How to cite: Markovska, O., V. Dudchenko, I. Stetsenko & T. Grechyshkina, 2025. Effective methods of preparing lavandin (*Lavandula hybrida* Rev.) cuttings for establishment of industrial plantations in southern Ukraine. Ege Univ. Ziraat Fak. Derg., 62 (3): 331-342, https://doi.org/10.20289/zfdergi.1517879

Research Article
(Araştırma Makalesi)

Ege Üniv. Ziraat Fak. Derg., 2025, 62 (3):331-342
https://doi.org/10.20289/zfdergi.1517879

Effective methods of preparing lavandin (*Lavandula hybrida* Rev.) cuttings for establishment of industrial plantations in southern Ukraine

Güney Ukrayna'da endüstriyel plantasyonların kurulumu için lavanta (*Lavandula hybrida* Rev.) çeliklerinin hazırlanmasında etkili yöntemler

Olena MARKOVSKA [1]

Volodymyr DUDCHENKO[1]

Iryna STETSENKO [1]

Tamara GRECHYSHKİNA[1]

[1] Kherson State Agrarian and Economic University, Faculty of Agronomy, Department of Botany and Plant Protection, 25030, Kirovograd region, Kropyvnytskyi, Ukraine

* Corresponding author (Sorumlu yazar):
markovska_o@ksaeu.kherson.ua

Received (Alınış): **18.07.2024** **Accepted** (Kabul Tarihi):**19.01.2025**

ABSTRACT

Objective: The purpose of the conducted experiment was to determine the effect of growth regulators and organic fertilizers on the rhizogenesis of lavandin cuttings (*Lavandula hybrida* Rev.).

Material and Methods: Research was conducted from 2020 to 2022 in the nursery of essential oil crops of the plant breeding department of the Institute of Rice of the National Academy of Agricultural Sciences. Lavandin maternal plants were used to prepare the cuttings. Before planting, the cuttings were treated with solutions of growth regulator and organic fertilizer.

Results: The percentage of rooted cuttings depended on the weather conditions and the method of their preparation before planting. Treatment of cuttings with a solution of a growth regulator and its mixture with an organic fertilizer significantly increased this indicator, had a positive effect on the dynamics of the accumulation of vegetative mas and allowed obtaining a larger number of seedlings of the first class.

Conclusion: Preparation of lavandin cuttings should be performed in early spring from semi-lignified shoots of the fifth and sixth orders of young, five-year-old maternal plants. For better rooting of cuttings, mixtures containing auxins (indolyl-3-butyric acid) and organic fertilizers with live cultures of soil microorganisms and nutrients in a form readily available to plants should be used.

Keywords: Agronomy, growth regulator, lavandin, organic fertilizer

ÖZ

Amaç: Bu çalışmanın amacı büyüme düzenleyicileri ve organik gübrelerin lavanta (*Lavandula hybrida* Rev.) çeliklerinin kök oluşumu üzerindeki etkisini belirlemektir.

Materyal ve Yöntemler: Araştırma 2020-2022 yılları arasında Ulusal Tarım Bilimleri Akademisi Pirinç Enstitüsü bitki ıslahı bölümünün uçucu yağ bitkileri fidanlığında gerçekleştirilmiştir. Çeliklerin hazırlanmasında lavanta ana bitkileri kullanılmıştır. Dikimden önce çelikler, büyüme düzenleyici ve organik gübre çözeltileri ile muamele edilmiştir.

Araştırma Bulguları: Köklenen çeliklerin yüzdesi hava koşullarına ve dikim öncesi hazırlama yöntemine bağlı olarak değişiklik göstermiştir. Çeliklerin bir büyüme düzenleyici ve organik gübre ile karıştırılmış çözeltisiyle muamele edilmesi köklenme oranını önemli ölçüde artırmış, vegetatif kütle birikiminin dinamikleri üzerinde olumlu bir etki yapmış ve birinci sınıf fidelerin sayısının artmasını sağlamıştır.

Sonuç: Lavanta çeliklerinin hazırlanması, beş yaşındaki ana bitkilerin beşinci ve altıncı yarı odunsu genç sürgünlerinden erken ilkbaharda yapılmalıdır. Çeliklerin daha iyi köklenmesi için, auxinler (indol-3-bütiirik asit) ve bitkilere yarayışlı besin maddeleri içeren, canlı toprak mikroorganizmaları ile zenginleştirilmiş organik gübre karışımları kullanılmalıdır.

Anahtar sözcükler: Tarım, büyüme düzenleyici, lavandin, organik gübre

INTRODUCTION

Lavandin (*Lavandula hybrida* Rev.), a perennial essential oil crop, is a promising unconventional crop that allows replacing grain crop cultivation on low-productivity, low-fertility, eroded, sloping and other soils while maintaining both ecological balance and economic efficiency of production (Angelova et al., 2015; Markovska et al., 2020; Dudchenko, V.V. & I.I. Stetsenko, 2023; Markovska & Stetsenko, 2023). It was obtained as a result of natural or synthetic crossing of narrow-leaved lavender (*Lavandula angustifolia* Mill.) with a broad-leaved lavender (*Lavandula latifolia* Medic.) (Svidenko & Yezhov, 2015). In our opinion, which is concordant with other researchers' findings (Pokajewicz et al., 2023), the cultivation of lavandin, which has two times more yield and four to five times more output of essential oil than lavender, should be given greater attention, since the majority of the essential oil of lavender on the market is actually the essential oil of lavandin, with which the former is adulterated (Schmidt & Wanner, 2015; Satyal & Sorensen, 2016; Wang et al., 2021). Linalool and linalyl acetate are the main are the main components of both lavandin and lavender essential oils (Kıvrak, 2018; Wells et al., 2018; Pokajewicz et al., 2022). Increased levels of 1,8-cineole, camphor and borneol are responsible for the spicy camphor shades of lavendin oil and increase its value as a source of natural raw material for the pharmaceutical industry (Pokajewicz et al., 2021)

