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*MD – 2002, Padurii str. 18, Chisinau, Republic of Moldova  
tel./fax: (+373 22) 52-38-98; 55-04-43  
www.gradinabotanica.asm.md  
e-mail: cancelarie.gb@asm.md*

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## I. STRUCTURAL AND FUNCTIONAL DIVERSITY OF PLANT ORGANISMS

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### FEATURES OF CULTIVATION OF BLACKBERRY IN THE REPUBLIC OF MOLDOVA

*Ciorchină Nina, Cutcovschi-Muștuc Alina, Lozinschii Mariana,  
Mîrza Alexandru, Trofim Mariana*

Botanical Garden (I) of ASM, Chisinau, Republic of Moldova

**Abstract:** *This article is devoted to the methods of propagation of blackberry and the agrotechnology of cultivation, starting with the creation of the plantation (selection and preparation of the land, the soil type, the soil fertilization and cultivation) and continuing with the process of planting, the types of supports for the stems of blackberry plants and other important topics such as pruning to increase the yield, pruning to improve the plant shape in autumn, spring, in the first and in the second year, the seasonal care, the protection against pests and diseases, the protection against adverse weather conditions, the specific care appropriate for the studied variety and the harvest.*

**Keywords:** *propagation methods, blackberry, creation of the plantation, pruning, care, support, irrigation, protection, harvest.*

## INTRODUCTION

The high interest in the crop in question is due to the biochemical composition of the blackberry cultivars, namely, the high amount of vitamins, minerals and antioxidants contained by them, but also the tolerance of the cultivars to low temperature, pests and diseases, as well as their capacity to grow on low-quality soils [2].

## MATERIALS AND METHODS

Blackberry, depending on the biological characteristics of the varieties, can be propagated by suckers, root or stem cuttings, particularly green cuttings, layering and division.

In the Republic of Moldova, where blackberry is mainly cultivated by amateurs in private plantations, the horizontal layering and tip layering are considered the most appropriate methods of propagation. However, the establishment of industrial plantations requires high quality, uniform and homogenous planting material, such plantlets are obtained by the *in vitro* cultivation method.

## RESULTS AND DISCUSSIONS

### *The mother plantation of blackberry*

The *mother plantation* consists of perfectly healthy donor plants, which have undergone the phytosanitary expertise, which are used to produce elite planting material, used later to create productive plantations. [2] A *layer plantation*, which lasts for 8-10 years, is a source of layers of fruit shrubs (blackberry, raspberry, gooseberry, blackcurrant, bilberry etc.). A *sucker plantation*, which lasts for 3 years, is a place where suckers of blackberry and raspberry, as well as hybrids of blackberry and raspberry, are cultivated. A *mother plantation of fruit shrubs* is exploited for 6-7 years and is a place from which lignified and green cuttings are harvested.

### *Propagation sectors*

The “*school of cuttings*”. It is currently used to root the cuttings of species and varieties of fruit shrubs.

The mother plantations are established on small areas, separate from the productive plantations.

When *choosing the land and the location of the mother plantation*, a number of environmental factors are

taken into account: temperature, precipitation, land exposure, air currents, soil, groundwater, relief, alternation of crops etc. Thus, the mother plantation is placed in an unpolluted area, which corresponds to the following climatic parameters: annual average temperature +8.5...+11°C, average temperature in the growing season +17...+20°C, minimal temperature in the rest reason -18...-26°C, autumns that are long and sunny, relatively droughty, with thermal contrast between day and night, favourable to the process of hardening off the cuttings.

The land must be flat or slightly inclined (3-4%), with south-western or south-eastern exposure and sheltered from the wind.

The most suitable soil is clayey or loamy, deep, of medium fertility, well-structured, aerated, with good water retention, such as forest soils, chernozems and alluvia, slightly acidic (pH – 6.5-6.8). The recommended groundwater depth is below 1.5 m [1, 2].

As a rule, it is chosen a field situated next to a source of water, necessary for the irrigation of plants in droughty periods.

It is recommended to apply fertilizers to the soil, in the mother plantation, in accordance with soil quality. The same principle is used with respect to the soil intended for the creation of the plantation; more details are given below. It is necessary to carry out soil analysis in specialized laboratories, accredited in the Republic of Moldova.

The healthy and competitive planting material is propagated in the mother plantation: cuttings, rooted layers and seedlings for the modernization and the establishment of intensive plantations.

Theoretically, blackberry is propagated by seeds, layering, suckers, root cuttings, stem cuttings, division, but most often, the planting material is obtained by:

*Layering* – a method that is used mostly to propagate wild varieties of blackberry. The tips of the stems, once in contact with the soil, produce roots and give rise to new plants. This method works well with creeping varieties. For this purpose, the tips of the stems are left on the ground at the end of August and, until winter comes, they develop roots. In spring, the rooted tips with a 30-cm-long fragment of the shoot are separated from the rest of the plant. The vertical layering of blackberry is also successfully practiced. It consists in bending the stems in the direction of the rows and covering them with a 5-6-cm-thick layer of soil, except the tip of the stem, which is positioned vertically and left above the ground. This operation is carried out in late summer. In spring, the stems are carefully dug out and cut into several fragments, depending on the number of roots that have grown, on average, 5-7 plants are obtained.

*Propagation by suckers* – is less common for blackberry, as compared with raspberry, because it has low capacity to produce suckers. There are few blackberry varieties that produce suckers. The obtained suckers are harvested in spring or autumn and are stratified in sand or moist perlite.

*Propagation by root cuttings*. The roots intended for obtaining cuttings are dug out of the soil in autumn, with a spade or plough. The roots thicker than 4 mm are used to obtain 10-cm-long cuttings, are bound in packets and stratified in wet sand. The cuttings are planted in spring, in protected ground, in pots or boxes, in a mixture of peat and sand in equal proportions, or even in open ground, at a depth of 6-8 cm and a distance of 1.0 m between them. In 20-25 days after planting, the first shoots emerge.

*Propagation by stem cuttings*. It is mainly practiced to obtain planting material of thornless varieties of blackberry. The cuttings are obtained from annual stems.

*Propagation by green cuttings*. It is carried out in the first half of June and requires protected ground (greenhouses, hotbeds, cold frames) for rooting. Green cuttings are obtained by cutting the tips of stems. The length of a cutting should be 7-8 cm; harvesting, storage, shaping and handling are done with great care, not to lose turgidity. After removing all leaves except the one at the tip, the cuttings are planted at a depth of 2-3 cm and at a distance of 8/4 cm, about 300 cuttings per m<sup>2</sup>.

Peat, sand and perlite, apart or mixed, are used as rooting substrate.

After planting, it is necessary to maintain the high humidity of the air, about 95-98%, and after the appearance of roots, to reduce gradually the humidity. After the shoots have reached 15-20 cm, the plants are

acclimatised for 2-3 weeks, then they are moved in open field until autumn.

*Propagation by lignified cuttings.* The stems harvested in autumn are cut at 50-70 cm and are stratified in moist sand or are stored in double polyethylene bags, at temperatures of 1-2°C. In winter, from the stratified stems are obtained cuttings with 1-2 buds, which are stored in sand or in the cold store, in vertical position to ease callus formation.

The cuttings are planted in protected ground, in boxes, in a mixture of peat and sand in equal proportions. In spring, after the weather becomes warmer and the shoots grow longer, the boxes are moved outside, and when the roots grow and occupy all the space in the boxes, the plants are transplanted in open ground and fertilizers are applied.

In summer, the current maintenance work is carried out: irrigation, weeding, phytosanitary treatment, and the shoots are cut at 40-50 cm.

*Propagation by semi-lignified (softwood) cuttings.* It is carried out in the same way as propagation by green cuttings, but the works are done in August-September, and the stems should not be thicker than 7-10 mm. In very special cases, the propagation of a valuable variety is achieved by division.

*Propagation by in vitro culture.* *In vitro* propagation of plants or micropropagation is a branch of plant biotechnology that consists in set of methods of plant propagation by using cell, tissue and plant organ culture, and has all the chances to become a priority in the technology of production of planting material, as it allows obtaining an unlimited number of healthy plants characterized by fast growth and development. The price of plants obtained by *in vitro* culture is often much lower, and the plantlets grown in the test tube are more resistant to adverse environmental conditions, diseases and pests, grow and develop faster than those obtained by traditional propagation methods. Another advantage of micropropagation is that from the mother plant, or donor plant, characterized by high productivity or special decorative qualities, by microcloning and multiplication of these clones, it is possible to obtain successive cycles, in one year, of over a million of homogeneous plants with the same characteristics as the donor plant.

This type of propagation can be carried out in special laboratories with appropriate equipment, conditions and tools. Such laboratories require considerable investment in the field of mass production of planting material and knowledge of the legislation on the acquisition and marketing of planting material, as well as in the field of research.

*In vitro* propagation is performed in sterile, artificially controlled conditions, in glassware or disposable plasticware, in growing media that contain solutions with all the nutrients needed for the initiation and development of the plant. This type of propagation consists of three main steps: a) the initiation of the *in vitro* culture, the phase in which the fragments of plants, tissue, pollen etc. (explants) are taken from the field, from the donor plant, to be sterilized and introduced in the *in vitro* culture; b) the stage in which reproduction is performed as such by microcloning and micropropagation by successive cycles, to obtain the intended amount of plantlets; c) the last stage, the adaptation and acclimatization – when plantlets are transplanted or moved from *in vitro* to *ex vitro* conditions, to be replanted from greenhouses in open ground [5].

Methodological aspects of micropropagation, using meristems from apical and lateral buds as initial explants. It is recommended to take the explants from young plants or younger plant areas, so as not to affect the vitality of future tissues. The meristem sampling of blackberry is recommended during the intensive growth of tissues in April-May, until flowering, or in June, so that the inoculated meristems survive and give rise to *in vitro* cultures. In the period of rest, in October-February, harvesting of meristems is not recommended because the process of maintaining the viability and regeneration of plantlets obtained *in vitro* is more difficult. To optimize the asepsis of the biological material, several sterilizing agents are recommended: commercial sodium hypochlorite, ethyl alcohol and mercuric chloride. The mercuric chloride was found to be the most appropriate one – with a percentage of viable plantlets of 75% [6].

The main advantage of micropropagation is the extremely high rate of propagation, besides, it doesn't depend on the season because it is carried out under controlled conditions, in growth chambers, where such

parameters as light, temperature and humidity can be regulated, and the plants are in process of active growth and propagation regardless of the season.

In addition, the assortment of plant varieties or species that are reproduced can be changed much faster using this method. Besides, *in vitro* propagation allows plants to grow on their own roots, avoiding grafting with all its disadvantages, primarily the disease transmission.

The material obtained *in vitro* can be stored by different methods and used when necessary; this results in considerable savings in land, space, energy and fuel [6, 9]. Planting material in the form of *in vitro* cultures can easily be transported and distributed both in the country and abroad. *In vitro* cultures are the easiest, cheapest and most efficient way to store, handle and transport plant material.

The disadvantages of this propagation method are insignificant in comparison with its advantages, and consist mainly in the initial cost of establishing a micropropagation unit and the fact that micropropagation is economically efficient only when propagating tens of thousands, hundreds of thousands or millions of plants, but not for a small number of plants [7].

### **Establishment and maintenance of blackberry plantations**

Prior to the establishment of the blackberry plantation, the land is designed, divided into parcels or marked out with stakes. Later, a mix of perennial grasses for hay or forage legumes (alfalfa, pea etc.) is usually sown. The crop will be established in a 3-year-long conversion period, to enrich the soil with humus. Soil preparation consists in a set of technical works that are performed using various tools and equipment, in the soil layer in which the roots develop, in order to create favourable conditions for the growth of young plants.

The soil preparation works are aimed at achieving the following objectives: loosening the soil to the depth necessary for the development of the roots; infiltration, storage and maintenance of water in soil; soil aeration and creation of conditions to activate the vitality of microorganisms; improvement and maintenance of structural conditions in the upper layer of the soil; removal of weeds, protection from soil erosion; creation of optimal conditions for the incorporation of plant waste and fertilizers into the soil.

The benefits of crop rotation are numerous and particularly important. By using it, the improvement and rational use of soil fertility is achieved. Based on these elements, the following types of crop rotation are established: crop rotation with fallow field; crop rotation with planted field; crop rotation with the use of green fertilizers.

The crop rotation with fallow field is commonly used in droughty areas and when the soil is heavily invaded by weeds, such as couch grass. It allows weed control by mechanical or herbicidal means.

The crop rotation with planted field is used in nurseries located in areas where atmospheric precipitation is minimal and where soil is destructured and easily becomes poor in nutrients, especially in nitrogen. When the crop rotation with planted field is used, the field that is improved should be cultivated with agricultural crops such as peas, vetch and spring oat, the growing season of which is short, and can be harvested early (beginning of June).

Immediately after mowing, stubble-turning is carried out, after which the soil is maintained until autumn with the works on the fallow field. On the field treated according to the above indications, the soil structure is maintained and improved, the soil is enriched in nitrogen, by nitrogen-fixing bacteria developed on the roots of legumes, which absorb it from the atmosphere. By the humification of the roots of the cultivated plants and by composting the plant mass produced on the field that is being improved, the soil is enriched with humus. The water storage capacity of the soil is also improved, by maintaining it with the works on the fallow field, after the agricultural crop is removed from the field.

The plot with fruit shrubs, including blackberry, is marked out in a rectangular pattern (the distance between rows is bigger and the distance between plants in a row is smaller). In case of slight slope, it is staked in parallelogram. Staking is always carried out perpendicularly to the main roads, and the main roads are laid out taking into account the orientation of the rows, which is made in north-south direction. In autumn, when deep tillage is performed, 30 t/ha of organic fertilizer from an organic livestock farm is applied. Blackberry is planted

in spring, after the danger of frost has passed [10].

**Choosing the land.** The best results are obtained on well aerated and drained soils, rich in humus and with good water availability. For blackberry plantations, the most suitable fields are those naturally sheltered from strong and cold winds, located in the vicinity of thoroughfares, water sources for irrigation, settlements and distribution centres.

Plain relief or slight slopes, up to 5-6° are more suitable for irrigation. The lower parts of the slopes with N, NE, NW, SW exposition are the most favourable.

The preferable soils are with sandy-clayey, clayey-sandy or clayey texture; the thickness of the humified layer – about 50 cm; the content of humus should be 2.5-3.5% or more; the soil should contain sufficient quantities of mobile nutrients; it should be slightly acid or neutral (pH=5.6-7). Poor, very heavy, calcareous soils (pH=7.3 and above) and those with excess moisture are contraindicated.

When choosing the land, we must also take into account the availability of cheap labour, to perform the manual work on cutting, harvesting etc., and the presence of transport facilities in the area [7].

**Land cultivation.** It starts 2-3 years before planting the blackberry. The land is freed from woody vegetation, multi-annual weeds and other objects, the soil is levelled.

**Preparing the land for planting.** At least 2 months before planting it is tilled at a depth of 35-40 cm. Organic and mineral fertilizers with phosphorus and potassium are applied throughout the area, at the recommended doses. The soil surface is broken up and smoothed out with the disc harrow or the cultivator and is maintained as cultivated field until planting.

**Varieties.** In order to stagger the period of ripening and harvesting of the fruits, in a plot, 2-3 varieties with different maturation periods will be planted, alternating 6-10 rows of each variety.

**Planting material.** It must be certified. The suckers and the cuttings should be at least 10 mm thick at the base of the stem and the root system – over 15-20 cm long.

**Planting of the blackberry.** The land, intended for the planting of blackberry, is divided into plots delimited by 4-m-wide roads and parcels of 100-150x100-200 m (1-3 ha). The installation of the trellis and the irrigation system is planned. Rows must continue each other in all parcels, creating opportunities for the rational use of the equipment. When planning the territory, the rows of blackberry should be oriented as close as possible to the N-S direction to create a favourable lighting and ventilation regime in the plantation.

The distance between the rows in the industrial plantations should be 2.5-3 m, and in the family gardens – 1.5-2 m. The distance between plants in a row – 1.2-1.5 m, depending on the vigour of the varieties.

The optimal time for planting is autumn, in October and November, when the growing season ends, or the beginning of spring, in March and April, preferably before bud opening. Blackberry is planted in holes (40x40x40 cm), in channels or open furrows dug with the plough, with a depth of 30-32 cm, or in holes dug with the hydraulic borer.

Before planting, the planting material is checked, being chosen only the suckers and the cuttings with viable buds and roots. On the day of planting, the planting material is trimmed (the stem is shortened to 30 cm from the base; the injured, dry and broken roots are removed; the too long roots are shortened to 15-20 cm, for planting in holes or furrows, and to 10-12 cm, for planting with the help of the hydraulic borer), the roots are dipped in mud and distributed for planting.

The depth of the planting is set so that the soil covers only the part of the stem, which was previously in the soil, in the “school of cuttings”, in the sucker plantation or in the layer plantation. When planting in holes or furrows, 4-5 kg of manure, 20-30 g of superphosphate and 10-15 g of potassium salt are mixed evenly with the soil at the bottom of the hole.

After planting, irrigation is necessary, with 5-6 l of water for each plant. If sprinkler irrigation is used, 250-300 m<sup>3</sup> of water per hectare are necessary. When the soil dries, each plant is hilled and the soil between rows is loosened [2].

### Plant training systems

The maintenance of thornless blackberry shrubs consists of a set of absolutely necessary operations. These operations help the plants regenerate and fructify annually, ensuring their proper development and stable yields. We consider it necessary to inform each blackberry grower about the importance of these works. In these works are skipped, or if they are not done in time, there is a risk that the thornless blackberry shrubs will be harder to maintain and control, and the tasty fruits, full of precious properties for the body, will not be obtained [4, 1].

Most thornless blackberry shrubs, regardless of variety, have fairly fragile stems. The long stems bend down and require artificial supports. In just one year, each shoot can grow up to 4-6 m, and if they are not properly trained, only pruning and care cannot guarantee any success. It is important that the trellis used in blackberry plantations, is robust enough to support the mature plants that, under their own weight and the weight of the fruits, bend and, without a support system, lie down to the ground.

The training systems have evolved, and among the factors that contributed to their diversification were: the different habit of the varieties, the expansion of the cultivated areas, the material possibilities and the inventiveness of the growers. There are various types of training, but all of them are based on the principle of the separation of the fruit-producing stems from those that will replace them in the future. Various plant training schemes, from the most simple and cheapest to more modern and more expensive ones, are given below [2, 3].

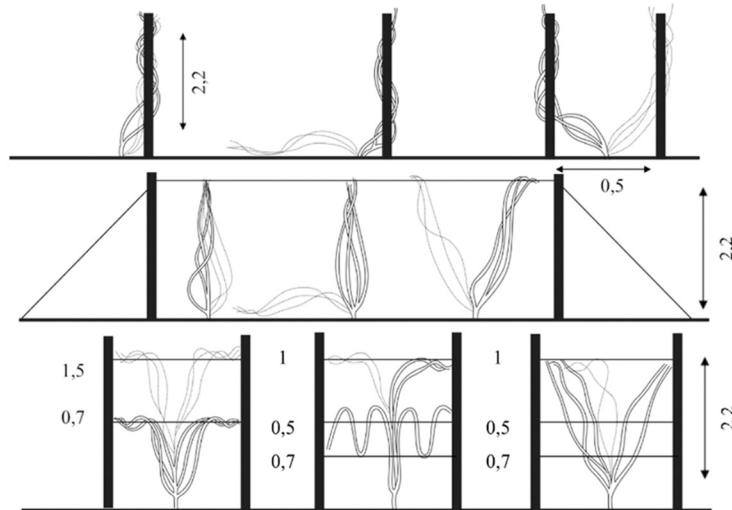


Fig. 3 Variants of training systems for thornless blackberry shrubs

**Variant I. Training to a single support (post).** This system consists in the presence of a tall post, of 2.3-2.4 m in height and 7-10 cm in diameter, fixed in the ground to a depth of 35-40 cm, at a distance of 25-30 cm from the plant, along the rows. The shoots are twisted around it, as a spiral, and tied to it, until the tip of the post, where they are cut (Fig. 3).

The new shoots that grow at the base of the bushes and the 1-year-old stems, respectively, are left on the ground and directed along the rows, all in the same direction. The main disadvantage of this system is that the numerous stems and the shoots with fruits are bunched together, favouring the development of *Botrytis cinerea*.

**Variant II. Training to two supports (posts).** This technique is similar to the previous one, except the use of two posts, placed on one side of the bush and on the other, at a distance of 25-30 cm, in the direction of the row. On a post, 2-year-old shoots are fixed, and on the other – the 1-year-old shoots. In this variant, the work is carried out easier than in the first.



**Variant III. Training blackberry to a two-wire trellis.** The wires are attached to the posts at a height of 1.0 m and 1.7 m above the ground. The 1-year-old and 2-year-old stems are tied to different wires, in one or both directions. The method of training the stems by twisting them around the wire is used rarely, and is suitable only to the varieties with few, but very long stems. In order to obtain the necessary number of fruit buds, the stems are cut longer and guided between 2 wires, in the form of sinusoidal curves, the obtained “waves” are guided in one or two directions.

**Variant IV. Training blackberry to a trellis in a fan shape.** This method is becoming more popular in large-scale production and is more appropriate to the biological requirements of blackberry. The plants have more access to air and sunlight, and the maintenance work is done much easier. In this case, 3 wires are used. They are fixed at a height of 0.6 m, 1.1 m and 1.7 m, being attached to posts of 1.8 m in height, placed at a distance of 10 m from each other. The fruit-producing stems are trained in oblique position in both directions, fixing them one by one to the wire of the trellis. The shoots are trained vertically, being loosely tied to the 3 wires. When the shoots grow longer than the last wire, they are trained along it towards south.

Trellises with posts made of iron, stainless steel or reinforced concrete, 2.0-2.5 m tall and well fixed in the ground, are used in modern industrial plantations. The distance between posts in rows can vary from 5 m to 10 m; their distribution depends on the length of the rows, as well as the average productivity per plant. In the areas where the danger of winter frosts persists, the support system should be mounted so that it can be flexible and lied down to the ground together with the plants trained on it and covered with straw or foil.

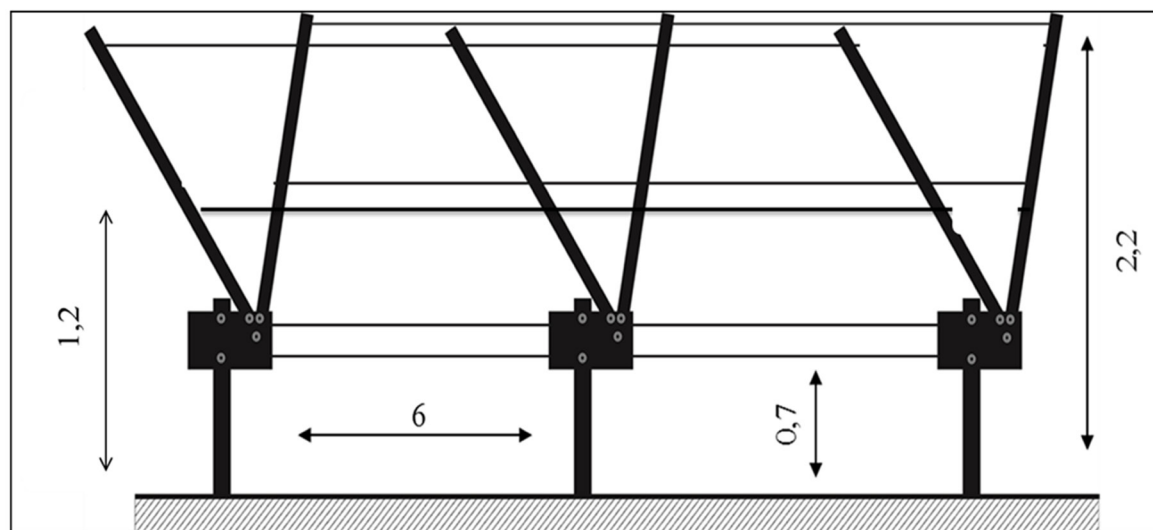


Fig. 4 Flexible metallic trellis, the scheme of the metal construction

### Pruning blackberry plants

Pruning is part of the set of absolutely necessary operations, if we want more than an ornamental plant. It helps the plants regenerate and fructify annually, ensuring their proper development and stable yields.

**Pruning to improve plant shape.** In the first year, immediately after planting, the stems are shortened to 15-20 cm from the ground. In the first year of life, the one immediately after planting, the plants of thornless blackberry grow quite slowly. If the planting material has more than 2-3 shoots, we recommend to keep the most robust one. The rest must be cut as close as possible to the root collar (the area where the root joins the stem) [8, 1]. The shoots that appear later, during the growing season are trained on the trellis.

In the second year, in spring, after the danger of frost has passed, 2-3 annual stems are chosen for fruit bearing and are shortened to 150-200 cm. The lateral shoots, till a height of 40-50 cm from the ground, are

pruned at the base. In this way, the risk that the berries can reach the ground, under their own weight, and get dirty or mouldy is avoided. The lateral branches, situated on these stems in the upper part are thinned and pruned at 25-30 cm (2-4 buds). The fruit shoots are trained uniformly on the trellis in a fan shape. In summer, 6-7 shoots are chosen for fruit-bearing in the next year.

**Pruning to increase the yield.** It starts in the third year. In spring, of the 6-7 shoots grown last year, only 4-6 better developed shoots should remain. They are pruned at the length required by the trellis, usually at 150-200 cm. If there are lateral branches, they are thinned and shortened as in the spring of the second year. The other shoots, including those that produced fruits in the previous year, should be cut at the base of the bush.

The shoots that produced fruits are removed only in spring, because, in winter, they protect the annual shoots from cold wind. The fruit shoots and the suckers that have been left to develop are trained on the trellis in a fan shape, at a distance of 10-15 cm from each other. The blackberry stems will be pruned again when they will grow longer, and the young shoots, which are much more fragile, will also be pruned with great care.

In the following years, blackberry shrubs should be pruned according to the same principles as in the third year, keeping by 6-8 fruit shoots on a plant, and the number of new, annual shoots should be by 20-25% higher as compared with the fruit shoots. Practically, the main rule is to remove the shoots that produced fruits in the previous year. They can be easily distinguished from the young ones, due to their dark brown colour and rigidity. The young shoots are more flexible and are brownish-green [1].

Once they grow older, because of the abundant fructification, the blackberry shrubs produce fewer new shoots (2-3 a year), which are very long, thick, with poorly matured wood and very sensitive to frost. In this situation, the shoots that are not yet lignified should be slightly pruned at 20-25 cm. From the newly formed buds, new branches grow – 2-4 on each shoot. Thus, 6-9 normally developed annual stems with well-matured tissues are obtained.

Tip pruning is carried out at the end of June or beginning of July. It is necessary for the shoots that are 1 year old, longer than 2 m, and exceed the height of the trellis. Tip pruning allows obtaining shoots that are no longer than 2.0-2.5 m, forces them to branch out, producing new shoots that will bear fruit next year. The procedure involves breaking the tips by hand, or cutting them with pruning shears, favouring the development of lateral branches. At the same time, tip pruning causes the shoots to thicken, making them stronger and more vigorous so that they will have more chances to survive the winter, besides, it helps improve the productivity [4].

#### **Soil maintenance, fertilization and irrigation**

Every year, the land is ploughed to a depth of 12-14 cm, in autumn, before the leaves fall. The strips of land on the rows are hoed. Later, the weeds are removed at the same time as the shoots are thinned. Starting with the third year, the soil in the areas between the rows is loosened 3-4 times a year, with the cultivator or the harrow, to a depth of 6-8 cm.

Lately, the practice that consists in maintaining the soil between the rows covered with grass is often used in the plantations of fruit trees and shrubs. This method is recommended to be used in plantations located on eroded slopes, as well as on flat plots in areas with sufficient precipitation (over 700 mm annually) and in irrigated plantations. This type of maintenance has its advantages and disadvantages. Among the advantages, there is the possibility to work on rainy days, when the soil is wet. The establishment of the grass alleys between rows starts in the 2<sup>nd</sup>-3<sup>rd</sup> year after planting the shrubs. The grass is repeatedly mowed, the plant residues can remain as mulch. After each mowing, irrigation is necessary.

The species, or the group of species, used as cover crops must meet certain criteria: to have shallow roots and not to compete with the blackberry shrubs; to grow quickly, preventing the infestation of the area with weeds; to form a thick and even cover; to be shade tolerant and frost resistant; to recover fast after mowing, besides, perennial plants that persist as long as the plantation in question is cultivated are preferred.

Maintenance **fertilization** is done according to soil quality, climatic conditions of the year and vigour of plants. Nitrogen fertilizers should be applied very carefully. Unilateral fertilization causes, in many plantations, excessive plant growth, poor productivity and phytosanitary problems (the occurrence of diseases and the



frequency of pests sometimes increases). Organic fertilization can provide balanced plant nutrition and adequate soil fertilization for the entire period of maintaining the plantation on the same site [7].

In general, complex fertilizers are recommended for blackberry plantations. The best balance in plant nutrition is ensured by NPK fertilizers in the ratio of 1:2:3, that is, a small amount of nitrogen, a medium amount of phosphorus and high – of potassium. On potassium-rich soils, the ratio 1:2:2 can be used.

At the doses recommended below, the active substance in the fertilizer should be taken into account. For example, in a complex fertilizer 5:10:22, there are 5 kg of nitrogen, 10 kg of phosphorus and 22 kg of potassium. Foliar fertilizers are very beneficial for blackberry crops, contributing to the nutrition of plants with micro and macroelements and increasing considerably their productivity [3]. Because blackberry fruits abundantly, it must be supported by a rational soil fertilization system, along with a good care.

After the establishment of the plantation, the first basic fertilization is done in 2 years, and then repeated every two years. It consists in the application of 30-40 t/ha of manure, 300-400 kg/ha of potassium chloride and 300 kg/ha of superphosphate.

For additional fertilization, liquid manure, from poultry or livestock farms, diluted with 4 parts of water can be used [3].

**Irrigation.** Blackberry needs a lot of water during the growing season. The lack of water causes poor pollination, small, uneven fruits, and some of them do not mature and dry out. The stems grow slowly, are thin, do not form lateral branches, and the productivity in the next year is also negatively influenced.

Favorable conditions for plant growth and fructification are created when soil moisture, in the layer 0-40 cm, is permanently maintained at 70-80% of the field capacity to retain water. Furrow, spray and drip irrigation can be chosen. If drip irrigation is used, the volume of water per unit area is reduced by 20% and plants are less prone to diseases. Irrigation starts in spring and is done every 2-3 weeks, if necessary. Under the conditions of the Republic of Moldova, during the growing season, it is advisable to irrigate the blackberry plantation 4-5 times with a volume of water of 300-400 m<sup>3</sup>/ha [3].

**Protection of blackberry from frost.** A limiting factor for blackberry is its vulnerability to low temperatures in winter, about -15°C. That is why protection from frost is absolutely necessary. Some specialists advise not to cut the 2-year-old stems and let them act as a shelter from frost for 1-year-old stems, and to remove them only in spring. To protect the stems, they should be arranged in the direction of the row and covered with straw and other plant residues or with soil. If stems are protected with straw, it is a good idea to prune the bushes in autumn, and to place the cut branches over the straw, along the rows. The protection method that consists in covering the stems with soil has some disadvantages, namely, a lot of stems are damaged when uncovering them, and in rainy years, a lot of buds rot [10]. Blackberry can be successfully covered with anti-hail net, supported by poles.

## CONCLUSIONS

1. Blackberry is a fruit shrub, which can be successfully cultivated in the Republic of Moldova, selecting varieties that are appropriate to the conditions of the country and implementing agro-technical practices, necessary for the development and the production of fruits.
2. Blackberry is commonly propagated vegetatively, by layering, suckers and stem cuttings, but the most efficient method is microcloning or *in vitro* micropropagation.
3. The varieties of thornless blackberry, patented in the Republic of Moldova, are used as donor plants for micropropagation. The technology of obtaining qualitative and homogenous planting material of blackberry varieties has been developed, and the stages of initiation, microcloning, rhizogenesis and acclimatization have been described.

## BIBLIOGRAPHY

1. Babuc V., Peşteanu A., Gudumac E. Conducerea şi tăierea arbuştilor fructiferi. Manual tehnologic; Chişinău Bons Offices, 2015, p. 256.
2. Balan V., Cimpoeş Gh., Barbaroşie M. Pomicultura Editura Muzeum, Chişinău 2001. 452 p.
3. Botez M., Bădescu Gh., Botor A. - Cultura arbuştilor fructiferi, Ed. Ceres, Bucureşti, 1984;
4. Mladin Gh., Mladin P. Cultura arbuştilor fructiferi pe spaţii restrânse; Editura Cereş, Bucureşti, 1992, 198 p.
5. Ciorchină Nina, Ciubotaru A. Particularităţile citoembriologice şi biotehnologice ale proceselor de regenerare *in vitro* şi *in situ* a unor culturi noi pentru Republica Moldova. – Chişinău, 2013, Revista Botanică, Vol. V, Nr. 4
6. Lozinschii M., Ciorchină N., Particularităţile microclonării soiurilor de mur fără spini Cester şi Loch Ness. Revista Botanică, Vol. V, Nr. 3 Chişinău 2013.
7. Ghid tehnic şi economic. Coord.: Dorin Sumedrea, Ilarie Isac, Mihail Iancu. Pomi, arbuşti fructiferi, căpşun, INVEL, Piteşti, 2014
8. Rapcea M. - Tehnologia tăierii pomilor şi arbuştilor fructiferi, Institutul de Cercetări pentru Pomicultură, Tipografia Academiei de ştiinţe a Republicii Moldova, Chişinău 2003, 182 p.
9. Лозинский М., Чоркинэ Н., Клапа Д., Клонирование *in vitro* некоторых сортов ежевики. Материалы международной научной конф. 200 летию НБС. Ялта Украина 5-8 июня 2012
10. <http://www.slideshare.net/GherghescuGabriel/cultivarea-arbustilor-fructiferi>

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**BLACKBERRY – IMPORTANCE, ORIGIN AND VALUE**

**Ciorchină Nina, Cutcovschi-Muștuc Alina, Lozinschii Mariana,  
Mîrza Alexandru, Trofim Mariana**

Botanical Garden (I) of ASM, Chisinau, Republic of Moldova

**Abstract:** This article is devoted to an assessment of the importance of blackberry as a fruit-bearing shrub, in the Republic of Moldova; it presents data on the therapeutic and nutritional value, as well as the health benefits of blackberries. The description of the stages of development, the morphobiological characteristics, the pedoclimatic requirements, the results of testing 15 varieties of thornless blackberry and the blackberry x raspberry hybrid, the so-called red blackberry, and the conditions for the acclimatization and the adaptation of the recommended varieties, in our country, is given below.

**Keywords:** blackberry, blackberry x raspberry hybrid, biologically active substances, variety, cultivar, nutritional value, therapeutic value.

**INTRODUCTION**

The popularity of blackberry is due to the biochemical composition of its cultivars, namely, the high amount of vitamins, minerals and antioxidants contained by them, but also the tolerance of the cultivars to low temperature, pests and diseases, as well as their capacity to grow on low-quality soils [8, 4]. In the recent years, in the Republic of Moldova, the market demand for new varieties of cultivated plants has increased, contributing directly to the implementation of the Food and Health Programme of the country. The creation of industrial plantations with new species of fruit-bearing shrubs is a novelty for the Republic of Moldova and plays an important role in the implementation of this programme. Berries, or “small fruits”, are characterized by high content of vitamins, minerals and antioxidants. They contain a class of compounds called “the 21<sup>st</sup> century vitamins”. The large-scale cultivation of fruit-bearing shrubs and especially of new, less frequently cultivated species help widening the assortment of crops and provides a source of healthy food with a wide range of fruits [9, 12].

**MATERIALS AND METHODS**

The species *Rubus fruticosus* is highly appreciated for its delicious and healthy fruits – blackberries. The genus *Rubus* includes 740 taxa, being the largest genus in the family Rosaceae. Its fruits have high medicinal, cosmetic and nutritional value, contain valuable nutrients and biologically active substances and are popular due to their therapeutic and nutritional qualities. Blackberries can be eaten fresh or used as a main ingredient in pastries, salads, jams, juices, ice cream, liqueurs and various desserts. The therapeutic qualities of blackberries are due to the numerous active principles they contain [5, 9, 2].

**RESULTS AND DISCUSSIONS**

According to the American Cancer Society, blackberries contain 3.69 mg ellagic acid per gram of fruit. Ellagic acid exhibits significant anticancer activity. During laboratory studies, it was noted that ellagic acid slows the growth of malignant tumours and kills the cancer cells of laboratory animals [8]. The fibre and the pectin present in blackberries are beneficial to the cardiovascular system, reducing cholesterol. Besides, the magnesium found in these fruits contributes to the health of the cardiovascular system by relaxing the arteries, allowing the oxygenated blood to circulate more easily in the body [11].

## PRODUCȚIA GLOBALĂ A FRUCTELOR DE MUR

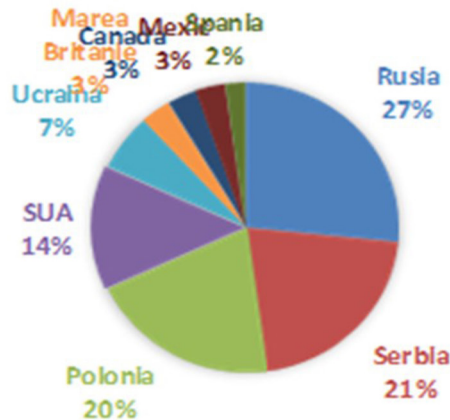


Fig. 1. Worldwide production of blackberries

Recently, in the Republic of Moldova, the market demand for the assortment of cultivated plants has increased, providing for the introduction and cultivation of the new species and varieties of plants, thus contributing directly to the implementation of the Food and Health Programme of the country. The creation of industrial plantations of fruit shrub varieties, which are highly productive in the Republic of Moldova, is an imperative nowadays and is part of the implementation of this programme. The need to cultivate and reproduce these plants is determined by the particular interest in fruit shrubs. Blackberry is one of these plants. Blackberry (*Rubus fruticosus*) is in demand, in Moldova, due to its taste and curative properties. Figure 1 reflects the situation regarding the production of blackberries in the countries where this crop is cultivated the most frequently. In these countries, except Russia, the largest part of the harvest is obtained from the spontaneous flora. In the spontaneous flora of the Republic of Moldova, there are 11 species of the genus *Rubus* [10, 4].

Thornless blackberry is grown for its fruits and leaves with tonic, diuretic, diaphoretic, laxative and depurative properties. It is recommended for the treatment of asthenia, dyspepsia, dermatoses, constipation and febrile states. People suffering from diabetes, dyspepsia and rheumatism are advised to eat fresh fruits, but processed blackberries, for example juices, syrups and jams, are also beneficial for health. The leaves have astringent, diuretic and laxative properties [26]. The varieties *Thornfree*, *Chester*, *Arapaho*, *Thornless Evergreen*, *Polar*, *Loch-Ness*, *Triple Crown*, *Tayberry* and *Loganberry* are currently of interest for many specialists around the world [9].

### Morphobiological characteristics, growth and fruit bearing

Blackberry is a subshrub with multiannual underground stem (rhizome), and the aboveground part – made up of annual and biennial stems (also called “canes”). Annually, vigorous shoots, which branch out and produce fruit buds, grow from the base of the plant. Later, the biennial stems produce fruits and then dry out and are removed from the plantation. Blackberry grows well if irrigated. It is less cold tolerant than raspberry. For this reason, warmer zones (centre, south of the country) and slopes with S or SW exposition are usually chosen for blackberry plantations and, in small gardens, blackberry is planted in areas that are sheltered from wind [6].

**Roots.** The root system is well developed and extensive. Most of the roots are located in the soil layer to a

depth of 50 cm. The roots are strong, well fixed in soil and spread over a large area around the plant. Blackberry plants have buds on the roots, which make it possible to propagate by root cuttings. Blackberry is quite rustic and can be cultivated for anti-erosion purpose or to use the lands where no other crop can be cultivated.

**Stem.** The aerial part consists of several very long biennial stems, reaching about 6-7 m, which keep growing until late autumn. Annually, from the base of the plant, several very vigorous shoots grow, branch out and produce fruit buds. In the following year, the biennial stems produce fruits and then are removed from the plantation. Numerous varieties of blackberry have stems with very coarse prickles, also called thorns, which can be long, straight or bent depending on the variety. The colour of the stems varies from green to red, violet-blue or even brown, depending on the variety, the age of the stems and the exposure to the sun.

**Leaves.** The leaves are imparipinnate or palmately compound, with 3-5 or 7 leaflets, which decrease in size from the tip to the base of the leaf. The leaf margin is finely serrated. The petiole is 5-7 cm long and may or may not have thorns that can be found, depending on the variety, on the midrib, almost until the tip of the leaf. At the bottom of the leaf, there are two small stipules (leaflets). In the axil of the leaves, on well-developed shoots, in the lower part, vegetative buds develop, as a rule, and in the middle and upper part – mixed buds.

**Buds.** At the base of the leaves, there are 2 buds, or more rarely – 3, one of which is a main bud. The main bud is large (mixed), elongated, at the tip, covered with scales with greenish-silver hairs. The secondary buds are very poorly developed, sometimes are noticeable only at the end of the growing season. The main (mixed) buds, in spring, produce shoots, on which inflorescences develop later. In cases when the main bud is lost, the secondary buds start developing and produce fruit. The most developed mixed buds, which produce the most numerous and the largest fruits, are located on the stem section ranging from 60 cm to 150 cm. Above this height, the mixed buds are weak, produce few flowers and are usually removed by pruning the stem in the following spring.

**Flowers.** The flowers are hermaphrodite, consisting of 5 large petals of various colour: from white to pink. Nectar is produced at the base of the flower and its secretion begins before the petals open and continues until they fall. Pollen and nectar are attractive to bees and the honey is of good quality. Each cyme is diffuse and contains 8-80 flowers that bloom in a staggered manner. Blooming starts from the top of the stem and progresses to the bottom, lasting for about 3 weeks.

**Fruits.** Blackberry is an aggregate fruit composed of several drupelets placed around a small, conical receptacle that, at maturity, detaches from the plant together with the fruit. Each drupelet contains a seed. The shape of the fruit (the blackberry) can be spherical, conical or cylindrical and the intermediates between them. The colour is generally black and glossy, with waxy coating. There are also blackberry varieties with red or dark red fruits. Fruit ripening begins in June and lasts until mid-August in some varieties, and in others – from the end of August until the end of October. The difference between blackberries and raspberries is also present in the characteristics of the fruit. An example is the receptacle, which is the fibrous core of the fruit. The receptacle of raspberry, when harvested, remains on the plant, creating the hollow core of the fruit, but the receptacle of blackberry remains attached to the fruit. Another distinction is the presence of trichomes (hairs) – raspberry drupelets are hairy, those of blackberries are glabrous and smooth, mostly glossy [1, 2].

#### **Environmental requirements of blackberry**

The cultivated varieties, unlike the wild ones, are much more demanding to ecological factors. The blackberry cultivated in zones with temperate-continental climate grows and bears fruit well only on lands that are sheltered from cold wind, on the slopes with southern, southeastern and eastern exposure, in areas with sufficient humidity. In sunny areas, the quality of fruits is higher and the stems lignify sufficiently until the winter comes.

**Temperature.** Blackberry is demanding in terms of temperature, during the growing season and the rest season. In winter, at -15°C, a part of buds freeze and at -17...-20°C, the wood is affected too.

**Light.** In forests, blackberry grows in partial shade, but the cultivated blackberry cannot tolerate shade, no matter how diffuse it may be. Cultivated blackberry produces high quality, well-coloured, sweet and flavoured

fruits only if grown on sunny lands.

**Moisture.** Blackberry requires large amounts of water, but it does not tolerate excess water even temporarily, as it causes root asphyxiation during the rest period. The lack of water adversely affects fruit production. The water shortage during flowering and formation of fruits causes a decrease in the number of produced fruits and, during the growth and maturation of fruits, it halts the development of fruits, which remain small, tasteless and some do not reach maturity. The most favourable areas for blackberry are those where precipitation exceeds 750 mm. Blackberry grows and fruits well if irrigated.

**Soil.** Cultivated blackberry grows well on semi-heavy, loamy or clayey soil, rich in nutrients, with pH 5.6-6.5 and with groundwater at a depth of 0.6-0.7 m.

**Relief.** It is the main factor that can change the climate regime. For the cultivation of blackberry, flat plots or smooth slopes with inclination of up to 10° are suitable, so that mechanized work can be performed. Narrow valleys with poor air circulation and without drainage and tops of hills, where there is a higher risk of frost in winter and drought in summer, are not recommended. Warmer zones (centre, south of the country) and slopes with southern or south-western exposition are usually chosen for blackberry plantations and, in small gardens, blackberry is planted in areas that are sheltered from cold wind. On slopes facing south, sun exposure is with 30% higher and the amount of available water and nutrients – lower, as compared with slopes facing north. In the lower part of the slopes, the amount of available water is about 20% higher, the minimum temperature can be 7-10% lower, and the wind speed is 1.5-1.8 times lower, in comparison with the upper part of the slopes (A. Ursu et al. 1985; C. Budan, 1993). During the ripening of the fruits, because of the winds, sand and dust can be deposited on the fruits, making them unfit for fresh consumption. In the rest season, temperatures below 0°C and cold and prolonged winds dehydrate the blackberry stems, making them less frost hardy. In order to avoid the harmful effects of air currents, it is recommended to create plantations in sheltered areas or to protect them with shelterbelts [1, 5].

#### **Taxonomic description of the main varieties of blackberry:**

At present, about 300 varieties and cultivars are known, the most appreciated of which have been created as a result of the American selection [10], where most of the blackberry species grow under natural conditions, easily interbreed and result in complex cultivars, being hybrids of several species. During the introduction of the varieties in Europe, local species were involved in the selection process and, as a result, the blackberry varieties that are cultivated nowadays were obtained from three European and nine American species. The varieties and the species of blackberry, according to the type of the shoots, the shape of the bushes and the method of propagation, are divided into two groups and an intermediate one: erect (which grow upright) and repent (or creeping). All these categories contain varieties with and without thorns. In the present study, we focused mainly on thornless cultivars, namely: *Loch Ness*, *Cester*, *Arapaho*, *Triple Crown*, *Black Satin* and *Rubus laciniatus* with the variety *Evergreen*. In order to highlight the biological and technical comparative characteristics, several types of new cultivars of blackberry have been studied: *Thornless evergreen*, *Cester*, *Arapaho*, *Thornfree*, *Smoothstem* – of American origin, *Polar* – of Polish origin, *Loch Ness* – of Scottish origin, obtained from the species *Rubus fruticosus* L., *Rubus laciniatus* and *R. canadensis*, of family *Rosaceae*.

Blackberry cultivars with special characteristics have been selected: frost resistance, drought resistance, resistance to phytopathogens, different fruit ripening terms. The cultivars are characterized by the capacity to be stored for prolonged periods, new taste qualities and resistance to mechanical stress.

These new varieties of blackberry would provide consumers, for a longer period of time, with fresh fruits rich in vitamins and other constituents – biologically active substances (BAS) of undeniable alimentary and therapeutic value.

The studied cultivars are characterised by different fruit ripening terms: *Arapaho*, *Loch Ness* and *Triple Crown* (*R. fruticosus*) are early ripening varieties, *Thornless evergreen* (*R. laciniatus*), *Chester* and *Thornfree* (*R. fruticosus*) – late ripening (July-September). The cultivars also differ in the biological characteristics of the plants: repent stems – *Evergreen*, *Loch Ness*, *Thornfree*, *Smoothstem*, semi-erect stems – *Cester*, *Triple Crown*



and erect stems – *Arapaho*, *Polar*. The cultivars *Cester* and *Arapaho* are characterised by medium vigour, and *Evergreen*, *Tornfree*, *Polar* and *Triple Crown* are vigorous plants [4, 5].

The research on the peculiarities of the development of these crops, as well as the assessment of their needs in terms of environmental factors, allowed us to find a real possibility of introducing the studied cultivars in various industries, in the Republic of Moldova. Lately, in order to meet the increasing demands of the growing population, the research has been focused on creating new varieties of blackberry with therapeutic and technological characteristics that are superior to the current ones, so that the necessary fruits could be available to customers all year round. The new cultivars, mutant forms and hybrids of blackberry can become a source of healthy food and a source of valuable raw material for the phytotherapeutic industry.

Currently, agrotechnical works and scientific research carried out by specialists from different fields may help increase the production of blackberry varieties in the Republic of Moldova. This article discusses some aspects of the selection of valuable blackberry cultivars, according to certain biological and technical criteria. Account was taken of their commercial importance, but also of the fact that the varieties differ in the quality of fruits and the tolerance to abiotic stress.

### **Promising blackberry varieties in the Republic of Moldova**

*Rubus fruticosus* “*Arapaho*” is native to Arkansas, USA, and was created in 1993. It is a semi-vigorous, erect cultivar. The fruits are produced on lateral shoots, if they are pruned when they reach a length of one meter. Fruits ripen in June-August, this being the latest and the most prolonged ripening among blackberry varieties. The fruits are conical, weighing 6-8 g, are firm and easy to handle and transport, when ripe – glossy black, with sweetish taste. The productivity of this variety is 4 kg/per plant. It can tolerate frosts of -24°C. It produces high quality fruits, with small seeds. This variety develops few suckers. It is suitable for industrial plantations, being a compact and erect shrub, recommended for machine harvesting. It is resistant to pests and diseases.

*Rubus fruticosus* “*Thorn Free*” – native to USA. It is a very vigorous, rustic, thornless plant. The stems grow very long (4-8 m) and thick (10-30 mm), during the growing season, they produce lateral shoots. The inflorescences are long, with a large number of flowers. The variety begins to produce fruits in the 2<sup>nd</sup>-3<sup>rd</sup> year after planting. It is characterised by very high productivity (20 t/ha) and large fruits (7-8 g). The fruits are of spherical or conically elongated shape. The drupelets are tightly joined and adherent to the receptacle. The epidermis is black with violet tinge, very glossy. The pulp is dark purple to black, with pleasant taste, slightly aromatic. The flowering – medium. The fruits mature from the middle of August until the beginning of September. This species is also characterised by high productivity, prolonged and staggered ripening, good resistance to frost and the main diseases and pests, but in some years it is vulnerable to rust, which affects the bark, and sometimes to purple blotch. Currently, it is the only cultivar that was homologated in the Republic of Moldova and was registered in the Catalogue of Plant Varieties, with the number 2522777, in 2012.

*Rubus fruticosus* “*Black Satin*” – native to USA, a very popular variety, quite vigorous, rustic, with long and erect shoots, which can grow up to 3-4 and even 5 m. The leaves are large, intense green, and the flowers – mauve-white. The variety is frost hardy, but can be affected at about -25°C, if the wood is not well matured for winter. It adapts well to various types of soil. Because the shrub has long shoots, it needs to be trained to a trellis, preferably in a fan shape. The variety is self-fertile, produces fruits of medium size, firm but with low consistency, of conically elongated shape, black and juicy. The fruit maturation stage lasts for 2 months and the harvest is performed from the end of June until the end of September. The fruits are excellent, very aromatic and appreciated by consumers, the attractive marketable appearance is preserved for a long period. This variety fruits abundantly every year, producing over 6-8 kg per plant, the yield may exceed 20 t/ha. It prefers sunny areas, sheltered from cold wind. The root system does not tolerate excess moisture.

*Rubus fruticosus* “*Cester*” – was created in USA, University of Arkansas (1985). It is a vigorous variety, without thorns, the fruit maturation stage – August-September. The plants are semi-erect, vigorous and grow fast, up to 3-4 m. The variety is frost hardy, suitable for the conditions of the Republic of Moldova, resistant to diseases, especially to foliar diseases. “*Cester*” is the most resistant to frost, of all the thornless blackberry



varieties. The fruits are produced on second-year shoots. They are large, with aromatic and pleasant taste, oval or spherical in shape, of 5-6 g, firm enough to be transported without being damaged and consist of large, black and glossy drupelets. The drupelets ripen evenly, are sweet and with excellent flavour; the variety is appreciated due to its special taste. The fruits of this variety are perfect to be eaten fresh or to prepare jams, jellies and pies. The fruits are harvested from the end of July until late autumn, when frosts begin. The productivity is very high: 5-6 kg per plant or 15-18 t/ha.

***Rubus fruticosus* “Loch Ness”** – native to United Kingdom, Scotland. It is a thornless variety, perfect for smaller gardens because it is compact, does not produce suckers. This variety produces very large blackberries, which are black and glossy. It is characterised by high productivity. It produces up to 3.6 kg of fruits per plant. Prefers very sunny areas. The cultivar is vigorous, its shoots are long, semi-erect, can grow up to 3-4 m. It is frost resistant, but can be affected at about -25°C, if the wood is not well matured for winter. The cultivar is resistant to diseases, especially to Botrytis, powdery mildew and rust, but is vulnerable to downy mildew (*Peronospora rubi*), when there is too much heat and moisture. It adapts well to various types of soil. The fruits are medium sized – 6-8 g, cone shaped, firm, can be stored well and have attractive marketable appearance, the drupes ripen evenly. The fruits have outstanding organoleptic properties, are very aromatic and are highly appreciated by consumers for their pleasant taste. Besides, they can be stored frozen and retain their qualities, including their black colour. This cultivar is also characterised by medium ripening, the fruits can be harvested from the end of July until September. It is one of the best adapted blackberry varieties to the Northern Europe, due to its winter hardiness.

***Rubus fruticosus* “Triple Crown”** – was introduced in 1998 by Beltsville Agricultural Research Center, Maryland, USA. It is the newest thornless variety of blackberry. It is semi-erect, produces shoots that grow up to 3 m. The frost resistance is average; it can withstand temperatures of -20°C. In the first 2 years after planting, it is recommended to protect the plants by covering them with straw or with foil. It has an extremely high productivity year after year. The fruits are large, 8-10 g, sweet and tasty, can be eaten fresh or in jams and pies. The harvesting period lasts from mid-July to mid-August, for about 30 days, when new blackberries ripen every day. It is a self-fertile variety. *Triple Crown* is a highly productive variety, about 15 t/ha, with sweet fruits, with well adjusted balance of sugar and acidity. The fruits are firm and able to withstand transportation.

