CULTIVATION OF *LAVANDULA* PLANTING MATERIAL IN THE CONDITIONS OF THE EDUCATIONAL LABORATORY OF HORTICULTURE AND VITICULTURE OF THE SUMY NAU

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Lavender is a leading crop for obtaining essential oil, which is in great demand both in Ukraine and around the world. Natural essential oil and essential oil raw materials are used in numerous branches of domestic industry and medicine. Lavender is also known for its value as a honey plant and a popular decorative element.

Many aspects of cultivation and biological features of plants of the genus *Lavandula* have been studied by scientists both in Ukraine (A.P. Merkuryev, T.M. Latushkina, I.V. Belova, O.P. Yunosheva, L.A. Kotyuk, V.D. Rabotyagov , D. B. Rakhmetov, L. V. Svidenko, L. D. Yurchak, O. I. Popova), and abroad.

Since the main areas under cultivation of lavender were located mainly in the Crimea and in the south of Ukraine, scientific research on this culture was carried out in accordance with the growing conditions in these regions. However, global changes in climate, such as an increase in temperature and a decrease in precipitation, open the possibility for the cultivation of lavender in the conditions of the forest-steppe zone. Despite this, scientific information on the specifics of lavender cultivation in this area, its reproduction and cultivation, is quite limited.

In order to further expand the area of industrial cultivation of lavender in Ukraine, scientific research is needed, which will allow to develop effective cultivation technologies with obtaining high-quality essential oil products. Thus, there is a need to conduct research in areas that were previously not typical for growing lavender, including the Forest Steppe of Ukraine. Until now, many aspects of this problem remained insufficiently researched, and these questions became the object of our research.

The purpose of the study: Studying the possibilities and optimization of the process of growing planting material of the *Lavandula* plant in the conditions of the northeastern forest-steppe of Ukraine.

Objectives of the study:

1. Analyze the history of lavender culture and the main conditions for its introduction;

2. To analyze the main morphological and biological features of *Lavandula* planting material, the practical value of *Lavandula*;

3. Investigate the location of the research object, soil and climatic conditions of the area, materials and methods of research;

4. Investigate the effect of stimulants on the rhizogenesis of lavender cuttings (*Lavandula*);

5. To characterize the features of the development of lavender plants when rooted by cuttings;

Object of research: The process of growing planting material of the *Lavandula* plant.

Research subject: Optimizing the conditions and parameters of growing *Lavandula* planting material in the conditions of the northeastern forest-steppe of Ukraine.

Used scientific methods and research methods: In the course of this study, both general scientific and special research methods were used. General scientific methods included such stages as formulating a hypothesis, conducting an experiment, systematic observations and analysis of the results of the obtained data. These methods allowed us to approach the solution of the investigated tasks in a structured and scientific manner.

Among the special methods that were used, it is worth noting the following: Laboratory method for determining the agrochemical parameters of the soil and the quality of the essential oil. Yield by calculation-weight method for determining yield. Determination of the content of inorganic elements in bio-raw materials and oil. Field method for determining the influence of biotic and abiotic factors of the environment on the growth, development and biometric parameters of plants. A statistical method for conducting dispersion and correlation analysis, which allowed us to objectively evaluate the results of the study. Calculation and comparative method for establishing the economic efficiency of the application of technological measures of lavender cultivation.

The collection of lavender has been known since the 12th century in the Provence region of France. The first attempts to create lavender plantations for oil production were known in the Duchy of Burgundy from the 14th century. The principles of lavender cultivation have been passed down from generation to generation and developed over the centuries [4] .

In the Middle Ages, lavender also became famous in the British Isles. From the beginning of the 13th century, the plant was included in the list of medicinal products, and already in 1568, its active cultivation began in England. From the end of the 16th century, lavender began to be cultivated in many botanical gardens of Western Europe, as well as on a small scale for apothecary and amateur needs [8] .

Due to the popularity and demand for essential oil and lavender flowers, by the middle of the 19th century, most of the raw materials were exported outside of Southern

Europe. However, the demand for lavender raw materials for the light and food industry exceeded the capabilities of wild plants, and therefore, from 1890, the first industrial lavender plantations began to be created in France.

The spread of lavender cultivation on a large scale took place in the 20s of the last century and spread to various countries, including Italy, Spain, Yugoslavia, Germany, Hungary, Bulgaria, the Czech Republic, Romania, the United States of America and some Asian countries.

These attempts to introduce and cultivate lavender testify to the interest in this plant and its importance in the pharmaceutical and decorative spheres in past centuries.

Initial attempts to create production lavender plantations were made in 1929 in the Crimea, especially in the vicinity of Gurzuf. Seed plantations were also established. From 1930 to 1932, the cultivation of lavender on an industrial level spread to the Crimea, the Kuban, and later to the southern regions of Ukraine, Kyrgyzstan, Tajikistan, and Georgia. Since 1946, lavender has been actively cultivated in Moldova [8].

Research was also carried out in Kyiv and in the north-west of Ukraine, where lavender plants kept their vital form, tolerated the winter well without shelter and bloomed annually. However, the seeds were formed in small quantities and not annually.

During this period, lavender selection was carried out abroad in various countries, such as France, Bulgaria, Czechoslovakia, Japan, Hungary, Austria, Romania, and Yugoslavia. For example, in France, seed populations of lavender are mainly researched and cultivated. High-yielding clonal varieties such as Blanket, Bled Alp, Blanche, La Carle Mayet, Materone, Barem were created there. Clonal varieties such as Kazanlik, Vinets, Aroma, Freshness, Karlovo, Hemus, which have a compact bush shape, are also grown in Bulgaria.

Lavender is a popular plant for landscaping. In foreign selection, there are many decorative varieties of lavender, which differ in various colors of the corolla. These include Dwarf Blue, Hidcote Blue, Munstead (with dark purple corolla), Hidcote Giant (with bright purple corolla), Atropurpurea, Twickel Purple (with dark purple), 10 Dutch (with blue), Nana Alba (with white), Loddon Pink, Rosea (with a purple-pink corolla) [3].

