Response of growth and active ingredients of *Lavandula angustifolia* plant to some bio-fertilization treatments

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ABSTRACT:

This study had been carried at the Horticulture Department, Faculty of Agriculture, Al- Azhar University, Nasr City during the two successive seasons, (2020/2021) and (2021/ 2022). The objective of this study is to investigate the effect of different bio-fertilization treatments (Aztobacter, Bacillus and VAM) on vegetative growth, essential oil percentage and chemical constituents of *lavandula angustifolia* plant. Lavender plants which received mixture of bio fertilization (AZ+BC+BM+VAM) produced the biggest mean values of plant height , dry weight and essential oil percentage and its major constituents, followed by those treated with (AZ+BC+VAM) and then come plants treated with (AZ+VAM), while the untreated plant gave the lowest values of plant height. GLC analysis essential oil of lavender shows that there is a clear difference in the composition of oil at the second season than that of the first season. At the first season the main constituents were recognized as camphor followed by eucalyptol, endo-borneol , β-Cymene, α-pinene and β-pinene. In the second GC-MS analyses showed the appearance of some compounds such as Linalool and terbineol and the absence of some other compounds such as camphor.

Keywords: Lavander; *Lavandula angustifolia*; bio-fertilization; Aztobacter; Bacillus; VAM.

INTRODUCTION

Volatile oils are aromatic oils that volatilize at room temperature and often have an aromatic smell. They are used in the manufacture of perfumes and cosmetics. They are also used medically in the treatment of many diseases due to their natural properties as disinfectants and antibiotics. Therefore, they are used in the pharmaceutical industry as antiseptic and antibacterial substances. (Pasias, *et al*. 2021).

One of these aromatic plants is Lavender (*Lavandula angustifolia) family*; Lamiaceae is one of its important genus. The lavender plant is a semi-shrub herbaceous plant, up to 60 cm high, with lumpy, woody growth at the bottom. The upper part bears dark silver, green leaves. The leaves are oblong, with a rough texture and aromatic scent. The plant bears flowers with a distinctive aromatic scent. (Chowdhury *et al*. 2017)

The chemical composition of lavender essential oil is a complex mixture that mainly are monoterpenes (e.g. eucalyptol, camphor, 1,8-cineole, and borneol , linalool) with few sesquiterpenes as minor oil constituents (Lane *et al*. 2010). In this context, Lavender has a great value in medicine, cosmetics industry, aromatherapy, perfume industry and as a culinary antibacterial, antifungal and antioxidant properties (Andrys and Kulpa, 2016). There have been several reports on the use of lavender essential oil as an antibiotic against many diseases, as an antiseptic for wounds, burns, and insect bites (Meftahizade, *et al*. 2011).

It is worth mentioning that there are lack information about the effect of bio-fertilization on growth and active ingredients of lavender in Egypt. In fact, little is known about its bio-fertilization recommendation that is available for its growers in Egypt.

It is known that bio-fertilizers facilitate the absorption of many nutrients into the soil, which leads to improve its absorption and utilization by plants (Haggag, *et al* 2014). In addition, bio-fertilization contain bacteria e.g. (Azotobacter and Bacillus sp) that stimulate growth regulators such as IAA and GA, which affect positively to encourage growth of the plant (Sharma and Kumar, 2008).

On the other hand, some types of fungal species of mycorrhizal fungi work in the same way to help in the secretion of organic acids that dissolve insoluble phosphorus in the soil, which facilitates its absorption by plants (De Melo Pereira, et al. 2012).

Mycorrhiza also works to increase plant immunity against diseases, pests and parasites due to its ability to produce antibiotics and growth regulators such as gibberellins, auxins and organic acids inside the plant (Tshikhudo, *et al*. 2023).

In general, it could be concluded that bio-fertilization produce soil nutrients especially nitrogen, and facilitate the absorption of nutrients, e.g. phosphorus, sulfur and nitrogen, which in turn facilitates the reduction of the need for mineral fertilization. It also stimulates the biological activity of the soil, dissolving trace minerals such as sulfur, zinc and manganese

Aboud *et al*., (2021), investigated the effect of bio-fertilizer from Mixtures of bacteria *Azotobacter* and *Azospirillum* by rates of 50 ml of each bacteria on Lavender *(Lavandula officinalis*). They mentioned that bio-fertilization increased Plant height and number of branches as well as fresh and dry weight and raised the percentage of oil content than the untreated plants

Shoeip *et al*., (2022), studied the effect of mineral and bio -fertilizers on the growth of *Lavandula Officinalis plant*. They applied both Azospirillum *spp.* and *Azotobacter spp* to the growing soil as soil drench at rate of 10^8 cfu /ml, They showed that the best values were recorded when mixing *Azospirilum spp. With Azotobacter spp*., followed by the values resulted from separate application with Azotobacter *spp.,* while the application with Azospirillum *spp.,* gave the least values of**???,**whereas they improved plant growth and chemical contents as compared to the control.

In this point of view, our current study was suggested to achieve the fallowing essential objects:

Work to recommend a practical protocol for lavender bio-fertilization under local conditions in (Cairo), which led to produce the highest yield of its growth.

Getting the best fertilizer treatments, from bio-fertilization, which give the highest production of volatile oil and the best possible quality?

MATERIAL AND METHODS

During the seasons of 2020/2021 and 2021/2022, this study was conducted on the Experimental Farm of the Horticultural Department, Faculty of Agriculture, Al-Azhar University, Nasr City, Cairo, Egypt. The objective of this study was to investigate the effect of some mineral and bio-fertilization on the vegetative growth and active ingredients of lavender *Lavandula* by *angustifolia* plant.

The soil of the experiment was prepared of mixture from clay soil and sandy soil at rate of (2: 1) plus to compost and was calculated for pots ate rate of 8 ton / Fadden. Serious of 30 cm diameter pots were filled with the mixture of the above prepared soil (0.250 Kg/pot), and were arranged according to the different treatments. Each treatment consisted of 3 replicates with 9 pots/each.

