Plant Archives Vol. 21, Supplement 1, 2021 pp. 2607-2619 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
doi link : https://doi.org/10.51470/PLANTARCHIVES.2021.v21.S1.425

EFFECT OF ORGANIC AND BIO-FERTILIZERON GROWTH, YIELD, AND ESSENTIAL OIL OF *LAVANDULA OFFICINALIS* L. PLANT GROWN IN TO SANDY SOIL

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ABSTRACT

Lavender (*Lavandula officinalis* L) has high economic and medicinal value. The current experiment was carried out during the two successive seasons 2018/2019 and 2019/2020. It aimed to investigate the effect of compost, biofertilizers (*Azospirillum* spp., *Azotobacter* spp.), mixtures of them, and active dry yeast on vegetative and chemical composition of lavender herbs cultivated on plastic pots filled with sandy soil. Fertilizers were added to the plant roots three times during the growing seasons. Growth and yield characteristics were quantitatively assessed and were compared to each other. Lavender essential oil percentage was determined from the fresh herb, as well as the oil constituents to assess the oil quality. Moreover, the study was tailed by an economic assay to determine the study feasibility. Results indicated that application of biofertilizers significantly increased plant height, number of branches, fresh weight, dry weight, yield, % essential oils, N, P, K%, crude protein content, total pigment, antioxidant, flavonoid, phenol, total carbohydrates, and free amino acids contents compared with the control treatment. Mixtures of bacteria (*Azotobacter*, *Azospirillum*) treatments were the superior in all measured variables. It also increased the percentage of essential oils. The main essential oils (EO) constituents were linalool, linalyl acetate, borneol, terpinen-4-ol, and 1,8-cineole. From the economic point of view, also the biofertilizer treatments were feasible, this could result in environmentally safe plants to minimize the hazards of pollution caused by using mineral fertilizers. The economic evaluation indicated that mixtures of bacteria resulted in the highest value of net return for lavender plants.
***Keywords*:** *Lavandula*, biofertilizers, Compost, *Azotobacter*, *Azospirillum*, yeast, yield, essential oil, Chemical compositions of essential oils, and economic evaluation.

Introduction

Lavender (*Lavandula officinalis* L.) belongs to the Lamiaceae family, which is characterized by its ornamental, medicinal, and economic value. Lavender is characterized by its high-quality essential oil which is considered raw material for many industries such as perfumes, cosmetics, and pharmaceutical industries (Chrysargyris *et al.*, 2020; Silva *et al.*, 2017; González-Coloma *et al.*, 2011; Touati *et al.*, 2011). Lavender herbage is rich in its oil content which has a high number of essential oils such as1,8 cineole, camphor, borneol, fenchol, α-pinene, β-pinene, trans-pinocarveol, and linalool (Mambrí *et al.*, 2018). According to (Demissie *et al.*, 2011; Meftahizade *et al.*, 2011) which reported the antiseptic activity of lavender plants, lavender essential oils were traditionally used as an agent in swabbing of wounds, burns, insect bites, and in veterinary practice to kill parasites. Lavender leaves and flowers have a high number of essential oils, which are effective in biological therapeutics, aromatherapy as a relaxant, carminative and sedative agents (El-Ghadban *et al.*, 2008; Hritcu *et al.*, 2012).

Fertilizer applications and minerals uptake are two factors that positively enhance and increase yield quantity and quality. Lavender essential oil characteristics are a factor of the form, type, and amount of the fertilizer treatments. Mineral fertilizers affect lavender growth and synthesis of essential oils, amino acids, proteins, enzymes, and nucleic acids (Chrysargyris *et al.*, 2018). Applications of nitrogen-fixing bacteria such as *Azotobacter* and *Azospirillum* spp. were reported to considerably enhance plant growth, due to the double role it plays as a bio-fertilizer that releases auxin, gibberellin, and cytokinin, which improves plant growth, in addition to minerals fixing in the root zone which enhances plant performance as well (Hammadi *et al.*, 2014).

Bio-fertilizers were known for their antifungal activities that increase plantlets germination, plants vigor, and fight plant diseases which contribute to the improvement of the vegetative growth, yield, and production for medicinal and aromatic plants (Moradi *et al.*, 2011; Shirkhodaei *et al.*, 2014; Khalil *et al.*, 2019). Nasr Alla *et al.* (2016) and Abdollahi *et al.*, (2016) on coriander plants, reported the increased vegetative growth and chemical parameters due to the biofertilizer application. Where Moradi *et al*. (2011) explained the effects of bio-fertilizers due to the different strain groups and nutrients mobilizing microorganisms which help in the availability of minerals and their forms in the composted material and increased levels of extractable minerals.

Active dry yeast has been used as a natural cofound biofertilizer which is reported to have stimulant effects on plant growth. Active dry yeast is a rich source of cytokinin which promotes cell division and amino acids and vitamin synthesis. In addition to CO_2 release into soil, which improves soil characteristics and increases plant photosynthetic activity. Many authors have reported the stimulant power of active dry yeast (Aly *et al*., 2007) on coriander, (Hemdan, 2008) on anise, (Dahab *et al*., 2010) on marjoram, and (Kenawy, 2010) on *Hibiscus sabdariffa*, L. plants, and (Matter and El-Sayed, 2015) on caraway plants.

Organic fertilizers have many forms such as natural mineral fertilizers, manure, husbandry animal waste, and compost. Compost is very rich in organic matter and minerals as well. Compost is a product where all-natural material and wastes are allowed to decompose to simpler organic and inorganic materials by the action of microorganisms (Hendawy *et al*., 2010). Compost not only rich in organic matter and nutrients but also with some useful microorganisms that improve soil's physical and chemical properties. Many studies have elaborated on the promotive role of compost in enhancing yield components (Ali *et al*., 2017; Hammadi *et al*., 2014; Darzi *et al.,* 2012).

The current experiment aimed to study the influence of compost, biofertilizers, and active dry yeast on the yield, oil productivity, and some chemical constituents of *Lavandula* plants.

Materials and Methods

This study was carried out during the two successive seasons of 2018/2019 and 2019/2020 in a net-house located in the Central Laboratory of Agricultural Climate Research Centre (CLAC), Dokki, Giza Governorate, Egypt. This experiment was a pot experiment with sand as a substrate. The experiment aimed to investigate the effect of biofertilizers (*Azospirillum* spp., *Azotobacter* spp.), mixtures of them, yeast and compost only by addition to the roots of lavender plants on vegetative growth, herb yield, essential oil quantity, and quality (chemical composition) compared with control (chemical fertilizer). A random sand sample was obtained before planting to determine its physical and chemical characteristics of sand and Irrigation water and compost analysis of the experimental soil before planting (table A and B), respectively.

Table (A) : Some physical, chemical characteristics of sand and irrigation water analysis of the experimental before planting.

Mechanical analysis (%)		Physical analysis		Chemical analysis (Anions and Cations (mmq/ L.)			
Coarse Sand	7.65	Bulk density g/l	1665	The experimental soil used		Irrigation water	
Fine Sand	54.87			pH (1: 2.5)	7.63	pH	7.60
Silt	23.52	Total pore space %	22	EC (dS/m3)	1.43	EC (dS/m^3)	1.20
Clay	13.96			SP %	27	SAR %	1.30
Texture class	Sandy Loam	water-holding capacity %	18.7	Ca^{++}	8.32	8.52	
Available nutrients (ppm)				Mg^{++}	1.05	3.62	
		Air porosity %	3.3	Na^{+}	3.50	3.24	
N	11.7			K^{+}	0.93	0.19	
P	10.00			CO_3^{--}	--	--	
K	20.20			HCO_3^{-}	2.28	6.29	
				Cl^{--}	1.92	2.20	
				SO_4^{--}	10.1	7.13	

Table (B): Some physical and chemical characteristics of the compost used

Physical properties		Values
Bulk density	Kg m^3	850
Moisture content	%	25.00
Chemical properties		
pH (1: 10)		7.71
EC (1: 10)	(ds/ m)	5.42
Organic matter	%	24
Organic Carbon	%	14.00
Ash	%	76.00
Total nitrogen	%	0.76
C/ N ratio		1 : 18
Total phosphorus	%	0.30
Total potassium	%	0.40
Available N (NH_4)	ppm	900
Available N (NO_3)	ppm	40
Seed Weed		--
Nematodes		--

Plant material and experimental design

Lavender Seedlings were obtained from the experimental station at El-Qanater El-Khairia. Seedlings were transplanted on 15thOctober 2018/2019 and 15thOctober 2019/2020. The seedlings were transplanted in plastic pots (5L volume) filled with well-mixed media of sand: compost (4:1v/v), except the control during the two seasons. The study was implemented in a completely randomized block design with six different treatments. Each treatment has three replicates, which has 10 pots at a distanceof 30cm between them. The solutions of *Azospirillum lipoferum*, Azotobacter *chroococcum*, mixtures of them, and yeast (4g/L) were prepared as described in the above section. Where, all addition was applied three times per cut, after 15 days from transplanting, respectively during the two seasons. But, the first of the two seasons was added directly after transplanting. The control treatment was fertilized by a chemical fertilizer according to the recommended dose in sandy soils.

Preparing of biofertilizers

The nitrogen fixer's bacteria (*Azotobacter chroococcum* and *Azospirillum lipoferum*) were isolated locally obtained from the Central Laboratory of organic agriculture (CLOA), Agriculture Research Center, Giza, Egypt. The N2-fixer's cultures containing 5X106 cfu/ ml. were used 50 ml. of each bacterial strain mixed with each other's before inoculation and diluted as 1:10 ml.

Experimental treatments:

T_1 = *Azospirillum lipoferum* +*Azotobacter chrooccocum.*

T_2= *Azotobacter chrooccocum.*

T_3 = *Azospirillum lipoferum.*

T_4 = yeast.

T_5 = compost.

T_6 = control (chemical fertilizer).

Data sampling: Three cuts were harvested per season. The plant's herbage was cut 5cm above the soil surface. Three random samples were selected for measurements and analysis. Plant physical and chemical parameters for the three cuts were examined as the following:

Soil temperature profile

Treatment soil temperature was recorded once a day using a handheld thermometer, then the monthly average was calculated from transplanting until the end of the experiment**.**

1-Vegetative growth characteristics of lavender herbs

Numbers of branches per plant, plant height (cm), Fresh and Dry weight (g/herb)**.**

2- Determination of the chemical composition of lavender herbs

2.1. Determination of essential oil (%) and essential oil yield

The distillation of 100 g fresh herb was continued for 2.5 to 3 hours after water boiling till no further increase in the oil was observed. Essential oil (ml/plant) was calculated by multiplying the average fresh weight of plant by the average oil percentage.

