introduction.

The purpose of the work is to study agrotechnical measures for growing planting material *M. pomifera* in the conditions of the northeastern Forest-Steppe.

To achieve this goal, the following main tasks have been identified:

– to analyze the experience of growing planting material *M. pomifera* based on literary sources;

– to assess the influence of the depth of seed sowing on its soil germination;

- to consider the influence of the type of substrate on the growth and development of seedlings;

- to study the influence of hormonal compounds on laboratory seed germination;

- to consider possible options for using *M. pomifera* in the national economy.

The object of research is *M. pomifera.*

The subject of research is the technology of growing planting material of *M. pomifera.*

The Moraceae family includes 55-60 genera and 1400-1650 taxa of deciduous or evergreen trees, lianas, shrubs, annual and perennial plant organisms [17-20]. Many of its species are cultivated by humans. In Ukraine, plants of the genus Morus are grown, and in Crimea - taxa of the genera *Maclura* and *Ficus* [20]. The family is characterized by polymorphism, specialization of many organs, and the absence of clear differences from other families, which, given the large number of species, makes their classification difficult. The family includes six subfamilies: *Moreae, Ficeae, Artosagreae*, and others [13, 17-18]. The subfamily *Moreae* differs from other subfamilies in having unisexual flowers collected in panicles, catkins, and spike-like inflorescences. The subfamily includes ten genera and about 70 species of monoecious and dioecious plants with a very wide range. Representatives of the genus *Morus L.* are confined to the temperate zone [13].

The genus *Maclura* belongs to the family *Moraceae* and includes 11 taxa [17, 21].

These are trees, shrubs, and climbing plants with strongly developed axillary spines. They are widespread in the subtropical and tropical zones of Africa, America, and Asia (Fig. 1).

Figure 1. Distribution area of Maclura

They are used to create thorny hedges, in ornamental plantings (solitary and group) [11, 20], and the wood is used in carpentry and construction. In addition, yellow paint is made from the root system of *Maclura tinctoria*. At the same time, only *M. pomifera* is widely used as an ornamental and deciduous crop, and the fruit is used in alternative medicine.

Figure 2. Maclura pomifera (Raf.) Schneid

M. pomifera is a single-stemmed prickly tree up to 20 m high and up to 0.50 m in diameter (Fig. 2). The crown is ovoid, in old trees it is spreading and dense. Strongly developed root system penetrates deeply into the soil. In the first 8-10 years, it has extremely intensive growth, which slows down with age. Plants are resistant to summer droughts, as well as to low temperatures in winter down to -32,2^{0}C. The growing season is 180-195 days, and the dormant season is 170-180 days. All parts of the plant contain a milky sap [30-32].

The plant is named after the famous American cartographer, geologist and philanthropist William Maclure (1753 - 1830) [15].

Figure 3. Shoot M. pomifera

Young shoots are green, pubescent, and woody ones are bare, brown, shiny. The bark of the plants is dark (Fig. 3), brown with furrows and cracks. The branches are knee-curved, the shoots are prickly, typical for the mentioned taxon. Spines up to 24 mm long, are slightly curved, formed in the leaf axils. Buds are 1.7-2.3 mm long, scales are numerous, rounded (Fig. 3) [31].

Figure 4. Leaves of M. pomifera

The leaf surface (Fig. 4) is ovate-elongated, dark green, shiny, 8-14 cm long, and up to 7 cm wide. The leaves are entire. The arrangement is alternate. Autumn color is yellow [34].

Figure 5. Inflorescence of M. pomifera

Flowers are dioecious, small, axillary, spherical, green in color (Fig. 5). The flower has 4 stamens and 4 sepals. Stamen flowers are collected in catkins 30-40 mm long, and female flowers are collected in spherical heads (up to 30 mm in diameter) (Fig. 5). Flowering occurs in May-June. Flowering of plants occurs within 15-20 days [13]. At the same time, annual flowering and fruiting of trees has been recorded in the Crimean conditions [18].

Figure 6. Progeny of M. pomifera

The plant forms large spherical inedible fruitlets (Fig. 6) (400-600 g) with a diameter of 12-15 cm, golden-greenish in color with milky juice, covered with a sticky liquid [10, 34]. When ripe, the color changes to orange. The fruits ripen in the second half of September. Inside the fruits there is a milky juice, which is released when cut. The smell when cut resembles a fresh cucumber. The trees are especially spectacular during the fruiting period. The yield from one tree is about 60 kg of fruit.