Both of temperature and humidity of the experimental site (Nasr City) during the two seasons of the experiment were obtained and presented in table (1). Solar radiation (the quantity of sun light on space unit by mg/m^2/day) was also obtained (Source: Egyptian Ministry of Agriculture & Land Reclamation, Agriculture Research Center, Central Lab. for Agriculture Climate) and recorded in table (1).

At the beginning of the experiment the mother plants of Lavandula angustifolia L. were obtained from the Horticulture Research Institute of Medicinal and Aromatic Plants Section in Giza, Egypt. Cuttings were prepared form mother plants at length of (10:15 cm), and planted in the previously prepared soil mixture until they were rooted. The rooted cuttings were planted in the above-prepared pots at mid of March in both seasons. Drip irrigation was used for watering plants in order to control the irrigation management using a frequency depending upon weather and plants conditions. The other agricultural procedures were performed whenever it is necessary.

Mixed cultures of three microorganisms were obtained from cultural collocation of Agric. Microbiology Dep. National Research Center, Egypt. The mixtures were prepared from (Azotobacter chroococcun), (Bacillus megaterium var. phosphaticum) and (Bacillus circulans) and were mixed according to (Venkateswarlu and Sethunathan 1984). Then they were used for plant inoculation.

Cretin kind of Vesicular arbscular mycorrhizal (VAM) fungi contains (Glomus etunicatum, Glomus intraradices and Glomus fasciculatum), was used for soil plant fertilization. The VAM solution was applied after transplanting at rate of 200 VAM spores/plant,x (20 gram/pot).

Each pot was inoculated with 10 ml of the bacterial suspension from the above-prepared three bacteria strains as well as mycorrhizal.

The bio-fertilization treatments were prepared as the follows:

10 mg from each of Azotobacter chroococcun, Bacillus megaterium var. phosphaticum and Bacillus. Circulans plus to 20 g of VAM (Bio 1).

10 mg of Azotobacter chroococcun plus to 20g of VAM. (Bio 2).

10 mg of each Azotobacter chroococcun and Bacillus circulans plus to 20g of VAM. (Bio 3chroococcun + Bacillus circulans + VAM. (Bio 3).

The following data were measured:

Plant height (cm) measured as the main plant stem from the ground surface upto its top.

Dry weight (g/plant): was obtained immediately after both cuts harvest during the two growing seasons.

Essential oil extraction: Samples of 25 g from the treated plants powders plus to the control were extracted with water-distillation for 3 hours using Clevenger-type apparatus according to (the Egyptian Pharmacopoeia, 1984). The volume of extracted volatile oil was recorded and its percentage (%) was estimated.

GC -MS Spectrometry analyses: The extracted lavender oil from each treatment was separately dehydrated with anhydrous sodium sulphate and kept in deep freezer until GC-MS analyses was performed according to (Margolin Eren, et al 2020).

The statistical design of the experiment was a complete randomized blocks design during the two seasons of the experiment. Snedecor (1980) using the analysis of variance (ANOVA) to conduct the statistical analysis.

RESULTS AND DISCUSSION

Effect of bio-fertilization on *Lavandula angustifolia L.* during the experimental seasons:

The effect on plant height (cm/plant):

The plant height (cm/plant) was recorded at monthly intervals during the experimental seasons of 2020/2021 and 2021/2022. The obtained results were tabulated in Tables (2&3) and illustrated in (Fig. 1&2). The mean values for plant height of *Lavandula angustifolia* were significantly affected by the different treatments of bio-fertilization in both seasons.

The bio-fertilization showed a different pattern in its effect on plant height Elshorbagy *et al* (2020) according to the type of the treatments. However, Lavender plants which received mixture of bio fertilization (AZ+BC+BM+VAM) resulted in the greatest mean values of plant height followed by those treated with (AZ+BC+VAM) and then that for plants treated with (AZ+VAM), while the untreated plant gave the least values of plant height. The averages were 19.48, 24.53, 23.38 and 23.85 cm/plant in the first cut while they were 22.31, 26.25, 25.28 and 25.56 cm/plant in the second cut at the first season for the control plant, Bio 1,Bio 3 and Bio 2 , respectively (Table 2).

It is worth mentioning that the least values in plant heights were observed for untreated plant with *Bacillus circulans* but still better than the control.

There is a report that VAM and Bacillus spp. can work with each other for promoting strongly plant growth as compared to that inoculated singly with either of them (Nanjundappa, *et al.* 2019) .

On the other hand, the rate of the gradual increase in plant height during the growing season showed a clear superiority for the plants treated with bio-fertilization compared to the control, but the difference in the rate of this increase was not sufficiently clear between the different treatments with bio-fertilization (Fig .1&2).

In addition, there was a remarkable increase in plant height rate at the period from June to July in the first cut and on November in the second cut compared to the other months of the experiment (Fig .1&2). This may be attributed to the favorable climate conditions at this period (Table 1).

This promoter action of bio-fertilizers on increasing plant height may be due to its role to improve plant growth by providing the availability of macro nutrients in the soil. They also help stimulating root system, thus increasing nutrients uptake and in return improving plant growth **(Yaseen *et al.*, 2020).**

The results of the second season confirmed strongly that of the first one since it took the same trend.

Our results come in accordance to Gharib, et al. (2008) on *Majorana hortensis and* El-Naggar *et al.*, (2015) on Ocimum basillicum plant and Elshorbagy *et al* (2020) on *Lavandula officinalis*.

Dry weights:

The mean values for herb dry weights of *Lavandula angustifolia* were affected significantly by the different treatments of bio-fertilization in both seasons.

The effect of bio -fertilization on Lavender plants indicated that plants which received mixture of bio fertilization (AZ+BC+BM+VAM

) produced the highest mean values of dry weight, followed by those treated with (AZ+BC+VAM) and then that plants which were treated with (AZ+VAM). Actually, the leastvalues were measured for the control.