Growing seedlings is an important stage in creating productive lavandin plantations. The effectiveness of this process is significantly influenced by hydrothermal conditions and the method of preparation of cuttings in the plant breeding nursery before planting (Svidenko & Rabotyagov, 2006; Dementieva & Boiko, 2021). Since *Lavandula hybrida* is a sterile interspecies hybrid between narrow-leaved and broad-leaved lavender, it cannot be propagated by seeds. The most common and widely used method of its propagation is through cuttings (Svidenko et al., 2021). Despite its simplicity, there is also a number of disadvantages - polyploidy events and a time-consuming propagation and rooting of cuttings (Kara et al., 2021).

Preparation of cuttings can be performed in two periods - in early spring (March-April) and in autumn (September-October) using healthy, young maternal plants that are three to five years old. Cuttings are taken from the base of shoots of the fifth-sixth order and immediately planted in cold greenhouses or open plots. The optimal length of cuttings, 10-15 cm, should ensure the presence of at least three buds. Planting of cuttings in the plant breeding nursery can also be done at different times in spring (end of March - beginning of April) or autumn (September). For better rooting of cuttings, acceleration of the growth and optimal development of the root system, various compounds containing auxins are often used. Indole-3-butyric acid and naphthalene acetic acid (IBA and NAA, respectively) are the most common compounds used to increase the percentage of rooted lavandin cuttings (Reed, 2021). The optimal feeding area for lavandin cuttings is 25 cm^2 (5×5). At this stage, manual weeding and irrigation with an interval of one time per week are required. If necessary, rapid evaporation can be avoided and conditions conducive to better rooting can be created by shading the cuttings with a special net (Stetsenko & Markovska, 2021).

Recently, in vitro microclonal propagation of essential oil crops has become widely used. This method is relatively inexpensive and has a number of advantages, particularly - few maternal plants are needed. It makes it possible to obtain a large number of seedlings that are genetically identical to the parent and free from viral infection relatively quickly, regardless of the season and environmental conditions (Manushkina, 2017). According to the report of researchers from Isparta University of Applied Sciences (Kara & Baydar, 2020), the use of microclonal propagation method allows obtaining higher yields and better floristic characteristics of lavandin plants compared to the use of cuttings.

Propagation of lavandin using cuttings is another example of an inexpensive and simple method that can be used in the field. It involves rooting the part of the stem or lignified branch that is still attached to the parental plant. This method is quite effective for growing seedlings to replace plants that have died for various reasons within industrial plantation rows (Colţun, 2016).

A method of propagation through splitting of old lavender and lavandin bushes is more common in decorative gardening, and is also suitable for replacing dead plants in industrial conditions. However, its disadvantages are strong lignification of old plants and the possibility of damage to their root system by soil pathogens through the cut surfaces of the bush (Reed, 2021).

It is known that the composition of lavender and lavandin essential oils is primarily influenced by the climatic and weather conditions of the growing region, physical and chemical properties of the soil (substrate) in which plants grow (Pistelli et al., 2017; Svidenko et al., 2022). To grow lavender or lavandin seedlings at the first stages of organogenesis for both decorative purposes and to prepare seedlings for planting in the open fields to obtain essential oils, various vessels (pots, containers) with a nutrient substrate, the basis of which is, as a rule, peat, are used (Najar et al., 2019; Reed et al., 2021). Although peat is currently the most common organic medium for growing plants in containers or pots due to its undoubted advantages (optimal pH for plant growth, appropriate water-holding properties, aeration capacity, low contamination with propagules of phytopathogenic microorganisms and weed seeds, etc.), its production from peatlands has lately been limited due to the environmental concerns associated with the carbon emissions. This has resulted in an increased demand and prices for the aforementioned substrate and motivated scientists to search for alternative materials and technologies (Giurgiu et al., 2017), which can be used for soil-free cultivation of seedlings of essential oil crops (Fascella, 2015; Fascella et al., 2020; Şekeroğlu et al., 2022).

Waste from agricultural production, in particular nut shells, rice husks, coconut fibre, cattle manure and peanut shells, municipal waste (green composts, sewage sludge) as well as industrial by-products (biochar, pine bark, bamboo wood residues) (Najar et al., 2019) are of great interest to the producers of substrates for seedlings of essential oil crops.

MATERIALS and METHODS

In order to determine the effect of growth regulators and organic fertilizers on the rhizogenesis of lavendin cuttings from 2020 to 2022, the experiment was conducted in the nursery of essential oil crops of the plant breeding department of the Institute of Rice the National Academy of Agricultural Sciences (southern steppe subzone of Ukraine). Prior to planting in the open plots, cuttings were placed in well-lit, wind-protected areas and treated with solutions of Grandis® (10 g/10 l of water) and Bio-gel (100 g/10 l of water) for 24 hours, leaving untreated cuttings (100 pcs.) for control according to the scheme: 1. No treatment (water); 2. Grandis®; 3. Bio-gel; 4. Grandis®+ Bio-gel.