Figure 7. Seeds

They contain up to 400 seeds (Fig. 7), stored for up to 7 months. The mass of 1000 seeds is 27.9 g, and their average number in the fruit is 120 - 150 pieces. [3-4]. It is not recommended to store seeds for more than 3 years due to a significant loss of their seeding suitability (from 90 to 10%). The optimal time for collecting seeds of *M. pomifera* in the Right Bank Forest-Steppe is the third decade of September - the first decade of October, and the optimal period for sowing it in open soil is the first decade of May.

Freshly collected seeds are used for propagation. It was found that the sowing quality of *M. pomifera* seed material and its size depend on the amount of moisture during the growing season.

Figure 8. M. pomifera sawn

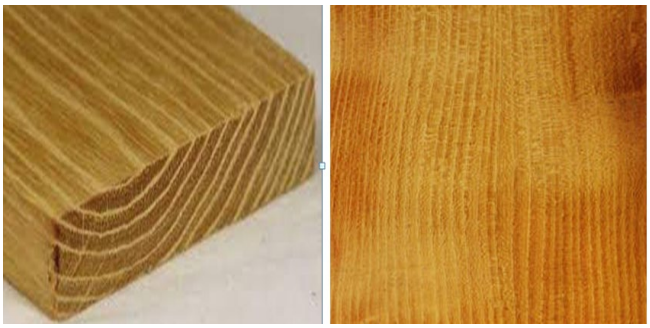

Figure 9. M. pomifera lumber

Maclura wood (Fig. 8-9) is dense, strong, and at the same time flexible and attractive in appearance [14, 19]. It has a yellow-golden color (as if filled with sunlight), is used for the manufacture of furniture and household items (Fig. 10).

Figure 10. Household items

It is stronger than *Quercus* in terms of mechanical and physical properties, and is therefore used for engraving work. It is easily polished, but difficult to drill [2].

It is quite difficult to perform carpentry work with this material. It is poorly sawn and planed. Native Americans used *Maclura* wood to make weapons (clubs and bows). Hunting and sports bows made from its wood are superior in quality to those made from *Taxus* [36].

The conducted analysis of the literature on the frost and winter hardiness of *M. pomifera* in various soil and climatic conditions creates the opportunity to draw conclusions about the resistance of the named taxon to adverse wintering factors: it withstands a decrease in temperature to -30°C.

In addition, it is classified as a drought-resistant plant species, in which significant damage to leaves and shoots is not observed in the summer heat.

The cultivar is fast-growing, heat- and light-loving, moderately demanding on the soil environment and humidity. It has been studied that *M. pomifera* tolerates both a deficiency of moisture in the soil and its excess. At the same time, in relation to the humidity of the soil environment, it is a mesoxerophyte, and in relation to the reaction of the soil environment, it belongs to indifferent plant organisms. The best soil for the growth and development of the mentioned taxon is podzolized black soil.

The cultivar grows naturally in the states of Texas, Virginia, and Georgia in the USA. *M. pomifera* is cultivated in the southern and western regions of Ukraine.

It is used in green farming and as a medicinal plant. It has excellent, strong wood that is resistant to rot. The plant is also used as a rootstock for *Cudrania tricuspidata* ("strawberry tree"), whose fruits are tasty and quite common [15].

City, methodology and research design. Research on seed propagation of *M. pomifera* was carried out on the basis of the training laboratory of the Department of Horticulture and Forestry. It should be noted that the seed material was collected from fruit-bearing plantations of the Poltava Agrarian and Economic College (Fig. 11-12).

In Ukraine, the laboratory method for determining the quality of seed material is germination. The mentioned method provides the opportunity to determine the number of germinated seeds and the qualitative state of seedlings. Qualitative indicators of seed material were determined in accordance with State Standard (GOST) 13056.6-97 [12, 13].

Figure 11. Fruits of M. pomifera

Figure 12. Seeds of M. pomifera

Before germination, it was soaked for 20 hours at a temperature of 18-20°C. After that, the seeds were washed and spread out in Petri dishes.

The study of the influence of hormonal compounds on the soil germination of *M. pomifera* seed material was carried out in the conditions of a closed ground construction.

Seeds were sown in the second decade of April (15.04). To form the soil mixture, forest soil and river sand were mixed.