***Rubus hybrid* “Loganberry”** – a hybrid obtained in California, in the 19<sup>th</sup> century, by crossing raspberry and blackberry. It is also called red blackberry. It is frost-sensitive, but very resistant to diseases. Its stems grow up to 4-5 cm long, are green-violet, fragile. The inflorescences are diffuse, with a small number of flowers. The fruits are large, of elongated, conical-cylindrical shape and composed of drupelets, which are big, tightly joined and adherent to the receptacle. The pulp is juicy, sour, with no particular aroma. Fruit maturation occurs from mid-July to August. Loganberries are perfect for jams and jellies, but can also be eaten fresh. They are very juicy, alterable and can be easily crushed. This variety has low productivity, up to 8-10 t/ha. It needs a trellis for support, because it grows up to 2.5-3 m. It is a self-fertile variety. Loganberry can be propagated by cuttings and by *in vitro* culture; it doesn't produce suckers and cannot be propagated by layering [6].

***Rubus hybrid* “Tayberry”** – this hybrid was patented in 1979, by Derek Jennings, at the Scottish Horticultural Research Institute, as cross between a blackberry and a red raspberry, and was named after the river Tay in Scotland. The shoots are semi-erect and need to be trained to a trellis. Tayberry produces fruits that sum up the qualities of blackberry and raspberry, encompassing the benefits of these two berries, which contain high amounts of pectin, soluble fibre, antioxidants and other biologically active substances, which are excellent for the human body. Tayberry has become popular in a short time and is increasingly attracting the attention of specialists, thanks to its very tasty fruits, larger than raspberries. The fruits are cone shaped and become reddish-purple when ripe. It has inherited from blackberry the shape of the fruit and the receptacle, which remains in the berry when it is picked. Unlike the parental forms, tayberry fruits ripen 2-3 weeks earlier than raspberries and blackberries. It should be noted that two types of tayberry are known on the market: with thorns, named Medana (1981), and without thorns – Buckingham, the latter being 2-3 times more productive,

the fruit weigh up to 15 g, the productivity reaches 5-8 kg per plant, more than 20 t/ha. The fruits are sour-sweet, with a strong flavour, can be eaten fresh, have therapeutic capacities, can lower cholesterol in the blood and have immunomodulatory properties. The conic shape of the fruit of the Buckingham variety is more pronounced and it is larger in size. The fruits of the Medana variety mature 7-10 days earlier than the Buckingham variety. The fruit ripening of both varieties is staggered and lasts all summer long. These varieties start fruiting in the 2<sup>nd</sup>-3<sup>rd</sup> year. Tayberry, as most hybrids, is resistant to frost, diseases and pests. Nevertheless, it has a disadvantage, when it comes to harvesting, the fruits detach from the plant only when fully ripe, but at this stage, they are very soft, alterable and can be easily crushed. This is the reason why tayberry is not cultivated as a commercial crop, but has remained a rustic shrub, commonly grown in household gardens. The fact that tayberry is not cultivated in industrial plantations is the main reason why its fruits are so expensive [6].

***Rubus laciniatus* "Thornless Evergreen"** – native to USA. It is a repent cultivar, its stems are 3-6 m long and creeping, of even thickness and medium vigour. The cultivar is frost-sensitive, vulnerable to rust; its leaves remain green even in winter. The inflorescences are medium-sized, diffuse, consist of 12-35 flowers. The variety is semi-vigorous and productive. The fruits are cone shaped, high quality, of 4-5 g, black, with tightly joined drupelets, with no receptacle, with juicy pulp, slightly acidic, firm and resistant to transportation, with sweet taste when full ripe. The fruit maturation stage lasts from July to September. It is a variety with medium productivity (12-14 t/ha). It cannot be propagated by root cuttings, because the obtained plants have thorns. It grows and develops well under the conditions of the Republic of Moldova. It is resistant to droughty conditions, in summer and winter, and cold tolerant.

#### **Harvesting blackberries**

The harvest of early ripening varieties begins in early June and lasts for 20-25 days, but the harvest of late ripening varieties – in mid-August and lasts for 50-60 days. Thus, blackberries are available for a long period and can be eaten fresh or processed (in juices, fruit syrups, jams etc.).

The productive potential depends on the cultivar and is about 5-12 t/ha. A plantation should be exploited for 12-15 years. In our country, blackberry is cultivated by amateurs in household gardens.

The harvesting period lasts 20-50 days, depending on the variety (see Table 1, description of varieties) and climatic conditions. The harvest of varieties with thorns and those without thorns, in excessively hot summers, begins and ends 15 to 20 days earlier. It is necessary to note that thornless blackberry varieties are characterized by a longer fruit maturation stage and, as a result, the harvesting is done in a staggered manner. Because the blackberry fruits are alterable, they are harvested when the weather is dry and cold. The fruits intended for fresh consumption should be harvested directly in containers with the capacity of 250-500 g. After that, they are put in the boxes and placed immediately in the refrigerator at 1-2°C. Blackberries can be stored in this space for 3-4 days, if the temperature is maintained within the determined limits. In most cases, blackberries are harvested manually. A worker can harvest 60-70 kg/day of fruits intended for fresh consumption and up to 100 kg/day of fruits intended for processing. In areas with cooler climate, blackberries are harvested once a week, and in warmer – every four days. In the countries where the fruit-growing industry is well developed, the blackberries, in large plantations, are harvested by machine. The harvesting machines move along the rows and are based on a set of vibrations, which induce ripe blackberries, together with the receptacle, to detach from the plant. An air jet is used to remove leaves and other light impurities and then the blackberries are gathered using fruit collectors and stored in containers with the capacity of 2 kg to 4 kg. Machine harvesting is repeated every 5-6 days [2].

## **CONCLUSIONS**

1. The cultivation of blackberry, in the Republic of Moldova, is profitable and necessary. Blackberry fruits possess high antioxidant capacity and are recommended, as a source of biologically active substances, for the food, cosmetic and pharmaceutical industry.

2. Promising blackberry varieties, for the Republic of Moldova, have been identified and tested. Agrotechnical procedures for their cultivation have been determined, the morphoanatomical and biochemical study has been carried out and the varieties that are resistant to unfavourable conditions, pathogens and pests, and produce fruits with high technological, taste and biochemical qualities, have been identified. As a result of testing several blackberry varieties, the ones that are of theoretical and practical value as fruit crops have been highlighted.
3. The obtained planting material served as a source for the creation of modern plantations on the territory of the Republic of Moldova. On the experimental plot of the Botanical Garden of ASM, a collection of 10 blackberry varieties without thorns and 8 blackberry x raspberry hybrids was established.

## BIBLIOGRAPHY

1. Balan V., Cimpoeș Gh., Barbaroșie M. Pomicultura Editura Muzeum, Chișinău 2001. 452 p.
2. Botez M., Bădescu Gh., Botor A. - Cultura arbuștilor fructiferi, Ed. Ceres, București, 1984;
3. Mladin Gh., Mladin P. Cultura arbuștilor fructiferi pe spații restrânse; Editura Cereș, București, 1992, 198 p.
4. Fernandez Fernandez Felicidad. 2008. Minor crops: An alternative for the UK fruit industry? Nuffield Farming Scholarships Trust (referat).
5. Ghid tehnic și economic. Coord.: Dorin Sumedrea, Ilarie Isac, Mihail Iancu. Pomi, arbuști fructiferi, căpșun, INVEL, Pitești, 2014.
6. Mîrza Alexandru, Rudi Ludmila, Antioxidant activity of extracts from the fruits of Tayberry (*Rubus loganobaccus* L. H. Bailey), Life sciences in the dialogue of general generations: "Connections between universities, Academia and business community" 25 March, 2016, Chisinau, Republic of Moldova, Abstract Book, p. 46.
7. <http://gradinamax.ro/product/mure>
8. <http://www.ayushveda.com/dietfitness/benefits-of-blackberry/>
9. Tămaș M., Ilie Oniga. 2009 Plante medicinale de perspectivă pentru introducere în cultură;
10. <http://www.biodiversityexplorer.org/plants/rosaceae/rubus.htm>
11. <http://www.daciccool.ro/sanatate-si-frumuseti/alimentatie-sanatoasa/7169-fructele-de-padure-un-manunchi-de-beneficii>
12. <http://www.formula-as.ro/2013/1088/medicina-naturii-44/>

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## IN VITRO MORPHOGENESIS OF RUBUS SPECIES

**Mariana LOZINSCHII**

Botanical Garden (Institute) of the Academy of Sciences of Moldova

**Abstract.** Various types of explants, used as biological material for initiation, and the composition of growth media were tested. Effective results were obtained by using media with leaf explants. This experiment was performed in 3 repetitions, using 10 blackberry taxa (Loch Ness, Arapaho, Triple Crown, Polar, Thornfree, Thornless Evergreen, Balck Satin, Chester, Reuben, Smoothstem). The main medium, in which pieces of leaf blade were placed, was Murashige and Skoog (MS) (1962) modified, with 5 g/l agar, 25 g/l sugar, pH 6.0, supplemented with growth regulators. The media were supplemented with different concentrations of auxins and cytokinins in different correlations and proportions: 6-Benzylaminopurine (BAP), kinetine (KIN), Naphthaleneacetic acid (NAA), Indole-3-acetic acid (IAA), 2,4-Dichlorophenoxyacetic acid (2,4-D)

**Keywords:** blackberry, callusogenesis, organogenesis, medium, in vitro, growth regulators

### INTRODUCTION

*In vitro* morphogenesis is a complex morphoanatomic and physiological process, associated with the differentiation phenomenon that results in the formation of an integral organism [1, 2].

Plant callus is a tissue with proliferating cells, with special characteristics in relation to other types of plant tissues. They are actively dividing and do not differentiate unless there is a certain hormonal balance in the cells, which is capable to influence the triggering of organogenesis processes [1, 5, 6]. Callus can be of various origins, depending on the causes that led to its generation [1]. In nature, callus forms to cover wounded areas of plants, it exerts a protective, wound-healing role [1]. In tissue culture, callus can be obtained from any living cell [1, 7]. Callogenesis can be achieved from various explant material: portions of leaves, stems, buds, cotyledons etc. The cytokinins BAP and TDZ are often used by other researchers to induce adventitious regeneration in different blackberry genotypes [3, 6, 7, 8]. However, their research gave positive results by obtaining regeneration from the leaves in media supplemented with TDZ alone, or TDZ combined with IBA (0.1; 1.0; 2.0 mg/l) and NAA (0.1 mg/l). The highest percentage of regeneration, 41.66%, was obtained on uncombined TDZ [3, 7, 8].

In order to optimize the media required to induce morphogenetic processes, different explants collected from biotechnologically propagated plantlets: apical meristem, pieces of shoot or leaf blade [4, 5], cultivated *in vitro*, were inoculated in media with various amounts of growth regulators. In order to observe the influence of the growth medium and growth regulators on the initiation and development of the callus, several variants of media with growth regulators were tested (Table 1). Thanks to these media, the processes of callus formation and plant regeneration were triggered. The experiments on the *in vitro* culture of blackberry varieties aimed at identifying the material that is necessary for *in vitro* organogenesis and the optimal conditions for initiating the callus formation and at obtaining pure, virus-free, blackberry plants.

### MATERIALS AND METHODS

Various types of explants collected from the *in vitro* cultures of blackberry, used as biological material for initiation, and the composition of the culture media were tested. The best results were obtained by using media with leaf explants. For this reason, the research was focused on leaf blade explants taken from plantlets cultivated *in vitro*. The plants, from which the leaves were excised, had been cultured in the growth medium MS 50% + 25 g sugar, pH 5.8. The leaf blade was taken from mature plants, which had grown for 21-30 days in the *in vitro* culture. The leaves were excised from the medial part of the plant obtained by *in vitro* culture. Subsequently, they were cut in a triangular shape, inoculated on the growth medium, slightly flattened in the medium, the abaxial side being in contact with the medium and the lateral parts of the leaf blade (Table 1). This

experiment was carried out in 3 repetitions, on 10 blackberry taxa (*Loch Ness*, *Arapaho*, *Triple Crown*, *Polar*, *Thornfree*, *Triple Crown*, *Thornless Evergreen*, *Chester*, *Reuben*, *Smoothstem*) [4, 5], during April-May, using by 36 samples of each taxon. The growth media for callogenesis and organogenesis were prepared according to the methods indicated below [1, 4, 5].

The basic medium on which the fragments of leaf blade were placed was MS 100% modified with 5 g/l agar, 25 g/l sugar, pH 6.0, supplemented with growth regulators according to Table 1. In order to maintain the callus culture of *R. fruticosus* taxa, *in vitro*, it is necessary to provide temperature of  $23 \pm 2^\circ\text{C}$ , photoperiod of 16 hours and air humidity, in the room, not lower than 65%.

## RESULTS AND DISCUSSIONS

In the research on blackberry plantlets, several media were studied to induce callus formation and organogenesis. Basic growth media, auxins and cytokinins were used for the cell and tissue culture [1]. In 5 days after inoculation, the initiation and the development of callus cells were observed on all growth media.

To obtain the most efficient regenerating callus, the media were supplemented with different concentrations of auxins and cytokinins in different correlations and proportions: BAP (2.0 mg/l; 1.50 mg/l; 1.0 mg/l); BAP 1.0 mg/l+ NAA (0.2; 0.5; 1.0); BAP 1.0 mg/l+ IAA (0.2; 0.5; 1.0); KIN (1.50 mg/l; 1.0 mg/l), KIN 1.0 mg/l +NAA 0.1 mg/l; 2,4-D (0.5 mg/l; 0.75 mg/l; 1.0 mg/l).

Table 1.

Tested media for the induction of callogenesis and organogenesis in blackberry

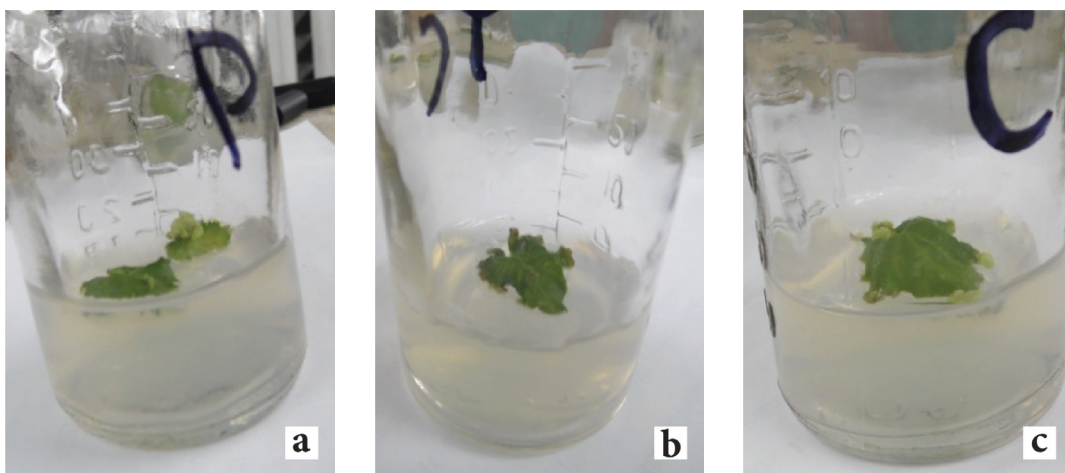
| No.  | Number of tested plantlets | Medium  | Growth regulators |      |        |      | sucrose<br>g/l | agar<br>g/l | pH  |
|------|----------------------------|---------|-------------------|------|--------|------|----------------|-------------|-----|
|      |                            |         | cytokinins        | mg/l | auxins | mg/l |                |             |     |
| N*1  | 36                         | MS 100% | BAP-              | 2.0  | -      | -    | 25             | 5.0         | 6.0 |
| N*2  | 36                         | MS 100% | BAP-              | 1.5  | -      | -    | 25             | 5.0         | 6.0 |
| N*3  | 36                         | MS 100% | BAP-              | 1.0  | -      | -    | 25             | 5.0         | 6.0 |
| N*4  | 36                         | MS 100% | BAP-              | 1.0  | NAA    | 0.2  | 25             | 5.0         | 6.0 |
| N*5  | 36                         | MS 100% | BAP               | 1.0  | NAA    | 0.5  | 25             | 5.0         | 6.0 |
| N*6  | 36                         | MS 100% | BAP               | 1.0  | IAA    | 0.2  | 25             | 5.0         | 6.0 |
| N*7  | 36                         | MS 100% | BAP               | 1.0  | IAA    | 0.5  | 25             | 5.0         | 6.0 |
| N*8  | 36                         | MS 100% | BAP               | 1.0  | IAA    | 1.0  | 25             | 5.0         | 6.0 |
| N*9  | 36                         | MS 100% | KIN               | 1.0  | NAA    | 1.0  | 25             | 5.0         | 6.0 |
| N*10 | 36                         | MS 100% | KIN               | 1.0  | -      | -    | 25             | 5.0         | 6.0 |
| N*11 | 36                         | MS 100% | KIN               | 1.5  | -      | -    | 25             | 5.0         | 6.0 |
| N*12 | 36                         | MS 50%  | KIN               | 1.0  | NAA    | 0.1  | 25             | 5.0         | 6.0 |
| N*13 | 36                         | MS 100% | -                 | -    | 2,4D   | 0.5  | 25             | 5.0         | 6.0 |
| N*14 | 18                         | MS 100% | -                 | -    | 2,4D   | 0.75 | 25             | 5.0         | 6.0 |
| N*15 | 18                         | MS 100% | -                 | -    | 2,4D   | 1.0  | 25             | 5.0         | 6.0 |

### Organogenesis in blackberry taxa

The period of callogenesis and its component phases correlates with the specificity of the tissue and the systematic belonging of the species that is cultured *in vitro*. The purpose of the experiment was to determine the duration of callogenesis and organogenesis of the leaf explants of blackberry. On the media supplemented with BAP, the initiation of organogenesis started 30 days after the inoculation of the pieces of leaf blade on media.

For a more effective development, we tested MS medium supplemented with growth regulators for the initiation of organogenesis.

The medium that induced the formation of morphogenic callus was the one supplemented with BAP (2 mg/l), so the most effective medium was N1, the results surpassed considerably the data from the literature [3, 6, 7, 8]. After the inoculation of leaf blade on modified MS medium, containing BAP (2 mg/l), during the research conducted by us, we noted that the leaf blade explants, cultured on the N1 medium, became corrugated and increased in size after 3-4 days. After 10-13 days, on the margin of the leaf blade, several spherical outgrowths of green or greenish-gray callus appeared (Figure 2), they confirm the data from literature, namely, that the callus generated from pieces of leaf blades can be green, greenish or green with yellowish shades, because the cells contain chlorophyll [1].



a) *Polar*

b) *Triple Crown*

c) *Chester*

Figure 1. Callus formations on the leaf blade of the respective blackberry varieties

It was found that the morphogenic centers were located at the surface of the callus mass and, at the margin, they were protected by the parenchymal cells of the callus, which had thicker walls. The embryogenic callus generated on the N1 medium is dense and compact (Figure 1). After a few days, the intense green, greenish-white or yellowish-green callus developed areas with embryogenic meristematic cells, and after 8 days of differentiation, the callus began to form meristemoids. The plantlets, on a piece of leaf blade, formed in the 30<sup>th</sup> day after inoculation.

The variety Loch Ness was characterized by the initiation of green, whitish and yellowish-green callus formations, pieces of leaf blade that then grew larger and prominent callus outgrowths that were different in shape and size, and were found on the margin of the leaf blade and, dispersedly, on its surface (Figure 4).



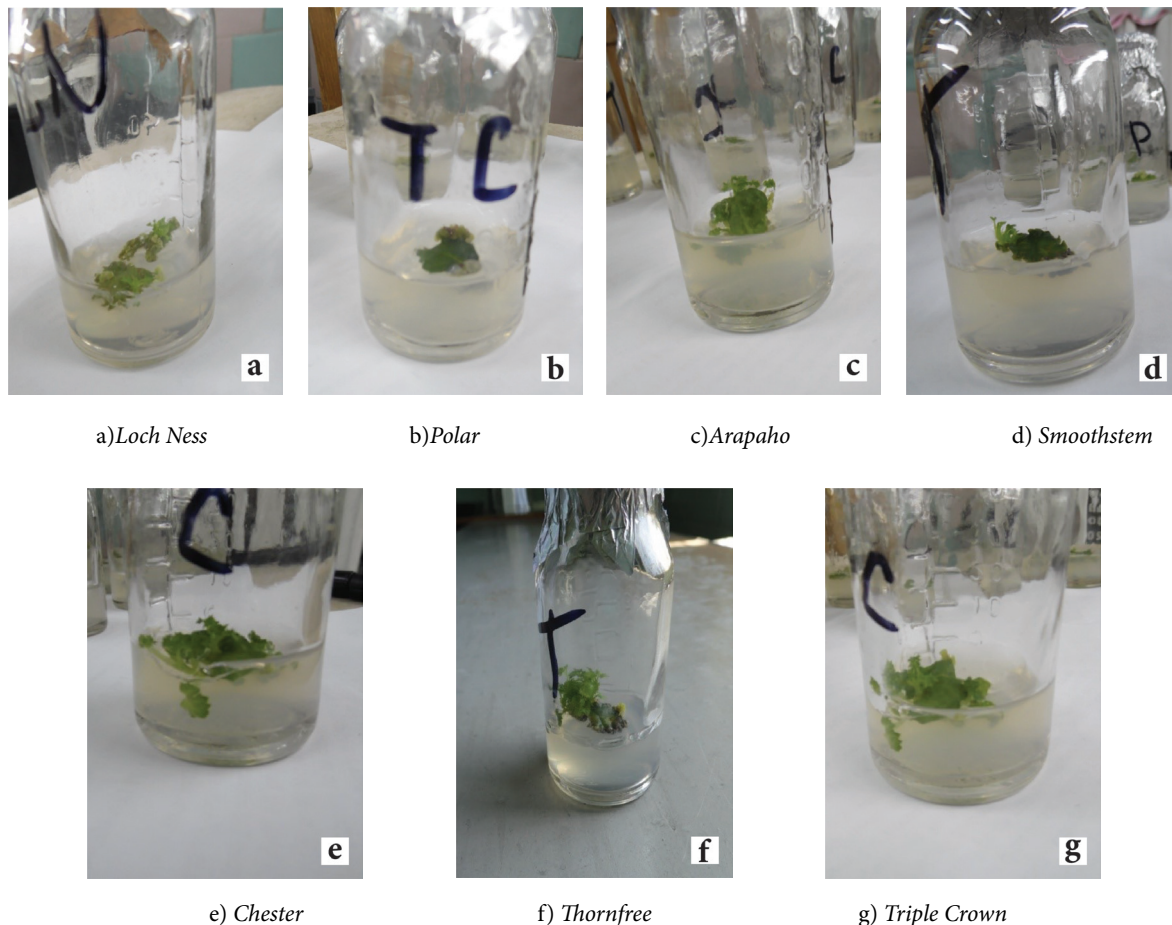


Figure 2. The location of meristemoids on the leaf blade

The locations of meristemoids on the leaf blade can be categorized into several groups:

- **dispersedly on the surface of the leaf blade:** *Loch Ness* (Figure 2 a), *Arapaho* (Figure 2 c), *Triple Crown* (Figure 2 g),
- **at the base of the leaf blade:** *Polar*, *Thornfree*, *Triple Crown*, *Thornless Evergreen* (Figure 2 b, f),
- **around the leaf blade:** *Chester* (Figure 2 b), *Reuben*,
- **at the base of the leaf blade and on nerves:** *Smoothstem*, *Triple Crown*, *Thornless Evergreen* (Figure 2 d, g).

The results of the research on the regenerative callus, initiated from fragments of leaf blade, show that the callus mass can differentiate into an embryoid, from which, stems and leaves can develop. For a complete development of the plantlet, the meristemoid is inoculated on freshly prepared MS growth medium, modified for further development [4, 5].

The media, selected for calus culture, have regenerative capacity, as evidenced by the appearance of leaf primordia. The vigorous development of morphogenic centers depends on certain factors: the duration of the callus culture, certain growth regulators, the season, the stage of development of the plant, the part of the plant being investigated, as well as external factors such as temperature, light etc. [1].

Among the studied taxa, the variety *Chester* stands out, with 10.02 plantlets formed on a piece of leaf blade



(Table 2). The variety *Black Satin* generated 9.4 plantlets on an explant of leaf blade. The varieties *Triple Crown* and *Smoothstem* generated 8 plantlets per explant. 7.5 plantlets were generated by the fragments of leaf blade of the varieties *Thornless Evergreen* and *Arapaho*. 6.5 plantlets were generated by the variety *Loch Ness*. A smaller number of plantlets was generated by the varieties *Polar* and *Reuben* – 6.2 and 6.3 plantlets, respectively (Table 2).

Table 2.

## Initiation of organogenesis on fragments of leaf blade

| No. | Medium | Variety              | Percentage of callus formation % | Number of plantlets formed from a fragment of leaf blade |     |     | Standard deviation | Number of tested samples |
|-----|--------|----------------------|----------------------------------|----------------------------------------------------------|-----|-----|--------------------|--------------------------|
|     |        |                      |                                  | Media                                                    | max | min |                    |                          |
| 1   | N*1    | <i>Chester</i>       | 85.18                            | 10.02±0.69                                               | 13  | 7   | 2.20               | 36                       |
| 2   | N*1    | <i>Th. Evergreen</i> | 66.66                            | 7.5±0.71                                                 | 14  | 4   | 2.27               | 36                       |
| 3   | N*1    | <i>Thornfree</i>     | 77.77                            | 7.8±0.32                                                 | 9   | 6   | 1.03               | 36                       |
| 4   | N*1    | <i>Arapaho</i>       | 85.12                            | 7.5±0.50                                                 | 9   | 5   | 1.58               | 36                       |
| 5   | N*1    | <i>Polar</i>         | 77.77                            | 6.2±0.55                                                 | 9   | 4   | 1.75               | 36                       |
| 6   | N*1    | <i>Reuben</i>        | 40.67                            | 6.3±0.39                                                 | 9   | 4   | 1.25               | 36                       |
| 7   | N*1    | <i>Triple Crown</i>  | 75.92                            | 8.0±0.59                                                 | 10  | 6   | 1.88               | 36                       |
| 8   | N*1    | <i>Black Satin</i>   | 75.92                            | 9.4±0.40                                                 | 12  | 8   | 1.26               | 36                       |
| 9   | N*1    | <i>Loch Ness</i>     | 77.77                            | 6.5±0.45                                                 | 8   | 4   | 1.43               | 36                       |
| 10  | N*1    | <i>Smoothstem</i>    | 81.48                            | 8±0.54                                                   | 9   | 4   | 1.71               | 36                       |

On the N1 medium, 36 samples of leaf blade fragments of each taxon were tested (Figure 3). It was determined that out of 36 samples cultured in 3 repetitions, 30.66 produced regenerative callus, which constituted 85.5%. About 29.3 samples of the variety *Smoothstem* produced callus mass, which represented 81.48%. The blackberry varieties *Thornfree*, *Polar* and *Loch Ness* produced 27.99 samples, with regenerative callus, out of 36, which constituted 77.77%. The varieties *Triple Crown* and *Black Satin* were characterised by a little lower percentage of callus formation, which constituted 75.92%. Only 66% of the pieces of leaf blade of the variety *Thornless Evergreen* generated callus, that is, 23.7 samples with callus out of 36 samples used in the experiment.

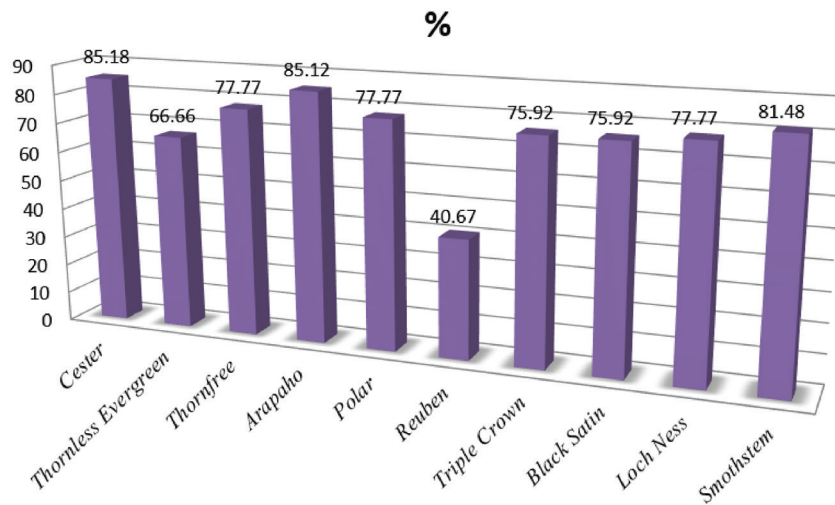
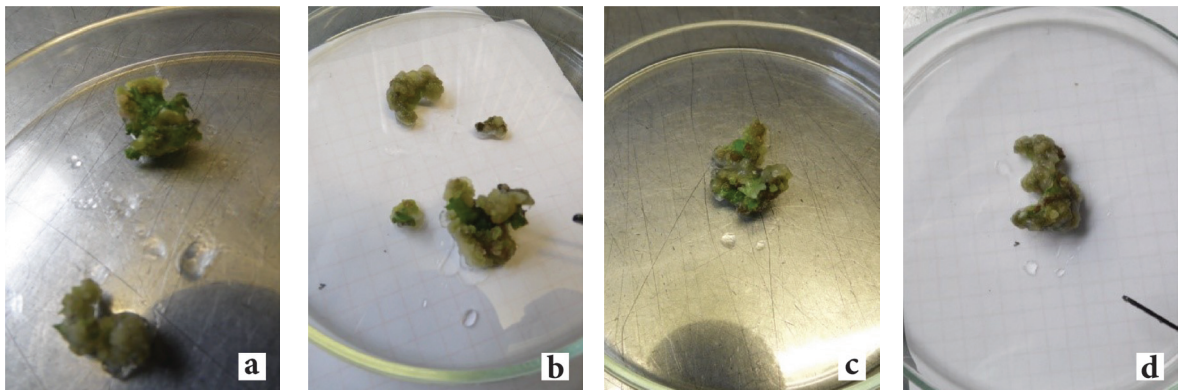


Figure 3. Callus formation on the growth medium N1

In the process of callogenesis on other media, the leaf blade samples also produced callus mass. Of course, the development was different and the type of callus varied in consistency, colour and structure. The callus developed from leaf blade, on the growth media N2-N15, differed in shape, colour and consistency, depending on the type and the quantity of the growth regulator that had been used. After the inoculation of the leaf blade on growth media MS 100%, supplemented with BAP (1 mg) and BAP (1.5 mg), 11 days after placing the samples on the studied media, some fragments of leaf blade became corrugated and larger. The differentiation of a white-green, translucent callus, with more lax consistency, was observed, and the cells of this type of callus were large, with extensive vacuome. This type of callus was non-generative (Figure 4 A).

On the media with BAP in combination with auxins, the derived callus was whitish, some clusters of cells were white-milky, its consistency was brittle, it was totally non-morphogenic and, after 35-40 days, it began to necrotize (Figure 4 A, B, C, D).



**Figure 4.** The development of callus from pieces of leaf blade on media supplemented with growth regulators

- A** – medium supplemented with BAP 1.0 mg/l; 1.5 mg/l); **B** – medium supplemented with BAP 1.0 mg/l + IAA 0.5 mg/l;  
**C** – medium supplemented with BAP 1.0 mg/l + NAA 0.5 mg/l;  
**D** – medium supplemented with BAP 1.0 mg/l + NAA 1.0 mg/l.

The media supplemented with 2,4-D in different concentrations (0.5 mg/l, 0.75 mg/l, 1.0 mg/l) had a non-regenerative and inhibitory effect, which confirms the data from literature [3, 6].

On the media supplemented with KIN cytokinin (N9, N10, N11, N12), the experimental variants did not give a positive morphogenic response, and a very low percentage of samples, after 35-40 days, became very productive in callus mass, from greenish-white to brownish-yellow in colour, with a predominantly friable consistency, non-morphogenic.

As a result of the research on callus formation on the above-mentioned media (Table 1), it was found that callus was produced on all the media, but not all of it was morphogenic. Organogenic callus was produced only on the growth medium N1. The best growth regulator for callus induction was BAP. Another growth regulator that induced callus formation was 2,4-D 1 mg/l in combination with KIN 1 mg/l.

The plantlets obtained from callus, on medium N1, were healthy, robust, vigorous and uncontaminated in the *in vitro* culture and, subsequently, *ex vitro*. In 7 days, they formed a well-developed root system and a stem with several internodes. The growth of these plantlets exceeded by 50% the growth and the rhizogenesis of plants that were traditionally obtained from meristems by micropropagation. These data confirm the fact that callus culture initiates plantlets that are virus-free and with greater potential for growth and development.

As a result of the study, it was found that the presence of meristemoids formed on the surface of the callus is a process of limited duration. Undoubtedly, the formation of mini-shoots on the callus occurs until a certain time, after which, they should be transplanted to another medium for further development (micropropagation or microcloning).

## CONCLUSIONS

1. The process of callogenesis usually initiates 13-15 days after placing the pieces of leaf blade on the growth medium. The use of the tested growth media N2-N15 results in the proliferation of non-regenerative callus on the pieces of leaf blade.
2. BAP, in amount of 2 mg/l, plays a primordial regenerative role, being effective for obtaining *in vitro* organogenesis in the studied varieties. Organogenesis initiates in the 28th-30th day after inoculation. The most effective and optimal medium for inducing organogenesis in blackberry varieties is N1.

## BIBLIOGRAPHY

1. Cachiță, C. D., ș. a. 2004, *Tratat de biotehnologie vegetală*, Ed. "Dacia", Cluj-Napoca, vol 1, 433 p.
2. Calalb T. *Structura și compoziția biochimică a fructelor de Aronia Melanocarpa (MICHX.)Elliot in vivo și in vitro*, Teză de dr. Hab. În biologie, Chișinău, 2010, 312 p.
3. Lazic T., Ruzic D., *Organogenesis in vitro from the leaf of blackberry cv, Čačanska Bestrna*. Genetica, 2007, vol 39 No.1, 69-78 p.
4. Lozinschii M., Ciorchină N., Calalb T. *Micropropagation of blackberry cultivars – perspectives for Republic of Moldova*. În revista: Marisia, Studii și materiale, Vol. XXXV, Științele naturii, 2015, p. 9-17,
5. Lozinschii M., Ciorchină N., *Growth Regulators influence on some Varieties of blackberry cultivars during the micro-cloning process*, Coservation of plant diversity, International symposium 3 rd edition, 2014, 22-24 May 2014, Chisinau, pag. 20.
6. Mcnicol, R. J. and Graham J.: *In vitro* regeneration of Rubus from leaf and stem segments. Plant Cell, Tissue and Organ Culture, 21, 1990, p. 45-50.
7. Meng R., Chen T., Fin C., Li Y., *Improving in vitro plant regeneration from leaf and petiol explants of Marion blackberry*. HortScience, vol 39(2), 2004, 316-320 p.
8. Tang H., et al.. *Plant regeneration from leaves of sweet and sour cheery cultivars*. Scientia Horticulturae, vol. 93, 2002, 235-244 p.

CZU 581 : 635.92.05

## LEAF MORPHOLOGY AND ANATOMY OF SOME SPECIES OF THE GENUS *KNIPHOFIA* MOENCH

*Irina Sfeclă*

Botanical Garden (Institute) of the Academy of Sciences of Moldova

**Abstract:** This article includes several aspects of histo-anatomical characteristics of the leaves of the species: *Kniphofia uvaria* (L.) Hook., *K. ensifolia* Bak., *K. tukii* Bak., *K. nelsonii* Mast and *K. sarmentosa* (Andr.) Kunth. Fresh biological material, harvested in 2015, from the specimens found in the collection of non-traditional perennial plants of the Botanical Garden (Institute) of ASM, was used for this study. The morphoanatomical features of the leaves allow determining such characteristics as succulence and water storage capacity, which helps the plants tolerate drought and cope with this stress factor, characteristic of xerophytes.

**Keywords:** *Kniphofia*, leaf, anatomy, morphology.

### INTRODUCTION

The first studies on the genus *Kniphofia* Moench (red-hot pokers, tritomes) have described the macro-morphological characteristics of the species [5, 7]. Of all the vegetative organs, leaf is the most used in plant taxonomy. Srivastava (1978) described the leaf epidermis as the second most important characteristic, after cytology, in solving taxonomical problems [9]. Leaf anatomy is used by many researchers in the classification of difficult taxonomic groups and, in the case of the genus *Kniphofia*, in solving some uncertainties regarding the specific and generic belonging. A. Berger has done the first descriptions, at anatomical level, of the species of red-hot pokers (tritomes) in his monumental work "Pflanzenreich" vol. IV, which includes descriptions on the genus *Kniphofia* [5]. In W. Russell's opinion, this study has many gaps and considers it necessary to carry out a more detailed study on the leaf structure of *Kniphofia aloides* Moench (syn. *Kniphofia uvaria* (L.) Hook.) [10]. Baijnath (1980) studied the leaf anatomy of 18 species of red-hot pokers to assess the taxonomic value of the anatomical features of leaves. He discovered that the leaf area and the internal anatomy proved to be useful features, especially for the exclusion of the genus *Notosceptrum* [1].

### MATERIALS AND METHODS

The biological material was collected in 2015, from the species: *Kniphofia ensifolia* Baker, *K. uvaria* (L.) Hook., *K. tukii* Baker, *K. nelsonii* Mast. and *K. sarmentosa* (Andr.) Kunth. Fresh material was used, from which cross sections were prepared by hand. To detach the epidermis, we used the peeling method. Stomatal density (SD) is the number of stomata per mm<sup>2</sup>. To determine the SD, we used the micrometric coefficient for each eye piece-objective pair at the microscope Biolam-D-12. Pictures were taken with Kodak AF camera, 8.2 megapixel. The statistical processing of the obtained data was performed by calculating the arithmetic mean and the standard error in the MS Excel program.

### RESULTS AND DISCUSSIONS

The genus *Kniphofia* Moench comprises about 75 species of perennial herbaceous plants, native to southern and eastern Africa, one species is endemic to Madagascar and one – to the southern part of the Arabian Peninsula [6]. For a long time in the post-Linnaean period, the genus *Kniphofia* was considered part of the Liliaceae Juss. family [2, 5, 6, 12]. At the moment, its taxonomic position is [13]:



|            |                                       |
|------------|---------------------------------------|
| KINGDOM:   | <i>Plantae</i>                        |
| PHYLUM:    | <i>Angiospermae</i>                   |
| CLASS:     | <i>Liliopsida (Monocotyledonatae)</i> |
| ORDER:     | <i>Asparagales</i> Link               |
| FAMILY:    | <i>Asphodelaceae</i> Dumort.          |
| SUBFAMILY: | <i>Asphodeloideae</i> Burnett.        |
| GENUS:     | <i>Kniphofia</i> Moench               |

The root system of *Kniphofias* consists of an underground rhizome, which develops numerous fleshy roots [3, 11]. The vast majority of species do not produce an aerial stem [4, 11]. The linear leaves form a dense rosette at the base of the plant [4]. The flowers range in colour from yellow to deep red. They are grouped in compact terminal spikes [4, 11]. The fruits are capsules that produce 8-10 seeds. The seeds are deltid, 2-3 mm long, green to dark brown. Red-hot pokers are generally cultivated as ornamental plants.



Fig. 1. The aspect of the studied species during the abundant flowering stage (1 - *Kniphofia uvaria* (L.) Hook.; 2 - *K. ensifolia* Baker; 3 - *K. nelsonii* Mast.; 4 - *K. tukii* Baker; 5 - *K. sarmentosa* (Andr.) Kunth.)

**Leaf morphology.** All the species of *Kniphofia* have semi-succulent leaves, a character that underlies the delimitation of the genus *Kniphofia* Moench from the genus *Aloe* L. [6, 8]. The characteristics of the leaf are often used to distinguish between species.

The leaves from the bottom of the rosette die every year. In spring, a new group of 6-20 leaves develops instead (Fig. 2 A, B). The leaves located in the centre of the group are shorter and narrower, more or less filiform. Only the characteristics of the leaves situated outside the annual group were used in the morphological description.

Table 1.

Morphological characteristics of leaves

| Morphological characteristics<br><i>K. ensifolia</i> Baker |   | SPECIES                        |                          |                             |                                           |                                           |
|------------------------------------------------------------|---|--------------------------------|--------------------------|-----------------------------|-------------------------------------------|-------------------------------------------|
|                                                            |   | <i>K. uvaria</i> (L.)<br>Hook. | <i>K. tukii</i><br>Baker | <i>K. nelsonii</i><br>Mast. | <i>K. sarmentosa</i><br>(Andr.)<br>Kunth. | <i>K. sarmentosa</i><br>(Andr.)<br>Kunth. |
| The number of leaves<br>in an annual group                 | 1 | 8-12                           | 10-20                    | 12-20                       | 12-16                                     | 6-8                                       |
|                                                            | 2 | 10.7±1.29                      | 14.3±0.80                | 16.6±2.31                   | 14.2±1.88                                 | 7.4±0.93                                  |
|                                                            | 3 | 12.00                          | 20.91                    | 13.97                       | 13.31                                     | 12.53                                     |
| The length of a leaf<br>(cm)                               | 1 | 56-118                         | 67-81                    | 61-84                       | 65-78                                     | 50-65                                     |
|                                                            | 2 | 88.3±18.8                      | 74.6±1.19                | 76.2±7.43                   | 71.7±4.56                                 | 58.9±4.75                                 |
|                                                            | 3 | 21.28                          | 5.54                     | 9.74                        | 6.35                                      | 8.06                                      |
| The width at the base<br>of a leaf (cm)                    | 1 | 1.5-4.5                        | 1.59-1.81                | 2.6-4.4                     | 2.8-4.6                                   | 1.2-3.1                                   |
|                                                            | 2 | 3.1±0.89                       | 1.69±0.02                | 3.6±0.58                    | 3.9±0.60                                  | 2.4±0.64                                  |
|                                                            | 3 | 28.89                          | 4.91                     | 16.26                       | 15.33                                     | 26.36                                     |

1 – maximum and minimum value; 2 – arithmetic mean and standard error; 3 – coefficient of variation

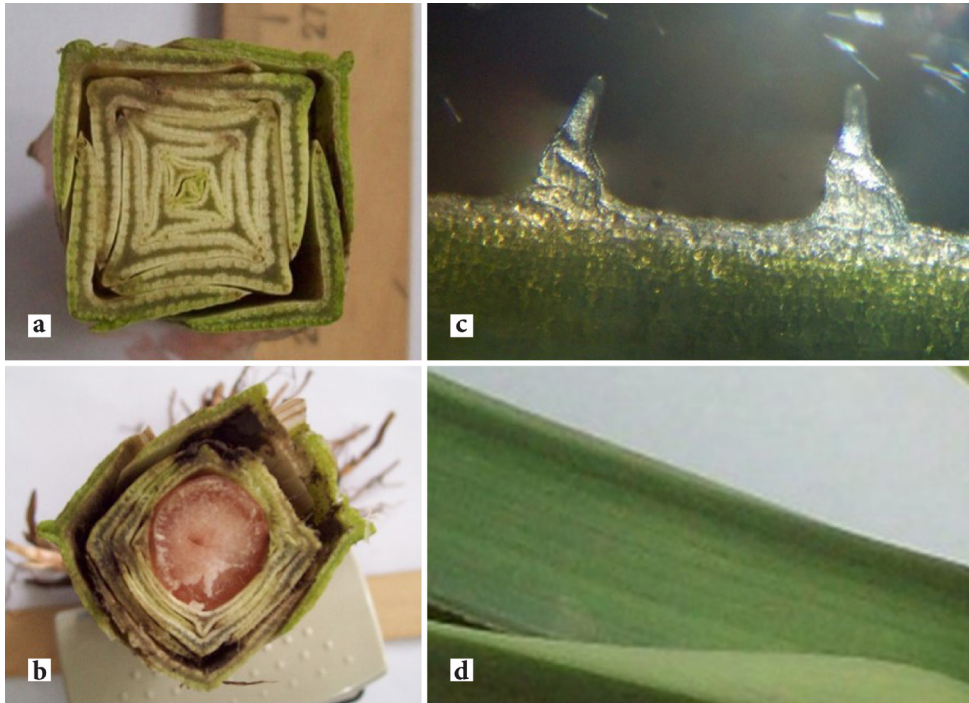


Fig 2. Some morphological characteristics of the leaf: A, B – leaf arrangement in the rosette (A – the base of the rosette of *K. uvaria* (L.) Hook. in cross section, B – *K. nelsonii* Mast.); C – the toothed margin of the leaf of *K. nelsonii* Mast.; D – the entire margin of the leaf of *K. tukii* Baker



The studied species have linear, long acuminate, opposite leaves (Fig. 2 A, B). The leaves of some species can be arched or recurved (*Kniphofia ensifolia*, *K. uvaria*), but most of them are at first erect and later geniculate from the middle (*K. nelsonii*, *K. sarmentosa* and *K. tukii*). A more rigid and fibrous texture is characteristic of *K. uvaria*. The midrib, on the upper side of the leaf, is canalicular and, on the lower side, is smooth or toothed and hull-like. The margin of the leaf blade is entire (*K. ensifolia*, *K. tukii*) or toothed (*K. nelsonii*, *K. sarmentosa*, *K. uvaria*) (Fig. 2 C, D). The teeth are 1-2 mm long. The leaf surface is glabrous in all the studied species. The thickness of the leaf is about 2 mm and is determined by the colourless palisade parenchyma. The large thickness of the leaf blade demonstrates the xeromorphism of the studied taxa. In cross section, the leaf blade is V-shaped at the base and Y-shaped at its tip (Fig. 2 A, B). The biometric analysis of the leaves of the studied species is presented in Table 1. The rosettes with a larger number of leaves are characteristic of *K. uvaria* and *K. tukii*, but the coefficient of variation of this feature is also higher in *K. uvaria*. Longer leaves are characteristic of *K. ensifolia*. With regard to the width of the leaf at the base, we can also highlight *K. uvaria*, which has the lowest index, of  $1.69 \pm 0.02$  cm.

**Leaf anatomy.** In terms of structure of the cross section, the leaf of *Kniphofia* consists of epidermis, mesophyll and vascular tissue (Fig. 3). Both epidermises are similar, consisting of a cell layer, with well-defined cuticle, made of prosenchymal cells (Fig. 3 A). The studied species have amphistomatic leaves, diacytic stomata with two accessory cells, characteristic of xeromorphs (Fig. 3 E). Their density on the upper epidermis, as well as on the lower one is on average 20-30 per  $\text{mm}^2$  (Fig. 3 C, D). In comparison with the mesophytes (SD  $1200/\text{mm}^2$  – *Filipendula ulmaria* (L.) Maxim.; millions/ $\text{mm}^2$  – *Helianthus annuus* L.), the stomatal density in xerophytes is lower (SD  $10/\text{mm}^2$  – *Sedum acre* L.) [14].

The mesophyll is isolateral. Under each epidermis, there are 1-2 layers of palisade cells, followed by lacunar tissue, rich in chlorophyll. The central part of the mesophyll consists of a colourless parenchyma composed of cells that are much larger than the cells of the palisade and lacunar tissue, of a rounded shape, which has storage function. The vascular bundles are quite numerous and located in lacunar tissue. They are arranged in two parallel rows, delimited by the colourless parenchyma. The midrib is more prominent on the underside and constitutes a vascular bundle (Fig. 3 A, B).

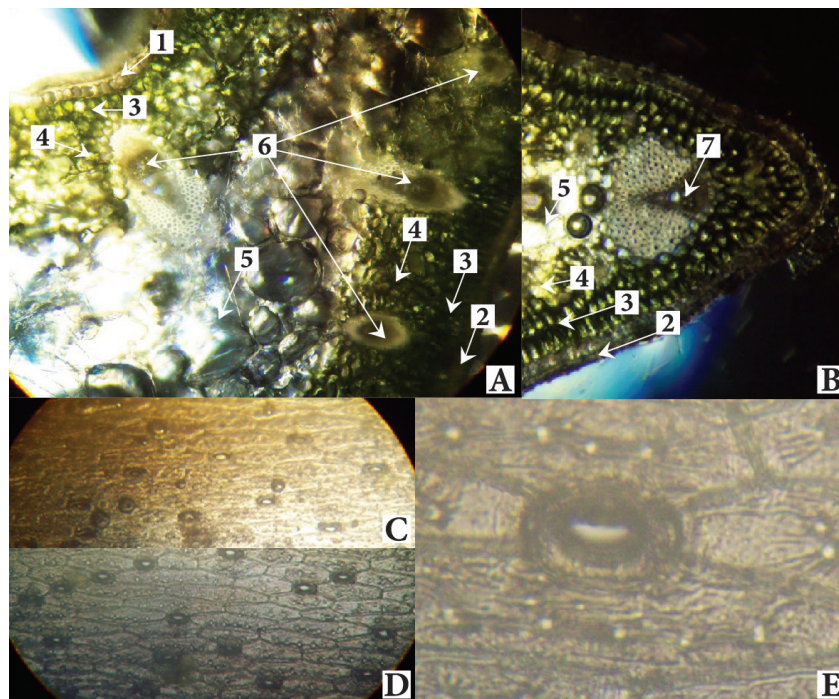


Fig. 3. Leaf anatomy (*Kniphofia ensifolia* Baker): A – cross section of the leaf blade; B – cross section of the midrib; C – upper epidermis; D – lower epidermis; E – the shape of a stoma. 1 – upper epidermis; 2 – lower epidermis; 3, 4, 5 – mesophyll (3 – palisade cells, 4 – lacunar tissue, 5 – colourless parenchyma); 6 – vascular bundle; 7 – midrib

## CONCLUSIONS

The morphoanatomical features of the leaf of the studied species of *Kniphofia* allow determining such characteristics as succulence and water storage capacity, which helps the plant tolerate drought and cope with this stress factor, characteristic of xerophytes.

The density of stomata is an important specific and physiological feature. The small density of stomata in red-hot pokers (20-30/mm<sup>2</sup>) denotes the fact that the plant limits the intensity of the process of transpiration and is an adaptive feature that improves its drought tolerance.

Such characteristics as the hull-like midrib and the margin of the leaf blade, which may be smooth (*K. ensifolia*, *K. tukii*) or toothed (*K. nelsonii*, *K. sarmentosa*, *K. uvaria*), are distinctive features that are used in species determination.

## BIBLIOGRAPHY

1. Baijnath, H. A. - Contribution to the study of leaf anatomy of the genus *Kniphofia* Moench (Liliaceae), Petaloid Monocotyledons No. 8, Dorchester. 1980, pp. 89-104.
2. Baker J. G. *Flora capensis*, 1896
3. Bală Maria, *Floricultura generală și specială*, Editura de vest Timișoara, 2007, 436 pp.
4. Baley L. H., 1947, *The standart cyclopedia of Horticulture*, Ed. The Macmillan Company New York.

5. Berger A. – Pflanzenreich, Leipzig, 1908, pp 31-57.
6. Codd 2005, Flora of southern Africa
7. Hooker J. D. - Genera Plantarum V 3, Londini, 1883, p. 775.
8. Moench C. (1794)
9. Morariu I., Botanica generală și sistematică, Editura „Ceres” București, p. 568.
10. Russell W. – Notw sur la structure des feuilles de Kniphofia aloides Moench, Buletin du Muséum national d'histoire naturelle N 1, Paris, 1938, pp. 176-177.
11. Tony Lord, 2003, Flora The gardener's bible, Ed. „Cassell” London.
12. Тахтаджян А. Л. Система и филогения цветковых растений. Изд. Наука, Москва, 1966 с.
13. <http://www.theplantlist.org/tpl1.1/search?q=kniphofia> (vizitat 25.09.2017)
14. [https://www.researchgate.net/publication/260266847\\_Particularitati\\_anatomice\\_si\\_adaptari\\_ecologice\\_ale\\_frunzelor\\_speciilor\\_genului\\_Plantago](https://www.researchgate.net/publication/260266847_Particularitati_anatomice_si_adaptari_ecologice_ale_frunzelor_speciilor_genului_Plantago) (vizitat 27.09.2017)

## II. CONSERVATION OF BIOLOGICAL DIVERSITY

CZU 58.006: 502.75:582.948.2(478)

### RARE AND ENDANGERED SPECIES OF THE *BORAGINACEAE* JUSS. FAMILY IN THE FLORA OF THE REPUBLIC OF MOLDOVA

**Cantemir Valentina**

*Botanical Garden (Institute) of the Academy of Sciences of Moldova,*

*e-mail: v\_cantemir@yahoo.com*

**Abstract:** Data on the bioecological and chorological features of 21 species of rare plants of the *Boraginaceae* family, 17 of which are threatened (categories: CR, EN, VU), assessed according to IUCN criteria (2001, 2003), are presented in this article. The list of species is proposed to be included in the Law on Rare Species Protected by the State and in the 4<sup>th</sup> edition of the Red Book of R. Moldova.

**Keywords:** flora, rare species, conservation status, *Boraginaceae*, R. Moldova.

## INTRODUCTION

The intensive crop farming and the overexploitation of natural resources, the pollution and the reckless management of forest, steppe, aquatic and riparian ecosystems have caused the loss of many populations of plant species and natural plant communities. Therefore, the number of species that become rare or threatened with extinction increases in all natural ecosystems. Currently, in the flora of the Republic of Moldova, the rare species constitute about 30% – a much higher index than the European and even the global average. The lack of population-chorological field research on rare species of vascular plants in the spontaneous flora does not allow the assessment of the degree of endangerment and the determination, according to the current situation, of the conservation status of rare species according to the criteria of the International Union for Conservation of Nature (IUCN). This fact is a drawback for the processes and activities related to plant biodiversity conservation.

## MATERIALS AND METHODS

The rare species of the *Boraginaceae* family (common names: borage, forget-me-not) were identified as a result of the floristic field research and the critical processing of the materials of the Herbarium, during 2016-2017. The rare taxa were evaluated according to the IUCN requirements and criteria [4, 5], and the conservation status was determined, assigning one of the following categories: Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC) and Data Deficient (DD). The nomenclature of species was indicated according to recent publications [6, 7, 9].

Abbreviations: RBRM (Red Book of the Republic of Moldova), RBB (Red Book of Bulgaria), RLR (Red List of Romania), RBR (Red Book of Romania), HD (Habitats Directive), BC (Berne Convention).