The average values for dry weight were, 16.78 , 13.22, 15.56 and 10.78 g/plant in the first cut while they were , 32.22 , 30.33, 31.00 and 18.22 g/plant in the second cut in the first seasons for plants treated with Bio-1, Bio-3 and Bio-2 and control , respectively.(Table 4) and (Fig 3). Data in the second season confirmed strongly that of the first one.

This stimulating effect on vegetative growth of plants by adding bio -fertilizers may be due to the role of *Azotobacter and Bacillus* on improving the properties of soil to enable it to contain higher level of nutrient elements, that are of great benefit to plant growth [Abdel-Mouty *et. al,* 2001, Awad, 2007, EL-Etr and Hassan 2017 and Hafez, and Mahmoud 2009].

What is noteworthy to mention that, the promoter action occurred on the vegetative growth of plants with bio-fertilizers application may be because of the ability of bio-fertilizer on increasing soil fertility and its uptake of many micro-nutrients thus reflecting on improving the vegetative growth of plants. Meanwhile**,** Subba (1993) described another beneficial face of bio-fertilizers on to its important role in fixing atmospheric N as well as increasing the secretion of growth hormones, e.g. IAA, GA_3 and cytokinens, plus to increasing the availability of macro - nutrients.

Our results are in accordance with those reported by Sharma and kumer. (2008) on *Pisum sativum* L, Naiel *et al* (2019) on *Rosmarinus officinalis. and* EL-Zawawy *et al.* (2021) on *Calendula officinalis* , as well as they are in accordance with those reported by(Negi; *et. al*. (2007) on vegetable pea plant, and Shoeip *et al*., (2022) on *Lavandula Officinalis plant*.

Effect of bio -fertilization on volatile oil content (%):

Data in Table (5) and Fig (4&5) revealed that, in most cases ; treatments of bio-fertilizer led to a significant increment in volatile oil percentages compared to the untreated plants in both seasons. The bio- fertilization showed different pattern in its effect on essential oil percentages since it was differed according to the type of the treatments. However, lavender plants which received mixture of bio fertilization (AZ+BC+BM+VAM) produced the biggest mean values of essential oil percentages followed by those treated with (AZ+BC+VAM) and then come plants treated with (AZ+VAM), while the untreated plant gave the lowest values of essential oil percentages.

The averages of essential oil percentages of herb treated with bio -fertilization in the first season were 2.00, 1.50, 1.60 and 1.20 % for the first cuts and, 1.78, 1.53, 1.73 and 1.44% for the second cut. While in the second season they were, 2.48, 2.00, 2.02 and 1.21% for the first cut; and 2.21, 1.47 , 1.79 and 1.31% for the second cut as compared to the control for plants treated with (AZ+BC+BM+VAM), (AZ+VAM), (AZ+BC+VAM) and control ,respectively (Table 5) and Fig (4&5).

These results agreed positively with those found by Shoeip *et al*., (2022) on *Lavandula Officinalis.,* Jacoub (1999) on *Ocimum basilicum* and *Thymus vulgaris*.

It is interesting to mention from our results that the essential oil percentages in the first cut were higher than that of the second cut, this may be due to the decrease in the temperature in the period of the second cut harvesting (Table 1). Moreover, it was clear that during the time of the second cut harvesting (October), the solar radiation was of low amount, that in turn reflected in low photosynthesis affected and reduced the oil percentage (Table1).

Effect bio -fertilization on chemical ingredients of the volatile oil of *lavandula angustifolia* during the first season.

Gas Chromatography analysis of the essential oil showed that, twenty-four compounds in the essential oil of *Lavandula angustifolia* appeared during the investigation. The components of lavender volatile oil differed according to the plant species, environmental conditions, plant age, physiological agents and agricultural treatments. (Khalajee *et al.* (2017), Touati *et al*. (2011), Kara and Baydar, (2013) and Chrysargyris *et al*. (2017).

The main recognized constituent was remarked as camphor followed by eucalyptol, endo-borneol , β-Cymene, α-pinene and β-pinene .

On other side, the bio- fertilization showed different pattern in its effect on the major constituents of the essential oil percentage since it differed according to the type of the treatments (Table 6). However, Lavender plants which received mixture of bio - fertilization (AZ+BC+BM+VAM) produced the highest mean values of eucalyptol and camphor percentage followed by those treated with (AZ+BC+VAM) and then come plants treated with (AZ+VAM), while the untreated plant produced the lowest level of eucalyptol and camphor percentage.

The averages of eucalyptol and camphor percentage of essential oil treated with bio fertilization were (, 54.49, 51.71, 52.39 and 50.92%) while the camphor levels were (, 28.11, 25.06, 27.41 and 23.91%) in the first season compared to the plants treated with (AZ+BC+BM+VAM), (AZ+VAM), (AZ+BC+VAM) and control, respectively (Table 6).

Our results were in agreement with Meftahizade *et al.,* (2011) on *Lavandula officinalis* and Hassanpouraghdam et al., (2011) on *Lavandula officinalis* .

Effect of bio- fertilization on chemical ingredients of aromatic oil of *Lavandula angustifolia* during the second season.

GLC analysis of lavender essential oil in Table (7) shows that there is clear difference in the composition and components of oil in the second season than that of the first season. GC-MS analyses showed the appearance of some compounds such as Linalool and terbineol and the absence of some other compounds such as camphor. This may be due to many different factors, including harvest date, dehydrogenation, ambient weather conditions of heat, humidity, transplanting time, and other agricultural processes such as irrigation, composting and succession (Demissie *et al.*, 2011 and Sellami *et al.*, 2009).

About 30 components(previously 24 components) appeared in the volatile oil of lavender during the GLC analysis. The main components were Eucalyptol, terpineol and Linalool and others.

