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RESEARCH ARTICLE

# Determination of Field Performances of *Lavandula angustifolia* and *Lavandula intermedia* Cuttings Rooted with Different Medium and Hormonal Stimulants in the First Plantation Year

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**ABSTRACT**

This study was carried out in Çanakkale province (Northwestern Anatolia) in 2020-2021 to determine the field performances of lavender cuttings rooted using appropriate auxin doses and rooting media in the propagation of lavender, which has high industrial and commercial value, by cuttings. In the study, cuttings of Hemus, Sevtopolis and Drujba varieties of *Lavandula angustifolia* species and Super A variety of *Lavandula intermedium* species were used. Lavender and lavandin cuttings rooted using appropriate auxin doses (Indol Butyric Acid 2000 ppm and Naphthalene Acetic Acide 1000 ppm) and rooting media (soil, peat and cocopeat) were transferred to the field and some morphological and agronomic characters were determined in the first plantation year. In the field study, the highest plant height (59.13 cm) value was obtained from *Lavandula angustifolia* var. Drujba variety rooted with cocopeat medium and NAA 1000 ppm dose. The highest values for the number of branches per plant (20.50 pieces), essential oil ratio (4.54%) and essential oil yield (1.15 kg/da) were obtained from *L.x intermedia* var. Super A variety rooted with cocopeat medium and NAA 1000 ppm dose. As a result of the field study, the Super A variety of the *Lavandula intermedia* species, rooted with cocopeat medium and NAA 1000 ppm dose, was found to be suitable for the ecology of the region (North-Western Anatolia).

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## 1. Introduction

A perennial member of the Lamiaceae family, lavender is a fragrant, semi-shrub used for its essential oils (Aslancan & Sarıbaş, 2011; Guenther, 1972). Fresh flowers, dried goods and essential oil of lavender are farmed for culinary and other uses. Due to the essential oil extracted from its blossoms, lavender is a very important essential oil plant. It is also extensively utilized in the detergent, perfume, cosmetic and fragrance industries (Mokhtarzadeh, 2011). In addition to being used as an aromatic and essential oil plant, lavender is used as a decorative plant in landscaping, beekeeping and ecotourism. Lavender is planted in France and Bulgaria, Spain, Italy, Greece, England, Russia, the United States, Austria and North African countries for the essential oil extracted from the plant's flowers and herbs (Ceylan, 1996).

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There are around 39 species of lavender native to the Mediterranean. According to Lis-Balchin (2002), lavender variants throughout the world began to increase in the early 1600s, highlighting the problems in recognizing species, hybrids and varieties because the same plant cultivated under various conditions in different geographical locations might look radically different. Cristea and Boros-Iacob (2017) refer to 132 scientific plant names in the genus *Lavandula* based on Lis-Balchin (2002)'s research. Only 47 of these were accepted as species names (Cristea & Boros-Iacob 2017; Lis-Balchin, 2002). There are three distinct lavender species in the globe, each with a high economic and commercial value (Cesur Turgut et al., 2017). Lavender (*Lavandula angustifolia* Mill. = *Lavandula officinalis* L. = *Lavandula vera* DC), Lavandin (*Lavandula intermedium* Emeric ex Loisel. = *Lavandula hybrida* L.) and Spike lavender (*Lavandula spica* = *Lavandula latifolia* Medik.) are three species with substantial economic benefits (Arabacı et al., 2007; Beetham & Entwistle, 1982). These plants are native to the Mediterranean's hilly areas, but they are now commonly grown throughout Southern Europe, Australia and the United States. Essential oil quality is better in lavender variations, while essential oil output is higher in lavandin varieties (Kara & Baydar, 2013).

Lavender essential oil is highly sought after globally and holds significant commercial value. Because of its phenolic metabolites, lavender essential oil is used to make expensive perfumes, scents and essences; pharmaceutical items, as well as products for the food and cosmetics industries (Prusinowska & Śmigielski, 2014). In our nation, which has a diverse vegetation, the popularity of lavender, an essential oil plant that can be farmed, is growing by the day and so is the need for seedlings. To compete in both domestic and international markets, plants that meet the criteria must be grown. Gaining a foothold in domestic and international markets requires providing seedlings with high yield and quality (Çiçek, 2019).

The most pressing issue in lavender is providing high-yielding, high-quality propagation material. The plant has two methods of reproduction: generative (by seeds) and vegetative (by cuttings). Although seeds can be used to propagate lavender species, asexual propagation produces more homogenous crops and high-quality clones increase the possibility of extracting essential oils of higher quality. As such, seeds should not be the preferred method of multiplication for lavender species (Tyub et al., 2007). Moreover, growth is slow in seed propagation and it is recommended to propagate by cuttings, as problems such as low germination, weed control and cultural operations are difficult and the plant's development is slow in the early stages and it exhibits a lot of variation in growth rate and oil composition. Plants grown by seeds lack plant standardization and homogeneity, complicating cultural methods and the presence of genotypic expansions may not give the superior quality essential oil that the species requires globally. Moreover, poor rooting and limited market availability have been a problem for superior clones of Lavandula species (Calvo & Segura, 1988).

Propagation by cuttings can be defined as the technique of obtaining a new plant with a piece of stem, root or leaf, called cutting, obtained from the mother plant to be produced. Propagation by cuttings is used in many medicinal and aromatic plants and ornamental plants. It is the simplest, cheapest and fastest production technique performed outdoors or indoors in a greenhouse environment. Since propagation by cuttings is taken from the mother plant, whose yield and quality are known, it guarantees high yield and quality in new plantations ıt will happen (Ürgenç, 1992). High quality is the most important criterion in essential oil plants. For these reasons, propagation by cuttings is one of the common methods applied to perennial, semi-shrub and bushy plants is one. However, there are some problems in *L. angustifolia* and *L.x intermedium*. The most important of these problems is rooting and to solve this problem, different studies have been conducted and according to the results, it has been reported that the rooting rate varies depending on the type of cutting taken (Bona et al., 2012a). In addition, in different studies conducted on the rooting of cuttings, it was found that various hormones, holding times in hormones and different medium used were effective in rooting and the best rooting was obtained from IBA (Indole butyric acid) (Ayanoğlu & Özkan, 2000; Bhat et al., 2008; Bona et al., 2012b; Çiçek, 2019). Not only IBA but also NAA (Naphthalene acetic acid) is used in the rooting of cuttings and various studies are carried out on the hormones used, the doses and holding times of these hormones.