2.2. GLC analysis of the essential oil

The essential oil constituents were identified by Gas-Liquid Chromatography (GLC) according to Radwan (1978).

2.3. Determination of Pigments, Chlorophyll a, b and carotene were determined according to A.O.A.C. (1990).

2.4. Mineral contents (N, P, & K) and crud protein (%):

Total nitrogen was determined according to the Kjeldahl method as A.O.A.C. (1990). Crude Protein (%) was calculated by(Percentage of nitrogen * 6.25). Total phosphorus was determined according to Murphy and Riley, (1962) as modified by Watanabe and Olsen, (1965) and total potassium was determined by using a flame photometer according to A.O.A.C, (1990).

2.5. Determination of total carbohydrates were determined according to A.O.A.C. (1990).

2.6. Determination of free amino acids

Free amino acids were determined colorimetrically by using ninhydrin solution according to Jayeraman (1985).

2.7. Phenolic compounds (mg /100g FW):

The colorimetric method of Folin-Denis as described by Shahidi and Naczk, (1995)

2.8. Determination of antioxidant properties:

The antioxidant activity of plant methanol extract was determined based on the radical scavenging ability using DPPH (2,2-diphenyl-1-picryhdrazyl) radical in reacting with a stable free radical according to **Gulluce *et al.* (2004).**

2.9. Flavonoid determination:

Total Flavonoid determination have been determined according to Jia *et al*., (1999)

2.10. Determination of endogenous hormones by using GLC (**Wasey and Orrin 1975**).

Economic evaluation:

Total cost determined by thefixed cost (L.E/fed) cost of(substrate (compost) + plastic pots+Irrigation) and variable cost (seedling + biofertilizer application + yeast ++ fertilization+ Workers). Total yield for the two seasons was summed and multiplied by an average market price to represents the total income

- Net return = Revenue (L.E/fed)- Total cost (L.E/fed)
- The revenue to total Cost (B/C) ratio was calculated to represent the profit percentage.

Statistical analysis:

The statistical significance of observed differences among treatment means was evaluated by analysis of variance (ANOVA). Means were compared by the least significant difference test (LSD, $p \leq 0.05$). The obtained data were statistically analyzed by Waller and Duncan (1969). Duncan's Multiple Range Test at 5% was used for comparison of means. Duncan's multiple range test at 5% level of probability was used to compare means of the treatments.

Results and Discussion

Effect of organic and biofertilizer on vegetative growth and chemical Parameters: -

In this section the effect of the organic and bio-fertilizers on plant height (cm), number of branches, fresh and dry weight (g/plant), Essential oil (%), oil (g/herp), phenol (mg/100g FW),total carbohydrates (%), Crude Protein (%), N, P, K (%), total Flavonoid (mg/100FW), total Antioxidant (mg/100FW)and Total Free Amino Acids (mg/100gm).

Effect on vegetative growth

Data in tables (1) shows the effect of biofertilizer (*Azotobacter*, *Azospirillum* spp.) mixtures of them treatment (T_1) have the highest values of the vegetative growth, the yield, and quality parameters. The application of bio-fertilizers significantly increased all parameters compared to the compost and the control treatments during the two seasons. Data also indicates that the application of treatment (T_1) was superior followed by the application of yeast for the three cuts and the two successive seasons.

Table (1) : Effect of organic and bio-fertilizer on vegetative growthof lavender plants

Treatment	Plant height (cm)			Number of branches/plants			Fresh weight (g/plant)			Dry weight (g/plant)		
Harvest	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
First season												
T_1	43.72^{a}	58.10^{a}	65.40^{a}	7.17^{a}	12.97^{a}	17.47^{a}	166.26^{a}	233.47^{a}	344.60^{a}	53.42^{a}	98.88^{a}	117.89^{a}
T_2	39.17^{b}	44.60^{b}	56.27^{b}	6.80^{a}	12.60^{a}	17.10^{a}	127.26^{b}	229.95^{b}	297.32^{b}	44.48^{b}	82.11^{b}	117.67^{a}
T_3	35.00^{c}	40.67^{cd}	53.05^{c}	6.89^{a}	12.69^{a}	17.19^{a}	122.95^{c}	212.07^{d}	280.31^{e}	37.22^{c}	77.09^{c}	109.45^{b}
T_4	36.33^{c}	41.30^{c}	52.28^{c}	6.00^{a}	11.80^{a}	16.30^{a}	99.63^{d}	224.64^{c}	288.30^{c}	37.59^{c}	81.08^{b}	110.69^{b}
T_5	30.91^{d}	40.23^{cd}	47.53^{d}	4.67^{b}	10.47^{b}	14.97^{b}	75.08^{e}	210.98^{d}	285.30^{d}	28.19^{d}	78.57^{c}	104.83^{c}
T_6	28.44^{e}	38.83^{d}	45.01^{e}	4.27^{b}	10.07^{b}	14.57^{b}	65.96^{f}	205.39^{e}	267.00^{f}	27.01^{d}	72.36^{d}	98.52^{d}
LSD	1.44	2.13	2.21	1.32	1.22	1.18	1.4	1.3	1.1	2.2	2.3	1.6
Second season												
T_1	38.61^{a}	53.03^{a}	59.50^{a}	7.00^{a}	11.00^{a}	15.33^{a}	158.95^{a}	222.17^{a}	334.88^{a}	52.39^{a}	84.96^{a}	113.33^{a}
T_2	35.14^{b}	42.31^{b}	54.75^{b}	5.33^{b}	9.33^{b}	13.67^{b}	118.63^{b}	220.90^{a}	287.60^{b}	43.04^{a}	74.39^{b}	111.22^{b}
T_3	33.17^{c}	40.17^{c}	53.00^{c}	5.00^{b}	9 .00^{b}	12.33^{b}	118.21^{b}	207.60^{b}	269.66^{d}	32.51^{b}	58.59^{d}	106.06^{c}
T_4	34.97^{b}	40.38b^{c}	51.60^{c}	5.00^{b}	9 .00^{b}	13.27^{b}	96.53^{c}	208.64^{b}	285.43^{c}	34.78^{b}	62.57^{c}	108.72^{d}
T_5	33.40^{c}	38.78^{cd}	47.25^{d}	4.33^{bc}	8.33^{bc}	12.33^{b}	67.90^{d}	200.50^{c}	260.08^{e}	26.66^{c}	62.31^{c}	87.28^{e}
T_6	31.20^{d}	37.83^{d}	42.31^{e}	3.33^{c}	7.33^{c}	9.33^{c}	60.05^{e}	188.78^{d}	208.30^{f}	24.87^{d}	44.54^{e}	86.85^{e}
LSD	1.5	2.05	2.24	1.45	1.33	1.47	1.1	2.1	2.1	1.5	1.8	1.9

*T_1= *Azospirillum lipoferum + Azotobacter chroococcum*,T_2=*Azotobacter chroococcum*, $T_{3=}$ *Azospirillum lipoferum*, T_4 =*yeast*, T_5=*compost*, T_6=*control.*

Many authors attributed the superior effect of biofertilizer to the ability to mobilize plant nutrients in the soil from unusable to usable form through biological processes. These fertilizers are considered as plant growth promotors with no harmful effects to plants, unlike chemical fertilizers. Biofertilizers protect plants from getting diseases (Sadhana, 2014). Our results are in agreement with those achieved by Abd-ElWahab and Hassan (2013) and Hekmat *et al.* (2017) who indicated that Bio-Fertilizers and yeast showed a significant increase in vegetative growth parameters of fennel and*Majorana* plants. Moreover, Sabra (2014) confirmed that active dry yeast enhanced plant vegetative growth parameters of Khella. The addition of compost and biofertilizers mixture increased fresh and dry weights in the fourth cut compared to the other treatments in marjoram plants(Dewidar, 2007).They attributed results to the effect of organic fertilizer in improving not only the soil's physical and biological properties but also chemical characteristics and increased the total number of bacteria and the populations of nitrogen-fixers in the rhizosphere of lavender plants resulting in more release of available nutrient elements to be absorbed by plant roots. It is well known that following up N, P, K in the vegetative growth of such plant, is of great importance, and correlate with the other foliage parameters and the macro-nutrients uptake by roots plant increased significantly by the addition of organic composts to the soil.

Effect of organic and bio-fertilizer on essential oil and essential oil compositions

Lavender oil is one of the most valuable aromatherapy oils. It is characterized by its anti-microbial activities which may be attributed to the main essential oils it contains such as 1,8 cineol, linalool, linalyl acetate, lavandulol, geraniol, or eucalyptol. Data presented in table (2) shows the essential oil percentage and oil content (mL/plant). It is evident that the application of biofertilizer of the treatment (T_1), resulted in the highest oil content in the two successive seasons, while the treatment (T_6) exerted the lowest one. All treatments showed a significant difference compared with the control treatment as well as among each other.