In recent decades, the cultivation of lavender has expanded significantly thanks to the introduction of machine technology. The yield reaches 6.5–7.0 centners per hectare, which makes this type of economic activity profitable. Mechanization simplified the most labor-intensive processes, such as growing seedlings in greenhouses and harvesting inflorescences with lavender harvesters, which replaced the cutting of seedlings with sickles. Also, the use of herbicides reduced manual weeding.

In the care of fruitful lavender plantations, it is recommended to take the following measures:

1. Treatment with herbicides in early spring.
2. One weeding in the rows and three inter-row treatments with a cultivator before harvesting.
3. One treatment with a cultivator after harvest.

4. In the autumn, at the beginning of the relative rest of the plants, carry out deep loosening with the simultaneous application of mineral fertilizers.

It is recommended to start picking flowers for essential oil in July when they are in full bloom, approximately 10-14 days after the beginning of flowering.

The productivity of cultivated lavender plantations depends on their care, the age of the plants, the lavender variety and meteorological conditions. It is important to note that lavender is a plant of a temperate climate, resistant to droughts and frosts. However, it has critical temperature limits that should not exceed -25...30 °C and below. In the presence of snow cover, the lavender plantation can tolerate lower temperatures. Late spring frosts, especially in mountainous areas, can damage plants.

If the shoots freeze, it is necessary to prune dry shoots, as well as "rejuvenate" the plants.

The analysis of long-term observations showed that lavender plantations, which are older than 5 years and do not have snow cover, can freeze partially or completely at an air temperature of -21...22 °C. If there is a snow cover of up to 10 cm, this critical temperature can be 5...7 °C lower. On the other hand, young lavender bushes (1–4 years old) survive the winter better in the same conditions [8] .

It is also important to note that the lavender crop begins to form in the summer of the previous year before harvesting. After the inflorescences are cut, buds formed on annual shoots can produce new growth and new inflorescences in the same year, provided there is sufficient moisture. This process of formation of flower-bearing shoots takes place without the need for low temperatures during a period of relative rest, which distinguishes lavender from some other plants, such as the ethereal rose.

The awakening of lavender in areas of industrial cultivation occurs in March–April, when the average daily air temperature consistently exceeds 8...10 °C in the Crimea and the Krasnodar region, or 10...14 °C in Moldova. In May, peduncles form, and in mid-June lavender plants enter the phase of the beginning of flowering [17] .

The beginning of flowering of varieties B-34 and Stepova occurs when the sum of average daily air temperatures is above 10 °C, which is equal to 1050 °C (on average by zone).

Regarding moisture circulation, there are three critical periods in the annual cycle of lavender development:

1. July-September, when the summer-autumn growth of shoots is formed.
2. March-April, when the maximum number of buds germinate.
3. May-June, when peduncles and flower whorls on them are formed [17] .

These critical periods can be defined by the need for moisture, and it is important to ensure adequate moisture levels during these times. How moisture-intensive a crop like lavender is requires a lot of moisture, and many other factors, including climate and cultivar. In general, the best lavender yields are obtained in wet years and in wet areas. It is also important to avoid excess moisture, as this can lead to diseases such as rot or wilt.

Places of natural growth of lavender are mainly located at an altitude of 700 to 1100 meters above sea level. These plants are usually found in mountainous regions where the climate is temperate and drier. Today, the industrial range of lavender is

quite extensive and includes regions from the African coast and the islands of the Mediterranean Sea, Asia Minor and India to Great Britain and Norway.

It is noted that the best area for growing "thin" lavender is located in the French Alps. It is important to consider that lavender is a plant that has an influence of climate and environment on its production and quality. Displacing it from natural conditions can affect the characteristics of the plant and its essential oil. Therefore, when growing lavender outside its natural range, it is important to create optimal conditions for its growth and development, which are close to those that exist in the natural places of its growth.

The experience of growing lavender in different countries, including ours, confirms the possibility of obtaining high-quality essential oil that meets the needs of industry. This is possible not only in mountainous regions. In the past, for example, in the USSR, the best essential oil was obtained from plantations on the southern slopes of the Crimean Mountains, in particular in the Chatyr-Daga and Demerji areas, where there was also great confidence in the safe wintering of plants.

However, these regions are not the only possible areas for the expansion or establishment of lavender plantations. According to many researchers [63–65], there are new areas in different zones of Ukraine where it is possible to develop this culture. In Central Asia already in the 1930s, studies were conducted that confirmed the possibility of growing lavender, and this region, according to S. N. Kudryashov [66], can be the "second homeland" for this plant. According to the conclusions of E.V. Wulf and V.I. Nilov [17], there is also no reason to reject areas such as the Right Bank Forest-Steppe of Ukraine on limestone soils or even areas of Polissia.

Indeed, the territory of agricultural regions of our country, generally speaking, meets the requirements for the heat necessary for lavender to bloom. This process begins at an average daily temperature of more than 10 °C, which is equivalent to 1050...3060 °C. Accumulation of this amount of heat in the areas of developed agriculture is possible, but the limitations for the spread of lavender are the conditions of its winter overwintering and the suitability of the soil [8].

Areas for the introduction of lavender are limited by climatic and soil conditions, and they require regular rejuvenation of plantations every 4-5 years. Lavender is frost-resistant, provided this agrotechnical measure is carried out. This makes it possible to grow lavender even in the northeastern regions of the country.

In the territory north of this line, the average absolute minimum air temperatures are -30 °C, often falling to -28 °C, and here the snow cover can reach 40-50 cm, especially in the northwestern regions of the country, and in the southeast it is usually does not exceed 20 cm. The winter hardiness of lavender is determined by the height of the snow cover, since without it the shoots of the plant can freeze.

In the area south of the isoline of average absolute minimum temperatures, equal to -21 °C, lavender can grow and develop at any age, even without frequent rejuvenation every 4-5 years. This includes the southern regions of Ukraine, including the Crimea, with the exception of areas with desert soils, salt marshes and areas with excess moisture in the soil [8].

The geographical distribution of yield and oil content of lavender inflorescences is determined by agro-climatic conditions, and its main feature can be described as close to mountainous and foothill areas, which have high humidity. These regions are the most favorable for growing this culture.

Interestingly, in some mountainous areas with a dry climate, characteristic of subtropical zones, where other crops require irrigation to grow, lavender can grow successfully. Under these conditions, yields may be lower, but lavender oiliness may be higher due to hot and dry weather.