## RESULTS AND DISCUSSIONS

The research on the rare species of *Boraginaceae* family was carried out in the framework of the institutional theme of the Botanical Garden of ASM, namely “Research on the populations of vascular plants of the wild flora and the elaboration of the list of species proposed for state protection”. The sizeable family of *Boraginaceae* Juss. comprises about 115 genera with more than 2 500 species, distributed all around the world,

primarily in tropical and subtropical and partly in northern temperate areas [2]. In the wild flora of the Republic of Moldova, this family includes 22 genera with about 55 species of herbaceous plants, 21 of which are rare and 17 – threatened species (categories: CR, EN, VU). Of all the rare species, only one (*Rindera umbellata*) has been included in the 2<sup>nd</sup> and 3<sup>rd</sup> editions of the Red Book of the Republic of Moldova, 7 species have been included in the Red Book of Romania (*Anchusa gmelinii*, *A. stylosa*, *Cynoglossum creticum*, *Heliotropium suaveolens*, *Myosotis discolor*, *Rindera umbellata*, *Symphytum tauricum*) and 4 species have been included in the Red Book of Bulgaria (*Anchusa stylosa*, *Cynoglossum germanicum*, *Echium rubrum*, *Symphytum tauricum*). [1, 3, 8]. The species analyzed and evaluated according to the IUCN criteria, depending on the number of plants present in a population, the distribution within one or several areas, the range etc., were classified as follows: 2 critically endangered species, 7 endangered species, 8 vulnerable species, 2 near threatened species, 2 data deficient species. The number of threatened species (categories: CR, EN, VU) is quite large, totalling 17 species. Below, the rare species of *Boraginaceae* family are listed in alphabetical order:

**1. *Anchusa gmelinii*** Ledeb. – conservation status [Vulnerable (VU B2ab (ii, iv))]. Present in RLR; RBR. Pontic hemicryptophyte. Rarely found in five localities: near t. Otaci, v. Cobusca-Nouă (Bulboaca), v. Seliște (Nisporeni), v. Doi-Bani (Dubăsari), “Iagorlâc” Reserve. Threatened because of the poor propagation, the habitat degradation and the small number of locations. (Fig. 1)



Fig. 1. *Anchusa gmelinii*



Fig. 2. *A. stylosa*

**2. *A. stylosa*** M. Bieb. – conservation status [Endangered (EN B2ab (i, ii, iii))]. Protected according to the Biological Diversity Act, Annex 3. Present in RBB, RBR. Its range includes Southeast Europe. Annual, thermophilic, Ponto-Balkan therophyte. Rarely encountered near mun. Chișinău and Tiraspol, on slopes with steppe vegetation. Threatened because of the human settlements in close proximity, the habitat degradation and the populations, which are too small. (Fig. 2)

**3. *Borago officinalis*** L. – conservation status [Data Deficient (DD)]. The plant is biennial hemicryptophyte or, more often, a therophyte with a long vegetation period characterized by semi-rosette shoots. Grows in the wild at the edge of forests, only on the left bank of Dniester river; rare species. The area comprises all parts of Europe, the Mediterranean region, Iran, less often in the Caucasus, Central Asia, western Siberia. Limiting factors: the negative anthropogenic influence, the specific habitat, the



Fig. 3. *Borago officinalis*



restricted distribution. Further field research is needed. (Fig. 3)

4. *Buglossoides arvensis* subsp. *sibthorpiana* (Griseb.) R. Fern. – conservation status [Vulnerable (VU B2ab (iii, v))]. Therophyte balcanic. It is rarely found on arid slopes with clayey soil, ruderal places, in the south of Bugeac. Threatened because of the overexploitation of lands, the habitat degradation, the decline in the number of mature plants.

5. *Buglossoides czernjajevii* (Klokov) Czer. – conservation status [Vulnerable (VU B2ab (iii))]. It is found sporadically in the herbaceous layer of glades and the edge of downy oak forests, as well as on grassy slopes in the south of the republic. The places where these plants grow on the territory of the Republic of Moldova are the most southern of the species range. The species is threatened by the limited range, being found in less than 10 locations.

6. *Cynoglossum creticum* Mill. – conservation status [Endangered (EN B2ab (iii))]. It has been included in RBR. Biennial therophyte, Mediterranean element. It is rarely found at the edge of the forest of oak and European beech in com. Novaci (Călărași), and in com. Bulboaca, Băcioi (mun. Chișinău), on slopes with steppe vegetation. It is threatened because of the exploitation of forests, mowing the grasslands and the degradation of slopes with steppe vegetation.

7. *C. germanicum* Jacq. – conservation status [Endangered (EN B1 ab(iii); C2a(ii))]. Protected in accordance with the Biological Diversity Act, Appendix 3. Present in RBB. Biennial, mesophilic, Central-European species. It is rarely found at the edge of forests and in scrublands, in two localities of Călărași and Căușeni districts. Limited to the exploitation of biotopes, poor populations in individuals, presence in few locations.

8. *Echium rubrum* Forssk. – conservation status [Vulnerable (VU B2ab(ii, iii))]. It has been included in the RBB and Habitats Directive. Biennial, Ponto-Pannonian therophyte. It is sporadically distributed on the territory of the Republic of Moldova. Limiting factors: mowing, the exploitation and degradation of slopes with steppe vegetation, the anthropogenic impact. (Fig. 4)

9. *Heliotropium suaveolens* M. Bieb. – conservation status [Endangered (EN B2ab(i, ii, iv, v))]. Present in RBR. Its range includes Southeast Europe. Eastern Sub-Mediterranean element. Found in only three localities in the south of R. Moldova. Limiting factors: the anthropogenic impact, the poor propagation, the small number of locations – less than 5, the decline in the number of mature plants.



Fig. 4. *Echium rubrum*

10. *H. ellipticum* Ledeb. – conservation status [Endangered (EN B2ab (i, ii, iv, v); C2a(i))]. Eurasian, thermophilic hemicytrophite. Identified in two localities: v. Zolonceni (Dubăsari), at the edge of the forest, along Răut River, and in v. Nezavertailovca, on rocky, steep riverbank, near Cuciurgan Reservoir. Limiting factors: the restricted specific habitat, the few locations, the small populations.

11. *Heliotropium europaeum* L. – conservation status (Near Threatened (NT B2ab(iii, iv, v); C2a(i))). It is found predominantly in the southern part of the country, sporadically, on calcareous slopes with steppe vegetation, sandy terraces, pastures. The biotope loss, the presence of localities nearby and the unregulated tourism within the range threaten the species.

12. *Lappula consanguinea* (Fischer et Meyer) Guerke – conservation status (Near Threatened (NT B2ab(iii)). It is found sporadically on calcareous slopes with steppe vegetation, on toltry (limestone), in the vicinity of Corjeuți (Edineț), Gura-Camenca (Florești), Măgura Veche (Cornești), Morovaia (Orhei), Doi-Bani



(Dubăsari). Species with very restricted habitat, with small populations. Threatened because of the exploitation of lands, the very restricted specific habitat.

**13. *Lycopsis orientalis* L.** – conservation status (Data Deficient, DD). Ponto-Mediterranean element. It is found rarely in ruderal areas, in the central and southern part of the floodplain of Dniester River. There is not enough information about the status of this species.

**14. *Myosotis discolor* Pers.** – conservation status [Endangered (EN B2ab(i, iii, iv); D)]. Present in RBR. European-Anatolian element. It is found on rocky slopes with grassy vegetation, in the vicinity of Cahul city and Zloți station. Limiting factors: the few locations, the eastern limit of the range of the species, the anthropogenic impact. (Fig. 5)



Fig. 5. *Myosotis discolor*

**15. *M. popovii* Dobrocz.** – conservation status [Endangered (EN B2ab(i, iii, iv); D)]. Rare species found in Strășeni and Căpriană, on slopes with steppe vegetation and at the edge of forests. Endemic species. Limiting factors: the poor propagation, the small populations and its presence in only two locations. (Fig. 6)



Fig. 6. *M. popovii*



Fig. 7. *Onosma lipskyi*

**16. *M. ramosissima* Rochel** – conservation status [Vulnerable (VU B2ab(iii, iv); D1)]. European therophyte. Rare species, found in Vișoara (Glodeni), Bahmut (Călărași), Chetriș (Fălești), in glades. Limiting factors: mowing and grazing in forests, the small populations, the few locations.

**17. *Onosma lipskyi* Klov & Dobrocz.** – conservation status [Vulnerable (VU B2ab(ii, iii))]. Biennial therophyte, Pontic element; identified on calcareous slopes with steppe vegetation, in three locations: Trebujeni (Orhei), Saharna (Rezina) and Molochișul Mare (Rîbnița). Limiting factors: the exploitation of steppe sectors, the small range, the specific habitat. (Fig. 7)

**18. *Onosma visianii*** Clementi – conservation status [Vulnerable (VU B2ab(iii))]. Biennial therophyte, Ponto-Pannono-Balkan, identified on calcareous slopes with steppe vegetation, in few locations. Threatened by the exploitation of steppe sectors, the disjunct distribution and the small populations. (Fig. 8)



Fig. 8. *O. visianii*

**19. *Rindera umbellata*** (Waldst. et Kit.) Bunge – conservation status [Critically Endangered (CR B1ab(i, iii, v); C2a(i))]. Present in RBRM, RBR. Ponto-Balkan hemicryptophyte, tertiary relict. Found in four localities in the south of the territory, in steppe and glades of oak forests. The last time, it was collected in 1948. Limiting factors: the anthropogenic impact, the exploitation of steppe sectors and the afforestation of glades. (Fig. 9, 10)



Fig. 9. *Rindera umbellata*



Fig. 10. *R. umbellata*

**20. *Rochelia disperma*** subsp. *retorta* (Pall.) Kotejova – conservation status [Vulnerable (VU B2ab(iii, iv, v)c(iv))]. Present in RBR. Ponto-Balkan therophyte. Found in Făurești, Ciorescu, Hâncești, Zloți, on sandy slopes with steppe vegetation. Limiting factors: the specific habitat, the poor propagation, the few locations, the anthropogenic impact.

**21. *Symphytum popovii*** Dobrocz. – conservation status [Critically Endangered (CR B1ab(ii, iii))]. European hemicryptophyte. Endemic species. Found in a single location – v. Cuhnești (d. Glodeni), in forest of oak with lime. Limiting factors: the poor propagation, the small populations and the limited range.

## CONCLUSIONS

- As a result of the floristic and chorological field research and the examination of the specimens of taxa of the *Boraginaceae* family from the Herbarium, 21 rare plant species were identified and categorized according to the IUCN criteria.
- It has been proposed to include the rare and threatened species of the *Boraginaceae* Juss. family, belonging to CR, EN and VU categories, in the list of species protected by the state and in the 4<sup>th</sup> edition of the Red Book of the Republic of Moldova.

## BIBLIOGRAPHY

1. Dihoru Gh., Negrean G. Cartea Roșie a plantelor vasculare din România. Editura Academiei Române, 2009. 630 p.
2. Dobroceaeva D. N. Boraginaceae. In: Dobroceaeva A. L. (ed.): Plant Life (Zhizn 'rasteniy), Moscow: Prosveshchenie, 5(2): 394-398. [In Russian]
3. Gheideman T. *Rindera umbellata* (Waldst et Kit.) Bunge – Rinderă umbelată. In: Cartea Roșie a Republicii Moldova, ed. II, 2001, Chișinău: Știința, p. 23.
4. IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland. 2001.
5. IUCN. Guidelines for application of IUCN Red List Criteria at Regional Levels: Version 3.0. IUCN Species Survival Commission. IUCN, Gland, Switzerland. 2003.
6. Negru A. Determinator de plante din flora Republicii Moldova. Chișinău: Universul, 2007, 391 p.
7. Negru A., Șabanov G., Cantemir V. și al. Plantele rare din flora spontană a Republicii Moldova. Chișinău, 2002. 198 p.
8. Peev, D. et al. (Eds.) 2015. Red Data Book of the Republic of Bulgaria. Volume 1. Plants and Fungi. BAS & MoEW, Sofia.
9. Sârbu I., Ștefan N., Oprea A. 2013. Plante vasculare din România: Determinator ilustrat de teren. Editura V.Bortaș. – București: 1320 p.

**CZU 58.006: 502.75: 581.6:615.32(478)**

**RARE VASCULAR FLORA AND MEDICINAL PLANT RESOURCES OF  
“SAHARNA” LANDSCAPE RESERVATION IN  
REPUBLIC OF MOLDOVA**

**Veaceslav Ghendov, Tatiana Izverscaia, Nina Ciocarlan**  
*Botanical Garden (Institute) of the Academy of Sciences of Moldova*

**Abstract:** The research was conducted in order to identify and document the rare and threatened vascular plant species in the Landscape reservation “Saharna”, including the flora with medicinal properties. The spontaneous flora in studied area comprises 501 species of higher vascular plants of 345 genera and 85 families. Among them 263 plant species contain a wide variety of chemical compounds, making them important from pharmacological viewpoint, used to treat different ailments. There are 46 rare species revealed in the floristic composition, protected in Republic of Moldova, 7 of which are included in the Red Book of Romania. Others 20 species are protected in Ukraine. Six rarest and the most valuable taxa are included in the Red Book of the Republic of Moldova, 3rd edition.

**Keywords:** flora, ex-situ conservation, “Saharna” reservation, medicinal plants, Republic of Moldova

## INTRODUCTION

The conservation status of plants is one of most widely used indicators for assessing the condition of ecosystems and their biodiversity. It also provides an important tool in establishing priorities for species conservation. At the global scale, the best source of information on the conservation status of plants is the *IUCN Red List of Threatened Species*. The Red List is designed to determine the relative risk of extinction, with the main purpose of cataloguing and highlighting those taxa that are facing a higher risk of extinction. It provides taxonomic, conservation status and distribution information on taxa that have been evaluated using IUCN Red List Categories and Criteria: Version 3.1 [13, 14].

Medicinal plants are both a source of income and a source of affordable healthcare. In Republic of Moldova as a developing country, in some areas local healthcare needs are satisfied primarily using raw materials from medicinal plants. The collection of medicinal plants must be guided by an accurate knowledge of the biology of the species concerned, and steps must be taken to avoid over-exploitation, and the collection of rare or otherwise endangered species [16].

The breeding of medicinal plants with desirable agronomic and therapeutic chemical derivatives makes it possible to conserve and selectively utilize highly valuable *in-situ* germplasm and *ex-situ* germplasm in botanic gardens, and in field seed banks. Cultivation allows production of uniform materials whose properties can be standardized and from which crude drugs can be obtained unadulterated. Data on plants held in botanic gardens is most readily accessible and a useful starting point. However, the knowledge and collaboration with farmers and traditional health practitioners would be very helpful in identifying, implementing and managing future medicinal plant cultivation. Many medicinal plants grow well on marginal, remote and degraded lands with low monetary inputs. Intensive studies are needed on selected medicinal plants in order to determine optimum environmental requirements for sustainable production.

Introduction of medicinal plants, at present, takes on special importance because it allows one to enlarge the cultivated flora with new valuable species and to use wild useful plants in a more rational way. In this context accumulation and maintenance of medicinal plants in collections or herb gardens allows to reduce anthropogenic pressure on natural populations, creating a source of vegetal material for future reintroduction in their natural habitat in order to increase the number of populations. On the other hand, this objective let to obtain scientific outcome and practical requirements for introduction into the culture of therapeutically important species improving assortment of medicinal plants used in the national economy [11].

## MATERIALS AND METHODS

The research was conducted during 2007-2017 in the Landscape reservation “Saharna” situated in the north-eastern central part of Moldova (Rezina district). All selected plant species are native to local flora and the taxonomy followed by the recent taxonomical literature. [3, 5, 10, 19, 23] Voucher specimens of the plants are lodged in the Herbarium of Botanical Garden (Institute) of ASM (Chisinau). In parallel with the collection of the material for herbarium the specialty literature was studied.

The present account includes all the taxa that are listed under: Environmental legislation of the Republic of Moldova (1996-1998) [17]; The Red Book of the Republic of Moldova (3<sup>rd</sup> edition) [22]; Red Data Book of Ukraine [20]; Red Book of vascular plants of Romania [6]; under The Convention on International Trade in Endangered Species of Wild Fauna and Flora. [4]

The designation of Habitat type was made according to the Interpretation Manual of EU Habitats, Directive 92/43/EEC on the basis of scientific criteria defined in Annex III of the Directive. [12]

Studies for rare plant species acclimatization in *ex situ* conditions were carried out at the Experimental subdivision of the Collection of medicinal plants in the Botanical Garden (Institute) of ASM. The genetic resource mobilization of rare medicinal plants was achieved by collecting seeds and plant material from the indigenous flora during field expeditions. Phenological observations and biometric measurements were performed annually during the entire vegetation period according to widely used methodological guidelines [18].

## RESULTS AND DISCUSSIONS

Landscape reservation “Saharna” is a protected area of national interest, located in Rezina district, in vicinity of Saharna village (geographic coordinates: N 47°42'23"; E 28°56'55", surface of the site is 674 hectares), territory in administration of Șoldănești Forestry. The reservation is located within the boundaries of the Euro-Siberian woods with *Quercus* spp. – \*91I0 [12], belonging to the Continental Biogeographical Region of the European continent that covers over a quarter of the European Union and extends in a broad band from west to east, starting in central France and continuing to the eastern edge of Poland in the north and Romania in the south. Outside the EU it stretches to the Ural mountains, on the border with Asia. In the south, the region is almost split in two by the high mountain ranges of the Alpine zone and the steppic plains of the Pannonian Region. [8]

The climate is very continental, with a large temperature range. The substrate consists of ‘Loess’ (a sedimentary unconsolidated aleurite rock, unstratified, loose, with high porosity, generally having 12-25% calcium carbonates. [9] The following tree species – *Quercus robur* and *Q. petraea* dominate in the tree layer of this habitat type, which is rich in continental stepic vegetation species: *Achillea setacea* Waldst. et Kit., *Agrimonia eupatoria* L., *Ajuga genevensis* L., *Amoria fragifera* (L.) Roskov, *Astragalus glycyphyllos* L., *Ballota nigra* L., *Briza media* L., *Bromopsis inermis* (Leyss.) Holub, *Crataegus monogyna* Jacq., *Daucus carota* L., *Dianthus membranaceus* Borb., *Inula germanica* L., *Medicago falcata* L., *Melilotus albus* Medik., *Melilotus officinalis* (L.) Pall., *Otites moldavica* Klok., *Plantago lanceolata* L., *Poa angustifolia* L., *Potentilla impolita* Wahlenb., *Prunus spinosa* L., *Ranunculus polyanthemos* L., *Rosa canina* L., *Teucrium chamaedrys* L., *Thalictrum minus* L., *Thymus marschallianus* Willd., *Tragopogon major* Jacq., *Urtica dioica* L., *Verbascum lychnitis* L., *Verbascum speciosum* Schrad., *Veronica arvensis* L., *Vicia tenuifolia* Roth, *Vicia tetrasperma* (L.) Schreb., *Viola arvensis* Murr. etc.

The spontaneous higher vascular flora in studied area comprises 501 species, belonging to 345 genera and 85 families, most of which (57,9%) are forest and grassland (steppe) plants. The analyses show the following number of largest families: *Asteraceae* (with 63 species), *Lamiaceae* (40), *Fabaceae* (37), *Poaceae* (36), *Brassicaceae* (32), *Rosaceae* (25), *Apiaceae* (23), *Scrophulariaceae* (21), *Caryophyllaceae* (17), *Boraginaceae* (16),



*Ranunculaceae* (12), *Rubiaceae* (12) and *Violaceae* (with 11 species) make up 68,86% of the floristic richness.

Among the ecotopologic elements (figure 1) predominate steppe and sylvestrian species comprising more than half (57,68% – 289 species) of all groups of taxa growing in the surveyed area. This amount is represented by: the typical steppe species (149 species) and those of *Quercus* spp. forested habitats (140 sp.). The share of other groups is irrelevant, except of ruderal weeds, with total number of 125 species (24,95%), which disclose the disturbance nature of this particular habitat.

The geographic component of studied flora is referred to 13 types of floristic elements (figure 2). The prevalent is Eurasian element, which sums up – 42% (212 species). A significant proportion 25% (123 sp.) of European and Mediterranean-European species. They are mostly sylvestrian species. The southern geoelements (Pontic, Pontic-Mediterranean, Mediterranean-pontic-sarmatian, Pannonian-Pontian, Pannonian-Sarmatian, etc.), characteristic of steppe and petrophytic biotopes, are represented by 107 species (25%). The share of circumboreal (7%), adventive (3%) and cosmopolitan (2%) is insignificant.

The main characteristic value of the territory is the fact that it supports species at the boundaries of their natural distribution areas. An analysis of the geographical distribution of species of the site showed that 39 species are growing in the region at the limits of their distribution areas (figure 3). A number of 11 species are of arid regions: *Arum orientale* Bieb., *Astragalus glaucus* Bieb., *Astragalus glycyphyllos* L., *Aurinia saxatilis* (L.) Desv., *Centaurea marschalliana* Spreng., *Centaurea trinervia* Steph., *Galanthus nivalis* L., *Hyacinthella leucophaea* (C. Koch) Schur, *Oberna schottiana* (Schur) Tzvel., *Piptatherum virescens* (Trin.) Boiss., *Stipa lessingiana* Trin. et Rupr., with the northern limit of distribution area.

There are twenty-two species – *Actaea spicata* L.,

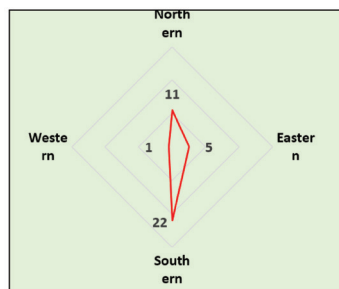


Figure 3. Representation of species (% of total)

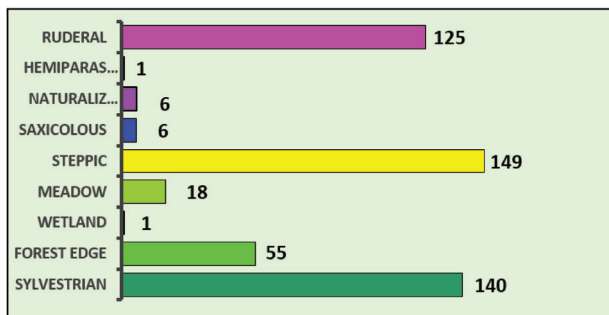


Figure 1. Ecotopologic species component (by number of taxa)

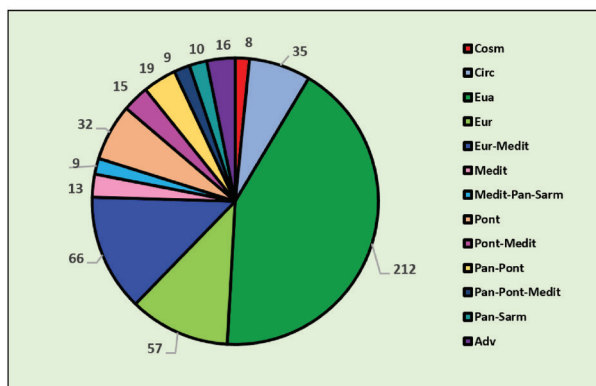


Figure 2. The distribution of species by types of floristic elements

*Anemonoides ranunculoides* (L.) Holub, *Asarum europaeum* L., *Carex alba* Scop., *Carex humilis* Leyss., *Cleistogenes bulgarica* (Bornm.) Keng, *Dentaria bulbifera* L., *Dictamnus albus* L., *Dryopteris filix-mas* (L.) Schott, *Equisetum telmateia* Ehrh., *Fragaria vesca* L., *Helianthemum nummularium* (L.) Mill., *Lilium martagon* L., *Melampyrum nemorosum* L., *Melica nutans* L., *Minuartia setacea* (Thuill.) Hayek, *Omphalodes scorpioides* (Haenke) Schrank, *Phyllitis scolopendrium* (L.) Newm., *Scrophularia vernalis* L., *Stipa pennata* L., *Stipa pulcherrima* C. Koch found on the southern limit of distribution, thus their main areas mostly expand to the north, north-west and north-east of the region. On the western there is one species – *Anthemis subtinctoria* Dobroc. and on the eastern borders, there are 5 taxa – *Carpinus betulus* L., *Glechoma hirsuta* Waldst. et Kit., *Millium vernale* Bieb., *Sorbus torminalis* (L.) Crantz



and *Viola alba* Bess.

There are 46 rare taxa protected by the state in the Republic of Moldova [17]:

- 7 species of category II – *Amygdalus nana* L., *Asparagus officinalis* L., *Asparagus tenuifolius* Lam., *Helichrysum arenarium* (L.) Moench, *Platanthera bifolia* (L.) Rich., *Seseli tortuosum* L., *Veratrum nigrum* L.;
- 2 species of category II-III – *Galanthus nivalis* L. and *Phyllitis scolopendrium* (L.) Newm.;
- 9 species of category IV – *Cerastium glutinosum* Fries, *Cotoneaster melanocarpus* Fisch. ex Blytt, *Dryopteris filix-mas* (L.) Schott, *Goniolimon besserianum* (Schult.) Kusn., *Lathyrus venetus* (Mill.) Wohlf., *Lonicera xylosteum* L., *Scrophularia vernalis* L., *Staphylea pinnata* L., *Tulipa biebersteiniana* Schult. et Schult. fil.;
- 16 species of category VIII – *Actaea spicata* L., *Asparagus verticillatus* L., *Asplenium ruta-muraria* L., *Asplenium trichomanes* L., *Aurinia saxatilis* (L.) Desv., *Cystopteris fragilis* (L.) Bernh., *Epipactis helleborine* (L.) Crantz, *Hyacinthella leucophaea* (C. Koch) Schur, *Iris pumila* L., *Lilium martagon* L., *Neottia nidus-avis* (L.) Rich., *Scorzonera purpurea* L., *Sorbus torminalis* (L.) Crantz, *Stipa lessingiana* Trin. et Rupr., *Stipa pulcherrima* C. Koch, *Stipa pennata* L.

Six rarest and the most valuable species are included in the Red Book of the Republic of Moldova, 3rd edition [22]: 1 species of category Critically Endangered (CR) – *Monotropa hypophegea* Wallr.; 2 species categories Endangered (EN) – *Cotoneaster melanocarpus* Fisch. ex Blytt, *Phyllitis scolopendrium* (L.) Newm.; and 3 species of category Vulnerable (VU) – *Galanthus nivalis* L., *Dryopteris filix-mas* (L.) Schott and *Nepeta parviflora* Bieb.

In the Operational Checklist of threatened and extinct species of the Republic of Moldova [7, 15, 21], created with the development of the Concept of National Ecological Network of the Republic of Moldova [1, 2, 7] there are 35 species included (Figure 4).

Some of the registered in the site species are also rare in the neighboring countries. For example, there are 7 species of plants included in the Red Book of Romania [6] – *Caragana frutex* (L.) C. Koch, *Centaurea trinervia* Steph., *Meniocus linifolius* (Steph.) DC., *Nepeta parviflora* Bieb., *Otites exaltata* (Friv.) Holub, *Seseli tortuosum* L., *Symphytum tauricum* Willd. Twenty species are included in the Red Book of Ukraine [20]: *Allium ursinum* L., *Arum orientale* Bieb., *Astragalus glaucus* Bieb., *Carex alba* Scop., *Dictamnus albus* L., *Epipactis helleborine* (L.) Crantz, *Galanthus nivalis* L., *Lathyrus venetus* (Mill.) Wohlf., *Lilium martagon* L., *Neottia nidus-avis* (L.) Rich., *Platanthera bifolia* (L.) Rich., *Scrophularia vernalis* L., *Sorbus torminalis* (L.) Crantz, *Staphylea pinnata* L., *Stipa capillata* L., *Stipa lessingiana* Trin. et Rupr., *Stipa pennata* L., *Stipa pulcherrima* C. Koch, *Tulipa biebersteiniana* Schult. et Schult. fil. and *Viola alba* Bess.

The field investigations and the survey of the scientific references allowed identifying 263 plant species in the area that contain a wide variety of chemical compounds making them very important from pharmacological point of view. The most representative families are *Asteraceae* (32 species), *Lamiaceae* (29), *Rosaceae* (19), *Brassicaceae* (19) and *Fabaceae* (15 species). Most of them are herbaceous, mainly perennial plants. The raw materials are used in many different forms: fresh, powdered, infusions, decoctions, tincture etc. In the most of the cases the vegetal matter is used as infusion. The most important medicinal properties of species in the area are anti-inflammatory, astringent, expectorant, diuretic, cholagogue, hypotensive, cicatrizing. The vast majority of them are mainly used for the diseases related to digestive system followed by urinary and respiratory disorders.

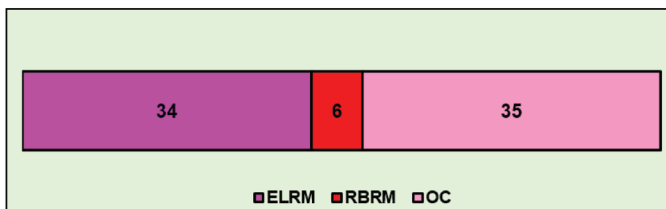


Figure 4. Representation of rare species protected on National level in Republic of Moldova (ELRM – Ecological Legislation of Republic of Moldova, RBRM – The Red Book of Republic of Moldova, OC – Operational Checklist)

Table 1.

## Threatened medicinal species in "Saharna" reservation

| Plant Family    | Species                                   | ELRM | RBRM | OC | RBVPR | RDBU | CITES | Medicinal properties                                   |
|-----------------|-------------------------------------------|------|------|----|-------|------|-------|--------------------------------------------------------|
| Alliaceae       | <i>Allium ursinum</i> L.                  |      |      |    |       | +    |       | antiviral, antibacterial, antiseptic, tonic, vermifuge |
| Amaryllidaceae  | <i>Galanthus nivalis</i> L.               | III  | VU   | +  |       | +    | II    | emmenagogue                                            |
| Araceae         | <i>Arum orientale</i> Bieb.               |      |      |    |       | +    |       | sedative, hemostatic, cicatrizing                      |
| Asparagaceae    | <i>Asparagus officinalis</i> L.           | II   |      | +  |       |      |       | antispasmodic, cardiac, diuretic, demulcent            |
| Asparagaceae    | <i>Asparagus tenuifolius</i> Lam.         | II   |      | +  |       |      |       | young shoots used as vegetable                         |
| Asparagaceae    | <i>Asparagus verticillatus</i> L.         | VIII |      | +  |       |      |       | young shoots used as vegetable                         |
| Aspleniaceae    | <i>Asplenium ruta-muraria</i> L.          | VIII |      |    |       |      |       | astringent, ophthalmic, emmenagogue                    |
| Aspleniaceae    | <i>Asplenium trichomanes</i> L.           | VIII |      |    |       |      |       | expectorant, laxative, emmenagogue                     |
| Aspleniaceae    | <i>Phyllitis scolopendrium</i> (L.) Newm. | III  | EN   | +  |       |      |       | purgative, astringent, analgesic, hemostatic           |
| Asteraceae      | <i>Helichrysum arenarium</i> (L.) Moench  | II   |      | +  |       |      |       | cholagogue, diuretic, stomachic, skin                  |
| Athyriaceae     | <i>Cystopteris fragilis</i> (L.) Bernh.   | VIII |      |    |       |      |       | anthelmintic                                           |
| Berberidaceae   | <i>Berberis vulgaris</i> L.               |      |      | +  |       |      |       | antibacterial, antirheumatic, cholagogue, hepatic      |
| Brassicaceae    | <i>Aurinia saxatilis</i> (L.) Desv.       | VIII |      |    |       |      |       | kidney and urinary affections, cicatrizing             |
| Dryopteridaceae | <i>Dryopteris filix-mas</i> (L.) Schott   | IV   | VU   | +  |       |      |       | anti-inflammatory, anti-rheumatic, antiviral           |
| Lamiaceae       | <i>Calamintha nepeta</i> (L.) Savi        |      |      | +  |       |      |       | antibacterial, diuretic, gastric, sedative             |
| Lamiaceae       | <i>Nepeta parviflora</i> Bieb.            |      | VU   |    | EN    |      |       | antioxidant, anti-inflammatory                         |
| Liliaceae       | <i>Lilium martagon</i> L.                 | VIII |      | +  |       | +    |       | cardiac, expectorant, diuretic, emollient,             |
| Melanthiaceae   | <i>Veratrum nigrum</i> L.                 | II   |      | +  |       |      |       | analgesic, vermifuge, emetic, expectorant              |
| Orchidaceae     | <i>Platanthera bifolia</i> (L.) Rich.     | II   |      |    |       | +    | II    | purgative, hipotensive, diaphoretic                    |

|                      |                                         |      |  |   |  |   |  |                                                  |
|----------------------|-----------------------------------------|------|--|---|--|---|--|--------------------------------------------------|
| <i>Ranunculaceae</i> | <i>Actaea spicata</i> L.                | VIII |  | + |  |   |  | sedative, purgative,<br>hipotensive, antimalaric |
| <i>Rosaceae</i>      | <i>Amygdalus nana</i> L.                | II   |  | + |  |   |  | simulates respiration and<br>improves digestion  |
| <i>Rosaceae</i>      | <i>Sorbus torminalis</i> (L.)<br>Crantz | VIII |  | + |  | + |  | anti-rheumatic, hypoglycemic                     |
| <i>Staphyleaceae</i> | <i>Staphylea pinnata</i> L.             | IV   |  | + |  | + |  | seeds are edible                                 |

In the Table 1 the rare medicinal plants are given in alphabetical order, each with the indication of the list (or lists) which it is included in, as follows: Environmental Legislation of the Republic of Moldova – ELM; The Red Book of the Republic of Moldova (3rd edition) – RBRM; Operational Checklist – OC; Red Data Book of Ukraine – RDBU; under The Convention on International Trade in Endangered Species of Wild Fauna and Flora – CITES; and therapeutic effects.

Some rare and threatened therapeutically important species (*Amygdalus nana* (Box 1, Photo 1), *Asparagus officinalis*, *Dryopteris filix-mas*, *Galanthus nivalis* (Box 1, Photo 2), *Helichrysum arenarium* (Box 1, Photo 3), *Lilium martagon*, *Nepeta parviflora* (Box 1, Photo 4), *Veratrum nigrum*, etc.) were brought and are cultivated in *ex-situ* conditions in the collection of Medicinal plants of Botanical Garden (I) of ASM (Figure 5) in order to protect them and to observe their reproductive behavior and accumulate experience on their agro technology.

The field investigation concluded that biological indicators of populations are increasingly deteriorating and all these taxa became threatened with extinction. The *ex-situ* conservation in the Botanical Garden (I) of ASM is a significant way to preserve these endangered species and to accumulate experience on their behavior in culture conditions.

Recognizing the need for medicinal species preservation it has been initiated a research program referring

Box 1. Threatened therapeutically important species the Landscape reservation “Saharna”



Photo 1. *Amygdalus nana* L.



Photo 2. *Galanthus nivalis* L.



Photo 3. *Helichrysum arenarium* (L.) Moench



Photo 4. *Nepeta parviflora* Bieb.

to their *ex-situ* conservation. The analyzed taxa were planted in the collections of the Botanical Garden in similar conditions of natural habitat.



Figure 5. Collection of medicinal plants  
(experimental subdivision)

The investigations regarding cultivation of these species were carried out at the experimental fields in the Botanical Garden. Adult plants were transplanted from their native populations under similar ecological conditions. Investigations include propagation aspects and research into cultivation techniques and conservation methods. In *ex situ* conditions the studied rare species undergo a complete ontogenetic cycle, which demonstrates their ecological plasticity, high adaptive potential and *ex situ* conservation perspective.

## CONCLUSION

The spontaneous higher vascular flora in Landscape reservation "Saharna" comprises 501 species, belonging to 345 genera and 85 families. There are 46 rare taxa registered, protected by the state. Six rarest and the most valuable species are included in the Red Book of the Republic of Moldova (3rd ed.): *Monotropa hypophegea*, *Cotoneaster melanocarpus*, *Phyllitis scolopendrium*, *Galanthus nivalis*, *Dryopteris filix-mas* and *Nepeta parviflora*.

The field investigations and the survey of the scientific references allowed identifying 263 medicinal plant species. The most valuable from pharmacological point of view are introduced to the Experimental subdivision of the Collection of Medicinal plants.

## BIBLIOGRAPHY

1. Andreev A., Gorbunenko P., Kazanteva O., Munteanu A., Negru A., Trombitki I., Coca M., Sirodoev G. Concept of National Ecological Network of Republic of Moldova. Academician L. S. Berg – 125 years: Collection of scientific articles. 2001. Bendery, p. 153-215. [in russian]
2. Andreev A., Josan L., Shabanova G., Ghendov V., Munteanu A. Natural biological diversity. National Ecological Network of Republic of Moldova in international view. 2009. Kishinev. BIOTICA. 37 p.
3. Ciocărlan V. Flora ilustrată a României: *Pteridophyta* et *Spermatophyta*. București: Ceres. 2009. 1076 p.
4. CITES. *Convention on International Trade in Endangered Species of Wild Fauna and Flora*. Secretariat, 2011. Available at: <http://www.cites.org/>
5. Czerepanov S. K. Vascular plants of Russia and adjacent states (the former USSR). Cambridge University Press. 1995. 516 p.
6. Dihoru Gh., Negrean G. Cartea Roșie a plantelor vasculare din România. Bucuresti: Ed. Academiei Române. 2009. 630 p.
7. Directory of core areas of National Ecological Network of Republic of Moldova. /Andreev A., Bezman-Moseiko O., Bondarenko A., Ghendov V., Izverscaia T., Shabanova G. 2012. Kishinev, 495 p. [in russian] Available on: <http://www.biotica-moldova.org/>
8. European Union Habitat Directive, Natura 2000 in the Continental Region. 2009. <http://ec.europa.eu/environment/nature>
9. Florea N. Loess was formed, but not sedimented. Rev. Roum. Geogr. 2010. 54(2), p. 159-169.
10. Gheideman, T. S.: *Opredeliteli vysshih rastenii Moldavskoi SSR*. Kishinev. Shtiintsa, Ed. III, 1986, 637p. [in russian]



11. Hawkins B. Plants for Life: Medicinal plant conservation and Botanic Gardens. Botanic Gardens Conservation International: Richmond U. K., 2008, p. 1- 48.
12. Interpretation Manual of European Union Habitats – EUR 28, European Commission DG Environment. Nature and biodiversity. 2013, 142 p.
13. IUCN. IUCN Red List Categories and Criteria: Version 3.1., IUCN Species Survival Commission. IUCN, Gland, Switzerland. 2001. Available on: [www.iucnredlist.org](http://www.iucnredlist.org).
14. IUCN. Guidelines for application of IUCN Red List Criteria at Regional Levels: Version 3.0., IUCN Species Survival Commission. IUCN, Gland, Switzerland. 2003. Available on: [www.iucnredlist.org](http://www.iucnredlist.org).
15. Izverscaia T. D., Ghendov V. S., Shabanova G. A. Operational list of vascular plants of the Republic of Moldova. Dendrology, floriculture and landscape gardening. Materials of Int. Sci. Conf., vol. 2. Nikitsky Botanical Gardens, Yalta, Ukraine, 2012, p. 29.
16. Lambert, J., Srivastava, J., Vietmeyer, N.: *Medicinal plants. Rescuing a Global Heritage*. World Bank technical paper Nr. 355, Washington, DC, 1997, 61 p.
17. Legislația ecologică a Republicii Moldova (1996-1998), Ecological Society “BIOTICA”. Chișinău, 1999. 223 p.
18. Metodica fenologicheskikh nabljudenij v botanicheskikh sadah SSSR //Bull. GBS AN SSSR. 1979, vol. 113. P. 3-8. [in russian]
19. Negru A. Determinator de plante din flora Republicii Moldova. Chisinau. 2007. 391 p.
20. Red Data Book of Ukraine. Vegetable Kingdom, Ed. by Didukh Ya. P. Kijev: Globalconsulting, 2009. 900 p. [in ukrainian]
21. Shabanova G. A., Izverscaia T. D., Ghendov V. S. Operational checklist of threatened and extinct species of higher plants. Andreev A. (Edr.) Guide for Assessment of core areas of ecological network. Chisinau, 2014, p. 24-30. Available on: [http://biotica-moldova.org/ru/lib\\_bio.htm](http://biotica-moldova.org/ru/lib_bio.htm) [in russian]
22. The Red Book of Republic of Moldova, 3<sup>rd</sup> ed. Chișinău, Știința, 2015. 492 p.
23. Tutin T., et al.: *Flora Europaea*. Cambridge: Cambridge University Press. Vol. 1-5. 1964-1980, et 2<sup>nd</sup> edition, Cambridge, vol. 1. 1993.



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## ECOLOGICAL RESTORATION OF PARTIALLY DERIVED FOREST STANDS IN “CODRII” RESERVE

*GOGU VITALIE**“Codrii” Reserve*

**Abstract:** This article describes the treatment by progressive cuttings, also called irregular group shelterwood with reserves, used in the ecological restoration of partially derived stands in “Codrii” Reserve, which includes several interventions: cutting to create patches, cutting to expand the patches and to provide the necessary amount of light to seedlings and overstory removal cutting.

### INTRODUCTION

Structurally degraded forest stands do not accomplish satisfactorily the assigned protection functions and produce small quantities of low-quality timber. Therefore, they need ecological restoration. The correct choice of methods and procedures of ecological restoration of stands is the basis for the success and effectiveness of each intervention, as well as of the overall work. The inappropriate use of silvicultural treatments or the lack of any cultural practice, conducted in immature stands, favours the expansion of secondary species at the expense of the species of the genus *Quercus*.

According to the specialized literature, the derived stands of the forest fund of the Republic of Moldova are replaced using clear-cutting. According to the Law no. 1538-XIII of 25.02.1998 on the fund of natural areas protected by the state, ecological restoration activities are allowed in derived stands from nature reserves in order to regenerate them and to restore forest ecosystems, but clear-cuts are prohibited [3]. In the specialized literature, there is no comprehensive description of the techniques and methods of forest restoration that should be implemented in the reserve. Previously, the ecological restoration of derived stands in “Codrii” Reserve was carried out by 2-3 successive cuts, removing, at the first intervention, from 60 to 90% of the volume of wood and reducing its stocking to 0.1-0.2, after that, forest crops were planted, or acorns (oak nuts) were sown in rows. In the present paper, the treatment of partially derived stands by progressive cuttings is described.

During the research, numerous aspects were studied and a series of measures was developed for the transformation of the derived stands into fundamental natural stands. As a result of the study on the state of the stands from the reserve, 230 sub-parcels (1718.5 ha) with inappropriate stands, which need ecological restoration, have been identified. Partially derived stands constitute 450.7 ha of the identified inappropriate stands, which need ecological restoration. A forest management unit (sub-parcel) was selected (14K) from those that have been included in the decennial plan of ecological restoration activities, according to the Forest Planning.

### MATERIALS AND METHODS

The forest stand of the parcel 14K, in the “Codrii” Reserve, was selected as research subject. The assessment of the initial state of the stand was performed by consulting the materials of the Forest Planning of the reserve [2] and, in parallel, by field research. In the given stand, a cutting area of 5.5 ha, intended for ecological restoration by progressive cutting, was delimited in the autumn of 2012. In the respective cutting area, two sample areas of rectangular shape, which constituted 10% of the cutting area, were selected for bi- and three-dimensional visualization. In the cutting area, the type of location and forest, the type of soil and the structure of the stand (stocking, height, share of the tree species, origin) were established.

Ecological restoration works were carried out in the stand of the selected cutting area, by progressive cutting in parallel with regeneration works. The success of the natural regeneration has been determined by

using sample areas, according to the method of Constantin Achimescu, Constantin Nițescu and Victor Popescu [1]. The number of sample areas is 5-7 per hectare.

The office work consisted in processing and correlation of measurements carried out in the field. Their registration, grouping and processing was done using the spreadsheet program: Microsoft Office Excel.

## RESULTS AND DISCUSSIONS

In the summer of 2012, in the studied forest stand, a cutting area of 5.5 ha was delimited to start the ecological restoration by progressive cutting. Progressive cutting, also called irregular group shelterwood with reserves, is a silvicultural treatment characterized by uneven and partial cuts, by harvesting small groups of trees and by sheltered regeneration. This treatment involves three types of cuttings: cutting to create patches, cutting to expand the patches and to provide the necessary amount of light to seedlings and overstory removal cutting. Progressive cutting gives the species of the genus *Quercus* the chance to withstand repeated cuts.

According to the Forest Planning, the stand of the sub-parcel 14K is located on a moderately uneven slope with western exposure, inclination of 26° and altitude of 215-340 m. The type of location – *hilly, of common oak with sessile oak forest, mixed broadleaf forest with sessile oak on plateaus, sunny and semi-sunny slopes with grey and grey-brown, high quality soil*, (6156), forest type – *mixed broadleaf forest with sessile oak, typical to hilly areas, with high productivity* (5322), soil type – *brown clay-illuvial soil* (2201). The litterfall forms a continuous and thin layer, the type of flora: *Asarum-Stellaria*, the stand is totally derived, of average productivity, composition – 3FR 5CA 1TE 1PA, the average age – 115 years. Origin – natural regeneration (from shoots), stocking – 0.7, the average volume – 248 m<sup>3</sup> per 1 ha.

According to the data obtained in the field, the studied cutting area is found on a moderately uneven slope with western exposure and inclination of 10°, with the following geographical coordinates: Lat. N47°06'20", Long. E28°22'52", Alt. 194-238 m.

The soil profile was studied in the middle part of the south-western slope with the inclination of 4-6°, at the altitude of 220 m (Figure 1). The soil layer – homogeneous. The litterfall consists of dead plant material in various stages of decomposition, grey-brown. The upper layer of the litterfall, O1- 3 cm, is grey-brown, consisting of fresh, almost undecomposed leaves and plants debris. The middle layer – O2- 1 cm, is brown, consists of organic matter that partially retained its tissue structure. The lower part of the litterfall – O3- 2 cm – dark brown, is a mixture of leaves and twigs in an advanced stage of decomposition. The quantity of dead leaves and stems in the researched area is about 1525 kg/ha.



Fig. 1. Typical grey sandy loam soil

Morphological description of the soil profile:

- A<sub>0</sub> 0-12 cm – dark grey, moist, little compacted, with stable, soft glomerular structure, clayey.
- A<sub>1</sub> 12-34 cm – yellowish-grey, moist, when dry – light grey, little compacted, nutlike and medium glomerular structure, clayey.
- B<sub>1</sub> 34-72 cm – yellowish-brown, moist, with poorly-defined, nutlike structure, clayey.
- B<sub>2</sub> 72-100 cm – brown, wet, with poorly defined polyhedral structure, illuvial, compacted, clayey.
- BC 100-140 cm – yellowish-brown, uneven, with poorly defined structure, compacted, clayey.
- C 140-150 cm – yellowish-brown, uneven, clayey.

The profile is differentiated, poorly defined when wet (A1-eluvial, B-illuvial). The structure is poorly defined, little stable. The A horizon contains a moderate amount of humus. The content of humus decreases gradually towards B1. Soil reaction – moderately acid. After the analysis of the soil profile, *typical grey sandy loam soil* was identified (Table 1).

Table 1.

Soil reaction and the amount of  $\text{CaCO}_3$ 

| Horizon (cm)          | Sample  | Hygroscopicity (%) | pH (KCl) | $\text{CaCO}_3$ (%) | Humus (%) |
|-----------------------|---------|--------------------|----------|---------------------|-----------|
| A <sub>0</sub> 0-12   | 0-10    | 3.72               | 6.2      | -                   | 4.3       |
| A <sub>1</sub> 12-34  | 20-30   | 2.89               | 4.4      | -                   | 2.4       |
| B <sub>1</sub> 34-72  | 50-60   | 4.42               | 4.7      | -                   | 0.8       |
| B <sub>2</sub> 72-100 | -       | -                  | -        | -                   | -         |
| BC 100-140            | -       | -                  | -        | -                   | -         |
| C 140-150             | 140-150 | 3.8                | 7.8      | -                   | -         |

As a result of the inventory of the grass cover, the following type of flora was determined: *Asarum-Stellaria*.

In order to establish the composition of the stand, 22 relevés were used (Figure 2), on which 349 trees were recorded: GGO=65 trees, GST=5.5 trees, GFA=28 trees, GFR=35.5 trees, GCA=178 trees, GTE=21 trees, GPA=4 trees, GJU=6 trees, GULM=3 trees, GCI=3 trees. The processing of cumulative data on the sample areas resulted in the following composition 19GO 1ST 8FA 51CA 10FR 6TE 2JU 1PA 1ULM 1CI, and 2GO 1FA 5CA 1FR 1TE respectively.

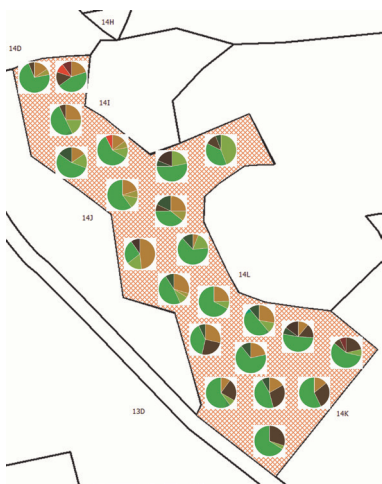


Fig. 2. Species ratio in the relevés

and beech, typical to hilly areas, PS (5312), which differs from the data presented in the Forest Planning.

In the summer of 2012, in this cutting area, the unusable understory was removed. In the cutting area, two sample areas of 0.55 ha each, or 10% of the cutting area, were delimited. In these sample areas, the inventory of all trees, by species, was carried out, they were numbered, their diameter and height were measured and the projection of the crown of each tree was indicated on a scheme (Figure 3).

It originated from natural regeneration (by shoots), stocking – 0.7. According to the results of the field research, according to the Bitterlich method, in the stand, it is obligatory the presence of sessile oak, with a share of 19%, European beech 8%, ash 10%, lime 6% and common hornbeam 51%, common oak, sycamore, field maple, sweet cherry and elm also occur. The presence of common beech of natural origin, for several generations, has indicated a typical forest biotope in which its presence must be mirrored. The type of soil – grey. In the composition of the stand, there are 3 units of the main species (2GO 1FA 5CA 1FR 1TE), so, the given stand is partially derived with indigenous species (PDI). Besides, the current character of the stand, which belongs to the category PDI (partially derived with indigenous species) differs from TDI (totally derived with indigenous species), described in the Forest Planning. Thus, this stand is located in the following type of biotope – hilly, of species of the genus *Quercus* with beech forest, mixed broadleaf forest with beech, on shaded slopes with gray, grey-brown, typical brown and slightly luvisolic soils (6253) and the type of forest is mixed broadleaf forest with sessile oak

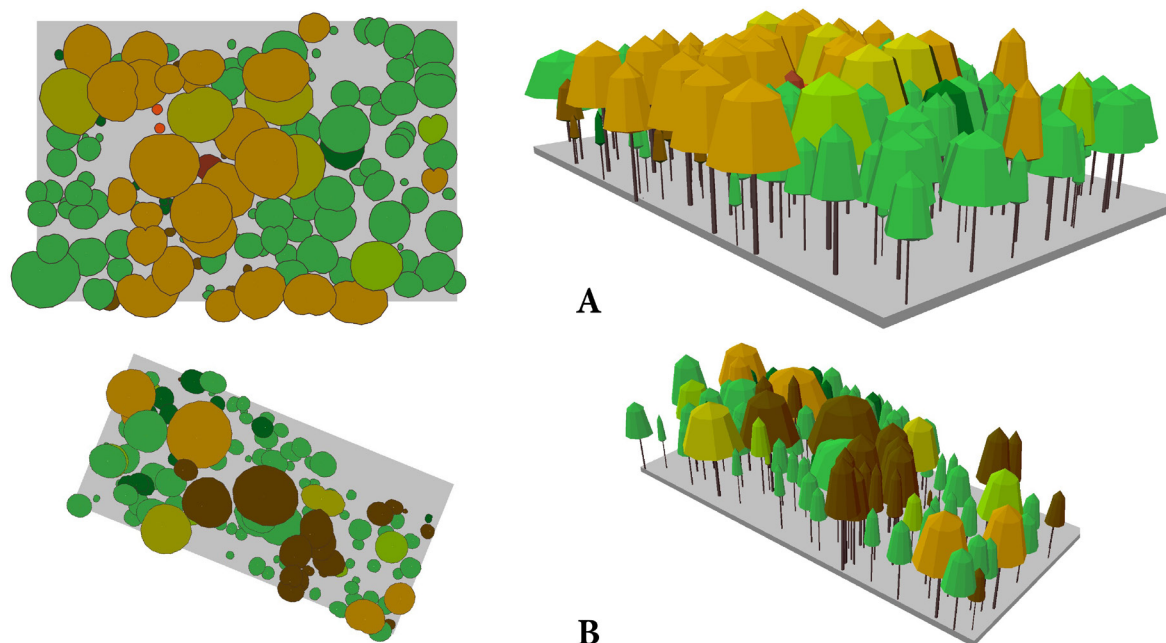
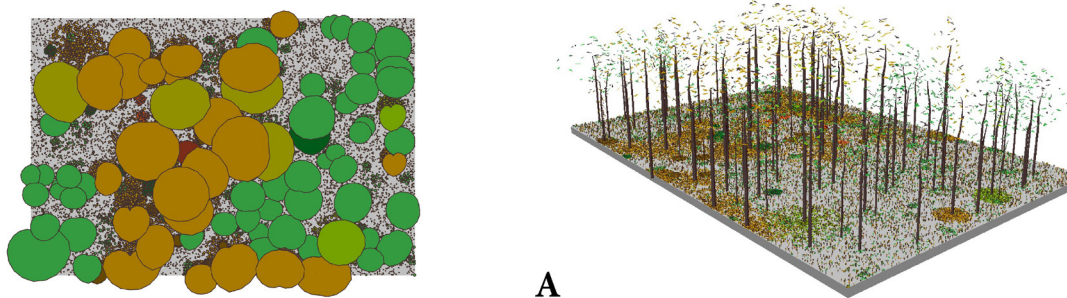


Fig. 3. Graphical representation of the initial stand in the sample areas

A. – sample area no. 1, B. – sample area no. 2

As a result, 173 trees, with a volume of 159.488 m<sup>3</sup>, were inventoried in the first sample area and 81 of these trees were marked to be removed during the *cuttings meant to create the patches*, in the winter of 2013. The volume of these trees was 18.027 m<sup>3</sup> or 11.3% of the total volume of trees in the sample area no.1. In the second sample area, 131 trees, with a volume of 135.892 m<sup>3</sup>, were inventoried and 33 trees, with a volume of 12.84 m<sup>3</sup> or 9.4% of the total volume of trees in this area (Figure 4, Table 2), were marked to be removed during the first intervention. Thus, in 1 hectare, the volume would be 269 m<sup>3</sup>, and in the whole cutting area – 1480 m<sup>3</sup>. In the whole cutting area, 448 trees with a volume of 157 m<sup>3</sup> or 28.5 m<sup>3</sup> per 1 ha (10.6%) were marked for removal.

The patches were created around the trees of the main species (sessile oak, common oak) and their size varied according to the diameter of the crowns, but did not exceed a tree height. In some patches, the accompanying species were completely removed, in others – selectively, reducing their stocking in a different way.