The research work was carried out according to the following scheme:

Factor A – biologically active substances: 1) epin; 2) baikal; 3) control (water); 4) charkor. Factor B – the influence of seed sowing depth on germination: 1) control (10-20 mm); 2) 20-30 mm; 3) 30-40 mm; 4) 40-50 mm; 5) 50-60 mm; 6) 60-70 mm. Factor C – the influence of the substrate on the growth of planting material: 1) soil + sand (2:1); 2) soil + humus (2:1); 3) soil + peat (2:1); 4) control (field soil).

After removing the seeds from the fruits, they were washed in water. The seed material was stored at room temperature in paper bags. The experiment was set up in 3 replicates, where 100 pcs. of seeds were sown.

During the growing season, agrotechnical measures were carried out for the seedlings: removal of weeds and watering.

The research work was carried out according to the methodology [12, 27]. Statistical data processing was carried out [24].

Research results. According to Sokolov S. Ya. [4, 33], *M. pomifera* can be propagated by seeds and cuttings (green and lignified) [23, 25-26].

Experience with the introduction of new taxa shows that generative propagation improves the resistance of the new generation to adverse environmental factors. This is especially important for thermophilic cultivars, to which the mentioned taxon belongs [30, 32].

Seed propagation (Fig. 13), and especially its comparative analysis, is an important indicator of the success of the introduction.

Figure 13. M. pomifera seedlings

Table 1. Qualitative indicators of *M. pomifera* seedlings

	Variant	Height, cm	± to control	Thickness, mm	± to control
1.	Soil + sand (2:1)	19,5	-0,2	2,2	- 0,1
2.	Soil + humus (2:1)	22,3	+ 2,6	2,4	+ 0,2
3.	Soil + peat (2:1)	21,0	+ 0,3	2,6	+ 0,3
4.	Control (field soil)	19,7	-	2,3	-
HIP $_{05}$		2,14			

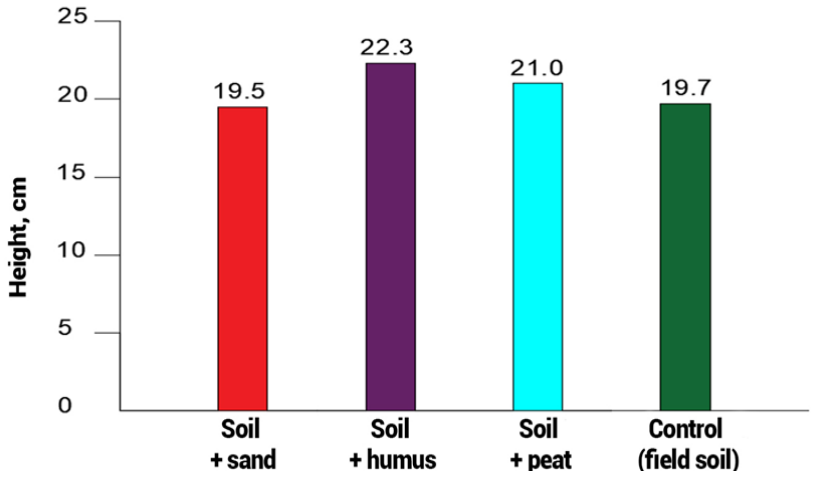

Figure 14. Effect of substrate type on the height of annual seedlings

Observations of the growth and development of *M. pomifera* seedlings on different soil mixtures (Table 1, Fig. 14) made it possible to find out that they grew best in the second variant (soil + humus).

The height of the seedlings in the mentioned variant was 22.3 cm, which is 2.6 cm more than in the control.