Grandis® growth regulator contains indole-3-butyric acid, 6 g/kg, amino acid complex, vitamins B_1, B_2, B_3, B_5, C, which promotes root formation in cuttings. Bio-gel is a mixture of useful soil microflora (nitrogen-fixing, phosphate- and potassium-mobilizing microorganisms, including Azotobacter, Bradyrhizobium Subtilis, Cereus, Megaterium, Lactobacillus, Trichoderma), macro- and microelements, enzymes, carbohydrates, vitamins, organic acids.

The soil order of the nursery plant breeding plots chestnut, suborder – dark chestnut, species – low-humus, genus – residual-saline, variety – medium loamy, class – carbonate loess (Table 1).

Table 1. The water-physical and agrochemical properties of the soil

Çizelge 1. *Toprağın su-fiziksel ve agrokimyasal özellikleri*

Water-physical properties		Agrochemical properties	
density of soil, г/см³	1,27	humus, %	2,1
density of the solid phase of the soil, g/cm³	2,61	pH	7,2
maximum adsorption moisture capacity, %	5,7	sum of absorbed bases, mg-eq. per 100 g of soil	19,58
wilting moisture,, %	9,1	nitrogen, mg/100 g of soil	7,14
lowest moisture capacity, %	21,5	phosphorus, mg/100 g of soil	4,32
capillary moisture capacity, %	35,7	potassium, mg/100 g of soil	37,4

The climate of the zone is moderate-continental with relatively mild winters (average temperatures of winter months range from -3ºC to -1ºC) and hot and long summers (average temperatures of +22-23ºC, maximum temperatures of over 40ºC). The average annual air temperature is 9.3ºC-9.8ºC. The average annual rainfall is about 400 mm, but this figure has increased over the last decade. The majority of precipitation occurs in the form of showers in summer. In winter, the snow cover is unstable, and in recent years - practically absent.

For the preparation of cuttings every year, the same maternal plants of Inii variety (2n = 48) were used. This variety was included in the State register of plant varieties suitable for propagation in Ukraine in 2019 (application number 16053002) (Anonymous, 2019). The variety was discovered from biotype No. 10511 in 2011 and improved through individual repeated selection. The bush is large, compact in shape, with a height of 110 cm and a diameter of 90 cm. The inflorescence is complex, cylindrical, dense, 9.0 cm long, and 2.5 cm in diameter, with 8-9 rings. Each ring contains from 14 to 23 flowers (an average of 19). The flower's corolla is white. The leaves are linear, gray-green, slightly pubescent, with a length of 5.9-6.2 cm and a width of 0.8 cm. The variety is mid-maturing, with a flowering duration of 30 days. It does not set seeds. It is winter-hardy and resistant to pest damage and disease. On average, the yield of the above-ground mass is 114 c per hectare, with a mass fraction of essential oil of 1.8% from freshly harvested raw material and an essential oil yield of 205 kg per hectare. The main components of the essential oil are linalool (58%) and linalyl acetate (11%). The distinguishing features from other varieties include its ornamental nature, broad leaf blade with a narrow tip at the apex, which is very noticeable during the growth phase, and the white color of the flower.The root is woody, rather thick in the upper part, branching, with its main mass in the first three years of life concentrated in the soil layer of 0-30 cm. When cultivated for longer terms, it is also able to penetrate into the deeper soil layers (Figure 1).

Figure 1. Lavandin plants of Inii variety in the third year of cultivation (original photo).

Şekil 1. *Yetiştirmenin üçüncü yılında Inii çeşidi lavandin bitkileri (orijinal fotoğraf).*

Lavandin of the Inii variety is a diploid hybrid (2n = 48) that does not produce seeds, so its reproduction is exclusively vegetative - through cuttings of semi-woody shoots. In this experiment, the cuttings were prepared in March, from young five-year-old maternal plants. Cuttings from shoots of the fifth and sixth orders are characterized by better rooting (86%; 72%). Cuttings from shoots of the first and second orders practically do not root. Cuttings cut at the base of the shoot have better rooting - 89%, whereas cuttings from the middle and upper grassy parts - 40 and 25%, respectively.

To prepare the cuttings, the tops of maternal plants were cut with secateurs at a height of 20–25 cm from the root neck. The length of the cuttings, each of which had at least three buds, was 15 cm. Every year, 10000 cuttings were prepared to obtain seedlings. Before planting the cuttings, the soil was intensively watered, dug up to a depth of 20–25 cm and fertilized with humus, carefully levelling the surface. The feeding area for lavendin cuttings was 50 cm^2 with a planting scheme of 5x10 cm. Care for the cuttings consisted of shading, regular watering with maintenance of soil moisture in the 0–20 cm soil layer at the level of 85% FMC (Romashchenko et al., 2014; Romashchenko, 2020). Throughout the growing season, the generative part of the plants was trimmed five times for better development of the vegetative mass as well as the root system. Propagation sites were maintained in a weed-free state, plants were fertilized three times with ammonium nitrate at a dose of N_{10} (Figure 2).

Figure 2. Propagation of the planting material of lavandin of the Inii variety (original photo).

Şekil 2. *Inii çeşidi lavandin fidanlarının çoğaltılması (orijinal fotoğraf).*

Rooting of cuttings was recorded each year of the research in two periods: June 15 and September 15. When recording the rooting of cuttings, dates of their planting as well as dates of beginning (10%) and complete rooting (75%) were recorded (Methods, 2016). For the statistical analysis of the data, analysis of variance (Agrostat new) was used, with p-values less than 0.05 considered significant (Ushkarenko et al., 2009). Comparison of means was conducted using Duncan's multiple range test.