Table 2 : Effect of organic and bio-fertilizer on essential oil percentage, oil (g/plant),Total oil (yield), and fresh weight leaves lavender plants

Treatment	Essential oil %			Oil (g/herp)			Total	Total
Harvest	1st	2nd	3rd	1st	2nd	3rd	Oil (yield)	Fresh weight
First season								
T_1	0.707[a]	0.487[a]	0.277[a]	1.176[a]	1.136[a]	0.953[a]	3.27	744.32
T_2	0.525[b]	0.437[b]	0.274[b]	0.668[b]	1.004[b]	0.814[b]	2.49	654.52
T_3	0.475[c]	0.314[e]	0.228[e]	0.584[c]	0.665[e]	0.640[e]	1.89	615.33
T_4	0.468[d]	0.425[c]	0.271[c]	0.466[d]	0.955[c]	0.781[c]	2.2	612.57
T_5	0.383[e]	0.360[d]	0.244[d]	0.287[e]	0.760[d]	0.697[d]	1.74	571.37
T_6	0.274[f]	0.255[f]	0.178[f]	0.181[f]	0.524[f]	0.475[f]	1.18	538.35
LSD	**0.003**	**0.002**	**0.002**	**0.001**	**0.002**	**0.002**		
Second season								
T_1	0.641[a]	0.478[a]	0.270[a]	1.019[a]	1.062[a]	0.904[a]	2.99	716
T_2	0.523[b]	0.434[b]	0.268[ab]	0.620[b]	0.959[b]	0.772[b]	2.35	627.13
T_3	0.472[c]	0.316[d]	0.221[c]	0.558[c]	0.655[d]	0.595[d]	1.81	595.47
T_4	0.460[d]	0.357[c]	0.267[b]	0.444[d]	0.744[c]	0.762[c]	1.95	590.6
T_5	0.406[e]	0.313[e]	0.218[d]	0.276[e]	0.628[e]	0.567[e]	1.47	528.48
T_6	0.338[f]	0.253[f]	0.165[e]	0.203[f]	0.478[f]	0.344[f]	1.03	457.13
LSD	**0.002**	**0.002**	**0.002**	**0.002**	**0.002**	**0.002**		

*T_1= *Azospirillumlipoferum + Azotobacter chroococum*,T_2= *Azotobacter chroococum,* $T_{3=}$ *Azospirillumlipoferum,* T_4 =*yeast,* T_5=*compost,* T_6=*control.*

The increase in oil yield might be due to either increase in the plant fresh weight or changes in leaf oil concentration. Safwat & Badran, (2002) confirmed the same results of the promoting effect of compost mixed with Azotobacter where the highest essential oil content was recorded in cumin plants. Moreover, the application of aquas compost increased essential oil percentage and yield in marjoram plants compared with their control during the three cuttings (Edris *et al*., 2003), J. citronella (Adholeya & Prakash, 2004). although, data showed that the value total oil (yield) of the treatment (T4) approximate was between the treatment (T_2 and T_3) during the two seasons. While the promoting effect of active dry yeast was reported on, rosemary (Balbaa and Talaat, 2007), fennel (Gomaa and Yousef, 2007, and Badran *et al*., 2007), chamomile (Hendawy and Khalid, 2011), Khella plants (Sabra 2014) and Caraway plants (Matter and El-Sayed, 2015) and *Majorana* plants (Hekmat *et al.,* 2017).

Effect of organic and biofertilizers on lavender essential oils composition:

GC profile also reveals the presence of thirteen identified compounds that existed in relatively different proportions (minor components). The effect of organic and biofertilizers on the different constituents of *Lavandula officinalis*, L crude essential oils are illustrated in tables (3,4) for the first, second, and third cuts two successive seasons. The main features that characterize the essential oil investigated in the present study are:

1. The superiority of linalool varied from one cut to another. The highest value was attained by the mixture of *Azotobacter* spp., *Azospirillum* spp., (59.10 and 57.08 %) in the first cut during the two seasons respectively. Whilst the lowest value (45.04 – 43.02 %) in the control second cut in the two seasons respectively.
2. 1,8 cineol was the second major constituent in all treatments and showed variable fluctuations due to fertilizer application, however, the highest concentrations were resulted from the application of yeast and compost with the same values in the second cut (17.80, 17.78%) for the two seasons respectively.
3. Camphene and Terpine-4-01 and linalyl acetate come in the third order in the essential oil composition in a varying ratio and responded differently due to the application of the fertilizers.

The anti-microbial activities of lavender essential oil were reported by many authors. Danh *et al*. (2013) reported the strong activity of linalool against a wide range of microorganisms. While Mantovani *et al*. (2013) reported the anti-parasitic activity of borneol. Adaszynska and Swarcewicz (2014) reported the anti-fungal activity of 1,8-cineol, linalool, terpinen-4-ol against Gram-positive and negative strains. Góra and Lis (2005) explained the anti-microbial activity of the essential oil by the ratio between the sum of linalyl acetate with linalool to the content of terpinen-4-ol. he reported a good anti-microbial activity when this ratio is greater than13. Considering this ratio, the application of the mixture of *Azotobacter* spp., *Azospirillum* spp., in the first season (16.1) and *Azospirillum spp*. (17.5) in the second season resulted in the highest anti-microbial activity compared to the other treatments in the two seasons. On the other hand, high concentrations of 1,8 cineole, camphor, or terpinen-4-ol adversely affect the quality of this oil (Góra and Lis, 1995). Compost application in growing basil contributes not only to an increase in essential oil content but also increases the concentration of linalool and borneol in the oil, with a simultaneous decrease in the content of methyl chavicol and 1,8-cineole (Taie *et al*., 2010 and Mambrí *et al*., 2018).

Effect on pigments content:

Concerning the response of photosynthetic pigments to the application of the different fertilizers throughout the vegetative phase. Data presented in tables (5) reveal that a significant difference had been recorded in the case of Chl a, b, carotenes, and total pigment in comparison with the untreated plants (control) and also among most of the treatments of each others during the two successive seasons. It is interesting to note that all treatments exerted a significant increase in total pigments, compared with the control treatment. This holds true for all treatments and the three cuts during the two seasons. tables (5) reveal that the application of biofertilizer mixture of *Azotobacter* spp., *Azospirillum* spp., resulted in the highest pigments contents (Chl. a, b and carotenes) during the two successive seasons, while the control treatment exerted the lowest one. We found our results in agreement with Abdou *et al*. (2011) on basil plants, Abdou *et al*. (2012) on fennel plants, and Hekmat *et al*. (2017) on Marjoram Plants. Fatma *et al.* (2008a, b) onMarjoram and lavender Plantsattributed the significant increase of photosynthetic pigments due to the application of bio-fertilizers to its regulatory effect that balances photosynthesis and photorespiration, delaying the aging of leaves, enhancing the protein and RNA synthesis.

Table 3 : Effect of organic and bio-fertilizer on essential oils composition of leaves lavender plants during the first season.

Treatment / Component	*Azotobacter + Azospirillum*			*Azotobacter*			*Azospirillum*			Yeast			Compost			Control		
cuts	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
α- pinene	2.91	2.98	4.56	4.91	5.98	5.44	5.34	6.70	6.02	5.35	6.68	6.01	5.35	5.18	5.26	6.73	6.23	6.48
Camphene	3.49	5.34	5.92	5.46	4.33	4.90	5.17	3.35	4.26	5.17	3.99	4.58	6.36	4.45	5.41	5.17	6.21	5.69
Myrcene	0.88	0.99	0.93	0.86	0.77	0.81	0.91	0.78	0.85	1.98	1.03	1.51	0.86	0.81	0.84	0.66	1.98	1.32
α- pinene	2.94	2.13	2.77	2.52	2.35	2.43	2.52	1.90	2.21	3.74	3.43	3.59	4.11	3.08	3.60	3.13	2.98	3.05
1,8 cineol	16.02	15.34	15.68	15.25	14.65	14.95	13.89	15.54	14.71	16.69	17.80	17.25	14.59	17.80	16.19	16.03	15.54	15.78
Limonene	2.67	2.31	2.49	3.67	2.14	2.91	3.92	1.68	2.80	2.22	1.39	1.80	2.62	2.02	2.32	2.22	1.30	1.76
Linalool	59.10	55.16	55.56	55.10	49.78	52.44	53.77	52.41	53.09	53.94	49.96	51.95	55.98	46.04	51.01	49.29	45.04	47.16
Camphor	2.27	2.81	2.35	3.04	2.40	2.72	2.04	2.69	2.36	2.89	3.29	2.90	1.39	3.29	2.34	2.05	2.83	2.44
Broneol	2.09	4.10	3.46	2.09	8.17	5.13	4.66	5.03	4.85	2.61	5.32	3.97	2.72	8.32	5.52	4.86	8.40	6.63
Terpine-4-01	3.84	3.72	3.62	3.94	3.45	3.80	3.81	3.81	3.94	3.81	3.77	3.53	3.94	3.76	3.92	4.78	4.31	4.55
linalyl acetate	2.91	2.96	1.34	2.91	3.07	2.99	3.26	2.88	3.07	2.37	2.57	2.47	2.46	2.99	2.72	2.11	1.73	1.92
Eugenol	0.92	1.07	1.99	1.12	1.20	1.16	1.64	1.39	1.52	1.56	1.10	1.33	1.08	1.85	1.47	2.30	2.99	2.64
α- canyoph	1.37	1.77	1.88	2.37	2.31	2.34	1.17	1.86	1.52	1.99	1.66	1.82	1.04	1.02	1.03	2.14	2.89	2.52

Table 4 : Effect of organic and bio-fertilizer on essential oils composition of leaves lavender plants during the second season.

Treatment / Component	*Azotobacter + Azospirillum*			*Azotobacter*			*Azospirillum*			Yeast			Compost			Control		
cuts	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
α- pinene	4.93	5.00	6.58	6.93	8.00	7.46	7.36	8.72	8.04	7.37	8.70	8.03	7.37	7.20	7.28	8.75	8.25	8.50
Camphene	3.03	4.89	5.47	5.01	3.87	4.44	4.71	2.89	3.80	4.71	3.53	4.12	5.90	3.99	4.95	4.71	5.76	5.23
Myrcene	0.86	0.97	0.91	0.84	0.75	0.79	0.89	0.76	0.83	1.96	1.01	1.49	0.84	0.79	0.82	0.64	1.96	1.30
α-pinene	2.92	2.11	2.75	2.50	2.33	2.41	2.50	1.88	2.19	3.72	3.41	3.57	4.09	3.06	3.58	3.11	2.96	3.03
1,8 cineol	16.00	15.32	15.66	15.23	14.63	14.93	13.87	15.52	14.69	16.67	17.78	17.23	14.57	17.78	16.17	16.01	15.52	15.76
Limonene	2.65	2.29	2.47	3.65	2.12	2.89	3.90	1.66	2.78	2.20	1.37	1.78	2.60	2.00	2.30	2.20	1.28	1.74
Linalool	57.08	53.14	53.54	53.08	47.76	50.42	51.75	50.39	51.07	51.92	47.94	49.93	53.96	44.02	48.99	47.27	43.02	45.14
Camphor	2.25	2.79	2.33	3.02	2.38	2.70	2.02	2.67	2.34	2.87	3.27	2.88	1.37	3.27	2.32	2.03	2.81	2.42
Broneol	2.07	4.08	3.44	2.07	8.15	5.11	4.64	5.01	4.83	2.59	5.30	3.95	2.70	8.30	5.50	4.84	8.38	6.61
Terpine-4-01	3.72	3.80	3.91	3.82	3.43	3.78	3.59	3.59	3.09	3.89	3.95	3.87	3.71	3.44	3.57	4.76	4.29	4.53
linalyl acetate	2.89	2.94	1.32	2.89	3.05	3.97	3.24	2.86	3.05	2.35	2.55	2.45	2.44	2.97	2.70	2.09	1.71	1.90
Eugenol	0.90	1.05	1.97	1.10	1.18	1.14	1.62	1.37	1.50	1.54	1.08	1.31	1.06	1.83	1.45	2.28	2.97	2.62
α-canyoph	1.35	1.75	1.86	2.35	2.29	2.32	1.15	1.84	1.50	1.97	1.64	1.80	1.02	1.00	1.01	2.12	2.87	2.50

