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Improving growth, yield and essential oil of lavander (*Lavandula officinalis*) L. by using compost and biofertilizer application in clay soil

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ABSTRACT

The current article aimed to examine the effect of organic and biofertilizers on the growth and yield of lavender essential oil (*Lavandula Officinalis* L.). This experiment was conducted over two consecutive seasons in 2018/2019 and 2019/2020 at the net house of the Central Laboratory of the Agricultural Climate Research Center in Dokki, Giza Governorate, Egypt. To assess the effects of biofertilizers (*Azospirillum* spp., *Azotobacter* spp.) and active dry yeast on the vegetative development, chemical composition, yield, and essential oil concentration of lavender. The obtained results showed that, treated plants with compost + *Azospirillum* spp. + *Azotobacter* spp. was the superior treatment, which improved plant growth characters i.e., plant height, number of branches, fresh and dry weights/herb. Chlorophyll a, b and carotenoids concentrations, the phenolic compounds, flavonoid content, total carbohydrates content in dry matter of herb, Nitrogen, Phosphorus and Potassium, total free amino acids, the total antioxidants and the endogenous hormones in all cuts. Essential oil content carried out to evaluate the quality of oil. Also, significant increase was showed with active dry yeast.

Keywords: *Lavandula Officinalis*, *Azotobacter* spp., *Azospirillum* spp., Active dry yeast, essential oil.

INTRODUCTION

Lavender (*Lavandula officinalis* L.) is a perennial herb that is a member of the *Lamiaceae* family. It is cultivated globally for its medicinal and economic properties, as well as for ornamental and decorative purposes. It is mainly produce for the purpose of extracting huge quantities of high-quality essential oil from the leaves and flowers for use in the perfumery, cosmetics, and pharmaceutical sectors (Silva *et al*., 2017).Lavender oil is mostly used as a relaxing, carminative and sedative agent. It is used as an antiseptic for wounds, burns and insect bites, as well as in veterinary practice to kill lice and other animal parasites (Meftahizade *et al.,* 2011). Organic and biofertilizers are safer for medicinal plants production instead of chemical fertilizers in all types of soil, which reduces environmental pollution. The significant effects of biofertilizers are due to the different groups of strains, which help in the availability of nutrients in the available forms and increase the minerals levels in the soil. (Sharaf EL-Din *et al.,* 2013).

Biofertilizers contain highly effective bacterial strains isolated from soil that help in activated the microbiological processes in the soil, resulting in a more effective supply of nitrogen, phosphorous, potassium and some micronutrients to plants. Therefore, biofertilizers help in the growth of microorganisms in the soil, which leads to an increase the amounts of organic and inorganic material produced by their metabolism and produce a large amount of organic matter after their death, which serves as a food source for living microbes. (Tosic*et et al.,* 2016), Also, (Abou- El Hassan *et al.,* 2019) showed that, Free-living nitrogen-fixing bacteria such as *Azotobacter chroococcum* and *Azospirillum lipoferum* are able to fix nitrogen and release phytohormones similar to gibberellic acid and indole acetic acid, which can stimulate plant growth and absorption the nutrients. Microbial biofertilizers consist of viable cells of beneficial microorganisms, which improving soil fertility and stimulate nutrients uptake to increase the plant quality and productivity. Biofertilizers reduces the rate of chemical fertilizers application to allow a better environment for the integrated management of plant nutrient (Raja, 2012, Fasusi *et al*., 2021). Active dry yeast contains many active ingredients such as protein, vitamins B (thiamin, riboflavin and pyridoxines), tryptophan, which is the primer of IAA structure that plays an important role as plants growth regulator, and cytokinins that plays main role in delaying leaves senescence by inhibiting of chlorophyll disintegration and improve protein and RNA synthesis. In soil, yeast improves humus content and enhancement soil structure, it also significantly reduces soil density and increases water-holding capacity resulting in improved nutrient and reduced soil degradation (Hassan and Moubarak, 2021). Yeast is a biostimulant and natural biofertilizer that enhances the growth and productivity of many crops. It is a natural source of cytokinins that stimulate cell division and differentiation and also stimulate protein and nucleic acid synthesis and chlorophyll production. It also contains some major and minor nutrients and growth regulators (such as algalins and Auxins), sugars and vitamins, especially vitamin B. It has a clear and important role in increasing the efficiency of enzymes and improving the absorption of nutrients that stimulate vegetative growth of plants in general. At the same time, yeast releases

CO_2, which is positively reflected in an increase in the total production of photosynthesis (Abd El Nasser *et al*., 2019, Taha *et al*., 2021).