Lavender, which is a dry farming plant that is extremely well adapted to water-limited, barren and sloping areas around the world, will be a great gain for the agricultural economy if varieties that produce marketable quality essential oil are determined and then the seedlings of these varieties can be rapidly propagated and delivered to producers. However, in lavender; there are almost no studies on the hormone doses used, different medium, steel types, different hormone applications and the holding time in the hormone with high practical applicability and different types. Especially those with high essential oil yield and essential oil quality; research is limited in terms of the applicability of rooting studies and field performances on Hemus, Sevtopolis and Drujba varieties belonging to the *Lavandula angustifolia* species and Super A variety belonging to the *Lavandula intermedium* species. The purpose of this study was to root cuttings of the Super A variety of *Lavandula intermedium* and the Hemus, Sevtopolis and Drujba varieties of *Lavandula angustifolia* in soil, peat and cocopeat media along with IBA (Indole butyric acid) 2000 ppm and NAA (Naphthalene acetic acid) 1000 ppm hormones. The performance of these rooted cuttings in the field was then assessed.

## 2. Materials and Methods

The lavender cuttings used in the research were obtained from an organic farming enterprise and private sector nurseries in Çanakkale Ezine Yaylacık village at the end of February 2020. Steels to be used in the research (1+0) are bare selected from rooted seedlings. Cuttings of Hemus, Sevtopolis and Drujba cultivars belonging to *Lavandula angustifolia* species and Super A cultivar belonging to *Lavandula intermedium* species were used in the research (Table 1). Plants in the 3rd year of plantation were used as rootstock. The greenhouse trial was carried out in a privately owned greenhouse located at the airport in Çanakkale Province, Merkez District, Barbaros Neighborhood from 2020 to 2021. Six-liter rooting pots were used in the experiment. The pots were thoroughly washed and disinfected before being filled with soil, peat and coco peat.

**Table 1.** Lavender and lavandin varieties used in the study.

| Type | Variety Name | Trade Name | Origin |
|---|---|---|---|
| *L. angustifolia* | Hemus | Lavender | Bulgaria-Kazanlık |
| | Sevtapolis | Lavender | Bulgaria-Kazanlık |
| | Drujba | Lavender | Bulgaria-Kazanlık |
| *L.x intermedia* | Super A | Lavandin | Türkiye-Isparta |

***Lavandula angustifolia* var. Hemus:** Hemus is a subgenus of the *Angustifolia* species and has 5 flower groups, 4+1 on each branch. It has dark purple flowers and since it has few flowers, its branches lean less to the sides when the plant blooms. For this reason, the plant stands more upright and collected. As a result, the plant grows more upright and has a more compact appearance. Depending on the climate and weather conditions, it generally becomes suitable for harvest from the last week of June (high adaptability and early). The timing of harvest generally begins in the last week of June, depending on climate and weather conditions, indicating its high adaptability and early growth. In terms of oil quality, linalyl and linalool acid ratios are quite high. For this reason, it ranks first in terms of quality. It has the highest quality rating as a result. However, since it has fewer flower groups on each branch than other species, it ranks lower in terms of flower and oil yield (Anonymous, 2025).

***Lavandula angustifolia* var. Sevtopolis:** Sevtopolis is a subgenus of the *Angustifolia* species and has 6 flower groups, 5+1 on each branch. Since it has a high number of flowers on one branch during the maturation period, it can lie sideways, thus resembling a large purple ball. However, its flowers have a lighter purple color compared to Hemus and Raya species. It is a bit late in terms of adaptation and this species matures later than other species. Depending on the climate and weather conditions, it is generally suitable for harvest in the first weeks of July. Oil quality follows Hemus. On the other hand, oil and flower yields are quite high. It yields 12-16 kg of oil per acre. Sevtopolis is the most planted and quality-guaranteed variety in both Bulgaria and Türkiye (Anonymous, 2025).

***Lavandula angustifolia* var. Drujba:** Drujba is a subgenus of the *Angustifolia* species and is similar to the Yubileyna genus in terms of its features and appearance. However, it is similar to the Sevtopolis genus in terms of flower and oil yield. For this reason, it can be said that the oil and flower yield is high. The medium-early flowering oil has an extremely subtle aroma and superior quality (Anonymous, 2025).

***L.x intermedia* var. Super A:** Super A is a subgenus of the *Intermedia* species. It has a long flower spike that blooms in June and July, is mostly bluish purple in color, has long flower stalks, has a pungent scent and has densely arranged silvery green leaves. It has very long branches, up to 90 cm in length. It is a lavandin variety that is used as an ornamental plant, as it has a high flower ratio and can be semi-declined. It also has a high yield of essential oils and flowers (Kara, 2011).