Lavender plants are also effective anti-erosion agents and can be used to conserve soils. Lavender plantations can be placed on slopes and on soils that are not suitable for growing other crops.

Lavender essential oil is most concentrated in glands located on flower calyxes. There is little oil in the flower corollas, but they are of the highest quality. The formation of essential oil in lavender plants is a protective response to drought. Therefore, the highest content of essential oil is observed in lavender inflorescences during hot daytime hours. The highest content of essential oil occurs 10-14 days after the beginning of flowering.

Researchers confirm that a decrease in temperature and an increase in air humidity beyond the specified parameters lead to a decrease in the content of essential oil in lavender plants. At low temperatures, dry air does not contribute to the formation of oil. According to the data of V. L. Zatuchnoi and M. Kh. Kigelman, dry sunny weather with high temperature contributes both to the strengthening of the process of oil formation and the accumulation of ethers.

Since lavender is mainly grown in southern Ukraine and Crimea, existing cultivation technologies were developed for these southern regions. Lavender is planted as a perennial plant outside crop rotation. For its planting, select areas that receive enough sun, have protection from north and north-east winds, and have a slight slope in the direction of south and south-west exposure.

The preparation of plots for lavender plantations takes place taking into account the technology and requires advance and thorough preparation. Special attention is paid to cleaning the field from weeds and tilling the soil to a certain depth.

If a lavender plantation is created after the cultivation of grain crops, grain-legume mixtures, then after harvesting these crops, the soil is treated, usually peeling, after 10-15 days the soil is treated with an amine salt-based herbicide to rid the soil of annual and biennial weeds, as well as thistles pink and yellow, the plants of which can grow quickly. After 10-20 days, peeling is repeated using a plow peeler.

In the southern regions of Ukraine, lavender plants are fed with mineral fertilizers (N100-120P100-120K40-60) and organic fertilizers (40-50 tons per hectare). Plantation plowing is carried out to a depth of 45-50 cm. After autumn plowing, the soil is leveled and left for the winter, and in the spring and summer of the following year it is kept in a state of black steam. At the end of September - at the beginning of October, lavender fields are cultivated with a chisel-cultivator to a depth of 20-25 cm [2,3].

Before planting lavender seedlings, a certain system of passages is created on the site. Longitudinal passages are made every 400-600 meters and transverse passages every 200-300 meters.

Lavender can be propagated both by seeds and vegetatively, using cuttings, division of the bush and branching (side shoots). Industrial conditions provide mainly a vegetative method of reproduction. Cuttings 8-10 cm long are cut in September-October from one-year semi-lignified shoots from 4-5-year-old mother bushes and planted in greenhouses. After the cuttings take root, seedlings grow from them.

The optimal time for planting lavender seedlings on the plantation is the second half of October and November. However, planting is also possible during the thaw in winter, as well as in early spring. Lavender is planted with the help of lavender ponds or by hand according to the scheme of 1.2 x 0.5 meters. When planting, the root neck of the seedlings is buried 5-6 cm below the soil surface, watered and covered with a layer of soil 3-5 cm thick.

Caring for young lavender plantations includes several important aspects [8] :

1. Protection against weeds: In early spring, before the start of lavender growth, soil herbicides such as simazine and promethrin are used at a dose of 2 kg/ha of the active substance. This helps rid the soil of weeds and ensure a healthy start for lavender.
2. Loosening the soil between the rows: Regular loosening of the soil between the rows of lavender helps to keep the soil in a relaxed state, facilitates the access of air and water to the roots of the plants.
3. Lavender planting: Timely planting of new plants in place of the dead helps to maintain the full area of the lavender plantation.

After entering the fruiting phase, lavender should be regularly fed with mineral fertilizers. In the second year of life, plants are recommended to be fed with nitrogen fertilizers at a dose of 50-60 kg/ha of the active substance in the spring.

Between the work of keeping the soil in a loose state and clean of weeds, it is also important to regularly trim the bushes. This includes removing dry and damaged branches. The next step is the rejuvenation of the bushes, which consists in pruning them by 1/2 of the annual growth. After rejuvenation, plants are fed with mineral fertilizers with the appropriate ratio of nitrogen and phosphorus (N60P60).

Plantation rejuvenation is recommended every 5-6 years of industrial operation.

The following measures can be used to control the main pests of lavender, such as the gamma bollworm, the head nematode, and the meadow butterfly, as well as to prevent root rot:

- Agricultural measures: Ensuring proper plant care, including adequate watering, fertilization, pruning, and removal of diseased or damaged plant parts. Regular inspection of the plantation can help detect pests and diseases in the early stages.
- Pesticide treatment: Use of pesticides or other chemicals as necessary to control pests and diseases. It is recommended to follow the manufacturer's instructions and take into account the recommendations regarding processing times and methods.

Regarding the collection of lavender, technical ripeness occurs in the flowering phase, when 50% of the flowers on the bushes open. The collection is carried out by cutting the flower stalks to a length of 10-12 cm. For collection, you can use a special lavender harvesting machine "Crimea", which simplifies the collection process.

Lavender seeds are small, about 2.1–2.8 mm long, 0.9–1.3 mm wide, and 0.5–0.8 mm thick. They have an oblong-elliptical shape and can be light brown to dark brown or even black in color. The seeds are smooth and glossy. Each seed has a scar, which has the shape of a sickle-shaped scar of white color, without a ridge.

Lavender (Lavandula) is a perennial evergreen semi-shrub that grows to a height of about 60 cm. This species of the genus Lavender grows naturally on the dry southern slopes of southern France, eastern Spain and North Africa. The main characteristics of this plant include [8]:

1. Root: The lavender root is woody and can penetrate deep into the soil. In the upper part, the root is usually thick and densely wet.
2. Leaves: Lavender leaves grow opposite each other, without a petiole (sessile). They can have a different color from dark to light green, sometimes gray-green. The leaves are usually lanceolate or linear, pubescent, narrowed at both ends, with slightly curved downward edges. These leaves remain on the plant throughout the year.
3. Shoots: A lavender bush can be spherical in shape and consist of an average of 400-500 semi-woody branched shoots, but this number can vary from 300 to 1000 per plant.
4. Lifespan: The average lifespan of lavender bushes is 20-25 years. After a certain period (usually 5–6 or 8–12 years), old shoots begin to dry out, and new replacement shoots are formed from buds on the root neck or on the lower parts of the branches.