Table 5 : Effect of organic and bio-fertilizer on pigments content of leaves

Treatment	Chl.a (mg/100 FW)			Chl.b (mg/100 FW)			Carotene (mg/100 FW)			Total pigment (mg/100 FW)		
Harvest	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
First season												
T_1	0.224^{a}	0.214^{a}	0.201^{a}	0.111^{c}	0.080^{b}	0.057^{a}	0.105^{a}	0.082^{b}	0.062^{b}	0.440^{a}	0.363^{b}	0.306^{a}
T_2	0.207^{b}	0.192^{b}	0.185^{b}	0.108^{d}	0.071^{d}	0.055^{b}	0.097^{b}	0.074^{d}	0.062^{b}	0.412^{d}	0.330^{c}	0.288^{b}
T_3	0.202^{c}	0.190^{c}	0.180^{c}	0.090^{f}	0.058^{f}	0.055^{b}	0.094^{c}	0.069^{e}	0.054^{c}	0.386^{f}	0.307^{e}	0.276^{d}
T_4	0.198^{d}	0.188^{d}	0.185^{b}	0.119^{b}	0.100^{a}	0.054^{b}	0.104^{a}	0.088^{a}	0.065^{a}	0.421^{c}	0.373^{a}	0.284^{c}
T_5	0.197^{d}	0.186^{e}	0.174^{d}	0.102^{e}	0.074^{c}	0.049^{c}	0.092^{d}	0.077^{c}	0.055^{c}	0.391^{e}	0.325^{d}	0.265^{e}
T_6	0.195^{e}	0.172^{f}	0.166^{e}	0.147^{a}	0.062^{e}	0.050^{c}	0.092^{d}	0.077^{c}	0.064^{a}	0.433^{b}	0.305^{f}	0.256^{f}
LSD	**0.0011**	**0.0011**	**0.0011**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.002**	**0.001**	**0.002**
Second season												
T_1	0.194^{a}	0.187^{a}	0.173^{a}	0.098^{c}	0.063^{a}	0.049^{a}	0.089^{b}	0.072^{ab}	0.055^{a}	0.401^{a}	0.329^{a}	0.277^{a}
T_2	0.175^{b}	0.171^{b}	0.165^{b}	0.091^{d}	0.058^{b}	0.046^{b}	0.070^{e}	0.071^{b}	0.054^{a}	0.353^{d}	0.304^{b}	0.265^{b}
T_3	0.173^{c}	0.167^{c}	0.151^{c}	0.086^{e}	0.056^{c}	0.043^{c}	0.088^{b}	0.068^{c}	0.050^{b}	0.364^{c}	0.297^{c}	0.244^{d}
T_4	0.172^{c}	0.165^{d}	0.148^{d}	0.101^{b}	0.056^{c}	0.046^{b}	0.097^{a}	0.073^{a}	0.054^{a}	0.386^{b}	0.301^{b}	0.248^{c}
T_5	0.168^{d}	0.161^{e}	0.147^{d}	0.099^{c}	0.054^{d}	0.044^{c}	0.080^{d}	0.072^{ab}	0.045^{c}	0.365^{c}	0.294^{c}	0.236^{e}
T_6	0.162^{e}	0.142^{f}	0.136^{e}	0.112^{a}	0.058^{b}	0.050^{a}	0.082^{c}	0.069^{c}	0.051^{b}	0.366^{c}	0.289^{d}	0.237^{e}
LSD	**0.0010**	**0.0010**	**0.0010**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.002**	**0.003**	**0.001**

*T_1= *Azospirillumlipoferum + Azotobacter chrooccocum,*T_2=*Azotobacter chrooccocum,* $T_{3=}$ *Azospirillumlipoferum,* T_4 =*yeast,* T_5=*compost,* T_6=*control.*
lavender plants

Effect on mineral content

Results reported in tables (6) demonstrate clearly that the application of biofertilizer of treatment (T_1) on lavender plants of increased (N, P, K percentage and crud protein) significantly compared with the control (T_6) treatment. The highest values of N were 2.61 %, P 0.606 %, K 1.84 %, and curd protein 16.31% that was obtained by the combination of biofertilizer (T_1) in the first cut first season. This treatment showed a significant increase compared to the treatment (T_6) (N 1.56%, P 0.404%, K 1.32%, and curd protein 9.75%) in the first cut, the first season as well. This was followed by the application of active dry yeast. This holds true for all cuts during the two seasons.

Table 6 : Effect of organic and bio-fertilizer on mineral content and crud protein percentage of leaves lavender plants

Treatment	Nitrogen (%)			Crude Protein (%)			Phosphorus (%)			Potassium (%)		
Harvest	**1st**	**2nd**	**3rd**	**1st**	**2nd**	**3rd**	**1st**	**2nd**	**3rd**	**1st**	**2nd**	**3rd**
First season												
T_1	2.61^{a}	1.98^{a}	1.95^{a}	16.31^{a}	12.38^{a}	12.19^{a}	0.660^{a}	0.524^{a}	0.428^{a}	1.84^{a}	1.80^{a}	1.77^{a}
T_2	1.74^{d}	1.46^{d}	1.43^{d}	10.88^{d}	9.13^{d}	8.94^{d}	0.456^{d}	0.448^{d}	0.319^{d}	1.60^{d}	1.52^{d}	1.47^{d}
T_3	1.63^{e}	1.40^{e}	1.37^{e}	10.19^{e}	8.75^{e}	8.56^{e}	0.424^{e}	0.389^{e}	0.296^{e}	1.48^{e}	1.40^{e}	1.33^{e}
T_4	2.21^{b}	1.77^{b}	1.74^{b}	13.81^{b}	11.06^{b}	10.88^{b}	0.562^{b}	0.492^{b}	0.389^{b}	1.65^{c}	1.59^{c}	1.57^{c}
T_5	1.95^{c}	1.61^{c}	1.58^{c}	12.19^{c}	10.06^{c}	9.88^{c}	0.505^{c}	0.467^{c}	0.349^{c}	1.70^{b}	1.68^{b}	1.64^{b}
T_6	1.56^{f}	1.27^{f}	1.24^{f}	9.75^{f}	7.94^{f}	7.75^{f}	0.404^{f}	0.357^{f}	0.281^{f}	1.32^{f}	1.20^{f}	1.13^{f}
LSD	**0.009**	**0.011**	**0.011**	**0.056**	**0.068**	**0.069**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**
Second season												
T_1	2.19^{a}	1.97^{a}	1.80^{a}	13.69^{a}	12.29^{a}	11.25^{a}	0.538^{a}	0.449^{a}	0.318^{a}	1.81^{a}	1.78^{a}	1.71^{a}
T_2	1.55^{b}	1.45^{d}	1.28^{d}	9.69^{d}	9.07^{d}	8.00^{d}	0.449^{d}	0.346^{d}	0.236^{d}	1.54^{d}	1.51^{d}	1.41^{d}
T_3	1.47^{c}	1.39^{e}	1.18^{e}	9.19^{e}	8.68^{e}	7.38e	0.419^{e}	0.314^{e}	0.204^{e}	1.46^{e}	1.34^{e}	1.23^{e}
T_4	1.91^{d}	1.76^{b}	1.55^{b}	11.94^{b}	10.99^{b}	9.69^{b}	0.505^{b}	0.395^{b}	0.285^{b}	1.59^{c}	1.58^{c}	1.46^{c}
T_5	1.72^{e}	1.60^{c}	1.40^{c}	10.75^{c}	10.02^{c}	8.75^{c}	0.488^{c}	0.378^{c}	0.268^{c}	1.69^{b}	1.67^{b}	1.52^{b}
T_6	1.37^{f}	1.26^{f}	1.15^{f}	8.56^{f}	7.90^{f}	7.19^{f}	0.391^{f}	0.287^{f}	0.171^{f}	1.30^{f}	1.17^{f}	1.12^{f}
LSD	**0.009**	**0.049**	**0.01**	**0.055**	**0.307**	**0.064**	**0.007**	**0.006**	**0.006**	**0.001**	**0.001**	**0.001**

*T_1= *Azospirillumlipoferum* + *Azotobacter chroococcum*,T_2=*Azotobacter chroococcum*, T_3= *Azospirillumlipoferum*, T_4 =*yeast*, T_5=*compost*, T_6=*control*.

Increasing N, P, and K concentrations by organic and bio-fertilizers might be attributed to the increase in root surface per unit of soil volume as well as the high capacity of the plants supplied with bio-fertilizer in building metabolites, which in turn contribute much to the increase of nutrient uptake. Inoculation with bacterial mixtures provided more balanced nutrition for plants and improvement in root uptake of nitrogen and phosphorus in a major mechanism of interaction between nitrogen-fixing and phosphate solubilizing bacteria (Belimov *et al*., 1995). Moreover, Ghallab and El-Gahadban (2004), Abdel Wahab *et al*. (2013), and Hekmat *et al.,* (2017) on Majorana plants, found that the macro-nutrients uptake by roots plant increased significantly by the addition of organic composts to the prepared soil.

On the other hand, figure (1) showed the highest average soil temperature with the mixture of *Azotobacter* spp. and *Azospirillum* spp. during the two seasons. The treatment (T_1) was the highest soil temperature followed by the treatment (T4) compared with the other treatments. The average soil temperature of the first cut is less than the second and third cuts. Where the soil temperature changes the decomposition and mineralization rate of organic matter of various organic materials. It also affects the quality of soil water, its conductivity, and plant availability.

soil temperature is a major determinant of the processes that are required for plant growth to take place in the soil (Onwuka and Mang, 2018).