Soil, peat and cocopeat were used as rooting medium. Based on an examination of the rooting media's basic structure, the high clay soil can be made more pliable and aerated with the use of the peat. It is inherently acidic, which decreases pH in highly alkaline soils. Peat also lessens the amount of nutrients that leach or run off. It has the advantage of having excellent soil and air holding properties and making water available when needed, allowing peat, fertilizer and water to pass to plants gradually. Peat soil has a fibrous structure (Gowthaman et al., 2022). Cocopeat is an all-purpose growing medium made from coconut shell. Its air-filled porosity and high water holding capacity make it an ideal growing medium for herb plants. It is 100% organic and environmentally friendly, pH value is 5.7-6.5, EC level is <1 mS/cm, ideal for plant growth, does not contain soil-borne pathogens and weeds. It is easy to use in seedling trays because it has a fluffy structure, does not clump and is not compressed. It supports fast, healthy root growth with constant moisture and oxygenation. It has tremendous oxygenation properties that are important for healthy root growth. Its high water holding capacity can hold moisture up to eight times its volume without sacrificing air supply. It is a tremendous soil conditioner and the presence of organic compounds in cocopeat encourages root growth and may offer some natural resistance to plant diseases. Cocopeat's physical and biochemical properties make it resistant to bacterial and fungal growth (Hartmann & Kester, 1983). The soil used as

rooting medium was taken from the agricultural land next to the airport in Çanakkale Province, Merkez District, Barbaros Neighborhood, where the cuttings will be rooted and transferred to the field. Characteristics of the trial area and rooting soil, soil depth (cm) 0-30, pH 7.6, lime (%) 5, EC (mmhos) 193, sand (%) 17, clay (%) 43, silt (%) 44, compound silty-clay, organic matter amount (%) was recorded as 2.88 (Table 2).

**Table 2.** Soil properties of the experimental area.

| | |
|---|---|
| Soil Depth (cm) | 0-30 |
| pH | 7.6 |
| Lime (%) | 5 |
| EC (mmhos) | 193 |
| Sand (%) | 17 |
| Clay (%) | 43 |
| Silt (%) | 44 |
| Compound | Silty-clay |
| Organic Matter Amount (%) | 2.88 |

Cuttings obtained from an organic farm in Çanakkale Ezine Yaylacık village and from private sector nurseries were taken from three-year-old shoots of Hemus, Sevtopolis and Drujba varieties of *Lavandula angustifolia* species and Super A variety of *Lavandula intermedium* species. The rooting phase trial of the research was established in the Random Plots Trial Design with 3 factors and 3 replications. According to the Experimental Design of Divided Plots in Random Plots, cuttings of Hemus, Sevtopolis and Drujba cultivars of *Lavandula angustifolia* species and Super A cultivar belonging to *Lavandula intermedium* were used in the main plots. Three different mediums on the lower plots and two different auxins 2000 ppm IBA doses on the bottom plots, the NAA dose as 1000 ppm and the control group and without any treatment for comparison were established in 3 replications. The shoots taken from the rootstock plants were cut to a length of about 10-12 cm and all the leaves of the lower ¾ part of each cutting were stripped and prepared for planting. The prepared cuttings were kept in the beaker for a while, with the bottoms remaining in the water. Afterwards, the rooting pots were thoroughly washed and sterilized.

In terms of the methods used, the hormone dose applied to the cuttings and the holding times vary. However, studies on minute and slow immersion methods rather than fast immersion and second-based studies are limited and almost non-existent. Therefore, in this research, the cuttings were prepared for planting by keeping them in the rooting hormone for five minutes in order to ensure better penetration of the cuttings with the rooting hormone, better coverage of the roots and the hormone doses used were not too high. In the study, cuttings were prepared for planting by keeping their bottom parts in the concentrations of IBA (control-0 and 2000 ppm) and NAA (control-0 and 1000 ppm) for 5 minutes. Then, the cuttings were planted in 6-liter rooting pots filled with soil, peat and coco peat and were watered regularly twice a week. In the research, the cuttings were checked regularly during the rooting period and no diseases or pests were observed. Rooting performances and rooting-related parameters of the cuttings removed from the rooting medium after an average of 60-70 days were measured and analyzed (Karakaş & İzci, 2024).

**Table 3.** Climate data for the trial period and long years.

| | **Average Temperature (°C)** | | | **Total Precipitation (mm)** | | |
|---|---|---|---|---|---|---|
| | **2020** | **2021** | **Long Year Averages** | **2020** | **2021** | **Long Year Averages** |
| **January** | 0.3 | 3.1 | 1.9 | 148.0 | 58.6 | 78.8 |
| **February** | 0.1 | 5.5 | 2.9 | 88.6 | 101.9 | 62.6 |
| **March** | 5.1 | 8.0 | 6.1 | 20.8 | 25.1 | 56.8 |
| **April** | 12.6 | 12.6 | 10.7 | 53.2 | 59.9 | 52.7 |
| **May** | 15.1 | 18.3 | 15.5 | 107.4 | 66.5 | 53.6 |
| **June** | 22.8 | | 20.1 | 18.1 | | 32.4 |
| **July** | 25.8 | | 23.5 | 0.8 | | 14.3 |
| **August** | 23.7 | | 23.2 | 34.6 | | 11.2 |
| **September** | 20 | | 18.7 | 16.4 | | 16.8 |
| **October** | 14.6 | | 13 | 38.8 | | 37.5 |
| **November** | 9.4 | | 7.5 | 25.9 | | 45.6 |
| **December** | 5.5 | | 3.5 | 70.3 | | 83.1 |
| **Average and Total** | **14.1** | | **12.2** | **541.7** | | **545.4** |

The rooting characteristics of the cuttings removed from the rooting medium were determined and transferred to the field to determine their field performance and the following morphological and agricultural characteristics of lavender varieties were determined. The field trial was conducted between 2020 and 2021 on the agricultural land located next to

the airport in Barbaros neighborhood, Central District, Çanakkale province. The field experiment was set up with 3 replications according to the Split Plot Trial Design in Randomized Plots. Each plot in the trial area was made up of 4 planting rows of 4 meters length, 120 cm between rows and 40 cm across rows. After the cuttings were rooted, barnyard manure was added to the soil and mixed before being transferred to the field in order to determine their field performance and then they were manually planted in the field and the first water was given to ensure their first interaction with the soil. Since the cuttings were taken from an agricultural enterprise where organic farming was carried out in Çanakkale Ezine Yaylacık village, no synthetic chemical pesticides or synthetic fertilization were applied after they were transferred to the field, preferably for the sustainability of organic agriculture. Climate data for the trial period are given in Table 3. After the rooted cuttings were transferred to the field, drip irrigation method was used, hoeing was done on the rows for weed control and the necessary agricultural procedures were carried out. Then, plant height and number of branches per plant were measured for the lavender varieties that completed their development and they were harvested during the full bloom period and essential oil ratio and essential oil yield were analyzed.