The aim of the present study is to investigate the effect of using compost, biofertilizers and active dry yeast in improving and stimulating plant growth, oil yield and some chemical constituents of Lavander (*Lavandula officinalis* L.) to reduce the amount of mineral fertilizers application to obtain a clean product with lower production costs.

MATERIAL AND METHODS

The research was conducted at the net house of the Central Laboratory of Agricultural Climate Research Centre (CLAC), Agricultural Research Center, Dokki, Giza Governorate, Egypt, for two seasons, 2018/2019 and 2019/2020. Aiming to investigate the effect of compost, biofertilizers using *Azospirillum* spp., *Azotobacter* spp. and active dry yeast as well as its mixture on vegetative growth, herb yield, essential oil production its constant and chemical composition of lavender. Randomized soil sample was collected before planting and the irrigation water to determine the physical and chemical analysis according to the standard method as described by (Jackson, 1973) in Table (1).

Table 1. Some physical and chemical characteristics of the experimental soil before planting and the irrigation water

Mechanical analysis (%)		**(Anions and Cations (mmq/ L.)**			
Coarse Sand	3.19	The experimental soil used		Irrigation water	
Fine Sand	17.32	pH (1: 2.5)	7.80	pH	7.60
Silt	19.85	EC (dS/m^3) (1:5)	1.44	EC (dS/m^3)	1.20
Clay	59.64	SP %	67	SAR %	1.30
Texture class	Clay	Ca^{++}:	7.27	8.52	
Available nutrients (ppm)		Mg^{++}	1.63	3.62	
		Na^{+}	4.30	3.24	
N	15.7	K^{+}	1.20	0.19	
P	12.6	CO_3^{--}	--	--	
K	33.7	HCO_3^{-}	1.35	6.29	
		Cl^{--}	2.32	2.20	
		SO_4^{--}	10.73	7.08	

The seedlings were obtained from the experimental station El-Qanater El-Khairia (belonged to Medicinal and Aromatic Dept. Horticulture Research Center, ARC). The experiment contained 6 treatments with 3 replicates, every replicate contained 10 seedlings at 30 cm between the plants in the randomized complete block design. Seedlings were transplanted on October 15th, 2018, and 12th 2019. Plants were cut three times during the growing season, on 15th February, 15th November and 20th August in the first season. On 2nd February, 20th November and 1st September in the second season.

Mineral fertilizer: Full recommended dose was added to the control treatment, according to the Ministry of Agriculture and Land reclamation. Egypt. Chemical NPK fertilizers consists of mixture of Ammonium nitrate (N 33%), superphosphate (P_2O_5 15.5%), and potassium sulphate (K_2 48%) as a source of macronutrients (300 –150 – 75) respectively.

Organic fertilizer: Compost added to the soil as a recommended dose (15 tons/fed.) to all the treatment before planting except the Control treatment (Chemical fertilizer). Physical and chemical properties of the compost shown in Table (2) according to (Page *et al*., 1982) in Table (2).

Table 2. Some physical and chemical characteristics of the compost used

Physical and Chemical properties		**Values**
Bulk density	**Kg m^3**	850
Moisture content	**%**	25.00
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		--

Active dry yeast: Active dry yeast (*Saccharomyces*) was dissolved in warm water (38°C) and sugar in a 1:1 ratio to activate the yeast growth and reproduction and left for 2 hours before being added to the soil. Active dry yeast was used at a rate of 4 g/l (El-Sayed *et al*., 2009). It was added after planting the seedling, then after every 15 days, and after each cut.

Microbial count determination:

1-Total microbial count: Before planting, soil samples were collected for microbiological examination in the rhizospheric zone of the plant, total bacteria (Difco, 1985), fungi (Allen, 1957), and actinomycetes (Jensen, 1930) were counted.

2-Total number of nitrogen- fixing bacteria: Using the Most Probable Number technique (MPN) according to (Reinhold *et al*., 1985). *Azotobacter* spp. were counted on Ashby's medium (Abd- El-Malek and Ishac, 1968) while *Azospirillum* spp. were counted on N- deficient semi- solid malate medium (Doberiner *et al.,* 1976). Tubes were incubated at 30° C for 5- 7 days according to (Eid, 1978). These isolates were identified according to cultural, morphological and physiological characteristics according to Bergy's (Manual George *et al*., 2005) as *Azotobacter chroococcum* and *Azospirillum lipoferum*.