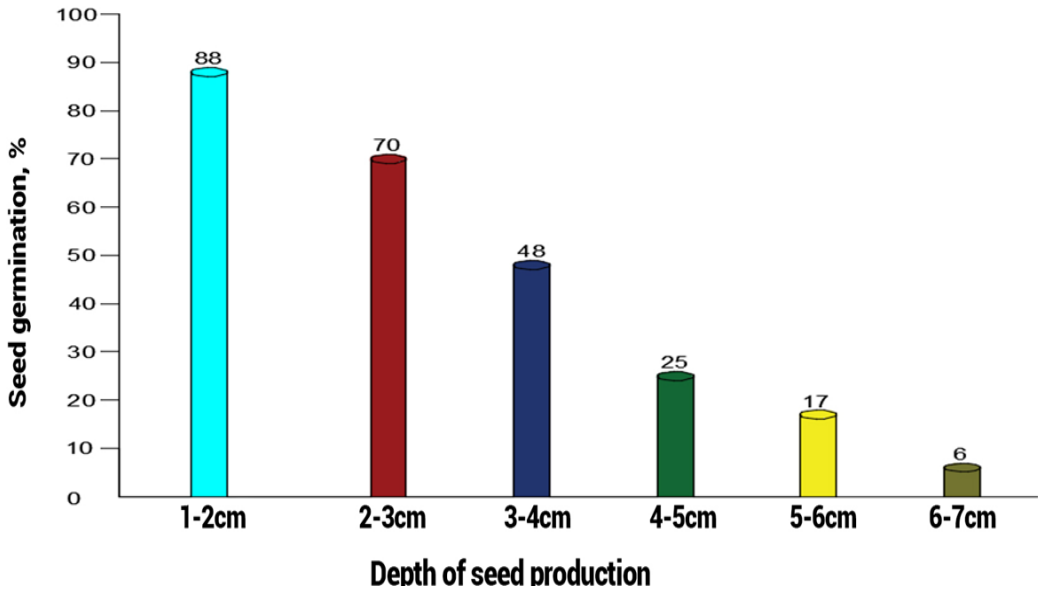

Figure 15. Germination of M. pomifera seeds

The thickness of the root collar in the experimental variants was within 2.2-2.6 mm. In addition, in the process of carrying out experimental work, the influence of the depth of seeding on soil germination was considered (Fig. 15).

According to the results obtained, in closed soil conditions, the maximum germination of the seed material (88%) was in the variant of sowing it to a depth of 10-20 mm. At the same time, when sowing seeds to a depth of 30-40 and 40-50 mm, a significantly worse result was obtained - germination was 48 and 25%, respectively. Under the conditions of sowing seed material to a depth of 60-70 mm, the minimum result was 6%. 25 days after the appearance of the first shoots, true leaves appeared.

Thus, the optimal depth of seed sowing, which ensures maximum field germination, in the conditions of the cultivation structure (10-20 mm), was found by research.

The study of the dynamics of growth processes in seedlings during the growing season was carried out in closed soil conditions (Fig. 16).

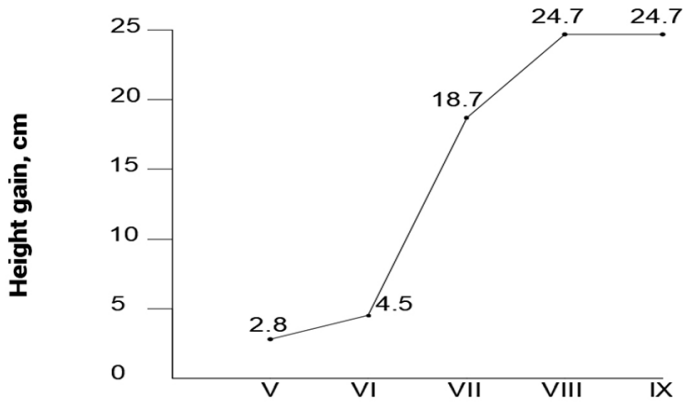

Figure 16. Growth dynamics of M. pomifera seedlings

Analyzing the results obtained, we emphasize that the maximum intensity of seedling growth was observed during June - August (4.5 to 24.7 cm). At the same time, the average height of seedlings during the growing season was 24.7 cm.

To restore the biochemical activity of seed tissues and ensure the growth of the embryo, it is necessary to create conditions for its germination. This is achieved by soaking, scarification, snowing, etc. [1, 20, 29]. At the same time, the above-mentioned measures for preparing seed material for sowing only ensure overcoming the state of forced dormancy in seeds, but do not affect the survival and growth of seedlings. It is known that pre-sowing seed preparation reduces the time for growing planting material.

Today, in Ukraine and abroad, growth regulators are widely used in the production of planting material for both forestry and horticultural purposes [16]. At the same time, attention is paid to compounds that are made on the basis of natural raw materials [27-28].