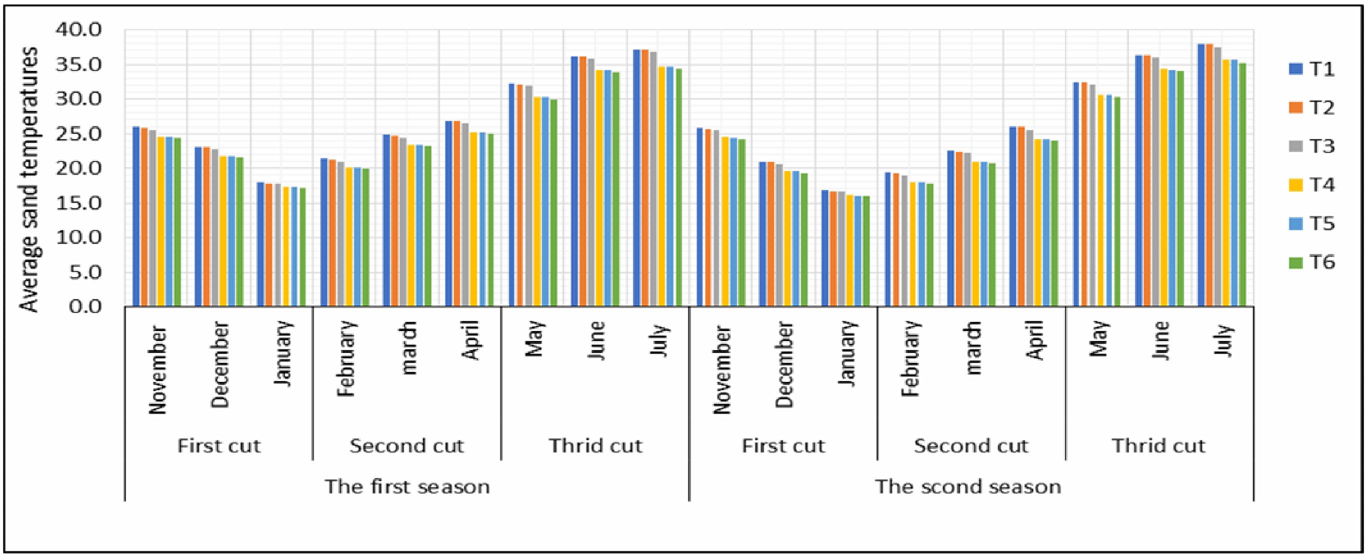

Fig. 1: The average monthly soil temperatures during the two seasons.

Effect of organic and biofertilizers on total flavonoid (mg/100FW), antioxidant (mg/100 FW), free amino acids (mg/100gm), phenols (mg/100g FW), and carbohydrates (%) of leaves lavender plants

Data listed in table (7) shows the richness of total phenols in the produced lavender herbage in most treatments. The lowest total phenol values were achieved in the case of the control while the highest significant values were recorded in the mixture of *Azotobacter* spp. and *Azospirillum* spp. The remarkable quantities of total phenols in lavender may throw some light on their economic value as a rich source of total phenols.

This section discusses the response of total flavonoid, total antioxidant, and total free amino acids to the application of the different fertilizers throughout the vegetative phase. Data illustrated in tables (7) reveals that a significant difference had been recorded in case total flavonoid, total antioxidant, and total free amino acids content in comparison with the control treatment and also among most of the treatments compared to each other through the three cuts and the two successive seasons. It is interesting to note that the mixture of *Azospirillum* spp.+ *Azotobacter* spp. exerted the highest significant increase of total flavonoid, total antioxidant, and total free amino acids while the lowest values were achieved in the case of control treatment. This holds true for the three consequent cuts during the two successive seasons.

Spiridon *et al*. (2011) and Gallego *et al*. (2013) reported ferulic acid, rosmarinic acid, p-coumaric acid, caffeic acid, and 2-Oglucosylcoumaric acid as the dominant phenolic acids in lavender plants. These phenolic compounds demonstrated a positive correlation of content of phenolic acids to antioxidant levels when they had been investigated for their antioxidant effects (Tsai *et al*., 2008).

It has been reported that lavender plants produce phenolic acids. These phenolic acids increase their extract's bioactivity. Among the most reported phenolic acids in lavender plants are ferulic acid, rosmarinic acid, p-coumaric acid, caffeic acid, and 2-Oglucosylcoumaric acid (Spiridon *et al*., 2011, Gallego *et al*., 2013). The phenolic compounds of lavender have been primarily investigated for their antioxidant effects, demonstrating a positive correlation of the content of phenolic acids to antioxidant levels (Tsai *et al*., 2008).

The antioxidant activity of lavender extracts was reported by many authors. Among them is Hohmann *et al*. (1999)who reported a high antioxidant activity of the aqueous methanolic extracts of lavender, while Miliauskas *et al*. 2004 and Lee and Shibamoto (2005) observed low antioxidant activities of volatile extracts of lavender in comparison to thyme, basil, and rosemary. This difference in the antioxidant activity of lavender extracts may be attributed to the extraction method.

Table 7 : Effect of organic and bio-fertilizer on total flavonoid (mg/100FW), antioxidant (mg/100 FW), free amino acids (mg/100gm), phenols (mg/100g FW), and carbohydrates (%) of leaves lavender plants

Treatment	Total Flavonoid (mg/100FW)			Total Antioxidant (mg/100FW)			Total Free Amino Acids mg/100gm			Phenol (mg/100g FW)			Total carbohydrates (%)		
Harvest	**1st**	**2nd**	**3rd**	**1st**	**2nd**	**3rd**	**1st**	**2nd**	**3rd**	**1st**	**2nd**	**3rd**	**1st**	**2nd**	**3rd**
First season															
T_1	21.31^{a}	17.16^{a}	13.42^{a}	84.74^{a}	86.74^{a}	85.74^{a}	13.74^{a}	12.71^{a}	8.43^{a}	4.36^{a}	4.10^{a}	2.78^{a}	9.85^{a}	8.33^{a}	6.37^{a}
T_2	15.88^{d}	13.94^{d}	10.17^{d}	74.24^{c}	76.24^{c}	75.24^{c}	11.44^{c}	10.40^{c}	7.37^{c}	2.76^{d}	2.49^{d}	2.07^{d}	6.68^{e}	5.84^{e}	3.91^{d}
T_3	15.19^{e}	13.55^{e}	9.79^{e}	81.89^{b}	83.89^{b}	82.89^{b}	12.50^{b}	11.47^{b}	8.14^{b}	2.56^{e}	2.29^{e}	1.95^{e}	6.99^{d}	6.21^{d}	4.08^{d}
T_4	18.81^{b}	15.86^{b}	12.11^{b}	70.66^{d}	72.66^{d}	71.66^{d}	10.79^{d}	9.76^{d}	7.02^{d}	3.76^{b}	3.50^{b}	2.47^{b}	8.98^{b}	7.40^{b}	5.73^{b}
T_5	17.19^{c}	14.89^{c}	11.11^{c}	67.58^{e}	69.58^{e}	68.58^{e}	10.28^{d}	9.25^{d}	6.71^{e}	3.17^{c}	2.90^{c}	2.25^{c}	7.71^{c}	6.74^{c}	4.81^{c}
T_6	14.75^{f}	12.77^{f}	8.98^{f}	61.37^{f}	63.37^{f}	62.37^{f}	9.34^{e}	8.31^{e}	6.09^{f}	2.29^{f}	2.02^{f}	1.85^{f}	6.45^{e}	5.55^{f}	3.56^{e}
LSD	0.056	0.068	0.069	0.79	0.79	0.79	0.61	0.61	0.08	0.089	0.011	0.065	0.284	0.196	0.202
Second season															
T_1	18.56^{a}	15.68^{a}	14.12^{a}	84.26^{a}	81.32^{a}	78.32^{a}	13.23^{a}	10.28^{a}	7.98^{a}	4.35^{a}	3.33^{a}	2.71^{a}	8.26^{a}	7.82^{a}	5.79^{a}
T_2	14.56^{d}	12.43^{d}	10.87^{d}	73.74^{c}	70.75^{c}	67.75^{c}	10.92^{c}	9.22^{c}	6.92^{c}	2.74^{d}	1.72^{e}	2.02^{d}	5.77^{e}	4.65^{e}	2.62^{e}
T_3	14.06^{e}	12.05^{e}	10.25^{e}	81.41^{b}	78.47^{b}	75.47^{b}	11.98^{b}	10.00^{b}	7.70^{b}	2.54^{e}	1.52^{f}	1.89^{e}	6.18^{d}	4.96^{d}	2.93^{d}
T_4	16.81^{b}	14.36^{b}	12.56^{b}	70.17^{d}	67.20^{d}	64.20^{d}	10.28^{d}	8.87^{d}	6.57^{d}	3.75^{b}	2.73^{b}	2.40^{b}	7.33^{b}	6.95^{b}	4.92^{b}
T_5	15.62^{c}	13.36^{c}	11.62^{c}	67.10^{e}	64.17^{e}	61.17^{e}	9.76^{d}	8.57^{e}	6.27^{e}	3.16^{c}	2.14^{c}	2.19^{c}	6.67^{c}	5.68^{c}	3.65^{c}
T_6	13.43^{f}	11.24^{f}	10.06^{f}	60.89^{f}	57.93^{f}	54.93^{f}	8.82^{e}	7.94^{f}	5.64^{f}	2.28^{f}	1.83^{d}	1.26^{f}	5.55^{f}	4.42^{f}	2.39^{e}
LSD	0.055	0.307	0.064	0.79	0.79	0.79	0.6	0.01	0.08	0.163	0.019	0.01	0.199	0.284	0.284

*T_1= *Azospirillumlipoferum + Azotobacter chrooccocum,*T_2=*Azotobacter chrooccocum,* $T_{3=}$ *Azospirillumlipoferum,* T_4 =*yeast,* T_5=*compost,* T_6=*control.*

Effect of organic and biofertilizers on endogenous hormones Gibberellic acid (GA_3), Indole acetic acid (IAA), and Abscisic acid:

Data presented in table (8) indicates that the use of organic and biofertilizers increased all endogenous hormones (Gibberellic acid (GA_3), Indole Acetic Acid (IAA), and Abscisic acid in lavender plants. Data also reveals that the gibberellic acid and abscisic acid increased in the first cut and gradually decreased from the second to the third cut, while the indole acetic acid decreases in the first cut and then increases gradually from the second to the third cuts. The mixture of *Azotobacter* spp. and *Azospirillum* spp. significantly increased lavender endogenous hormones in three cuts of the two seasons compared to control treatment.