Preparing of biofertilizers: The nitrogen fixer's bacteria, which isolated locally from the cultivated soil were grown to maximum growth to 10^8 cfu /ml. on the specific medium. Equal volumes of each bacterial strain were mixed to make a mixture of inoculum, then diluted as 1:10 ml water to use as a soil drench. It was added several times, the first time after planting and then every 15 days.

Experimental treatments:

1. Chemical fertilizer as recommended dose (Control).
2. Compost
3. *Azospirillum lipoferum*
4. *Azotobacter chroococcum*
5. *Azospirillum lipoferum* + *Azotobacter chrooccocum*
6. Active dry Yeast

Vegetative growth characteristics: Plant height (cm), numbers of branches, fresh weight, and dry weight (g) per plant.

Chemical composition of plant: Leaf pigments content (chlorophyll a, b and carotenoids concentrations) (mg/ g fresh weight of leaf) according to (Askar and Treptow, 1993).

The phenolic compounds (mg /100g fw)as described by (Shahidi and Naczk, 1995). Total flavonoids content was determined according to (Mabry *et al*., 1970).Total phenol and carbohydrates content in dry weight of plant were determined according to (A.O.A.C. 1980).

Total Free Amino Acids (mg/100gm) assays according to (Carpena-ruiz, *et al*., 1989). Total Antioxidant was evaluated according to (Wojdyło*, et al*., 2007) with modifications (Chrysargyris *et al*., 2016).

Total Nitrogen % (dw) described by (Piper, 1950), Using an atomic absorption spectrophotometer (Barkin Elmer 3300), Total phosphorus and potassium % were determined (Chapman and Pratt, 1961).

Proportion of essential oils based on (Guenther, 1952). The fresh weight of the plant was used to compute the essential oil yield (ml/plant). The laboratory of Medicinal and Aromatic Plants Research (NRC), Dokki, Cairo, of ARC performed the gas-liquid chromatographic (GLC). GLC is used to determine endogenous hormones (Wasfy and Orrin, 1975).

Soil temperature: using a digital thermometer, Art.No.30.5000/30.5002 produced by TFA, Germany, the temperature was calculated as an average for (maximum + minimum) per month from transplanting until the end of the experiment.

Statistical analysis:

A field experiment was conducted over two seasons, 2018-2019 and 2019-2020. With six treatments and three repetitions, the experiment was performed using a randomized full block design. The received data was analyzed statistically by (Waller and Duncan, 1969). The least significant difference value L.S.D. was used to compare the means of all treatments at the 0.05 level of probability. Duncan's Multiple Range Test was used to compare means at a 5% level.

Results

Microbiological determinations:

Total microbial counts and the most probable number of N_2- fixers isolated from the rhizosphere soil before cultivation:

The total microbial counts carried out in the soil before planting. Data in Table (3) found that, the differences between microbial groups such as the total bacteria, fungi and actinomycetes counts were 11 x 10^6 - 3.3 x 10^4 - 1.12 x 10^5 cfu cells/ml culture medium respectively. The most probable numbers (MPN) of *Azospirillum* spp. and *Azotobacter* spp. detected that, the number of populations was nearly similar, although *Azospirillum* spp. (2.0 X10^4/ml) was less than *Azotobacter* spp. (2.5 X10^4/ml).

Table 3. The microbial counts and the most probable number of N_2- fixers isolated from the rhizosphere of lavender herbs.

The microbial counts (cfu cells/ml culture medium)	
Bacteria	11 X 10^6 cfu
Fungi	3.3 X 10^4 cfu
Actinomycetes	1.12 X 10^5 cfu
Most probable number of N_2- fixers (MPN X10^5 ml^{-1} on specific cultural media)	
***Azospirillum* sp.**	2.0 X10^4/ml
***Azotobacter* sp.**	2.5 X10^4/ml

Vegetative Growth:

Data presented in Table 4 revealed that, all biofertilizer treatments were significantly increased the vegetative growth parameters (plant height, number of branches/plant, fresh and dry weights of leaves) compared to the control treatment (T_1) and compost treatment (T_2) along the three cuts of the plant in both seasons. Best values were recorded in T_5 (compost + *Azospirilum* spp. + *Azotobacter* spp.), followed by T_4 (Compost + *Azotobacter* spp.), T_3 (Compost + *Azospirillum* spp.), and T_6 (Compost + ADY). The active dry yeast (ADY) gave a significant effect on plant high, a number of branches, fresh and dry weight of leaves in all cuts in both seasons.