Seedlings were dug up and sorted into first class, second class and non-standard groups in October (Figure 3). The first class included well-developed seedlings with a height of at least 12 cm, a diameter of the above-ground part of 8 cm, a diameter and length of the root system of at least 12 cm (Anonymous, 2016). Seedlings that did not meet the requirements of the first and second classes were classified as non-standard and left for growing.

Figure 3. Seedlings of lavandin of the Inii variety (original photo).

Şekil 3. *Inii çeşidi lavanta fidanları (orijinal fotoğraf).*

RESULTS and DİSCUSSİON

In the years when the experiment was conducted, the percentage of rooted cuttings depended on the moisture levels and the method of treatment before planting. Stanev et al. (2016) argue that climatic conditions in new regions of lavender cultivation can significantly affect plant growth, development, and productivity. This is supported by our research. The weather conditions during the rooting of cuttings in 2020-2022 differed significantly in the amount of precipitation from March to August. 2020 and 2022 were dry (hydrothermal index in 2020 – 0.47; in 2022 – 0.39), with amounts of precipitation that were smaller than or slightly above the average long-term values (2020 – 280 mm; 2022 – 224 mm). Pryvedeniuk et al. (2023) state that despite drought resistance, plants of the genus Lavandula require high soil moisture for intensive growth and development at the initial stages. The most effective method of irrigation for Lavandula plantations is drip irrigation (Kachanova et al., 2023). Considering the need for additional soil moistening during the rooting of cuttings in the arid conditions, the humidity of the arable layer was maintained at the level of 85% FMC using a drip irrigation system with a controlled irrigation rate. This ensured creation of optimal conditions for moisture supply and did not lead to negative pathological processes in the rhizosphere of the cuttings that can be caused by excess moisture in the soil. Consequently, the percentage of rooted cuttings was significantly higher in 2020 and 2022, compared to 2021 (hydrothermal index - 1.54, total precipitation - 842.5 mm), when the amount of precipitation during the rooting of cuttings was excessive, exceeding the multi-year average by 2.4 times.

Propagation by cuttings is the most commonly used method for producing seedlings of perennial plants (Kara & Baydar, 2020). However, the effectiveness of rooting cuttings significantly depends on the environment in which they are grown and the substances used to enhance rhizogenesis (Karakaş & İzci, 2024). This aligns with our research findings. The number of rooted cuttings was the lowest in 2021, which can be explained by excess humidity of the nurseries that acted like soil greenhouses but lacked engineered drainage to quickly remove excess moisture. Thus, the percentage of rooted cuttings ranged from 67.2 to 86.5%, depending on the experimental condition, which was 3.8-5.6% less than the average indicators of 2020-2022, and 6.8-8.7% less compared to the same indicators of 2022 (Table 2).

Table 2. Percentages of rooted lavandin cuttings for each experiment variant prior to planting (2020-2022)

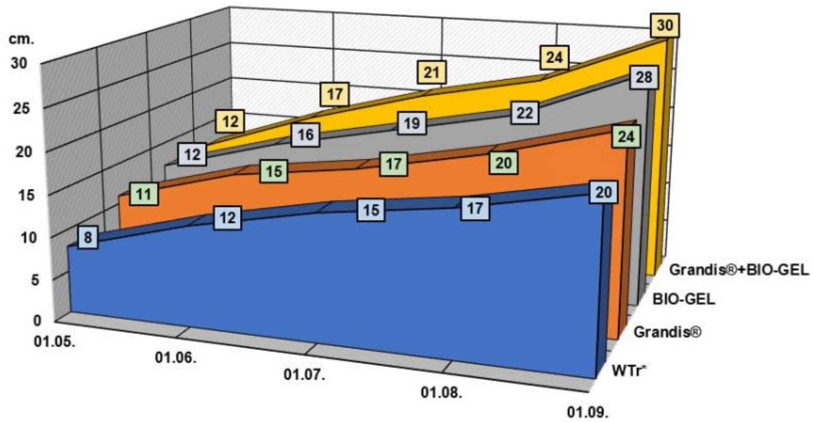
Çizelge 2. *Dikim öncesi her deney varyantı için köklü lavanta çeliklerinin yüzdesi (2020-2022)*

Experimental condition	Years of propagation of planting material							
	2020		2021		2022		Average for 2020-2022	
	15.06	15.09	15.06	15.09	15.06	15.09	15.06	15.09
No treatment	81.5±5,61c	72.4±4,91c	74.4±4,89c	67.2±4,25c	79.4±4,68c	74.0±4,74c	78.4	71.0
Grandis®	96.2±6,72a	94.5±5,92a	90.1±5,02a	86.5±5,47a	97.1±5,65a	95.0±5,68a	94.5	92.0
Bio-gel	94.1±6,13b	92.2±4,95b	86.7±5,11b	82.1±4,98b	92.3±5,21b	89.1±5,18b	91.0	87.8
Grandis®+ Bio-gel	96.8±6,34a	95.0±5,21a	90.5±5,24c	86.0±5,14a	96.4±5,45a	95.2±5,26c	94.6	92.1

*a, b, c … – Duncan’s multiple range test ($p < 0.05$).

In addition, 24-hour treatment of cuttings before planting with a growth regulator Grandis® (10 g/10 l of water) and an organic bio-fertilizer Bio-gel (100 g/10 l of water) had a significant effect on their rooting. It was determined Grandis® contributed to an increase in the percentage of rooting, which on the date before planting averaged at 92.0% over three years, exceeding the control (no treatment) by 29.6%. This confirms the well-known fact of the positive impact of synthetic auxins (indole-3-butyric acid) on the rooting of lavender cuttings (Halloran Kasım, 2002). The use of Bio-gel also had a positive effect on the rooting process of lavendin cuttings compared to the control (no treatment). The average percentage of rooting over three years for this condition was 87.8%, exceeding the control by 23.7%. Treatment of cuttings with Grandis®+Bio-gel mixture had a positive effect on the rooting process - 92.1%. However, this value did not significantly differ from the condition when Grandis® was used on its own.