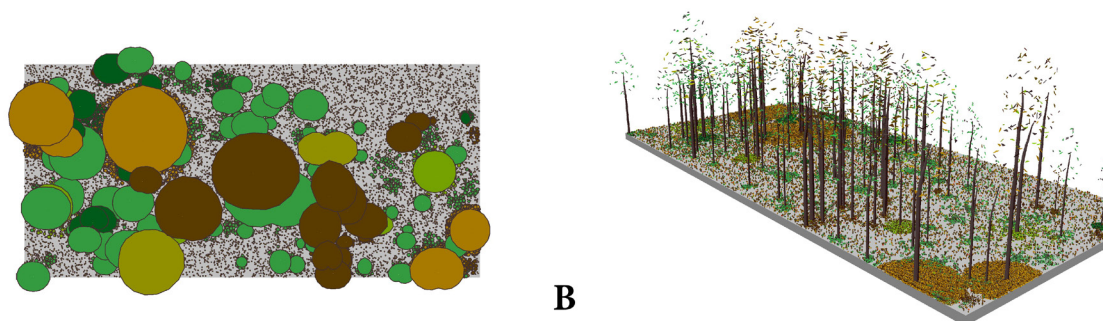


Fig. 4. Graphical representation of the stand and of the seedlings after the cutting to create the patches:  
A. – sample area no. 1, B. – sample area no. 2

In the autumn of 2012, around sessile oak and common oak trees, the soil was loosened with the hoe, to help the natural regeneration.

In order to perform the inventory of the seedlings, in the autumn of 2013, 32 plots of 15 m<sup>2</sup> each were delimited, in total 480 m<sup>2</sup>. In a hectare, there were: sessile oak 39062 seedlings (0.05-0.25 m), common beech – 1375 seedlings (0.05-1.1 m), ash – 3562 seedlings (0.05-0.4 m), common hornbeam – 9270 seedlings (0.04-0.3 m), sycamore – 12354 seedlings (0.05-0.6 m), field maple – 9041 seedlings (0.05-0.4 m), lime – 3625 seedlings (0.08-0.4 m), elm – 1292 seedlings (0.05-0.3 m), wild service tree – 83 seedlings (0.1-0.6 m) and sweet cherry – 62 seedlings (0.1-0.55 m). As a result of the carried out work, the regenerated area represented 34%.

Table 2.

**The volume of wood harvested during each intervention in the sample areas**

| Treatment, type of cutting                                           | Initial number of trees (units) | Total volume (m³) | The year when the harvest was done | Number of harvested trees (units) | Harvested volume (m³) | Harvested volume from the initial volume (%) |
|----------------------------------------------------------------------|---------------------------------|-------------------|------------------------------------|-----------------------------------|-----------------------|----------------------------------------------|
| Sample area no.1                                                     |                                 |                   |                                    |                                   |                       |                                              |
| Progressive – to create the patches                                  | 173                             | 159.488           | 2013                               | 81                                | 18.027                | 11.3                                         |
| Progressive – to expand the patches and to allow the access of light |                                 |                   | 2014                               | 18                                | 15.901                | 10.0                                         |
| Progressive – to expand the patches and to allow the access of light |                                 |                   | 2016                               | 19                                | 34.62                 | 21.7                                         |
| Total                                                                |                                 |                   | -                                  | 118                               | 68.548                | 43.0                                         |
| Sample area no. 2                                                    |                                 |                   |                                    |                                   |                       |                                              |
| Progressive – to create the patches                                  | 131                             | 135.892           | 2013                               | 33                                | 12.84                 | 9.4                                          |
| Progressive – to expand the patches and to allow the access of light |                                 |                   | 2014                               | 28                                | 21.649                | 15.9                                         |
| Progressive – to expand the patches and to allow the access of light |                                 |                   | 2016                               | 26                                | 31.971                | 23.5                                         |
| Total                                                                |                                 |                   | -                                  | 87                                | 66.46                 | 48.8                                         |



As a result of measuring luminous flux on the leaves of the seedlings, from 5-10 klx to 50 klx were recorded. Because of the presence of some insufficiently illuminated areas (5-10 klx) and the large number of sessile oak seedlings, the cuttings meant to expand the patches and to allow the access of light to seedlings were repeated (in the winter of 2014). In the patches where the stocking was 0.4-0.6, it was reduced to 0.2-0.3, in others – where the stocking was 0.2-0.3, the trees of the accompanying species were completely removed around the trees of the main species, but the patches were enlarged selectively, reducing the stocking to 0.4-0.5.

From the first sample area, 18 trees were removed, with a volume of 15.901 m<sup>3</sup> or 10% of the initial volume, and from the second – 28 trees with the volume of 21.649 m<sup>3</sup> or 15.9% of the initial volume in the sample area (Figure 5). From the whole cutting area, 295 trees with a volume of 177 m<sup>3</sup>, or 32 m<sup>3</sup> per 1 ha, (11.9%) were removed.

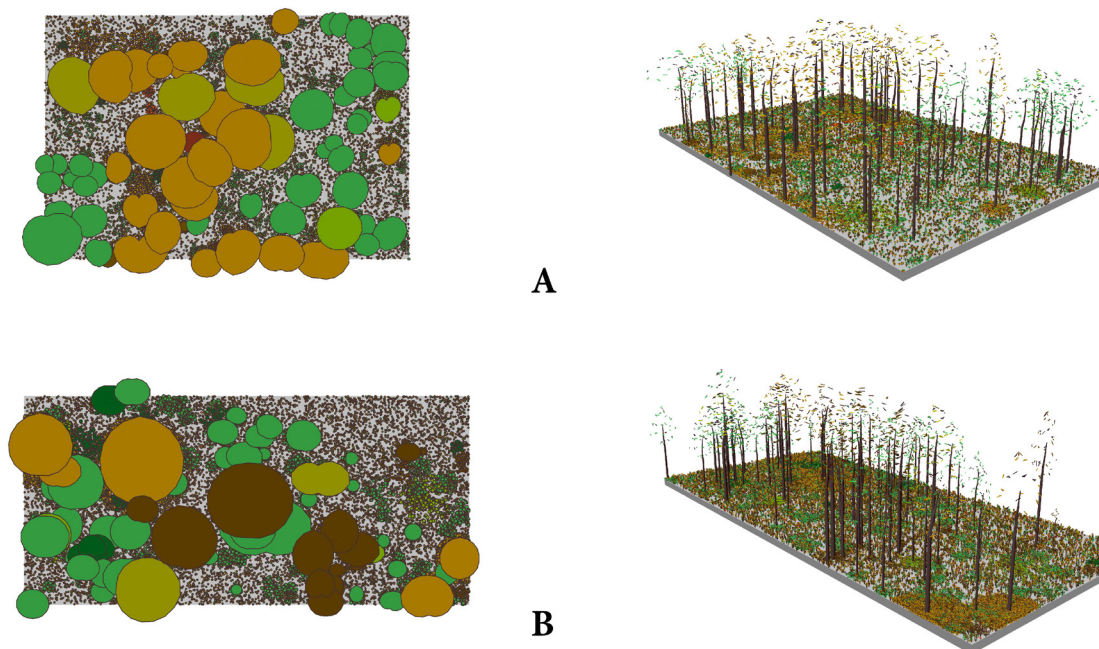


Fig. 5. Graphical representation of the stands and seedlings after the first cutting to expand the patches and to allow the access of light to seedlings: A. – sample area no. 1, B. – sample area no. 2.

During the inventory of the seedlings, in the autumn of 2014, there were: 21354 sessile oak seedlings (0.1-0.35 m), 1687 common beech seedlings (0.05-1.0 m), 3062 ash seedlings (0.05-0.5 m), 12145 common hornbeam seedlings (0.05-0.4 m), 8750 sycamore seedlings (0.1-0.6 m), 6166 field maple seedlings (0.15-0.8 m), 1062 lime seedlings (0.15-0.8 m), 812 elm seedlings (0.1-0.5 m), 62 wild service tree seedlings (0.18-0.8 m) and 42 sweet cherry seedlings (0.25-0.7 m). There was a decrease in the number of seedlings, especially of sessile oak, because a part of the seeds was destroyed during the exploitation. Due to the fructification of sessile oak, in 2014 too, the soil loosening was performed in the autumn of the same year, in the areas where no seedlings from 2013 remained. At the same time, 50 kg of acorns were collected from the same sub-parcel and then sown in the patches formed after the removal of the dead trees of accompanying species, as well as by the expansion of the patches. The acorns were sown in small holes, unevenly, by 3-5 acorns in a hole.

During the inventory of the seedlings, in the autumn of 2015, the following data were obtained: sessile oak – 37625 seedlings (0.05-0.7 m), common beech – 1750 seedlings (0.1-1.2 m), ash – 3020 seedlings (0.1-0.8 m),

common hornbeam – 15687 seedlings (0.05-0.7 m), sycamore – 9166 seedlings (0.1-1.02 m), field maple – 6145 seedlings (0.3-1.1 m), lime – 2520 seedlings (0.24-1.0 m), elm – 812 seedlings (0.22-0.7 m), wild service tree – 83 seedlings (0.08-1.0 m) and sweet cherry – 20 seedlings (0.4-0.92 m). As compared with the previous year, the number of sessile oak seedlings increased by over 16,000 seedlings per hectare, due to the fructification of sessile oak trees and sowing in the newly created patches, from where the accompanying species were removed, and due to the expansion of the already formed patches.

In the winter of 2016, the *second cutting*, meant to *expand the patches and to provide the seedlings with the necessary amount of light*, was carried out. It consisted in the complete removal of accompanying species from the patches where the stocking was 0.2-0.3 and the expansion of the patches where the stocking was 0.4-0.5 was reduced to 0.2-0.3, in addition, the already existing patches were enlarged by selective removal of trees of secondary species, reducing the stocking to 0.4-0.5. However, in several patches, where the trees of secondary species were completely removed during the first cut, the main species was removed too, when the patches were expanded. During the second cut, 19 trees with a volume of 34.62 m<sup>3</sup>, or 21.7% of the initial volume, were removed from the sample area no. 1, and 26 trees with a volume of 31.971 m<sup>3</sup>, or 23.5% of the initial volume, were removed from the sample area no. 2 (Figure 6). In total, 293 trees with a volume of 319 m<sup>3</sup>, or 58 m<sup>3</sup> per 1 ha (21.6%), were removed from the entire cutting area.

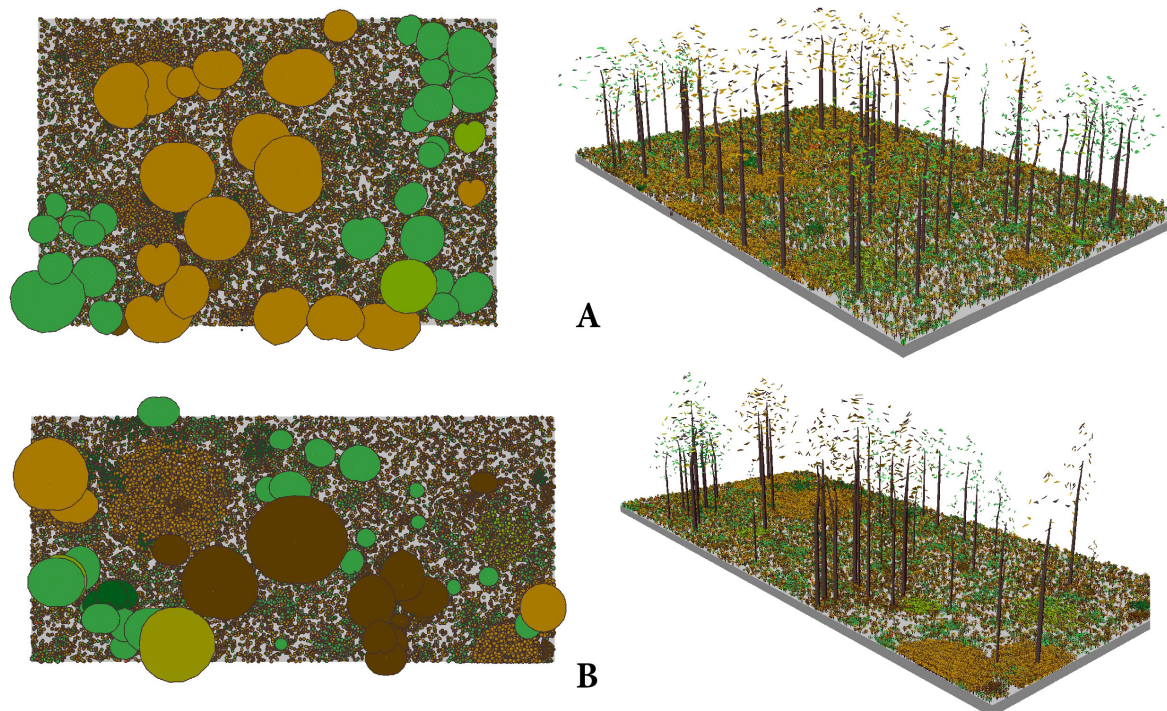


Fig. 6. Graphical representation of the stands and seedlings after the second cutting to expand the patches and to allow the access of light to seedlings: A. – sample area no. 1, B. – sample area no. 2.

During the first three cuts, 43% of the initial volume was removed from the sample area no.1, 48.8% – from the sample area no. 2 and 44.1% – from the whole cutting area.

During the inventory of the seedlings, in August 2016, the following data were obtained: sessile oak – 35333 seedlings (0.1-1 m), common beech – 2833 seedlings (0.1-1.2 m), ash – 5770 seedlings (0.1-0.7 m), common hornbeam – 14937 seedlings (0.1-0.6 m), sycamore – 8541 seedlings (0.1-1.0 m), field maple – 3833

seedlings (0.15-1.0 m), lime – 2729 seedlings (0.15-1.0 m), elm – 333 seedlings (0.2-0.7 m), wild service tree – 104 seedlings (0.1-1.2 m) and sweet cherry – 21 seedlings (1.2 m).

As a result of the inventory of seedlings, it was determined a successful regeneration of 69% of the cutting area (Figure 7).

When performing the progressive cutting for the ecological restoration of the partially derived stands from the reserve, we can point out that:

- Very good results, in terms of regeneration of the stands, can be obtained by performing progressive and mixed cuts;
- The first intervention, to create the patches, is carried out in the winter of the next year, after the species of the genus *Quercus* produce fruits;
- The patches are created around the mature trees of the main species, and should have an area of up to a tree height, depending on the crowns of the trees;
- The patches created around the trees of the main species regenerate naturally, but the rest of the cutting area – artificially, by sowing seeds in holes, unevenly;
- The trees of the main species are harvested, in the created patches, 4-6 years after the emergence of seedlings.

## CONCLUSIONS

1. The ecological restoration by progressive cuttings, also called irregular group shelterwood with reserves, in partially derived stands, allowed the natural development of the seedlings of the main species.
2. The patches are created in the winter of the next year, after the species of the genus *Quercus* produce fruits.
3. Because of the insufficient number of obtained seedlings of the main species, additional measures had to be taken in order to support and complete their development.
4. The patches created around the trees of the main species regenerated naturally, but the rest of the cutting area – by sowing seeds in an uneven pattern.
5. In the first two years after the emergence of the seedlings of the main species, thinning of accompanying species should be carried out 1-2 times in a growing season, to allow the development of seedlings under better conditions.
6. As a result of the ecological restoration of partially derived stands in “Codrii” Reserve, in the course of four years, a successful natural and artificial regeneration of 69% of the area, with 38166 seedlings of the main species (sessile oak, beech), (h=0.1-1.2 m) was obtained.

## BIBLIOGRAPHY

1. Achimescu C. și alții. *Tehnica culturilor silvice. Aplicarea tratamentelor*. București: Ceres, 1980. 311 p.
2. *Amenajamentul Rezervației „Codrii”*, Chișinău, 1997, 2010, vol. I-II.
3. *Legea privind fondul ariilor naturale protejate de stat*. Chișinău, 2002. 102 p.
4. Gogu V. Peculiarities of stands regeneration in the ecological reconstruction process in the „Codrii” Reserve. In: *International scientific symposium “Conservation of plant diversity”*. Chișinău, 2015, p. 23.
5. Gogu V. Regenerating stands as a basis for ecological reconstruction in „Codrii” Reserve. In: *Buletin științific. Revistă de Etnografie, Științele naturii și Muzeologie*. Vol. 24(37). Chișinău, 2016, p. 114-122.
6. Gogu V. The peculiarities of ecological reconstruction in partial derivative stands. În: *International scientific symposium “Conservation of plant diversity”*. Chișinău, 2017, p. 29.
7. Palancean A., Gogu V. The argumentation of the expediency of undertaking environmental reconstruction in the „Codrii” Natural Reserve. In: *Journal of Botany*. Vol. V, nr. 2 (7). Chișinău, 2013, p. 19-26.

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## CHARACTERISTICS OF THE TREATMENTS WITH REPEATED CUTTINGS IN THE RESTORATION OF TOTALLY DERIVED STANDS

*Gogu Vitalie*  
“Codrii” Reserve

**Abstract:** This article presents the results of the research on the successive cutting treatment applied in the totally derived stands from “Codrii” Reserve, which comprises several steps: the preparatory cutting, the seed cutting, the cutting to provide the necessary amount of light to seedlings and the final cutting. The time when each stage is implemented depends on the stocking of the stand and the available amount of light, which influences the growth and development of seedlings.

### INTRODUCTION

The forests of the “Codrii” Reserve, before it was created, were managed in different ways, and the works carried out in this area were focused mainly on the exploitation of forest resources, while such operations as regeneration from seeds and the appropriate management of stands were usually neglected. The inappropriate management has contributed to the decline in the share of basic species (sessile oak, common oak, common beech) in the composition of stands and weakened the ecological balance by repeated coppicing (regeneration from shoots). This type of management, focused only on harvesting timber, has inevitably led to the substitution of species of the genus *Quercus* with accompanying species such as ash, lime and hornbeam. Consequently, 1441.9 ha (186 forest management units) of the total area of 5040.7 ha are totally derived stands. Totally derived stands are those characterized by radically transformed composition, low productivity and lack of the main species. These stands need ecological reconstruction.

According to the specialized literature, the substitution of derived stands can be achieved by: clearcuts in small cutting areas, progressive or alternate clearcuts, but these methods are not allowed in nature reserves, according to the Law no. 1538-XIII of 25.02.1998 on the fund of natural areas protected by the state. Thus, successive cuts and artificial regeneration, by seeding acorns under the shelter of older trees, are performed in these stands. Successive cutting is a silvicultural treatment that consists in the successive harvest of old trees, in several stages, the removal of trees being more or less uniform. This treatment involves several types of cuts to harvest the timber from a given area [3, 4, 5].

*The seed cutting* is aimed at creating favourable conditions for the germination of the seeds, already sown in the previous year, and the development of seedlings, providing the necessary heat, humidity and light. The severity of the cut depends on the canopy closure, the shade tolerance of the species to be regenerated and on the site quality. The harvest is performed as evenly as possible on the entire cutting area, so that the sowing will also be done uniformly.

*The cutting to allow the access of light* is carried out when the seedlings do not receive the necessary amount of light, under the shelter of older trees, and consists in an additional thinning of the old stand. It is performed considering the need of seedlings for more light, as well as the need for protection from drought, excessive sun exposure, frost and competing plants.

*The final cutting* is aimed at harvesting the last exploitable trees and is performed when at least 0.8 of the cutting area is uniformly regenerated and the seedlings are able to develop independently, so that shelter is no longer required. If this cut is carried out too late, the overstory may hinder the development of seedlings and may cause damages in case of exploitation.

*The preparatory cutting*, which is usually performed before the seed cut, was not necessary in the case of the studied stand.



## MATERIALS AND METHODS

In order to identify some characteristics of the treatments with repeated cuttings in the restoration of totally derived stands, the stands of the "Codrii" Reserve, found in the forest management units (parcels) 35B and 35J, were studied. The study was done by office and field research methods, bibliographic documentation, analysis of materials on forest planning and direct observation. Bitterlich relascope was used to determine the current composition of the forest. The type of site and the type of forest were identified according to the ecotypological scheme [2]. The geographical coordinates were determined according to the *Etrex* GPS. The illuminance in the understory was measured with the lux meter.

## RESULTS AND DISCUSSIONS

According to the Forest Planning of 2013, ecological restoration activities were planned in the stands found in the forest management units 35B and 35J [1]. In the summer of 2012, two cutting areas of 2.0 ha and 1.4 ha, respectively, were delimited to start the successive cuttings. This treatment involves two or more cuts, repeated in a certain period, by which the old stand is removed gradually and as uniformly as possible, thus creating favourable conditions for the establishment and development a new generation of seedlings [5].

The cutting plot in the parcel 35B has an area of 2 ha and is located in the lower third of the slope with south-eastern exposure, inclination of 10° and geographical coordinates: Lat. N 47°05'58", Long. E 28°24'16" and altitude of 311-322 m. According to the data obtained in the field, the forest type is *mixed broadleaf forest with sessile oak and common oak, typical of hilly areas*, PS (5512), the site type – *hilly, of common oak with sessile oak forest, mixed broadleaf forest with sessile oak on plateaus, sunny and semi-sunny slopes with grey and grey-brown, high quality soil* (BS), (6156) and the soil type is *typical grey sandy loam* of the mollisol order. As a result of the determination of the composition of the stand, by using 15 relevés, 86Ca10Fr2St2Pa and 9Ca1Fr+St,Pa, respectively, were recorded. The stand is totally derived, with the average age of 100 years, stocking – 0.7.

In the delimited cutting area, the unusable seedlings were cut and, after that, a sample area of 0.20 ha, or 10% of the cutting area, was selected. In this sample area, the inventory of all trees, by species, was taken, they were numbered, and their diameter and height were measured. As a result, 47 trees, with a volume of 53.35 m<sup>3</sup>, were inventoried (Table 1). In 1 ha, that would be 267 m<sup>3</sup>, or 534 m<sup>3</sup> – in the entire cutting area. 24 trees with a volume of 13.88 m<sup>3</sup>, or 26% of the total volume of trees in the sample area, were selected for the seed cutting, planned for the winter of 2013. In the whole cutting area, 250 trees with a volume of 131 m<sup>3</sup>, or 65.5 m<sup>3</sup> per 1 ha (24.5%), were selected and removed, according to the inventory records. Mostly, trees of the midstory were selected and the stocking was reduced to 0.5-0.6. As a result of this cutting, a more even distribution of the foliage was obtained.

In the autumn of 2012, acorns of sessile oak (20 kg) and common oak (100 kg) were sown. In total – 120 kg per 1 ha, or in the entire cutting area, 240 kg of acorns were sown in rows (trenches); the distance between rows was 3.5 m. The inventory of the forest crops, in the autumn of 2013, was taken by delimiting sample segments, with a length of 20-30 m, for the sown sessile oak and common oak. The sample segments were delimited uniformly and represented 5% of the total of sown rows. In 1 ha, 6820 sessile oak seedlings, with a height of 0.1-0.25 m, and 20160 seedlings of common oak, with a height of 0.1-0.4 m, were obtained. In total, 26980 seedlings of the main species were recorded, which constituted 94.6%, as compared with the areas sown according to the project. It is a success for the 1-year-old forest crops. Among the seedlings of the accompanying species regenerated naturally, on 1 ha, there were 16416 ash seedlings – 0.18 m, 35666 hornbeam seedlings – 0.13 m and 15000 sycamore seedlings – 0.22 m.

After measuring the luminous flux on the leaves of the seedlings with the lux meter, it was 3-50 klx, so, it was necessary to carry out the second repeated cutting, in the winter of 2015.

During the inventory of the trees of sessile oak and common oak (obtained as a result of artificial



regeneration), in the autumn of 2014, 6220 sessile oak seedlings (0.2-0.5 m) and 18860 common oak seedlings (0.2-0.7 m) were recorded in 1 ha. In total, 25080 sessile oak and common oak seedlings were recorded, which represents 88%.

During the cutting to allow the access of light, carried out in the winter of 2015, 18 trees with a volume of 27.46 m<sup>3</sup>, or 51.5% of the initial volume, were removed from the sample area. During the first two cuttings, a volume of 41.34 m<sup>3</sup>, or 77.5% of the initial volume, was removed from the sample area. From the entire cutting area, 153 trees with a volume of 267 m<sup>3</sup>, or 133.5 m<sup>3</sup> per 1 ha (50%), were removed during the second cutting.

Table 1.

**The volume of timber harvested from the sample area during each intervention**

| Treatment / type of cutting                       | Initial number of trees (pcs.) | Total volume (m <sup>3</sup> ) | Year | Number of harvested trees (pcs.) | Volume of harvested timber (m <sup>3</sup> ) | Harvested volume from initial volume (%) |
|---------------------------------------------------|--------------------------------|--------------------------------|------|----------------------------------|----------------------------------------------|------------------------------------------|
| Successive / seed cutting                         | 47                             | 53.35                          | 2013 | 24                               | 13.88                                        | 26.0                                     |
| Successive / cutting to allow the access of light | 47                             | 53.35                          | 2015 | 18                               | 27.46                                        | 51.5                                     |
| Total                                             | 47                             | 53.35                          | -    | 42                               | 41.34                                        | 77.5                                     |

In total, during the first 2 interventions, 77.5% was harvested from the sample area, and from the whole cutting area – 74.5% of the initial volume.

According to the inventory of seedlings, taken in the autumn of 2015, there were 5500 sessile oak seedlings (0.3-0.7 m) and 17250 common oak seedlings (0.3-0.1 m), (Figure 1.). As for the seedlings of accompanying species, 22833 ash seedlings (0.46 m), 24083 hornbeam seedlings (0.38 m) and 12500 sycamore seedlings (0.43 m) were recorded. In 2014, most of the seedlings of sessile oak and common oak grew well, but 8% of the seedlings died, mainly because of the timber harvesting during the second stage of the successive cuttings.



Fig. 1. Regeneration of the stand in the forest management unit 35B, 2015  
(a – general aspect, b – the height of seedlings)

The cutting area of the forest management unit 35J is located at the flat bottom of a valley, between

two slopes with eastern and western exposition, with the geographical coordinates: Lat. N47°05'51", Long. E28°24'24", Alt. 298-310 m. According to the results of the field research, this stand belongs to the forest type – *mixed broadleaf forest with common oak, typical of hilly areas*, PS (6211), the site type – *hilly, of oak forest and mixed broadleaf forest with common oak with hornbeam, on valley and the lower third of slopes with grey and grey-brown, high quality soil* (BS) (6271), the soil type – *diluvial ochric, clayey-sandy soil*.

The processing of cumulative data on relevés led to the following result: 80Fr12Ca4Ju4Ulm, respectively, the composition – 8Fr1Ca1DT. The forest stocking was 0.8, the origin – from shoots (natural regeneration), the average age of the stand – 120 years.

A cutting area of 1.4 ha was delimited in 2012, to perform the treatment by successive cuttings. The unusable seedlings were cut and, after that, a sample area of 0.14 ha, or 10% of the cutting area, was selected. In this sample area, the inventory of all trees, by species, was taken, they were numbered and their diameter and height were measured. As a result, 37 trees were inventoried, their volume was 60.321 m<sup>3</sup> (Table 2.). That would be 431 m<sup>3</sup> per 1 ha or 603 m<sup>3</sup> in the whole cutting area.

For the seed cutting, planned for the winter of 2013, 18 trees with a volume of 7.461 m<sup>3</sup>, or 12.4% of the total volume of trees in the sample area, were selected. In the whole cutting area, 157 trees with a volume of 67 m<sup>3</sup> or 47.9 m<sup>3</sup> per 1 ha (11.1%), were selected and cut (according to the inventory records). Mostly, trees of the midstory were selected and the stocking was reduced from 0.8 to 0.7.

In the autumn of 2012, acorns of common oak were sown, by 120 kg per 1 ha, or 168 kg in the entire cutting area. The acorns were sown in rows (trenches) and the distance between rows was 3 m. The inventory of the forest crops, in the autumn of 2013, was taken by delimiting sample segments, with a length of 20-30 m, for the sown species (common oak). The sample segments were delimited uniformly and represented 5% of the total of sown rows. In 1 ha, 27786 common oak seedlings (0.1-0.4 m) were found, they represented 84.2% as compared with the areas sown according to the project, which constituted 33000 seedlings per 1 ha. It is a good result for the forest crops, in the first year after sowing. As for the accompanying species, no seedling obtained by natural regeneration was recorded in 2013.

As a result of the inventory of seedlings, taken in the autumn of 2014, 16871 seedlings (0.2-0.8 m) were recorded in 1 ha, which represented only 51.1%. No seedling obtained by natural regeneration was recorded in 2014 too.

Since during the first cutting, a few trees were removed, where the stocking of the mature stand decreased from 0.8 to 0.7, during 2014, a part of the seedlings died because of the insufficient amount of light (3-5 klx). The seedlings of pedunculate oak are light-loving and cannot grow in the shade more than 2 years. Therefore, another cut was necessary in 2014, to provide more light to the seedlings. But, because the amount of timber planned to be harvested in 2014 exceeded the norm established by the Forest Planning, this cutting was not allowed. So, it was planned for 2015, and this delay led to the death of some seedlings and to the stagnation in the growth of others.

In the autumn of 2014, the forest crops were supplemented by sowing 60 kg of acorns in 1 ha, or 84 kg – in the entire area. Another cutting to allow the access of light was performed in the winter of 2015, when 11 trees with a volume of 35.21 m<sup>3</sup>, or 58.3% of the initial volume of trees in the sample area, were removed. 80 trees with a volume of 309 m<sup>3</sup>, or 220.7 m<sup>3</sup> per 1 ha (51.3%), were removed from the entire cutting area. During the first two interventions, 29 trees with a volume of 42.671 m<sup>3</sup>, or 70.7% of the initial volume of trees in the sample area, were removed, and 376 m<sup>3</sup> were removed from the entire cutting area, or 268.6 m<sup>3</sup> per 1 ha (62.3%).

Table 2.

The volume of timber harvested from the sample area during each intervention

| Treatment / type of cutting                       | Initial number of trees (pcs.) | Total volume (m <sup>3</sup> ) | Year | Number of harvested trees (pcs.) | Volume of harvested timber (m <sup>3</sup> ) | Harvested volume from initial volume (%) |
|---------------------------------------------------|--------------------------------|--------------------------------|------|----------------------------------|----------------------------------------------|------------------------------------------|
| Successive / seed cutting                         | 37                             | 60.321                         | 2013 | 18                               | 7.461                                        | 12.4                                     |
| Successive / cutting to allow the access of light | 37                             | 60.321                         | 2015 | 11                               | 35.21                                        | 58.3                                     |
| Total                                             | 37                             | 60.321                         |      | 29                               | 42.671                                       | 70.7                                     |

As a result of the inventory carried out in the autumn of 2015, 22529 common oak seedlings, with a height of 0.2-1.1 m, were recorded (Figure 2B). In the areas where the illuminance was over 50 klx, the seedlings were the tallest (Figure 2A), but in the areas where less light reached the understory, respectively, the seedlings were smaller (Figure 2C). As for the seedlings of accompanying species obtained by natural regeneration, in 1 ha, there were: 19111 ash seedlings (0.12 m), 16444 hornbeam seedlings (0.10 m), 1888 field maple seedlings (0.13 m), 1222 sycamore seedlings (0.17 m), 555 lime seedlings (0.17 m) and 333 elm seedlings (0.10 m).



Fig. 2. Regeneration of the stand in the forest management unit 35], 2015  
(A – well-developed seedlings, B – general aspect, C – seedlings that grew slower because of unfavourable conditions)

In both cutting areas, weeds were removed to reduce the competition between seedlings and tall weeds, or those that invade the land, a competition that can slow down the growth of seedlings and even lead to the death of some seedlings of the desired species, which are small and grow slower than the weeds. Weeds should be removed every year until the seedlings grow taller than the herbaceous layer and constitute a new layer. The correct choice of the number of interventions, of the season when the cuts are performed and implementation of the techniques guarantee the efficiency of the silvicultural treatment.

The final stage of the successive cuts, in both cutting areas, will be performed in the winter of 2019.

As a result of the research carried out on the basis of these stands, we can conclude that an important role in the growth and development of seedlings is played by the amount of light that reaches their leaves and the correlation of the stocking of the stand with the period when the cutting to allow the access of light is carried

out. Thus, in the cutting area 35B, where the stocking was reduced to 0.5-0.6 during the seed cutting, the seedlings of the main species developed uniformly on the entire area, but where the stocking was reduced only to 0.7, the seedlings grew slower and some of them died, in the areas where the illuminance was 3-5 klx.

## CONCLUSIONS

- In totally derived stands, where the silvicultural treatment by successive cuttings is implemented, the intensity of the first intervention – seed cutting – can exceed 25% of the volume of trees.
- The species of the genus *Quercus* (sessile oak, common oak), which are shade-intolerant and can grow under the shelter of old trees only for a short period, need cutting to allow the access of light in the 1st-3rd year after sowing, depending on the stocking of the stand.
- The cutting to allow the access of light in the understory is carried out, in the stands with the stocking of 0.7, one year after the seed cutting, but in those with the stocking of 0.5-0.6 – after 2 years.
- For an adequate development, the seedlings of the studied species need an amount of light of over 20-30 klx.

## BIBLIOGRAPHY

1. *Amenajamentul Rezervației „Codrii”*, Chișinău, 2010, vol. I-II.
2. Chiriță C., Vlad I. ș.a. *Stațiuni forestiere*. București: Editura Academiei RSR, 1977.
3. Florescu I. *Tratamente silviculturale*. București: Ceres, 1991. 270 p.
4. Giurgiu V. Repere pentru un necesar program al reconstrucției ecologice. În: *Protejarea și dezvoltarea durabilă a pădurilor României*. București, 1995.
5. Negulescu, E. G., Ciurac, Gh. *Silvicultura*. Editura Agro-Silvică de Stat, București. 1959.
6. Palancean A. Clasificarea arboretelor în dependență de influența factorului uman și evidențierea arboretelor necorespunzătoare. În: *Revista pădurilor*. București, 2014.
7. Palancean A. Reconstrucția ecologică a arboreturilor existente și crearea pădurilor noi în contextul schimbărilor climatice. În: *Materialele simpozionului internațional. Dezvoltarea durabilă a sectorului forestier – noi obiective și priorități*. Chișinău, 17-19 noiembrie 2011, p.142-146.
8. Gogu V. Peculiarities of stands regeneration in the ecological reconstruction process in the „Codrii” Reserve. In: *International Scientific Symposium Conservation of Plant Diversity*. Chisinau, 28-30 september, 2015, p. 23.
9. Gogu V. Regenerating stands as a basis for ecological reconstruction in „Codrii” Natural Reserve. In: *Buletin științific. Revistă de Etnografie, Științele Naturii și Muzeologie*. Vol. 24(37). Chișinău, 2016, p. 114-122.



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## THE GENUS *PILOSELLA* HILL (ASTERACEAE DUMORT.) IN “IAGORLÎC” SCIENTIFIC RESERVE

**Olga Ionița**

Botanical Garden (Institute) of the Academy of Sciences of Moldova

e-mail: o\_ionita@mail.ru

**Abstract.** The floristic investigations of the genus *Pilosella* Hill revealed six species in the flora of “Iagorlic” Scientific Reserve – *Pilosella officinarum* F. Schultz et Sch. Bip., *P. caespitosa* (Dumort.) P. D. Sell et C. West, *P. echioides* (Lumn.) F. Schult. et Sch. Bip., *P. glaucescens* (Bess.) Sojak, *P. flagellaris* (Willd.) Arv.-Touv., *P. praealta* (Vill. ex Gochn.) F. Schultz et Sch. Bip., the last three of which were new taxa for this area. After the chorological analysis, it was concluded that 3 species are rare: *Pilosella caespitosa*, *P. glaucescens* and *P. flagellaris*.

### INTRODUCTION

The genus *Pilosella*, known by the common name hawkweed, was described by J. Hill (1756), soon after the publication of the genus *Hieracium* (Linnaeus, 1753). For a long time, it was not accepted as an independent generic taxonomic unit, but was considered a taxonomic unit with the status of subgenus – *Pilosella* (Gray, 1821) or section – *Piloselloidea* (Koch, 1837) in the genus *Hieracium* s. l. [11]. The definitive delimitation of the genera *Hieracium* L. s. str. and *Pilosella* Hill was made in the last decades of the 20<sup>th</sup> century, as a result of the research and the published works of botanists such as: J. Sojak, P. D. Sell and C. West, J. Holub, J. Dostal, R. Shlyakov (1989) and others [10].

The genus *Hieracium* s.l. is known as a polymorphous and difficult taxonomic unit, previously represented, in the flora of the Republic of Moldova, by a single genus – *Hieracium* L. As a result of the monographic processing of the subfamily *Cichorioideae* Kitam. in the flora of this area, the genus *Pilosella* Hill and the genus *Hieracium* L. s. str. were recognized as two different, independent genera. The genus *Pilosella* Hill differs from the genus *Hieracium* L. s. str. mainly in the structure of the achene, which, as a rule, shows far more advanced conservative properties, unlike vegetative properties, and is more safely used in the activities of delimiting superspecific taxonomic categories [1].

In the summer of 2016, a floristic research on the family *Asteraceae* Dumort. was carried out in the territory of “Iagorlic” Scientific Reserve, located on the left bank of Dniester River, in Dubăsari district, at a distance of 12 km from Dubăsari town, at the mouth of Iagorlic River. About 780 species of wild vascular plants, which belong to 357 genera and 82 families, were found in the flora of “Iagorlic” Scientific Reserve [12]. The family *Asteraceae* included 127 species, of 49 genera, accounting for the largest share, about 16%. The reserve is characterized by various ecotopes, which determine the floristic richness of the territory.

### MATERIALS AND METHODS

This study was based on the floristic research on the genus *Pilosella* Hill (*Asteraceae* Dumort.) in “Iagorlic” Scientific Reserve and on consulting the literature and the collections from the Herbarium. The critical analysis of the *Pilosella* species was carried out according to the classical comparative-morphological method [9]. Guides for determining plant species and basic literature on floristics, related to the researched territory, were consulted for the determination of the taxonomic belonging of the specimens from the Herbarium and the specification of the bio-ecological, phytogeographical and chorological features of the species [5-8, 13, 15]. The evaluation of the rare species and the determination of their conservation status were performed according to the criteria of the International Union for Conservation of Nature (IUCN) (2001, 2003) [3, 4]. The nomenclature of taxa is



presented according to the fundamental papers in this field [5, 7, 8, 14].

## RESULTS AND DISCUSSIONS

As a result of the floristic and taxonomic research on the genus *Pilosella* in "Iagorlic" Scientific Reserve, 6 species were found: *Pilosella officinarum* F. Schultz et Sch. Bip., *P. caespitosa* (Dumort.) P. D. Sell et C. West, *P. echiioides* (Lumn.) F. Schult. et Sch. Bip., *P. glaucescens* (Bess.) Sojak, *P. flagellaris* (Willd.) Arv.-Touv. and *P. praealta* (Vill. ex Gochn.) F. Schultz et Sch. Bip., the last 3 of which were new taxa for the flora of the reserve. According to the chorological analysis, we came to the conclusion that 3 of the studied species are rare: *Pilosella caespitosa*, *P. glaucescens* and *P. flagellaris*.

The brief description of the genus *Pilosella* is given below. The synonymy, the first source where it was mentioned, the name in Latin, Romanian and English, the geoelement, the flowering and fruiting stage, the habitat, the local distribution, the abundance and the range of each species are presented. The rare species have been classified into categories according to their conservation status, the limiting factors have been identified and the necessary measures for their conservation have been proposed.

### The genus *Pilosella* Hill – *hawkweed*

Perennial plants, with the basal leaves arranged in a rosette, some species with marcescent leaves in the flowering stage, often with above-ground flexuous stolons (runners). The leaves are obovate, linear-lanceolate or linear, at the base gradually narrowed, with entire or distantly small-toothed margin. The anthodia (flower heads) with bisexual ligulate flowers are arranged in simple or compound corymbiform inflorescences, rarely, they are found by 1-2 on the tip of stems and shoots, or solitarily on scapiform stems. The involucre is (5) 6-12 (14) mm long, the involucral bracts are unevenly imbricate, herbaceous, often covered with simple, glandular and star-shaped hairs in various proportions. The receptacle is flat or slightly convex, foveolate (pitted), glabrous, without bracts. The flowers are yellow, rarely reddish-orange. The achenes are 1.2-2.5 mm long, without rostrum, grooved, with apical crenate corona. The pappus is uniseriate, composed of simple, fragile, white-gray hairs [6, 7, 10, 14].

**L e c t o t y p e :** *P. officinarum* F. Schultz et Sch. Bip.

There are a few thousand species common in the extratropical regions of Eurasia (excluding East Asia) and North Africa. In the flora of the Republic of Moldova, there are 11 species.

The presence of the species and intermediate forms, which are usually of hybrid origin, complicates the determination of the species of this genus. Many of them are the result of hybridization between different basic collective species (*species collectivae principales*), often three or more [13]. A mandatory condition for the accurate determination of the hawkweed is to collect the specimens correctly, making sure that the decumbent stolons, if present, are preserved.

**1. *P. caespitosa*** (Dumort.) P. D. Sell et C. West, 1967, *Watsonia*, 6, 5: 314, s. restr.; Шляков, 1989, Фл. евр. части СССР, 8: 349. – *Hieracium caespitosum* Dumort. 1827, *Fl. Belg.*: 27; P. D. Sell et C. West, 1976, *Fl. Europ.* 4: 373; Гейдеман, 1986, *Опред. высш. раст. МССР*, изд. 3: 584; Доброчаева, Котов, Прокудин, 1999, *Опред. высш. раст. Укр.* изд. 2: 385; Negru, 2007, *Det. pl. fl. R. Mold.*: 270; Ciocârlan, 2009, *Fl. Ilus. Rom.*: 870. – **Vulturică cespitoasă. – Meadow hawkweed, yellow hawkweed.**

Perennial, hemicryptophytic plant. Flowers and produces fruits in May-July. Praticolous species, grows solitarily or in small and diffuse groups, at the edge of forests, in glades, grasslands, slopes with steppe vegetation. The range of this species includes Central and South-Eastern Europe, the Caucasus and Western Siberia; it is an adventive species in Western Europe, North America and New Zealand. East-European-West-Siberian element.

Rare species, conservation status: **Vulnerable** VU B2b (iii, iv, v).

It has been found that, during the last decades, the number of places where this species grows has decreased in the territory of the Republic of Moldova. Seven places where it can be collected are known: Briceni, Rosoșani and Cotuieni communes, Briceni district; Rădoaia commune, Sângerei district; Căinari railway station, Căușeni

district; Şişcani commune, Nisporeni district, Țăghira (Movila Măgura) commune, Ungheni district and Goian commune, Dubăsari district.

The species is threatened by habitat loss through forest exploitation, unregulated tourism, mowing on slopes and in forest glades. Protective measures: protection of the places where the species grows, observance of the regime of the protected natural areas and monitoring of the population of the species.

**2. *P. echioides*** (Lumn.) F. Schultz et Sch. Bip. 1862, Flora (Regensb.), 45: 431; Шляков, 1989, Фл. евр. части СССР, 8: 329. – *Hieracium echioides* Lumn. 1791, Fl. Posop. 1: 348; Юксип, 1960, Фл. СССР, 30: 418; Гейдеман, 1986, Определ. высш. раст. МССР, изд. 3: 582; Доброчаева, Котов, Прокудин, 1999, Определ. высш. раст. Укр. изд. 2: 380; Negru, 2007, Det. pl. fl. R. Mold.: 270. – *H. echioides* subsp. *echioides*; P. D. Sell a. C. West, 1976, Fl. Europ. 4: 375, s. restr.; Ciocârlan, 2009, Fl. Ilus. Rom.: 870. – **Vulturită echinoidă.**

Perennial, hemicryptophytic plant. Flowers and produces fruits in May-July. It is a steppe species, grows solitarily or in groups by 2-5 plants, on arid slopes, sunny hills, rocky areas and in sectors with steppe vegetation of “Iagorlic” Scientific Reserve. It sporadically occurs throughout the territory of the Republic of Moldova. The range of the species includes Central and South-Eastern Europe, the Caucasus, the Mediterranean Basin, Asia Minor, Central Asia, Iran, Mongolia. Eurasian element.



Figure 1. *Pilosella flagellaris* (Willd.) Arv.-Touv.

**3. *P. flagellaris*** (Willd.) Arv.-Touv. 1873, Monogr. Pilos. Hier. Dauph.: 13; Шляков, 1989, Фл. евр. части СССР, 8: 375. – *Hieracium flagellare* Willd. 1814, Enum. Pl. Horti Berol., Suppl.: 54; Юксип, 1960, Фл. СССР, 30: 643; P. D. Sell a. C. West, 1976, Fl. Europ. 4: 369, pro sp. coll. propr.; Доброчаева, Котов, Прокудин, 1999, Определ. высш. раст. Укр. изд. 2: 385; Ciocârlan, 2009, Fl. Ilus. Rom.: 869, cum auct. (Willd.) Naeg. et Peter. – **Vulturită flagelară. – Shetland mouse-ear hawkweed** (Figure 1).

Perennial, hemicryptophytic plant. Flowers and produces fruits in June-July. It is a steppe species, grows solitarily or in groups at the edge of forests, on arid slopes with steppe vegetation. The range of the species includes the Scandinavian Peninsula (Finland), Central and Eastern Europe. European element.

Rare species, conservation status: **Vulnerable** VU D2

New species for the Republic of Moldova, found for the first time in 2010 [2]. It was collected in 5 localities: Zăbriceni commune, Briceni district; Naslavcea and Lencăuți communes, Ocnița district; Rădenii Vechi commune, Ungheni district and Lozova commune, Strășeni district. During the field research conducted in the summer of 2016, it was found in the territory of “Iagorlic” Scientific Reserve. This taxon is threatened by deforestation, excessive grazing and mowing. It is an ornamental plant, the basal rosettes and the stolons

form a thick ground cover. *Protective measures*: inclusion in the list of species protected by law, protection of the areas where this species is found, rigorous observance of the regime of the nature reserve and monitoring of the population.

**4. *P. glaucescens*** (Bess.) Sojak, 1971, Preslia (Praha), 43, 2: 185, s. restr.; Шляков, 1989, Фл. евр. части СССР, 8: 341. – *Hieracium glaucescens* Bess. 1809, Prim. Fl. Galic. 2: 149; Юксип, 1960, Фл. СССР, 30: 462; Гейдеман, 1986, Определ. высш. раст. МССР, изд. 3: 584; Доброчаева, Котов, Прокудин, 1999, Определ. высш. раст. Укр. изд. 2: 381; Negru, 2007, Det. pl. fl. R. Mold.: 271. – *H. praealtum* Vill. ex Gochnat subsp. *thausasium* (Peter) P. D. Sell, 1976, Bot. Jour. Linn. Soc. 71: 260; P. D. Sell a C. West, 1976, Fl. Europ. 4: 372 – **Vulturită glaucescentă**. (Figure 2)

Perennial, hemicryptophytic plant. Flowers and produces fruits in May-July. Steppe species, grows solitarily or in groups by 2-4 plants, in grasslands, on dry slopes with steppe vegetation, at the edge of the forests, fields and along roadsides. The range of the species includes Central and South-Eastern Europe, the Mediterranean Basin (eastern part) and Asia Minor. Pannonian-Pontic-East-Mediterranean element.

Rare species, conservation status: **Near threatened** NT B2ab(iii, iv)D2.

The degradation and loss of steppe areas adversely affect the development of populations, reducing their viability. In the Republic of Moldova, it was found in 4 localities: Sărata-Galbenă and Bozieni communes, Hâncești district; Băcioi commune, Chișinău municipality; Țăghira commune, Ungheni district.



Figure 2. *Pilosella glaucescens* (Bess.) Sojak

In the summer of 2016, it was collected from the territory of “Iagorlic” Scientific Reserve, where it grew in small populations. This species is threatened by the expansion of agricultural lands, grazing and afforestation of slopes with non-native woody species. *Protective measures*: protection of steppe sectors, monitoring of population status, identification of new areas where the species grows.

**5. *P. officinarum*** F. Schultz et Sch. Bip. 1862, Flora (Regensb.), 45: 421.; Шляков, 1989, Фл. евр. части СССР, 8: 358. – *Hieracium pilosella* L. 1753, Sp. Pl.: 800, p. p.; Юксип, 1960, Фл. СССР, 30: 692; P. D. Sell a C. West, 1976, Fl. Europ. 4: 368; Гейдеман, 1986, Определ. высш. раст. МССР, изд. 3: 582; Доброчаева, Котов, Прокудин, 1999, Определ. высш. раст. Укр. изд. 2: 379; Negru, 2007, Det. pl. fl. R. Mold.: 270; Ciocârlan, 2009, Fl. Ilus. Rom.: 867. – **Vulturită comună**. – **mouse-ear hawkweed**. (Figure 3)

Perennial, hemicryptophytic plant. Flowers and produces fruits in May-September. Praticolous species, grows in grasslands, sunny areas, steppe sectors. It grows sporadically, solitarily or in groups, forming numerous populations throughout the studied territory. The range of the species includes the Scandinavian Peninsula,



Atlantic Europe, Central and Southeastern Europe, the Mediterranean Basin, Asia Minor, the Caucasus, Western Siberia; it is an adventive species in North America and New Zealand. Ornamental plant during flowering. West-European element.

**6. *P. praealta*** (Vill. ex Gochn.) F. Schultz et Sch. Bip. 1862, Flora (Regensb.), 45: 429; Шляков, 1989, Фл. евр. части СССР, 8: 332. – *Hieracium praealtum* Vill. ex Gochn. 1808, Tent. Pl. Cichor.: 17; Юксип, 1960, Фл. СССР, 30: 441. – *H. praealtum* subsp. *praealtum*; P. D. Sell a C. West, 1976, Fl. Europ. 4: 371, s. restr. – **Vulturică preînaltă.**

Perennial, hemicryptophytic plant. Flowers and produces fruits in June-July. Praticolous species, grows solitarily or in groups in sunny grasslands, glades, at the edge of forest sectors, in cutting areas in forests, on slopes with steppe vegetation, at the edge of fields. It grows sporadically in all the districts of the country. Recently, in the summer of 2016, it was found in a new place – Goian commune, Dubăsari district, in the territory of “Iagorlic” Scientific Reserve. The range of the species includes Central and Southeastern Europe, the Mediterranean Basin. European-Mediterranean element.



Figure 3. *Pilosella officinarum* F. Schultz et Sch. Bip.

## CONCLUSIONS

The wild flora of the Republic of Moldova includes 11 species of the genus *Pilosella* Hill, 6 of them have been found in “Iagorlic” Scientific Reserve: *Pilosella officinarum* F. Schultz et Sch. Bip., *P. caespitosa* (Dumort.) P. D. Sell et C. West, *P. echioides* (Lumn.) F. Schult. et Sch. Bip., *P. glaucescens* (Bess.) Sojak, *P. flagellaris* (Willd.) Arv.-Touv. and *P. praealta* (Vill. ex Gochn.) F. Schultz et Sch. Bip.

As a result of the research, 3 new species for the flora of “Iagorlic” Scientific Reserve have been found: *Pilosella glaucescens*, *P. flagellaris* and *P. praealta*.

Three of the hawkweed species, found in “Iagorlic” Scientific Reserve, are rare: *Pilosella caespitosa* (Dumort.) P. D. Sell et C. West, *P. glaucescens* (Bess.) Sojak and *P. flagellaris* (Willd.) Arv.-Touv. The monitoring of their populations continues, as it is necessary for the development of special conservation measures.

## BIBLIOGRAPHY

1. Ionița O. *Pilosella* Hill genus in the Bessarabia's flora. In: Journal of plant development. Iași: 2011, 18. p. 109-116.
2. Ionița O., Negru A. Specii noi de *Pilosella* Hill (*Asteraceae* Dumort.) din flora Basarabiei. In: Akademos, 2010, nr. 4 (19), p. 124-126.
3. IUCN. *Guidelines for application of IUCN Red List Criteria at Regional Levels*: Version 3.0. IUCN Species Survival Commission. IUCN, Gland, Switzerland: 2003.
4. IUCN. *IUCN Red List Categories and Criteria*: Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland: 2001.
5. Negru A. Determinator de plante din flora Republicii Moldova. Chișinău: 2007. 391 p.
6. Nyarady E. Flora Republicii Populare Române. v. 10, București: Editura Academiei Republicii Populare Române, 1965. 750 p.
7. Sell P. & West C. *Hieracium* L. In: Tutin T. G. et al. Flora Europaea. Cambridge University Press, 1976, vol. 4, p. 358-

410.

8. Гейдеман Т. Определитель высших растений МССР. Кишинев: Штиинца, 1986, третье изд. с. 567-586.
9. Коровина О. Н. Методические указания к систематике растений. Л., 1986. 210 с.
10. Тихомиров В. Род *Pilosella* Hill. во флоре Беларуси. Автореферат Диссертации на соиск. ученой степ. канд. биолог. наук. Минск, 2001. 21 с.
11. Тупицина Н. Ястребинки Сибири. Новосибирск: Наука, 2004. 207 с.
12. Шабанова Г., Изверская Т. Флора сосудистых растений Государственного заповедника «Ягорлык». В: Заповедник «Ягорлык». Ch: Eco-Tiras, 2006, с. 50-114.
13. Шляков Р. Род *Hieracium* L. В: Флора Европейской части СССР. Ленинград: Наука, 1989, т. 8, с. 140-300.
14. Шляков Р. Род *Pilosella* Hill. В: Флора Европейской части СССР. Ленинград: Наука, 1989, т. 8, с. 300-358.
15. Юксип А. Род *Hieracium*. В: Флора СССР. М-Л: Изд. АН СССР, 1960, т. 30, 732 с.



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## FLORISTIC NOTES IN BESSARABIA NO. 148-164

*Pînzaru Pavel<sup>1</sup>, Ruschuk Alexander<sup>2</sup>, Ruschuk Vera<sup>3</sup>*

1. Botanical Garden (Institute) of the Academy of Sciences of Moldova,

e-mail: [p\\_panzaru@yahoo.it](mailto:p_panzaru@yahoo.it)

2. T. G. Schevchenko University, Tiraspol

3. Institute of Scientific Research in Ecology and Natural Resources, Tiraspol

**Abstract:** The article presents new data on the distribution of 17 rare species in Bessarabia. The species *Orchis purpurea* Huds. was recorded for the first time in the territory from the left bank of Dniester river. The species *Potentilla bifurca* L. has been found in "La Izvor" Park in Chisinau. The species *Spiraea crenata* L. has been proposed to be included in the Red Book of the Republic of Moldova, in the category Vulnerable (VU).