Table 4. Effect of organic and biofertilizer on Plant height (cm), Number of branches per herb, Fresh and dry weight (g) of lavender herb during the two seasons.

	Plant height (cm)			Number of branches/herb			Fresh weight (g)			Dry weight (g)		
Harvest	**1st cut**	**2nd cut**	**3rd cut**	**1st cut**	**2nd cut**	**3rd cut**	1st cut	**2nd cut**	**3rd cut**	**1st cut**	**2nd cut**	**3rd cut**
						First season						
T_1	27.50^{e}	47.50^{d}	50.67^{f}	7.83	8.00^{d}	14.50^{c}	70.49^{f}	152.66^{f}	273.42^{f}	17.29^{e}	44.76^{e}	79.80^{e}
T_2	32.26^{e}	58.33^{c}	59.00^{e}	6.17	7.53^{d}	14.50^{c}	77.39^{e}	172.37^{e}	300.00^{e}	21.39^{d}	45.78^{de}	87.35^{d}
T_3	30.77^{d}	60.00^{b}	61.67^{c}	8.17	10.33^{c}	15.40^{c}	117.55^{c}	308.28^{c}	348.96^{c}	22.13^{d}	46.63^{d}	88.91^{c}
T_4	38.39^{b}	60.17^{b}	78.00^{b}	8.50	12.33^{c}	17.90^{b}	122.98^{b}	344.49^{b}	392.90^{b}	26.27^{b}	78.64^{b}	112.09^{a}
T_5	44.07^{a}	63.80^{a}	87.29^{a}	8.57	15.16^{a}	19.00^{a}	129.02^{a}	401.22^{a}	396.72^{a}	29.75^{a}	105.65^{a}	113.02^{a}
T_6	33.17^{c}	59.50^{b}	60.50^{d}	8.00	11.50^{b}	15.00^{c}	106.59^{d}	186.83^{d}	336.09^{d}	24.62^{c}	70.23^{c}	98.88^{b}
F test	**89.80**	**88.65**	**566.60**	**2.26**	**26.19**	**9.37**	**1728.83**	**29339.08**	**6141.49**	**24.60**	**989.60**	**506.33**
LSD	**1.081**	**1.020**	**0.989**	**no lsd**	**0.961**	**1.083**	**1.02**	**1.05**	**1.08**	**1.47**	**1.34**	**1.05**
						Second season						
T_1	27.33^{e}	43.75^{e}	50.00^{e}	7.42	7.83^{d}	10.50^{e}	69.40^{f}	142.45^{f}	253.42^{f}	18.31^{d}	40.65^{d}	74.05^{d}
T_2	28.50^{d}	50.33^{d}	56.25^{d}	7.00	7.33^{d}	13.71^{d}	71.73^{e}	154.84^{e}	287.96^{e}	21.00^{c}	40.77^{d}	81.45^{c}
T_3	28.00^{de}	56.67^{c}	58.80^{c}	8.08	9.65^{c}	16.39^{b}	106.76^{c}	243.92^{c}	337.34^{c}	21.69^{c}	41.58^{d}	81.35^{c}
T_4	34.00^{b}	58.95^{b}	68.84^{b}	8.08	11.70^{b}	16.63^{b}	115.90^{b}	277.91^{b}	343.27^{b}	24.48^{b}	61.69^{b}	92.28^{b}
T_5	42.27^{a}	60.31^{a}	86.57^{a}	8.24	14.83^{a}	17.33^{a}	120.96^{a}	392.76^{a}	385.36^{a}	29.49^{a}	102.25^{a}	106.39^{a}
T_6	30.83^{c}	56.67^{c}	58.46^{c}	7.08	11.05^{b}	14.73^{c}	95.85^{d}	166.90^{d}	316.97^{d}	22.00^{c}	56.66^{c}	82.42^{c}
F test	**85.48**	**412.20**	**485.18**	**0.76**	**18.91**	**19.59**	**1145.79**	**23243.73**	**6107.04**	**42.07**	**1350.51**	**333.58**
LSD	**1.058**	**0.532**	**1.020**	**no lsd**	**1.10**	**0.985**	**1.12**	**1.09**	**1.03**	**1.05**	**1.12**	**1.08**

T_1= Control, T_2= Compost T_3= Compost + *Azospirillum lipoferum*, T_4 = Compost +*Azotobacter chrooccocum*, T_5= Compost +*Azospirillum lipoferum* + *Azotobacter chrooccocum*, T_6= Compost + Active dry *yeast.