Table 8 : Effect of organic and bio-fertilizer on endogenous hormones (Gibberellic acid (GA_3), Indole acetic acid (IAA), and Abscisic acid (mg/100 FW) of leaves lavender plants

Treatment Harvest	Gibberellic acid			Indole acetic acid			Abscisic acid		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
First season									
T_1	2.71[a]	1.57[a]	1.40[a]	0.27[a]	0.33[a]	0.43[a]	0.42[a]	0.23[a]	0.04[a]
T_2	1.22[c]	1.05[b]	0.63[bc]	0.18[b]	0.29[a]	0.30[b]	0.17[bc]	0.12[bc]	0.02[bc]
T_3	1.74 [b]	1.62[a]	0.52[c]	0.18[b]	0.17[b]	0.17[cd]	0.31[ab]	0.16[ab]	0.01[c]
T_4	1.34[bc]	1.13[b]	0.60[bc]	0.21[ab]	0.16[b]	0.08[de]	0.19[bc]	0.13[bc]	0.03[abc]
T_5	1.26[bc]	0.97[b]	1.08[ab]	0.17[b]	0.15[b]	0.07[e]	0.15[c]	0.10[bc]	0.04[ab]
T_6	1.17[c]	0.67[c]	1.08[ab]	0.10[c]	0.14[b]	0.19[c]	0.08[c]	0.06[c]	0.03[ab]
LSD	0.52	0.29	0.52	0.07	0.06	0.09	0.16	0.08	0.02
Second season									
T_1	1.94[a]	0.95[a]	0.05[ab]	0.06[a]	0.24[a]	0.50[a]	0.55[a]	0.32[a]	0.16[a]
T_2	1.75[a]	0.18[d]	0.04[bc]	0.03[b]	0.09[c]	0.17[d]	0.01[c]	0.06[c]	0.11[b]
T_3	1.26[b]	0.74[b]	0.04[bc]	0.03[b]	0.19[b]	0.45[ab]	0.11[bc]	0.11[bc]	0.12[b]
T_4	1.38[b]	0.53[c]	0.05[a]	0.03[b]	0.26[a]	0.36[c]	0.03[c]	0.09[c]	0.08[c]
T_5	0.34[c]	0.86[a]	0.01[d]	0.02[b]	0.22[ab]	0.38[bc]	0.26[b]	0.17[b]	0.09[c]
T_6	0.49[c]	0.19[d]	0.03[c]	0.02[b]	0.08[c]	0.18[d]	0.01[c]	0.06[c]	0.12[b]
LSD	**0.3**	**0.12**	**0.01**	**0.02**	**0.05**	**0.08**	**0.16**	**0.08**	**0.02**

*T_1= *Azospirillumlipoferum + Azotobacter chrooccocum,*T_2=*Azotobacter chrooccocum,* $T_{3=}$ *Azospirillumlipoferum,* T_4 =*yeast,* T_5=*compost,* T_6=*control.*

These results are in agreement with those obtained by Abdallah *et al.* (2013) on sunflower and Abdallah *et al.* (2015) on wheat, Aly *et al.* (2007) on coriander, Hemdan (2008) on anise, Dahab *et al*. (2010) on marjoram, Jacoub (1999) on Ocimum basilicum, Abd Ellatif (2006) on *Salvia officinalis* and Costa *et al*. (2008) on *Ocimum selloi*. These results may be attributed to the effect of *Azospirillum* and *Azotobacter* addition to nitrogen fixation ability, with the production of growth stimulants cause increased uptake of inorganic nitrogen and the growth (Tilak *et al*., 2005), while yeast promotes cell division and cell elongation (Khedr and Farid, 2000).

In this regard, species contained in biofertilizers increase the availability of nutrients to plants, but soil texture, aeration, and hydration do not need to be preserved. These species, by increasing the content of plant nutrients, increase the fertility of the soil. By reducing the root membrane potential, N_2 fixation, synthesis of certain enzymes and phytohormones that modulate the level of plant hormones, as well as solubilization of inorganic phosphate and mineralization of organic phosphate, which makes phosphorus available, biofertilizers can have a positive impact on growth and yield characteristics (Rodriguez and Fraga, 1999 and Amer *et al*., 2019). The positive effect of microorganisms on improving the growth and performance of medicinal plants. That (*Azospirillum* and *Azotobacter*) are the most significant growth-stimulating bacteria that have a significant effect on plant growth regulators, especially gibberellins, auxins, and cytokinins, in addition to biological nitrogen fixation and soil phosphate solubilization, and thus contribute to improving plant efficiency (Subba-Rao, 1979 and Amer *et al*., 2019).

Economic evaluation of lavender essential oil

Economic **e**valuation is a criterion that can be used to evaluate the benefits in terms of economic value or cash return investment. in this study, the sum of the total fixed cost is calculated once for the two seasons and the variable costs were estimated for one season and multiplied by two represents the total cost. While the total yield for the two seasons was summed and multiplied by an average market price to represents the total income. The difference between the total cost and the total income is the profit. The Income to Cost (B/C) ratio was calculated to represent the profit percentage, where its value reflects the economic feasibility of the proposed treatments. When the B/C ratio is less than one the proposed treatment is not feasible in terms of cost to revenue aspects. In contrast, if the B/C ratio is greater than one the project is profitable.

Table 9 : Economic evaluation study for the application of different treatments on lavender essential oil (L.E./fed.).

Treatment	Input			Output			
				Economic criterion			
	Fixed Cost (L.E/fed)	Variable Cost (L.E/fed)	Total cost (L.E/fed)	Revenue (L.E/fed)	Net Revenue (L.E/fed)	B/C ratio	Treatment Order
T1	101400	103200	204600	1126800	922200	5.51	1
T2	101400	103200	204600	871200	666600	4.26	2
T3	101400	103200	204600	666000	461400	3.26	4
T4	101400	79065.6	180465.6	747000	566534.4	4.14	3
T5	101400	78000	179400	577800	398400	3.22	5
T6	87000	86100	173100	397800	224700	2.30	6

**T1= Azospirillum lipoferum + Azotobacter chrooccocum, T2= Azotobacter chrooccocum, T3 Azospirillum lipoferum, T4 = yeast, T5=compost, T6=control. ; *(B/C ratio) =The Benfit / Cost ratio*

Table (9) represents the results of the conducted economic feasibility study for these proposed treatments. It is clear that all treatments are economically feasible including the control treatment however, looking at the B/C ratio, one can find that the maximum return or profit comes from the mixture of *Azospirillum* spp.+ *Azotobacter* spp., followed by *Azotobacter* spp. as indicated by the treatment order column in table (9) and figures (2).

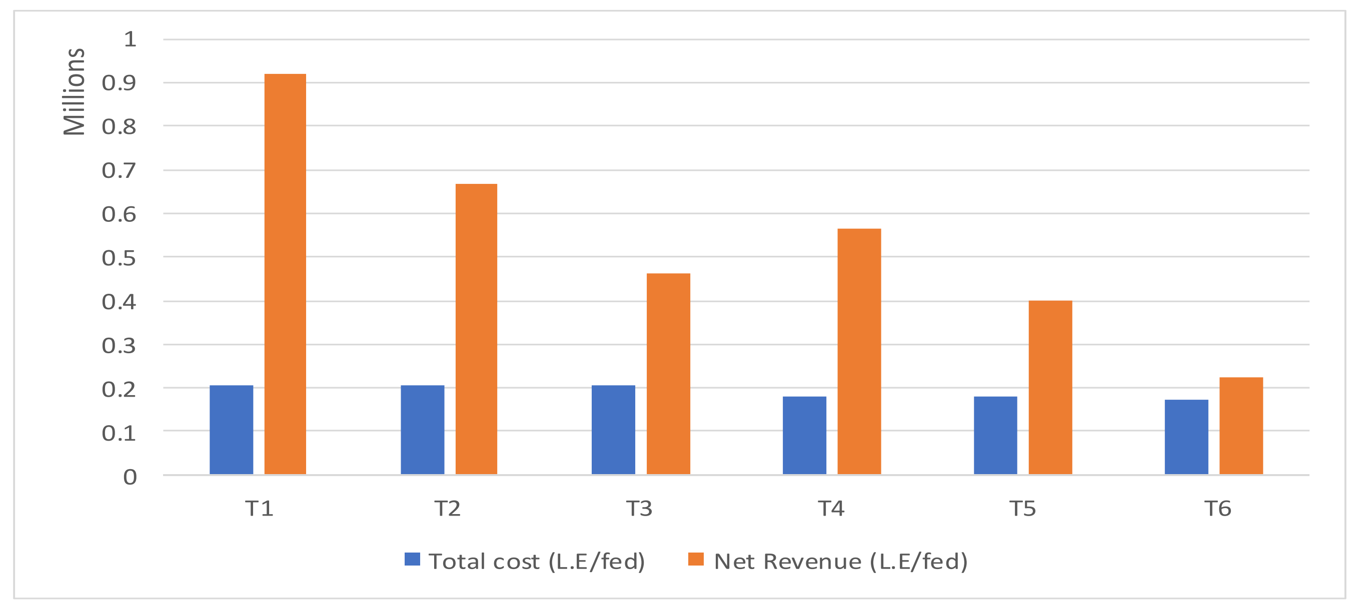

Fig. 2: Relationship between total costs and revenue for lavender essential oil

Economic evaluation was carried out by calculating the benefit to cost ratio (B/C parameter), with the highest return 922200 L.E/fed. in T1. The profitability gets it from revenue minimum total costs and the proportion of benefits to costs estimated at 5.51and decreased in the order T2>T4>T3>T5>T6, respectively. Generally, it may be stated that it could be biofertilizers has the highest valuable and net return for lavender essential oil.