Analysis of the dynamics of the formation of above-ground mass of lavandin cuttings during the period of their rooting highlighted the positive impact of treatment with the rooting agent Grandis® and an organic fertilizer Bio-gel on this indicator. The height of seedlings before planting in the field when using Grandis® was 24 cm, Bio-gel - 28.0 cm, which exceeded the control by 28.6% and 16.7%, respectively (Figure 4).

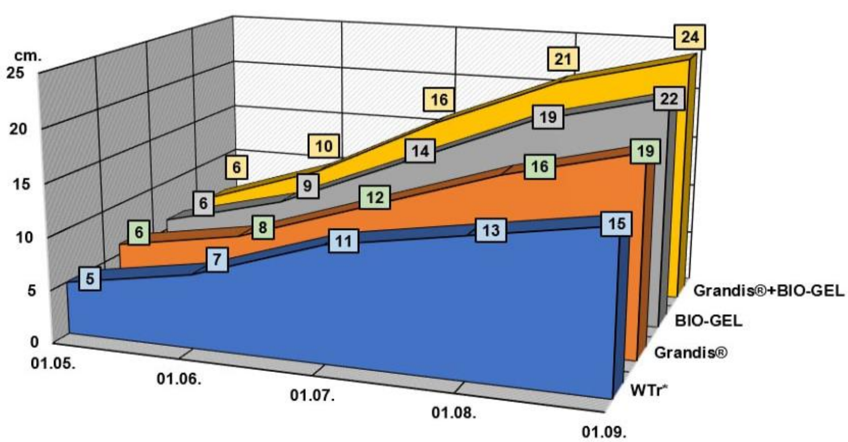


LSD_{05}, 1.12 sm

Figure 4. Dynamics of the formation of the height of lavandin cuttings depending on the method of treatment before planting, 2020-2022.

Şekil 4. *Dikim öncesi muameleye bağlı olarak lavanta çeliklerinin uzunluk değişimleri, 2020-2022.*

Well-developed cuttings were able to form 15-25 shoots during the rooting process, rendering plants strong enough to compete with the weeds and to form a significant number of flower stalks at an earlier stage. With the use of organic fertilizer Bio-gel, lavendin cuttings formed bushes of a much larger diameter, compared to the control (no treatment). To illustrate, when Bio-gel was used, the diameter of the bushes was 22.0 cm or 46.7% greater than the control (15.0 cm). The use of Grandis® also contributed to the formation of more developed bushes, compared to the control, the diameter of which before planting was 19.0 cm, exceeding the control by 4.0 cm or 26.7% (Figure 5).



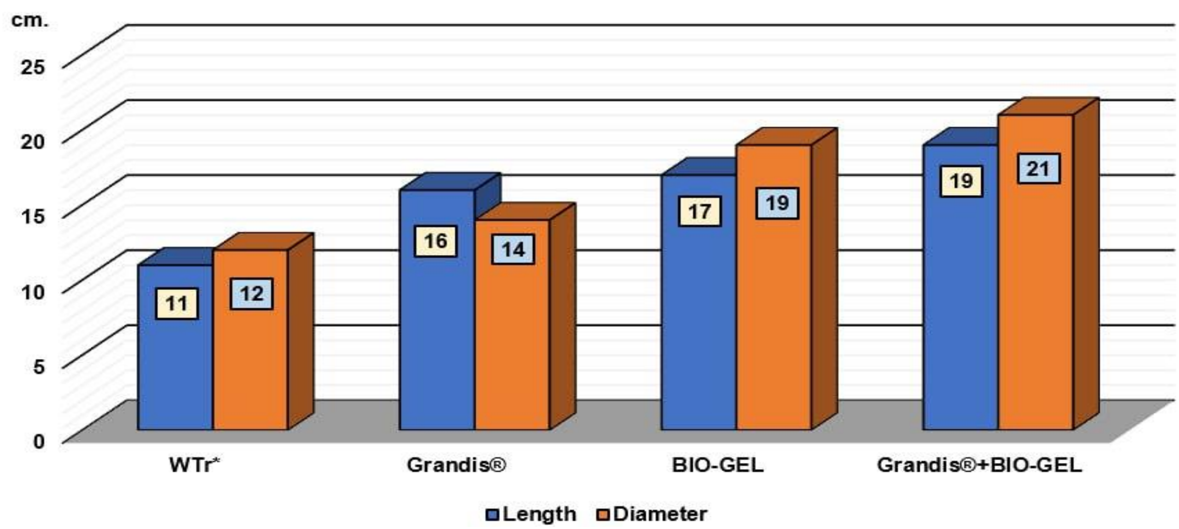
LSD_{05}, 1.58 cm

Figure 5. Dynamics of the formation of lavandin bush diameter depending on the method of treatment before planting, 2020-2022.

Şekil 5. *Dikim öncesi muameleye bağlı olarak lavanta çeliklerinin çap değişimleri, 2020-2022.*

The growth of lavandin cuttings during rooting was most significantly influenced by treatment with the mixture of Grandis®+Bio-gel. The presence of indolyl-3-butyric acid in Grandis®, which ensures active rhizogenesis, and the presence of a wide variety of beneficial soil microorganisms and nutrients in Bio-gel contributed to the formation of well-developed seedlings with a plant height of 30.0 cm and a bush diameter of 24.0 cm.

