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IMPACT OF DIFFERENT ORGANIC FERTILIZERS ON LAVENDER PRODUCTIVITY (*Lavandula officinalis* Chaix)

SUMMARY

The impact of four organic fertilizers (Chap liquid, Guano, Slavol and Vermicompost) on the productivity of lavender was carried out at the organic lavender plantation "Sunny Valley" in Danilovgrad during 2019. Non-fertilized control variant was included in the experiment. The efficiency of the nutrition systems applied is monitored through the most important productivity parameters of lavender: plant height, number of flower shoots and herb yield.

The highest average height of the lavender plant was measured on variants using Slavol (59.5 cm), Shap liquid (58.8 cm) and Vermicompost (58.0 cm), while the lowest plants were measured on the control variant (49.8 cm). All fertilizer variants applied had a significant effect on increasing the height of the lavender plant.

The largest number of flower shoots was measured in variants fertilized with Vermicompost - 444.5 and Slavol - 405.8, while the smallest number was determined on the control variant - 292. Differences in the number of flower shoots between all studied organic fertilizers and controls were statistically justified.

All fertilizer variants resulted in a significant increase in the herb yield of lavender. The highest yield of the herb was achieved by applying the organic fertilizer Slavol - 337.3 g. This variant showed a significant increase in herb weight compared to the control - 225.3 g, but also to the variant fertilized with Chap liquid - 284.8 g.

Keywords: lavender, organic fertilizer, productivity.

INTRODUCTION

Lavender (*Lavandula officinalis* Chaix) is an evergreen perennial shrub that has long been used in traditional medicine, cosmetics and the food industry (Biswas et al., 2009). Lavender is grown for its fresh flowers or inflorescences, from which essential oil is obtained by distillation. The main ingredients of

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lavender oil are linalyl acetate (25-46%) and linalool (20-45%). Due to its high terpenes content, lavender essential oil has sedative, carminative, antiseptic, analgesic and antimicrobial properties (Biesiada et al., 2008). Lavender is an important part of the essential oil industry. Thanks to great technological and industrial advances, lavender is increasingly being used in other industries. As a regular ingredient in a large number of personal care products, its share is increasing in the global herbal market. Due to increased global demand, lavender has been increasingly grown in plantations lately (Touati et al., 2011). The annual production of lavender oil in the world is about 200 tons (Curtis, 2005). Apart from its commercial importance, its aesthetic value is also gaining in importance. Although Montenegro has a long tradition of growing lavender, it has been introduced into the culture recently. The current area under lavender is only a few hectares, but due to its growing popularity in the coming period, a more significant growth of areas should be expected. In the coastal areas of Montenegro, lavender is an indispensable part of urban decorative flora (Stešević et al., 2014).

Appropriate cultivation methods are necessary for the successful production of lavender, which include optimal mineral nutrition systems (Klados and Tzortzakis, 2014). Since the number of literature data on lavender production and the effect of fertilization on antioxidant properties, composition and yield of essential oil are rather scarce, it is not surprising that there is a growing demand for such information.

Lavender does not have excessive requirements for nutrients, so it grows well on the types of soil where the cultivation of most other crops is not profitable. However, for obtaining high yields of herb and satisfactory quality of essential oil, fertilization is one of the most important agrotechnical measures. The synthesis of essential oil depends on the type of fertilizer and the applied dose. Of all the essential nutrients, nitrogen, phosphorous, and potassium have the greatest impact on lavender growth and essential oil synthesis. Lavender has the highest requirements for nitrogen, while the needs for phosphorus and potassium are small, and vary depending on the type of soil and nutritional status. However, it should be borne in mind that increased amounts of nitrogen negatively affect the production of essential oil, so precausation is essential in nitrogen application. These elements have a very positive effect on the function and level of enzymes involved in terpene biosynthesis (Hafsi et al., 2014).

Increased global demand has also conditioned increased demands for raw lavender from organic production. For these reasons, this experiment was performed to study the influence of different organic fertilizers on some important parameters of lavender productivity.

MATERIAL AND METHODS

The study of the impact of various organic fertilizers on the productivity of lavender was performed in 2019 in the organic lavender plantation "Sun Valley"

in the vicinity of Danilovgrad. Lavender was planted at a distance of 1.5x0.5 m, providing density of 13,300 plants/ha.

The experiment was performed in a randomized block system in 4 replications, and the size of the experimental plot was 7.5 m^2. In the experiment, 4 organic fertilizers were studied: Chap liquid (Ch), Guano (G), Slavol (S) and Vermicompost (apple pulp 60% and beef manure 40%) (V). Fertilization was done twice during the lavender growing season. The first time on March 27, at the beginning of the lavender growing season, and the second, 15 days after the first - April 10. A non-fertilized control variant (K) was also included in the experiment. Fertilization was performed by watering the plants with 200 ml of water solution of fertilizers in the following concentrations: Chap liquid - 150 ml of fertilizer in 10 l of water, Guano - 150 g of fertilizer in 10 l of water, Slavol - 150 ml of fertilizer in 10 l of water and Vermicompost - 1 kg fertilizer in 10 litters of water. Basic data on applied fertilizers are given in Table 1.