**Key words:** rare plants, new records, Bessarabia.

## INTRODUCTION

Further, in "Floral Notes in Bessarabia" [15], new data regarding the distribution of rare species in the flora of Bessarabia and the adjacent territory from the left bank of the Dniester river are presented.

## MATERIALS AND METHODS

All the floristic notes presented in this article have been obtained as a result of the floristic study carried out in the field, in April and July 2017, in some localities of the districts Râbnîța, Grigoriopol, Hîncești, Anenii Noi, Chișinău municipality and UTAG (Etulia, district Vulcănești), and the study of the herbarium and specialized literature. The herbarized plants are found in the Herbarium of the Botanical Garden (I) of ASM [CHIS] and in the author's own collection (CHIS-PP).

The species are highlighted based on the traditional morphological-ecological method. Floristic nomenclature [17]. The rare species of the flora of the republic – according to the Law no. 66-68, from 1998, published in the Official Monitor of RM [12], and the Red Book of the Republic of Moldova (2015).

Floristic notes refer to new, rare or newly found species in one of the regions of Bessarabia and Transnistria. The presence of the species is indicated by "+" and their absence by "-", the range is indicated by region: **BasN** – includes the localities of northern Bessarabia (Cernăuți region), **BasS** – localities of southern Bessarabia (Odessa region), **RMN** – the North of the republic: Ocnița, Briceni, Edineț, Dondușeni, Rîșcani, Drochia, Soroca, Glodeni, Fălești, Singerei, Florești, Șoldănești, Rezina and Telenesti districts, Bălți municipality, **RMC** – central part of the republic: Ungheni, Călărași, Orhei, Criuleni, Strășeni, Nisporeni, Hîncești, Ialoveni, Anenii Noi and Dubăsari districts (localities from the right bank of Dniester), Chișinău municipality, Tighina municipality; **RMS** – the South of the republic: Leova, Cimișlia, Căușeni, Ștefan-Vodă, Basarabeasca, Cantemir, Cahul and Taraclia districts and the UTAG - Autonomous Territorial Unit of Gagauzia (with Comrat, Vulcănești and Ceadăr-Lunga districts), **RME** – East: The Administrative-Territorial Units of the Left Bank of the Dniester, **/RAR** – rare species, **/A** – naturalized exotic species, **/A** – occasionally cultivated exotic species.

## RESULTS AND DISCUSSIONS

The recent floristic studies have revealed new locations where 17 rare species of the flora of the Republic of Moldova grow. The species *Orchis purpurea* Huds. was found for the first time on the left bank of Dniester.

The species *Potentilla bifurca* L. was rediscovered in the “La Izvor” Park in Chisinau.

**148. *Allium inaequale*** Janka, 1800, Linnaea, 30: 603 (*Amaryllidaceae*)

+ **RME/RAR:** Anenii Noi district, Șerpeni commune, on the right bank of Dniester. Rare species, grows in clayey-sandy soil with gravel, in phytocoenoses of the association *Bothriochloetum ischaemi* (Krist. 1937) I. Pop 1977, 02.IV.2017, 20.VIII.2017, registered by P. Pinzaru.

**Note.** Pontic-Central-Asian, xeromesophilic, calciphilic geophyte. Vulnerable species (VU), included in the Red Book of the Republic of Moldova. [3]

**149. *Astragalus exscapus*** L. 1771, Mant. Pl. Altera: 275 (*Fabaceae*)

+ **RMC/RAR:** Anenii Noi district, Șerpeni commune, on the right bank of Dniester, on slopes with steppe vegetation, with glades of scrubs, in clayey-sandy soil with gravel, sporadic species, 02.IV.2017, 16.V.2017, leg. P. Pinzaru. [CHIS, CHIS-PP]

**Note.** East European, xeromesophilic, steppe hemicyptophyte. Vulnerable species (VU), it is rarely found in Telenești, Nisporeni districts and UTAG (Bugeac). [17]

**150. *Astragalus vesicarius*** L. var. *angelicae* Pinzaru, 2013, Novosti Sist. Vyssh. Rast. 44: 219 (*Fabaceae*)

+ **RMS:** UTAG, Etulia commune, grows in small groups, on hills with clayey-sandy soil with gravel, on the slopes of ravines, 28.VI.2016, leg. P. Pinzaru [CHIS-PP]. It has white or whitish corolla: two plants were planted in a private garden; they bloomed on 08.V.2017.

+ **RME:** Administrative-Territorial Units of the Left Bank of the Dniester, Molochișul Mare village, on calcareous slopes, 07.V.2017, leg. P. Pinzaru, A. Ruschuk, V. Ruschuk; Administrative-Territorial Units of the Left Bank of the Dniester, Colosova and Tașlic villages, south of Grigoriopol town, grows on calcareous slopes 07-08.V.2017, leg. P. Pinzaru, A. Ruschuk, V. Ruschuk. [CHIS, CHIS-PP]

**Note.** Endemic, xerophilic chamaephyte, characteristic of the vegetation of areas with Sarmatian limestone and arid hills with steppe vegetation and clayey-sandy soil with gravel. This variety has also been found in the districts: Florești (Cenușa, Gura Camencii, Prodănești, Prodăneștii Vechi), Telenești (Ordășei), Orhei (or. Orhei, Păhârnicieni, Trebujeni), Chișinău municipality (Făurești, or. Chișinău), Aneii Noi (Delacău, Telița) and Dubăsari (Molovata). [15, 16]

**151. *Bellevalia speciosa*** Woronow ex Grossh. 1925, Fl. Tifl. 1: 113 (*Asparagaceae*)

Syn.: - *Bellevalia sarmatica* (Georgi) Woronow

+ **RME/RAR:** Administrative-Territorial Units of the Left Bank of the Dniester, Molochișul Mare village, on the right bank of Ocna creek, on slopes with steppe vegetation, registered on 07.V.2017, P. Pinzaru, A. Ruschuk, V. Ruschuk.

**Note.** Pontic, xeromesophilic, steppe geophyte. Vulnerable species (VU), included in the Red Book of the Republic of Moldova. [4, 7, 16]

**152. *Bombycilaena erecta*** (L.) Smoljan. 1955, in Bot. Mater. Gerb. Bot. Inst. Komarova akad. Nauk SSSR 17: 450 (*Asteraceae*)

+ **RMC/RAR:** Hîncești district, Pogănești village, sporadic, grows in phytocoenoses dominated by *Bothriochloa ischaemum* O. Kuntze, 09.VII.2017, leg. P. Pinzaru. [CHIS, CHIS-PP]

+ **RMS/RAR:** Cahul district, Slobozia Mare village, grows in phytocoenoses dominated by *Bothriochloa ischaemum* O. Kuntze, 01.VII.2009 col. G. Titica, leg. P. Pinzaru, 05.IX.2017. [CHIS]

**Note.** Sub-Mediterranean, xerophilic, steppe hemicyptophyte. Vulnerable species (VU), found in the district Cahul (Alexandru Ioan Cuza) and in the Autonomous Territorial Unit of Gagauzia (Etulia). [14]

**153. *Chamaecytisus ratisbonensis*** (Schaeff.) Rothm. 1944, Feddes Repert. Spec. Nov. Regni Veg. 53: 143 (*Fabaceae*)

+ **RME/RAR:** Administrative-Territorial Units of the Left Bank of the Dniester, south of Grigoriopol town and in the vicinity of Tașlic village, grows on calcareous slopes, in phytocoenoses of the association *Sileno-Pimpinellietum tragii* P. Pinzaru 1997, grows sporadically, 08.V.2017, leg. P. Pinzaru, A. Ruschuk; Administrative-

Territorial Units of the Left Bank of the Dniester, Colosova village, on slopes with steppe vegetation and clayey-sandy soil, 07.V.2017, leg. P. Pinzaru, A. Ruschuk, V. Ruschuk. [CHIS, CHIS-PP]

**Note.** Central-European, xerophilic, calciphilic camephyte. Vulnerable species (VU). It has been found in the districts: Florești, Șoldănești, Taraclia, Cahul and districts from the left bank of Dniester (Camenca, Rîbința and Dubăsari).

**154. *Ephedra distachya* L. 1753, Sp. Pl.: 1040 (*Ephedraceae*)**

+ **RMC/RAR:** Hîncești district, Pogănești village, with abundance 1-3, on an area of about 200 m<sup>2</sup>, on the left bank of Prut river, in sandy clay, in phytocoenoses dominated by *Bothriochloa ischaemum* O. Kuntze, 09.VII.2017, leg. P. Pinzaru. [CHIS, CHIS-PP]

**Note.** Eurasian, xerophilic, steppe camephyte. Vulnerable species (VU), included in the Red Book of Moldova. [8, 11]

**155. *Eremogone biebersteinii* (Schltdl.) Holub, 1974, Folia Geobot. Phytotax. 9: 273 (*Caryophyllaceae*)**

+ **RME/RAR:** Administrative-Territorial Units of the Left Bank of the Dniester, Colosova village, in small groups, in thickets of *Caragana frutex* var. *mollis* (M. Bieb.) C. K. Schneid. or *Spiraea crenata* L., 07.V.2017, leg. P. Pinzaru, A. Ruschuk, V. Ruschuk; Tașlîc village, on calcareous slopes, in phytocoenoses of the association *Sileno-Pimpinellietum tragii* P. Pânzaru 1997, sporadically distributed species, 08.V.2017, leg. P. Pinzaru, A. Ruschuk. [CHIS, CHIS-PP]

**Note.** Pontic, xeromesophilic, steppe hemicryptophyte. Critically endangered species (CR), included in the Red Book of the Republic of Moldova. [9]

**156. *Linum tauricum* Willd. 1809, Enum. Pl. Horti Bot. Berol.: 339 (*Linaceae*)**

Syn.: - *Linum linearifolium* (Lindem.) Jav.

+ **RME/RAR:** Administrative-Territorial Units of the Left Bank of the Dniester, Tașlîc village, grows sporadically on calcareous slopes, in phytocoenoses of the association *Sileno-Pimpinelleitum tragii* P. Pânzaru, 08.V.2017, recorded by P. Pinzaru, A. Ruschuk. [CHIS]

**Note.** Pontic-Balkan, xerophilic, calciphilic camephyte. Endangered species (EN), included in the Red Book of the Republic of Moldova [1]. It has been detected in the districts: Florești (Gvozdova, Cenușa, towards Stîrceni), Telenești (Ordășei), Orhei (Morovaia), Chișinău municipality (Făurești), Administrative-Territorial Units of the Left Bank of the Dniester (Hrușca, Molochișul Mare, Hîrjău, Sărăței, Pîcalovo, Șmalena, Goian). [16]

**157. *Orchis purpurea* Huds. 1762, Fl. Angl.: 334 (*Orchidaceae*)**

+ **RME/RAR:** Administrative-Territorial Units of the Left Bank of the Dniester, Molochișul Mare commune, on the right bank of Ocna creek, on calcareous slope with southern exposition, in scrubs of the association *Prunetum tenellae* Soó 1951. Three plants with flowers and three juvenile plants were found, 07.V.2017, A. Ruschuk, P. Pinzaru, V. Ruschuk.

**Note.** European, xeromesophilic, forest geophyte. Endangered species, included in the Red Book of the Republic of Moldova. It has been detected only in the forests of the central area of the republic and in the north – in the forest of Văscăuți village, Florești district. [2, 16-18]

**158. *Ornithogalum kochii* Parl. 1857, Fl. Ital. (*Asparagaceae*)**

+ **RME/RAR:** Administrative-Territorial Units of the Left Bank of the Dniester, Tașlîc village, on the left bank of Tașlîc creek, on slope with steppe vegetation, 08.V.2017, leg. P. Pinzaru, A. Ruschuk.

**Note.** Mediterranean-Pontic, xeromesophilic, steppe, forest geophyte. This species is at lower risk [LR] of extinction. On the left bank of Dniester river, it has been found in the Administrative-Territorial Units of the Left Bank of the Dniester (Hrușca, Camenca, Rașcov, Caterinovca), it grows in few locations, but abundantly (2-3). [16]

**159. *Peucedanum oreoselinum* (L.) Moench, 1794, Methodus, 82 (*Apiaceae*)**

+ **RMC/RAR:** Anenii Noi district, Geamăna commune, a single plant in a scrub of *Spiraea crenata* L., 06.V.2017, recorded by P. Pinzaru.

**Note.** European, xeromesophilic hemicryptophyte. Data deficient [DD] species. It was detected in the districts: Ocnița (Ocnița), Edineț (Clișcăuți) and Glodeni (Cobani, Moara Domnească, Balatina). [20]

**160. *Potentilla bifurca*** L. 1753, Sp. Pl.: 497 (*Rosaceae*)

+ **RMC/RAR:** Chișinău municipality, in "La Izvor" park from ariera Sculeni, in the meadow between the lake and the central alley of the park, 20.V.2017, leg. P. Pinzaru, E. Chiriac, B. Nedbaliuc. [CHIS, CHIS-PP]

*Potentilla bifurca*, with abundance + coverage of 1-2, grows in phytocoenoses dominated by *Poa bulbosa* L. (abundance 2-3), together with *Achillea* ssp., *Agropyron pectinatum* (M. Bieb.) P. Beauv., *Arenaria serpyllifolia* L., *Cardaria draba* (L.) Desv., *Chenopodium album* L., *Convolvulus arvensis* L., *Dactylis glomerata* L., *Elytrigia repens* (L.) Nevski, *Lathyrus tuberosus* L., *Lolium perenne* L., *Medicago falcata* L., *Melilotus officinalis* (L.) Pall., *Plantago lanceolata* L. *Poa angustifolia* L., *Potentilla argentea* L., *Thesium arvense* Horv., *Trifolium pratense* L., *Veronica arvensis* L.

**Note.** Caucasian-Eurasian species, herbaceous, xeromesophilic-mesophilic camephyte. This species was recorded for the first time in 1994, on the outskirts of Chișinău, in Bariera Sculeni sector [5], where it then disappeared.

**161. *Saxifraga tridactylites*** L. 1753, Sp. Pl.: 404. (*Saxifragaceae*)

+ **RME/RAR:** Administrative-Territorial Units of the Left Bank of the Dniester, Tașlic village, on the left bank of Tașlic creek, in rendzina soil with gravel, in phytocoenoses of the associations *Sileno-Pimpinellietum tragii* P. Pinzaru and *Spiraeetum crenatae* Morariu et Ulariu 1981, 07.V.2017, leg. P. Pinzaru, A. Ruschuk [CHIS].

**Note.** Eurasian, xerophilic, calciphilic therophyte. Species included in the Red Book of the Republic of Moldova, in the category: critically endangered (CR) [10]. Usually, it grows on calcareous rocks from the basins of Dniester and Prut rivers, the phytocoenoses dominated by *S. tridactylites*, from the Republic of Moldova, are included in the association *Sedo acris-Saxifragetum tridactylitis* Pinzaru 2015 [13]. It is proposed for listing as vulnerable (VU).

**162. *Scozonera austriaca*** Willd. 1803, Sp. Pl., ed.4, 3(3): 1498 (*Asteraceae*)

+ **RME/RAR:** Administrative-Territorial Units of the Left Bank of the Dniester, Molochișul Mare village, on the right bank of Ocna creek, on calcareous slope with steppe vegetation. It grows sporadically in phytocoenoses of the association *Carici humilis-Stipetum pennatae* (Pop et al. 1964) Pop et Hodișan 1985, 07.VI.2017, leg. P. Pinzaru, A. Ruschuk, V. Ruschuk. [CHIS, CHIS-PP]

**Note.** Eurasian (Sub-Mediterranean), xeromesophilic, calciphilic geophyte. Critically endangered species (CR), included in the Red Book of the Republic of Moldova and formerly known as growing in the districts: Rezina (Țipova), Telenești (Zgârdești), Administrative-Territorial Units of the Left Bank of the Dniester (Doibani) and Cahul (Cahul city). [6]

**163. *Scorzonera hispanica*** L. 1753, Sp. Pl.: 791 (*Asteraceae*)

+ **RME/RAR:** Administrative-Territorial Units of the Left Bank of the Dniester, Colosova village, grows sporadically on hills with steppe vegetation, among small shrubs, 07.V.2017, recorded by P. Pinzaru, A. Ruschuk, V. Ruschuk. [CHIS]

+ **RMC/RAR:** Anenii Noi district, Geamăna commune, grows sporadically in glades of downy oak (*Quercus pubescens* Willd.) forests, 06 V 2017, recorded by P. Pinzaru.

**Note.** Pontic-Mediterranean, xeromesophilic, steppe geophyte. Rare species, listed in the low risk (LR) category. It is found in the districts of the centre and south of the republic. [18]

**164. *Spiraea crenata*** L. 1753, Sp. Pl.: 489 (*Rosaceae*)

+ **RME/RAR:** Administrative-Territorial Units of the Left Bank of the Dniester, Tașlic village, on the left bank of Tașlic creek, a cluster of plants of 15 m<sup>2</sup>, on calcareous slope, 08.V.2015, leg. P. Pinzaru, A. Ruschuk. This species is characteristic of the association *Spiraeetum crenatae* Morariu et Ulariu 1981. [CHIS, CHIS-PP]

**Note.** Eurasian, xeromesophilic, calciphilic nanophanerophyte. Vulnerable species (VU), it has been proposed to include it in the Red Book of the Republic of Moldova. According to the data from the Herbarium, it was found in the districts: Administrative-Territorial Units of the Left Bank of the Dniester (or. Dubăsari,

Colosova, Andriașevca Nouă), Florești (Vertiujeni), Anenii Noi (Bulboaca, Delacău, Geamăna, Crețoaia), Hîncești (Valea Florii, Bălceana), Ialoveni (Răzeni), Cimișlia (Zloți) and Fălești (Măgura). [16]

## CONCLUSIONS

*Potentilla bifurca* L. is a rare, little known species and new research is needed to determine the category of rarity to which it belongs. The species *Spiraea crenata* L. forms thickets on small areas and is proposed to be included in the Red Book of the Republic of Moldova, in the category Vulnerable (VU).

## BIBLIOGRAPHY

1. Cantemir V. *Linum linearifolium* Javorka//The Red Book of the Republic of Moldova. Chișinău: Știința, 2015, p. 78.
2. Chirtoaca V. *Orchis purpurea* Huds.//The Red Book of the Republic of Moldova. Chișinău: Știința, 2001, p. 91.
3. Ghendov V. *Allium inaequale* Janka//The Red Book of the Republic of Moldova. Chișinău: Știința, 2015, p. 118.
4. Ghendov V., Izverscaia T. *Bellevia sarmatica* (Georgi) Woronow//The Red Book of the Republic of Moldova. Chișinău: Știința, 2015, p.136.
5. Grabco N., Onu A., Donea E. Contribuții la studierea speciei *Potentilla bifurca* L.//Materiale conf. Corpului didactico-științific „Bilanțul activității științifice a U.S.M. pe anii 1993-1994”. 20-27 martie 1995. Științele naturii. Chișinău, 1995, p.238.
6. Ionița O. *Scorzonera austriaca* Willd.//The Red Book of the Republic of Moldova. Chișinău: Știința, 2015, p. 27.
7. Istrati A., Negru A. *Bellevia sarmatica* (Georgi) Woronow//The Red Book of the Republic of Moldova. Chișinău: Știința, 2001, p. 73.
8. Istrati A., Negru A. *Ephedra distachya* L.//The Red Book of the Republic of Moldova. Chișinău: Știința, 2001, p. 97.
9. Izverscaia T. *Eremogone biebersteinii* (Schlecht) Holub//The Red Book of the Republic of Moldova. Chișinău: Știința, 2015, p. 46.
10. Izverscaia T. *Saxifraga tridactylites* L.//The Red Book of the Republic of Moldova. Chișinău: Știința, 2015, p. 107.
11. Izverscaia T., Bucațel V. *Ephedra distachya* L.//The Red Book of the Republic of Moldova. Chișinău: Știința, 2015, p. 169.
12. Legislația ecologică a Republicii Moldova (1996-1998). Societatea ecologică „BIOTICA”. Chișinău: Tipografia Centrală, 1999, 223 p.
13. Pinzaru Pavel. *Sedo acris-Saxifragetum tridactylitis* – asociație nouă în vegetația Republicii Moldova. În: Culegere de materiale. Conferința Științifică Biologia și Progresul Științific. Consacrată aniversării a 85 de ani din ziua nașterii și 62 de ani de activitate științifică și didactică a Profesorului universitar, Petru Gh. Tarhun. Chișinău: Pontos, 2015, p. 78-85.
14. Pinzaru P. Floristic notes in Bessarabia No. 62-69//Journal of Botany vol. VIII, Nr.2(13), 2016, p. 21-26.
15. Pinzaru P. Note floristice din Basarabia nr. 70-147./Pinzaru P., Sîrbu T. Flora vasculară din Republica Moldova. Lista speciilor și ecologia. Chișinău: Tipografia UST, 2016, p. 33-51.
16. Pinzaru P. Plante rare ale raionului Florești din Republica Moldova. Chișinău: Tipografia UST, 2017, 118 p.
17. Pânzaru P., Negru A., Izverschi T. Taxoni rari din flora Republicii Moldova. Chișinău. 2002, 148 p.
18. Pinzaru P. & Sîrbu T. Flora vasculară din Republica Moldova. Lista speciilor și ecologia. Chișinău: Tipografia UST, 2016, 261 p.
19. Postolache Gh. *Orchis purpurea* Huds.//The Red Book of the Republic of Moldova. Chișinău: Știința, 2015, p. 161.
20. Tofan-Burac T., Chifu T. Flora și vegetația din lunca Prutului. Iași: CORSON, 2002, p. 128.



CZU 581.52(450.211)

## VASCULAR FLORA OF THE SPECIAL NATURE RESERVE OF MONTI PELATI AND TORRE CIVES IN THE PROVINCE OF TURIN (ITALY)

*Pinzaru Pavel*

Botanical Garden (Institute) of the Academy of Sciences of Moldova,

e-mail: [p\\_panzaru@yahoo.it](mailto:p_panzaru@yahoo.it)

**Abstract:** The vascular flora of the Special Nature Reserve of Monti Pelati and Torre Cives comprises 316 species of 209 genera, 78 families, among them, there are: 14 Pteridophyta, 9 Pinophyta and 293 Magnoliophyta. There are 6 rare species, for the flora of Piedmont region, namely: *Cephalanthera longifolia* (L.) Fritsch, *C. rubra* (L.) Rich., *Epipactis atropurpurea* (Hoffm.) Besser, *Narcissus poeticus* L., *Platanthera bifolia* (L.) Rich., *Gentiana pneumonanthe* L. (EN category), the last one has been included in the "Red Book of Italy".

**Keywords:** flora, the Special Nature Reserve of Monti Pelati and Torre Cives, the Province of Turin.

### INTRODUCTION



Special Nature Reserve of Monti Pelati and Torre Cives

The Special Nature Reserve of Monti Pelati and Torre Cives is situated in the territory of the communes Baldissero Canavese, Castellamonte and Vidrasco in the Province of Turin, Piedmont region, Italy. It is protected by the Law no. 29 of 14 June 1993. The area of the reserve is 147 ha; it spreads to the right of the Chiusella Valley. It is oriented SSW-NNE, its length is approximately 3 km and its width – about 0.5 km, the maximum altitude is 581 m. At this altitude, one can find Torre Cives, a tower built in the 12th century. The Nature Reserve of Monti Pelati and Torre Cives has a particular charm and is an unique territory, completely different from the rest of Canavese, the rocky landscape looks somehow otherworldly. Almost half of the territory of the reserve consists of rocky outcrops, predominantly peridotites, green basic rocks, which contain magnesium-rich olivine, pyroxene and hornblende (a mineral in the form of dark green or dark brown crystals, with a glassy shine,

consisting of magnesium silicates, rich in iron). At the surface, there are veins of magnesite and magnesium carbonate. Over the Cives height there are visible minerals called serpentine or hydrated peridotite, and at the top – schistose serpentine, a lamellar rock. The reserve is characterized by a xerothermic microclimate, with the average temperature 4-5 degrees higher than in the surrounding areas. Annual average precipitation reaches 1.270 mm. The soils are characterized by excess magnesium, an element that may be toxic to plants, affecting their growth, which is a reason why the vegetation is so sparse [5, 9, 14]. Up to now, the flora of the magnesite quarries, consisting of 80 vascular plant species, has been studied only by R. Caramiello and F. Montacchini (1977). M. Pividori (1991) published several notes on the current and prospective state of forest vegetation, enumerating the species of trees found in the reserve.

This paper contains the results of the floristic research pursued on the entire area of the reserve.

## MATERIALS AND METHODS

The materials presented in this paper have been obtained by the author as a result of the floristic research conducted in the field during 2007-2008 and 2011. The plant families and genera are given according to [1, 8], the list of species – according to Conti et al. (2005). Rare plants [4, 6, 7].

## RESULTS AND DISCUSSIONS

As a result of the floristic and phytosociological research, we have found that the herbaceous vegetation makes up, in most cases, praticalous, mesophilic phytocoenoses with a small overall coverage 20-40 (60)%, consisting of *Schoenus nigricans* or *Molinia caerulea*. On the more arid hills, there are steppe xerophilous phytocoenoses of *Stipa moraldoi* with *Carex humilis*, of *Chrysopogon gryllus* and *Bromus erectus* with *Danthonia decumbens*. Sporadically, there are isolated shrubs, rarely in small groups: *Juniperus communis*, *Salix eleagnos*, *Lembotropis nigricans* [= *Cytisus nigricans*], *Rosa canina*, *R. galica*, *Frangula alnus* and some species of trees, which are quite small: *Pinus mugo*, *P. sylvestris*, *Ailantus altissima*, *Betula pendula*, *Quercus pubescens*, *Larix decidua*. The forest area occupies less than 10% of the reserve's territory and consists of: *Pinus nigra*, *P. strobus*, *P. sylvestris*, *Betula pendula* and *Larix decidua*.

On the northern slope of the Torre Cives height, a mixed forest sector is developing: *Quercus pubescens*, *Q. petraea*, *Betula pendula*, *Acer pseudoplatanus*, *A. platanoides*, *Carpinus betulus*, *Castanea sativa*, *Celtis australis*, *Sorbus aria*, *S. intermedia*, with *Larix decidua*. The layer of shrubs consists of: *Frangula alnus*, *Euonymus europaeus*, *Juniperus communis*, *Berberis vulgaris*. The herbaceous layer is uneven, consisting of: *Dryopteris filix-mas*, *D. affinis*, *D. carthusiana*, *Anemonoides nemorosa*, *Melica uniflora*, *Serratula tinctoria*, *Prenanthes purpurea*, *Polygonatum multiflorum*, *Brachypodium sylvaticum*, *Arabis turrata*, *Viola reichenbachiana*, *Hypericum montanum*, *Solidago virgaurea*, *Narcissus poeticus*, *Carex montana*. In the lower part of the hills, exposed to the South, South-East, there is a forest strip, about 30-50 m wide, consisting of *Quercus pubescens*, *Tilia cordata*, *Castanea sativa*, *Acer campestre*. Here also grow such shrubs as: *Ruscus aculeatus*, *Buxus sempervivum*, *Lonicera nigra*, *Ligustrum vulgare*, *Cornus sanguinea*, rarely, one can see *Chamaecytisus supinus* and *Spirea japonica*. The herbaceous layer is uneven and consists of: *Carex montana*, *C. flacca*, *Sedum maximum*, *Stachys officinalis*, *Melampyrum pratense*, *Peucedanum oreoselinum*, *P. cervaria*, *Polygonatum odoratum*, *Brachypodium sylvaticum*, *Tamus communis*; very rarely: *Cephalanthera longifolia*, *C. rubra*, *Clematis recta*.

According to the floristic research carried out, the vascular flora of the reserve comprises 316 species, 211 genera and 78 families, among them – 14 *Pteridophyta*, 9 *Pinophyta* and 293 *Magnoliophyta*. In this area, there are 6 species of rare plants for the Piedmont region: *Cephalanthera longifolia* (L.) Fritsch, *C. rubra* (L.) Rich., *Epipactis atropurpurea* (Hoffm.) Besser, *Narcissus poeticus* L., *Platanthera bifolia* (L.) Rich., *Gentiana pneumonanthe* L., the last one has been included in the Red Book of Italy [4, 6, 7]. The following species are

also rare: *Gladiolus italicus* Mill., *Asplenium cuneifolium* Viv., *Paraceterach marantae* (L.) R. M. Tryon [= *Notholaena macrantae* (L.) Desv.], *Campanula bertolae* Colla f. *rosinae* Pinzaru, *Campanula glomerata* L. var. *selvaggii* Pinzaru, *Stipa moraldoi* Pinzaru, *Linum suffruticosum* subsp. *appressum* (Coball.) Rivas Mart., *Fumana procumbens* (Dunal) Gren. & Godr.

Biomorphological spectrum: hemicryptophytes = 164 species, phanerophytes = 35, geophytes = 32, therophytes = 26, nanophanerophytes = 26, camephytes = 23, therophyto- hemicryptophytes = 9, epiphytes = 2.

Phytogeographical spectrum: Eurasian species are the most numerous = 56 species, followed by European species = 53, Mediterranean = 30, West-European/Asian = 25, cosmopolitan or sub-cosmopolitan = 25, South-European = 23, Euro-Siberian = 20. The species *Campanula bertolae* Colla is endemic to Western Alps.

The list of species registered by the author and by other Italian botanists who have studied this reserve is given below. The cultivated species are marked with \*.

**PTERIDOPHYTA: CI. LYCOPODIOPSIDA**, 1. SELAGINELLACEAE: *Selaginella selaginoides* (L.) Schrank & Mart., **CI. POLYPODIOSIDA**, 2. EQUISETACEAE: *Equisetum arvense* L., 3. ASPLENIACEAE: *Asplenium adianthum-nigrum* L., *A. cuneifolium* Viv. – Soldano, Martinetto et Minuzzo (2011), *A. onopteris* L., *A. ruta-muraria* L., *A. septentrionale* (L.) Hoffm., *A. trichomanes* L., 4. ATHYRIACEAE, *Athyrium filix-femina* (L.) Roth, 5. DENNSTAEDTIACEAE: *Pteridium aquilinum* (L.) Kuhn, 6. DRYOPTERIDACEAE: *Dryopteris affinis* (Lowe) Fraser-Jenk., *D. carthusiana* (Vill.) N.P.Fuchs., *D. filix-mas* (L.) Schott, 7. POLYPODIACEAE: *Polypodium vulgare* L., 8. PTERIDACEAE: *Notholaena marantae* (L.) Desv., **PINOPHYTA, CI. PINOPSIDA**, 9. PINACEAE: \**Picea abies* (L.) H.Karst. – Pividori (1991), *Pinus mugo* Turra [= *P. montana* auct. non Mill.] – Pividori (1991), \**P. nigra* J.F.Arnold – Pividori (1991), \**P. strobus* L. – Pividori (1991), \**P. sylvestris* L. – Caramiello et Montacchini (1977); Pividori (1991), \**Larix decidua* Mill. – Pividori (1991), 10. CUPRESSACEAE: *Juniperus communis* L. – Caramiello et Montacchini (1977); Pividori (1991), \**Thuja orientalis* L., 11. TAXACEAE: \**Taxus baccata* L., 12. MAGNOLIOPHYTA, **CI. MAGNOLIOPSIDA**, ADOXACEAE: *Sambucus nigra* L. – N; Eur., *Viburnum lantana* L., *V. opulus* L., 13. AMARANTHACEAE: *Chenopodium album* L., 14. APIACEAE: *Peucedanum cervaria* (L.) Lapeyr., *P. oroselinum* (L.) Moench. – Caramiello et Montacchini (1977), *P. venetum* (Spreng.) W.D.J.Koch, *Pimpinella major* (L.) Huds., *P. saxifraga* L. – Caramiello et Montacchini (1977), *Trinia glauca* (L.) Dumort. – Caramiello et Montacchini (1977), 15. APOCYNACEAE: *Vinca minor* L., *Vincetoxicum hirundinaria* Medik., 16. ARALIACEAE: *Hedera helix* L., 17. ASTERACEAE: *Achillea millefolium* L. – Caramiello et Montacchini (1977), *Artemisia vulgaris* L., *Aster amellus* L. – Caramiello et Montacchini (1977), *Bellis perennis* L., *Carlina vulgaris* L. – Caramiello et Montacchini (1977), *Centaurea jacea* subsp. *gaudinii* (Bois. & Reut.) Gremli, *C. jacea* L. subsp. *jacea* – Caramiello et Montacchini (1977), *C. scabiosa* L. subsp. *grinensis* (Reut.) Nyman [= *C. scabiosa* L. var. *tenuifolia* Schleich.] – Caramiello et Montacchini (1977), *Cichorium intybus* L., *Cirsium arvense* (L.) Scop. – Caramiello et Montacchini (1977), *C. vulgare* (Savi) Ten., *Crepis biennis* L., *Conyza canadensis* (L.) Cronquist, *Erigeron annuus* (Willd.) Wagenitz, *Eupatorium cannabinum* L., *Hieracium lactucella* Wall., *H. recemosum* Willd., *Hypochaeris radicata* L. – Caramiello et Montacchini (1977), *Inula conyzae* (Griess.) Meikle, *I. hirta* L. – Caramiello et Montacchini (1977), *Lactuca muralis* (L.) Gaertn., *Lapsana communis* L., *Leontodon hispidus* L. – Caramiello et Montacchini (1977), *L. rosani* (Ten.) DC. – Caramiello et Montacchini (1977), *Leucanthemum vulgare* Lam., *Picris hieracioides* L. – Caramiello et Montacchini (1977), *Pilosella officinarum* Vaill., *P. piloselloides* (Vill.) Soják. – Caramiello et Montacchini (1977), *Prenanthes purpurea* L., *Senecio vulgaris* L., *Serratula tinctoria* L. – Caramiello et Montacchini (1977), *Solidago gigantea* Aiton, *S. virgaurea* L. – Caramiello et Montacchini (1977), *Sonchus asper* Hill, *S. oleraceus* L., *Taraxacum camyloides* G. E. Haglund, *T. erythrospermum* Andr. et Besser, *Tussilago farfara* L. – Caramiello et Montacchini (1977), 18. BERBERIDACEAE: *Berberis vulgaris* L., 19. BETULACEAE: *Alnus glutinosa* (L.) Gaertn. – Pividori (1991), \**Betula pendula* Roth – Caramiello et Montacchini (1977), Pividori (1991), *Carpinus betulus* L., *Corylus avellana* L., 20. BRASSICACEAE: *Arabis turrata* L., *Brassica nigra* (L.) W. D. J. Koch, *Cardamine flexuosa* With., *Lepidium graminifolium* L., 21. BOROGINACEAE: *Echium vulgare* L., 22. BUXACEAE: *Buxus sempervirens* L., 23. CAMPANULACEAE: *Campanula bertolae* Colla f. *bertolae* – Caramiello et Montacchini (1977), *C. bertolae*



Colla forma *rosinae* Pinzaru – Pinzaru (2012), *C. glomerata* L. var. *cervicarioides* (Schult.) DC., *C. glomerata* L. var. *selvaggii* Pinzaru – Pinzaru (2012), *C. persicifolia* L., *C. rapunculoides* L., *C. rotundifolia* L., 24. CANNABACEAE: *Celtis australis* L., 25. CAPRIFOLIACEAE: *Knautia arvensis* (L.) Coulter– Caramiello et Montacchini (1977), *Lonicera nigra* L., *Scabiosa columbaria* L., 26. CARYOPHYLLACEAE: *Arenaria serpyllifolia* L., *Cerastium glomerata* Thuill., *C. semidecandrum* L. – Caramiello et Montacchini (1977), *Dianthus sylvestris* Wulfen – Caramiello et Montacchini (1977), *Gypsophila muralis* L., *Minuartia laricifolia* (L.) Schinz & Thell., *Petrorhagia saxifraga* (L.) Link – Caramiello et Montacchini (1977), *Saponaria officinalis* L., *S. ocimoides* L., *Silene alba* Mill., *S. armeria* L., *S. nutans* L., *S. vulgaris* (Moench) Garcke, *Stellaria media* (L.) Vill., 27. CELASTRACEAE: *Euonymus europaeus* L., 28. CISTACEAE: *Fumana procumbens* (Dnnal) Gren et Godron– Caramiello et Montacchini (1977), *Helianthemum nummularium* (L.) Mill. – Caramiello et Montacchini (1977), 29. CONVULVACEAE: *Calystegia sepium* (L.) R.Br., 30. CORNACEAE: *Cornus sanguinea* L., 31. CRASSULACEAE: *Sedum dasyphyllum* L., *S. maximum* (L.) Holub, *S. sexangulare* L., 32. ERICACEAE: *Calluna vulgaris* (L.) Hill – Caramiello et Montacchini (1977), 33. EUPHORBIACEAE *Euphorbia verrucosa* L., 34. FABACEAE: \**Albizzia julibrissin* (Willd.) Durazzo, \**Cercis silicuastrum* L., *Chamaecytisus supinus* (L.) Link, *Cytisus scoparius* (L.) Link, *Gentiana germanica* L. – Caramiello et Montacchini (1977), *Genista tinctoria* L.– Caramiello et Montacchini (1977), *Hyppocrepis comosa* L. – Caramiello et Montacchini (1977), *Lembotropis nigricans* (L.) Griseb.[= *Cytisus nigricans* L.], *Lotus corniculatus* L. var. *corniculatus* – Caramiello et Montacchini (1977), *L. corniculatus* L. subsp. *hirsutus* (W. D. j. Koch) Rothm., *L. pediculatus* Cav., *Medicago lupulina* L., *M. minima* (L.) L., *Melilotus albus* Medik., *Ononis spinosa* L. – Caramiello et Montacchini (1977), *Robinia pseudacacia* L. – Caramiello et Montacchini (1977), Pividori (1991), *Tetragonolobus maritimus* (L.) Roth, *Trifolium repens* L., *T. striatum* L. – Caramiello et Montacchini (1977), *Vicia hirsuta* (L.) Gray, *V. sativa* L., 35. FAGACEAE: *Castanea sativa* Mill., *Quercus petraea* (Matt.) Liebl., *Q. pubescens* Willd. – Pividori (1991), *Q. robur* L., \**Q. rubra* L. – Pividori (1991), 36. GENTIANACEAE: *Centaurium erythraea* Rafn, *Gentiana pneumonanthe* L., 37. GERANIACEAE: *Geranium columbinum* L., *G. mollis* L., *G. pusillum* L., *G. pyrenaicum* Burm f., 38. HYPERICACEAE: *Hypericum montanum* L., *H. perforatum* L., 39. JUGLANDACEAE: \**Juglans regia* L., 40. LAMIACEAE: *Ajuga reptans* L., *Glechoma hederacea* L., *Lamium maculatum* (L.) L., *Prunella grandiflora* (L.) Scholler., *P. vulgaris* L. – Caramiello et Montacchini (1977), *Salvia glutinosa* L., *S. pratensis* L., *Stachys officinalis* (L.) Trevis – Caramiello et Montacchini (1977), *S. recta* L. – Caramiello et Montacchini (1977), *Teucrium chamaedrys* L. – Caramiello et Montacchini (1977), *T. scorodonia* L., *Thymus longicaulis* C.Presl, *T. carniolicus* Borbas, *T. praecox* Opiz. – Caramiello et Montacchini (1977), 41. LINACEAE: *Linum tenuifolium* L., *L. suffruticosum* L. subsp. *appressum* (Caball.) Rivas Mat. – Caramiello et Montacchini (1977), 42. MALVACEAE: *Malva neglecta* Wallr., *Tilia cordata* Mill., 43. MORACEAE:\**Ficus carica* L. – Pividori (1991), 44. OLEACEAE: *Fraxinus excelsior* L. – Pividori (1991), *Ligustrum vulgare* L., 45. ONAGRACEAE: *Epilobium palustre* L. – Caramiello et Montacchini (1977), 46. OROBANCHACEAE: *Euphrasia rostkoviana* Hayne – Caramiello et Montacchini (1977), *Melampyrum pratense* L., 47. OXALIDACEAE: *Oxalis stricta* L., 48. PAULOWNIACEAE: *Paulownia tomentosa* (Thunb.) Steud., 49. PLANTAGINACEAE: *Globularia bisnagarica* L. – Caramiello et Montacchini (1977), *G. cordifolia* L., *Plantago lanceolata* L. – Caramiello et Montacchini (1977), *P. major* L., *P. serpentina* All. – Caramiello et Montacchini (1977), *Veronica arvensis* L., *V. spicata* L. – Caramiello et Montacchini (1977), *V. persica* Poir., 50. PLATANACEAE: *Platanus orientalis* L., 51. POLYGALACEAE: *Polygala comosa* Schkuhr, *P. vulgaris* L. – Caramiello et Montacchini (1977), *P. chamaebuxus* L., 52. POLYGONACEAE: *Rumex acetosa* L., *R. acetosella* L., 53. PORTULACACEAE: *Portulaca oleracea* L., 54. PRIMULACEAE: *Lysimachia vulgaris* L., 55. RHAMNACEAE: *Frangula alnus* Mill. – Caramiello et Montacchini (1977); Pividori (1991), 56. RANUNCULACEAE: *Anemonoides nemorosa* (L.) Holub, *Clematis recta* L., *C. vitalba* L., *Ranunculus acris* L., *R. bulbosus* L., *Thalictrum minus* L., 7. ROSACEAE: *Agrimonia eupatoria* L., *Filipendula vulgaris* Moench – Caramiello et Montacchini (1977), *Fragaria viridis* Duchesne, *Geum urbanum* L., \**Malus domestica* Borkh., *Potentilla alba* L., *P. argentea* L., *P. erecta* (L.) Rauschel – Caramiello et Montacchini (1977), *P. hirta* L., *P. reptans* L., *Prunus avium* L. – Pividori (1991), *P. spinosa* L., *Rosa canina* L., *R. galica* L., *Rubus ulmifolius* Schott,

*Sanguisorba minor* Scop., *Sorbus aria* (L.) Crantz, *S. intermedia* (Ehrh.) Pers., *Spiraea japonica* L., 58. RUBIACEAE: *Cruciata glabra* (L.) Ehrend., *Galium album* L. – Caramiello et Montacchini (1977), *G. lucidum* All. – Caramiello et Montacchini (1977), *G. mollugo* L., *G. verum* L., 59. SALICACEAE: *Populus nigra* L. – Caramiello et Montacchini (1977), Pividori (1991), *P. tremula* L. – Pividori (1991), *Salix alba* L., *S. capraea* L., *S. eleagnos* Scop. – Caramiello et Montacchini (1977), Pividori (1991), 60. SANTALACEAE: *Thesium linophyllum* L. – Caramiello et Montacchini (1977), 61. SAPINDACEAE: *Acer campestre* L., *A. platanoides* L., *A. pseudoplatanus* L., 62. SCROPHULARIACEAE: *Scrophularia canina* L. – Caramiello et Montacchini (1977), *Verbascum phoeniceum* L., 63. SOLANACEAE: *Solanum nigrum* L., 64. SIMAROUBIACEAE: *Ailanthus altissimum* (Mill.) Swingle. – Caramiello et Montacchini (1977), 65. ULMACEAE: *Ulmus glabra* Huds., *U. minor* Mill., 66. URTICACEAE: *Urtica dioica* L., 67. VERBENACEAE: *Verbena officinalis* L., 68. VIOLACEAE: *Viola canina* L., *V. hirta* L. – Caramiello et Montacchini (1977), *V. odorata* L., *V. reichenbachiana* Boreau; **CL. LILIOPSIDA**, 69. AMARYLLIDACEAE: *Allium oleraceum* L., *A. rotundum* L., *A. sphaerocephalon* L., 70. ASPARAGACEAE: *Anthericum liliago* L., *Asparagus officinalis* L., *Muscari botryoides* (L.) Mill. – Caramiello et Montacchini (1977), *Ornithogalum gussonei* Ten., *Polygonatum multiflorum* (L.) All., *P. odoratum* (Mill.) Druce, *Ruscus aculeatus* L. – Pividori (1991), 71. COLCHICACEAE: *Colchicum autumnale* L., 72. CYPERACEAE: *Carex acutiformis* Ehrh., *C. haleriana* Asso, *C. humilis* Leyss. – Caramiello et Montacchini (1977), *C. flacca* Schreb., *C. montana* L., *C. contigua* Hoppe [= *C. spicata* Huds.], *C. sylvatica* Huds., *Cyperus flavescens* L., *Schoenus nigricans* L. – Caramiello et Montacchini (1977), 73. DIOSCREACEAE: *Tamus communis* L., 74. IRIDACEAE: *Gladiolus italicus* Mill., *\*Iris germanica* L., *Narcissus poeticus* L., 75. JUNCACEAE: *Juncus tenuis* Willd., *Luzula campestris* (L.) DC. – Caramiello et Montacchini (1977), *L. nivea* (L.) DC., 76. ORCHIDACEAE: *Cephalanthera longifolia* (L.) Fritsch, *C. rubra* (L.) Rich., *Epipactis atrorubens* Besser, *Platanthera bifolia* (L.) Rich. – Caramiello et Montacchini (1977), 77. POACEAE: *Achnatherum calamagrostis* (L.) P.Beauv. – Caramiello et Montacchini (1977), *Anthoxanthum odoratum* L. – Caramiello et Montacchini (1977), *Arrhenatherum elatius* (L.) P. Beauv. ex J. Presl & C. Presl, *\*Bambusa arundinacea* Schreb., *Bothriochloa ischaemum* (L.) Keng – Caramiello et Montacchini (1977), *Brachypodium phoenicoides* (L.) Roem. & Schult., *B. pinnatum* (L.) P.Beauv. – Caramiello et Montacchini (1977), *B. rupestre* (Host.) Roem. & Schult., *B. sylvaticum* (Huds.) P.Beauv., *Bromus erectus* Huds. – Caramiello et Montacchini (1977), *B. tectoum* L., *Briza media* L. – Caramiello et Montacchini (1977), *Chrysopogon grillus* (L.) Trin. – Caramiello et Montacchini (1977), *Dactylis glomerata* L., *Danthonia alpina* Vest – Caramiello et Montacchini (1977), *D. decumbens* (L.) DC. – Caramiello et Montacchini (1977), *Festuca filiformis* Pourr. – Caramiello et Montacchini (1977), *F. laevigata* Gaudin – Caramiello et Montacchini (1977), *F. valesiaca* Schleich. ex Gaudin, *Helictotrichon versicolor* (Vill.) Pilg., *Holcus lanatus* L., *Hordeum murinum* L., *Melica ciliata* L., *M. nutans* L., *M. uniflora* Retz., *Molinia caeruleae* (L.) Moench – Caramiello et Montacchini (1977), *Phragmites australis* (Cav.) Steud., *Poa angustifolia* L., *P. annua* L., *P. pratensis* L. – Caramiello et Montacchini (1977), *Puccinellia distans* (Jacq.) Parl., *Setaria viridis* (L.) P.Beauv., *Stipa moraldoi* Pinzaru [= *S. epilosa* Martinovsky subsp. *montana* Moraldo, *S. montana* (Moraldo) Pinzaru] – Soldano, Minuzzo et Martinetto (2011), Pinzaru (2012, 2013), *Vulpia myuros* (L.) C.C.Gmel., 78. TYPHACEAE: *Typha latifolia* L.

## CONCLUSIONS

The vascular flora of the reserve enumerates 316 species of 211 genera and 78 families, including 6 rare species, protected in Piedmont: *Cephalanthera longifolia* (L.) Fritsch, *C. rubra* (L.) Rich., *Epipactis atropurpurea* (Hoffm.) Besser, *Narcissus poeticus* L., *Platanthera bifolia* (L.) Rich., *Gentiana pneumonanthe* L., the last one has been included in the Red Book of Italy. Many species are represented by a small number of plants.

The vegetation of the reserve is very poor, only on the tops of the slopes, there are steppe phytocoenoses with a denser herbaceous layer.



## BIBLIOGRAPHY

1. A community- derived classification for extant lycophytes and ferns. Ed. by Schneider H., Schuettpelz E. – J.Syst. Evol. 2016, 54(6): 563-603.
2. Caramiello R., Montacchini F. La flora delle cave di magnesite di Caselette e di Baldissero Canavese/Allionia, 1977, 22: 209-220.
3. Conti F., Abbate G., Alessandrini A., Blasi C. An annotated checklist of the Italian vascular flora. Roma: Palombi, 2005, 420 pp.
4. Conti F., Manzi A., Perdotti F. Libro Rosso delle piante d'Italia. 1992, 636 p.
5. Monti Pelati e Torre Cives/La Rete Natura 2000 in Piemonte. I Siti di Importanza Comunitaria. Regione Piemonte. IPLA. Natura 2000 : 64-67.
6. Le specie botaniche del Piemonte a protezione assoluta (Art. 15 comma 1L.R. 32/1982. A cura di Viola Erdini. Regione Piemonte. Assessorato ambiente, parchi e aree protette. 2009, 291 p.
7. Marconi G. Piante minacciate di estinzione in Italia. Il „Libro Rosso” fotografico. 2007, 463 p.
8. Peruzzi L. Checklist dei generi e delle famiglie della flora vascolare italiana/Informatore Botanico Italiano, 2010, 42 (1): 151-170.
9. Pividori M. Situazione attuale e prospettive future della vegetazione forestale sui Monti Pelati (Baldissero Canavese). Atti Convegno: I Monti Pelati di Baldissero. Importanza paesistica e scientifica/Parella (Torino) 18 novembre 1989. 1991:19-23.
10. Pinzaru P. New species and varieties in the floras of Piedmont and Valle Aosta in Italy/Novitates systematicae plantarum vascularum. Mosquae, Petropoli. 2012, T. 43: 96-110 (in Russian).
11. Pinzaru P. Notes on the of flora of the Republic of Moldova and Piedmont region in Italy./Novitates systematicae plantarum vascularum. Mosquae, Petropoli. 2013, T. 44: 218-229 (in Russian).
12. Soldano A., Moraldo D., Minuzzo C., Martinetto E. Nota floristica piemontese n. 337. *Asplenium cuneifolium* Viv. subsp. *cuneifolium* (*Aspleniaceae*) in Selvaggi A., Soldano A., Pascale M.(eds.) – Note floristiche piemontesi n. 309-392/Revista piemontese di Storia Naturale, 2011, 32: 386.
13. Soldano A., Minuzzo C., Martinetto E. - Nota floristica piemontese n. 319. *Stipa epilosa* Martinovsky subsp. *montana* B. Moraldo (*Poaceae*) in Selvaggi A., Soldano A., Pascale M.(eds.) – Note floristiche piemontesi n. 309-392/Revista piemontese di Storia Naturale, 2011, 32: 379.
14. Villa F. I Monti Pelati di Baldissero: caratteristiche geologiche e considerazioni tecnico-legislative sulle attività estrattive presenti nell'area. Atti Convegno: I Monti Pelati di Baldissero. Importanza paesistica e scientifica/Parella (Torino) 18 novembre 1989. 1991, p. 51-56.



Panorama cu Torre Cives



*Gentiana pneumonanthe* L.



*Campanula bertolae* Colla forma *rosinae* Pinzaru



*Stipa moraldoi* Pinzaru



*Campanula glomerata* L. var. *selvaggii* Pinzaru

### III. INTRODUCTION OF PLANTS AND SUSTAINABLE USE OF PLANT RESOURCES

CZU: 633:582.6 (478)

## CONTRIBUTIONS TO THE MOBILIZATION, RESEARCH AND CAPITALIZATION OF MEDICINAL LAMIACEAE SPECIES IN THE BOTANICAL GARDEN (I) OF ASM

*Nina Ciocarlan*

Botanical Garden (Institute) of Academy of Sciences, Chisinau, Republic of Moldova

**Abstract:** This paper presents updated data referring to the current state of medicinal *Lamiaceae* Lindl. species introduced and studied in the Botanical Garden (Institute) of ASM as well as the dynamics of taxa increase over the last decade. The list of new allochthonous *Lamiaceae* species introduced in the Botanical Garden (I) of ASM in 2005-2017 periods is given. The scientific data obtained add the information about biological peculiarities and chemical composition of promising *Lamiaceae* species growing in the Botanical Garden (I) of ASM, broadening the raw material base of medicinal plants by their introduction into cultivation.

**Key words:** medicinal plants, *Lamiaceae*, ex situ collection, mobilization, capitalization

### INTRODUCTION

The *Lamiaceae* Lindl. family (*Labiatae* Juss.) is the largest family of the order *Lamiales*, comprising about 220 genera and almost 4000 species spread all over the world, but mostly in the Mediterranean region and Southwestern Asia. [2, 14-16]. In the flora of the Republic of Moldova *Lamiaceae* family is represented by 28 genera and 82 species [19].

*Lamiaceae* family includes herbs, sometimes subshrubs or shrubs, annual or perennial, usually aromatic plants. Stems and branches are usually 4-angled. Leaves opposite, rarely whorled or alternate, simple to pinnately dissected or compound, without stipules. Inflorescences generally compound, sometimes flowers solitary and axillary; verticillasters 2- to many flowered, subtended by leaves or bracts. Flowers bisexual, zygomorphic, and bracteolate or not. Calyx persistent, 5-toothed, 2-lipped; upper lip 3-toothed or entire; lower lip 2- or 4-toothed. Corolla limb usually 2-lipped; upper lip 2-lobed and lower 3-lobed, rarely upper lip entire and lower 4-lobed, also rarely limb (4- or 5-lobed; tube hairy annulate inside. Stamens 4 or 2, free, rarely filaments connate, sometimes one staminodial; ovary superior, 2-carpellate but appearing equally 4-lobed when mature due to further partition; style single, usually branched above and gynobasic. Fruit usually 4 dry nutlets [15, 16].

The *Lamiaceae* is one of the most important plant families with extensive economic importance. The spectrum of their applications in the folk and modern medicine is wide. The majority of *Lamiaceae*, being aromatic plants are used in perfumery, cosmetics, and food industries as active ingredients or as flavour and fragrance. Many are cultivated as ornamentals but others are widely used as culinary herbs and spices. *Lamiaceae* species are used for medical purposes due to the presence of a large group of chemical compounds [21, 28] with antimicrobial, antifungal, antibacterial, anti-inflammatory and antioxidant activities [17, 18, 23, 28]. Nowadays, the utilization of medicinal plants in pharmaceutical industry is being extended annually by the introduction of new plant species, including *Lamiaceae* in the new formula of medical preparations.

In this context, the inventory, introduction, biological and phytochemical studies of *Lamiaceae* species from the collection of the Botanical Garden (Institute) of ASM, in order to increase therapeutic possibilities and their practical use in national economy was the main goal of this study. Introduction of medicinal *Lamiaceae* species involved the following steps: mobilization of gene pool; the study of the biological characteristics of plants and finding effective methods of cultivation; selection of the most productive individuals and populations; accumulation of seed and planting material; identification and research of promising medicinal plants for national economy.