Kobets et al. (2024) demonstrated the effectiveness of using preparations of various origins as rhizogenesis activators in the propagation technology of *L. angustifolia* using one-year-old woody cuttings, which is consistent with the results of our study. One of the main factors impacting the effectiveness of the rooting process is the normal development of the root system. Treatment of the cuttings before planting with solutions of an organic fertilizer Bio-gel, a growth regulator Grandis® and a mixture of both contributed to a better development of the root system of the cuttings compared to the control (no treatment). The root system developed best when cuttings were treated with Grandis®+Bio-gel mixture before planting. With this method of preparation, the plants formed a root system with a length of 21.0 cm and a diameter of 19.0 cm, which exceeded the control value by 9.0 and 8.0 cm, respectively (Figure 6).



LSD_{05}, 1.02 cm (L), 1.14 cm (D)

Figure 6. Dynamics of the formation of the root system of lavandin cuttings depending on the method of treatment before planting, 2020-2022.

Şekil 6. *Dikim öncesi muameleye bağlı olarak lavanta çeliklerinin kök sisteminin oluşumları, 2020-2022.*

An important indicator in the process of growing lavendin seedlings is the output of conditioned standard seedlings that can quickly take root after transplanting, tolerate the winter well and exhibit strong growth in the following year. Treatment of cuttings before planting with a mixture of a growth regulator and an organic fertilizer resulted in a greater number of seedlings of the first class. The fraction of seedlings of the first class from this treatment method, which were formed at the time of transplanting, was 78.0%, which exceeded the control by 39.3% (Figure 7). The fraction of seedlings of the second class was 12% and of non-standard group – 10%, both of which were smaller than the control values by 52 and 47.4%, respectively.

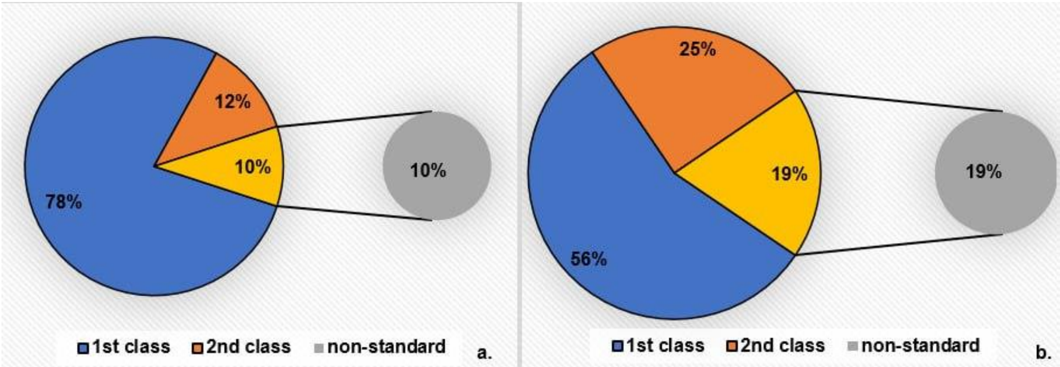


Figure 7. Output of standard seedlings from lavandin cuttings depending on the method of treatment prior to rooting (a –treatment with a mixture of Grandis®+Bio-gel, b –no treatment), 2020-2022.

Şekil 7. *Köklenmeden önceki muameleye bağlı olarak lavanta çeliklerinden standart fidan oluşumu (a – Grandis®+Bio-gel karışımı ile muamele, b – muamele yok), 2020-2022.*

CONCLUSIONS

The results of this study showed that treating lavender cuttings before planting with a composition of growth regulator and organic fertilizer resulted in a higher number of first-class seedlings (well-developed, undamaged, with a root system diameter and length of at least 12 cm, a stem diameter of 8 cm, and a height of 12 cm). With this method of preparing the cuttings, the number of first-class seedlings formed by the time of transplanting was 78.0%, which exceeded this indicator in the control variant by 39.3%. Thus, for the rapid production of a large number of standard lavender seedlings, it is advisable to use spring cuttings that should be soaked in a composite solution of Grandis® (indole-3-butyric acid; a complex of amino acids; a group of vitamins (B1, B2, B3, B5, C)) and BIO-GEL (a mixture of nitrogen-fixing, phosphate- and potassium-mobilizing microorganisms, Azotobacter, Bradyrhizobium Subtilis, Cereus, Megaterium, Lactobacillus, Trichoderma; macro- and microelements, enzymes, hydrocarbons, vitamins, organic acids) at rates of 10 g + 100 g/10 l of water for 24 hours. This method provides the best rooting rates – 92.1% and the yield of standard cuttings – 90.0%.

Data Availability

Data will be made available upon reasonable request.

Author Contributions

Conception and design of the study: OM, VD, IS, TG; sample collection: OM, VD, IS, TG; analysis and interpretation of data: OM, VD, IS, TG; statistical analysis: OM, VD, IS, TG; visualization: OM, VD, IS, TG; writing manuscript: OM, VD, IS, TG.

Conflict of Interest

There is no conflict of interest between the authors in this study.

Ethical Statement

We declare that there is no need for an ethics committee for this research.

Financial Support

This study was not financially supported.

Article Description

This article was edited by Section Editor Assoc. Prof. Dr. Ali Rıza ONGUN.

REFERENCES

Angelova, V.R., D.F. Grekov, V.K. Kisyov & K.I. Ivanov, 2015. Potential of lavender (*Lavandula vera* L.) for phytoremediation of soils contaminated with heavy metals. International Scholarly & Scientific Research & Innovation, 9 (5): 465-472.