The different effect of bio -fertilization on the major constituents of the essential oil percentage was in relation to the treatments. Whereas, plants which received mixture of bio-fertilization (AZ+BC+BM+VAM) produced the highest mean values of the major constituents of the essential oil, followed by those treated with (AZ+BC+VAM) and then came the plants which were treated with (AZ+VAM). Actually, the least values were determined for the control (Table 7).

The averages of eucalyptol percentages were, 18.88, 18.54 ,18.65 and 17.46% while for terbineol they were, 1.36, 1.25, 1.32 and 0.94% and the third components linalool values were, 0.92, 0.66 0.68 and 0.01% for plants treated with (AZ+BC+BM+VAM), (AZ+VAM), (AZ+BC+VAM) and control, respectively (Table 7).

Related results were in harmony with ours as those mentioned by Shoeip *et al.,* (2022) on *Lavandula officinalis.,* Jianu *et al* (2013) on *Lavandula angustifolia,* Demissie et al. (2011), on *Lavandula angustifolia* and Garzoli et al (2019) on *Lavandula X intermedia*.

SUMMARY

This study had been performed at the Department of Horticulture, of Agriculture Faculty, Al- Azhar University, Nasr City during the two seasons, of (2020/2021) and (2021/ 2022). The main aims of this study are to examine the effect of different bio-fertilization treatments (Bacillus and VAM) on vegetative growth, essential oil percentage and chemical ingredients of *Lavandula angustifolia* plant.

Three rates of bio -fertilizers treatments (Azotobacter chrococcum + Bacillus circulans + Bacillus megaterium + mycorrhiza) , (Azotobacter chrococcum + Bacillus circulans + mycorrhiza) and (Azotobacter chrococcum + mycorrhiza) were added to lavender plants at monthly intervals. The treatments were to study its effect on herb vegetative growth, chemical constituents, essential oil percentage and its constituents of *Lavandula angustifolia* plants.

Accordingly, our current study was suggested to achieve the fallowing essential objects:

Work to recommend a practical protocol for lavender fertilization under local conditions in Egypt, which led to produce the highest yield of its growth.

Getting the best fertilizer treatments, whether from chemical fertilizer or from Nano and bio-fertilization, which give the highest production of volatile oil and the best possible quality.

The obtained data could be summarized as follows:

The effect on plant height (cm/plant):

Lavender plants which received mixture of bio - fertilization (AZ+BC+BM+VAM) produced the highest mean values of plant height followed by those treated with (AZ+BC+VAM) and then come plants treated with (AZ+VAM), while the untreated plant gave the lowest values of plant height.

What it I noteworthy that it was noticed that at the period from June until July there were a remarkable increase in rate of plant height growth as compared to the other growing months of the experiment. This may be due to the suitability of temperature and the solar radiation at this period.

Dry weight (gm/plant).

The effect of bio -fertilization on Lavender plants indicated that plants which received mixture of bio fertilization (AZ+BC+BM+VAM) produced the greatest fresh and dry weight, followed by those treated with (AZ+BC+VAM) and then with that were treated with (AZ+VAM). Actually, the least values were measured for the control.

Effect of bio- fertilization on essential oil content (%).

The treatment of bio-fertilizers led to a significant increase in the volatile oil percentages compared with control in both seasons.

Lavender plants which received mixture of bio- fertilization (AZ+BC+BM+VAM) produced the highest mean values for essential oil percentages followed by those treated with (AZ+BC+VAM) and then with that treated with (AZ+VAM), while the untreated plant gave the lowest values of essential oil percentages.

Effect of bio-fertilization on chemical ingredients of aromatic oil of *Lavandula angustifolia* during the first season.

Gas Chromatography analysis of the essential oil showed that, twenty-four compounds in the essential oil of *Lavandula angustifolia*___were appeared during the investigation.

The main constituent was recognized as camphor followed by eucalyptol, endo-borneol , β-Cymene, α-pinene and β-pinene .

On other side, Lavender plants which received mixture of bio -fertilization (AZ+BC+BM+VAM) produced the biggest mean values of eucalyptol and camphor percentage followed by those treated with (AZ+BC+VAM) and then with that treated with (AZ+VAM), while the untreated plant gave the lowest values of eucalyptol and camphor percentage.

Effect of bio fertilization on chemical ingredients of aromatic oil of *Lavandula angustifolia* during the second season.

GLC analysis of lavender essential oil shows that there is a clear difference in the composition and components of oil in the second season than that of the first season.

GC-MS analyses showed the appearance of some compounds such as Linalool and terbineol and the absence of some other compounds such as camphor.

About 30 components were found in the aromatic oil of lavender. The main components were Eucalyptol, terpineol and Linalool and others.

The highest percentages among all the components was eucalyptol followed by terpineol level while Linalool came after as the most biggest components of lavender essential oil under our investigation.

The influence of bio fertilization on the major ingredient of the aromatic oil percentage was differed according to the treatments.

plants which received mixture of bio fertilization (AZ+BC+BM+VAM) produced the highest mean values on the major constituents of the essential oil percentage followed by these treated with (AZ+BC+VAM) and then came the plants which were treated with (AZ+VAM). Actually, the least values were from the control.

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Table 1: The climatic condition at the experiment site (Nasr City) location where the experiments on *Lavandula angustifolia* L. were conducted during 2020/2021and 2021/ 2022 seasons.

Months	2021			2022		
	Minimum Temperature (°C)	Maximum Temperature (°C)	Solar Radiation (MJ/m^2/day)	Minimum Temperature (°C)	Maximum Temperature (°C)	Solar Radiation (MJ/m^2/day)
March	9.20	23.28	20.05	7.03	21.18	19.49
April	11.72	29.43	25.57	14.07	32.18	22.89
May	17.90	36.84	28.51	16.93	33.79	25.93
June	19.52	36.89	29.24	20.93	37.31	28.59
July	22.47	39.01	28.30	21.43	38.18	28.63
August	22.96	39.45	26.62	22.81	38.19	26.26
September	20.96	35.75	22.20	21.23	36.37	22.69
October	17.77	31.39	18.44	17.75	30.53	17.94
November	15.28	27.76	13.80	13.29	25.20	13.90

(Source: Egyptian Ministry of agriculture & Land Reclamation Agriculture search center Central Lab. for Agriculture Climate)

Table 2: Effect of bio-fertilization on the monthly averages of plant height (cm) of *Lavandula angustifolia* in the two cuts during 2020/2021 season.