## MATERIALS AND METHODS

The research was carried out during the years 2005-2017. The genetic resource mobilization of *Lamiaceae* medicinal species was achieved through international exchange of seeds (*Delectus Seminum*) and by collecting seeds and plant material from the indigenous flora during field expeditions. Studies for new plant species acclimatization were carried out in the Experimental subdivision of the Collection of Medicinal Plants (CMP). An extensive literature survey of studied species was made according to their therapeutic importance and utilization in ethno and modern medicine. Phenologic observations were performed annually during the entire vegetation period according to widely used methodological guidelines [24, 27, 29].

## RESULTS AND DISCUSSIONS

At present, in the Collection of Medicinal Plants from Botanical Garden (Institute) of ASM the *Lamiaceae* family is represented by 99 taxa belonging to 30 genera. A total of 76 taxa of medicinal *Lamiaceae* species introduced in the collection in 2005-2017 periods were obtained from the seeds received by *Delectus Seminum*. Another 23 species were brought from the spontaneous flora during the field expeditions (Fig. 1). Among the richest genera we can enumerate: *Salvia* with 11 taxa; *Nepeta* and *Thymus* with 9 taxa each and *Teucrium* with 7 species; three genera with 6 taxa (*Mentha*, *Hyssopus* and *Satureja*). Two genera (*Origanum* and *Lavandula*) include 4 taxa each, *Calamintha*, *Leonurus* *Dracocephalum* and *Scutellaria* are represented by 3 taxa. Ten genera (*Ajuga*, *Caryopteris*, *Galeobdolon*, *Leonotis*, *Majorana*, *Lamium*, *Melissa*, *Pycnanthemum*, *Prasium* and *Prunella*) are monospecific. Other seven genera (*Agastache*, *Clinopodium*, *Elscholtzia*, *Perilla*, *Rosmarinus*, *Phlomis*, and *Stachys*) are represented by 2 taxa (fig. 2).

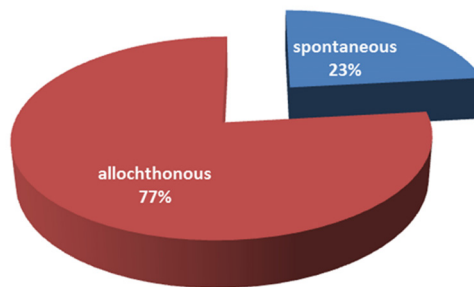


Fig. 1. The percentage of spontaneous and allochthonous species

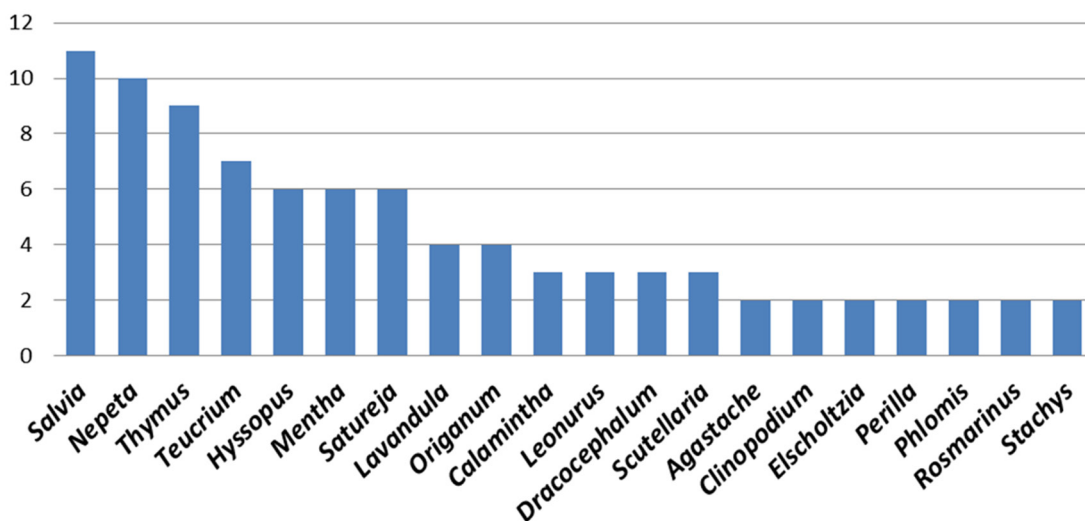


Fig. 2. The most representative genera

Only in 2011 the number of medicinal *Lamiaceae* plants introduced in the collection through international seed exchange increased with 8 species. In the same year 5 spontaneous *Lamiaceae* species were collected from the wild and transplanted in the collection (Fig. 3, Table 1).

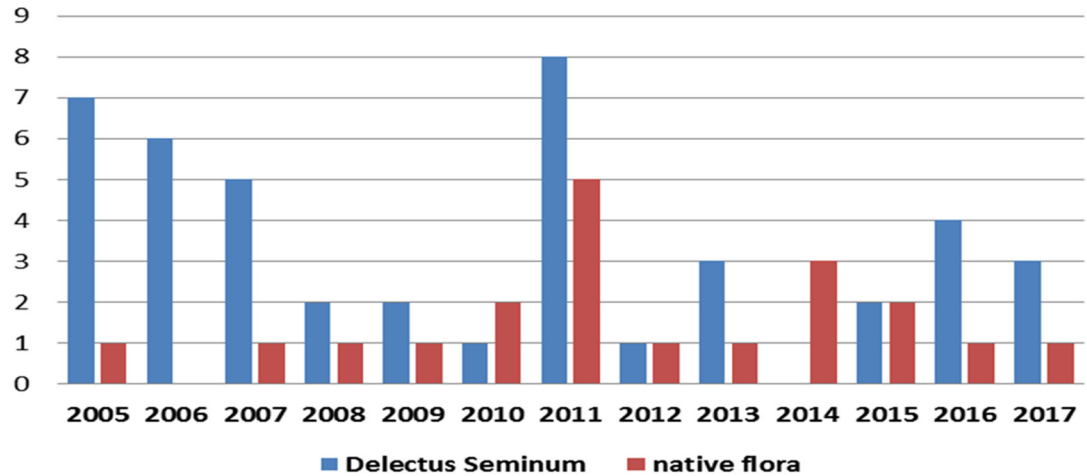


Fig. 3. Dynamics of presence of the number of *Lamiaceae* species (2005-2017 periods)

A number of new allochthonous *Lamiaceae* species (Table 1) included in the Medicinal plant collection underwent first introduction research in the conditions of Botanical Garden (I) of ASM.

Table 1.

**New allochthonous *Lamiaceae* species introduced in the Botanical Garden (I) of ASM in 2005-2017 periods**

| Scientific name                                       | Provenience                |      | Therapeutic effects                                                                          |
|-------------------------------------------------------|----------------------------|------|----------------------------------------------------------------------------------------------|
|                                                       | scientific institution     | year |                                                                                              |
| <i>Lavandula latifolia</i> Medik.                     | BG, Padova, Italy          | 2005 | expectorant, bactericidal, tonic, antifungal, cicatrizing                                    |
| <i>Salvia tesquicola</i> Klok. et Pobed.              | BG, Prague, Czech Republic | 2005 | aromatic, antioxidant, antimicrobial, antifungal, antiseptic                                 |
| <i>Elsholtzia stauntonii</i> Benth.                   | BG, Leipzig , Austria      | 2005 | antiviral, antibacterial, anti-inflammatory, antioxidant, myocardial ischemia protection     |
| <i>Origanum tythanthum</i> Gontsch.                   | BG, Prague, Czech Republic | 2005 | antimicrobial, antibacterial, hypolipidemic, hypocholesterolemic                             |
| <i>Origanum virens</i> Link ex C. A. Mey.             | BG, Stuttgart, Germany     | 2005 | antimicrobial, antifungal, antioxidant, expectorant, anti-inflammatory                       |
| <i>Agastache rugosa</i> (Fisch. et C. A. Mey.) Kuntze | BG, Zurich, Switzerland    | 2005 | antibacterial , anti-HIV integration activities, antioxidant, cardiovascular, cytoprotective |



|                                                                        |                                                   |      |                                                                                               |
|------------------------------------------------------------------------|---------------------------------------------------|------|-----------------------------------------------------------------------------------------------|
| <i>Lavandula stoechas</i> L.                                           | Museum of Natural History,<br>Paris, France       | 2005 | antibacterial, cytotoxic, antioxidant,<br>antimicrobial, anticonvulsant,<br>antispasmodic,    |
| <i>Lavandula multifida</i> L.                                          | BG, Basel, Switzerland                            | 2006 | antiseptic, anti-inflammatory, antifungal                                                     |
| <i>Scutellaria baicalensis</i> Georgi                                  | BG, Lodz, Poland                                  | 2006 | anti-inflammatory, tonic, anticancer,<br>antispasmodic, expectorant, hemostatic               |
| <i>Mentha gattefossei</i> Maire                                        | BG, Coimbra, Portugal                             | 2006 | less studied for its applicability in<br>phytotherapy                                         |
| <i>Satureja montana</i> L. ssp. <i>illyrica</i><br>(Host.) Nym.        | BG, Essen, Germany                                | 2006 | antioxidant, antibacterial, choleric,<br>stimulant, digestive, antiseptic,<br>antidiarrheal   |
| <i>Nepeta camphorata</i> Boiss. et<br>Heldr.                           | BG, Basel, Switzerland                            | 2006 | spasmolytic, febrifuge                                                                        |
| <i>Origanum laevigatum</i> Boiss.                                      | BG, Essen, Germany                                | 2006 | expectorant, antibacterial, antiseptic,<br>diuretic                                           |
| <i>Leonotis nepetifolia</i> (L.) R. Br.                                | Museum of Natural History,<br>Paris, France       | 2007 | psychoactive, relaxant, anthelmintic anti-<br>convulsive, hypoglycemic, anti-diarrheic        |
| <i>Leonurus sibiricus</i> L.                                           | BG "Al. Borza", Cluj-Napoca,<br>Romania           | 2007 | antibacterial, cardiac, tonic, diuretic,<br>hypnotic, stimulant, antispasmodic,<br>depurative |
| <i>Satureja thymbra</i> L.                                             | Museum of Natural History,<br>Paris, France       | 2007 | antibacterial, aromatic, digestive,<br>expectorant, tonic                                     |
| <i>Melissa officinalis</i> L. ssp.<br><i>altissima</i> (Smith) Arcang. | University of Medical Sciences,<br>Poznan, Poland | 2007 | sedative, hemostatic, lactogenic,<br>antibacterial, antifungal, antioxidant                   |
| <i>Hyssopus officinalis</i> L. ssp.<br><i>aristatus</i> (Godr.) Briq.  | University of Medical Sciences,<br>Poznan, Poland | 2007 | expectorant, anti-inflammatory,<br>cicatrizing, anthelmintic                                  |
| <i>Dracocephalum ruyschiana</i> L.                                     | BG, Klagenfurt, Austria                           | 2008 | antimicrobial, antispasmodic, febrifuge,<br>ophthalmic, wound healing                         |
| <i>Thymus comosus</i> Heuff. ex<br>Griseb.                             | BG, Cluj Napoca, Romania                          | 2008 | antiseptic, expectorant, tonic, diuretic                                                      |
| <i>Agastache urticifolia</i> (Benth.)<br>Kuntze                        | National BG of Belgium                            | 2009 | analgesic, stomachic, anti-rheumatic                                                          |
| <i>Pycnanthemum virginianum</i> (L.)<br>T. Durand et B. D. Jacks.      | BG, Essen, Germany                                | 2009 | analgesic, carminative, diaphoretic,<br>febrifuge                                             |
| <i>Prasium majus</i> L.                                                | Museum of Natural History,<br>Paris, France       | 2010 | antioxidant, diuretic, anti-diarrheic                                                         |
| <i>Nepeta cataria</i> L. 'Citriodora'                                  | BG, Graz, Austria                                 | 2011 | sedative, antispasmodic, antioxidant,<br>anti-inflammatory                                    |
| <i>Salvia canariensis</i> L.                                           | BG, Genoa, Italy                                  | 2011 | expectorant, antimicrobial, cytostatic                                                        |
| <i>Salvia kopetdaghensis</i> Kudr.                                     | BG, Klagenfurt, Austria                           | 2011 | spasmolytic, anti-inflammatory,<br>cicatrizing                                                |

|                                                           |                                                               |      |                                                                                              |
|-----------------------------------------------------------|---------------------------------------------------------------|------|----------------------------------------------------------------------------------------------|
| <i>Prunella vulgaris</i> L. var. <i>lilacina</i>          | Tokyo Metropolitan Medicinal Plant Garden                     | 2011 | anti-inflammatory, antiseptic, diuretic, hemostatic, febrifuge                               |
| <i>Leonurus japonicus</i> Houtt.                          | Research Center for Medicinal Plant Resources, Ibaraki, Japan | 2011 | cardio protective, anti-oxidative, antimicrobial, neuroprotective and anti-cancer            |
| <i>Hyssopus cretaceus</i> Dubjan.                         | Mountain BG of the Dagestan Scientific Center, Makhachkala    | 2011 | expectorant, anti-inflammatory, cicatrizing, anthelmintic                                    |
| <i>Hyssopus ambiguous</i> (Trautv.) Iljin                 | Mountain BG of the Dagestan Scientific Center, Makhachkala    | 2011 | tonic, astringent, expectorant, anti-inflammatory,                                           |
| <i>Calamintha foliosa</i> Opiz                            | Civico Orto Botanico di Trieste, Italy                        | 2011 | antibacterial, gastric, sedative                                                             |
| <i>Dracocephalum renati</i> Emb.                          | BG, Basel, Switzerland                                        | 2012 | Cicatrizing, hemostatic, anti-inflammatory                                                   |
| <i>Perilla frutescens</i> (L.) Britt. var. <i>acuta</i>   | Tokyo Metropolitan Medicinal Plant Garden                     | 2013 | antimicrobial, anti-inflammatory, anti-allergic, immuno-modulator, antioxidant and antitumor |
| <i>Nepeta grandiflora</i> Bieb.                           | BG, Targu Mures, Romania                                      | 2013 | anti-inflammatory, spasmolytic, antidiarrheal                                                |
| <i>Caryopteris incana</i> (Thumb. ex Houtt.) Miq.         | BG, Graz, Austria                                             | 2013 | antiseptic, anti-inflammatory, antimicrobial                                                 |
| <i>Thymus ellipticus</i> Opiz                             | BG, Targu Mures, Romania                                      | 2015 | expectorant, antiseptic, spasmolytic, analgesic, anthelmintic                                |
| <i>Teucrium flavum</i> L.                                 | BG, Munich, Germany                                           | 2015 | antioxidant, antidiabetic, cardiovascular, analgesic                                         |
| <i>Nepeta wilsonii</i> Duthie                             | BG, Vienna, Austria                                           | 2016 | diuretic, antiseptic, antitussive, antispasmodic, expectorant                                |
| <i>Nepeta nuda</i> L. var. <i>albiflora</i> (Boiss.) Gams | BG, Vienna, Austria                                           | 2016 | antispasmodic, expectorant, diuretic, antiseptic, antitussive, febrifuge                     |
| <i>Teucrium hircanicum</i> L.                             | Humboldt University, Berlin, Germany                          | 2016 | hypotensive, antitumor, haemostatic                                                          |
| <i>Dracocephalum argunense</i> Fisch. ex Link             | BG, Stuttgart, Germany                                        | 2016 | anti-allergic, cicatrizing, hemostatic, choleric                                             |
| <i>Teucrium orientale</i> L.                              | BG, Munich, Germany                                           | 2017 | bacteriostatic, spasmolytic, antioxidant and anti-inflammatory                               |
| <i>Teucrium botrys</i> L.                                 | BG, Frankfurt, Germany                                        | 2017 | cytotoxic, anti-anemic, cholagogue, febrifuge                                                |
| <i>Clinopodium acinos</i> (L.) Kuntze                     | BG, Porrentruy, Switzerland                                   | 2017 | antioxidant, antimicrobial, cicatrizing                                                      |

BG – Botanical Garden

Further is presented the list of *Lamiaceae* medicinal plants introduced in the collection from spontaneous flora of Republic of Moldova (Table 2).

Table 2.

**Medicinal *Lamiaceae* species introduced in the Botanical Garden (I) of ASM from spontaneous flora of Republic of Moldova**

| Scientific name                     | Place and date of sample collection |      | Therapeutic effects                                                                             |
|-------------------------------------|-------------------------------------|------|-------------------------------------------------------------------------------------------------|
|                                     | location, district                  | year |                                                                                                 |
| <i>Scutellaria altissima</i> L.     | Huliboaca, mun. Chişinău            | 2005 | antitussive, hemostatic                                                                         |
| <i>Teucrium chamaedrys</i> L.       | Cricova, mun. Chişinău              | 2007 | anti-inflammatory, antiseptic, decongestant                                                     |
| <i>Thymus marschallianus</i> Willd. | Maşcăuţi, Criuleni                  | 2008 | cicatrizing, expectorant, spasmolytic                                                           |
| <i>Phlomis pungens</i> L.           | Zloţi, Cimişlia                     | 2009 | cicatrizing, immuno-stimulatory, sedative                                                       |
| <i>Origanum vulgare</i> L.          | Hârtop, Floreşti                    | 2010 | cholagogue, anti-spastic, expectorant, antibacterial, antiseptic                                |
| <i>Betonica officinalis</i> L.      | Rădenii Vechi, Ungheni              | 2010 | hypotensive, anti-inflammatory, emetic, antibacterial, antifungal, expectorant                  |
| <i>Ajuga reptans</i> L.             | Huliboaca, mun. Chişinău            | 2011 | anti-inflammatory, cicatrizing, hemostatic, expectorant, diuretic, anti-spastic, anti-diarrheic |
| <i>Calamintha nepeta</i> (L.) Savi  | Saharna, Rezina                     | 2011 | antibacterial, diuretic, gastric, sedative                                                      |
| <i>Salvia aethiopsis</i> L.         | Făureşti, mun. Chişinău             | 2011 | anti-inflammatory, cicatrizing, astringent                                                      |
| <i>Salvia nemorosa</i> L.           | Hârtopul Mare, Criuleni             | 2011 | cicatrizing, antibacterial, antimycotic                                                         |
| <i>Lamium album</i> L.              | Saharna, Rezina                     | 2011 | hemostatic, expectorant, diuretic, cicatrizing, anti-inflammatory, depurative, cholagogue       |
| <i>Phlomis tuberosa</i> L.          | Huliboaca, mun. Chişinău            | 2012 | tonic, hemostatic, antibacterial, antifungal, cicatrizing, antitumor                            |
| <i>Mentha verticillata</i> L.       | Sărata Răzeşi, Leova                | 2013 | diuretic, spasmolytic, hemostatic, antiseptic, sedative, analgesic, expectorant, antibacterial  |
| <i>Nepeta cataria</i> L.            | Mireşti, Nisporeni                  | 2014 | antispasmodic, expectorant, antitussive, astringent, carminative, appetizing, sedative          |
| <i>Nepeta pannonica</i> L.          | Zloţi, Cimişlia                     | 2014 | antispasmodic, febrifuge, tonic, antiseptic, anti-inflammatory, antimicrobial, antioxidant      |
| <i>Nepeta parviflora</i> Bieb.      | Bugeac, Comrat                      | 2014 | antioxidant, anti-inflammatory                                                                  |
| <i>Teucrium polium</i> L.           | Cricova, mun. Chişinău              | 2015 | antibacterial, antioxidant, hemostatic                                                          |
| <i>Salvia pratensis</i> L.          | Hârtopul Mare, Criuleni             | 2015 | anti-inflammatory, antimicrobial                                                                |
| <i>Salvia verticillata</i> L.       | Ciorescu, mun. Chişinău             | 2016 | antibacterial, anti-diabetic, cytotoxic                                                         |
| <i>Galeobdolon luteum</i> Huds      | Curchi, Orhei                       | 2017 | respiratory affections                                                                          |

For the introduction program, the research regarding plant biology features, ontogenetic cycle, growth and development in a new conditions during the vegetative period is very important. Thus, in recent years the research on biomorphological and ontogenetic peculiarities of the species of the genera: *Satureja* L., *Origanum* L., *Salvia* L., *Agastache* Clayt et Gronov., *Mentha* L., *Nepeta* L., *Perilla* L., *Lamium* L., *Teucrium* L. and *Thymus*

L. have been conducted.

Further is presented the description of some of the most valuable representatives of the *Lamiaceae* family introduced in the Botanical Garden (I) of ASM in 2005-2017 periods.

Genus *Ajuga* L. – Bugleweed (Vinețică). Two *Ajuga* species (*Ajuga reptans* L. (fig. 4) and *A. genevensis* L.) cultivated in *ex situ* undergo a complete ontogenetic cycle, passing consecutively all life periods. The phytochemical analysis highlighted a high content of flavonoids, hydroxycinnamic acids and total polyphenols in the methanol extract of *A. reptans* and *A. genevensis*. The etanolic extracts showed an evident antioxidant activity due to higher concentrations of flavonoids and hydroxycinnamic acids [11].

Genus *Mentha* L. – Mint (Mintă). The genus includes the important group of medicinal, aromatic and culinary herbs. The spectrum of their applications in the folk and modern medicine is wide. In the context of the optimal growth characteristics and phytochemical profile promising results were obtained for *Mentha gattefossei* Maire, an endangered species, listed in the IUCN Red List of threatened species [20]. In the climatic and soil conditions of the Republic of Moldova the plants undergo a complete ontogenetic cycle, which demonstrates high adaptive potential and *ex-situ* conservation perspective [8]. The volatile oil of *M. gattefossei* cultivated in Moldova is characterized by the predominance of oxygenated monoterpenes and belongs to chemotype pulegone/menthone, thus demonstrating antioxidant activity [1].

Genus *Nepeta* L. – Catnip (Cătușnică). Within the nine *Nepeta* L. species growing in the collection, our study was focused on three species (*Nepeta cataria* L., *N. pannonica* L. and *N. parviflora* Bieb.) [7]. Is to be mentioned that *N. parviflora*, species threatened with extinction in the local flora (included in the Red Book of the Republic of Moldova, 3<sup>rd</sup> edition [22] is rich in phenolic compounds with high antioxidant activity [26].

Thus, introduction into culture has potential both for its capitalization and conservation.

Genus *Origanum* L. – Oregano (Sovârv). The comprehensive biological and phytochemical studies on the species of the genus *Origanum* L. (*Origanum vulgare* L., *O. onites* L., *O. hirtum* Link, *Origanum tythanthum* Gontsch., *O. laevigatum* Boiss.) grown in herb collection were undertaken. Investigated species are important sources of essential oils, containing increased amounts of thymol and carvacrol, requested these days in the pharmaceutical and food industries [3].

Genus *Perilla* L. – Perilla (Susan sălbatic). Our research refers to the study of *Perilla frutescens* (L.) Britt. var. *purpurascens* (Hayata) H. W. Li which nowadays is cultivated in many European and North American countries for medicinal, culinary and ornamental uses. In climatic and soil conditions specific to Republic of Moldova the plants pass consecutively all phenological phases starting from the seed sowing to the seed setting and senile stages. The phytochemical analysis highlighted the rosmarinic acid as the main compound in all analyzed samples. The optimal harvest period is month July when content in polyphenolic compounds is at highest level [9].

Genus *Satureja* L. – Savory (Cimbru). Six species of the genus *Satureja* L. (*Satureja montana* L., *S. kitaibelii* Wierzb., *S. parnassica* Heldr. et. Sart ex. Boiss., *S. thymbra* L., *S. subspicata* Bartl. ex. Vis. (fig. 5), *S. montana* ssp. *illyrica* (Host.) Nym.) were included in the research agenda. The investigation results showed that the species *S. montana*, *S. kitaibelii*, *S. subspicata* and *S. parnassica* are medicinal plants with promising therapeutic effect which grow and develop normally in the climatic conditions of Republic of Moldova, completing the entire



Fig. 4. *Ajuga reptans*



ontogenetic cycle [5]. High content of carvacrol registered in *S. montana* attribute to the plants antimicrobial, antimycotic and antifungal qualities, representing an important source of raw materials for the pharmaceutical industry [4]. Results of the analysis regarding the content and chemical composition of *S. subspicata* essential oil, argues also, of important therapeutic value of this plants. The *S. subspicata* essential oil consists mostly of phenolic monoterpenes, monoterpene hydrocarbons, bicyclic sesquiterpenes and their oxygenated derivatives. The most abundant components are phenolic terpene carvacrol, monoterpene hydrocarbons *p*-cimen and  $\gamma$ -terpinene. Unreported before components like  $\gamma$ -terpinene, (*E*)- and (*Z*)-citral,  $\beta$ -bisabolene, nerol,  $\beta$ -caryophyllene in the essential oil may increase the biological activity and perfumery value of *S. subspicata* oil of Moldovan origin [12].



Fig. 5. *Satureja subspicata*



Fig. 6. *Teucrium hircanicum*

Genus *Teucrium* L. – Germander (Jugărel) represents mostly perennial herbs, shrubs or subshrubs. Modern pharmacological studies suggest that some *Teucrium* L. species are found to be rich natural sources of new bioactive substances with antimicrobial, antioxidant and antifungal activities [25]. In our study an intensive vegetative growth with abundant flowering under *ex situ* conditions was observed for *Teucrium hircanicum* L. (fig. 6) and *Teucrium polium* L. It was also revealed that under the conditions of cultivation the rhythm of seasonal development of spontaneous *T. polium* is generally the same as in natural habitat [6]. The main components of the *T. polium* essential oil are Germacrene D,  $\beta$ -pinene,  $\alpha$ -pinene and bicyclogermacrene. The *T. polium* essential oil belonging to Germacrene D chemotype represents an important source with potential application as an antimicrobial agent in the treatment of various diseases.

Genus *Thymus* L. – Thyme (Cimbru). *Thymus* species are important medicinal herbs, rich in various active substances such as carvacrol, thymol, *p*-cymene and terpinene with strong spasmolytic, antibacterial and antioxidant activities [10]. As a result of our studies, the high

antioxidant activity was shown by two chemotypes of *Thymus marshallianus* Willd. species from spontaneous flora and *ex situ* experiments which have high polyphenolic content and volatile fraction rich in *o*-cymene,  $\gamma$ -terpinene and trans-citral [13].

Thus, the results of a long-term study of plants of the *Lamiaceae* family indicate the prospects of introduction of representatives of this family in the conditions of Republic of Moldova. According to assessment of introduction capabilities, 62 species are highly stable, 28 species – stable and 9 species are unstable. The vast majority of *Lamiaceae* species introduced in the collection of medicinal plants are successfully cultivated being highly adapted to local edaphic and climatic conditions. They pass all the stages of seasonal development, show good indicators of seed reproduction giving a viable self-seeding. The results of this research made possible to identify promising species for extensive cultivation and further implementation in pharmaceutical, food and cosmetic industries.



## CONCLUSIONS

In the period 2005-2017 by means of international seed exchange the collection was enriched with 76 *Lamiaceae* species, forms and varieties received by *Delectus Seminum* and 23 introduced from spontaneous flora. The comprehensive biological and phytochemical results have been obtained on species of the following genera: *Satureja* L., *Origanum* L., *Salvia* L., *Agastache* Clayt. et Gronov., *Mentha* L., *Nepeta* L., *Perilla* L., *Lamium* L., *Teucrium* L. and *Thymus* L. demonstrating their potential for introduction into crop growing. The available literature and the results obtained showed that most of bioactivities and medicinal properties of these species could be attributed to their essential oils, known to have applications in the food, pharmaceutical and cosmetic industries.

## REFERENCES

1. Aprotosoia A. C., Ciocarlan N., Ciot I. A., Miron A. Polyphenolic composition and *in vitro* antioxidant activity of a ethanolic extract from *Mentha gattefossei* Maire. Book of Abstracts, 2<sup>nd</sup> International Conference on Natural Products Utilization, Plovdiv, Bulgaria, 2015, p. 106.
2. Cantino P.D., Harley R.M., Wagstaff S.J. Genera of *Labiatae*: status and classification. In: Harley R.M., Reynolds T. (eds.), *Advances in Labiatae Science*, Royal Botanic Gardens, Kew, 1992, p. 511-513.
3. Ciocarlan N., Zarbock-Udrea S., Deleanu C. Aspecte comparative privind compoziția uleiurilor volatile din trei specii de *Origanum*. Buletinul Academiei de Științe a Moldovei. Științele vieții, 1(301), 2007, p. 70-76.
4. Ciocarlan N. Date privind conținutul în timol și carvacrol în uleiul volatil al unor specii din genurile *Satureja* L. și *Origanum* L. Mater. Conferinței naționale cu participare internațională "Probleme actuale ale geneticii, fiziologiei și ameliorării plantelor" Chișinău, 2008, p. 300-305.
5. Ciocarlan N. Specii de *Satureja* L. cultivate în Grădina Botanică a AȘM. *Mediul Ambient*. Nr. 2(44), 2009, p. 27-30.
6. Ciocarlan N. *Teucrium* L. (*Lamiaceae*) species in the flora of Republic of Moldova and their therapeutic value. In: *Ботанические чтения*. Ишим: Изд-во ИГПИИ им. П.П.Ершова, 2013, p. 152-154.
7. Ciocarlan N., Ghendov V., Sirbu T. Biomorphological and ecological peculiarities of *Nepeta*, *Lamium*, *Agastache* and *Perilla* species from natural ecosystems and experimental fields. In: The 4<sup>th</sup> Symposium of Ethnoph. with Inter. Participation, Brasov, Romania, Transylvania University Press, 2013, p. 22.
8. Ciocarlan N. *Mentha gattefossei* Maire – a threatened medicinal species cultivated in the Botanical Garden (I) of ASM. *Mediul ambient*, Nr. 2 (74), 2014, p. 19-22.
9. Ciocarlan N., Sirbu T., Stefanache C. P. et al. Biological and phytochemical research on *Perilla frutescens* var. *purpurascens* (Hayata) H.W.Li in Republic of Moldova. Buletinul Academiei de Științe a AȘM. Științele vieții, Nr. 2(323), 2014, p. 82-90.
10. Ciocarlan N. Family *Lamiaceae*: main important medicinal and aromatic spontaneous species in Republic of Moldova. *Journal of Botany*, vol. VIII, Nr. 1(12), 2016, p. 86-91.
11. Ciocarlan N., Ghendov V., Aprotosoia A. C., Miron A. Studii biologice și fitochimice la speciile *Ajuga reptans* L. și *Ajuga genevensis* L. *Journal of Botany*, vol. VIII, Nr. 2(13), 2016, p. 50-55.
12. Dragalin I., Aricu A., Ciocarlan N. et al. GC-MS analysis of the essential oil of *Satureja subspicata* Bartl. ex Vis. of Moldovan origin. *Chemistry Journal of Moldova*, 2016, 11(2), p. 105-108.
13. Hanganu D., Olah N., Benedec D. et al. Studiu comparativ al profilului fitochimic și biologic al speciei *Thymus marschallianus* Willd. (*Lamiaceae*). *Congresul Național de Farmacie din Romania*, ed. a XVI-a, București, 2016, p.127.
14. Harley R., Atkins S., Budantsev A. et al. The families and genera of vascular plants. In: Kaderit, J. (ed.), vol. 7 – *Lamiales*, Springer Ed., 2004.
15. Heywood V.H., Richardson I.B.K. *Labiatae*. In: Tutin et al. *Flora Europaea*, Cambridge: Cambridge University Press, 1972, vol III, p. 126-192.
16. Li Xiwen, Ian C. Hedge. *Lamiaceae* family. In: *Flora of China* 17:1994, p. 50-299.
17. Lugasi A., Hovari J., Hagimasi K. et al. Antioxidant properties of a mixture of *Lamiaceae* plants intended to use as a food additive. *Acta Alimentara*, 2006, vol. 35(1), p. 85-97.
18. Matkowsi A., Piotrowska A. Antioxidant and free radical scavenging activities of some medicinal plants from *Lamiaceae*. *Fitoterapia*, 2006, vol. 77, p. 346-353.
19. Negru A. Determinator de plante din flora Republicii Moldova. Chișinău: Ed. Universul, 2007, p. 218-231.
20. Rhazi L. *Mentha gattefossei*. In: IUCN Red List of Threatened Species. Version 2013.2 [www.iucnredlist.org](http://www.iucnredlist.org).
21. Richardson P. The chemistry of *Labiatae*: an introduction and overview. In: Harley R.M., Reynolds T. (eds.), *Advances in Labiatae Science*, Royal Botanic Gardens, Kew, 1992, p. 291-297.
22. The Red Book of Republic of Moldova, 3<sup>rd</sup> edition, Chișinău, Știința, 2015, p. 75.
23. Sarac N., Ugur A. Antimicrobial activities and usage in folkloric medicine of some *Lamiaceae* species growing in Mugla, Turkey.

- Eurasian Journal of Biosciences, 2007, vol. 1(4), p. 28-37.
24. Sparks T. H., Menzel A., Stenseth N.C. European Cooperation in Plant Phenology. Climate Research, 2009, vol. 39, 12 p.
  25. Stancovic M. S., Curcic M. G., Zizic J. B. et al. *Teucrium* Plant Species as Natural Sources of Novel Anticancer Compounds: Antiproliferative, Proapoptotic and Antioxidant Properties. Int. J. Med. Sci., 2011, 12(7), p. 4190-4205.
  26. Stefanache C.P., Trifan A., Ciocarlan N. et al. Phenolic content and antioxidant activity of *Nepeta parviflora* Bieb. species from the wild populations in Republic of Moldova. Planta Medica, 2015, Issue 16, vol.81, P. 176.
  27. Бейдеман И.Н. Методика изучения фенологии растений и растительных сообществ. Методические указания, Изд-во: Наука, 1974, 155 стр.
  28. Дикорастущие полезные растения России /Отв. ред. Буданцев А. Л., Лесиовская Е. Е. СПб.: Издательство СПХФА, 2001, стр. 325-359.
  29. Майсурадзе Н. И. Методика исследований при интродукции лекарственных растений /Н.И. Майсурадзе, В. П. Киселев, О. А. Черкасов и др. Лекарственное растениеводство. М., 1984, Вып. 3, 33 стр.

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## RESEARCH ON THE BIOLOGY AND PHYTOCHEMISTRY OF THE SPECIES *ROSMARINUS OFFICINALIS* L.

*Maricica Colțun, Virginia Corcodel*  
Botanical Garden (Institute) of ASM

**Abstract:** The results of a thorough study on the biology, content of essential oil, the chemical composition and the usage of the species *Rosmarinus officinalis* L., which is a perennial, herbaceous plant in the family Lamiaceae, are presented in this article. In the Republic of Moldova, it is researched as an aromatic and medicinal plant, which contains high amounts of biologically active substances, especially essential oil, used a lot in perfumery and cosmetics, as well as in medicine.

**Keywords:** rosemary, subshrub, usage, medicine, essential oil, aromatic plant.

### INTRODUCTION

Nowadays, after a stagnation period, the natural products and essential oils used in the perfume industry, food industry and traditional medicine are gaining popularity. This trend has manifested itself on the global market by replacing synthetic products with natural ones. Such a trend has also been observed in our republic. Famous perfume manufacturers use about 60-90% natural essential oil in their products. In the production of medicinal and aromatic plants, quality is assessed depending on the content of active principles. Their presence in plants is conditioned by ecological factors, the zone where the species grows, the cultivation technology and the biological value of the species. The introduction, conservation and sustainable use of the diversity of medicinal and aromatic plants, accumulated in the Botanical Garden, remain one of the long-term priority tasks.



Fig. 1. *Rosmarinus officinalis* L.

One of the studied species is rosemary (*Rosmarinus officinalis* L.), which was introduced in the Botanical Garden in 1996, from Crimea, as aromatic and medicinal plant, which contains a high amount of biologically active substances, especially essential oil, used a lot in perfumery and cosmetics, as well as in medicine. Rosemary is native to the western part of the Black Sea Basin. It is cultivated in France, Spain, Asia Minor, USA, on the southern coast of Crimea, Azerbaijan and in Middle Asia. At present, the largest producers and distributors are Yugoslavia, France, Italy, Spain and Greece.

### MATERIALS AND METHODS

For carrying out a complex study on *Rosmarinus officinalis* L., the plants present in the collection of the Plant Resources Laboratory were used as research subjects. The original material was received from Crimea. The plants were cultivated in open field, in ecologically balanced conditions, on general agrotechnical background, using no fertilizers, transferred to the greenhouse in winter. The phenological observations were made on 25 plants, every 3 days, until the end of the flowering stage and once a week – until the end of the growing season,

according to a program developed by the Moscow Botanical Garden. The content of essential oil of the fresh leaves and flowers, collected in the synthesis stage, was determined by using the hydrodistillation method. Direct fire was used to heat the liquid; the apparatus was constantly monitored to avoid overheating of the distillation flask.

The conditions of performing the analysis at Agilent 1100 (USA) high resolution and high pressure liquid chromatograph, Zorbax XDB C18 column, Extend C18 pre-column: mobile phase – MeCN: H<sub>2</sub>O in gradient, flux – from 0.4 to 1.2 ml per minute, duration of the analysis – 43 min. and temperature – 400°C.

## RESULTS AND DISCUSSIONS

Rosemary is an evergreen subshrub, of the family Lamiaceae, specific to Southern Europe, reaching the average height of 0.5-1.2 m in the conditions of R. Moldova. It has woody, branched root, with numerous hairs, and very branched tetrahedral stem. The leaves, which are needle-shaped, linear with smooth surface, petiole-free, narrow, 1.5-3.5 cm long, 0.2-0.5 cm wide, lanceolate, opposite, with slightly revolute edges (Fig. 1), are a characteristic feature of the plant. The upper surface of the leaf is dark green and shiny, the lower surface – silvery, covered with hairs.

The annual shoots are light grey and the multiannual shoots – dark grey. The flowers, grouped in whorls (Fig.3), develop in the axil of the leaves of upper branches. The fruits are brown, ovate nutlets. There are two varieties of rosemary: one with golden leaves and the other with silver leaves [1]. Blossoms throughout the summer.

In the conditions of the Botanical Garden, rosemary does not reach the stage of germination, that is, it does not form seeds. It is propagated by division of the root or by cuttings. The percentage of rooting after division – 100%. Under the conditions of the Botanical Garden, rosemary is cultivated in open field only for 180-200 days; in late autumn, it is transferred to the greenhouse where it spends the winter.



Fig. 3. Rosemary flowers



Fig. 2. Rooted cuttings

Fragments of 1st and 2nd order shoots with 3-4 internodes and a length of 7-10 cm serve as cuttings. The experiments were conducted in the greenhouse, at temperature of 20°C and relative air humidity of 65-70%. In mid April, the cuttings had a well-developed root system and were 10-12 cm tall. In the beginning of May, after the threat of spring frosts had passed, the hardened off cuttings were planted in open ground. The planting scheme: 50 x 60 cm.

In the conditions of the Botanical Garden, rosemary cannot withstand winter temperatures in open ground. It tolerates well the droughty periods of the year, thrives on light, deeply drained soils that warm up easily, with southern exhibition. Flowers and branches of rosemary have a strong,

aromatic smell, similar to camphor; its leaves have spicy, bitter, aromatic taste. The name of the species is



supposedly derived from the Greek words rhops (small shrub) and myrinos (aromatic) or from the Latin words ros (dew) and marinus (sea) [1]. In the conditions of the Botanical Garden, the rosemary plants overwinter in the greenhouse. Prolonged frosts lead to the loss of the aboveground parts of the plant. In summer, rosemary plants develop very well in open field. Even in the most favourable conditions, they rarely produce seeds. In the conditions of the Republic of Moldova, rosemary blooms twice a year: the first flowering occurs in February-March, in greenhouse conditions, and the second flowering – in September-October, in open field. The flowering stage lasts 28-30 days. Rosemary is cultivated for its aerial part (*Rosmarini herba* or *rosmarini folium* – the rosemary leaf). For medicinal purposes, the leaves are harvested before the flowering stage or at the beginning of the flowering stage, and are dried in the shade, at usual temperature. The rosemary oil (*Oleum rosmarini*) is obtained from leaves and annual shoots.

As a result of the research, it has been found that the plant product contains 1-2.5% essential oil, along with polyphenocarboxylic acids (rosmarinic acid – an ester of caffeic acid, with  $\alpha$ -hydroxydihydrocaffeic, caffeic, chlorogenic, neochlorogenic acids), bitter substances with tricyclic structure of diterpenoid type (camosol-picrosalvin, carnosic acid, rosmanol, rosmadial, rosmaridiphenol), triterpenes (ursolic acid, oleanolic acid,  $\alpha$ -amyrin,  $\beta$ - amyrin, betulin) etc. The major constituents of essential oil are 1,8-cineole,  $\alpha$ -pinene, camphor, bornyl acetate, borneol, camphene,  $\alpha$ -terpineol, limonene,  $\beta$ -pinene,  $\beta$ -caryophyllene and myrcene. Essential oil imparts to the product stomachic, carminative and spasmolytic properties. Bitter substances also have stomachic properties and, in addition, they influence the secretion of bile, causing initially an increase in its fluidity, followed by a slight change in the volume of secreted bile [2].

The rosemary essential oil is a liquid with cooling effect, colourless or slightly yellowish, with camphor-like smell and strong taste, which produces a sensation of cooling. Its density is 0,900- 0,920 g/mL. According to the obtained data, the fresh green mass of rosemary, cultivated under the conditions of BG, contains 0.1-0.2%, the leaves and young shoots – 0.3-0.4%, the dry matter – 1-2% and the flowers – 0.5-1% essential oil. In collaboration with the Centre of Advanced Biological Technologies of the Institute of Physiology, Genetics and Plant Protection, the chemical composition of the essential oil was investigated using the liquid chromatography method. According to the chromatogram of the essential oil, obtained from 3-4-year-old rosemary plants, 13 components were identified. The terpenic components of the oil were identified by comparison with control samples. The chemical composition of the studied essential oil, from the determined collection, is presented below (Table 1). The predominant component is verbenone, followed by geraniol.

Table 1.

**The chemical composition of the essential oil of the species *Rosmarinus officinalis* L.  
from the collection of the Botanical Garden (I)**

| No. | Compound          | TR (minutes) | Intensity (mAU) | Content of comp. (%/S) |
|-----|-------------------|--------------|-----------------|------------------------|
| 1.  | Camphene          | 14.01        | 6.77            | 0.128                  |
| 2.  | Verbenone         | 19.70        | 865             | 16.16                  |
| 3.  | Thymol            | 28.52        | 8.85            | 0.11                   |
| 4.  | Caryophyllene     | 22.43        | 73.82           | 0.92                   |
| 5.  | Pinene            | 26.47        | 9.38            | 0.13                   |
| 6.  | Geraniol          | 24.66        | 1050            | 13.59                  |
| 7.  | Borneol           | 39.56        | 543             | 2.61                   |
| 8.  | Isobornyl acetate | 41.67        | 117             | 1.1                    |



|     |                 |        |       |      |
|-----|-----------------|--------|-------|------|
| 9.  | Linalyl acetate | 20.45  | 71.71 | 2.11 |
| 10. | Camphor         | 24.02  | 379.9 | 3.94 |
| 11. | Ocimene         | 35.5   | 92    | 1.65 |
| 12. | Linalool        | 27.34  | 296   | 5.46 |
| 13. | Carvacrol       | 27.919 | 6.43  | 0.05 |

The preparations containing rosemary stimulate the secretion of digestive juices and have choleric, cholagogue, antiseptic and diuretic properties. They are indicated for biliary and liver disorders in anorexia, stomach disorders and chronic rhinitis. Essential oil is recommended in cases of physical debility, asthenia and convalescence. It stimulates mental activity and improves brain oxygenation [3]. However, exceeding the recommended therapeutic doses may lead to convulsions. The rosemary essential oil has been appreciated by the perfumers of the company "Viorica Cosmetic" with 4.9 points out of 5 and has been recommended to be used in perfumery and cosmetic industry, namely in lotions and perfumes for men.

Due to its strong fragrance, rosemary gives each food a unique and delicious flavour. Rosemary leaves are used as a spice for fish, meat, salads, sauces and vegetables. It is also used for spicing pasta, cakes as well as to provide aroma for tea and soft drinks [4].

## CONCLUSIONS

1. In the conditions of the Botanical Garden, rosemary is cultivated in open field for 180-200 days; in late autumn, it is transferred to the greenhouse, where it overwinters. It is cultivated as a medicinal and aromatic plant with rich content of biologically active substances, especially essential oil, a popular ingredient in perfumery and cosmetics as well as in medicine.
2. The plants are propagated by root division or cuttings. The percentage of rooting after division – 100%. Fragments of 1st and 2nd order shoots with 3-4 internodes and a length of 7-10 cm serve as cuttings. In the beginning of May, after the threat of spring frosts had passed, the hardened off cuttings were planted in open ground. The planting scheme: 50 x 60 cm.
3. The study of the features of accumulation of essential oil in plants testifies that it varies depending on the phenological phase and organ of the plant. The highest amount of essential oil is contained in flowers – 0.5-1%, in leaves and young shoots – 0.3-0.4% and in dry matter – 0.1-0.2%.
4. In the essential oil of *Rosmarinus officinalis* L., 13 components have been found, the basic ones being verbenone and geraniol.
5. The essential oil is in great demand in perfumery and cosmetic industry (4.9 points out of 5 possible) and in the pharmaceutical industry due to its health benefits.

## BIBLIOGRAPHY

1. Fischer Eugen. Dicționarul plantelor medicinale. Revenire, recunoaștere, vindecare. București, GEMMA PRES, 2002. 400 p.
2. Ursula H., Stănescu, Monica Hâncianu, Anca Miron, Clara Aprotosoia. Plante medicinale de la A la Z: monografii ale produselor de interes terapeutic. Iași, Editura T.Popa, 2004. 640 p.
3. Fischer Eugen, Dicționarul plantelor medicinale. Revenire, recunoaștere, vindecare. București, GEMMA PRES, 2002. 400 p.
4. Rausch Andreea, Brigine Lorz, Plante aromatice. Cultivare., gastronomie, cosmetică, efecte terapeutice., București. Editura ALLFA. 2008. 305 p.

CZU 581.1:582.632.2

## ANTIOXIDANT ACTIVITY OF SUBSTANCES EXTRACTED FROM BUDS OF THE TREES OF SPONTANEOUS OAK SPECIES

*Cuza Petru, Florenta Gheorghe*

State University of Moldova

**Abstract.** We determined the summed activity of oxidases, catalases and reducing substances of the extracts from the English oak buds, pubescent oak and sessile oak, sampling in autumn, winter and spring from trees growing nearby. In the extracts from the oak tree buds, there were clearly different trends in antioxidant activity during the transit period from one season to another. Due to the specific activity of antioxidant substances in buds, the pubescent oak falls earlier in autumn rest and comes out of dormancy, in spring, later. Exceptional antioxidant processes take place in the buds of the sessile oak, as a result of which, this species enters dormancy later in autumn and, in spring, comes out of it early. Catalase activity from buds under winter conditions may serve as an indicator of low-temperature species resistance. In this aspect, the pubescent oak, compared to the English oak and the sessile oak, is the species less adapted to winter conditions.

### INTRODUCTION

In recent years, as a result of the global warming trend [1, 7], scientists and society pay a great deal of attention to the resilience of biological systems and, especially, of plants to the action of high temperatures. Global climate change and the associated risks endanger the long-term development of human civilization. In the 21st century, diminishing moisture and increasing moisture differences in different geographic regions are forecast, in comparison with those of the last century. This scenario will be characteristic of temperate areas, where the frequency and intensity of the drought will increase. High temperatures combined with the action of other unfamiliar factors will increase the risks to which vegetation is exposed in areas with unstable climatic conditions, including moderate latitudes [5]. Unpredictable climate phenomena will negatively affect the stability of natural ecosystems. That is why the company will have to take additional precautions to mitigate the consequences of climate change.

The survival of trees in high-temperature conditions, which change from one season to another, depends on the oxidative-reductive processes that take place in plant tissues and especially in buds. Due to the plant's ability to enter the rest, buds are more resistant to excessive temperatures and rapid temperature changes. Namely, buds make sure the regeneration of trees affected by late spring frosts [2].

When young leaves and branches are affected by high temperatures, regeneration of plants can be achieved by resting buds, which, coming out of dormancy, make sure the continuity of branches and leaves. For these reasons, it is necessary to know the degree of resistance of different plant species to the influence of excessive temperatures when performing afforestation and regeneration of degraded forests. This problem is becoming more and more current in view of the global warming trend [3].

The global climate warming phenomenon is not only associated with the increase in positive temperatures, but also with the maintenance of negative temperature levels. Therefore, the range of extreme temperatures within which the plants vegetate extends with serious consequences related to their ability to survive. For these reasons, the development of tests that would determine the resistance of the plant species taken in research to the extreme influence of the action of high and low temperatures is becoming more and more current. Considering the nominations, scientific research has been carried out in order to determine the physiological state of the buds (the resting organ), taking as a model the spontaneous species of oak spread in the Republic of Moldova.

## MATERIAL AND METHODS

For the analysis of the activity of the antioxidant substances in buds in the territory of the Zloti forestry district, from the Cimisia forestry-hunting enterprise, were selected English oak, sessile oak and pubescent oak trees, which are located in close proximity. In each stand, an experimental surface was delimited, of which five trees were selected. The selection took into account the fact that the trees are of the same age and of class, I and II Kraft (class I is predominant trees and class II – dominant trees), being the tallest and their crowns – well developed. It was taken into account that the selected trees were illuminated above the crown and on the side. Dendrometric indices (base diameter and total height), altitude and geographic coordinates were determined for each tree.

The buds were collected from branches of the south-eastern part of the lower part of the crown. The sampling of the plant material was carried out on the same day for all three experimental areas (entrance in autumn October 25 *st* 2012, middle of winter January 29 *st* 2013, middle of spring April 11 *st* 2013).

In the laboratory, the biochemical analysis of the collected apical and lateral buds was performed. After the crushing of 0.1 g of porcelain in the porcelain mortar, the obtained material was extracted for 30 minutes at 25°C in 2 ml of buffer containing 0.2 MTris, pH-7. Subsequently, the extract was centrifuged for 15 minutes at 4000 g. The supernatant was separated and passed through a small column of Sephadex G 25, the substances obtained being separated from two fractions: low molecular weight (fraction 1) and high molecular weight (Fraction 2).

To find the overall capacity of fractions 1 and 2, for reducing the free oxygen content due to the potential for direct reduction of the antioxidant substances of fraction 1 and the enzymatic activity of the oxidases of Fraction 2 to 1.56 ml of the aforementioned buffer, 40 µcl of Fraction 1 or 2 were added and incubated at 25°C. In all experiments, the dynamics of the oxygen content of the experimental solutions was determined using the YSI (US) oximeter as compared to the control solution (containing only 1.6 ml of the buffer solution). At 15-30 minutes after initiation of incubation at 25°C, the oxygen content of the solution reached the stationary phase when the percentage of oxygen used equals that penetrated the solution to the diffusion process. The difference in the percentage of oxygen in the control and experimental solutions was determined by the capacity of fraction 1 or 2 to reduce oxygen, which is the cause of the reduction in the percentage of oxygen in the solution to the stationary phase. To determine the activity of the catalysts in fraction 2, the oxygen content dynamics was determined by adding 1.5 ml of buffer solution, 60 µcl of 0.05% H<sub>2</sub>O<sub>2</sub> and 40 µcl of the solution from fraction 2 followed by incubation at 25°C.

The dynamics of the change in oxygen content was influenced by the oxygen removal activity due to the degradation of hydrogen peroxide by catalases, as well as by the oxygen binding activity by the oxidases. The summary of these processes was determined on the basis of the percentage of oxygen in solution to the stationary stage. As mentioned above, in our experiments, the stationary phase was reached 15-30 minutes after the beginning of the incubation of the reaction components in the buffer solution.

## RESULTS AND DISCUSSIONS

Oxidative reductive processes are extremely important to plant passage through dormancy to growth [4, 6]. During this period, phenolic substances, being in a reduced state, participate more effectively in the elimination of reactive oxygen in species [4]. For this reason, the processes associated with oxygen metabolism in the extracts from shoots taken in autumn, winter and spring, from trees of different spontaneous oak species were compared. The data on the activity of antioxidant substances in extracts from buds collected in autumn are shown in Figure 1. The transition from the active period of vegetation in summer to autumn rest is a physiological process involving the metabolic processes carried out in both the apical buds and the lateral buds. This reflects the so-called catalase activity associated with the need for hydrogen peroxide decomposition, the formation of which is higher as the metabolic processes are more active (Figure 1).

From this point of view, it is highlighted the sessile oak, in the buds of which the catalase activity is higher as compared to the buds of the English oak and the pubescent oak. This demonstrates that, in autumn, the dormancy process of the sessile oak is delayed, as compared to those of the pubescent oak and the English oak. In the buds of pubescent oak, there is a tendency to lower both the activity of the catalase and the oxidase and antioxidant activity, which denotes the earlier induction to dormancy in both the apical buds and the lateral buds as compared to the same processes in the sessile oak and the English oak.

