

**Examination of the influence of soil type on the yield and morphological parameters of *Mellisa officinalis***

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**Abstract**

*Mellisa officinalis* is a medicinal and spice plant known for centuries and is used in cooking and pharmacy. Although *M. officinalis* is easily adaptable to different habitat conditions, finding the most adequate agroecological conditions, primarily soil conditions, where this plant species can show the best productivity is important. In this regard, an experimental, potted production of *M. officinalis* was carried out in four different types of soil (arenosol, fluvisol, cambisol, chernozem) to examine which of the types best favors the yield of this plant species. A significant difference in the leaf yield of *M. officinalis* grown in different soil types was observed ( $P < 0.05$ ). The best leaf yield per plant was recorded in heavier soils (cambisol and chernozem) (1.56; 1.57 g), while in lighter soils (arenosol and fluvisol), the yield was significantly lower (0.92; 0.98 g). The research showed that of the tested soils, heavier soils (cambisol and chernozem), due to their favorable physical and chemical properties, have the most favorable effect on the growth and yield of *M. officinalis*.

*Key words:* arenosol, fluvisol, cambisol, chernozem, lemon balm

**Introduction**

*Mellisa officinalis* is a perennial herb that belongs to the Lamiaceae family. It is popularly known as motherwort, lemon balm, bee grass, etc., and has been used in culinary and traditional medicine for over 2000 years. Mainly, it is used for the treatment of the central nervous system and mental diseases, respiratory, cancer, and cardiovascular diseases. It is also used as a heart tonic, sleeping aid, memory enhancer and antidepressant (Ghazizadeh, 2021). Recent research

indicates that *M. officinalis* exhibits numerous biological activities such as antimicrobial, hypoglycemic, hypolipidemic, anticancer, antidepressant, anxiolytic, antinociceptive, anti-inflammatory, antioxidant and spasmolytic properties (Miraj et al., 2016). Other phytochemical research confirmed the presence of volatile compounds of flavonoids, triterpenes, phenolic and dihydroxycinnamic acids (Mencherini, 2007).

*M. officinalis* has a highly branched root system with many lateral vascular roots that have great suction power. The tree is herbaceous, upright, 30 to 125 cm tall, semi-shrubby, and covered with small fine hairs. The leaves are egg-shaped to rhomboid, scaly, toothed around the edge, different lengths (2-8 cm), and widths (1.5-3.5 cm), which are attached to the stem by long petioles (1.5-3.5 cm). 6-10 compound flowers appear in the axils of the leaves in the form of shortened dichasial. The flowers are white, and pale pink and form from 1 to 4 nuts, and after flowering, an elongated egg-shaped, shiny, dark-brown grain of 1.5-2 mm in length is formed (Stepanović, 2011).

*M. officinalis* grows in the temperature range of 15 to 35 ° and has high water requirements (500-600 mm) during the growing season (Saeb, 2012). The very physiology of the plant, primarily, a well-developed root system, makes this plant much more resistant to adverse environmental conditions (Turhan, 2006). However, research by Orcutt et al. (2000), indicate that biotic and abiotic factors can exert different influence on plant production. Soil type is an important abiotic factor that can exert a different influence on the growth and development of plants through the supply of water and necessary nutrients (Garg et al., 2012). Similarly, this is confirmed by the research of Radanović et al. (2006), who state that soil types and textural classes are closely related to the growth and development of medicinal plants. Similar research by Sari et al. (2002), on the mother plant, states that environmental factors, primarily soil factors, can have different effects on its productivity. However, since no detailed research was conducted to assess the effects of different types of soil on the productive properties of *M. officinalis*, the aim of this paper was to show the influence of four types of soil on the basic yield parameters and morphological characteristics of *M. officinalis*.

## Material and Methods

### *Production of seedlings*

Seedling production began at the end of January 2022 in the laboratory of the Department of Research and Development in Agriculture, in Belgrade, Serbia (44°49' N, 20°28' E). The motherwort (*M. officinalis*) seeds used in this experiment originated from the collection of the

Institute for the Study of Medicinal Plants "Dr. Josif Pančić", in Pančevo, Serbia (44° 52'20.0" N, 20°42'04.7" E). The sowing procedure itself was carried out according to the procedure described in the research by Mrđan et al., (2022). More precisely, the seeds were sown in styrofoam containers with 160 openings, previously filled with the substrate "Cultivo I SF" (Gramoflor, Romania) with the following performances declared by the manufacturer: granulation: 0 - 5 mm; nutrient content: NPK 18:10:20+Mg+me in the amount of 1 kg/m<sup>3</sup>, slow-acting fertilizer: RADIGEN®- Jost GmbH in the amount of 50 g/m<sup>3</sup>; hydrogel in the amount of 1 kg/m<sup>3</sup>.