Table 2. Germination duration and germination of *M. pomifera* seeds

№	Option	First sprouts appearance	The emergence of mass sprouts	Germination period, days	Seed germination, %
1.	Control (water)	7.05	16.05	40	88,0
2.	Epin	1.05-	6.05-	33	92,0
3.	Baikal	2.05	7.05	31	93,0
4.	Charkor	1.05	6.05	30	93,0

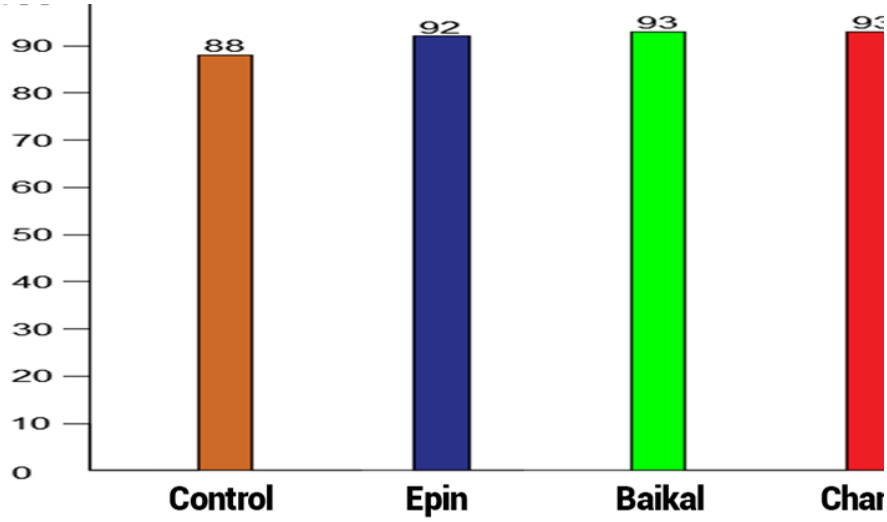

Figure 17. Effect of growth regulators on seed germination of M. pomifera

To determine the influence of physiologically active compounds on the germination processes of *M. pomifera* seeds, we performed experimental studies to determine their germination (Table 2, Fig. 17).

The first shoots of *M. pomifera* appeared in the experimental variants on the 15-17th day, and in the control - on the 22nd day after the germination. The maximum germination intensity in the control variant was noted on the 31st day, and in the experimental variants - on the 21-22nd day. The seed germination rate in the control variant was 88%, which is 4-5% less than in the search variants.

Figure 18. M. pomifera

M. pomifera (Fig. 18) is a wonderful ornamental tree with inedible fruits. It is planted in parks and gardens. Due to its decorative, beautiful wide crown, shiny and long leaves and original fruits, it is used in landscape design. The thorns make it possible to use it to create protective strips.

The *M. pomifera* tree can grow up to 18 m in height, which makes it an excellent material for creating shade or hedges. It grows intensively, which makes it possible to achieve the appropriate decorative effect in the garden plot quickly.

Figure 19. Single plantings of Maclura

Figure 20. Group plantings of Maclura pomifera

In ornamental gardening of park plants, it is practiced to plant *M. pomifera* in the form of single (Fig. 19) and group plantings (Fig. 20), elegant lawns that create partial shade for shade-tolerant shrubs and low-growing trees.

Figure 21. Field protection plantings of M. pomifera

M. pomifera is widely used in erosion control plantings, buffer strips, and reclamation plantings (Fig. 21). In private households, it is used to create elegant living fences that protect homestead plots from uninvited guests, including hares.

The mentioned cultivar grows well in the sun, tolerates light shade. It prefers fertile and well-aerated soil, but it is unpretentious and can grow on any soil. Even saline soils are suitable for it. Due to its well-developed root system, the tree is able to absorb nutrients and water from deep soil horizons, which provides it with resistance to arid conditions. The plant is resistant to frost (-30°C) and winds. It tolerates anthro pyogenic conditions well. To intensify growth processes, it is advisable to prune at a young age.

Planting of planting material with an open root system is recommended in the spring, when frosts have passed. It is advisable to prepare the planting hole in advance, forming a drainage system. In the first growing season after planting the seedling, it is necessary to water it regularly, and mulch the trunk circle. Plant feeding is not required. Sanitary pruning of the crown is performed annually, and shaping once every three years. The above-ground part of young plants is protected with agrofibre in the cold season.

M. pomifera is suitable for landscaping urban areas and forming ornamental plantings. Its fruits are not edible, but are a component for the manufacture of medicines that are popular in alternative medicine.

To date, official medicine has studied *M. pomifera* little, but it has recognized it as a source of valuable beneficial compounds.

The fruit pulp (Fig. 22) of *M. pomifera* contains osagin and pomiferin, which are present in the fruit in a ratio of about 1: 2 by weight, and, at the same time, constitute 5-7% of the weight of dry fruit. Fresh fruits include pectin (45%), sugar (up to 5%), fat (6%), resin (16%). The water content in the fruit pulp is approximately 70% [4].