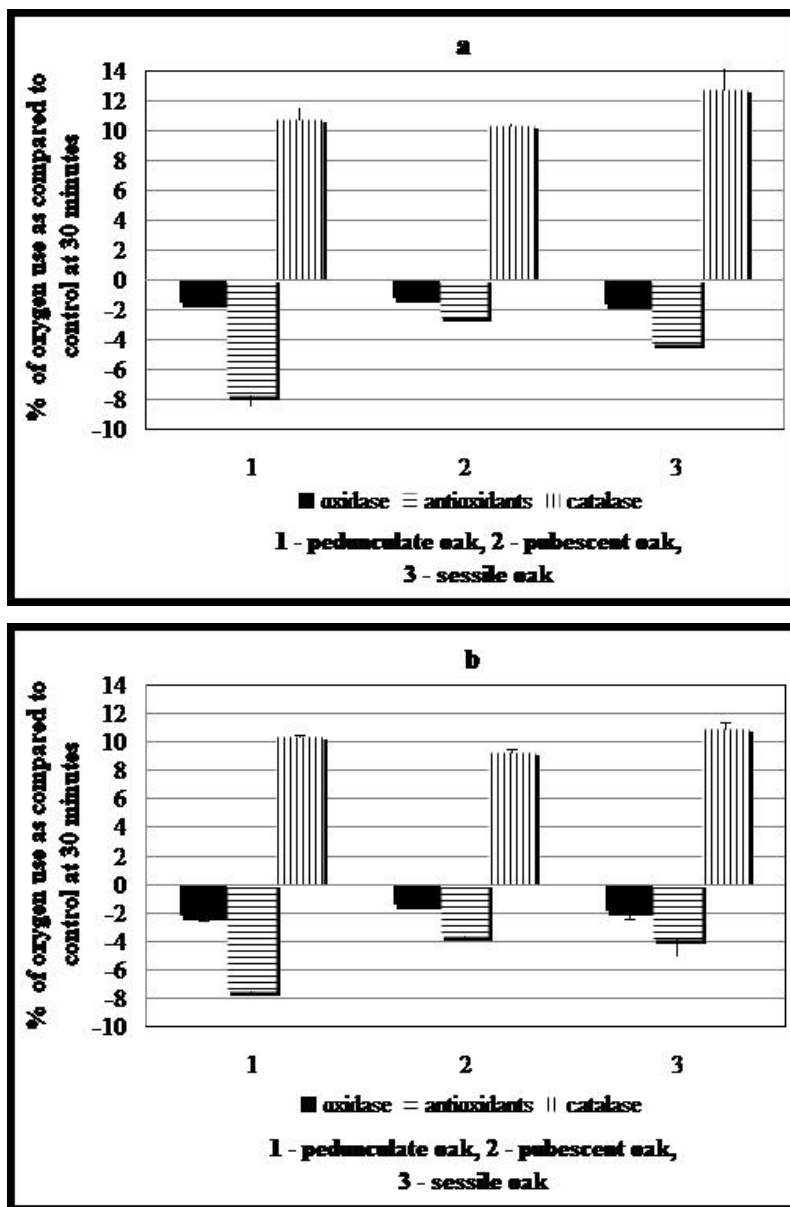


Figure 1. Summary of the activity of catalases, oxidases and antioxidant substances extracted from apical buds (a) and lateral buds (b) of English oak, pubescent oak and sessile oak collected in autumn (25.10.12)

The mentioned differences may be dependent both on the species' biological particularities and on the location of the trees in the experimental areas. From this point of view, it is possible to mention only one thing: in the early autumn, the activity of the catalase at the buds of the three oak species is higher, as the altitude of the forest resort in which these species grow is higher (Table 1, Figure 1).

Table 1

**Dendrometric characteristics of the selected trees and the geographical locations of the growth site characteristic of the selected trees**

| Number                                | Tree number | Diameter, cm | Height, m | Altitude, m | Geographic coordinates |           |
|---------------------------------------|-------------|--------------|-----------|-------------|------------------------|-----------|
|                                       |             |              |           |             | X                      | Y         |
| Experimental surface of English oak   |             |              |           |             |                        |           |
| 1                                     | 110         | 26           | 17        | 257         | 464115,94              | 285352,22 |
| 2                                     | 122         | 24           | 17        | 260         | 464116,32              | 285352,74 |
| 3                                     | 300         | 26           | 19        | 261         | 464116,57              | 285352,52 |
| 4                                     | 312         | 24           | 16        | 260         | 464116,63              | 285352,22 |
| 5                                     | 313         | 26           | 16        | 258         | 464116,58              | 285351,56 |
| Experimental surface of pubescent oak |             |              |           |             |                        |           |
| 1                                     | 64          | 24           | 17        | 223         | 464057,30              | 265326,47 |
| 2                                     | 90          | 22           | 17        | 224         | 464057,61              | 285326,59 |
| 3                                     | 107         | 26           | 14        | 224         | 464058,38              | 285326,40 |
| 4                                     | 113         | 24           | 13        | 223         | 464057,86              | 285326,24 |
| 5                                     | 173         | 24           | 14        | 228         | 464057,16              | 285328,32 |
| Experimental surface of sessile oak   |             |              |           |             |                        |           |
| 1                                     | 69          | 26           | 18        | 269         | 464219,48              | 285358,51 |
| 2                                     | 73          | 26           | 18        | 269         | 464219,50              | 285358,79 |
| 3                                     | 94          | 26           | 19        | 269         | 494219,29              | 285358,26 |
| 4                                     | 96          | 26           | 18        | 266,7       | 464219,36              | 285358,09 |
| 5                                     | 118         | 26           | 18        | 265         | 464219,14              | 285358,10 |

The data presented in Figure 2 give the possibility to mention that in both apical buds and lateral buds the activity of catalase is even higher in species that are more adapted to winter conditions. From this point of view, the activity of catalase is highlighted in the extracts from the English oak buds, an intermediate activity is manifested in the sessile oak, the lowest activity is characteristic for the extracts from the pubescent oak buds.



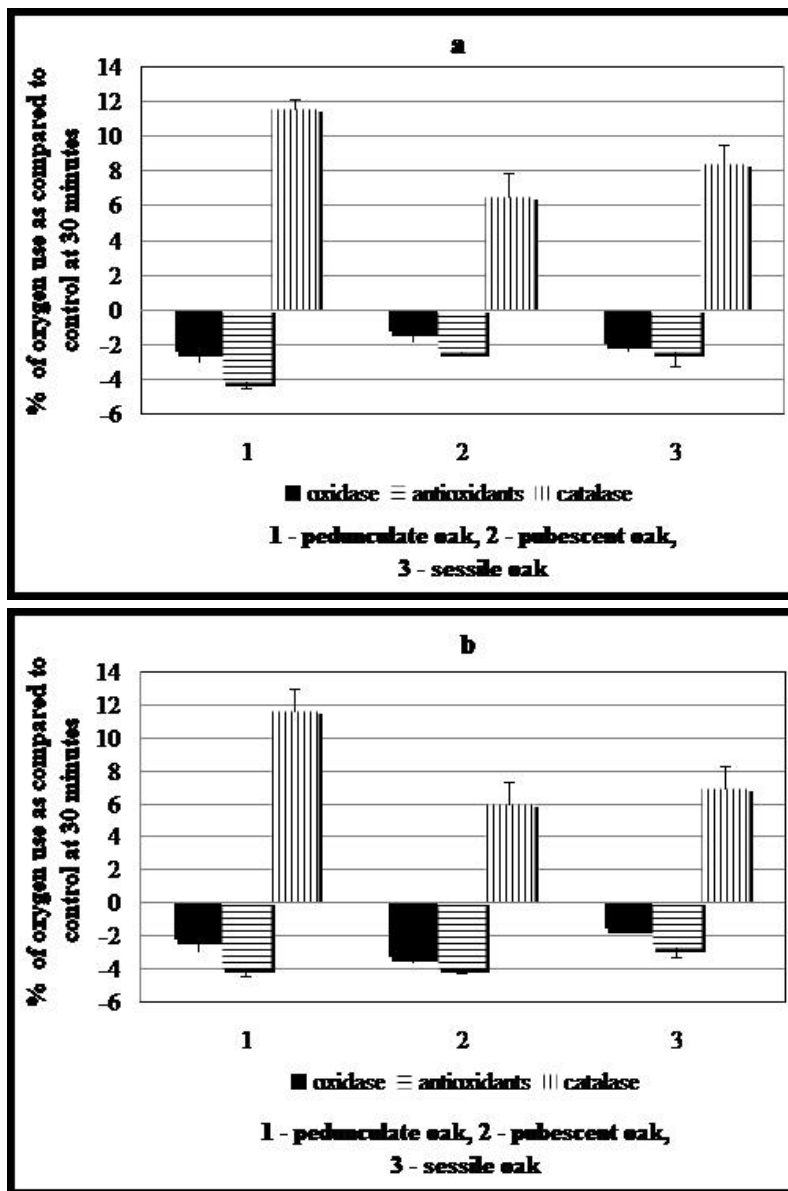


Figure 2. Summary of the activity of catalases, oxidases and antioxidant substances extracted from apical buds (a) and lateral buds (b) of English oak, pubescent oak and sessile oak collected in winter (29.01.13)

It should not be forgotten that, in this period, catalase activities in apical and lateral bud extracts of all three species were generally the same. Analogously – the activity of antioxidant substances and oxidases. Overall, the obtained data support the idea that maintaining the viability of winter buds is a phenomenon associated with the metabolic activity of oxidases, and the control of the reactive oxygen species that leak into tree buds is primarily determined by the activity of the catalases, the more pronounced, the more resistant to frost the oak species is (distribution of the species after the resistance to frost is found on the basis of their

geographical spread).

In spring, the differences between catalase activity in apical and lateral buds of oak sprouts and oak wood are less pronounced, compared to that characteristic of pubescent oak (Figure 3). This fact denotes that the metabolic processes in pubescent oak are associated with the slower initiation of spring growth, which is explained by the delay in eliminating the dormant side buds.

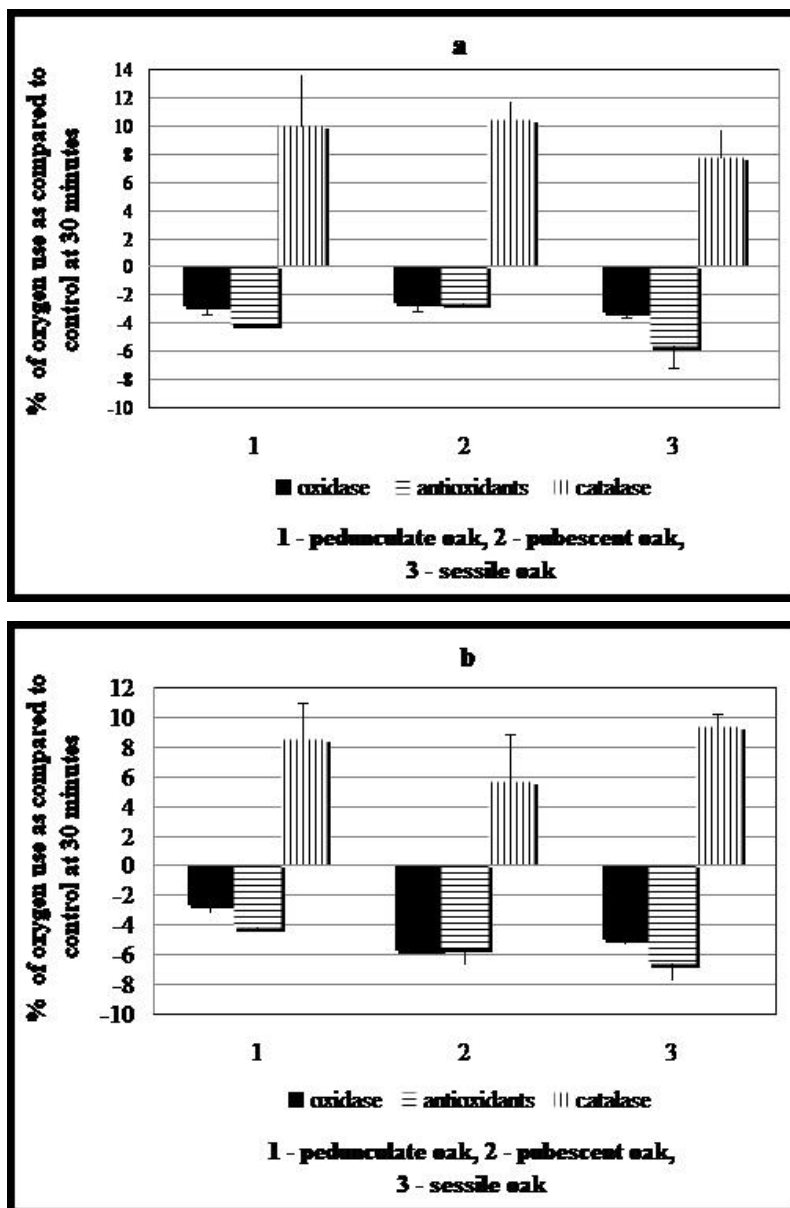


Figure 3. Summary of the activity of catalases, oxidases and antioxidant substances extracted from apical buds (a) and laterals (b) of English oak, pubescent oak and sessile oak collected in spring (11.04.13)

At the pubescent oak, during this period, the process of initiation of growth (and metabolism) takes place only in apical buds. At the same time, the accumulation of oxidases and antioxidant substances, together with the moderate activity of catalase, demonstrates that the processes of elimination of dormancy are on the way of initiation in the lateral buds of pubescent oak. Overall, the mentioned data suggest the idea that pubescent oak, in April, began processes of active elimination of dormancy in apical buds and at a moderate level in lateral buds. This conclusion is also supported by the fact that in the apical buds of this species, the activity of antioxidant substances and oxidases is lower as compared to those characteristic for lateral buds. This is reflected in the late exit of pubescent oak from dormancy in spring, as compared to the English oak and sessile oak.

Comparing the activity of catalase from spruce buds and English oak, we notice pronounced differences. At sessile oak, the activity of catalase, oxidases and antioxidants in lateral buds is higher compared to apical buds (Figure 3). At the English oak, the differences between the activities of the components mentioned in the apical and lateral buds during this period are less pronounced. The reported ones denote the fact that, in the English oak, the processes of elimination of dormancy in both types of buds have been initiated, when the dormancy processes are more active in the lateral buds, whereas in the apical buds the maximum activity for eliminating the dormancy has already been achieved.

Overall, the results show the existence of essential differences between oak species, in terms of adaptation to environmental conditions, during the transition period from one season to another. Adaptation strategies to environmental conditions are specific to each oak species. The pubescent oak is highlighted by the fact that it falls earlier in autumn rest and comes out of spring dormancy later. The activity of antioxidant substances shows that in the spring and autumn, from the point of view of these processes in buds, the pubescent oak is essentially different from the sessile oak, and the English oak occupies an intermediate position. The activity of the antioxidant processes in the buds of the sessile oak, as compared to those in the English oak buds and the pubescent oak, gives the possibility to conclude that, in autumn, it enters the rest period later and, in spring, comes out of dormancy early. Thus, the data on the activity of antioxidant substances in buds denote that the entrance of oak species in autumn rest is manifested in the following sequence: the pubescent oak, which is followed by the English oak and finally the sessile oak. The exit from the dormancy state is determined by the following sequence: the oak is followed by the English oak and then the pubescent oak.

## CONCLUSIONS

1. The summaries of the activity of the substances that characterize the oxidoreductive potential of oak tree buds can serve as indicators of their autumn dormancy and spring revival.
2. In oak species, there are different adaptation strategies to environmental conditions during different seasons. Thus, the pubescent oak, due to the specific activity of the antioxidant substances in buds, falls in autumn rest earlier and comes out of spring dormancy later. Exceptional antioxidant processes take place in the buds of the oak, which result in entering later the rest period in autumn and coming out of it early in spring.
3. Catalase activity in buds under winter conditions may serve as an indicator of species' resistance to low temperatures. In this aspect, the pubescent oak, as compared to the English oak and the sessile oak, is the species less adapted to winter conditions.

**BIBLIOGRAPHY**

1. Brundtland G. H., Mansour K. Our Common Future. Report of the World Commission on Environment and Development. United Nations Document: 1987, A/42/427.
2. Cuza P. Instalarea și menținerea speciilor de stejar (aspecte teoretice și practice). Chișinău: Mediul ambiant, 2017. 256 p.
3. Hasselman K. Climate change research after Kioto. // Nature. 1997. Vol. 390. P. 225-226.
4. Pakkish Z., Rahemi M., Baghizadeh A. Seasonal changes of peroxidase, polyphenol oxidase enzyme activity and phenol content during and after rest in pistachio (*Pistacia vera* L.) flower buds. // World Applied Sciences Journal. 2009. Nr. 6. P.1193-1199.
5. Porter J. R., Semenov M. A. Crop responses to climatic variation. // Phil. Trans. Soc. Bot. 2005. Vol. 360. P. 2021-2035.
6. Puntarulo S., Sanchez R. A., Boveris A. Hydrogen peroxide metabolism in soybean embryonic axes at the onset of germination. // Plant Physiol. 1988. Vol. 86. P. 626-630.
7. Schneider S. H. The greenhouse effect: Science and policy. // Science. 1989. Vol. 243. P. 771-781.

# THE COMPARATIVE ANALYSIS OF THE POPLAR (*Populus alba*) REACTION FROM THE NATURE RESERVE “PADUREA DOMNEASCA” TO THE INFLUENCE OF ENVIRONMENTAL FACTORS

**Mamai Iulian, PhD student,**  
State University of Moldova

*Abstract.* The objective of the present study is to elaborate the dendrochronology of the white poplar (*Populus alba* L.) within the “Padurea Domneasca” Natural Reserve in order to identify the type of relation between the growth of trees and climatic factors. The calculated correlation coefficients have allowed identifying the climate-growth relations of the white poplar within the reserve, pointing out more periods of the year, statistically significant, which influence the growing processes.

*Key words:* Dendrochronology, radial growth, correlation coefficients, temperature, precipitations.

## INTRODUCTION

The forest as a whole is one of the terrestrial ecosystems with the greatest structural and functional complexity, which by control and continuous supervision allows the establishment of certain laws that can be verified, adopted and expanded outside of it (within the validity) in order to elaborate some special programs of ecological reconstruction and restoring steady state. Achieving and implementing a sustainable forest management is a priority objective, strongly debated by national and international policies. This objective cannot be achieved if the information needed on the factors influencing the state of forest ecosystems is always available.[1]

Relations between forest ecosystems and the climate are increasingly highlighted in environmental science due to climate change in recent decades, and knowledge of how forests react to climate change is a challenge for research in the field. Climate change is a topical subject, as the effects of these changes are noticeable, favoring irreversible processes of forest ecosystems, namely drying the stands, succession with other species, increasing the risk of spreading diseases and pests, all of which have led to declining productivity and the vitality of the stands and, last but not least, the diminishing of the assigned protection function.

The existence and structure of ecosystems are closely correlated with climatic factors, and differentiated distribution of species is made depending on ecological preferences. Thus, the vegetation distribution of a meadow is dependent on the tolerance limits of each species and is dependent on variations in existing climatic conditions.

The present study aims to elaborate the dendrochronological series of White Poplar (*Populus alba* L.) of the Nature Reserve “Pădurea Domnească” to identify the type of relationship between tree growth and climatic factors.

## MATERIALS AND METHODS

In the context of a series of actions for drainage of this meadow (1970-1990), the construction of the Stâncă - Costești dam (1977), climate change (since the 1990s), it was agreed to establish two reference periods for which the poplar response is to be identified. The first period is up to 1977, which coincides with the period until the construction of the dam, and the second period is the one after 1977, which coincides with the period after the construction of the dam so far.

The elaboration of the dendrochronological series and determination of the reaction to the trees to the climate was carried out according to the study methodology described in the work “Methodological Foundations and Dendrochronology Applications” by Dr. Ing. Ionel Popa[1], including the following steps:

- Sampling of the Pressler drill blade at 1.30 m height, the extracted cores were stored in paper tubes for



a slow drying, then the extracted samples were mounted on a wood support, made according to the diameter of the samples, and subsequently were sanded with coarse-to-fine coarse-grain abrasive tape. The annual ring width measurement was achieved with the CooRecorder2.3 Program, after the extracted cores were scanned at a 600-1200 dpi resolution.

- The CDendro interlacing, which presents a program for reading and manipulation of coordinate files built in CooRecorder, is also used to interdating the primary dendrochronological series. And the verification of the correctness was done with the software COFECHA.
- All individuals breeding series have been standardized to eliminate nonclimatic signals and maximize climate information on the dendrochronological series. For this purpose, in the first phase, a first standardization was applied to eliminate the influence of age with a negative exponential function, then a second standardization was applied by means of a cube spline function of 67% of the length of the series, and the average index series standardized growth was achieved through the weighted average, using the ASTRANwin software for this purpose.
- Tree response to climate change was analyzed using Pearson type correlation coefficients. The correlations between the dendrochronological series and the different climatic (monthly, seasonal, yearly) climatic values even after the construction of the Stâncă-Costești dam were determined using the DENDROCLIM 2002 program.

## RESULTS AND DISCUSSIONS

The white poplar occupies the areas between depressions, ridges and higher places, with alluvial soils, short floods, and within the reserve occupies an area of 1153.6 ha (22%).

The average growth range (Figure 1) of the white poplar of the “Padurea Domneasca” Nature Reserve was taken from a relatively white plot of white poplar from u.a: 68 E, 24 samples were extracted from 24 trees according to the criteria dendrochronological.

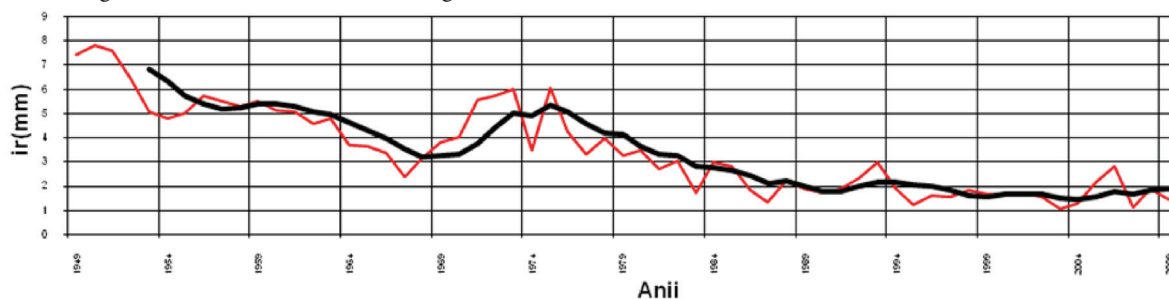


Figure 1. Medium growth range of white poplar in the Royal Forest Nature Reserve

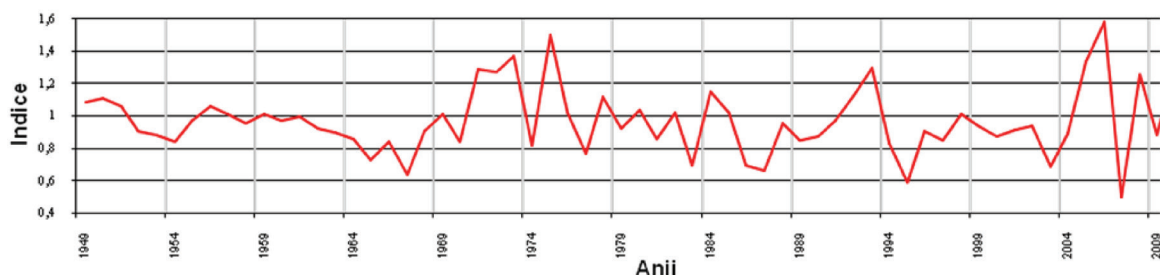


Figure 2. Dendrochronological series (RES) of white poplar

The average growth curve is typical of a structurally homogeneous tree with an active growth in the first 30 years, identifying significant periods of acceleration of significant auxological processes, thus surprising the main silvicultural works carried out, which led to essential changes in from an auxiliary point of view, starting with 1990 there has been a sudden decrease of the increases.

The dendrochronological series (Figure 2) elaborated on white poplar within the Nature Reserve "Padurea Domneasca" cover the period 1949 - 2013, the length of the individual ranges ranging from 60 to 80 years, with an annual average increase of 3.9 mm.

Thus, for establishing the climatic relation - radial growth, correlation indexes were calculated, which describe the intensity and the meaning of the association of the growth indices with the following climatic parameters:

#### a) Precipitation

The calculated correlation indices highlight the way of reaction or influence of precipitation fallen in certain periods of the year on the radial growths, with an obvious dependence on the white poplar's reaction to the amount of rainfall that fell during the construction of the dam. (Figure 3)

It is worth mentioning the fact that there is a statistically positive and statistically significant correlation between the radial growth and precipitation amount recorded at the Hydrometeorological Station in the city of Falesti in October of the previous year and the annual and the previous year quantities.

For the period after the construction of the dam (after to 1977) there was a significant positive reaction to the white poplar on the amount of precipitation in the months: March, April, as well as for the periodic values: the annual quantity, the annual quantity and the previous year, - May, November - March, April - August, April - May.

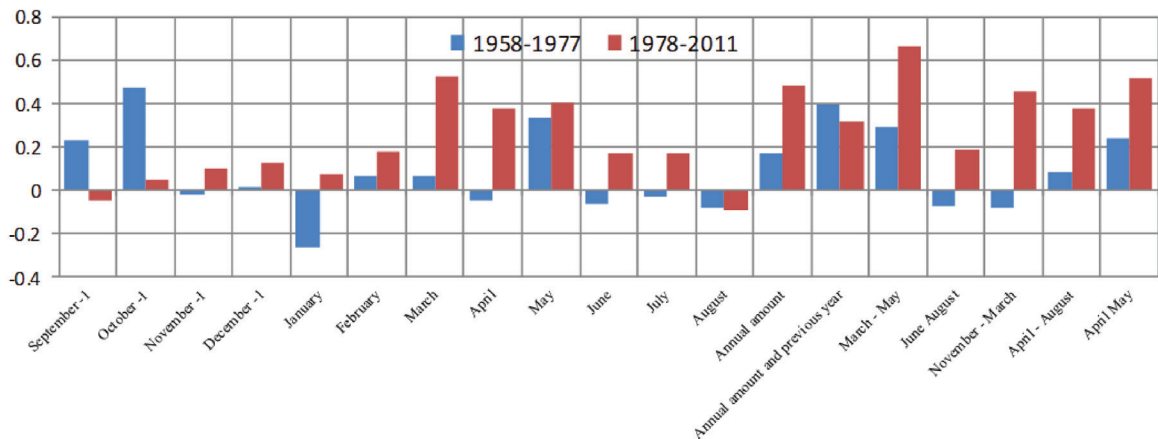


Figure 3 Correlation coefficients between white poplar growth index (RES) and monthly and seasonal rainfall

#### b) Temperature

The analysis of the relation between the white poplar growth index and the monthly temperature values (Figure 4) show that the thermal regime exert a diametrically opposite influence on the two periods.

The auxiliary processes of the white poplar in the reserve until the dam construction are positively influence by the average temperature values recorded at the Hydrometeorological Station in the town of Falesti (1959-1977) in December last year and April.

For the period after the construction of the dam, the temperature values recorded at the Hydrometeorological Station in the town of Falesti in June negatively influences the radial growth indexes.

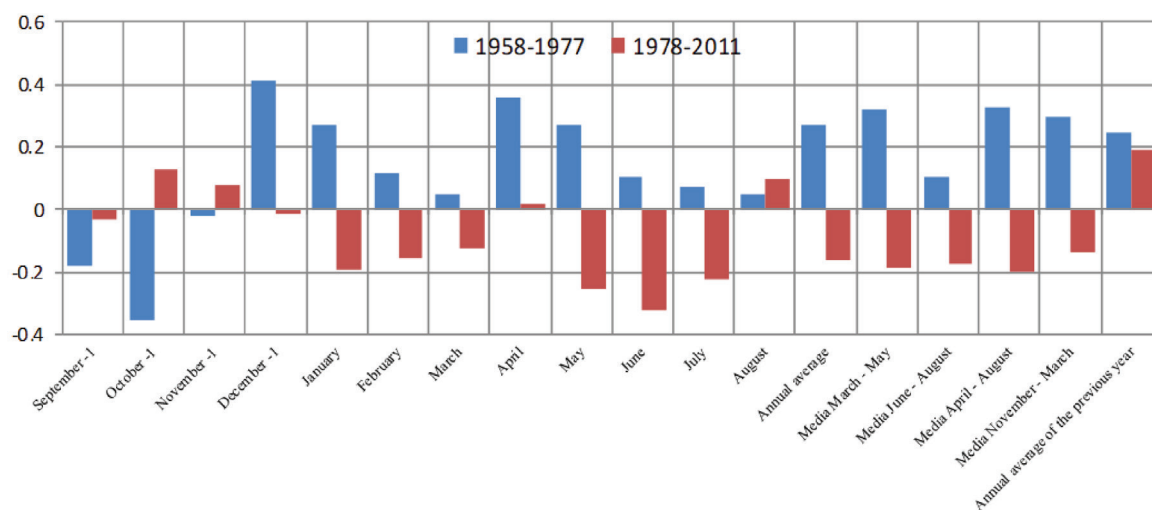


Figure 4 Correlation coefficients between white poplar growth index (RES) and monthly and seasonal temperatures

## CONCLUSIONS

In the synthesis of the previously exposed correlation coefficients, we have been able to identify the climate-growth relationships of the white poplar within the reserve, highlighting several statistically significant periods of the year influencing auxological processes.

According to the correlation coefficients calculated for the period up to the construction of the dam, the white poplar reacts positively to the amount of precipitation in the current and the previous year and to the amount of precipitation in October of the previous year. For the period after 1977, the white poplar has a positive reaction to the amount of precipitation in March, April, May, the annual quantity, including that of the previous year, from March to May, November, April to August, , April to May. At the same time, it is notice the negative effect of the rising temperatures after 1977 in June, July, the average annual, June-August, April-August, in this context it can be start that the action of the thermal regime influences strongly the auxological processes white poplar.

## BIBLIOGRAPHY

1. Leca Ș., Creșterea arborilor și arboretelor în sistemul de monitorizare forestieră intensivă., Brașov, 2014, pag 4
2. Popa I. Fundamente metodologice și aplicații de dendrocronologie, Cîmpulung Moldovenesc, 2004, 200 pag.

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## EVALUATION OF PHOTOSYNTHETIC ACTIVITY IN PEAR TREES DEPENDING ON THE ACTION OF BIOLOGICAL ACTIVE SUBSTANCES

Gheorghe SCURTU<sup>1</sup>, Nicolae BUJOREANU<sup>1</sup>, Ion HAREA<sup>1</sup>, Alexandru NICUȚA<sup>1</sup>, Roman PAȘA<sup>1</sup>,  
Vladimir CORNEA<sup>2</sup>, Dumitru DADU<sup>2</sup>, Serghei CHISILP, Nicolae DONICA<sup>2</sup>, Ana GRIBCOVA<sup>2</sup>

<sup>1</sup>Institute of Genetics, Physiology and Plant Protection of the Academy of Sciences of Moldova

<sup>2</sup>Scientific – Practical Institute for Horticulture and Food Technologies, Republic of Moldova

E-mail: [planeta\\_scurtu@yahoo.com](mailto:planeta_scurtu@yahoo.com)

**Abstract:** Research to elucidate the effectiveness of photosynthesis in pear plants has been carried out. The obtained results have shown that the physiological state of the plants during the active of the vegetation period can be characterized depending on the season and the specificity of the vegetation period performance in dynamic of the photosynthesis efficacy. It has been established that in the spring, during the vegetation period, the pear trees with the increase of the intensity of the photosynthesis.

**Keywords:** Photosynthesis, pear tree, Verbascosida, LCI-4 Portable Photosynthesis System.

### INTRODUCTION

It is known that photosynthetic activity in the pear orchard depends on a complex of internal and external factors, which manifest in dynamics on the date of measurements. The intensity of photosynthesis is the basic indicator that characterizes the functionality of the photosynthetic apparatus, which is widely used in the scientific and practical physiological investigations. The purpose of the investigations is to evaluate in dynamics the productive potential of the plantation for the production of pear trees (*Pyrus communis* L., family *Rosaceae*), by the capacity of assimilation of the photosynthetic apparatus response to the action of the biologically active substances.

### MATERIALS AND METHODS

The scientific researches were carried out in the pear orchard before harvesting period of the company "Delectar", Onesti com., Hâncești district. The control pear trees were sprayed with water and the aqueous solution of the Verbascosida – obtained from *Verbascum densiflorum* Bertol, family *Scrophulariaceae* plants. (Patent of Invention No. 289, 2010. BOPI nr. 11\2010, 2011, Growth regulator., 1982) natural growth regulator at a concentration of 0.01%. The study investigates the two varieties of late pears *Noyabrscaya* and *Vystavochmaya*. Two weeks later, in dynamics, during the vegetation period, photosynthetic intensity and other 11 parameters (indicated below) were determined in the leaves of the pear trees directly in the orchard, for the first time by using the LCI-4 Portable Photosynthesis System, presented at the International Conference of Plant Physiology in Poland, 1994 and donated to the Republic of Moldova by the World Bank for the purpose of linking physiological researches to international standards.

The LCI-4 (BCI, 1994) device (photo 1) consists of a contact chamber connected to pear leaves, a block composed of two specialized computers: 1 - measures the required parameters, 2 - analyzes the data obtained, which displays them on the screen and accumulates them in memory, where can be removed to a memory card.





Photo 1. LCI-4 Portable Photosynthesis System

Analyzing the above photosynthesis formula and Photo 1 we note that of the 12 parameters (shown below) by measurements with LCI - 4 Portable Photosynthesis System: 4 parameters refer to  $\text{CO}_2$  determination; 2 parameters refer to the determination of  $\text{H}_2\text{O}$ ; 3 - P.A.R. and T – temperature in the measurable room and of the leaf.

1. V -  $\text{CO}_2$  flow (reference), VPM
- 2, 3. T,  $^{\circ}\text{C}$  – in the measurable room / of the leaf
4. The intensity of photosynthesis,  $\mu\text{mol m}^{-2} \text{s}^{-1}$
5. The intensity of transpiration,  $\text{mmol m}^{-2} \text{s}^{-1}$
6. Conductivity of the stomatas at  $\text{CO}_2$ ,  $\text{mol m}^{-2} \text{s}^{-1}$
7. Photosynthetic active radiation,  $\mu\text{mol m}^{-2} \text{s}^{-1}$

8. Can -  $\text{CO}_2$  from exterior,  $h=3\text{m}$  from the soil, VPM
9. Cj -  $\text{CO}_2$  in the measurable room, VPM
10.  $\Delta C (=C_{\text{ref}} - C_{\text{an}})$ , VPM
11. Ean –saturation of the air with humidity, mbar
12.  $\Delta E$ -partial pressure, mbar



Photo 2. Noiabriscaia variety



Photo 3. Vystavochная variety

*Noyabrskaya* variety (Dushutina X. K., 1979 p.166), short description: this pear (variety (Photo 2) originates from the Republic of Moldova, winter variety, standard variety, premium class. Author is Xenia Dushutina. *Noyabrskaya* is a hybrid of the varieties *Nicolai Kriuger* x *Triumph of Vienna*. Spread under the name *Xenia*. Variety is popular in Europe due to the superior quality of the fruits (a ball of 4. 6 out of 5.0 possible) and their long-lasting, widely used in the fruit processing industry. This variety is one of the most resistant to frost, diseases, etc.

It is the most cultivated variety of pears in the Republic of Moldova due to the very large size of fruits, which can reach up to 600 g/one. When harvesting, the fruits are green and stony, but after several weeks of storage they soften and turn yellow and flavored, with a unique taste.

The harvest is done in October and full maturity reaches in November, hence the name of this particular variety. Under optimal conditions it can be kept until April.



This pear *Vystavochnaya* variety Dushutina X. K., 1979 p.168), (Photo 3) originates from the Republic of Moldova, autumn variety, standard variety, premium class. Author is Xenia Dushutina. *Vystavochnaya* is a hybrid of the varieties *Triumph of Vienna* x *Olyvie de Serr*, resistant to winter conditions, fertile. The trees have average growth, born regularly. They are resistant to mane and staining of the leaves. The fruits are large, reaching the weight of 240-350 g, are picked at the beginning of October, good taste (ball of 3.8 - 4.0 out of 5.0 possible), are used for consumption in November-January, under refrigerator storage conditions-in January-February. Fruit in maturation is well on trees.

Results on the mathematical analysis photosynthetic activity with graphical presentation of the results, *Noyabrskaya* variety and *Vystavochnaya* variety.

Each measurement includes three rehearsals-mandatory conditions.

## RESULTS AND DISCUSSIONS

The results obtained on both varieties of pears show ensures of the formation of more assimilation centers in the apical tissues of the pear trees that allow the use of photosynthetic assimilations at the beginning of the intensive growth of shoots, as well of the growth of foliage and fruits (16.06.2016). At the same time, the data obtained demonstrates that the photosynthetic apparatus in the application of SBA Verbascozida 0.01% has a significantly higher capacity to insure the needs of pear plants compared to the control (Tab. 1, 2; Fig. 1. 2).

Table 1

Average data for mathematical analysis, *Noyabrskaya* variety.

| Factors            | Date of observation |            |           |            |           |           |
|--------------------|---------------------|------------|-----------|------------|-----------|-----------|
|                    | 30.05. 16           | 16.06. 16  | 07.07. 16 | 21.07. 16  | 12.08. 16 | 08.09. 16 |
| Control            | 4.27±0.6            | 6.88±0.48  | 3.32±0.27 | 5.10±0.65  | 5.04±0.05 | 2.46±0.30 |
| Verbascozida 0,01% | 4.41±0.09           | 16.07±1.89 | 3.13±0.02 | 11.64±0.33 | 6.66±0.13 | 2.78±0.28 |

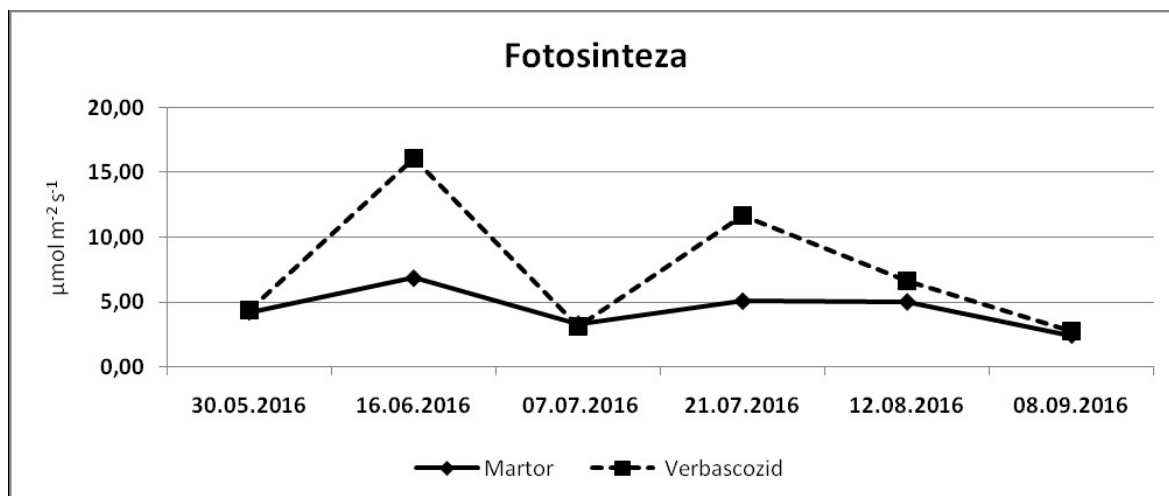


Fig. 1. The intensity of photosynthesis in the dynamics of the vegetation period

Table 2

Average data for mathematical analysis, *Vystavochnaya* variety.

| Factors            | Date of observation |           |           |           |           |           |
|--------------------|---------------------|-----------|-----------|-----------|-----------|-----------|
|                    | 30.05.16            | 16.06.16  | 07.07.16  | 21.07.16  | 12.08.16  | 08.09.16  |
| Control            | 4.22±0,29           | 3.30±0,11 | 2.98±0,22 | 1.61±0,25 | 4.29±0,44 | 2.91±0,20 |
| Verbascozida 0,01% | 6.81±0,14           | 6.07±0,47 | 3.93±0,03 | 5.44±0,13 | 5.84±0,18 | 2.86±0,25 |

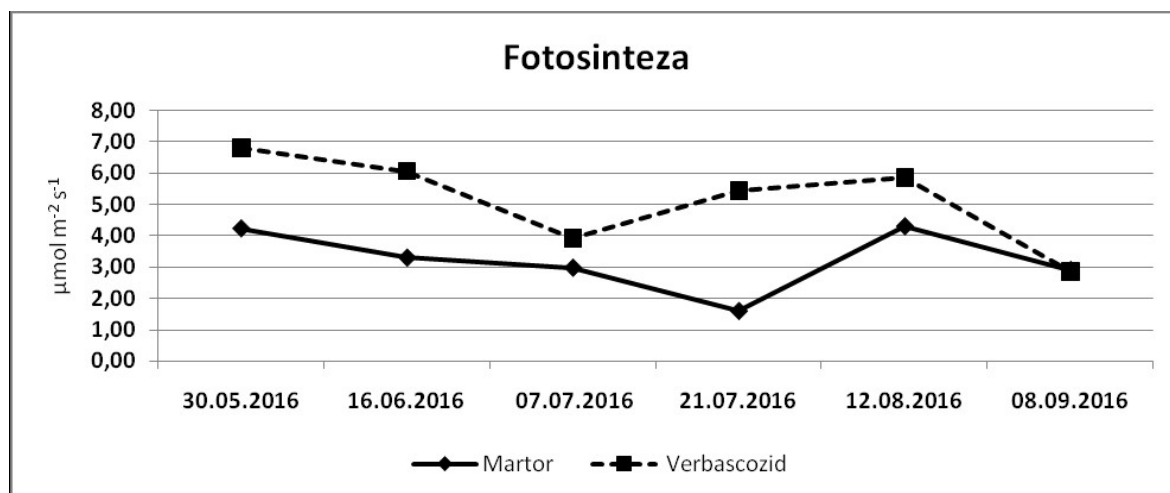


Fig. 2. The intensity of photosynthesis in the dynamics of the vegetation period

At the end of the vegetation period, when the effectiveness of the photosynthetic active centers diminishes (from 21 July to 08 September 2016), less characteristic for the 07.07.2016 period (because of the sudden cooling of the air and the heavy rains), the ability to synthesize the assimilation becomes equal to their of use and storage by the acceptance centers, which results in the equilibrium of both the control and Verbascozida 0.01% variant, the latter being eliminated from the plant (fig.1, 2). Similar results were obtained by the authors (3, 5).

The presence of photosynthesis of the foliage apparatus of the trees during the harvesting period contributes to an increase in the possibilities for preserving fruits.

## CONCLUSIONS

1. The results of the researches showed that the intensity of the photosynthetic processes in the application of SBA Verbascozida 0.01% is much higher compared to the control variant.
2. Verbascozida growth regulator at a concentration of 0.01% significantly alters the intensity of photosynthetic processes and determines the ability to form and transport of assimilates.
3. At the end of the vegetation period, the intensity of processes of photosynthesis, transport and use of photosynthetic products in both variants is the same.

## BIBLIOGRAPHY

1. BCI. Instruction for utilization the LCI – 4, Portable Photosynthesis System, UK, 1994.
2. Душутина К. К. *Селекция Груши*, Кишинев, 1979, с. 166; 168.
3. Климов С. В. *Адаптация растений к стрессам через изменение донорно-акцепторных отношений на разных уровнях структурной организации*, 2008, т. 128, N 3, с. 128.
4. Рубин Б. А. *Физиология сельскохозяйственных растений*, М: МГУ, 1970, т. IX. с.233.
5. Рабинович Е. *Фотосинтез*. Отв. ред. Ничипорович А. А. М: ИЛ, 1953, т. 2, с. 287.
6. Чайлахян М. Х. *Регуляторы роста и развития растений*, М: ИФР им. Тимирязева, 1982, с.303

CZU58.006 : 502.75 : 582.852 : 581.52

## INTRODUCTION OF PLANTS OF THE FAMILY CACTACEAE JUSS. IN THE BOTANICAL GARDEN (INSTITUTE) OF ASM

*Țîmbali Valentina, Rogacico Sergiu, Gușanova Victoria*

Botanical Garden (Institute) of the Academy of Sciences of Moldova

**Abstract.** The family *Cactaceae* Juss. is represented, in the collections of the Botanical Garden (I) of ASM, by 897 taxa belonging to 137 genera. 462 taxa reach the generative phase (blossom) and 236 produce fruits with seeds. The plants of this family reproduce by seed and vegetatively. The value of the cactus collection of the BG is indubitable and the diversity of the family *Cactaceae* impresses the visitors.

### INTRODUCTION

One of the important problems in using the resources of the world's flora is the introduction of greenhouse plants, because a large number of crops, used by people, as well as houseplants are native to tropical and subtropical countries.

Family *Cactaceae* is one of the largest groups of higher plants, which counts more than 3000 species, native to the Americas, most of them are found in Mexico, desert regions of Peru, Chile, Argentina and Bolivia. The phytogeographical area of the family lies between 35° north latitude, in Canada, and 54° south latitude, near the Strait of Magellan. Because the distribution area is so large and the environmental conditions are extremely varied, these plants have specific morphological and biological peculiarities that are actually adaptations to the more or less favourable environmental conditions. The climate of the Americas encompasses all types, from polar to equatorial climate. The distribution area of cacti extends over 12 000 km, and has equatorial, subequatorial, tropical, temperate, desert and even cold climate. The specific spreading area of plants of the family *Cactaceae* includes almost all landforms: from the spectacular canyons of southern US to Mexican, Peruvian, Bolivian and Argentinean plateaus, hills, mountains often exceeding 5000 m in height, steppes, the Pampas, deserts or tropical forests. Because of this wide variety of landforms, the soil composition is also diverse. Some species of *Opuntia* Mill. have acclimatized very well and have spread in Southern Europe, Northern Africa, India and Australia. In their native countries, many species of cacti were once the only natural resources used as food for humans and animals and for other utilitarian purposes.

Cacti are xerophytic plants with succulent stems, fleshy, columnar or globular, usually with ribs. According to the habitat, they are divided in two groups: cacti that inhabit arid regions (typical cacti) and cacti that inhabit tropical forests (*Epiphyllum* Haw., *Rhipsalis* Gaertn., *Lipismium* Pfeiff., *Hateora* Br. et Rose, *Schlumbergera* Lem., *Selenicereus* Br. et Rose etc.).

The flowers of cacti are usually solitary, except the flowers of the genera *Pereskia* and *Rhodocactus*, which are grouped in raceme inflorescences, always sessile, bisexual (except *Mammillaria dioica* K. Brand.), mostly actinomorphic, rarely zygomorphic (*Aporocactus*, *Cleistocactus*, *Cochemeia*, *Schlumbergera*). At the moment of flowering, on the representatives of some genera (*Melocactus* Link. et Otto), a cephalium – a dense structure with bristles, from which the flowers are produced, appears at the tip of the stem. Some species of *Pilosocereus* Byles et Rowley, in the flowering stage, produce a large number of spiky trichomes on areoles, which have been called pseudocephalia.

### MATERIALS AND METHODS

The subjects of the study were the plants of the *Cactaceae* collection of the BG (I), which at the moment includes 897 taxa, belonging to 137 genera. Phenological observations on plant growth and development were

carried out according to “The Methodology of Phenological Observations in the Botanical Gardens of the USSR” (Методика фенологических наблюдений в ботанических садах СССР”) (1975). The scientific inventory of the collection is accomplished every year. The critical processing of taxa was carried out according to Backeberg (1979) and Copăcescu (2001). Among the first species of cacti (1963-1964), which constituted the basis for the creation of the collection, were: *Eriocactus leninghausii* Backbg. *Consolea rubescens* Lem., *Cylindropuntia leptocaulis* (DC) F. Knuth., *Cleistocactus strausii* (Heese) Backeb.

## RESULTS AND DISCUSSIONS

In the Botanical Garden (I) of ASM, in the course of about 50 years, the collection of plants of the family *Cactaceae* has been created. It includes now 897 taxa, belonging to 137 genera and 3 subfamilies: *Pereskioideae*, *Opuntioideae* and *Cereoideae* (Backeberg, 1979; Copăcescu, 2001). The collection of plants of the subfamily *Cereoideae* is the richest: 125 genera and 811 taxa, followed by *Opuntioideae* with 10 genera and 79 taxa and by *Pereskioideae* with 2 genera and 7 taxa, respectively.

Table 1.

Some aspects of the systematic composition of the fam. *Cactaceae* in the collection of the BG (I) of ASM

| №     | Subfamily                   | The most important genera         | Number of species in the genus | Number of genera in the subfamily |
|-------|-----------------------------|-----------------------------------|--------------------------------|-----------------------------------|
| 1     | <i>Pereskioideae</i> Schum. | <i>Pereskia</i> Mill.             | 4                              | 2                                 |
| 2     | <i>Opuntioideae</i> Schum.  | <i>Austrocylindropuntia</i> Back. | 7                              | 10                                |
|       |                             | <i>Opuntia</i> Mill.              | 47                             |                                   |
|       |                             | <i>Tephrocactus</i> Lem. etc      | 15                             |                                   |
| 3     | <i>Cereoideae</i> Schum.    | <i>Echinocereus</i> Engelm.       | 29                             | 125                               |
|       |                             | <i>Echinofossulocactus</i> Law.   | 15                             |                                   |
|       |                             | <i>Ferocactus</i> Britt et Rose   | 18                             |                                   |
|       |                             | <i>Gymnocalycium</i> Pfeiff       | 29                             |                                   |
|       |                             | <i>Lobivia</i> Britt et Rose      | 33                             |                                   |
|       |                             | <i>Mammillaria</i> Haw.           | 203                            |                                   |
|       |                             | <i>Neochilenia</i> Backeb.        | 19                             |                                   |
|       |                             | <i>Notocactus</i> Berger          | 22                             |                                   |
|       |                             | <i>Parodia</i> Speg.              | 23                             |                                   |
|       |                             | <i>Rebutia</i> Schum.             | 26                             |                                   |
|       |                             | <i>Rhipsalis</i> Gaerth. etc      | 28                             |                                   |
| Total |                             |                                   | 897                            | 137                               |

The number of taxa within the genera is as follows: *Mammillaria* Haw. – 203; *Opuntia* Mill. – 47; *Lobivia* Britt et Rose – 33; *Gymnocalycium* Pfeiff. – 29; *Rhipsalis* Gaerth. – 28; *Echinocereus* Engelm. – 29; *Coryphantha* Lem. – 22; *Astrophytum* Lem. – 18; *Notocactus* Berger – 22; *Neochilenia* Baskeb. – 19; *Ferocactus* Britt et Rose – 18; *Parodia* Speg. – 23; *Rebutia* Schum. – 26; *Cleistocactus* Lem. – 15; *Aylostera* Speg. – 21; *Dolichothele* Britt et



Rose – 12; *Trichocereus* Riccob. – 13 etc. 462 taxa are able to reach the generative stage (54.42%) and 236 (27.8%) produce fruit.

Table 2.

**The number of taxa that reach the generative stage in some genera**

| N  | Genus                | Total number of taxa | Number of taxa that produce flowers | % of taxa that produce flowers | Number of taxa that produce fruits | % of taxa that produce fruits |
|----|----------------------|----------------------|-------------------------------------|--------------------------------|------------------------------------|-------------------------------|
| 1  | <i>Mammillaria</i>   | 203                  | 159                                 | 78.3                           | 78                                 | 38.4                          |
| 2  | <i>Opuntia</i>       | 47                   | 7                                   | 14.9                           | 7                                  | 14.9                          |
| 3  | <i>Lobivia</i>       | 33                   | 19                                  | 57.6                           |                                    |                               |
| 4  | <i>Echinocereus</i>  | 29                   | 4                                   | 13.8                           |                                    |                               |
| 5  | <i>Gymnocalycium</i> | 29                   | 9                                   | 31.0                           |                                    |                               |
| 6  | <i>Rebutia</i>       | 26                   | 13                                  | 50.0                           | 4                                  | 15.4                          |
| 7  | <i>Rhipsalis</i>     | 28                   | 8                                   | 28.6                           | 5                                  | 17.6                          |
| 8  | <i>Parodia</i>       | 23                   | 13                                  | 57.0                           | 4                                  | 17.4                          |
| 9  | <i>Coryphantha</i>   | 22                   | 9                                   | 40.9                           | 4                                  | 18.2                          |
| 10 | <i>Aylostera</i>     | 21                   | 10                                  | 47.6                           | 6                                  | 28.6                          |

The species of *Mammillaria*, *Astrophytum* Lem., *Parodia*, *Dolichothele* Br. et Rose, *Opuntia*, *Rhipsalis* and *Rebutia* bloom more often.

Cacti bloom, practically, all year round, but most taxa – in spring and summer. Most species of the genera *Mammillaria* and *Opuntia* bloom abundantly in March-May. To get high-quality seeds, fruits are harvested when ripe, usually from autumn until spring. The size of a fruit may range from a few millimetres, for example *Rhipsalis* Gartn., *Lepismium* Pfeiff., to 5 cm or even more in the case of *Opuntia* Mill., *Trichocereus* Ricc., *Hylocereus* Br. & R. etc. A fruit contains from 1-2 seeds, as in *Rhipsalis*, *Lepismium*, *Pelecypora* Ehren. up to 1500, in *Espostoa blossfeldiorum* Bak. The number of fruits on a plant varies from one genus to another. The species of the genera *Mammillaria* Haw., *Opuntia* etc. are the richest in flowers and fruits. The shapes of seeds are very diverse: spherical, oval, kidney-shaped, lenticular, prismatic etc. Seed size also varies significantly. The smallest seeds, 0.3-1.0 mm long, are characteristic of the plants of the genera *Parodia* Speg., *Blossfeldia* Werd. and *Strombocactus* Br. & R., while the seeds of *Astrophytum* Lem., *Opuntia* and *Pereskia* Mill. are bigger and reach 3-5 mm.

To preserve the germination capacity for a longer period, it is recommended to store the seeds at temperatures of + 2-+ 5°C.

During the research, it was determined that the germination rate of freshly-harvested seeds of some species of *Mammillaria* was 85-98%, while that of seeds that had been stored for 7 years, under laboratory conditions, decreased to 20-30.

Table 3.