Lavender is a prized species for its fragrant flowers, from which lavender oil is extracted, which has numerous uses in perfumery, aromatherapy and beauty products, as well as in cooking and for the creation of scented sachets and sachets.

Each main shoot of the plant ends with an inflorescence, which can have a spike-shaped or cylindrical shape and consists of separate multi-flowered pseudo coils. These pseudo spindles consist of two oppositely located half-spindles, each of which includes several flowers.

Lavender flowers have a cylindrical cup shape with five teeth and on the surface contain eight-cell glands, which are the main places for the accumulation of essential oil. The number of these spikes can indicate the amount of essential oil in the flowers.

This detailed information about the structure of lavender flowers is important for understanding how essential oil is formed and stored in these plants (Figure 1.1).

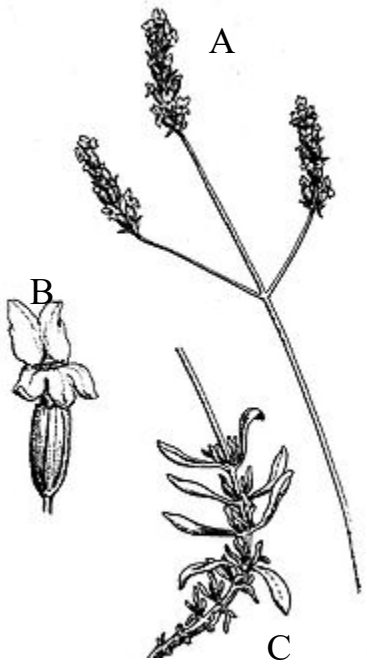

Figure 1.1. Micromorphology of lavandula flowers [18].

a - The top of the inflorescence during budding, with pronounced ribbing of the cups.

b - Dry cup with small light ethereal glands (original).

c - Magnified view of calyx surface with hairy epidermal cells (pubescence) and globular ether oil glands.

These images and details of their structure demonstrate the features of the sepals of lavender flowers.

The lavender flower has a top, which during budding is formed as a two-lipped corolla with fused petals. It also has four stamens and one pistil. The nectaries are located near the base of the flower tube and are protected from rain by a ring of hairs. The ovary is upper and four-lobed. The fruit is dry and consists of four dark, smooth nuts.

Until now, there is uncertainty about the total number of chromosomes in the lavender diploid set. Various sources indicate that this number can vary from 2n = 36 to 75. It is generally accepted that the base ploidy level of lavender and broadleaf is 2n = 50. But recent studies also mention that the diploid chromosome set of lavender can be 2n = 48 [8].

Varieties of lavender differ in a variety of morphological features, including the height of plants and the shape of the bush, the size of the leaf blade, their color and degree of pubescence, the color of flowers and the structure of the inflorescence. In the 1930s, H.K. Gunko, who was a pioneer of lavender breeding in the USSR, published the first intraspecific classification of morphological types of lavender. He singled out three types based on the shape of the bush: spherical, with radially branched flower-bearing shoots; cone-shaped or dome-shaped; and thyroid, in which flowering shoots grow vertically, and inflorescences are located horizontally [17].

Forms with thyroid bushes, 30 to 65 cm high, which are best adapted to mechanized methods of growing and harvesting, have the most economic value. Regarding the type of inflorescence, there are two main types within the lavender species: spike-shaped, where the number of flowers in whorls decreases towards the top, and cylindrical, where the number of flowers in whorls remains the same from the base to the top of the inflorescence. According to the number of flowers in the inflorescences, three groups are distinguished: few-flowered (3-5 flowers in whorls), intermediate (6-12 flowers in whorls) and multi-flowered (13 or more flowers in whorls) [16].

Lavender is characterized by significant intraspecific diversity in the color of flower cups and corollas. Usually, the colors of corollas and calyxes match and can belong to one of three main color groups: dark purple, pink and white. It is important to note that the dominant dark purple coloration is the most common, and the white flowers are recessive and are observed mainly within the natural range of this species.

Regarding the type of flower cups, H.K. Hunko singled out elongated, cylindrical, oval; with pronounced ribbing and smooth; with pressed and distant pubescence; strongly and weakly pubescent (hairy) [14].

Lavender is an allogamous (cross-pollinated) entomophilous plant that relies on bees of various species for pollination. Bees are attracted by the smell of nectar, so most of the ancient varieties of lavender are hybrids. In this regard, when propagated by seed, lavender shows great variability in biotypes and has a wide range of properties, such as yield and essential oil content.

Lavender shows adaptations not only to cross-pollination, but also to self-pollination. However, when self-pollinating lavender using individual insulators, only 3–13% of flowers can form fruits. This is because lavender pollen is fine, sticky and loose, measuring around 37-42 μm. Opening of anthers and maturation of pollen occurs even in young, closed buds. The stigma of the queen is also ready for fertilization during this period. However, at the beginning of flowering, when the pistil receptacle emerges from the pistil tube, the probability of self-pollination decreases to a minimum [21, 22].

Lavender can also be propagated vegetatively using stem cuttings and roots. Propagation by stem cuttings is the most common growing method, as it allows preserving the biological and economic properties of varieties. However, even with vegetative reproduction, bud mutations and deviations from high-yield varieties in biological and biochemical characteristics can occur.

Clonal propagation of lavender is a high value, but expensive method. To make lavender production cheaper, it is possible to create stable self-pollinating lines of plants, from which annual sowing would give interline hybrids. This would allow using the effect of heterosis. In nature, you can find lavender plants that have female flowers equipped with sterile anthers and a fertile pistil. This usually refers to the seed progeny of an artificially pollinated clone. After several generations of inbreeding, the number of sterile plants in the offspring increases.

Lavender essential oil is considered high-quality and is widely used in high-end perfumery and cosmetics. It is a component of many perfumes, colognes and eau de toilettes, especially those produced by extraction of volatile solvents. Lavender

essential oil contains components such as linalool and linalyl acetate, which give it its characteristic aroma. [14].