Yield (Leaves and oilper herb):

Table (5) showed that, all biofertilizer treatments had a significant impact on yield in both seasons compared to the control. During the two seasons, biofertilizer produced a large amount of leaves and oil yield. In this regard, active dry yeast came in the second place, while the control treatment recorded the lowest yield in the first and second seasons.

Table 5. Effect of organic and biofertilizer on Total Yield of leaves (g) and oil (ml) per herb of all three cuts during the two seasons.

Treatments	**Leaves Yield (g)**		**Oil Yield (ml)**			**Total Oil production (ml/Fed.)**
	1st Season	**2nd Season**	**1st Season**	**2nd Season**	**Two seasons**	
T_1 Control	496.58	465.27	1.14	1.03	2.17	45.570
T_2 Compost	549.76	514.54	1.47	1.29	2.76	57.960
T_3 Compost + *Azospirillum*spp	774.79	688.01	1.87	1.61	3.48	73.080
T_4 Compost + *Azotobacter*spp	860.36	737.08	3.01	2.49	5.50	115.500
T_5 Compost + *Azospirillum*spp + *Azotobacter*spp	926.96	899.08	3.54	3.33	6.87	144.270
T_6 Compost + Yeast	629.51	579.72	1.94	1.63	3.57	74.970

Chemical composition:

Leaf Pigments Content (Total Chlorophyll a, b and Carotenoids):

Data in Table (6) indicated that, the content of pigments (chlorophyll a, b and carotenoids) in the fresh leaves of *Lavandula officinalis* L. plant were significant increase in the biofertilizer treatments, which gave the highest values compared to the control along all the three cuts in the two seasons. T_5 (Compost + *Azospirillum* spp. + *Azotobacter* spp.) and T_6 (Compost + Yeast) gave the highest results. Then followed by other bio-treatments as T_3 (Compost + *Azospirillum* spp) and T_4 (Compost +

Azotobacter spp.). Data showed that, all biofertilizer treatments and the treatment applied with ADY gave a significant effect on total chlorophyll content in both experimental seasons than the control treatment.

Table 6. Effect of organic and biofertilizer on chlorophyll a, b, carotene and total pigment percentage of leaves lavender fresh matter.