Figure 22. Fruits of M. pomifera

The fruits of *M. pomifera* contain:

- Flavonoids - highly active anticarcinogens and antioxidants.
- Isoflavones - intensify and improve metabolic processes.
- Sterols - improve the absorption of vitamins of various groups (B, E. C, A and D).
- Pectin. Necessary for collagen synthesis. Minimizes cholesterol content. Provides removal of toxins and salts from the body.
- Citric acid is useful for joints, and also creates prerequisites for the removal of uric acid from the body.
- Bioflavonoids have a regenerating and analgesic effect. Improves the elasticity of blood vessel walls.
- Saponins are necessary for the absorption of beneficial compounds. They ensure the restoration of the body's salt, mineral and water balance.
- Bile acids. Optimize fat metabolism.
- Fatty acids have a positive effect on the immune system.

The seed oil of *M. pomifera* contains linoleic, oleic, palmitic and stearic acids. The content of the fruits and extracts indicates the presence of calcium, phosphorus, potassium, silicon, magnesium and sodium.

Figure 23. Sciurus vulgaris feasts on the fruits of M. pomifera

The fruits of the mentioned species are not poisonous, but they are not edible, because they have a dry, bitter pulp. The seeds of the fruits are edible, if they are roasted, they taste a little like sunflower seeds. *S. vulgaris* willingly eat the seeds of *M. pomifera* (Fig. 23). Information about the toxicity of the fruit is erroneous, possibly due to imperfect translation. It is advisable to remember that the concentrated juice is poisonous and can cause burns if it comes into contact with the skin and mucous membranes [13].

M. pomifera, as a medicinal plant, has been long and widely used in folk medicine in many countries of the world. In particular, in Bolivia, the bark and leaves are used for internal bleeding, the fruit juice is used to treat toothache, and lotions are made from a decoction of the root system against eye inflammation.

Figure 24. Medicines from the fruits of M. pomifera

In folk medicine, medicines are made from the fruits of *M. pomifera* (Fig. 24): ointments, tinctures, compresses and rubbing products, decoctions [13].

Figure 25. Pharmaceutical medicines based on M. pomifera

Most often, medicines from *Maclura* fruits are used in the form of a rub, ointment or tincture (Fig. 25). In addition, oil extraction of the fruits is carried out in the manufacture of medicines.

Maclura tincture is considered effective. It is used as a medicine for the following diseases: varicose veins; fibroids; hypertension; bruises, joint pain; colds; polyarthritis and gout; eczema; partial paralysis after a stroke; mastopathy; prostate adenoma; oncology.

In addition, tincture of *M. pomifera* is used for rubbing for the following diseases: rheumatism, radiculitis, osteochondrosis (rubbed on diseased areas of the body) [36]. The course of treatment is up to 7 days with a break of 30 days.

For sinusitis, compresses are made from the tincture. Soaked tampons are kept in the nose for 15 minutes. The course lasts 5 days (done twice a day).

Studies have shown that the alcoholic extract of *Maclura* fruits negatively affects the activity of the enzymes collagenase, hyaluronidase and elastase, which directly affect the aging process of the human body. In this way, it was proven that the compounds of the mentioned plant should be used in the production of anti-aging cosmetic products.

There is information about the sufficient effectiveness of the extract from the seeds of *M. pomifera* against acne, age spots and other skin diseases.

Despite the healing properties of *Maclura* fruits, it is advisable not to forget about its toxicity [35]. In the process of manufacturing medicines, it is necessary to strictly observe the proportions and use them in appropriate doses. In addition, it is advisable to consult a doctor before using the products.

The literature contains information about the effectiveness of the plant in the treatment of breast cancer, hemorrhoids, infertility and prostatitis.

The fruits of *M. pomifera* are rich in flavonoids: kaempferol and isoflavone. Indeed, these compounds have an antitumor effect and are the basis of therapy in the treatment of cancer patients. *Maclura* fruits in the mentioned pathology of the human body can be used for the treatment of both malignant and benign formations. This remedy has the ability to slow down the division of cancer cells [59]. In this disease, it is used internally and externally. In particular, suppositories are used for vaginal treatment. Medicinal products from *M. pomifera* plants affect the growth of malignant neoplasms. Oncology prevention can be carried out, as well as therapy at different phases of the disease, during the progressive phase it is recommended to increase the dose of medicines.