Linalool is a lily-of-the-valley-scented liquid that is used directly in perfumery and as a raw material for the production of other aromatic compounds. Linalyl acetate is also a liquid with a pleasant fruity aroma. Linalool can be used to obtain citral, and one of the practically important derivatives of citral is ionone, which has a violet aroma. In addition, lavender oil is structurally similar to the carotene pigment, which may also be important for the synthesis of valuable compounds [36].

Therefore, lavender essential oil is a valuable source of aromatic compounds and has important applications in the perfumery and cosmetic industry.

Lavender oil is an ideal agent for flavoring toilet soaps, as it has a high resistance to the alkalinity of soaps. This allows you to preserve the wonderful aroma in products with lavender oil. Fragrant lavender flowers are also used to purify the air in rooms, to scent linen and clothes, and to repel moths. In the fight against mosquitoes, special candles are created using lavender [36, 37].

Lavender also has significant medicinal uses. Lavender inflorescences collected during flowering, as well as essential oil from them, are used in medicine. It is used to treat various diseases, including migraines, neurasthenia, rheumatism, cardiovascular diseases, urolithiasis and pyelonephritis. Lavender is also used for therapeutic baths for inflammation of the joints, dislocations, as well as a wound healing agent and for skin diseases.

In various countries and traditional medical practices, lavender is also used to treat diseases of the stomach and intestines, inflammation of the middle ear, bronchitis, laryngitis, and as a diuretic. Thus, lavender has important medical and aromatic applications [18–20].

Preparations made from lavender flowers have numerous beneficial properties. In particular, they have a diuretic, anticonvulsant and sedative effect, improve cerebral blood circulation. A solution of lavender essential oil can stimulate wound healing, especially with chemical burns, and promotes complete regeneration of the epidermis. Lavender oil is also part of drugs that have neurotropic and myotropic activity, and are used for inhalation as a preventive measure against influenza infections. Moreover, lavender oil can lower cranial blood pressure, relieve bronchospasm, increase intestinal tone, increase the acidity of gastric juice, and improve appetite [51, 52] .

In domestic medicine, lavender oil is also used to treat purulent wounds and gangrene. Bulgarian doctors recommend lavender flowers as a mild sedative and antispasmodic agent for migraines, nervous palpitations, neurasthenia, as well as a choleretic agent and for gastrointestinal colic. Essential oil dissolved in alcohol can be used for rubbing against rheumatic pains. In addition, lavender oil is used in dentistry and for inhalation treatment in rhinitis, laryngitis, and pneumonia [13, 14].

Studies of the phytoncide activity of lavender essential oil have confirmed its ability to reduce the content of bacteria in the air, such as staphylococci and streptococci. The use of lavender essential oil vapors in workplaces has resulted in a normalized heart rate, reduced fatigue and headaches after a day's work, increased vitality and a general improvement in well-being. The course of preventive

aerophytotherapy also increased the general resistance of the body, which was manifested in the reduction of morbidity.

These results indicate the possibility of using lavender essential oil for indoor air sanitation and as a therapeutic and preventive agent for acute respiratory diseases. This is especially relevant in the context of increased attention to the health and hygiene of the indoor air environment, especially during periods of epidemics and pandemics.

Lavender does have a variety of important uses. Its honey and essential oil, which are used in many fields, are especially valuable.

Lavender honey has a wonderful aroma and healing properties. It is a tasty and useful product that can be used to improve general health and treat various diseases [7–9].

Lavender essential oil also has a wide range of uses. This oil is used in perfumery, cosmetics and aromatherapy. It has a number of useful properties, including soothing, anti-inflammatory and wound-healing effects.

Lavender plants are often used in gastronomy to flavor dishes and drinks, as well as as a spice ingredient [13] .

Decorative lavender is used for landscaping and decorating gardens, flower beds and gazebos. It adds beauty and fragrance to landscape design.

Lavender plants can be useful in combating soil erosion because their roots help hold the soil in place and prevent it from weathering.

In summary, lavender is a multi-functional plant that is important in agriculture, medicine and perfume industries, as well as in decorative and landscape design.

The northeastern forest-steppe of Ukraine, located in the Sumy region, is known for its rich natural diversity and favorable conditions for the development of agriculture and agricultural products. In this context, the cultivation of planting material Lavandula, or lavender, acquires special importance. In this subsection, we will consider in detail the aspects of growing Lavandula planting material in the conditions of the north-eastern forest-steppe of Ukraine.

Due to its physical and geographical conditions, the territory of the Sumy district is one of the most developed territories of the Dnieper region. The antiquity of development left a significant mark on the current state of natural resources. This is especially clear on the example of land resources - in connection with the practically one-sided agrarian direction of the district's economic complex, the long-term use of extensive land use methods, its agricultural potential has significantly decreased. This was reflected in the decrease in the amount of humus in the soil (as a result of erosion and other unfavorable processes); in increasing the content of ballast substances; in violation of the soil structure.

Sumy district is located in the southern part of Sumy region, in the forest-steppe zone. It stretches 49 kilometers from south to north, and 57 kilometers from west to east. The climate is continental.

The thermal regime is determined on the basis of the average monthly air temperature. The lowest average temperatures are recorded in the coldest month - January, when they are approximately -6.1°C. From April, an active process of increasing the air temperature begins, and from April to April the temperature can vary

from +5 to +16°C. The highest average monthly temperature is observed in July, when it reaches a maximum value of +20.7°C (detailed data are given in Table 1.1) [16].

Table 1.1 Air temperature indicators at the Lebedyn weather station, °S.

Meteorological indicators	I	I	II	V	V	VI	VII	VIII	IX	X	XI	XII	Annual
Absolute min temperature	-36	-33	-28	-14	-6	+2	+5	+2	-6	-9	-22	-33	-36
Absolute max temperature	+7	+6	+17	+26	+32	+34	+36	+38	+34	+26	+19	+10	+38
Average monthly and annual temperatures	-6.1	-6.7	-1.7	+6.7	+14.7	+17.6	+20.7	+18.3	+13.3	+7.1	-0.3	-4.9	+7.4

The climatic regime of this area can be characterized as continental. Maximum temperatures are observed in summer and can reach +36...+38°C. The lowest absolute temperature values were recorded at approximately -36°C. Severe frosts are most commonly observed in January and February. The annual amplitude between extreme temperatures is approximately 74°C, and the average monthly amplitude is about 27°C.