	Chl.a (mg/100 fw)			Chl.b (mg/100 fw)			Carotenoid (mg/100 fw)			Total pigment (mg/100 fw)		
Harvest	**1st cut**	**2nd cut**	**3rd cut**	**1st cut**	**2nd cut**	**3rd cut**	**1st cut**	**2nd cut**	**3rd cut**	**1st cut**	**2nd cut**	**3rd cut**
						First season						
T_1	0.377[c]	0.315[e]	0.196[a]	0.049[e]	0.030[f]	0.062[c]	0.087[d]	0.064[e]	0.036[e]	0.513[d]	0.409[e]	0.294[d]
T_2	0.262[e]	0.257[f]	0.162[d]	0.052[d]	0.041[d]	0.045[f]	0.086[e]	0.063[e]	0.035[e]	0.400[f]	0.361[f]	0.242[f]
T_3	0.351[d]	0.333[d]	0.171[c]	0.071[c]	0.037[e]	0.060[d]	0.086[e]	0.066[d]	0.051[d]	0.508[e]	0.436[d]	0.282[e]
T_4	0.398[b]	0.349[b]	0.180[b]	0.080[a]	0.062[c]	0.064[b]	0.094[b]	0.074[b]	0.062[b]	0.572[b]	0.485[b]	0.306[b]
T_5	0.436[a]	0.376[a]	0.196[a]	0.081[a]	0.073[a]	0.067[a]	0.099[a]	0.077[a]	0.069[a]	0.616[a]	0.526[a]	0.332[a]
T_6	0.377[c]	0.339[c]	0.195[a]	0.075[b]	0.069[b]	0.051[e]	0.090[c]	0.072[c]	0.055[c]	0.542[c]	0.480[c]	0.301[c]
F test	**8601.42**	**4050.42**	**604.88**	**494**	**830**	**177.42**	**68.67**	**83.67**	**470.67**	**3354.60**	**4424.38**	**1007.29**
LSD	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.002**	**0.002**	**0.002**
						Second season						
T_1	0.350[d]	0.314[e]	0.159[c]	0.068[c]	0.068[b]	0.051[b]	0.074[e]	0.049[e]	0.048[d]	0.492[c]	0.431[d]	0.258[c]
T_2	0.256[e]	0.221[f]	0.134[e]	0.058[d]	0.054[e]	0.033[e]	0.073[e]	0.050[e]	0.034[f]	0.387[e]	0.325[f]	0.201[e]
T_3	0.355[c]	0.326[d]	0.156[d]	0.068[c]	0.060[d]	0.035[d]	0.078[d]	0.055[d]	0.046[e]	0.468[d]	0.336[e]	0.237[d]
T_4	0.377[b]	0.335[b]	0.160[b]	0.070[b]	0.063[c]	0.043[c]	0.080[c]	0.068[b]	0.055[b]	0.527[b]	0.441[c]	0.258[c]
T_5	0.412[a]	0.369[a]	0.187[a]	0.076[a]	0.073[a]	0.054[a]	0.086[a]	0.071[a]	0.066[a]	0.574[a]	0.513[a]	0.307[a]
T_6	0.355[c]	0.332[c]	0.160[b]	0.059[d]	0.068[b]	0.050[b]	0.083[b]	0.059[c]	0.050[c]	0.497[c]	0.459[b]	0.260[b]
F test	**785.05**	**6277.42**	**709.67**	**117.75**	**125.09**	**211.27**	**64**	**210.67**	**278.42**	**554.65**	**2510.91**	**1433.64**
LSD	**0.003**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.005**	**0.002**	**0.002**

T_1= Control, T_2= Compost, T_3=Compost + *Azospirillum lipoferum*, T_4 = Compost +*Azotobacter chrooccocum*, T_5= Compost +*Azospirillum lipoferum* + *Azotobacter chrooccocum*, T_6= Compost + Active dry *yeast.

Total Phenols (%), Total Flavonoid (mg/100gm), Total free amino acids, and total antioxidants in leaves:

Data in Table (7) explained that, all biofertilizer treatment significantly increased the total phenols, total flavonoid, total free amino acids and total antioxidant in the fresh leaves compared to the control treatments in both seasons. The superior treatment was T_5 (Compost + *Azospirillum* spp. + *Azotobacter* spp.) which recorded 5.17, 4.55 and 3.82 % total phenols in the three cuts respectively, during the first season. Then recorded 5.00, 4.54 and 3.54 % in the three cuts respectively during the second season. Followed by T_6 (Compost + ADY) gave 5.05, 4.45 and 3.72% respectively in the first season and 4.92, 4.18 and 3.44 respectively during the second season.

Table 7. Effect of organic and biofertilizer on total phenol (%) per dry weight of leaves and total flavonoid, free amino acids and antioxidants (mg/100gm)of lavender herbs