M. pomifera medicinal products are banned for use during pregnancy, lactation, for children under 12 years of age, allergic reactions, diabetes mellitus, and concomitant use of antibiotics. In addition, the tincture should not be combined with alcoholic beverages, but it is permissible to combine it with herbal decoctions and fruit juices [36]

The wonderful properties of the named species, the possibility of use in everyday life and treatment, and high decorativeness deserve not only interest, but also the desire to have such a valuable culture on the private plot.

Conclusions

1. Seed propagation is the main one for *M. pomifera*, since its seeds are characterized by a high germination rate.

2. In the conditions of a cultivation structure, the maximum soil germination of seeds of 88% was observed in the case of sowing to a depth of 10-20 mm, and under the conditions of sowing to a depth of 60-70 mm, only 6% of the seed material germinated.

3. The growth of *M. pomifera* plants during the growing season was 24.7 cm. At the same time, intensive plant growth was observed during June - August.

4. The optimal soil mixture for the growth and development of seedlings of the studied species was a mixture of field soil and humus.

5. Laboratory seed germination was within 88-93%.

6. The experimental cultivar has sufficient decorative characteristics (crown habitus, original leaves and inflorescences) and is a promising taxon for landscape design: forming alleys, compositional groups, single-stem plantings and hedges.

7. *M. pomifera* is used in alternative and traditional medicine, as well as in cosmetology.

REFERENCES

1. Balabak A. F. (2003) Reproduction of rare fruit and berry crops: monograph. Uman: Operativa poligrafiya, 109 p.
2. Vitenko V. A., (1999) Maclura aurantiaca Nutt. in the Right-Bank Forest-Steppe of Ukraine. *Collection of scientific papers*, P. 520–522.
3. Vitenko V. A. (1999) Morphological characteristics and seed germination of Maclura aurantiaca Nutt. *Introduction of plants*, No. 3–4, P. 101–103.
4. Vitenko V. A. (2002) Comparative assessment of methods of reproduction of Maclura pomifera (Rafin.) Schneid. *Theoretical and applied aspects of plant introduction and green construction*, P. 74–76.
5. Vitenko V. A. (2002) Prospects for the introduction of Maclura pomifera (Rafin.) Schneid. in the conditions of the Ukrainian steppe. *The role of botanical gardens in the green construction of cities, resort and recreational area,* P. 40–43.
6. Vitenko V. A., (2003) Winter hardiness and frost resistance of maclura in the conditions of the Right-Bank Forest-Steppe of Ukraine. *Ancient parks and problems of their preservation*, P. 108–112.
7. Vitenko V. A. (2003) History of the introduction of Maclura pomifera (Rafin.) Schneid in the territory of Ukraine and its use in landscaping gardens and parks. *Theoretical and applied aspects of plant introduction and green construction*, P. 24–26.
8. Vitenko V. A., (2004) Biological and ecological features of Maclura pomifera (Rafin.) Schneid. during introduction in the conditions of the Right-Bank Forest-Steppe of Ukraine: Author's abstract of candidate of agricultural sciences. Kyiv: NAU, 17 p.
9. Vitenko V. A., (2005) Biological and ecological features of Maclura pomifera (Rafin.) Schneid. during induction in the conditions of the Right-Bank Forest-Steppe of Ukraine. *Autochthonous and introduced plants of Ukraine: collection of scientific works of the National Academy of Sciences of Ukraine, National Dendrological Park "Sofiivka*". Kyiv: Akademperiodyka, P. 171-183.
10. Vitenko V. A., (2005) Fruiting Maclura in the Right-Bank Forest-Steppe of Ukraine. Uman: Publishing house ALMI, 2006. 132 p.
11. Vlasyuk S. G. Bondarenko A. O., (2020) Fundamentals of ornamental gardening *Gardening and viticulture,* P. 351-365.
12. Gordienko M. I., Maurer V. M., Kovalevsky S. B., (2000) Methodical instructions for the study and research of forest crops. Kyiv, 101 p.
13. Zayachuk V. Ya., (2008) Dendrology: textbook. Lviv: Apriori, 656 p.
14. Zayachuk V. Ya., (2019) Dendrology: textbook. Kyiv: Vyscha Shkola, 675 p.
15. Kalinichenko O. A., (2003) Decorative dendrology: teaching aids. Kyiv: Vyscha Shkola, 199 p.
16. Kobyletska M. S., Terek O. I., (2017) Plant biochemistry: textbook. Lviv: Ivan Franko National University of Lviv, 270 p.
17. Kokhanovsky V. M., Kovalenko I. M., (2013) Decorative dendrology: textbook. Sumy: "Sumy National Agrarian University", 283 p.
18. Kokhanovsky V. M., Melnyk T. I., Kovalenko I. M., Melnyk A. V., (2020) Decorative dendrology: textbook. Sumy: FOP Tsoma S. P., 263 p.
19. Kokhno M. A., (2002) Dendroflora of Ukraine. Wild and cultivated trees and shrubs. Angiosperms. Kyiv: Publishing house "Phytosociotsentr", 448 p.
20. Kucheryavy V. V., Kucheryavy V. S., (2019) Greening of settlements, Lviv: Novyi svit- 2000, 224 p.
21. Lukashchuk G. B., (2020) Dendrology. Lviv: Lviv Polytechnic, 348 p.