Conclusion

Biofertilizers as a better supplement can improve the growth and yield of cereal crops. Nitrogen-fixing biofertilizers mainly *Azospirillum* and *Azotobacter* are able to fix 20-40 kg N/ha and produce growth-promoting substances like IAA. Inoculation with a symbiotic nitrogen fixer like *Azospirillum* or *Azotobacter* may improve plant growth and yield due to supplementing the growing plants with fixed nitrogen and growth-promoting substances. Hence, it is imperative to popularize the use of biofertilizers, which is a low-cost input technology to reduce the dependence on inorganic fertilizers and contribute to a pollution-free atmosphere, which is the need of the day. From the obtained results it can be concluded that biofertilizers are recommended for improving plant growth, oil yield and main components of lavender hortensis, plants and the highest concentration of these biofertilizers were more effective for increasing oil percentage and oil yield/plant. Generally, it may be stated that it could be biofertilizers has the highest valuable and net return for lavender plants.

References

A.O.A.C. (1990). Official methods of analysis of the association of Official analytical chemists 15th Ed. Published by the association of official analytical chemists, INC suite 400. 2200 Wilson Boulevard, Arlington, Virginia. 22201 USA.

Abd El-Latif, E.S.M. (2006). Effect of chemical, organic fertilizers and spraying with active dry yeast on growth, oil production and plant constituents of sage (*Salvia officinalis* L.) plant. M.Sc. Thesis, Faculty of Agriculture, Cairo University.

Abdallah, M.M.; Abd El-Monem, A.A.; Hassanein, R.A. and El-Bassiouny, H.M.S. (2013). Response of sunflower plant to the application of certain vitamins and arbuscular mycorrhiza under different water regimes. Austr J Basic Appl Sci.; 7: 915–932.

Abdallah, M.M.S.; El-Bassiouny, H.M.S.; Bakry B.A. and Sadak, M.S. (2015). Effect of arbuscular mycorrhiza and glutamic acid on growth, yield, some chemical composition and nutritional quality of wheat plant grown in newly reclaimed sandy soil. RJPBCS 6:1038–1054.

Abd-ElWahab M.; Mahmoud M. and Hassan, A.Z.A. (2013). Response of fennel plants to organic bio fertilizer in replacement of chemical fertilization. Top class Journal of Agricultural Research, 1(3): 29-35.

Abdollahi, F.; Salehi, A.; Shahabi, R. and Rahimi, A. (2016). Effect of different nitrogen sources on vegetative traits, grain yield and essential oil yield of coriander (*Coriandrum Sativum*). Cercetări Agronomice în Moldova. Vol. XLIX, No. 1 (165) / 2016: 51:65.

Abdou, M.A.H.; Abdalla, M.Y.A.; Hegazy, A.A. and Marzok, Z.S.A. (2011). Physiological studies on clove basil plant. J. Plant Production, Mansoura Univ. 2(11): 1451–1469.

Abdou, M.A.H.; Taha, R.A.; Abd-Elraaof, R.M. and Salah El-Deen, R.M. (2012). Response of Fennel plants to organic, bio and mineral fertilization. Egypt j. Bot. 2nd International conference, Minia Univ.; pp. 191-205.

Abo EL-Fadl N.I.; EL-Mesirry, D.S. and Rady, H.M. (2017). Effect of Foliar spraying with Yeast Extract and Hydrogen Peroxide on Yield and Quality of Sweet Potato, 62(3): 303-310.

Adaszynska, S.M. and Swarcewicz, M. (2014). Chemical composition and biological activity of medicallavender. Wiad. Chem. 68: 11–12.

Adholeya, A. and Prakash, A. (2004). Effect of different organic manures/composts on the herbage and essential oil yield of Cymbopogon winter ianus and their influence on the native AM population in a marginal alfisol. Bioresour Technol. Tanu.; 92: 311–319.

Ali, A.F.; Hassan, E.A.; Hamad, E.H. and Abo-Quta, W.M.H. (2017). Effect of Compost, Ascorbic Acid and Salicylic Acid Treatments on Growth, Yield and Oil Production of Fennel Plant. Assiut J. Agric. Sci., 48: 139–154.

Aly, M.K.; Mohamed, M.A.; Attia, F.A.; El-Sayed, A.A. and Abd El-Gawad, M.H. (2007). Effect of some organic and biofertilization treatments on coriander plants. II- Volatile oil and chemical composition. 1st Inter. Conf Desert. Cultivation, Problem & Solutions. Minia Univ. p.113-125.

Amer, H.M.; Salem, S.H.; Salaheldin, S.; Hussein, M.S. and Abd El-Fatah, S.I. (2019). The growth, chemical composition and evaluation of antimicrobial activity of *Salvia officinalis* oil under Partial substitution of mineral NPK fertilizer by bio-fertilizer. 08: 457-468.

Badran, F.S.; Abdalla, N.M. and Ibrahim, S.M. (2007). Response of fennel plants to seeding rate and partial replacement of mineral NPK by biofertilization treatments. Proc. Of the 8th African Crop Sci. Conf.; El-Minia, Egypt, 8(1): 417-422.

Balbaa, L.K. and Talaat, I.M. (2007). Physiological response of rosemary plants (*Rosmarinus officinalis*, L.) to ascorbic acid, phenylalanine and ornithine. Egypt, J. of Appl, Sci.; 22 (HB): 375-385.

Belimov, A.A.; Kojemiakov, A.P. and Chuvarliyeva, C.V. (1995). Interaction between barley and mixed cultures of nitrogen fixing and phosphate-solubilizing bacteria. Plant and Soil, 173: 29-37.

Chrysargyris, A.; Michailidi, E. and Tzortzakis, N. (2018). Physiological and biochemical responses of *Lavandula angustifolia* to salinity under mineral foliar application. Front. Plant Sci.; 9, 489: 1–23.

Chrysargyris, A.; Mikallou, M.; Petropoulos, S.A. and Tzortzakis, N. (2020). Profiling of Essential Oils Components and Polyphenols for Their Antioxidant Activity of Medicinal and Aromatic Plants Grown in Different Environmental Conditions. Agronomy, 10(5): 1-28.

Costa, L.C.B.; Pinto, J.E.B.P.; Castro, E.M.; Bertolucci, S.K.V.; Corrêa, R.M.; Reis, E.S.; Alves, P.B. and Niculau, E.S. (2008). Sources and doses of organic fertilization in *Ocimumselloi* growth, essential oil yield and chemical composition. Ciência Rural. 38(8): 2173-2180.

Dahab, T.A.M.; Harridy, I.M.A. and Mansour, B.A.B. (2010). Effect of irrigation and antitranspirant treatments on growth, yield and chemical constituents of marjoram plants (*Majorana hortensis* Moench). Bulletin of Fac. of Agric. Cairo Univ.; 61(3): 274-285.

Danh, L.T.; Han, L.N.; Triet, N.D.A.; Zhao, J.; Mammucari, R. and Foster, N. (2013). Comparison of chemical composition, antioxidant and antimicrobial activity of lavender (*Lavandula angustifolia* L.) Essential oils extracted by supercritical CO_2, hexane and hydrodistillation. Food Bioprocess Technol. 6: 3481–3489.

Darzi, M.T.; Hadi, M.H.S. and Rejali, F. (2012). Effects of the application of vermicompost and nitrogen fixing bacteria on quantity and quality of the essential oil in dill (*Anethum graveolens*). J. Medicinal Plants Res.; 6(21): 3793-3799.

Demissie, Z.A.; Sarker, L.S. and Mahmoud, S.S. (2011) Cloning and functional characterization of β-phellandrene synthase from *Lavandula angustifolia*. Planta, 233: 685–696.

Dewidar, A.A.A. (2007). Post-harvest studies on some aromatic plants. Ph.D. Thesis, Fac. Agric.; Kafr El-Sheikh Univ.; Egypt.

Edris, A.E.; Ahmad, S. and Fadel, H.M. (2003). Effect of organic agriculture practices on the volatile aroma components of some essential oil plants growing in Egypt II: sweet marjoram (*Origanum marjorana* L.) essential oil. Flavour Fragr. J.; 4: 345–51.

El-Ghadban, E.A.E.; El-Tobgy, K.M.K. and Soliman, S.G.I. (2008). Response of lavender plant *(lavandula multifida* L.) to compost and active dry yeast. 13(1): 79-99.

Fatma, A.G.; Lobna, A.M. and Osama, N.M. (2008). Effect of Compost and Bio-fertilizers on Growth, Yield and Essential Oil of Sweet Marjoram (*Majorana hortensis*) Plant. Int. J. Agri. Biol.; Vol. 10(4).

Fatma, S.A.M.; Zeinab, A.M.; Taha, M.A. and El-Behairy, U.A. (2008). Some chemical chances of *Lavendula officinais* plant treated with nicotine amid. Biol. Chem. Environ Sci, 3(2):83-103.

Gallego, M.G.; Gordon, M.H.; Segovia, F.J.; Skowyra, M. and Almajano, M.P. (2013). Antioxidant properties of three aromatic herbs (rosemary, thyme and lavender) in oil-in-water emulsions. Journal of the Americal Oil Chemists' Society, 90: 1559–1568.

George, G.; Brenner, D.J.; Krieg, N.R. and James, R.S. (2005). Staley Phylum XXVIII, 1106. Williams and Wilkins, 1984. In: Bergey's Manual of Systematic Bacteriology 2nd. Vol. 2. Eds. George, Garrity, Don, J. Brenner; Noel, R. Krieg and James, R. Staley. The Proteo-bacteria (Part B 384-402. and C7-82.). (Springer-Verlag) Dordrecht Heidelberg London New York. pp. 1203.

Ghallab, A.M. and El-Gahadban, E.A.E. (2004). Physiological response of marjoram plants to bio fertilizer and organic fertilization. J. Agric. Sci. Mansoura Univ.; 29(4): 1743-1759.

Gomaa, A.O. and Youssef, A.S.M. (2007). Bio-fertilizers as a partial alternative to chemical NPK fertilization and its influence on the productively of fennel plants (*Foeniculum vulgare*, Miller). The third Conf. of Sustain. Agric. Develop. Fac. of Agric.; Fayoum Univ.; 327-352.

González-Coloma, A.; Delgado, F.; Rodilla, J.M.; Silva, L.; Sanz, J. and Burillo, J. (2011). Chemical and biological profiles of *Lavandula luisieri* essential oil from western Iberia Peninsula populations. Biochem. Syst. Ecol. 39: 1–8.

Góra, J. and Lis, A. (1995). The most valuable oils–Lavender oil. Aromaterapia PTA, 2: 5–11.