Treatments	Concentrations	1 st cut					2 nd cut				
		April	May	June	July	Means	Aug	Sep	Oct	Nov	Means
Control	0.0	14.89	16.26	18.89	27.89	19.48	16.56	21.56	24.33	26.78	22.31
Bio	AZ+BC+BM+VAM	17.89	20.34	24.78	35.11	24.53	20.00	24.56	28.00	32.44	26.25
	AZ +VAM	17.44	19.31	24.22	32.56	23.38	19.44	23.11	27.56	30.99	25.28
	AZ+BC +VAM	17.67	19.50	24.78	33.44	23.85	19.67	23.56	28.00	31.00	25.56
L.S.D (NPK x Nano x Bio)		ns	1.61	2.21	3.21	1.80	2.13	1.86	3.05	3.26	2.08

AZ=Azotobacter chrococcum, Bm=Bacillus megaterium , BC=Bacillus circulans , VAM= mycorrhiza fangi

Table 3: Effect of bio-fertilization on the monthly averages of plant height (cm) of *Lavandula angustifolia* on the two cuts during 2021/2022 season.

Treatments	Concentrations	1 st cut					2 nd cut				
		April	May	June	July	Means	Aug	Sep	Oct	Nov	Means
Control	0.0	12.33	15.44	18.56	21.89	17.06	15.00	18.11	21.33	26.78	20.31
Bio	AZ+BC+BM+VAM	14.56	18.11	21.00	26.56	20.06	17.89	20.89	25.44	32.44	24.17
	AZ +VAM	13.56	15.78	18.00	23.78	17.86	16.00	19.67	22.78	29.44	21.97
	AZ+BC +VAM	13.89	16.11	18.89	24.00	18.14	16.44	20.00	23.56	30.00	22.50
L.S.D (NPK x Nano x Bio)		0.83	1.29	1.36	2.16	1.16	1.96	1.70	1.85	3.04	1.44

AZ=Azotobacter chrococcum, Bm=Bacillus megaterium , BC=Bacillus circulans , VAM= mycorrhiza fungi .

Table 4: Effect of bio-fertilization on the fresh and dry weights of *Lavandula angustifolia* on the first and second cuts during 2020/2021and 2021/2022 seasons

Treatments		Dry weight (g/plant)			
		Season(2020/2021)		Season(2021/2022)	
Concentrations		1 st cut	2 nd cut	1 st cut	2 nd cut
Control	0.0	10.78	18.22	11.00	22.56
Bio	AZ+BC+BM+VAM	16.78	32.22	15.11	34.33
	AZ +VAM	13.22	30.33	12.11	32.56
	AZ+BC +VAM	15.56	31.00	13.44	33.22
L.S.D (NPK x Nano x Bio)		5.75	7.54	2.97	10.16

AZ=Azotobacter chrococcum, Bm=Bacillus megaterium , BC=Bacillus circulans ,VAM= mycorrhiza fangi

Table 5: Effect of Bio fertilization on the essential oil percentage (%) of *Lavandula angustifolia* during the two seasons of 2020/2021and 2021/2022.

First season (2020/2021).			
Treatments		Oil percentage (%)	
	Concentrations	1St cut	2Nd cut
Control	0.0	1.20	1.44
	AZ+BC+BM+VAM	2.00	1.78
Bio	AZ +VAM	1.50	1.53
	AZ+BC +VAM	1.60	1.73
LSD (0.05)		0.71	0.73
Second season (2021/2022).			
		Oil percentage (%)	
Treatments	Concentrations	1St cut	2Nd cut
Control	0.0	1.21	1.31
	AZ+BC+BM+VAM	2.48	2.21
Bio	AZ +VAM	2.00	1.47
	AZ+BC +VAM	2.02	1.79
LSD (0.05)		0.35	0.31

AZ=Azotobacter chrococcum, Bm=Bacillus megaterium , BC=Bacillus circulans , VAM= mycorrhiza fangi.

Table 6: Effect of bio- fertilizers on essential oil compounds from *Lavandula angustifolia* during season of (2020/2021).

		Treatments	Bio- fertilization		
RT	Compounds	control	Bio (1)	Bio (2)	Bio (3)
3.99	Tricyclene	0.31	--	--	--
4.2	α-Pinene	1.58	3.89	3.45	3.56
4.61	Camphene	1.86	2.18	2.31	2.36
4.72	Verbenene	0.34	0.38	0.36	0.4
5.14	α-Phellandrene	0.23	--	--	--
5.28	(-)-2(10)-Pinene	1.65	2.3	2.05	2.25
5.64	2,3-Dehydro-1,8-cineole	0.39	0.32	0.33	0.37
6.43	Terpinolene	--	--	--	--
6.75	p-Cymene	0.98	1.63	1.37	1.45
6.92	Eucalyptol	50.92	54.49	51.71	52.39
7.72	trans-Sabinene hydrate	0.27	0.22	0.2	0.26
8.41	cis-β-Terpineol	--	0.16	0.1	0.12
8.96	Fenchone	0.18	0.46	0.56	0.46
10.5	Camphenol	0.25	0.35	0.34	0.37
11.11	Pinocarveol	0.45	0.52	0.45	0.55
11.32	Camphor	23.91	28.11	25.06	27.41
11.91	Pinocarvone	0.46	0.69	0.55	0.6
12.42	Isoborneol	1.66	1.93	1.78	1.95
13.33	Myrtenal	0.97	0.81	0.78	0.91
13.43	Myrtenol	0.41	0.28	0.26	0.27
13.95	l-Verbenone	0.2	0.15	0.09	0.16
15.03	Carvone	--	0.15	0.18	0.14
28.69	Caryophyllene oxide	0.21	0.41	0.38	0.39
31.07	δ-Cadinol	--	--	--	--

Table 7: Effect of bio -fertilizers on compounds of essential oil from *Lavandula angustifolia* during season of (2021/2022).