	Total phenol % (dw)			Total Flavonoid (mg/100gm)			Total Free Amino Acids (mg/100gm)			Total Antioxidants (mg/100gm)		
Harvest	**1st cut**	**2nd cut**	**3rd cut**	**1st cut**	**2nd cut**	**3rd cut**	**1st cut**	**2nd cut**	**3rd cut**	**1st cut**	**2nd cut**	**3rd cut**
						First season						
T_1	4.96[c]	3.87[e]	3.04[c]	12.17[f]	11.58[f]	10.98[f]	8.14[f]	7.62[e]	7.10[e]	60.89[f]	57.93[f]	63.22[e]
T_2	4.71[d]	4.00[d]	2.95[d]	13.42[e]	12.83[e]	12.23[e]	9.08[e]	8.56[d]	8.05[d]	67.10[e]	64.17[e]	64.64[d]
T_3	3.31[f]	3.00[f]	1.92[f]	16.28[b]	15.69[b]	15.09[b]	11.19[b]	10.67[b]	10.15[b]	81.41[b]	78.47[b]	71.20[b]
T_4	4.06[e]	3.48[b]	2.88[e]	14.75[c]	14.08[c]	13.55[c]	10.33[c]	9.82[c]	9.30[c]	73.74[c]	70.75[c]	70.42[b]
T_5	5.17[a]	4.55[a]	3.82[a]	16.85[a]	16.14[a]	15.66[a]	12.40[a]	11.88[a]	11.37[a]	84.26[a]	81.32[a]	84.74[a]
T_6	5.05[b]	4.45[c]	3.72[b]	14.03[d]	13.44[d]	12.84[d]	9.65[d]	9.14[cd]	8.62[d]	70.17[d]	67.20[d]	67.58[c]
F test	13399.89	9685.59	1178.75	30.95	19.14	19.96	12.29	13.87	18.95	410.74	411.72	357.22
LSD	0.011	0.010	0.011	0.547	0.683	0.681	0.75	0.706	0.604	0.75	0.75	0.706
						Second season						
T_1	4.83[a]	3.59[d]	2.76[d]	15.04[f]	12.84[f]	10.98[f]	6.02[f]	5.41[f]	4.58[f]	54.93[f]	65.22[e]	64.22[e]
T_2	4.33[b]	3.72[c]	2.93[c]	15.32[e]	13.12[e]	12.23[e]	6.64[e]	6.00[e]	5.10[e]	61.17[e]	66.64[c]	65.64[d]
T_3	3.22[d]	2.54[f]	1.86[f]	16.64[b]	14.44[b]	15.09[b]	8.07[b]	7.35[b]	6.29[b]	75.47[b]	73.20[b]	72.20[b]
T_4	3.93[c]	3.42[e]	2.12[e]	16.48[c]	14.28[c]	13.55[c]	7.30[c]	6.62[c]	5.65[c]	67.75[c]	72.42[b]	71.42[b]
T_5	5.00[a]	4.54[a]	3.54[a]	19.34[a]	17.14[a]	15.66[a]	8.35[a]	7.62[a]	6.53[a]	78.32[a]	86.74[a]	85.74[a]
T_6	4.92[a]	4.18[b]	3.44[b]	15.91[d]	13.71[d]	12.84[d]	6.94[d]	6.29[d]	5.35[d]	64.20[d]	69.58[c]	68.58[c]
F test	25.59	11825.75	11920.89	12.66	19.42	25.4	6.34	4.21	4.42	410.74	317.58	316.08
LSD	0.238	0.011	0.011	0.75	0.605	0.603	0.602	0.7	0.602	0.75	0.749	0.751

*T_1= Control, T_2= Compost T_3= Compost + *Azospirillum lipoferum*, T_4 = Compost +*Azotobacter chrooccocum*, T_5= Compost +*Azospirillum lipoferum* + *Azotobacter chrooccocum*, T_6= Compost + Active dry *yeast.*

Endogenous hormones: Gibberellic acid (GA3), Indole acetic acid (IAA) and Abscisic acid

Results in table 8 showed that, all biofertilizer treatments led to an increase in the endogenous hormones in lavender plant compared to the control. Gibberellic acid increased in the third cut during the two seasons of the two treatment T_3, followed by T_5. In addition, T_3 recorded the highest values in the Indole acetic acid in the second cut (0.48 and 0.50) respectively during the first and second season. However, the highest values Abscisic acid were obtained with the treatment T_5 in the first and third cut and T_3 in the second cut during the two seasons.

Table 8. Effect of organic and biofertilizer on the endogenous hormones of lavender leaves