**Figure 1.** Cuttings rooted with different medium and hormones and their appearance after being transferred to the field.

### *2.1.* Features and Methods Examined in the Field Trial

**Plant Height (cm):** In 10 plants from each plot, the part from the soil surface to the top of the spike was measured and the average was taken.

**Number of Branches per Plant (piece/plant):** The number of branches in ten plants in each plot was counted and the average was taken.

**Essential Oil Ratio (%):** Water Distillation Method was used to obtain the essential oil ratios of lavender. According to this method, 25 g samples from each parcel were subjected to water distillation for 3 hours and essential oil was obtained. The essential oil rate was determined volumetrically (ml/100 g) in this Clevenger-type essential oil apparatus (Atalay, 2008; Ünal et al., 2005).

**Essential Oil Yield:** It was found by multiplying the essential oil rates of each parcel and the dry herb yield (Atalay, 2008; Ünal et al., 2005).

### *2.2.* Statistical Analysis and Evaluations

Variance analysis was performed according to the split-plot trial design in which random parcels were divided and according to this analysis, the average values of the application that were statistically significant were grouped according to DUNCAN. Statistical evaluations were made using the SAS package program.

## 3. Results and Discussion

### *3.1.* Obtained Rooted *L. angustifolia var.* and *L.x intermedia var.* Adaptation of Plants and Transplanting into the Field

In the research, cuttings of Hemus, Sevtopolis, Drujba and Super A varieties were rooted in different environments under in vivo conditions at a dose of IBA 2000 ppm and NAA 1000 ppm and then transferred to the field and some morphological and agricultural characteristics were determined. *L. angustifolia var.* and *L.x intermedia var*. field performances of the plants such as plant height, number of branches per plant, essential oil rate and essential oil yield were determined.

### *3.2.* Plant Height

In order to determine the field performance of lavender and lavandin plants obtained after rooting the cuttings of Hemus, Sevtopolis, Drujba and Super A varieties, the effects of the hormones and media used on the plant height (cm) of the plants transplanted to the field were examined using analysis of variance. According to the variance analysis results; plant height performance of plants obtained from varieties, environments, IBA 2000 ppm and NAA 1000 ppm dose, variety × hormone, variety × environment interaction by transplanting into the field was found to be statistically significant at $p \leq 0.01$ level. Plants grown by variety × environment × hormone interaction were found to have statistically significant plant height performance at the $p \leq 0.05$ level upon transplantation into the field. When the plants were transplanted into the field, it was found that the plant height performance resulting from

the medium×hormone dose interaction was statistically insignificant (Table 4).

Among the varieties, the highest plant height was observed in plants obtained from in the Drujba variety, with 59.13 cm, while the lowest plant height was observed in the Sevtopolis variety, with 32.20 cm. When the general effects of different rooting environments were examined, the highest plant height of 59.13 cm was observed in cocopeat medium, while the lowest plant height was observed in soil medium, with 32.20 cm. The plants rooted in the NAA 1000 ppm application had the highest plant height, measuring 59.13 cm, when the overall effects of various hormone applications are analyzed. On the other hand, plants derived from cuttings rooted in the control application with 32.20 cm had the lowest plant height (Figure 1, Table 5).

**Table 4.** Field performance of lavender and lavandin plants.

| | Source of Variation | Plant Height | Number of Branches per Plant | Essential Oil Ratio | Essential Oil Yield |
|---|---|---|---|---|---|
| Calculated F Values | **Recurrence** | 4.971 | 0.713 | 0.820 | 2.052 ns |
| | **Variety** | 71537.870** | 10.332** | 15467.627** | 15167.824 ** |
| | **Error 1** | | | | |
| | **Medium** | 59.893** | 2.321 | 95.418 | 3.420 |
| | **Variety x Medium** | 26.272** | 1.049 | 3.490* | 1.800 |
| | **Error 2** | | | | |
| | **Hormone** | 41951.815** | 2.975 | 234568.170** | 16224.026** |
| | **Variety x Hormone** | 340.696** | 4.401** | 3592.778** | 130.503** |
| | **Medium x Hormone** | 1.578 | 1.501 | 55.182 | 1.112 |
| | **Variety×Medium xHormone** | 2.026** | 1.837 | 3.748** | 0.821 |
| | **Error 3** | | | | |
| | CV(Variety) = %0.34 | CV(Medium) = %0.94 | CV(Hormone) = %0.26 | | |
| | CV(Variety) = %21.04 | CV(Medium) = %15.05 | CV(Hormone) = %17.1 | | |
| | CV(Variety) = %1.02 | CV(Medium) = %1.47 | CV(Hormone) = %0.11 | | |
| | CV(Variety) = %0.74 | CV(Medium) = %1.35 | CV(Hormone) = %0.41 | | |

*, **: Significant at $p \leq 0.05$ and $p \leq 0.01$ levels, respectively.

In the study, when the effect of the variety × medium interaction on the field performance and plant height of the plants obtained from the rooted cuttings was examined, it was statistically significant ($p \leq 0.01$) (Table 4). Plants derived from cuttings grown in the interaction of the Drujba variety and cocopeat medium had the highest plant height, measuring 49.60 cm, whereas plants derived from cuttings rooted in the interaction of the Sevtopolis variety and soil medium had the lowest plant height, measuring 32.20 cm (Table 5). In the study, when the effect of the variety × hormone interaction on the field performance and plant height of the plants obtained from the rooted cuttings was examined, it was statistically significant ($p \leq 0.01$) (Table 4). The highest plant height 59.13 cm was observed in plants obtained from cuttings rooted in the interaction of Drujba variety with NAA 1000 ppm dose, while the lowest plant height 32.20 cm was observed in plants obtained from cuttings rooted in interaction 0 (control) with Sevtopolis variety (Table 5).