			Treatments		
RT	Compounds	control	Bio (1)	Bio (2)	Bio (3)
4.2	α-Pinene	6.31	3.77	3.44	3.56
4.61	Camphene	1.41	2.01	2.06	2.05
5.14	α-Phellandrene	1.22	1.35	0.95	1.31
5.28	(-)-2(10)-Pinene	5.47	2.45	2.65	2.51
5.73	β-Pinene	0.25	0.42	0.4	0.4
6.75	p-Cymene	0.65	1.57	1.25	1.37
6.92	Eucalyptol	17.61	18.88	18.54	18.65
7.18	trans-β-Ocimene	--	0.82	0.75	0.79
8.07	ç-Terpinene	--	--	--	--
8.41	cis-β-Terpineol	0.21	0.43	0.4	0.41
8.96	Fenchone	2.07	0.56	0.43	0.51
9.71	Linalool	0.01	0.92	0.66	0.68
10.46	α-Campholenal	0.68	1.15	0.91	1.01
11.27	(+)-2-Bornanone	24.6	25.31	25	25.12
11.35	trans-Pinocarveol	--	0.37	0.24	0.25
11.62	Verbenol	1.22	0.22	0.2	0.17
11.91	Pinocarvone	0.39	0.63	0.59	0.66
12.37	Isoborneol	--	5.51	4.85	5.01
12.41	endo-Borneol	--	4.32	4.02	4.22
12.59	Crypton	1.86	1.56	1.46	1.46
12.66	Terpinen-4-ol	1.39	1.25	1.11	1.22
13.33	Myrtenal	2.06	0.8	0.8	0.88
13.51	α-Terpineol	0.94	1.36	1.25	1.32
13.78	Myrtenol	1.36	1.57	1.41	1.52
14.63	cis-Carveol	--	0.61	0.41	0.5
15.23	Carvone	0.46	1.31	0.75	0.97
15.88	Cuminaldehyde	0.57	--	--	--
19.34	Hexyl (E)-2-methylbut-2-enoate	0.54	--	--	--
28.69	Caryophyllene oxide	1.25	1.37	1.32	1.35
30.91	tau.-Cadinol	3.5	3.54	3.21	3.47

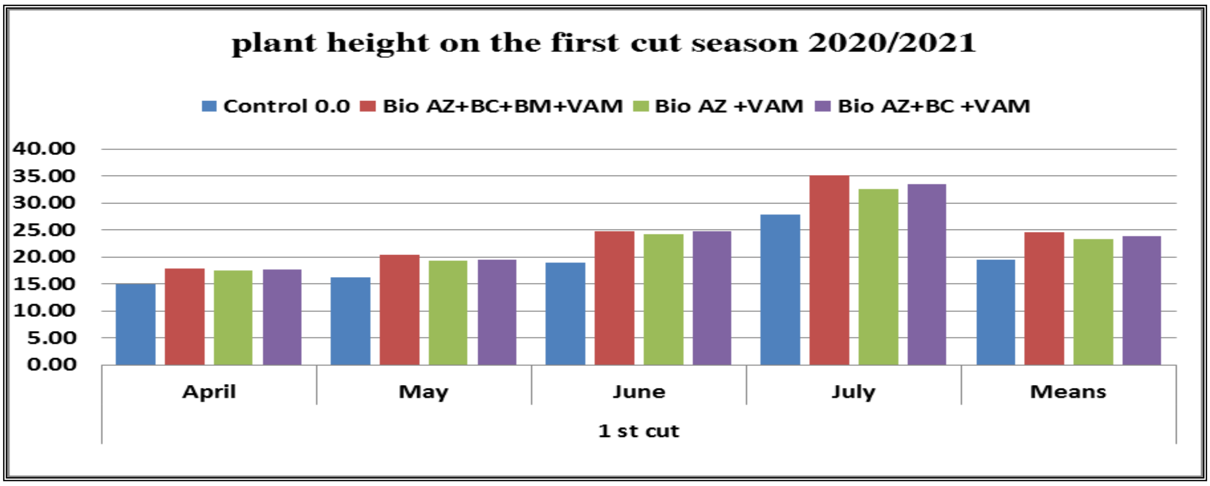

Figure 1: Effect of bio- fertilization on the monthly averages of plant height (cm/plant) of *Lavandula angustifolia* during the first cut of the first season (2020/2021).