The mode of moistening of the region depends on the annual amount of precipitation, which is 500 mm in the Lebedyn district. Summer precipitation makes up 70% of the total annual precipitation, this is due to the arrival of moist air masses from the west and northwest. The maximum amount of precipitation per month is observed in July (63 mm), and the minimum - in February (26 mm) (see table 1.2) [1 6].

In May, the amount of precipitation increases, which leads to the strengthening of erosion processes. Showers during this period can be very intense. Often in the summer months, along with the rain, hail falls, which causes significant damage to agriculture. During the cold period of the year, precipitation in the form of snow falls on the territory of the district. The snow cover lasts an average of 90 days. The depth of the snow cover is approximately 15-18 cm, with a peak in February. The increase in the thickness of the snow cover in February is primarily related to the accumulation of snow during the cold season, and not to a large amount of precipitation during this

period. The maximum depth of soil freezing reaches 162 cm, the minimum is 30 cm, and the average is 67 cm.

The soil cover of the Lebedyn district is quite complex and is determined by various factors, such as relief, geological composition of soil-forming rocks, moisture conditions and the influence of natural vegetation, as well as the relationship between forest and steppe. The main territory of the district (70.2%) is dominated by chernozems, which were formed on watersheds covered with forest rocks and under grassy meadow-steppe vegetation. These soils are among the most fertile and widespread in Ukraine.

Also, in the area under the oak forests, which cover or used to cover large areas of the watershed slopes and banks of streams, you can find gray forest soils, silted and regraded chernozems. This indicates the influence of the forest component on the formation of soil cover. So, the watershed lands of the Sumy district are mainly covered by three groups of soils: typical chernozems, which include typical, podzolized, and regraded chernozems. These soils may be washed to some extent on slopes. River valleys and stream bottoms are covered with a complex complex of hydromorphic soils, which include meadow chernozems, meadow, meadow-swamp, and swamp soils. These soils often have salinity and brackishness.

Table 1.2 Humidity indicators at the Lebedyn weather station.

Meteorological Indexes	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XI	Annual
Absolute air humidity (mb)	3.5	3.5	4.8	7.2	10.5	13.9	15.7	13.9	10.7	8.8	5.9	4.0	8.5
Relative humidity air (%)	88	87	85	74	68	70	71	67	75	79	85	89	78
mid-month, amount of precipitation (mm)	34	26	29	39	51	59	63	47	44	40	34	34	500
Maximum amount precipitation (mm)	100	63	82	103	132	199	157	185	93	118	129	113	930
Minimum amount precipitation (mm)	6	10	1	1	3	12	23	8	0	0	8	6	374

The research program on the topic of the thesis provides for the study of opportunities and optimization of the process of growing Lavandula planting material in the conditions of the northeastern forest-steppe of Ukraine (Vegetative propagation using plant growth stimulants and their effect on the adaptive potential of lavender (2020 - 2021).

The study took into account three main factors: A - varieties of lavender (Orion control, Feuerfogel, Livadia, Vostok, Kenning Gumberg, Maestro, Veseli notki, Richard Walls, Mriya), B - plant growth stimulants used and C - different concentrations of these stimulants (see Table 1.4).

In an experiment with vegetative reproduction, the influence of stimulants on the rhizogenesis of lavender cuttings was studied in order to determine how effective these stimulants are and what their influence is on the rooting process. The study also included optimizing the concentrations of stimulant solutions in order to obtain the maximum number of healthy, rooted lavender cuttings that would have a well-developed root system. This will contribute to the further development of an efficient and rapid method of propagation of this plant culture in the Forest-Steppe Zone for its decorative use.

The following biologically active substances were used to treat lavender cuttings: 3-indolylbutyric acid (IMK, C12H13NO2) and succinic acid (C4H6O4) in different concentrations of the aqueous solution: 140, 280, and 420 mg/l. The duration of exposure was 16 hours. Cuttings that were simply soaked in water for a day at a temperature of 20-22°C were used as a control. Stimulant-treated cuttings were pruned in the second half of May.

Table 1.4 Scheme of the experiment.

Factor A	Factor B	Factor C
Sort	Stimulants growth	Concentration, mg/l
Orion, Feuerfogel control Livadia East Canning Humberg Maestro Funny notes Richard Walls Dream	3-indolylbutyric acid (IMK, C12H13NO2) succinic acid (C4H6O4)	140 280 420

In the experiment, a mixture of peat (with a pH level of 6.9) and river sand in a ratio of 3:2 was used as a substrate for rooting cuttings. The air temperature in the rooting zone was maintained in the range of 30-35°C, the temperature of the substrate - 20-25°C, and the relative humidity was in the range of 80-90%. The cuttings were placed on a scheme of 5 x 5 cm, and their planting depth was 3-4 cm.

Cuttings were watered by an automatic fogging system. During the first 25-30 days, fine-dispersed water was sprayed for 30 seconds at five-minute intervals. After the formation of roots, the interval between irrigations was increased.

Method Z was used to determine the duration of rooting. I. Ivanova (1982). Agrotechnics of cultivation, grafting and study of regeneration ability were determined according to the Methodology of the State Varietal Testing of Agricultural Crops (1989).

To assess the differences, homogeneity and stability of lavender varieties, the methodology of the Ukrainian Institute of Plant Varieties Expertise, developed for lavender, was used.

Phenological observations and calculations of the phases of growth and development of plants were carried out in accordance with the Methodology for the qualification examination of flower-decorative, essential oil, medicinal and forest plant varieties for suitability for distribution in Ukraine.

Varieties of lavender were subject to a detailed morphological description and comparative assessment of their decorativeness, biological, ecological and economic characteristics during the growing season. These actions were performed in accordance with the methodology developed by the State Variety Test for lavender (Lavandula) varieties to determine their difference, uniformity and stability in 2006 [19].

The introduction of decorative forms of lavender in gardens and other areas of production is limited by the complexity of its reproduction [17]. The generative method of reproduction, despite the high yield of planting material and the possibility of saving resources and costs, is not optimal in selection and seed production. The vegetative method of reproduction ensures full preservation of all valuable characteristics of the mother plant [29].

There are various methods of vegetative propagation, including in vitro culture of plant cells, tissues and organs, widely used in breeding and seed production, as well as traditional methods such as separation of rooted shoots from mother plants, division of bushes, grafting with green and annual lignified shoots . The last method is the most effective [24].