It was observed that the average field performance of lavender cuttings rooted in the environment×hormone interaction varied between 32.656-58.133 cm in plant height. Plants derived from cuttings rooted in the interaction of cocopeat medium with NAA 1000 ppm dose showed the highest plant height (59.13 cm), while plants derived from cuttings rooted in the soil medium interaction with 0 (control) treatment showed the lowest plant height (32.20 cm) (Table 5). In general, when the effect of cuttings rooted in medium×hormone interaction on field performance and plant height was examined, the highest plant height values were observed in plants obtained from cuttings rooted in the interaction of NAA 1000 ppm dose and cocopeat medium. In general, a significant increase in plant height is observed in plants obtained from cuttings rooted with the interaction of cocopeat and NAA 1000 ppm dose, especially in Drujba and Super A varieties. When the variety, medium and hormone interaction was tested in the study for its effect on the field performance and plant height of the plants grown from rooted cuttings, it was shown to be statistically significant at the $p \leq 0.05$ level (Table 4). It was observed that the field performance and plant height averages of the plants obtained from the cuttings rooted in the variety×medium×hormone interaction varied between 35.100-54.367 cm. The highest plant height, 59.13 cm, was observed in plants obtained from cuttings rooted in the interaction of Drujba variety with NAA 1000 ppm dose and cocopeat medium. The lowest plant height, 32.20 cm, was observed in plants obtained from cuttings rooted

in Sevtopolis variety 0 (control) and soil interaction (Table 5). In general, when the effect of the cuttings rooted in the variety×medium×hormone interaction on plant height in the field performance was examined, the highest values were observed in the plants obtained from the cuttings rooted in the interaction with the Drujba variety, NAA 1000 ppm dose and cocopeat medium.

**Table 5.** Averages of plant height (cm) and the groups formed.

| | | **Control** | **IBA** | **NAA** | **Average** |
|---|---|---|---|---|---|
| | Soil | 41.53 | 45.50 | 49.60 | 45.544 |
| Hemus | Peat | 40.93 | 44.97 | 48.87 | 44.922 |
| | Cocopeat | 42.57 | 46.73 | 50.77 | 46.689 |
| **Average** | | **41.678** | **45.733** | **49.744** | **45.719 C** |
| | Soil | 32.20 | 34.97 | 38.13 | 35.100 |
| Sevtopolis | Peat | 33.00 | 36.00 | 39.47 | 36.156 |
| | Cocopeat | 32.77 | 35.77 | 38.97 | 35.833 |
| **Average** | | **32.656** | **35.578** | **38.856** | **35.696 D** |
| | Soil | 48.60 | 53.10 | 58.10 | 53.267 |
| Drujba | Peat | 47.77 | 52.30 | 57.17 | 52.411 |
| | Cocopeat | 49.60 | 54.37 | 59.13 | 54.367 |
| **Average** | | **48.656** | **53.256** | **58.133** | **53.348 A** |
| | Soil | 47.27 | 51.50 | 56.30 | 51.689 |
| Super A | Peat | 49.00 | 53.33 | 58.20 | 53.511 |
| | Cocopeat | 48.73 | 52.87 | 57.87 | 53.156 |
| **Average** | | **48.333** | **52.567** | **57.456** | **52.785 B** |
| **Variety Average** | | **42.831 C** | **46.783 B** | **51.047 C** | **46.887** |
| **Rooting Medium Average** | | **46.400 C** | **46.750 B** | **47.511 A** | |

* There is no statistical difference between averages indicated with the same letter.

In the study conducted between 2013 and 2015 in Plovdiv, Bulgaria, it was reported that the average plant height was 58 cm in the Sevtapolis variety, 57 cm in the Drujba variety and 52 cm in the Hemus variety (Yanchev, 2017). In the study conducted in Konya by Atalay (2008), it was reported that the plant height of *L. angustifolia* varieties varied between 46.1 and 56.8 cm. Kara (2011), reported that in the study conducted between 2009 and 2010 on the Super A variety in Isparta, the average plant height was obtained as 81.4 cm. Kalyoncu (2021) conducted a study to examine the effect of planting density on yield and quality of lavender varieties grown organically between 2016 and 2019 in Çanakkale ecological conditions. As a result of the study, the highest plant height of 87.75 cm in both years was obtained from the Super A variety with a planting density of 140x99. In the research, it was observed that our findings regarding the plant heights of lavender were found to be within the values reported in the literature.

### *3.3.* Number of Branches per Plant

Among the varieties, the highest number of branches per plant was observed in plants obtained from cuttings rooted in the Super A variety, with 20.50, while the lowest number of branches per plant was observed in plants obtained from cuttings rooted in the Sevtopolis variety with 9.53 units. When the general effects of different rooting environments were examined, the highest number of branches per plant 20.50, was observed in plants obtained from cuttings rooted in cocopeat medium, while the lowest number of branches per plant 9.53, was observed in plants obtained from cuttings rooted in soil medium. When the general effects of different hormone applications were examined, the highest number of branches per plant was observed in plants obtained from cuttings rooted in NAA 1000 ppm application with 20.50 units. The lowest number of branches per plant, 9.53, was observed in plants obtained from cuttings rooted in the 0 (control) application (Table 6). In the study, when the effect of the variety×hormone interaction on the number of branches per plant on the field performance of the plants obtained from the rooted cuttings was examined it was found to be statistically significant at the ($p \leq 0.01$) level (Table 4). In general, when the effect of the cuttings rooted in the variety×hormone interaction on the field performance and number of branches per plant was examined, the highest values of the number of branches per plant were observed in the plants obtained from the cuttings rooted in the interaction of Super A variety and NAA 1000 ppm application.