Anonymous, 2016. Methods for Conducting Expertise of Plant Varieties in Thegroup of Medicinal and Essential Oil Plants for Distinctiveness, Uniformity, and Stability. Kyiv, 885 pp.

Anonymous, 2019. State Register of plant varieties suitable for distribution in Ukraine, 2019. Ministry of Agrarian Policy and Food of Ukraine. (Web page: https://minagro.gov.ua/file-storage/reyestr-sortiv-roslin) (Date accessed: April 2024).

Colţun, M., 2016. Step-by-step creation of a lavender plantation. Journal of Botany, VIII, 2 (13): 76-80.

Dementieva, O.I. & T.O. Boiko, 2021. Growing and reproduction of *Lavandula hybrida* Rev. under the conditions of closed soil in the south of Ukraine. Taurian Scientific Bulletin, 121: 259-264. https://doi.org/10.32851/2226-0099.2021.121.34

Dudchenko, V.V. & I.I. Stetsenko, 2023. Productivity of lavandin and the economic efficiency of its cultivation under different elements of technology. Scientific Reports of NUBiP Ukraine, 104 (4). http://dx.doi.org/10.31548/dopovidi4 (104).2023.004

Fascella, G., 2015. "Growing Substrates Alternative to Peat for Ornamental Plants, Chapter 3: 47-68". In: Soilless Culture - Use of Substrates for the Production of Quality Horticultural Crops (Ed. Md Asaduzzaman). Intech Open, 174 pp. https://doi.org/10.5772/59596

Fascella, G., M.M. Mammano, F. D'Angiolillo, A. Pannico & Y. Rouphael, 2020. Coniferous wood biochar as substrate component of two containerized Lavender species: Effects on morpho-physiological traits and nutrients partitioning. Scientia Horticulturae, 267: 109356. https://doi.org/10.1016/j.scienta.2020.109356

Giurgiu, R.M., G. Morar, A. Dumitraș, G. Vlăsceanu, A. Dune & F.-G. Schroeder, 2017. A study of the cultivation of medicinal plants in hydroponic and aeroponic technologies in a protected environment. Acta Horticulturae, 1170: 84. https://doi.org/10.17660/actahortic.2017.1170.84

Halloran, N. & M. U. Kasım, 2002. Use of growth regulators and residue levels in fruits and vegetables. Gıda, 27 (5), 351-359.

Kachanova, T., T. Manushkina & O. Kovalenko, 2023. Features of growth and development of *Lavandula angustifolia* when grown under drip irrigation conditions in the Southern Steppe zone of Ukraine. Scientific Horizons, 26 (3): 81-91. https://doi.org/10.48077/scihor3.2023.81

Kara, N. & H. Baydar, 2020. The floral and scent characteristics of lavandin from the micropropagation and cutting propagation. Turkish Journal of Field Crops, 25 (2): 114-121. https://doi.org/10.17557/tjfc.831884

Kara, N., S. Erbaş & H. Baydar, 2021. A research on rejuvenation pruning of lavandin (*Lavandula* x *intermedia* Emeric ex Loisel.). Ege Üniversitesi Ziraat Fakültesi Dergisi, 58 (1): 25-31. https://doi.org/10.20289/zfdergi.685521

Karakas, İ. & B. İzci, 2024. Effects of rooting mediums and growth regulating agents on rooting parameters of Lavender and Lavandin Cuttings (Lavandula sp.). Journal of Agricultural Production, 5 (3): 138-152. https://doi.org/10.56430/japro.1485102

Kıvrak, S., 2018. Essential oil composition and antioxidant activities of eight cultivars of Lavender and Lavandin from western Anatolia. Industrial Crops and Products, 117: 88-96. https://doi.org/10.1016/j.indcrop.2018.02.089

Kobets, O., N. Derevianko, M. Zavhorodnii & M. Berezovska, 2024. Prospects for the use of growth regulators in vegetative propagation technology of Lavandula angustifolia. Regulatory Mechanisms in Biosystems, 15 (2): 198-206. https://doi.org/10.15421/022429

Manushkina, T.M., 2017. Biotechnologies of clonal micropropagation of essential oil plants of the Lamiaceae Lindl. family in vitro. Bulletin of Agricultural Science of the Black Sea Region, 3 (95): 121-128. https://doi.org/10.31521/2313-092X

Markovska, O., L. Svidenko & I. Stetsenko, 2020. Comparative assessment of morphometric features and agronomic characteristics of *Lavandula angustifolia* Mill. and *Lavandula hybrida*. Review of Scientific Horizons, 2 (87): 24-31. https://doi.org/10.33249/2663-2144-2020-87-02-24-31

Markovska, O.Ye & I.I Stetsenko, 2023. Productivity of 'Iniy' lavendin variety depends on irrigation methods and fertilizer system. Taurian Scientific Bulletin, 131: 138-147. https://doi.org/10.32782/2226-0099.2023.131.17

Najar, B., S. Demasi, M. Caser, W. Gaino, P.L. Cioni, L. Pistelli & V. Scariot, 2019. Cultivation substrate composition influences morphology. Volatilome and essential oil of *Lavandula angustifolia* Mill. Agronomy, 9: 411. https://doi.org/10.3390/agronomy9080411

Pistelli, L., B. Najar, S. Giovanelli, L. Lorenzini, S. Tavarini & L.G. Angelini, 2017. Agronomic and phytochemical evaluation of lavandin and lavender cultivars cultivated in the Tyrrhenian area of Tuscany (Italy). Industrial Crops and Products, 109: 37-44. https://doi.org/10.1016/j.indcrop.2017.07.041