After sowing, the sown pots are placed in a polyethylene tent (picture 1), (Grow Box), at air humidity of 40 to 60%; air temperature from 20°C to 25°C. Lighting was regulated using fluorescent tubes with a photoperiod of 12 h, while the substrate was maintained at a moderate humidity and temperature of 21±2 °C.

Air temperature and relative humidity in the Grow Box were monitored using a data logger (HAXO-8) and substrate temperatures using a thermometer (Testo 110).

#### *Tempering process*

With the appearance of the first true leaves at the end of February 2022, the containers were taken out of the polyethylene tent and were occasionally taken outside in order to adapt the seedlings to lower air temperatures, reduced relative humidity, and natural light radiation for a period of 3 weeks as recommended by Mrđan et al., (2022). After that, in mid-March, the plants were transplanted into styrofoam containers with 40 cells filled with the same substrate (Cultivo I SF) and then transferred to an unheated greenhouse, in 30% shade with an average daily T of 24±2 °. Seedlings were watered as needed. At the beginning of April, the containers were taken out of the greenhouse for adaptation for 3 weeks, and then the plants were transplanted into plastic pots (ø 13 cm).

#### *Experimental design*

The experiment was set up at the end of April according to the split-plot system with four replications, where soil type (F1 = 4 soil types) was the main factor. In general, 160 uniform seedlings were selected and transplanted into 160 pots filled with four different soil types (Table 1), of which each soil type had 40 pots.

Table 1. Physical and chemical characteristics of soil

Soil type	pH		CaCO <sub>3</sub> [%]	Humus [%]	N [%]	P <sub>2</sub> O <sub>5</sub> [mg/100 g]	K <sub>2</sub> O [mg/100 g]	Fine sand [%] 0.02- 0.2 [mm]	Coarse sand [%] 0.2-2 [mm]	Powder [%] 0.02- 0.002 [mm]	Clay [%] <0.002 [mm]
	in KCl	in H <sub>2</sub> O									
<b>Arenosol (1)</b>	7.99	8.55	19.08	0.40	0.044	1.39	2.00	67.79	28.96	1.1	2.31
<b>Fluvisol (2)</b>	7.49	8.08	14.10	1.28	0.110	3.99	7.29	66.07	27.91	5.7	1.89
<b>Cambisol (3)</b>	3.62	4.74	0.1	1.90	0.120	2.79	13.38	29.99	1.93	80.01	17.98
<b>Chernozem (4)</b>	<b>6.70</b>	<b>7.50</b>	<b>0.99</b>	<b>2.89</b>	<b>0.220</b>	<b>4.95</b>	<b>33.58</b>	27.62	0.31	31.98	39.02

The planted pots were placed on the experimental field of the Institute for the Study of Medicinal Plants "Dr. J. Pančić" in Pančevo, South Banat, Serbia (77 m above sea level; 44°52'18.9" N 20°42'09.0" E). The placed pots were in semi-shade, on a black "agro textile" foil that covers the soil in natural conditions. At the same time, the pots were irrigated using drippers with a flow rate of 1 liter per hour for each pot. Irrigation was done every two days for 20 minutes (Figure 2). Meteorological data during the experiment were collected from an automatic meteorological station, not far from the experimental field (Table 2).



Figures 1. and 2. *M. officinalis* in a grow box and on agro textile

Table 2. Meteorological parameters during the experiment (April-Jul 2022)

Climatic parameters	April	Maj	Jun	Jul
Temperature (°C)	17.9	27.0	31.3	32.8
Precipitation (mm)	57.2	34.9	23.5	72.0

*Harvest, morphological and statistical analysis*

After 180 days, in mid-July, with the appearance of the first flowers according to Singh et al. (2014), the plants were harvested and then their height (cm) was measured. After that, fresh and after drying at 105 °C to constant mass and absolute dry above-ground biomass (g/plant) were measured. In order to calculate the Radman yield, after drying, the leaves were separated from the stem (splitting) on a metal sieve with a 10 mm opening. The obtained results were statistically analyzed using SPSS software, where the obtained mean values were compared using Duncan's test ( $p < 0.05$ ).