**Table 6.** Averages of the number of branches (number) per plant and the groups formed.

| | | Control | IBA | NAA | Average |
|---|---|---|---|---|---|
| | Soil | 11.87 | 13.03 | 14.10 | 13.000 |
| Hemus | Peat | 12.27 | 13.10 | 14.37 | 13.244 |
| | Cocopeat | 12.13 | 13.23 | 14.47 | 13.278 |
| **Average** | | **12.089** | **13.122** | **14.311** | **13.174 B** |
| | Soil | 9.53 | 10.50 | 11.43 | 10.489 |
| Sevtopolis | Peat | 11.37 | 12.77 | 14.23 | 12.789 |
| | Cocopeat | 11.60 | 12.87 | 14.30 | 12.922 |
| **Average** | | **10.833** | **12.044** | **13.322** | **12.067 B** |
| | Soil | 14.40 | 15.07 | 16.43 | 15.300 |
| Drujba | Peat | 14.20 | 15.70 | 16.90 | 15.600 |
| | Cocopeat | 14.20 | 15.43 | 16.90 | 15.511 |
| **Average** | | **14.267** | **15.400** | **16.744** | **15.470 A** |
| | Soil | 14.10 | 15.57 | 17.07 | 15.578 |
| Super A | Peat | 17.67 | 19.80 | 20.23 | 19.233 |
| | Cocopeat | 17.13 | 19.27 | 20.50 | 18.967 |
| **Average** | | **16.300** | **18.211** | **19.267** | **17.926 A** |
| **Variety Average** | | **13.372** | **14.694** | **15.911** | **14.659** |
| **Rooting Medium Average** | | **13.591** | **15.217** | **15.170** | |

* There is no statistical difference between averages indicated with the same letter.

### *3.4.* Essential Oil Ratio

In order to determine the field performance of the cuttings of Hemus, Sevtopolis, Drujba and Super A varieties which were rooted in different medium and with different hormones under in vivo conditions, after rooting variance analysis was carried out on the effect of the essential oil ratio of the plants transplanted into the field. According to the variance analysis result; it was observed that the essential oil ratio performance of the plants obtained from the interaction of variety, medium, 2000 ppm IBA and NAA 1000 ppm, variety×hormone, medium×hormone, variety×medium×hormone, was statistically significant at the $p \leq 0.01$ level. Additionally, after the plants obtained from the variety× medium interaction were transplanted into the field, it was observed that the essential oil ratio performance was statistically significant at the $p \leq 0.05$ level (Table 4).

**Table 7.** Averages and groups of essential oil content (%).

| | | Control | IBA | NAA | Average |
|---|---|---|---|---|---|
| | Soil | 2.15 | 2.34 | 22.56 | 2.350 |
| Hemus | Peat | 2.16 | 2.36 | 2.58 | 2.367 |
| | Cocopeat | 2.24 | 2.44 | 2.67 | 2.451 |
| **Average** | | **2.182** | **2.383** | **2.602** | **2.389 D** |
| | Soil | 2.46 | 2.69 | 2.94 | 2.698 |
| Sevtopolis | Peat | 2.44 | 2.66 | 2.90 | 2.666 |
| | Cocopeat | 2.56 | 2.79 | 3.05 | 2.798 |
| **Average** | | **2.485** | **2.714** | **2.963** | **2.721 C** |
| | Soil | 2.51 | 2.74 | 2.99 | 2.750 |
| Drujba | Peat | 2.53 | 2.76 | 3.02 | 2.769 |
| | Cocopeat | 2.62 | 2.86 | 3.12 | 2.867 |
| **Average** | | **2.553** | **2.788** | **3.045** | **2.795 B** |
| | Soil | 3.67 | 4.01 | 4.38 | 4.020 |
| Super A | Peat | 3.63 | 3.96 | 4.33 | 3.972 |
| | Cocopeat | 3.81 | 4.16 | 4.54 | 4.169 |
| **Average** | | **3.703** | **4.043** | **4.415** | **4.054 A** |
| **Variety Average** | | **2.731 C** | **2.982 B** | **3.256 A** | **2.990** |
| **Rooting Medium Average** | | **2.954 B** | **2.944 B** | **3.072 A** | |

* There is no statistical difference between averages indicated with the same letter.

Among the varieties the highest essential oil rate was observed in plants obtained from cuttings rooted in the Super A variety with 4.54%, while the lowest essential oil rate was observed in plants obtained from cuttings rooted in the Hemus variety with 2.15%. When the general effects of different rooting environments were examined, the highest essential oil rate 4.54% was observed in plants obtained from cuttings rooted in cocopeat medium, while the lowest essential oil rate 2.15% was observed in plants obtained from cuttings rooted in soil medium. When the general effects of different hormone applications are examined, the highest essential oil rate 4.54% was observed in plants obtained from cuttings rooted in the NAA 1000 ppm application, while the lowest essential oil rate 2.15% was observed in plants obtained from cuttings rooted in the control application (Table 7).

Field performance averages of essential oil ratios of lavender cuttings rooted in the variety×medium interaction varied and the highest essential oil ratio of 3.81% was observed in plants obtained from cuttings rooted in the interaction of the Super A variety and cocopeat medium. When the effect of cuttings rooted in variety×hormone interaction on field performance and essential oil ratio was examined, the highest essential oil ratio was observed in plants obtained from cuttings rooted in the interaction of Super A variety with all hormone applications, compared to others. Field performance averages of essential oil ratio of lavender cuttings rooted in medium×hormone interaction varied and the highest essential oil ratio, 4.54%, was observed in plants obtained from cuttings rooted in the interaction of NAA 1000 ppm and cocopeat medium. The highest essential oil rate obtained from lavender cuttings rooted in the variety×medium×hormone interaction 4.54% was observed in the plants obtained from the Super A variety the cuttings rooted in the interaction of NAA 1000 ppm hormone and cocopeat medium (Table 7).