One of the factors that increase the effectiveness of decorative gardening is the use of high-quality planting material and growing technology, which includes the use of biologically active substances to support the rooting of cuttings. It is important to emphasize that each culture requires experimental determination of optimal concentrations of growth stimulants, as plants may have their own individual limitations regarding their perception.

Some researchers describe the phenomenon when plants react to the concentration of well-known growth stimulants even unlike the stimulating effect at certain concentrations. On the contrary, it can cause inhibition of growth processes, contrary to the expected result [24].

Today, five main groups of phytohormones are known, which are common not only among higher plants, but also among lower multicellular organisms. These groups include auxins, gibberellins, cytokinins, abscisins, and ethylene. The action of each of these groups of phytohormones is characterized for plants of different species. In

addition to these five "classical" phytohormones, plants also have other endogenous substances that, under certain conditions, can affect plant growth, similarly to phytohormones. They are collectively called "natural plant growth regulators" [22].

Regarding the method of growing planting material, cassettes for seedlings are now the most advanced modern method. Despite the limited volume of each cassette cell, the plants grown in them are more viable. Based on cassettes can reach 99%. This is almost 30% more than when growing plants using traditional methods [23, 24].

In addition, the use of cassettes allows efficient use of the area of the complex and their reuse during the season. In decorative horticulture, together with sprinkler irrigation systems, this helps to increase the amount of planting material that can be obtained from a unit of area. The use of growth promoters such as indolylbutyric acid (IBA) and succinic acid to improve rooting over three years of research showed a positive result in the form of an increase in the number of rooted lavender plants (see Tables 1.5 and 1.6).

As can be seen from the table, the effect of the BMI stimulator on the rooting process of green lavender cuttings was quite pronounced compared to the control, reaching more than 20% in some variants. However, in variants with different concentrations of the stimulator, the differences in the rooting of the cuttings were insignificant, ranging from 1.2% to 3.3%. On average, over three years of research, the optimal concentration of the BMI stimulator turned out to be 280 mg/l, which contributed to the rooting of green lavender cuttings at the level of 97.6%.

Table 1.5 The effect of the BMI stimulator of different concentrations on the rooting of green cuttings of lavender varieties (%), average for 2020–2021.

Sort	Concentration stimulant, mg/l			
	Without processing (CONTROL)	140	280	420
Orion (CONTROL)	71	94	98	95
Feuerfogel	78	96	98	97
Livadia	77	92	99	99
East	76	93	96	96
Canning Humberg	75	95	97	95
Maestro	79	96	99	98
Merry notes	77	96	97	95
Richard Walls	76	92	97	96
Dream	73	95	97	95
Average	76.1	94.3	97.6	96.4
V, %	3.3	1.8	1.0	1.5
NIR 05	3	2	1	2

The variety Maestro showed the highest yield of rooted cuttings, usually reaching a level of 99.0% on average over three years of studies. While the varieties

"Vostok" and "Richard Walls" showed the lowest yield of rooted cuttings, at the levels of 96.0% and 97.0%, respectively. These high indicators indicate that the stimulator was correctly selected to promote high rooting of green cuttings. In particular, all varieties that participated in the study showed high suitability for rooting cuttings (see Table 3.2).

During the years of cultivation, no influence on the effectiveness of rooting of green lavender cuttings was found. Even in 2021, when the difference between the lowest (Kening Gumberg variety) and the highest (Maestro variety) rooting rates was 3.3%, in the following year 2021 this difference decreased to 2.7% (Orion and "Feuerfogel").

Table 1.6 Effect of succinic acid concentration on rooting of green cuttings of lavender varieties (%), 2020–2021.

Sort	Concentration stimulant, mg/l			
	without processing (CONTROL)	140	280	420
Orion (CONTROL)	71	74	78	75
Feuerfogel	78	86	88	87
Livadia	77	82	89	85
East	76	73	76	86
Canning Humberg	75	85	87	85
Maestro	79	85	85	86
Merry notes	77	86	86	85
Richard Walls	76	87	87	86
Dream	77	83	86	85
Average	76.1	82.3	84.5	84.4
V, %	3.0	6.4	5.3	4.3
NIR 05	2	6	5	4

From the results of research over the years, it can be concluded that there is no significant dependence of the rooting of green lavender cuttings on the variety. However, plants respond positively to the concentration of the stimulator indolylbutyric acid (IBA). In all years of research, the percentage of rooted cuttings was higher when using a stimulator with a concentration of 280 mg/l.

The results of the analysis of the rooting of cuttings using succinic acid also showed a positive effect of this stimulator on the process of root formation in plants of varieties that participated in the study. However, compared with indolylbutyric acid, rooting rates were lower but higher than in the control group. The influence of the variety factor was also smaller compared to indolylbutyric acid. For example, Feuerfogel and Richard Walls cuttings, which showed the highest rooting rates compared to the control, increased the rates by 9.0% and 10.7%, respectively, which is half the rate of using indolylbutyric acid. The variety "Orion" was less sensitive to succinic acid, and the difference between the varieties with the highest rooting rates was more than 11%.

Feuerfogel and Richard Walls showed the highest rooting results of lavender cuttings during the years of research when the succinic acid stimulant was applied. On average during this period, the variety "Feuerfogel" had rooting at the level of 87.3%, and the variety "Richard Walls" - 88.7%.

The optimal concentrations of succinic acid for rooting of green lavender cuttings turned out to be 280 mg/l and 420 mg/l in all years of research.

The analysis of rooting processes using the succinic acid stimulator confirmed its positive effect on the formation of roots in the cuttings of the varieties that participated in the study. Compared to the control, the rooting rate was higher by 8.4% and 8.3% in variants with concentrations of 280 mg/l and 420 mg/l, respectively, and at the level of 6.2% when using the lowest concentration of stimulant.

Varietal planting material was used to propagate lavender through rooted cuttings. Growing such plant material for production purposes is extremely expensive and requires significant capital investment in the process of creating plantations. However, it is worth considering that lavender can be grown in one place for up to 20-25 years, while ensuring a high yield. It is known from literary sources that two methods are the most promising for propagating lavender plants: the use of green cuttings and one-year lignified cuttings.