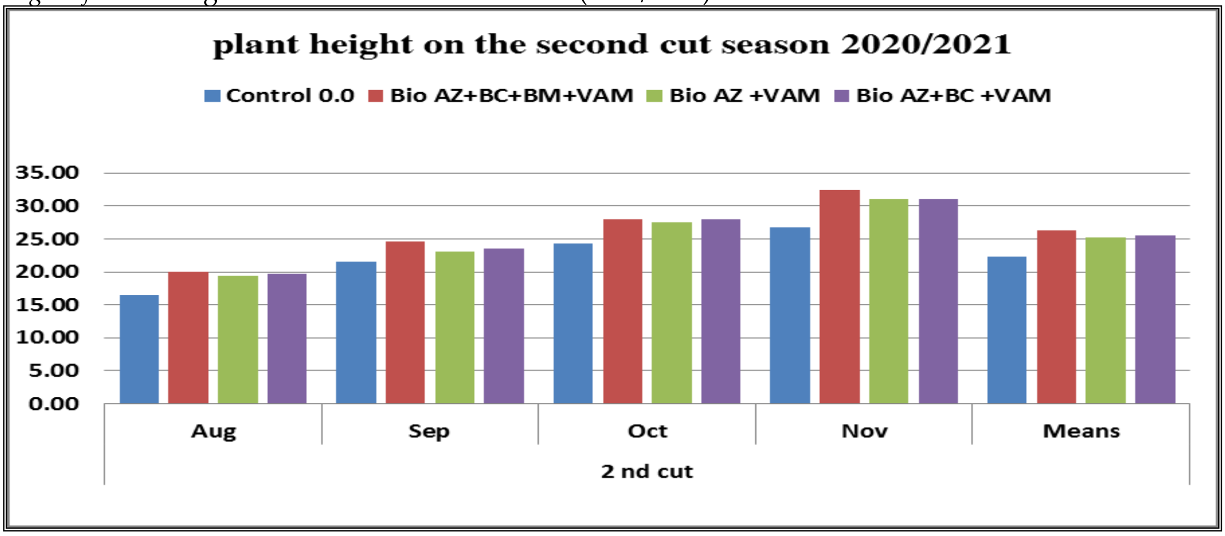

Figure 2: Effect of bio- fertilization on the monthly averages of plant height (cm/plant) of Lavandula *angustifolia* during the second cut of the first season (2020/2021).

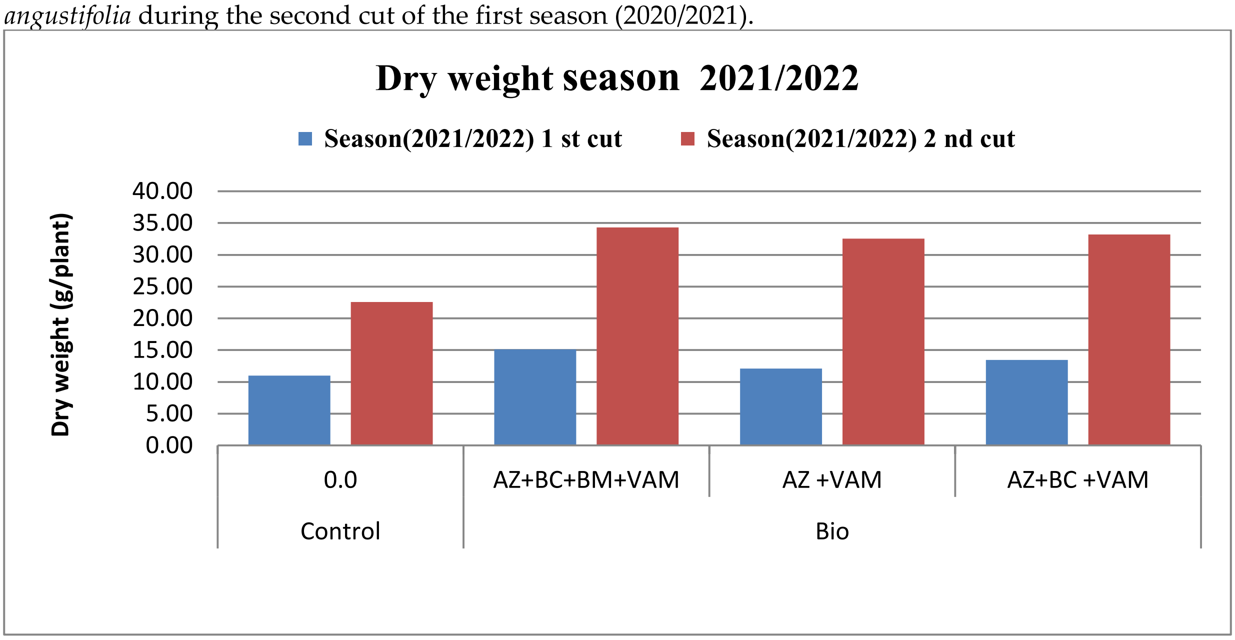

Figure 3: Effect of bio- fertilization on the dry weights of *Lavandula angustifolia* on the first and second cuts during 2020/2021and 2021/2022 season.

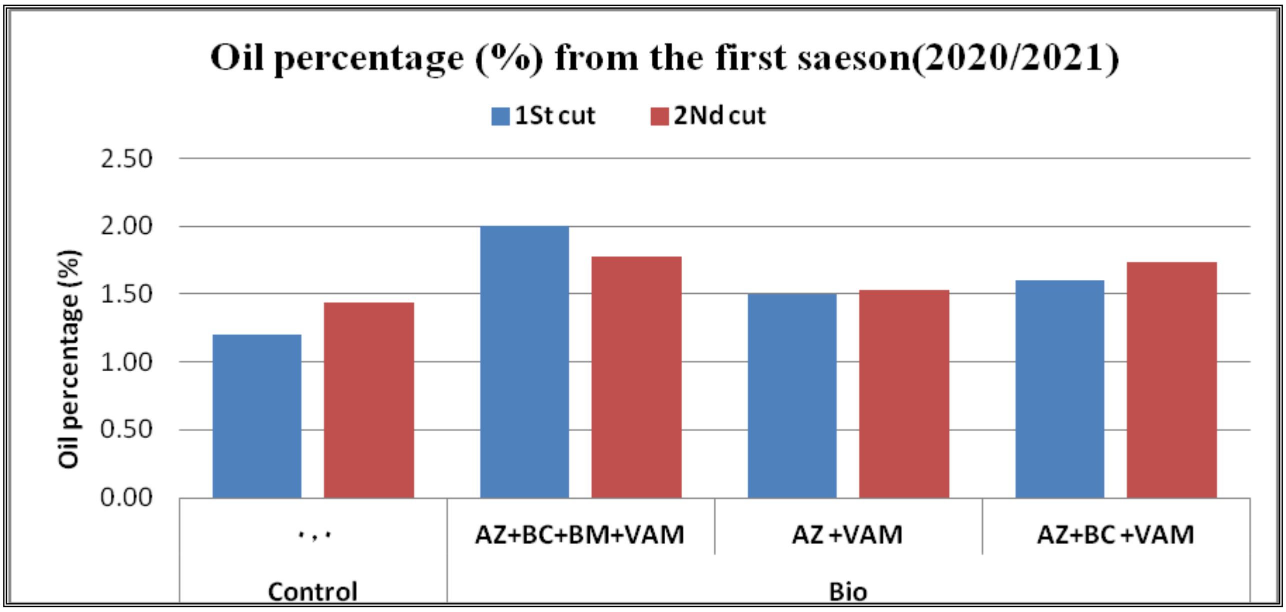

Figure 4: Effect of bio- fertilization on the essential oil percentage (%) of *Lavandula angustifolia* during 2020/2021 season.