22. Maurer V. M., Kushnir A. I., (2008) Methodological recommendations for the propagation of woody ornamental plants of the Botanical Garden of NUBiP of Ukraine. Kyiv: NUBiP, 55 p.
23. Mezhensky V. M., Mezhenska L. O., Yakubenko B. E., (2014) Non-traditional berry crops: recommendations for selection and propagation. Kyiv: CP "Komprint", 119 p.
24. Mezhensky V. M., (2018) Fundamentals of scientific research in horticulture. Calculations in Microsoft Excel. Kyiv: Lira-K, 212 p.
25. Sikura A. O., (2002) Seed propagation of Maclura pomifera (Rafin.) Schneid. in the conditions of the Right-Bank Forest-Steppe of Ukraine. *Introduction of plants,* No. 1, P. 77–85.
26. Sudarikova Yulia., (2019) Exotic trees, bushes and lianas in the landscapes of Ukraine. Kyiv, 336 p.
27. Eresinska M., (1982) Regulation of cellular energy metabolism. *Membr. Biol*,. 70, No. 1, P. 1 – 14.
28. Hochachka P. W., (1984) Biochemical adaptation. Princeton Univ. Press, 537 p.
29. Szabla K., Pabian R., (2003) Container nursery. New technologies and techniques in forest nursery. Warsaw: State Forest Information Center, 212 p.
30. Vitenko, V. A., (2001) Evaluation of the success of the introduction of Maclura pomifera (Raf.) *Schneid in the conditions of the Right-Bank Forest-Steppe of Ukraine. Introduction of plants,* N. 3-4, P. 31–36.
31. Vitenko V. A., (2000) Comparison of growth and development of Maclura pomifera (Raf.) Schneid. in the National Botanical Garden named after M. M. Grishko of the NAS of Ukraine and the Synytsky Arboretum of the Uman Forestry Department by modeling method. *Introduction of plants,* No. 2, P. 127-129. [Electronic resource] Access mode: http://nbuv.gov.ua/UJRN/IR_2000_2_29.
32. Vitenko V. A., (2001) Assessment of the success of the introduction of Maclura pomifera (Raf.) Schneid in the conditions of the Right-Bank Forest-Steppe of Ukraine. *Introduction of Plants*, No. 3-4, P. 31-36 [Electronic resource] Access mode: http://nbuv.gov.ua/UJRN/IR_2001_3-4_5.
33. Vitenko V. A., (2002) Seed propagation of Maclura pomifera (Raf.) Schneid. in the conditions of the Right-Bank Forest-Steppe of Ukraine. *Introduction of Plants,* No. 1. P. 77-82. [Electronic resource] Access mode: http://nbuv.gov.ua/UJRN/IR_2002_1_13
34. Vitenko V. A., Shlapak V. P., (2006) Results of the introduction of Maclura pomifera (Rafin.) Schneid in the conditions of the Right-Bank Forest-Steppe of Ukraine. *Introduction of Plants,* No. 1, P. 17-22. [Electronic resource] Access mode: http://nbuv.gov.ua/UJRN/IR_2006_1_4.
35. *Maclura pomifera* [Electronic resource] Access mode: https://aquagradus.com/uk/adamovo-yabloko-maklyura-recepty-nastoek-i-ih-lechebnye-svojstva?srsltid.
36. Therapeutic properties of *Maclura pomifera* [Electronic resource] Access mode: https://fitomarket.com.ua/ua/fitoblog/makljura-adamovo-jabloko-i-ee-lechebnie-svojstva.