Table 1. Basic characteristics of the studied fertilizers

Fertilizer	**Chemical composition**						
	Organic matter content in dry matter (%)	**Total Nitrogen %**	**P_2O_5 (%)**	**K_2O (%)**	**Ca (%)**	**Mg (%)**	**pH**
Chap liquid (Ch)	70,5	3,62	0,95	4,67	0,75	0,40	7,5
Guano (G)	21-26	3-5	9-12	1-2	23-28	0,5-1	6,5-7,5
Slavol (S)	Slavol is a liquid microbiological fertilizer growth stimulator, certified for use in organic and conventional agricultural production. It contains microorganisms that produce auxins (indole 3 acetic acid) during the fermentation process. It contains nitrogen fixator and phosphomineralizators.						
Vermicompost (V) (Apple pulp 60% and beef manure 40%)	Vermicompost is an organic fertilizer that is obtained from manure, biological and communal waste and compost with the help of California worms. It contains a higher concentration of micro and macro biogenic elements than the substrate. Composition: organic matter 62, 3%, P_2O_5 0, 89%, K_2O 0, 5%, Ca 4, 40% and Mg 1, 09%. Ph of Vermicompost is 6, 8.						

The efficiency of the studied fertilizers was monitored through the following parameters: plant height, number of flower shoots and herb yield. The measurement of these parameters was performed on the day of harvest - June 15.

The soil in the experimental field belongs to the type of rendzina. It is low acidic (pH in water is 6.72, and in nKCl 5.77) and insufficiently supplied with plant nutrients (P_2O_5 3.5 mg/100 grams of soil and K_2O 11.3 mg/100 grams of

soil). It is characterized by favourable water and air properties and high content of humus (3.92%) and limestone (25.08%).

Based on the data shown in Table 2, meteorological conditions in 2019 were favourable for lavender crop. Warm (25.4 ^{o}C) and dry (15 mm) weather in June favoured the synthesis of essential oil and harvest.

Statistical processing of the data was done by the method of factorial analysis of variance (ANOVA), and the assessment of the differences between the mean values was performed using the LSD test.

Table 2. Meteorological conditions in the course of experiment

Month												Aver.
Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Air temperature (^{o}C)												
3.7	8.0	12.7	15.1	15.8	25.4	26.0	26.6	21.9	16.8	13.0	8.4	16.1
Amount of precipitation (mm)												Total
225	88	47	149	204	15	122	20	85	48	489	224	1715

RESULTS AND DISCUSSION

From the results given in Table 3, it can be seen that all fertilization variants had a significant effect on the height of the lavender plant. The greatest influence on the increase in average height was shown by the variants with the use of Slavol (59.5 cm), Shap liquid (58.8 cm) and Vermicompost (58.0 cm), while the lowest plants were measured in the control. Statistical processing of the data revealed a very significant increase in plant height in all fertilized variants. The analysis within the applied fertilizers revealed a significant increase in height on the variant fertilized with Slavol compared to the variant fertilized with Guan.

Jovovic et al. (2018, 2019a, 2019b) found a positive impact of Shap liquid, Slavol and some other organic fertilizers on the quality of lavender, immortelle and rosemary seedlings. They state that all the studied organic fertilizers significantly influenced the increase of plant height, aboveground biomass and root weight.

Tab. 2. Research results

Parameter	**Fertilization variant**				
	K	**G**	**Ch**	**S**	**V**
Plant height	49.8	56.8	58.8	59.5	58.0
Number of flower shoots	292.0	362.5	390.3	405.8	444.5
Herb yield (g)	225.3	313.5	284.8	337.3	314.0

	Lsd 0,05	Lsd 0,01
Plant height	2.105	2.910
Number of flower shoots	38.151	52.744
Herb yield (g)	41.038	56.735

The highest number of flower shoots was counted in the variants fertilized with Vermicompost - 444.5 and Slavol - 405.8, and the lowest in the non-

fertilized variant - 292.0. Differences in the number of flower shoots between all studied organic fertilizers and control were statistically justified. Lavender plants fertilized with Vermicompost had a statistically significantly higher shrub compared to variants fertilized with other organic fertilizers. By comparing the height of lavender plants in variants with the application of Slavol, Chap liquid and Guan, no differences were found for any level of probability.

Plants with the highest herb weight were found in the variant with the use of liquid organic fertilizer Slavol - 337.3 g. This fertilizer showed a significant increase in the weight of the herb compared to the control - 225.3 g, but also with the variant fertilized with Chap liquid - 284.8 g. The control variant gave significantly lower herb yield compared to all other tested fertilized variants.

The results given in Table 3 clearly show an increase in the yield of herb on all fertilized variants. The largest contribution to the increase in yield was found in the variants with the use of Slavol (150%), Vermicompost and Guan (139%). Such results were also influenced by favourable weather conditions. Higher amounts of precipitation in April (149 mm) and May (204 mm) caused higher efficiency of applied fertilizers, and thus higher vegetative growth of lavender.

Tab. 3. Fresh herb yield (kg ha^{-1})

Parameter	**Fertilization variant**				
	K	**G**	**Ch**	**S**	**V**
Herb yield (kg ha^{-1})	2996	4170	3788	4486	4176
Increase compared to control (%)	-	139	126	150	139

A significant increase in the biomass and the number of flowering spikesof of lavender fertilized with organic and organic-mineral fertilizers is also reported by Kara and Baydar (2013), Matysiak and Nogowska (2016) and Macedo Silvaa (2017). However, Raij (2011) states preference to mineral fertilizers, especially in the first harvest, due to higher nutrient availability and easier assimilations, lavender plants react very quickly after their application.

CONCLUSIONS

Based on the analyzed data for plant height, number of flower shoots and herb yield of lavender the following conclusions are:

- All the studied fertilizers had a very significant effect on increasing the height of the lavender plant.
- A very significant increase in the number of flower shoots was found on all fertilized variants.
- All variants with the application of organic fertilizers gave a higher yield of fresh herb compared to the non-fertilized control.

Since we have not had similar studies so far, this research should be continued in the future in order to obtain precise information on which fertilizers, in what dose

and with how many treatments the lavender crop should be fertilized in this and climatically similar areas.

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