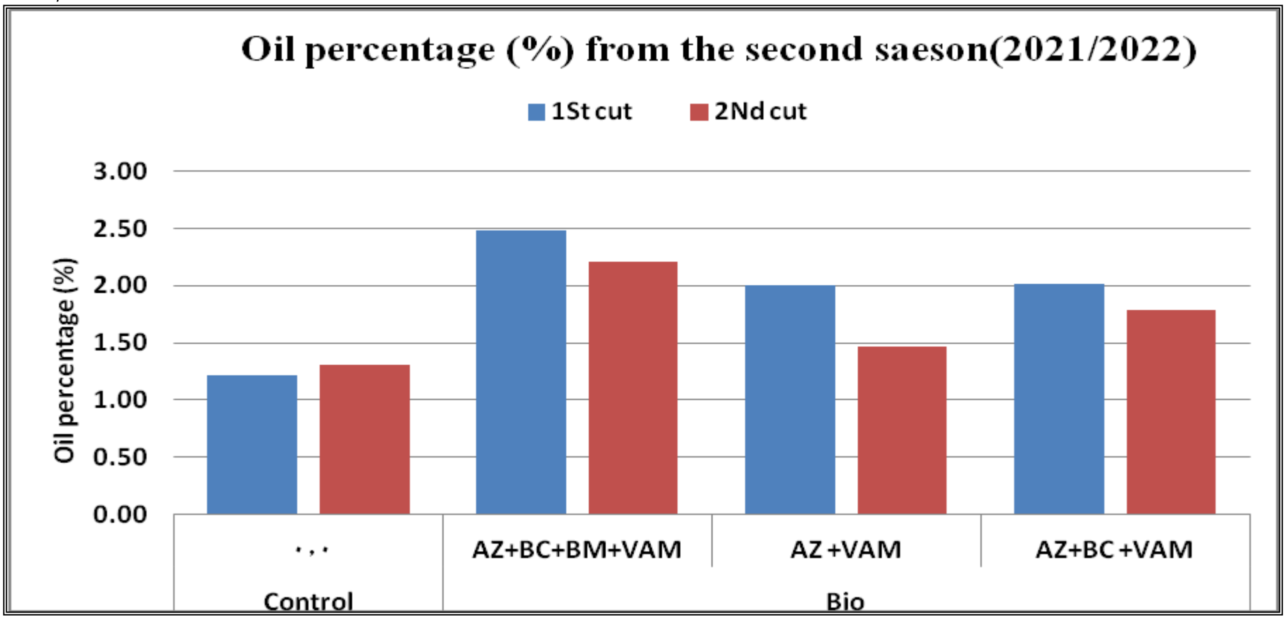

Figure 5: Effect of bio-fertilization on the essential oil percentage (%) of *Lavandula angustifolia* during season of 2021/2022.

استجابه النمو والمحتوى من المواد الفعالة في نبات اللافندر للتسميد الحيوى

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الملخص العربي:

قد أجريت هذه الدراسة في قسم البساتين ،كلية الزراعة ، جامعة الأزهر ، مدينة نصر خلال الموسمين المتتاليين ، (2021/2020) و (2022/2021) التسميد الحيوية المختلفة الهدف من هذه الدراسة علي النمو الخضري ، ونسبة الزيت الطيار والمكونات الكيميائية فى نبات اللافندر حيث استخدمت ثلاثة معدلات من علاجات الأسمدة الحيوية

(Azotobacter chrococcum + bacillus circulans + bacillus megaterium + mycorrhiza) و (Azotobacter chrococcum + bacillus circulans + mycorrhiza)و(Azotobacter chrococcum + mycorhiza)

اوضحت النتائج ان النباتات التي تلقت مزيجًا من التسميد الحيوي (AZ+BC+BM+VAM) أنتجت أكبر القيم المتوسطة لارتفاع النبات والوزن الجاف واعلى نسبه من الزيت ومكوناته الرئيسيه تليها أولئك الذين عولجوا بمخلوط (AZ+BC+VAM) ثم تأتي فى النهاية النباتات التى عولجت بخليط من (AZ+VAM) ، بينما أعطى النبات الغيرمعالج (الكنترول) أقل قيم لارتفاع النبات والوزن الجاف ونسبه الزيت واهم المكوناته الاساسيه. بالنسبه لتأثير التسميد الحيوي على المكونات الكيميائية للزيت الأساسي من خلال الموسم الأول فقد أظهر تحليل كروماتوجرافيا فى الموسم الاول التعرف على مكونات رئيسيه وهى:

camphor, . eucalyptol, endo-borneol , β-Cymene, α-pinene and β-pinene

اما فى الموسم الثانى اثبت تحليل زيت اللافندر الأساسي أن هناك اختلافًا واضحًا في تكوين ومكونات الزيت عن الموسم الأول حيث أظهرت تحليلات GC-MS ظهور بعض المركبات مثل Linalool و Terbineol وغياب الأخرى مثلCamphor .

الكلمات الاسترشادية: التسميد الحيوي, بكتريا ازوتوباكتر, ميكروهيزا, المواد الفعالة, نبات اللافندر.