**The duration and the percentage of seed germination in some species of cacti from the collection of the BG (I) of ASM**

| №  | Species                                                       | Length of the germination period (days) | % of germination |
|----|---------------------------------------------------------------|-----------------------------------------|------------------|
| 1  | <i>Astrophytum senile</i> Fric.                               | 6                                       | 99               |
| 2  | <i>A. hybrid</i>                                              | 6                                       | 53               |
| 3  | <i>Aylostera areolata</i>                                     | 12                                      | 55               |
| 4  | <i>A. bloetera</i>                                            | 14                                      | 25               |
| 5  | <i>A. buiningiana</i> Rausch                                  | 14                                      | 15               |
| 6  | <i>A. nogalescens</i> Ritt.                                   | 22                                      | 20               |
| 7  | <i>Gymnocalycium castellanosi</i> Backb.                      | 9                                       | 45               |
| 8  | <i>Lophophora williamsii</i> Coult.                           | 7                                       | 30               |
| 9  | <i>Mammillaria pacifica</i> Bod.                              | 16                                      | 20               |
| 10 | <i>M. nigra</i> Ehrenb.                                       | 6                                       | 98               |
| 11 | <i>Pfeiffera ianthothele</i> Web.                             | 16                                      | 25               |
| 12 | <i>Notocactus purpureus</i> Ritt.                             | 32                                      | 20               |
| 13 | <i>N. schlosseri</i> Van Vliet                                | 22                                      | 10               |
| 14 | <i>N. mammulosus</i> Berg.                                    | 11                                      | 25               |
| 15 | <i>Hamatocactus setispinus</i> Br.&R.                         | 10                                      | 99               |
| 16 | <i>H. sinuatus</i> Orc.                                       | 18                                      | 80               |
| 17 | <i>Neochilenia pilispina</i> Backbg                           | 11                                      | 80               |
| 18 | <i>Parodia cardenasii</i> Ritt.                               | 12                                      | 15               |
| 19 | <i>P. borealis</i> Ritt.                                      | 10                                      | 5                |
| 20 | <i>P. gracilis</i> Ritt.                                      | 17                                      | 3                |
| 21 | <i>P. multicostata</i> Ritt. et Jelinek                       | 18                                      | 15               |
| 22 | <i>P. schwebsiana</i> Backbg.                                 | 18                                      | 20               |
| 23 | <i>Rebutia allegraina</i> Kohl.                               | 12                                      | 95               |
| 24 | <i>R. iselniana</i> Krainz                                    | 8                                       | 99               |
| 25 | <i>R. xanthocarpa</i> Backbg. var. <i>dasyphrissa</i> Backbg. | 14                                      | 53               |
| 26 | <i>Hildewintera aureispina</i> Backbg.                        | 8                                       | 20               |
| 27 | <i>Epithelantha micromeris</i> Web.                           | 13                                      | 2                |
| 28 | <i>Dolichothele campotricha</i> Tieg.                         | 21                                      | 15               |
| 29 | <i>D. baumii</i> Werdt.                                       | 12                                      | 10               |
| 30 | <i>D. decipiens</i> Tieg.                                     | 13                                      | 98               |
| 31 | <i>Lepismium tucumanense</i> Backbg.                          | 5                                       | 95               |
| 32 | <i>Erythrorhipsalis pilocarpa</i> Berg.                       | 10                                      | 40               |
| 33 | <i>Rhipsalis roseana</i> Berg.                                | 12                                      | 95               |
| 34 | <i>Acanthorhipsalis monacantha</i> Br.&R.                     | 12                                      | 30               |
| 36 | <i>Weingartia lanata</i> Ritt                                 | 7                                       | 15               |

Given the data presented in the table, we find that the length of the germination period of the studied species ranges from 6 days, in the species of the genus *Astrophytum*, to 32, in *Notocactus purpureus*, and the

germination rate – from 3-5%, in *Parodia*, to 98-99%, in *Mammillaria nigra* and *Astrophytum senile*.

To obtain good results, it is necessary to carry out a phytosanitary treatment of seeds before planting them in the substrate. The infection of crops with cryptogamic diseases or molds may compromise the cultivation. In the greenhouses of the BG (I) of ASM, wet treatment is used by introducing the seeds in 3-5% solution of  $\text{KMnO}_4$ . According to the data found in the specialized literature (Copăcescu, 2001), dry treatment can also be carried out by sprinkling the seeds with fungicides – Captan or Zineb.

The optimal substrate for sowing cactus seeds, used in BG (I), is river sand that has been previously well-washed and sterilized by boiling for 20-30 minutes. Often, because of high humidity and low temperature, seeds are attacked by various diseases or molds. To avoid this phenomenon, a new substrate was found as a result of the research, which turned out to be ideal for growing cacti – volcanic magma.

The seeds are sown, in the greenhouses of BG (I), usually in January and February. After planting the seeds in the substrate, the trays with seeds are placed in a glass cabinet, where maintenance conditions can be regulated (temperature, humidity and light). The daily examination of seedlings is very important for growing cacti. Special attention needs to be paid to soil moisture because over-watering can cause the seedlings to rot, since their hypocotyls are very sensitive to water.

For germination, the seeds need an optimal temperature, about + 22-+ 25°C, high soil moisture and air humidity (80-85%) and moderate light.

Table 4.

**Stem-succulent trees of the family Cactaceae in the collection of the BG (I) of the ASM**

| Subclass                                                          | Group       | Species                                                                                                                                                                                                                                                                                                                                                          |
|-------------------------------------------------------------------|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Trees with subulate, ephemeral (metamorphosed) leaves on branches | Tall trees  | <i>Cereus peruvianus</i> Mill.,<br><i>C.p.var.monstruosus</i> ,<br><i>Consolea rubescens</i> Lem.,<br><i>Brasiliopuntia brasiliensis</i><br>Berg., <i>Quiabentia chacoensis</i><br>Backb., <i>Opuntia bergeriana</i><br>Web., <i>O. leucotricha</i><br>DC., <i>O. pilifera</i> Web., <i>O.</i><br><i>streptacantha</i> Lem., <i>O.</i><br><i>robusta</i> Wendl., |
|                                                                   | Small trees | <i>Marginatocereus marginatus</i><br>Backb., <i>Myrtillocactus</i><br><i>geometrizans</i> Cons.,                                                                                                                                                                                                                                                                 |
|                                                                   | Dwarf trees | <i>Pilosocereus arrabidaei</i> Byl.<br>& Rowl.,                                                                                                                                                                                                                                                                                                                  |
| Trees with true or partially reduced leaves on branches.          | Small trees | <i>Pereskia aculeata</i> Mill.,<br><i>Pereskopsis spathulata</i> Br.et.<br>R., <i>Rhodocactus grandifolius</i><br>Knuth                                                                                                                                                                                                                                          |

After germination, when the seedlings reach 0.2-0.5 cm high, they are pricked out and sown in trays or

small plastic pots filled with mixed substrate: leaf soil : red peat of neutral acidity : river sand : small pieces of wood charcoal (ratio – 3:3:3:1). Pricking out seedlings is necessary practically every month, during a year, but most importantly – in the first half of the year. Young cactus seedlings should not be exposed to direct sunlight, they grow better in slightly shady places, with a little sun in the morning and afternoon.

The plants of this family are polycarpic; the life of the stem corresponds to the life span of the plant. As the plants mature, the stems lignify, being able to live beyond the impressive age of 200 years. In the cactus collection of the BG (I), a specimen of *Echinicactus grusonii* Hildl., grown from seed, reached the age of 51 in 1965, there are even older plants in the collection. According to the classification of succulent plants, developed by Gaidarji M. M. (2009), the family *Cactaceae* includes all types of woody plants: trees, shrubs and subshrubs. Most species of this family are stem succulents.

Most cactus genera (subfamily *Cereoideae*) have no true leaves. The species of the genera *Pereskia* and *Rhodocactus* Knuth. (subfamily *Pereskioideae*) have true leaves with ovate blade, pinnate nerves, entire margin, thick, waxy, dark green. The petiole is very short, cylindrical and thick. The sheath appears as a dilation of the lower end of the petiole. Species of the subfamily *Opuntioideae* (*Opuntia*, *Austrocylindropuntia*, *Tephrocactus*, *Cylindropuntia* etc.) have metamorphosed leaves, awl-shaped, with sharp-pointed tip, called subulate leaves, which last for a short period of time. In terms of evolution, *Pereskioideae* is the oldest subfamily.

The diversity of natural conditions and environmental factors has contributed to the creation of numerous shapes and sizes, which vary from 1 cm to 25 m. In the collection of the BG (I) of ASM, there are plants that grow up to 1 cm in diameter (*Aylosteria* sp. Speg.) and plants that grow up to 4-6 m tall (*Austrocylindropuntia tunicata* Link et Otto, *Cereus peruvianus* (L.) Mill., *Consolea rubescens* Lem., *Myrtillocactus geometrizans* Juss., *Quabentia chacoensis* Backeb., *Brasiliopuntia brasiliensis* Berger, *Opuntia bergeriana* Web. *O. pilifera* Web. etc.)

In greenhouse conditions, in the BG (I) of ASM, most cactus species bloom from March (the second half) to May. In this period, most species of *Mammillaria* and *Opuntia* reach the generative stage. From November to February cactus plants are dormant.

Cacti can be propagated by division of the young plants from the mother plant, by cutting (tropical cacti) and by seed. Cactus seeds (except *Opuntia*) are surrounded by a thin and fragile membrane. A fruit can contain from 1-3 seeds, for example *Pelecypora pseudopectinata* Backeb., to 1500 – *Espostoa blossfeldiorum* (Werd.) F.Buxb. Most cactus species have small seeds. They can be from 0.3-0.5 mm long (in *Parodia*, *Blossfeldia*, *Strombocactus* etc.) to 3-5 mm long (in *Astrophytum*, *Opuntia* and *Pereskia*).

To maintain the germination capacity for a longer period, it is recommended to store the seeds at + 2-+ 5°C.

In the course of the research, it was found that the germination rate of the freshly-harvested seeds of some species of *Mammillaria* was 85-98%, but the germination rate of the seeds that had been stored for 7 years, under laboratory conditions, decreased to 20-30%. The germination rate of the freshly-harvested seeds of *Astrophytum senile* Fric. was 90-94%, while – of *A. ornatum* Web. after 3 years of storage – only 3%. The seeds of *A. senile* var. *aureum* Back. and *A. myriostigma* Lem. practically did not germinate.

The value of the cactus collection of the BG is indubitable and the diversity of the family *Cactaceae* impresses the visitors.

## CONCLUSIONS

1. The Botanical Garden owns a cactus (fam. *Cactaceae*) collection of a matchless value in the Republic of Moldova, created over about 50 years, including at the moment 897 taxa, belonging to 137 genera and 3 subfamilies: *Pereskioideae*, *Opuntioideae* and *Cereoideae*.
2. The cactus collection of the BG (I) of ASM serves as educational material for the pupils and students who study biology.
3. The optimal time for planting cactus seeds in the substrate is January and February.
4. The germination period of the seeds of the studied species varied from 6 days to 32, and the germination

rate – from 3-5% to 98-99%.

5. As a result of the research, it has been found that the best conditions for seed germination are: temperatures of + 22-+25, high soil moisture and air humidity (80-85%) and moderate light.

## BIBLIOGRAPHY

1. Backeberg, N. 1979 - *Das Kakteenlexicon* , Veb Gustav Fischer Verlag Jena, 822 p.
2. Copăcescu S. V., 2001 – *Cactușii Monografie*, Editura „Ceres” București, 695 p.
3. Гайдаржи М. Н. Жизненные формы и онтоморфогенез суккулентных растений. Автореферат диссертации на соискании степени доктора биологических наук. Киев, 2009, 45 стр.
4. *Методика фенологических наблюдений в ботанических садах СССР*, 1975- Москва, «Наука»



CZU 582.394:522.4:58.006(478)

## INTRODUCTION OF PLANTS OF THE CLASS POLYPODIOPSIDA IN THE BOTANICAL GARDEN (I) OF ASM

*Țîmbali Valentina*

Botanical Garden (Institute) of the Academy of Sciences of Moldova

**Abstract.** Over about 45 years, in the greenhouses of the Botanical Garden (Institute) of the Academy of Sciences of Moldova, a collection of ferns has been created, and now it includes 66 taxa, belonging to 11 families and 27 genera. Of the 66 taxa, under greenhouse conditions, in the BG, 44 produce spores. In the greenhouse, the following species reproduce by free dispersal of spores: *Adiantum capillus-veneris* L., *Athirium filix-femina* (L.) Roth, *Pteris cretica* L., *P. palustri* Poir. and *Cyrtomium falcatum* (C. Presl.) Copel.

The most decorative and resistant ferns, meant to be used as indoor ornamental plants, are representatives of the genera: *Adiantum* L., *Asplenium* L., *Nephrolepis* Schott, *Platynerium* Desv, *Pteris* L. and *Phlebodium* J.Smith.

**Keywords:** collection, ferns, genus, species, sori, spores

### INTRODUCTION

Ferns appeared about 350 million years ago and were the first vascular land plants, which had vegetative body, represented by the sporophyte generation and which has become dominant. They appeared in the Paleozoic Era, in the late Devonian Period and reached a peak of evolution in the Carboniferous Period, due to the favourable conditions of that period. In addition to the tree ferns, which looked imposingly due to their height, there were also species of shorter ferns. They formed low shrublands or climbed and lived on the branches of tall ferns, forming vast and luxurious forests. At the end of their life cycle, these plants fell in the waters of the surrounding marshes.

Over thousands of years, huge amounts of organic plant matter have accumulated in the mud of these marshes, which, through the carbonization process, have turned into huge coal and oil deposits, which are currently exploited. This group of plants currently includes about 300 genera with more than 10,000 taxa [4].

Some of these ancient plant species grew very tall, and if the 30 m high tree fern is extinct, there are smaller varieties now, along with more recently evolved species.

The range of these plants is very large and they live in a wide variety of habitats, beginning with deserts and ending with marshlands, lakes, rice fields and salty waters. However, most ferns are found in tropical rainforests, where they grow not only on the soil, under trees, but also as epiphytes, on the trunks and branches of trees, often in very large numbers.

In terms of size, the ferns range from tropical trees (which can reach up to 25 m in height and the diameter of the trunk – 50 cm) to small plants with a height of only a few millimetres. Some ferns of the group with fleshy fronds are so small that a whole colony can grow under one medium-sized leaf. Their filigree-like fronds are almost transparent and need high humidity to survive. At the other extreme, there are about 700 species of tree ferns. In New Zealand and in the areas with humid climate in Australia, they can grow up to 15 m tall and their fronds, which are similar to palm leaves, can reach a length of 6 m. Some species float on stagnant waters and those of the genus *Azolla* Lam. cover the surface of ponds during the summer and, usually, survive in winter. Other species, such as *Lygodium* Swartz, are climbing ferns, which can twine around trees up to a height of 10 m.

Nowadays, ferns are cultivated only as ornamental plants.

### MATERIALS AND METHODS

The ferns of the collection of tropical and subtropical plants of the Botanical Garden (Institute) of the Academy of Sciences of Moldova served as research subjects. Currently, in the collection of ferns of the Botanical

Garden (Institute) of the ASM, there are 66 taxa of 11 families and 27 genera. The phenological observations on plant growth and development were carried out according to "The methodology of phenological observations in the botanical gardens of the USSR" (Методика фенологических наблюдений в ботанических садах СССР) (1975). The scientific inventory of the collection is taken yearly. The critical processing of the taxa is carried out according to S. G. Saakov (1983). The planned introduction of ferns in the greenhouses of the Botanical Garden (Institute) of ASM started in 1975 [1]. At that time, 9 species were introduced in the greenhouses. Among the first species of ferns, which formed the basis of the collection, there were: *Adiantum capillus-veneris* L., *Asplenium bulbiferum* Forst., *Nephrolepis cordifolia* (L.) C. Presl, *Pteris cretica* L., *Platycerium alcicorne* Desv. etc. During 1976, the collection was enriched and consisted of 26 species and, at the end of 1990, it included 82 taxa.

## RESULTS AND DISCUSSIONS

In the Botanical Garden (Institute) of ASM, during about 45 years, the collection of plants of the phylum *Pteridophyta*, the class *Polypodiopsida*, was created and has been enriched, so that it now includes 66 taxa, which belong to 11 families and 27 genera. The systematic composition of the fern collection is shown in Table 1.

According to the data from Table 1, the following families are best represented in the collections of the Botanical Garden (Institute): *Polypodiaceae* (18 taxa), *Oleandraceae* (14), *Adiantaceae* (8), *Aspleniaceae* (6), *Dryopteridaceae* (6) etc.

Of the 66 taxa from the collection, 44 (66.67%) develop sori with spores. Practically, all the taxa of the following genera produce spores: *Adiantum* (6), *Nephrolepis* (4), *Pteris* (6), *Phlebodium* (3) and *Platycerium* (2) etc. In greenhouse conditions, the ferns propagate vegetatively, by division (*Adiantum*, *Nephrolepis* and *Pteris*), by offsets – young plantlets formed on the mother plant (*Asplenium bulbiferum* Forst. and *Tectaria gemmifera* (Fée) Alst.) or by fragmentation of rhizomes or stolons (*Polypodium* and *Nephrolepis*). Some species reproduce by free dissemination of spores, for example: *Adiantum capillus-veneris*, *Athyrium filix-femina*, *Cyrtomium falcatum*, *Pteris cretica* and *P. palustris*. To reproduce by spores, the ferns need special conditions: constant temperature of the air and the substrate (+26...+28°C), humidity of the air and of the substrate of 80-85%, porous and well sterilized substrate, consisting of acidic red peat and river sand. The spores are incorporated into the surface of the substrate. To maintain the air humidity, the pots are covered with glass and periodically vented.

In the Botanical Garden (Institute), the collection of ferns is located in the greenhouse with tropical plants grown in pots and in vegetative containers on racks, where the air temperature varies from +7°C, in autumn, to +30...+35°C, in summer, the relative air humidity is 70-85%, in summer, and in spring-summer, the plants are protected from direct sunlight.

The optimal period for the transplantation and the vegetative propagation of ferns is January-February. The optimal substrate consists of leaf soil, red peat, manure and sand, in a ratio of 2:2:1:0.5.

Diseases and pests:

The appearance of brown spots on leaves is a consequence of too cold air, irrigation with cold water or excess moisture. The margins of the leaves become brown because of high temperatures and dry air. The leaves become yellow because of too much sun exposure.

Ferns are often attacked by aphids, especially by woolly aphids. Insecticides are successfully used to control them.

The most fern taxa from the collections of the Botanical Garden can be successfully used to decorate rooms with north-western exposure, with no direct sunlight and with air temperature from +16°C to +26°C. Ferns are popular ornamental plants, primarily, due to their aesthetically pleasant appearance and, secondly, due to the ability of many species to absorb harmful substances from the air.

Table 1

**The taxonomic composition of the collection of plants of the class Polypodiopsida of GB (I) ASM**

| No. | Family                                    | Genus                                         | Number of taxa in the genus | Total number of taxa in the family |
|-----|-------------------------------------------|-----------------------------------------------|-----------------------------|------------------------------------|
| 1   | <i>Adiantaceae</i> Ching                  | <i>Adiantum</i> L.                            | 6                           | 8                                  |
| 1   |                                           | <i>Pellaea</i> Link                           | 2                           |                                    |
| 22  | <i>Aspleniaceae</i> Mett. et Frank        | <i>Asplenium</i> L.<br><i>Phyllitis</i> Ludw. | 5<br>1                      | 6                                  |
| 33  | <i>Athyriaceae</i> Alston                 | <i>Athyrium</i> Swartz                        | 1                           | 2                                  |
| 44  |                                           | <i>Stenochlaena</i> J. Smith                  | 1                           |                                    |
| 55  | <i>Dennstaedtiaceae</i>                   | <i>Microlepia</i> C. Presl.                   | 2                           | 2                                  |
| 66  | <i>Oleandraceae</i> Ching. ex Pichi-Serm  | <i>Nephrolepis</i> Schott                     | 14                          | 14                                 |
|     | <i>Dryopteridaceae</i> Ching              | <i>Cyrtomium</i> C. Presl.                    | 1                           | 6                                  |
| 77  |                                           | <i>Dryopteris</i> Adans                       | 1                           |                                    |
|     |                                           | <i>Polystichum</i> Roth                       | 1                           |                                    |
|     |                                           | <i>Arachniodes</i> Blume                      | 1                           |                                    |
|     |                                           | <i>Tectaria</i> Cav.                          | 2                           |                                    |
|     | <i>Polypodiaceae</i> Bercht. et J. Presl. | <i>Campyloneurum</i> C. Presl.                | 1                           | 18                                 |
|     |                                           | <i>Colysis</i> C. Presl.                      | 3                           |                                    |
|     |                                           | <i>Goniophlebium</i> C. Presl                 | 1                           |                                    |
|     |                                           | <i>Niphidium</i> J. Smith                     | 1                           |                                    |
| 8   |                                           | <i>Microsorium</i> Link                       | 2                           |                                    |
|     |                                           | <i>Phlebodium</i> J. Smith.                   | 3                           |                                    |
|     |                                           | <i>Polypodium</i> L.                          | 3                           |                                    |
|     |                                           | <i>Phymatosorus</i> Pic. Serm.                | 1                           |                                    |
|     |                                           | <i>Platynerium</i> Desv.                      | 2                           |                                    |
|     |                                           | <i>Pyrrosia</i> Mirb.                         | 1                           |                                    |
| 9   | <i>Pteridaceae</i> Reich.                 | <i>Pteris</i> L                               | 6                           | 6                                  |
| 10  | <i>Thelypteridaceae</i> Pichi-Serm.       | <i>Cyclosorus</i> Link.                       | 1                           | 1                                  |
| 11  | <i>Davalliaceae</i> Mett. et Frank.       | <i>Davallia</i> (L.) Sm.                      | 2                           | 3                                  |
|     |                                           | <i>Scyphylaria</i>                            | 1                           |                                    |
|     | TOTAL                                     | 27                                            | 66                          | 66                                 |

The most decorative and hardy ferns, suitable for use as houseplants, are the species: *Adiantum capillus-veneris*, A. c.-v. Cv. *Fimbriatum*, *Pellaea rotundifolia* Hook, *Asplenium nidus* L., A.n. cv. *Fimbriatum*, A. *bulbiferum*, A. *antiquum* Makino cv. *Osaka*, *Phyllitis scolopendrium* L., *Nephrolepis cordifolia* L., N. *exaltata* (L.) Schott, N. *e.*

*cv. Bostoniensis*, *N. e. cv. Hillii*, *N. e. cv. Noorwody*, *N. e. cv. Verona*, *N. scotii* Schott., *N. biserrata* Schott *cv. Furcans*, *Platyserium alaicorne* Desv., *Niphidium crassifolium* Underw. et Maxon, *Phlebodium aureum* Smith, *Polypodium brasiliensis*, *Pteris cretica*, *P. c. var. albo-lineata*, *P. c. cv. Revertioniana*, *P. c. cv. cristata*, *Cyrtomium falcatum* etc.

## CONCLUSIONS

1. In the Botanical Garden (Institute) of the ASM, there is a collection of plants of the class Polypodiopsida, created and enriched during about 45 years, currently including 66 taxa, which belong to 27 genera and 11 families. The best represented families are: Polypodiaceae (18 taxa), Oleandraceae (14), Adiantaceae (8), Aspleniaceae (6) and Dryopteridaceae (6).
2. The collection of ferns of the Botanical Garden (Institute) of ASM serves as educational material for primary, secondary and high school pupils, students and master's degree students.
3. As a result of the research, the optimal terms and conditions for the transplantation and propagation of ferns have been determined.
4. The most decorative and hardy ferns, suitable for use as houseplants, are the representatives of the families: Adiantaceae, Polypodiaceae, Oleandraceae, Aspleniaceae etc.

## BIBLIOGRAPHY

1. Арнаутов Н. Н., Арнаутова Е. М. Васильева И. М. *Каталог оранжерейных растений Ботанического сада института им.В. Л. Комарова* – СПб., 2003, стр. 19-24.
2. Дворянинова К. Ф., Шестак В. И. *Тропические и субтропические растения в оранжереях Ботанического сада АН МССР-Кишинев «Штиинца»*, 1985, стр. 9-17.
3. *Методика фенологических наблюдений в ботанических садах СССР*, 1975 - Москва, «Наука»
4. *Жизнь растений в шести томах, том четвертый*, Москва, Мхи. Плауны. Хвоицы. Папоротники. Голосеменные растения. М.: «Просвещение», 1978, стр. 180-254.
5. Сааков С. Г. *Оранжерейные и комнатные растения*. Л.: «Наука», 1983, стр. 502-535.

#### IV. LANDSCAPE ARCHITECTURE, ECOLOGICAL EDUCATION

CZU 502.3:58.006:502.75(478)

### ECOLOGICAL EDUCATION IN RAISING PUBLIC AWARENESS ON ENVIRONMENTAL PROTECTION IN THE REPUBLIC OF MOLDOVA

*Alexandru Teleuță, Ion Roșca*

Botanical Garden (Institute) of the Academy of Sciences, Chișinău, Republic of Moldova

**Abstract:** *The ECOSPECTRU Public Association has been promoting, during 12 months, the creation of an environmental education centre and has made a call to the civil society on need to conserve the plant world. The Botanical Garden (Institute) of ASM plays a vital role in the implementation of environmental education. The conservation of biodiversity, including plant diversity, is a desideratum that humankind cannot achieve without education.*

**Keywords:** *environmental education, Botanical Garden, biodiversity conservation*

#### GENERAL INFORMATION

The assimilation of the community experience in biodiversity conservation, environmental protection and environmental education, respectively, is recognized as one of the priorities of the Republic of Moldova in the course of accession to the European Union. The dissemination of information on Pan-European standards and strategies, which we are striving for, is a basic condition in the approach to this process at national level and in the effective integration of our efforts in the global process of biodiversity conservation. In a changing world, affected by the anthropogenic impact, the free flow of information and the collaboration at national and international level are key elements of the common effort that humankind has to make to reduce and stop the decline of biodiversity. As clearly stated in a series of international documents (Convention on Biological Diversity, Agenda 21 etc.) and of the European Union (Habitats Directive, Action Plan for Botanic Gardens etc.), a series of major tasks and responsibilities are assigned to botanical gardens from all over the world. The activities planned by the ECOSPECTRU Public Association, in the Botanical Garden of Chisinau, offer young people a chance to learn more about plants, their habitats, the major threats to plant diversity, its role in everyday life and the importance of rational use of plant resources of the world. The Environmental Education Centre, in the framework of the Botanical Garden, can play a significant role in shaping a progressive attitude toward a democratic approach to environmental decision-making. At present, it is unanimously recognized the role of plants as a vital part of the world's natural heritage and an essential resource for the planet (Convention on Biological Diversity, 1992; Gran Canaria Declaration on the Global Strategy for Plant Conservation).

The strategic directions in the development of the Botanical Garden as an environmental education centre consist of the following prerogatives: the development of the Botanical Garden as an environmental education centre focused on building the concept of plant conservation; the development of the Botanical Garden as an environmental education centre for pupils "Today's children are the future guardians of the planet"; the development of the Botanical Garden as a real resource for higher education; the development of the Botanical Garden as an information centre for decision-makers from local and central administrations, directly involved in and responsible for the evolution of the complementary relationship between the sustainable use of plant resources and the long-term development of human society; the development of the Botanical Garden as a centre for informing the general public about the plant world and the need to conserve it; the promotion of the scientific and cultural heritage of the Botanical Garden by marking a tourist route in the territory of the Botanical Garden, which is a necessity for the knowledge, understanding and appreciation of the real value of everything it holds.



**Main goal:** To raise the level of education on the conservation of plant diversity by raising people's awareness, at the environmental education centre, and to create a tourist route in the territory of the Botanical Garden (Institute) of ASM.

**Specific objectives:**

- ✓ To raise awareness of environmental, economical, social, political and environmental issues;
- ✓ To help people acquire knowledge, skills, principles, attitudes and abilities to act;
- ✓ To lay the basis for a new behavior (of individuals, social groups and society) towards environment;
- ✓ To provide clear answers to the questions about the interdependence of economic, social, political and environmental issues;
- ✓ To provide every person the chance to acquire information, knowledge and skills to develop awareness and a positive attitude towards environment and biodiversity conservation;
- ✓ To encourage an environmentally appropriate behavior of each individual, group and society as a whole;
- ✓ To train the team of guides and trainers within the Botanical Garden;
- ✓ To label the groups of plants;
- ✓ To install educational information panels;
- ✓ To distribute leaflets with information about the environmental education center to visitors, for educational and informational purposes;
- ✓ To publish brochures with information about endangered species from R. Moldova;
- ✓ To describe the plants of economic importance;
- ✓ To organize exhibitions of rare and/or endangered plants and to provide information about the state of their natural habitats for educational purpose; to create exhibitions for people with special needs;
- ✓ To organize seminars and programs on dissemination of environmental education for several groups of beneficiaries within the Botanical Garden, Orhei National Park and "Lower Prut" Biosphere Reserve;
- ✓ To participate in the formation of the social opinion (meetings with the population);
- ✓ To create the Association of Botanical Gardens and Dendrological Parks on both sides of Dniester River.
- ✓ To mark the tourist route with the theme "Conservation of Plant Diversity" within the Botanical Garden.

## REFERENCES

1. Anca Sirbu. Asociația Grădinilor Botanice din România-un pas spre integrarea europeană. București/alo, București, 2001: 128 p.
2. Anca Sirbu. Diversitatea plantelor în contextul strategiei europene de conservare a biodiversității, Cursuri postuniversitare elaborate în cadrul proiectului TEMPUS – Phare IB – JEP 14030, SINTEZE. București/alo, București, 2001: 320 p.
3. Naela Costică. Ghid de formare metodologică în domeniul educației de mediu, versiune destinată educatorilor din Grădini Botanice. Iași/Corona Iași, 2007, 113 p.
4. Alexandru Teleuță, Michael R Appleton, Bogdan Popa, et.al., Raportul V național cu privire la diversitatea biologică, Chișinău, Bons Offices SRL, 2014, 72 p.
5. Alexandru Teleuță, Ala Rotaru, Michael R Appleton, et.al. Strategia privind diversitatea biologică a Republicii Moldova pentru anii 2015-2020. m. Chișinău, Bons Offices SRL, 2016, 68 p.

## O PERSONALITATE MARCANTĂ – SAVANT ȘI MANAGER – ALEXANDRU TELEUȚĂ LA 65 DE ANI

Mult stimate d-le director al Grădinii Botanice.



Cu ocazia frumoasei aniversări pe care o marcați, 65 de ani de la naștere, colaboratorii Grădinii Botanice, Vă transmit cele mai sincere și frumoase felicitări și profunde sentimente de recunoștințe pentru eforturile depuse în calitate de om al științei.

Omul pe care îl sărbătorim la împlinirea frumoasei vârste de 65 ani s-a născut la 31 octombrie 1952, în satul Oziornoe, raionul Izmail, regiunea Odesa. După absolvirea școlii medii în 1969, în satul natal, își continue studiile la facultatea de Agronomie a fostului Institut Agricol „M. Frunze” din or. Chișinău, pe care l-a absolvit în 1974. În anul 1975 își prelungește studiile la aspirantura Institutului Unional pentru Fitotehnie „N.I. Vavilov”.

Activitatea de cercetare și-a început-o în anul 1975 ca cercetător științific la Institutul de cercetări Porumbeni, iar din 1978 a fost încadrat ca cercetător la Grădina Botanică (Institut), unde activează și până în prezent.

Printre rezultatele principale obținute: elaborarea și promovarea Strategiei Naționale și Planul de Acțiuni în

domeniul conservării Diversității Biologice, Elaborarea mai multor proiecte de legi și regulamente cu privire la conservarea și utilizarea durabilă a resurselor biologice ale Republicii Moldova; Proiecte cu privire la dezvoltare sistemului de arii naturale protejate al Republicii Moldova, Proiecte ce țin de reconstrucția verde și Dezvoltarea Grădinii Botanice ș.a.

Indiscutabil este aportul doctorului Alexandru Teleuță în organizarea procesului științific în domeniul botanicii și dezvoltării în continuare a Grădinii Botanice.

Rezultatele științifice ale D-lui s-au soldat cu peste 240 de lucrări științifice, coautor a 15 adeverințe de soiuri de plante furajere omologate în Moldova.

Cu prilejul frumosului jubileu 65 de ani din ziua nașterii, 42 ani de activitate științifică și 11 ani în calitate de manager, Colectivul Grădinii Botanice (Institut) a Academiei de Științe a Moldovei, Vă adresează cele mai cordiale felicitări, urări de prosperitate și valoroase realizări în nobila operă de manageriat și cercetare.

Dumneavoastră, domnule Director, ați trăit o viață, trecând toate treptele de urcare, Vă dorim, domnule Alexandru TELEUȚĂ, să rămâneți mereu așa de energic, cum Vă cunoaștem, plin de entuziasm și speranțe. Să Vă dea Domnul și pe viitor sănătate, puteri și izbândă întru realizarea tuturor celor planificate, să fiți și în continuare fidel științei și adevărului, sa pășiți cu încredere pe drumul vieții.

*Colectivul Grădinii Botanice (Institut)*

## DR. VALENTINA CANTEMIR LA A 65 – A ANIVERSARE

*Dr. Teleuță Alexandru, dr. Țîmbali Valentina*



Valentina Cantemir s-a născut la 19 decembrie 1952, într-o familie de buni gospodari, în orașelul Rîșcani. În anul 1970 a absolvit școala medie nr. 1 din localitate și continuă studiile la Facultatea de Biologie și Pedologie a Universității de Stat din Moldova, specialitatea Biologie, profesor de Biologie și Chimie. Lumea plantelor a captivat-o întotdeauna și alegerea finală a fost specializarea la catedra de *Botanică*, moment ce i-a marcat viața și activitatea în continuare.

După facultate, în 1977 dna V. Cantemir vine în calitate de cercetător științific inferior în secția Naturii din cadrul Muzeului Național de Etnografie și Istorie Naturală, unde a activat până în anul 1980. În același an se transferă la Grădina Botanică (I) a AȘM, în cadrul Laboratorului Floră și Geobotanică, unde a urmat toate treptele unui cercetător, începând cu funcția de laborant superior, până la cercetător științific coordonator. În perioada aa. 2012-2015 a suplinat funcția de șef al Laboratorului Floră spontană și Herbar. Timp îndelungat muncește în domeniul paleobotanicii, fiind un discipol și descendent al Școlii de paleobotanică, fondată de academicianul Andrei Negru. Teza de

doctor în biologie ține de același domeniu: „Sredne-pozdnesarmatskaia flora Severo-Zapadnogo Pricernomoria (po paleocarpologhiceshim dannîm), susținută public în 1993, la specialitatea „*Botanica*”. Cercetările au finalizat cu rezultate semnificative: evidențierea pentru prima dată a florei Sarmațianului mediu și superior din nord-vestul Bazinului Mării Negre, constituind 114 specii de plante, inclusiv 10 taxoni paleofloristici noi pentru știință (pe baza rămășițelor paleocarpologice). Pentru rezultate semnificative în domeniul paleobotanicii, obținute de dna dr. hab. Ana Ștefîrță și dr. Valentina Cantemir, acad. Andrei Negru numește o specie de plante fosile în numele lor *Crataegus schtekanta* Negru.

În perioada aa. 2000-2015 dna V. Cantemir a activat în cadrul temei „Cercetarea florei vasculare a Republicii Moldova și teritoriilor limitrofe, evidențierea componenței taxonomice pentru elaborarea Cărții Roșii și editarea monografiei *Flora Basarabiei*”, concomitent fiind curator *Delectus seminum* în cadrul laboratorului vizat, a contribuit esențial la mobilizarea și completarea genofondului de plante *in vivo* și *ex situ* al Grădinii Botanice a AȘM cu mii de taxoni atât pentru teren protejat, cât și neprotejat.

Rezultatele științifice ale dnei dr. V. Cantemir s-au soldat cu peste 200 lucrări științifice, inclusiv coautor a 10 monografii, vizând flora fosilă și cea contemporană, cele mai valoroase fiind: *Plantele rare din flora spontană a R. M.*, 2002; *Lumea vegetală a Moldovei*, vol 2 „Plante cu flori” - I, 2005; vol. 3 „Plante cu flori” - II, 2006; *Cartea Roșie a R. Moldova*, ed. II, 2001; *Cartea Roșie a R. Moldova*, ed. III, 2015; *Catalogul de semințe* (2009-2010), 2010; *Flora Basarabiei*, vol. I, 2011; *Flora Basarabiei*, vol. II, 2016. Dna dr. V. Cantemir a avut un aport esențial la elaborarea și realizarea proiectului de editare a volumului II, a monografiei „*Flora Basarabiei*”(2016), fiind coautor și redactor de volum, dânsa a depus o muncă onorabilă la redactarea întregului volum, pregătirea pentru tipar și editarea lui.

În cadrul AO Societății de Botanică din R. Moldova, dr. V. Cantemir îndeplinește funcția de secretar științific. Prin concursul căreia au fost elaborate proiecte de editare pentru atragerea fondurilor financiare și editate cele 2 volume de carte „*Flora Basarabiei*”.

Activitatea științifică a domniei sale prin rezultatele sale a contribuit și continuie să contribuie semnificativ la dezvoltarea domeniului biologiei vegetale: cercetării florei spontane contemporane și fosile a Republicii

Moldova și teritoriilor limitrofe. În baza hotărârii Consiliului Național pentru Atestare și Acreditare din R.M. în a. 2002 i se conferă titlul de cercetător științific superior la specialitatea "Botanica". Dna V. Cantemir este Laureat al Premiului AȘM „Boris Melnic” (2016), deținătoarea diplomei Medalia de aur Infoinvent-2017, pentru monografia științifică „Flora Basarabiei”, vol. I, II, diplome de excelență.

Cu prilejul frumoasei vârste de 65 de ani din ziua nașterii și 37 ani de activitate științifică în cadrul Grădinii Botanice a AȘM, colectivul în care activați, colegii de breaslă Vă adresează cele mai sincere urări de sănătate și noi realizări frumoase întru prosperarea științei botanice basarabene. La Mulți Ani!

## **MICOLOGUL ȘTEFAN MANIC LA A 70 – A ANIVERSARE**

*Dr. Valentina Cantemir*



Primăvara simbolizează renașterea vieții. Și într-o asemenea zi de reînviere a naturii, la 22 martie, șapte decenii în urmă v-ați născut Dumneavoastră într-o localitate pitorească de la poalele Codrilor, și anume în satul Stolniceni, raionul Hîncești. Părinții, oameni harnici, buni gospodari, v-au cultivat din copilărie dragostea față de natură și de plaiul nostru mioritic. Soarta a vrut ca să vă dedicați totalmente activitatea profesională și de cercetare domeniului biologiei și în mod aparte micologiei, mai bine zis tot Codrii născuți v-au îndrumat întreaga viață.

Primii pași pe tărâmul cercetării i-ați făcut pășind cu dreptul la facultatea de Biologie și Chimie a Institutului Pedagogic de Stat din Tiraspol (1965). Din anii de studenție ați simțit acea sete față de știință, ce s-a transformat peste ani într-un atașament de invidiat, alături fiindu-vă colegii de breaslă actualmente regretatul *academician Andrei Negru* și *doctorul habilitat Ana Ștefîrță*. După absolvirea facultății ați lucrat în calitate de profesor de biologie și chimie la școala natală, iarăși alături fiindu-vă Codrul.

În 1972-1976, întreprindeți numeroase expediții de colectare a materialului paleobotanic, specializându-vă în cercetarea lemnului fosil. În 1976, vi se aprobă tema tezei de doctorat „Шляпочные грибы Молдавии”, o direcție de pionierat în cercetarea fungilor. Sub conducerea vestitului agaricolog Boris Vasilcov, finalizați lucrarea de doctorat și în 1982 susțineți și teza de doctor în științe biologice, în care ați prezentat circa 300 de specii noi de macromicete pentru teritoriul Republicii Moldova.

În 1990, în bază de concurs, ați ocupat funcția de director al Rezervației științifice „Codrii” și timp de aproape un sfert de veac ați făcut o muncă excepțională în calitate de manager cu rezultate concrete și palpabile, cum ar fi: inventarierea florei și faunei în zona strict protejată, pas întreprins pentru prima dată în republică; în rezervație au fost organizate 4 Simpozioane Internaționale cu genericul „Rezervația științifică „Codrii”: Realizări, probleme, perspective”; ați contribuit la modernizarea Muzeului naturii, cu obținerea statutului de Muzeu Național; la dotarea sălilor instituției cu calculatoare; la reutilizarea atelierelor de botanică și zoologie; la amenajarea unei cantine și a unui hotel pentru vizitatori etc.

Pe parcursul a mai bine de trei decenii (1976-2016) tema abordată de omul de știință Ștefan Manic vizează diversitatea taxonomică a macromicetelor și în 2015 susțineți teza de doctor habilitat în științe biologice cu tema: „Macromicetele din ecosistemele Republicii Moldova”, conducător științific acad. Andrei Negru.

„Dacă muncim numai pentru bunurile materiale, ne clădim singuri temnița”, considera *Antoine de Saint-Exupery*. Probabil că și Dumneavoastră, mult stimat Ștefan MANIC, v-ați edificat viața după asemenea lozincă, căci palmaresul rezultatelor activității profesionale și științifice ale Domniei Voastre este consistent și de o valoare de neprețuit pentru știința Republicii Moldova, pentru protecția mediului ambiant, pentru viitorul regnului vegetal și dezvoltarea economică a țării.

Codrii, inima meleagului nostru, pot să vă cânte doine de proslăvire, însoțite de trilurile de privighetori, de șipotul de izvoare, iar vântul să se bucure că se poate zbenguie printre ramuri de stejari viguroși, flori rare de pădure, printre pălărioarele multicolore ale numeroaselor ciuperci – „Mulți Ani trăiască cel ce ne protejează!”

***Semnatarii acestui mesaj din partea colegilor Laboratorului Flora spontană și Ierbar, Societății de Micologie și AO Societății de Botanică din Republica Moldova Vă aduc, mult stimat omagiat Ștefan MANIC, cele mai sincere felicitări, dorindu-Vă sănătate, forțe creative, noi realizări întru binele științei moldave și prosperarea Codrilor, veșmântul verde al scumpului nostru meleag. La Mulți Ani!***



## EUGENIA MANEA-CERNEI – LA VÂRSTA ÎNȚELEPCIUNII

**Tatiana Sirbu**  
**Grădina Botanică (I) a AȘM**

**Motto**

„Fiecare om este o legendă pe Pământ, cu stelele, mărele și Saharele sale.”;

„Fiecare din noi să tindă a fi un Orfeu cu vibrații magice asupra Naturii, asupra florei și doar atunci planeta, întreg Universul vor reveni la armonia și echilibrul inițial dorit de Creator. Să fim flămânzi de cântec, de frumos, precum floarea de lumină”.

**E. Manea-Cernei**



În urmă cu șapte decenii și jumătate, într-un început de noiembrie, s-a născut doamna Eugenia Manea-Cernei – remarcabil savant, poet, filosof și un irepetabil OM. Despre Domnia Sa am putea vorbi la nesfârșit, fiind, după părerea mea, o nestemată, un tezaur al neamului nostru, un suflet de o frumusețe deosebită ce sălășluiește într-un ocean imens de înțelepciune și erudiție. Vocea lină, cuvintele care le înșiră ca pe mărgăritare, atât de cumpătate și frumoase, că nu poți să nu admiri încântat talentele acestei distinse Doamne, care pe bune a atins „Himalaya sufletului”, făurindu-și o viața ca un templu: frumos ca florile ce le iubește mult, interesant și tainic totodată.

Satul natal Căinari Vechi din județul Soroca și familia pe care o iubește la nesfârșit au constituit leagănul și „laboratorul primar” în care s-au înfiripat și s-au dezvoltat numeroasele talente ale Eugeniei Manea. Natura plaiului natal au determinat-o probabil, după absolvirea școlii medii din Frumușica, să devină studentă a Universității din Tiraspol. Binențeles că a selectat domeniul științelor naturale și geografie, secția biologie și chimie.

După absolvire un an lucrează profesoară de chimie și biologie în școala medie din Văleni, județul Cahul. Dar spiritul său setos de cunoștințe căuta alte tărâmuri necunoscute. Și a urmat doctorantura la Institutul de Botanică „V.L.Komarov” din Sankt Petersburg, fiind discipola Mariei Savcenko - savant cu renume din laboratorul „Morfologie evolutivă”. Grație unei stagieri (aa. 1966-1967) în renumitele sere ale institutului s-a specializat în domeniul plantelor tropicale și subtropicale. Mereu înconjurată de frumos, de plante, practic se dizolvă în lumea lor, transformându-se într-o zână ocrotitoare a acestora și un cercetător tenace, ce le cunoaște și le înțelege tainele.

Realizându-și doctoratul în anii 1971-1973, cercetând particularitățile anatomo- morfologice ale organelor reproductive ale reprezentanților familiei *Araceae*, inițiază o nouă etapă, cea de cercetător, savant. Până în anul 1999 va activa în Grădina Botanică (Institut) a AȘM, în cadrul laboratorului „Floricultură”, cu excepția a.a.1978-1980, când s-a ocupat de studiul anatomo-morfologic al fructului și seminței la 22 de reprezentanți din familiile *Berberidaceae*, *Ceratophyllaceae*, *Paeoniaceae* și *Ranunculaceae* în cadrul laboratorului „Anatomia plantelor”. Aici, în Grădina Botanică, doamna Eugenia Cernei s-a manifestat ca un adevărat om de știință, creativ, plin de inițiative și idei și nu numai...

A fost printre primii botaniști, care au contribuit la transferarea genofondului de plante din vechea Grădină Botanică, actualul *Dendrarium*, în spațiul nou de astăzi. Din spusele dumneaei, a fost o muncă istovitoare. Dar grație lor, acestor oameni, care vroiau să schimbe lumea, avem astăzi acest muzeu al naturii, această oază verde în orașul nostru, de care ne mândrim nespus. A trecut toate etapele specifice unui om de știință: de la cercetător științific inferior (1970-1978), superior (1978-1989), până la - coordonator (1989-1999).

Din Sankt-Petersburg, încă doctorandă fiind, a adus cca 200 specii noi, mai târziu aduce și testează sute de specii și soiuri, astfel contribuind esențial la înnobilarea genofondului de plante ornamentale.

Ași vrea să remarc unele rezultate, mai semnificative obținute de doamna Eugenia Cernei în cercetare. A

clasificat pentru prima dată plantele floricole cultivate *ex-situ* conform zonelor fitogeografice. Analiza ecologică, fitogeografică și de apreciere a gradului de aclimatizare a 236 de specii investigate atestă că în condițiile de climă și sol din Republica Moldova sunt recomandate pentru cultivare reprezentanții zonelor Irano-Turanice, zonei Mediteranene și ale Munților Stâncoși din America de Nord. Din Sankt-Petersburg, încă doctorandă fiind, a adus cca 200 specii noi, mai târziu testează sute de specii și soiuri, astfel contribuind esențial la înobilarea genofondului de plante ornamentale. A cercetat biomorfologia și posibilitățile de adaptare ale reprezentanților din familia *Alliaceae*, *Amaryllidaceae*, *Liliaceae* și *Iridaceae*, în special, a genului *Iris*.

Aici facem un popas. STÂNJENEII! Sunt dragostea întregii ei vieți! Și cu siguranță într-o altă viață, dincolo de moarte, tot ei vor fi. A adunat o colecție de peste 250 de soiuri de stânjenei (din selecțiile franceză, engleză, germană, americană, rusă) și 65 specii din diverse zone fitogeografice ale globului. Ei au fost baza *Iridarium*-lui, fondat pe principii științifice - o expoziție de proporții, o adevărată capodoperă științifică, cu sectoarele: sistematic, geografic, evolutiv, cromatic etc. Cu regret, în timpuri mai grele pentru țară și Grădina Botanică, acest colțisor de rai a fost dat perzaniei. Dar nu și stânjeneii. Ei înfloresc la fel de încântător în fiecare primăvară, ca niște aștri pe Pământ, asemeni unor vâltori feerice, însă efemere și cred că-și așteaptă și acum *Stânjenea*...

Din dragostea mare față de frumos, de *Iris* în special, sau născut numeroase soiuri de stânjenei. Utilizând metodele de ameliorare intra- și interspecifică, precum și cele de inducere a mutațiilor la stânjeneii din grupurile *Spuria*, *Sibirica* și *Germanica* a obținut numeroși hibrizi și forme, selectând doar 170, care se deosebeau prin indici decorativi și de rezistență valoroși în condițiile pedoclimatice ale Moldovei. În anul 1989 Comisia de Stat a Federației Ruse pentru ocrotirea realizărilor în selecție a înregistrat soiul „Viola”. Mai târziu Comisia de Stat pentru încercarea soiurilor de plante din Republica Moldova a înregistrat 17 soiuri noi de *Iris*: enumerăm „Irida”, „Candida”, „Alunelul”, „Doina Dorului”, „Grafie Magică”, „Calea Izvoarelor”, „Lia-Ciocârliă”, „Pecetea Latinei”, „Taina Luceafărului”, „Vraja Lumunii”, „Fulguri Selenare”, „Rândunică-Rândunel” etc.

Genul *Eremurus* constituie o altă afecțiune a cercetătorului Eugenia Cernei. Ani în șir a creat o colecție impresionantă a acestei culturi exotice (cca 20 specii), aclimatizate pentru prima dată în Moldova. Soiul „Ionel-Voinicel” a încununat această muncă. Astăzi elegantul *Eremurus* este adorat de iubitorii de frumos din întreaga țară.

Rezultatele cercetării s-au conturat în implementări cu pondere. Spațiile verzi din localitățile urbane și rurale ale țării sunt decorate cu mai bine de 40 de specii și soiuri de stânjenei și cepe decorative. Este coautor al „Sortimentului de plante decorative pentru amenajarea spațiilor verzi din Moldova” - recomandare practică pentru specialiștii în domeniu.

Este coautor în amenajarea maiestrosului „*Alpinariu*” - una dintre principalele expoziții ale Grădinii Botanice. Un neântrecut maestru în arta aranjamentelor florale, participând la multiple expoziții republicane și internaționale pentru promovarea acestei arte. În acest context, a publicat „Curcubeul florilor” (cu ediții în limba rusă și bulgară), „Îveti i fantazia” - cărți care s-au bucurat de un mare succes. În anul 2001 a publicat „Clepsidra cu flori” - lucrare de popularizare a farmecului poetic al florilor. Iar peste patru ani vede lumina zilei culegerea „Cad ploile - amintiri” și „Lângă rugurile toamnei”. Mai târziu apare placheta de versuri și cântece „Sub poleiri de lună”, minunata enciclopedie „Știeți că...” ce cuprinde informații din domeniul științelor, artelor, literaturii, religiei etc. etc. Neobosita autoare muncește neconținut și chiar de curând a creat o nouă perlă - „*Frumosul ca liant al Timpului*” - o sinteză a minunatului drum prin timp, ce se numește *viață*...

Activitatea de cercetare a fost prezentată și apreciată înalt în cadrul a numeroase congrese, conferințe, seminare, expoziții științifice. În baza investigațiilor în domeniul introducerii și ameliorării plantelor decorative dna Eugenia Manea-Cernei a publicat 110 lucrări științifice și a fost distinsă cu două medalii de argint și două de bronz de către EREN din Moscova. A pregătit un doctor în biologie și numeroși studenți, specialiști în domeniu, care prin intermediul practicilor, seminarelor au asimilat nu numai informație academică, dar și lecții de *estetică*, *etică* și *de omenie*.

Erudiția, mintea analitică și sufletul poetic ale Doamnei Eugenia Manea-Cernei continuă să înnaripeze și să îndrumeze noile generații spre cucerirea, înțelegerea tainelor și legităților naturii, spre crearea frumosului și dăruirea lui omenirii.

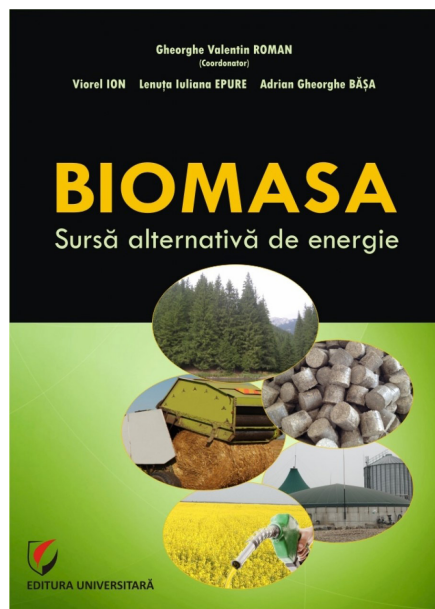
Vă dorim să ne fiți alături timp îndelungat cu vorba și sfatul, să ne fiți în continuare mentorul nostru spiritual și să ne bucurați cu noi și noi lucrări! La mulți ani, Multstimată Doamnă!

## Review. BIOMASS. Alternative Energy Source (BIOMASA. Sursă alternativă de energie)

Authors: ROMAN Gh. V. (coord.), ION V., EPURE L. I., BĂȘĂ A. Gh. Bucharest: Editura

Universitară, 2016. 432p. ISBN: 978-606-28-0506-7

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Agriculture and rural development play a significant role in the development of bio-economy using renewable biological resources from soil and aquatic resources to produce food, bioenergy and materials. The share of renewable energy sources, including biomass, in the energy systems around the world, is constantly growing, since they are unanimously recognized in the EU as environmentally friendly alternatives to conventional sources of energy, which lead to reductions in CO<sub>2</sub> emissions, lower import dependence, the development of new industries and the creation of new jobs.

The present paper is based on the results of the experiments conducted by the authors, who are members of the Plant Sciences Department of the Faculty of Agriculture, in Bucharest, and have been involved in the research and development activity in the field of biomass energy utilization, over four decades, in the framework of the *National Program on Production of Plant Biomass (Phytomass) for the Purpose of Obtaining Energy and Chemicals (1981-1990)* and European projects: *Lessons of Denmark and Austria on the Valorisation of Biomass (1993-1996)*, *Bioethanol Production from*

*Sweet-Sorghum (1993-1996)*; *EC Biomass for the Energy Strategy of Central and Eastern European Countries (1997-1999)*; *Clear Data for Clean Fuels (2003-2005)*; *Optimization of Biomass and Approach to Water Conservation (2012-2016)*.

This book provides us a thorough overview of biomass as an alternative energy source. The book consists of 8 chapters and a postface, ending with an extensive set of 265 references. [Chapter 1](#) is concerned with the link between energy, agriculture and natural environment, through the flow of energy into food systems, conventional and renewable sources of energy, greenhouse effect and climate change. [Chapter 2](#) – general aspects regarding biomass and the relationship between solar energy, photosynthesis and ecosystem productivity. [Chapter 3](#) – methods of converting biomass into energy: physical, thermo-chemical and biological. [Chapter 4](#) – agricultural crops producing starch, sweet substances, fats and lignocellulose, fast-growing forest plants and aquatic plant species are presented as energy crops. In addition to own data, obtained during field and laboratory experiments, on the species of agricultural plants of interest in the areas with temperate climate, presented and commented in detail, reference is also made to the data obtained in other international scientific centres, including the results of the introduction and the use of new energy crops in the Botanical Garden (Institute) of ASM. [Chapter 5](#) – agricultural waste and its use for energy production. General data on the residues from growing agricultural crops and animal breeding and their energy potential in Romania are presented in this chapter. [Chapter 6](#) – forest vegetation and energy production. Forest species, their characteristics and their energy potential is presented here. [Chapter 7](#) – organic household, municipal and industrial waste, the collection, purification, processing and the evaluation of its energy potential. The last chapter focuses on environmental, economic and social aspects related to biomass as a source of energy, the legislation in force. The dilemma Food or Energy is used as postface.

I sincerely hope that this book will be used as a teaching book and I anticipate that it will be particularly

useful not only to scientists with research interests in the areas of agricultural science, natural resource management, material science, environmental chemistry etc., but also to academic and industrial scientists/researchers with an interest in using energy crops and agricultural, forest and municipal residues as novel products for industries and/or recycling technologies. I am sure that this book will play an important role in the process of production of energy crops and utilization of biomass.

Victor TITEI, head of Laboratory of Vegetal Resources, Botanical Garden (Institute) of Academy of Sciences of Moldova.