Pokajewicz, K., M. Białoń, L. Svydenko, N. Hudz, R. Balwierz, D. Marciniak & P.P. Wieczorek, 2022. Comparative evaluation of the essential oil of the new Ukrainian *Lavandula angustifolia* and *Lavandula* x *intermedia* cultivars grown on the same plots. Molecules, 27 (7): 2152. https://doi.org/10.3390/molecules27072152

Pokajewicz, K., M. Białoń, L. Svydenko, R. Fedin & N. Hudz, 2021. Chemical composition of the essential oil of the new cultivars of *Lavandula angustifolia* Mill. Bred in Ukraine. Molecules, 26 (18): 5681. https://doi.org/10.3390/molecules26185681

Pokajewicz, K., M. Czarniecka-Wiera, A. Krajewska, E. Maciejczyk & P.P. Wieczorek, 2023. *Lavandula* × *intermedia* – a bastard Lavender or a plant of many values? Part I. Biology and Chemical Composition of Lavandin. Molecules, 28: 2943. https://doi.org/10.3390/molecules28072943

Pryvedeniuk, N., L. Hlushchenko, T., Kutsyk, A., Shatkovskyi, K., Shatkovska & T. Shevchenko, 2023 Influence of mineral fertilizers and planting density on the growth, development and yield of narrow-leaved lavender (*Lavandula angustifolia* Mill). Agriculture and Forestry, 69 (2): 165-180. doi:10.17707/AgricultForest.69.2.13

Reed, D., 2021. Influence of Growth Regulators and Media on Asexual Propagation of *Lavandula* x *intermedia* . Texas Tech University, (Unpublished) Master of Science Thesis, 86 pp.

Reed, D., T. Montague & C. Simpson, 2021. Adventitious rooting of *Lavandula* x intermedia cuttings. Journal of Environmental Horticulture, 39 (4): 150-159. https://doi.org/10.24266/0738-2898-39.4.150

Romashchenko, M.I. & A.P. Shatkovsky, 2014. Methodological Recommendations for Conducting Research on Drip İrrigation. Kyiv, 46 pp.

Romashchenko, M.I., 2020. Recommendations for Operational Control and Management of İrrigation Regime of Agricultural Crops using Tensiometric Method. Kyiv, 71 pp.

Satyal, P. & A.C. Sorensen, 2016. Authentication of lavender essential oil: commercial essential oil samples and validity of standard specifications. International Journal of Professional Holistic Aromatherapy, 5 (3): 17-22.

Schmidt, E. & J. Wanner, 2015. "Adulterations of Essential Oils, 707-746". In: Handbook of Essential Oils: Science, Technology, and Applications. 2th Ed. (Eds. K.H.C. Başer & G. Buchbauer), Boca Raton, CRC Press, 1128 pp.

Stanev, S., T. Zagorcheva & I. Atanassov, 2016. lavender cultivation in Bulgaria – 21st century developments, breeding challenges and opportunities. Bulgarian Journal of Agricultural Science, 22 (4): 584-590.

Stetsenko, I.I. & O.Ye. Markovska, 2021. "Vegetative propagation of *Lavandula hybrida* Rev., 74-78". Proceedings of the III conference all-Ukrainian scientific-practical conference of young scientists on the occasion of Science Day Modern science: current state and development prospects (May 19, 2021, Kherson), 225 pp.

Svidenko, L.V. & V.D. Rabotyagov, 2006. Variability of the component composition of essential oil in lavandin in the conditions of Kherson region. Medical Chemistry, 8 (2): 61-64.

Svidenko, L.V. & V.M. Yezhov, 2015. Prospects of growing some essential oil crops in the Southern Steppe. Bulletin of Agricultural Science, 6: 20-24.

Svidenko, L.V., L.A. Glushchenko, O.M. Vergun, N.I. Hudz & Markovska O.Ye., 2022. Evaluation of the impact of weather conditions on economic valuable traits of *Lavandula angustifolia* L. in the conditions of Kherson region. Agroecological Journal, 3: 84-93. https://doi.org/10.33730/2077-4893.3.2022.266413

Svidenko, L.V., O.Ye. Markovska & I.I. Stetsenko, 2021. "Peculiarities of cultivation of lavender seedling material in the South of Ukraine, 323-325". Proceedings of the I İnternational Scientific and Practical Conference Current Aspects of The Development of Science and Education (April 13-14, 2021, Odessa), 508 pp.

Şekeroğlu, N., G. Cimen, M. Kulak & S. Gezici, 2022. Plastic mulching or conventional cultivation of lavender flower: what influence on the yield, essential oil and their neuroprotective effects? Trakya University Journal of Natural Sciences, 23 (1): 43-52. https://doi.org/10.23902/trkjnat.992275

Ushkarenko, V.O., V.L. Nikishenko & S.P. Goloborodko, 2009. Disperse and Correlation Analysis in Agriculture and Plant Science. Kherson, 370 pp.

Wang, M., J. Zhao, Z. Ali, C. Avonto & I. Khan, 2021. A novel approach for lavender essential oil authentication and quality assessment. Journal of Pharmaceutical and Biomedical Analysis, 199 (4): 114050. https://doi.org/10.1016/j.jpba.2021.114050

Wells, R., F. Truong, A.M. Adal, L.S. Sarker & S.S. Mahmoud, 2018. Lavandula Essential oils: a current review of applications in medicinal, food, and cosmetic industries of Lavender. Natural Product Communications, 13 (10): 1403-1417. https://doi.org/10.1177/1934578X1801301038