One of the key stages of growing lavender seedlings is the organization of the nursery. The indicators of the rooting of cuttings, the number of seedlings obtained, their cost price and the profitability of the production of planting material depend on the correct agricultural technology in the nursery. It is important to note that the ability of cuttings to form additional roots largely depends on the area where the mother plants are located, their age and growing conditions. According to F.Ya. Polikarpova, the rate of production of planting material largely depends on the productivity of mother plants.

The tasks of the research were as follows:

1. To determine the possibility of using full-fledged queens of lavender seedlings obtained from green cuttings for planting, and to compare this method with the classical method of laying queens with seedlings obtained from one-year lignified cuttings.
2. Set the optimal load on the mother bush during the collection of cuttings.
3. Determine the number of seedlings obtained in each option for choosing the most optimal conditions and terms of operation of lavender queens, taking into account the biological features of these plants.
4. To clarify the optimal conditions for growing lavender queens, which ensure a high level of rooting of cuttings, and to determine the rational terms of their exploitation.
5. To study the relationship between the time of grafting and the age of the mother plant and its effect on the rooting of lavender cuttings.

Studies have shown that the maximum number of lavender seedlings of the "Veseli Notki" variety per unit area in the nursery, which can be obtained by one-time harvesting of one-year lignified cuttings, is reached in the fourth year of vegetation and amounts to 84,660 pieces. In the case of planting a mother plant with seedlings

obtained from green cuttings, in the fifth year of vegetation, the yield of seedlings from 100 m2 is 69.96 thousand pieces, if two-time harvesting of green cuttings is carried out. It should be noted that the productivity of queen cells increases with age, reaching a peak in the fourth year of plant vegetation.

The results of research on the rooting of cuttings of the variety "Richard Walls" are shown in table 1.7. The obtained data indicate that the rooting of green cuttings, namely the yield of conditioned seedlings, starting from the third year of vegetation, was high and amounted to 59%. During the following growing year, this indicator increased by 10%, but in the fifth growing year (in 2018), it decreased by 12% compared to previous years.

Table 1.7 The influence of the intensity of cuttings harvesting and the age of the lavender mother plant of the Veseli notki variety planted with rooted one-year lignified cuttings on the yield of seedlings, thousands of pieces, S = 100 m ^{2}.

Version research (factor IN)	Year vegetation (factor AND)					Average on factor IN
	2017	2018	2019	2020	2021	
1. One-time preparation one-year woody cuttings	1.97	14.47	25.92	26.00	29.96	19.66
2. One-time preparationgreen cuttings	2.05	1.80	45,37	50.29	18.83	23.67
3. Double provisiongreen cuttings	4.19	7.96	40.34	57.35	23.65	26.70
4. One-time preparationgreen and one-year woody cuttings	4.28	15.75	28,25	43.66	16.59	21.70
5. Double provisiongreen and disposable cuttings one-year woody cuttings	9,16	21.66	49.65	64.20	29,32	34.80
Average by factor AND	4.33	12.33	37.90	48.30	23.67	
V, %	67.4	61.9	27.6	30.3	25.4	23.3

Also, it was found that the maximum annual growth of vegetative shoots in 2-10-year-old plants was recorded for the species U. laevis and was 144.2 cm, as well as for the weeping form of U. g. 'Pendula' and was 151.1 cm. On the other hand, the lowest maximum growth of annual shoots was observed in decorative forms, in particular U. g. 'Crispa Pyramidalis' (19.2 cm) and U. g. 'Albovariegata' (25.2 cm). A minimal increase was found in the decorative forms of U. g. 'Crispa Pyramidalis' (5.5 cm) and U. g. 'Albovariegata' (7.9 cm), and was significantly different from the indicators of the weeping form of U. g. 'Pendula'.

CONCLUSIONS

Based on the assigned tasks, we reached the following conclusions:

1. In the master's thesis, a detailed review of the literature related to the cultivation of *Lavandula* planting material (lavender) in the conditions of the northeastern forest-steppe of Ukraine was carried out. The review included research and practical aspects related to the cultivation of this crop in this region.

Based on the results of the review, the following conclusions can be drawn: Growing lavender in the northeastern forest-steppe of Ukraine is a relevant and promising branch of agriculture. This culture can have great decorative and economic potential. To successfully grow lavender in a given region, it is important to choose varieties that match the local climate and soil conditions. Agrotechnical aspects such as substrate selection, temperature control, humidity and other parameters are of great importance to achieve the best results in cultivation. The use of growth stimulants and optimization of solution concentrations can have a positive effect on lavender rhizogenesis and rooting. An important aspect is the study of phenological and morphological features of lavender, which allows you to effectively control its development and growth. In order to increase the quality and quantity of lavender planting material, it is important to observe variety testing and evaluation of different varieties for their decorativeness and economic value. The peculiarities of the climate and soils of the northeastern forest-steppe of Ukraine are of great importance in the cultivation of lavender, and they should be taken into account in the planning and agricultural techniques of cultivation.

2. In the master's thesis, the natural conditions and research methods for growing Lavandula planting material (lavender) in the conditions of the northeastern forest-steppe of Ukraine were carefully considered. The natural conditions and methods were chosen taking into account the specifics of this region and the features of the lavender culture.

3. The results of research over several years indicate the absence of a significant influence of varieties on the rooting of green lavender cuttings. However, a positive effect of changing the concentration of the BMI stimulator was found. In all years of the experiment, rooting rates were the highest when using a concentration of 280 mg/l. According to research results, the best rooting results of green lavender cuttings were shown by Feuerfogel (87.3%) and Richard Walls (88.7%) varieties. The optimal concentrations of succinic acid for rooting were in the range of 280-420 mg/l.

Studies have shown that the highest yield of lavender saplings of the Veseli notki variety per unit area in the nursery, where green cuttings were used, can be obtained using a one-time harvest of one-year-old wooden cuttings. The productivity of queen cells increases over the years and reaches its peak in the fourth year of plant growth.

The low level of damage to cambium tissues of three-year-old wood under the influence of low temperatures indicates the possibility of recovery of lavender plants after harsh winters. Taking into account the correct selection of varieties and the appropriate cultivation technology, lavender can be successfully introduced in the forest-steppe zone of Ukraine.

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