Góra, J. and Lis, A. (2005). The Most Valuable Essential Oils; UMK Publishing: Torun, Poland, pp. 165–175.

Gulluce, M.; Sokmen, M.; Sahin, F.; Sokmen, A.; Adiguzel, A. and Ozer, H. (2004). Biological activities of the essential oil and methanolic extract of *Micromeria fruticosa* (L) Druce ssp serpy llifolia (Bieb) PH Davis plants from the eastern Anatolia region of Turkey. J. Sci. Food. Agric.; 84: 735-741.

Hammadi, F.S.; Darzi, M.T. and Hadi, M.H.S. (2014). Influence of Compost and Biofertilizer on yield and essential oil of dill (*Anethum graveolens* L.) International journal of Advanced Biological and Biomedical Research. 2: 446-455.

Hekmat, Y.M.; Sharaf-Eldin, M.N. and Sheashaa, A.M. (2017). Effect of Bio-Fertilizers, Plants Extracts and Active Dry Yeast onMarjoram Plants. J. Plant Production, Mansoura Univ.; 8(5): 657 – 663.

Hemdan, S.H. (2008). Effect of some organic and biofertilization treatments on anise plants. M. Sc. Thesis, Fac. of Agric.; Minia University.

Hendawy, S.F. and Khalid, K.A. (2011). Effect of chemical and organic fertilizers on yield and essential oil of chamomile flower heads. Medicinal and Aromatic Plant Science and Biotechnology, 5(1): 43- 48.

Hendawy, S.F.; Azza, A.; Ezz, E.; Aziz, E.E. and Omer, E. (2010). Productivity and oil quality of *Thymus vulgaris* L. under organic fertilization conditions. Ozean Journal of Applied Sciences. 3(2): 203-216.

Hohmann, J.; Zupkó, I.; Rédei, D.; Csányi, M.; Falkay, G.; Máthé, I. and Janicsák, G. (1999). Protective effects of the aerial parts of *Salvia officinalis*, *Melissa officinalis* and *Levandula angustifolia* and their constituents against enzyme dependent and enzyme independent lipid peroxidation. Planta Medica, 65: 576-578.

Hritcu, L.; Cioanca, O. and Hancianu, M. (2012). Effects of lavender oil inhalation on improving scopolamine-induced spatial memory impairment in laboratory rats. Phytomed 19: 529–534.

Jacoub, R.W. (1999). Effect of some organic and non-organic fertilizers on growth, oil yield and chemical composition of *Ocimum basilicum*, L. and *Thymus vulgaris*, L. plants. Ph. D. Thesis, Fac. Agric.; Cairo Univ.; Egypt.

Jayeraman, J. (1985). Laboratory manual in biochemistry, Willy Eastern Limited, New Delhi, cited by Ashour, A.E.A. (1990). Effect of drought on some biochemical constituents of plant. Ph.D. Thesis, Fac. Agric.; Ain Shams Univ.

Jia, Q.; Hong, M. and Minter, D. (1999). A novel iridoid from picrorhiza Kurroa. Journal of Natural product, 62: 901-903.

Kenawy, A.G. (2010). Effect of some biofertilization treatments on the growth, yield and chemical composition of *Hibiscus sabdariffa* L. plants. M.Sc. Thesis, Fac. of Agric.; Mania Univ.

Khalil, M.K.; Taha, K.F.; Nesem, M.A. and Sallam, S.S. (2019). Effect of chemical fertilization, biofrtilizer and thidiazuron on growth and yield of celery (*Apium graveolens* L.) plant. az. j. Pharm Sci., 59: 27-53.

Khedr, Z.M.A. and Farid, S. (2000). Response of naturally virus infected plants to yeast extract and phosphoric acid application. Annals of Agricultural Sciences, Moshtohor, Egypt. 38(2): 927-939.

Lee, S.J.; Umano, K.; Shibamoto, T. and Lee, K.G. (2005). Identification of volatile components in basil (*Ocimum basilicum* L.) and thyme leaves (*Thymus vulgaris* L.) and their antioxidant properties. Food Chem., 91: 131–137.

Mambrí, A.P.S.; Andriolo, J.L.; Manfron, M.P.; Pinheiro, M.G.S.; Cardoso, L.F. and Neves, G.M. (2018). Yield and composition of lavender essential oil grown in substrate Horticulture Brasileira 36: 259-264.

Mantovani, A.L.L.; Vieira, G.P.G.; Cunha, W.R.; Groppo, M.; Santos, R.A.; Rodrigues, V.; Magalhaes, L.G. and Crotti, A.E.M. (2013). Chemical composition, antischistosomal and cytotoxic effects of the essential oil of *Lavandula angustifolia* grown in Southeastern Brazil. Rev. Bras. Farmacogn. 23: 877–884.

Matter, F.M.A. and El-Sayed, S.A.A. (2015). Influence of mixed NPK fertilizers with foliar spray of active dry yeast on caraway under newly reclaimed soil conditions. 5: 423-430.

Meftahizade, H.; Moradkhani, H.; Barjin, A.F. and Naseri, B. (2011). Application of *Lavandula officinalis* L. antioxidant of essential oils in shelf life of confectionary. African Journal of Biotechnology, 10(2): 196-200.

Miliauskas, G.; Venskutonis, P.R. and Van Beek, T.A. (2004). Screening of radical scavening activity of some medicinal and aromatic plant extracts. Food Chem., 85: 231–237.

Moradi, R.; Mahallati, M.N.; Moghaddam, P.R.; Lakzian, A. and Nezhadali, A. (2011). The effect of application of organic and biological fertilizers on quantity and quality of essential oil in fennel (*Foeniculum vulgare*). J. Hortic. Sci.; 25(1): 25-33.

Murphy, R.J. and Riley, J.P. (1962). A modified single solution method for determination of phosphate in natural waters. Anal. Chim. Acta., 27: 31-36.

Nasr Alla, M.W.; Radwan, F.I.; Abido, A.A. and Shaban, S.H. (2016). Effect of Some Macro Elements and Bio Fertilization on The Growth, Yield and Chemical Composition of Coriander Plant (*Coriandrum sativum* L.). J. Adv. Agric. Res. (Fac. Agric. Saba Basha). Vol. 21(4).

Onwuka, B. and Mang, B. (2018). Effects of soil temperature on some soil properties and plant growth. Advances in Plants & Agriculture Research. 8(1):34–37.

Radwan, S.S. (1978). Coupling of two-dimension thin layer chromatography with gas chromatography for the quantitative analysis of lipids classes and their constituent fatty acids. J. chromatogram Sci, 16: 538-542.

Rodriguez, H. and Fraga, R. (1999). Phosphate solubilizing bacteria and their role in plant growth promotion. Biotech. Advan.; 17: 319-339.

Sabra, M.M. (2014). Physiological studies on khella (*Ammi visnaga*) plant. M.Sc. Thesis, Fac. Agric.; Fayoum University.

Sadhana, B. (2014). Arbuscular Mycorrhizal Fungi (AMF) as a Biofertilizer- a Review. 3(4): 384-400.

Safwat, M.S.A. and Badran, F.S. (2002). Efficiency of organic and biofertilizers, in comparison with chemical fertilization, on growth, yield and essential oil of cumin plants. The 10th Conference Medicinal and Aromatic Plants in Arab Countries "Sustainable Development", pp: 11-19.

Shahidi, F. and Naczk, M. (1995). Methods of Analysis and Quantification of Phenolic Compounds. Food phenolic:

sources, chemistry, effects and applications. pp: 287-293. Techno. Pub. Company, Inc: Lancaster.

Shirkhodaei, M.; Darzi, M.T. and Hadi, M.H.S. (2014). Influence of vermicompost and biostimulant on the growth and biomass of coriander (*Coriandrum sativum* L.). Int. J. Adv. Biol. Biomed. Res.; 2: 706-714.

Silva, S.M.; Luz, J.M.Q.; Nogueira, P.A.M.; Blank, A.F.; Sampaio, T.S.; Pinto, J.A. O. and Junior, A.W. (2017) Organo-mineral fertilization effects on biomass and essential oil of lavender (*Lavandula dentata* L.). Industrial Crops & Products, 103: 133–140.

Spiridon, I.; Colceru, S.; Anghel, N.; Teaca, C.A.; Bodirlau, R. and Armatu, A. (2011). Antioxidant capacity and total phenolic contents of oregano (*Origanum vulgare*), lavender (*Lavandula angustifolia*) and lemon balm (*Melissa officinalis*) from romania. Natural Product Research, 25: 1657–1661.

Subba-Rao, N.S.; Tilak, K.V.B.R.; Singh, C.S. and Lakshmi-Kumari, M. (1979). Response of a few economic species of graminaceous plant to inoculation with *Azospirillum brusilense*. Curr. Sci., 48: 133-134.

Taie, H.A.A.; Salama, Z.A.R. and Radwan, S. (2010). Potential activity of basil plants as a source of antioxidant and anticancer agents as affected by organic and bio-organic fertilization. Notulae Botanicae Horti Agrobotanici Cluj-Napoca. 38(1): 119-127.

Tilak, K.V.B.R.; Ranganayaki, N.; Pal, K.K.; De, R.; Saxena, A.K.; Shekhar-Nautiyal, C.; Mittal, S.; Tripathi, A.K. and Johri, B.N. (2005) Diversity of plant growth and soil health supporting bacteria. Current Science 89(1): 136-150.

Touati, B.; Chograni, H.; Hassen, I.; Boussaïd, M.; Toumi, L. and Brahim, N.B. (2011). Chemical composition of the leaf and flower of essential oils of tunisian *Lavandula dentata* L. (*Lamiaceae*). Chem. Biodiverse. 8: 1560–1570.

Tsai, T.; Tsai, T.; Chien, Y.; Lee, C. and Tsai, P. (2008). In vitro antimicrobial activities against cariogenic streptococci and their antioxidant capacities: a comparative study of green tea versus different herbs. Food Chemistry, 110: 859–864.

Waller, R.A. and Duncan, D.B. (1969). Abays rule for the symmetric multiple comparison problems. Amer. Stat. Assoc. J. Dec.:1485-1503.

Wasfy, W.S. and Orrin, E.S. (1975). Identification of plant hormones from cotton ovules. Plant Physiol 55: 550-554.

Watanabe, F.S. and Olsen, S.R. (1965). Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts form soil. Soil Sci. Soc. Am. Proc., 29: 677-678.