In different studies regarding the essential oil ratio of lavender, Wichtl (1971) and Wagner (1993) reported that the essential oil content of lavender should be 1.5%. Marotti et al. (1989) reported that the essential oil ratio varied between 1.04-1.71% and Baydar et al. (2001) reported that the essential oil content in Isparta ecological conditions was 3.4% in the first year and 6.7% in the second year. Balcı (2019) stated that the essential oil rate in lavender (*Lavandula angustifolia* Mill.) varies between 3.96 and 5.80%, Baydar and Erbaş (2007) reported that the essential oil rate in lavender was 8.25% in the first harvest and 7.30% in the last harvest. Yanchev (2017), in his study on the yield and quality of Bulgarian lavender varieties, reported that the essential oil rate varied between 1.9-2.6%. It is reported that the active substances obtained from medicinal and aromatic plants vary depending on the genotype, cultivation techniques, ecological conditions, harvest time, plant parts, distillation method and drying method (Aburjai et al., 2005; Arabacı & Ceylan, 1990; Arabacı et al., 2007; Atalay, 2008; Kalyoncu, 2021; Marotti et al., 1989; Piccaglia et al., 1993; Pinto et al., 2007; Vonasek et al., 1987).

Kara (2011), in a study conducted under Isparta ecological conditions, reported that the highest essential oil content in lavender was in the Super A variety. Arabacı et al. (2007), in their study to investigate the effect of nitrogenous fertilizer and plant density on the essential oil rate, yield and composition of *Lavandula hybrida Reverchon* (lavandin) grown under different ecological conditions, found that the essential oil rate they obtained, especially in Çanaklale conditions, was approximately the same Kalyoncu (2021) reported that in the research conducted to examine the effect of planting density on yield and quality on lavender varieties grown organically in Çanakkale ecological conditions between 2016 and 2019, the highest essential oil rate values were obtained in the Super A variety. In the research conducted in Bulgaria between 2005 and 2007, the essential oil rate in *Lavandula angustifolia* Hemus variety was found to be 1.6% on average, while the essential oil rate in *Lavandula angustifolia* Drujba varieties was reported to be 1.8% (Stanev et al., 2016). It has been observed that all these results support our study and our findings regarding the essential oil ratio.

### *3.5.* Essential Oil Yield

Among the varieties, the highest essential oil yield was observed in plants obtained from cuttings rooted in the Super A variety with 1.15 kg/da, while the lowest essential oil yield was observed in plants obtained from cuttings rooted in the Sevtopolis variety with 0.64 kg/da. When the general effects of different rooting environments were examined, the highest essential oil yield was observed in plants obtained from cuttings rooted in cocopeat and peat medium with 1.15 kg/da, while the lowest essential oil yield was observed in plants obtained from cuttings rooted in soil medium with 0.64 kg/da. When the general effects of different hormone applications are examined, the highest essential oil yield with 1.15 kg/da was observed in plants obtained from cuttings rooted in the NAA 1000 ppm dose application, while the lowest essential oil yield with 0.64 kg/da was observed in plants obtained from cuttings rooted in the control application (Table 8).

In order to determine the field performance of the cuttings of Hemus, Sevtopolis, Drujba and Super A varieties which were rooted in different medium and with different hormones under in vivo conditions, after rooting variance analysis was carried out on the effect of the essential oil yield of the plants transplanted into the field. According to the variance analysis result; it was observed that the essential oil ratio performance of the plants obtained from the interaction of variety, medium, 2000 ppm IBA and NAA 1000 ppm, variety×hormone, was statistically significant at the $p \leq 0.01$ level. Additionally, after the plants obtained from the medium, variety×medium, medium×hormone, variety×medium×hormone interaction were transplanted into the field, it was observed that the

essential oil ratio performance was statistically insignificant (Table 4).

**Table 8.** Average values of essential oil yield (kg/da) and the groups formed.

| | | Control | IBA | NAA | Average |
|---|---|---|---|---|---|
| | Soil | 0.72 | 0.79 | 0.85 | 0.789 |
| Hemus | Peat | 0.73 | 0.80 | 0.87 | 0.797 |
| | Cocopeat | 0.72 | 0.79 | 0.86 | 0.788 |
| **Average** | | **0.724** | **0.790** | **0.860** | **0.791 C** |
| | Soil | 0.64 | 0.70 | 0.77 | 0.703 |
| Sevtopolis | Peat | 0.65 | 0.71 | 0.77 | 0.710 |
| | Cocopeat | 0.65 | 0.71 | 0.78 | 0.714 |
| **Average** | | **0.647** | **0.707** | **0.772** | **0.709 D** |
| | Soil | 0.84 | 0.92 | 0.99 | 0.916 |
| Drujba | Peat | 0.85 | 0.93 | 1.02 | 0.933 |
| | Cocopeat | 0.84 | 0.91 | 1.00 | 0.915 |
| **Average** | | **0.842** | **0.920** | **1.002** | **0.922 B** |
| | Soil | 0.96 | 1.05 | 1.14 | 1.048 |
| Super A | Peat | 0.97 | 1.05 | 1.15 | 1.056 |
| | Cocopeat | 0.97 | 1.06 | 1.15 | 1.060 |
| **Average** | | **0.964** | **1.053** | **1.148** | **1.055 A** |
| **Variety Average** | | **0.795** | **0.867** | **0.946** | **0.869** |
| **Rooting Medium Average** | | **0.866 B** | **0.870 AB** | **0.873 A** | |

* There is no statistical difference between averages indicated with the same letter.