**Results and Discussion**

The tested types of soil had different effects on all measured parameters (Table 3). This is explained by the research of Hassink (1996), in which it is stated that the texture of the soil exerts a great influence on the accumulation of organic matter, the water balance of Hook et al. (2000), and then on the availability of nutrients to plants (Brady, N. C. 1990). The types of soil in our research significantly influenced the height of *M. officinalis*. The highest average height was achieved by growing in soils with a heavier mechanical composition: chernozem and cambisol, while it was lower in soils with a lighter mechanical composition: arenosol and fluvisol (Table 3).

The average weight of fresh and dry above-ground biomass varied significantly due to differences in soil types, which at the same time manifested different influences on the average weight of leaves and branches in cultivated plants (table 3). The highest average weight of fresh and dry plants of *M. officinalis* was achieved by growing in heavier soils, cambisol and then in chernozem. More precisely, the average weight of fresh and dry plants was from 59.1% to 67.6% higher than in soils with a lighter mechanical composition (arenosol and fluvisol) (Table 3). Similar effects were achieved by the research of Moqbeli et al. (2011), when growing *M. officinalis* in different soil types.

More precisely, a significantly higher height, fresh and dry weight of the plant was obtained by cultivation in soils with a heavier mechanical composition, while the morphological parameters in the research of Gordanić et al. (2021), were significantly better, which is explained by its production in a commercial substrate. In the research of Kahkashan et al. (2016), by growing *Mentha arvensis* in different types of soils, the maximum yield was the same as in ours, in soils with a heavier mechanical composition.

Table 3. Average values of plant height and yield of *M. officinalis* grown in pots for 160 days

Treatment	Plant height (cm)	weight (FW) (g/plant)	weight (DW) (g/plant)	Leaf weight (g/plant)	Weight branches (g/plant)	Ratio branches:leaf
Arenosol (1)	38.8±2.02d	5.2±0.42d	1.39±0.41d	0.92±0.13c	0.46±0.25	2:1
Fluvisol (2)	39.5±1.94c	5.5±0.31c	1.42±0.53c	0.98±0.25b	0.42±0.34	2.1:0.9
Cambisol (3)	40.2±3.03b	6.7±0.36a	2.35±0.22b	1.56±0.33a	0.78±0.42	2:1
Chernozem (4)	43.4±2.75a	6.25±0.28b	2.05±0.14a	1.57±0.24a	0.47±0.34	2.3:0.7

\*Mean values marked with the same lowercase letters within the same column do not differ significantly ( $p < 0.05$ ).

The highest average weight of leaves and branches was in chernozem, while it was slightly lower in cambisol, with a significantly lower weight in arenosol and fluvisol (Table 3). Taking into account that the greatest use value of *M. officinalis* is the leaf, it is important to emphasize that the proportion of the leaf in relation to the stem differed considerably. The most favorable ratio (Table 3) was achieved by growing *M. officinalis* in chernozem, which, unlike others, can be attributed to more favorable physical and chemical characteristics of the soil (Table 1). Namely, favorable pH, high content of humus, and then optimal content of N, P, K in chernozem (table 1), played a major role in the dominant share of leaves of *M. officinalis* in contrast to the other three soils. Research by Hokkanen (2006) states that the physical and chemical properties of the soil play an important role in the water capacity of the soil. Similar research by Siemens et al. (2002), shows how soil resources (water, air, nutrients) can directly influence growth rate inhibition.

Accordingly, the textural properties of our soils were quite different: arenosol and fluvisol mostly contained fine sand (67.79 - 66.07%), cambisol mostly contained dust (50.01%), while chernozem had a similar proportion of dust (33.05%). and clay fractions (39.02%), which caused different moisture retention.

According to McCauley et al. (2005), these differences are very significant because soils with a more dominant share of clay materials (heavier soils) have better water capacity, which may be the main reason for the manifestation of positive characteristics of chernozem in this research. The dominant effect of chernozem was confirmed in similar research by Gordanić et al. (2022), who tested growing *A. ursinum* in different soil types.

### Conclusion

The results of the study show that soil types have a great influence on the morphological parameters and yield of *M. officinalis*. This study shows that *M. officinalis* can be grown

successfully as a potted crop using all four soil types tested. By growing *M. officinalis* in soils with a heavier mechanical composition (chernozem), the best morphological characteristics as well as a high-quality yield are achieved.

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