In the study, when the effect of the variety×hormone interaction on the field performance and essential oil yield of the plants obtained from the rooted cuttings was examined, it was statistically significant at the ($p \leq 0.01$) level (Table 4). Field performance and essential oil yield averages of lavender cuttings rooted in the variety×medium interaction varied and the highest essential oil yield with 1.15 kg/da was observed in plants obtained from cuttings rooted in the interaction of Super A variety and NAA 1000 ppm dose. The lowest essential oil yield, with 0.64 kg/da, was observed in plants obtained from cuttings rooted in Sevtopolis variety and 0 (control) interaction. In general, when the effect of cuttings rooted in variety×hormone interaction on field performance and essential oil yield was examined, the highest essential oil yield compared to others was observed in plants obtained from cuttings rooted in the interaction of Super A variety with all hormone applications (Table 8).

Balcı (2019), in the study conducted to determine the appropriate harvest time for the essential oil rate and yield of lavender (*Lavandula angustifolia* Mill.) in the ecological conditions of Karaisalı district of Adana province, in the first year (plant year), essential oil yield was 0.90-0.206 kg/da it has been reported that it occurred between. Kalyoncu (2021), Hemus, Sevtopolis and Drujba varieties and Super A varieties were used in the research conducted to examine the effect of planting density on yield and quality on lavender varieties grown organically between 2016 and 2019 in Çanakkale ecological conditions. According to two-year averages, since the highest essential oil yield averages were obtained from the Super A variety, these results are approximately similar to our study in terms of essential oil yield. In previous studies on lavender essential oil yield, Marotti et al. (1989) found that the essential oil yield for *Lavandula hybrida* Reverchon was between 15.1 and 17.4 kg/da, Baydar et al. (2001) reported that the essential oil yield was between 1.93-9.89 kg/da in Isparta ecological conditions and Lis-Balchin (2002) reported that the lavandin yield was up to 120 kg/da. The results of these studies also contradict our findings. However, essential oil yield in lavender plants may vary depending on genotype, characteristics of the variety used, cultivation techniques, ecological conditions, harvest time, plant parts used and distillation method (Pinto et al., 2007).

### *3.6.* Investigation of Correlation Between Factors and Characteristics in Lavender Varieties Used in the Study

The correlation coefficients between the characteristics examined in the lavender varieties used in the study were calculated and shown in Table 3. When the plant height characteristic was examined; positively significant correlation values were obtained with the variety (r=0.548) and hormone (r=0.423) used in the study and insignificant correlation values

were obtained with the medium. High and positive significant relationships were also determined between plant height and the number of branches per plant (r=0.481), essential oil content (r=0.549) and essential oil yield (r=0.901). When we examined the number of branches per plant feature, positive significant relationships were determined between variety (r=0.409), plant height (r=0.481), essential oil content (r=0.359) and essential oil yield (r=0.480) (Table 9).

**Table 9.** Correlation coefficients (r) between factors and characteristics in lavender varieties.

| Correlation Between Features | Variety | Medium | Hormone | Plant Height | Number of Branches per Plant | Essential Oil Ratio | Essential Oil Yield |
|---|---|---|---|---|---|---|---|
| **Plant Height** | 0.548** | 0.057ns | 0.423** | - | 0.481** | 0.549** | 0.901** |
| **Number of Branches per Plant** | 0.409** | 0.138ns | 0.133ns | 0.481** | - | 0.359** | 0.480** |
| **Essential Oil Ratio** | 0.842** | 0.071ns | 0.319** | *0.549*** | *0.359*** | - | *0.847*** |
| **Essential Oil Yield** | 0.771** | 0.011ns | 0.424** | 0.901** | 0.480** | 0.847** | - |

*, **: Significant at $p \leq 0.05$ and $p \leq 0.01$ levels, respectively.

When we examined the essential oil ratio feature, positive and significant correlation values were obtained with the variety (r=0.842) and hormone (r=0.319) used in the study and insignificant correlation values were obtained with the medium. In addition, high and positive significant relationships were determined between the essential oil content trait and the number of branches per plant (r=0.359), plant height (r=0.549) and essential oil yield (r=0.847) traits. When we examined the essential oil yield feature, positive and significant correlation values were obtained with the variety (r=0.771) and hormone (r=0.424) used in the study and insignificant correlation values were obtained with the medium. In addition, high and positive significant relationships were determined between the characteristics such as plant height (r=0.901), number of branches per plant (r=0.480) and essential oil ratio (r=0.847) that contribute to the essential oil yield. In lavender plants, essential oil yield and essential oil ratio are important features (Table 9). Especially, it is desired that the essential oil yield and essential oil ratio are high. Therefore, valuable information has been obtained in our research in terms of other features that have positive and important relationships between this feature.

## 4. Conclusion

With the developments in recent years, the cultivation of medicinal and aromatic plants is increasing day by day. In addition to yield in medicinal and aromatic plants, the concept of quality is also an important element. Because the main used and effective part in these plants is the substances in the content of that plant. For this reason, scientific research for advanced cultivation techniques that improve quality has intensified and very important developments have been made. Lavender cultivation in Türkiye has spread to many regions, especially in our province of Isparta. Çanakkale has an important potential for lavender production due to its ecological conditions. In terms of cultivation, we can say that the most promising variety among the varieties used in the research is the *L.x intermedia* var. Super A variety, in line with the parameters examined in terms of determining the field performance of the plants transferred to the field after rooting the cuttings with the cocopeat medium and NAA 2000 ppm dose application. It shows that obtaining cuttings of plantations to be created with these varieties using cocopeat medium will be advantageous and that applying NAA 1000 ppm to cuttings has positive effects on parameters such as plant height, number of branches per plant, essential oil ratio and essential oil yield in terms of field performance of rooted lavender cuttings.

## Compliance with Ethical Standards

This study does not require ethical committee approval.

## Conflict of Interest

The authors declare that there is no conflict of interest.

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