Harvest	Gabbrilic acid			Indole acetic acid			Abscisic acid		
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut
First season									
T_1	0.58^{c}	0.11^{c}	0.14^{b}	0.24^{c}	0.09^{f}	0.11^{e}	0.09^{f}	0.08^{c}	0.19^{b}
T_2	0.71^{bc}	0.47^{b}	0.19^{b}	0.29^{a}	0.21^{d}	0.21^{b}	0.21^{d}	0.08^{c}	0.17^{c}
T_3	1.40^{a}	1.65^{a}	0.73^{ab}	0.28^{a}	0.48^{a}	0.19^{c}	0.34^{b}	0.16^{a}	0.07^{e}
T_4	1.09^{ab}	1.39^{a}	1.13^{a}	0.26^{b}	0.34^{b}	0.32^{a}	0.24^{c}	0.10^{b}	0.11^{d}
T_5	0.84^{bc}	0.66^{b}	0.67^{ab}	0.23^{c}	0.24^{c}	0.17^{d}	0.48^{a}	0.06^{d}	0.29^{a}
T_6	0.53^{c}	0.39^{bc}	0.16^{b}	0.26^{b}	0.19^{e}	0.18^{cd}	0.19^{e}	0.08^{c}	0.17^{c}
F test	2773.42	6.54	6416.87	23.4	686.13	134.63	514.59	31.54	212.5
LSD	0.011	0.409	0.009	0.008	0.009	0.01	0.01	0.011	0.009
Second season									
T_1	0.47^{c}	0.13^{b}	0.17^{b}	0.23^{d}	0.10^{e}	0.17^{d}	0.10^{d}	0.09^{c}	0.23^{b}
T_2	0.73^{bc}	0.49^{b}	0.21^{b}	0.31^{a}	0.23^{c}	0.23^{b}	0.18^{c}	0.10^{bc}	0.19^{c}
T_3	1.41^{a}	1.66^{a}	0.74^{ab}	0.29^{b}	0.50^{a}	0.21^{c}	0.23^{b}	0.17^{a}	0.08^{e}
T_4	1.10^{ab}	1.40^{a}	1.14^{a}	0.27^{c}	0.35^{b}	0.33^{a}	0.22^{b}	0.11^{b}	0.13^{d}
T_5	0.74^{bc}	0.52^{b}	0.65^{ab}	0.24^{d}	0.21^{d}	0.12^{e}	0.39^{a}	0.09^{c}	0.29^{a}
T_6	0.55^{c}	0.41^{b}	0.18^{b}	0.28^{c}	0.21^{d}	0.20^{c}	0.18^{c}	0.10^{bc}	0.19^{c}
F test	3573.75	6.75	5878.13	25.88	545.25	184.5	288.83	28.55	152.72
LSD	0.01	0.406	0.009	0.01	0.01	0.009	0.01	0.01	0.01

*T_1= Control, T_2= Compost, T_3= Compost + *Azospirillum lipoferum,* T_4 = Compost +*Azotobacter chroococcum,* T_5= Compost +*Azospirillum lipoferum* + *Azotobacter chroococcum,* T_6= Compost + Active dry *yeast.*

Total nitrogen, phosphorus, and potassium percentages in the leaves:

Data presented in Table (9) revealed that, in both seasons all biofertilizer treatments significantly increased N, P, and K percentages (%) in leaves compared to the control treatment. T_5 gave the highest values of N, P, and K % which recorded (2.09 - 1.88 and 1.73 N %) and (1.97- 1.86 and 1.62 N %) during both seasons respectively.The highest values of P and K percentage were recorded in the treatment T_5 (Compost + *Azospirillum*s pp. + *Azotobacter* spp.) compared to the control.

Table 9. Effect of organic and biofertilizer on the total nitrogen, phosphorus and potassium percentage of dry lavender leaves.

Harvest	Total nitrogen (%)			Total phosphorus (%)			Total Potassium (%)		
	1stcut	2ndcut	3rd cut	1stcut	2ndcut	3rd cut	1stcut	2ndcut	3rd cut
First season									
T_1	2.00^{d}	1.79^{b}	1.72^{a}	0.689^{d}	0.625^{d}	0.548^{d}	1.115^{f}	1.088^{f}	0.967^{f}
T_2	2.01^{cd}	1.71^{d}	1.63^{c}	0.632^{e}	0.584^{e}	0.469^{e}	1.188^{e}	1.117^{e}	0.997^{e}
T_3	1.98^{e}	1.45^{e}	1.30^{d}	0.594^{f}	0.512^{f}	0.356^{f}	1.310^{c}	1.215^{c}	1.095^{c}
T_4	2.07^{b}	1.79^{b}	1.66^{b}	0.816^{b}	0.750^{b}	0.658^{b}	1.373^{b}	1.274^{b}	1.154^{b}
T_5	2.09^{a}	1.88^{a}	1.73^{a}	0.870^{a}	0.799^{a}	0.696^{a}	1.458^{a}	1.326^{a}	1.205^{a}
T_6	2.02^{c}	1.76^{c}	1.64^{c}	0.734^{c}	0.697^{c}	0.624^{c}	1.264^{d}	1.171^{d}	1.050^{d}
F test	49.55	562.63	710.63	28227.75	28843.42	46250.72	38523.67	20918.75	20930
LSD	0.010	0.011	0.010	0.001	0.001	0.001	0.001	0.001	0.001
Second season									
T_1	1.80^{d}	1.77^{b}	1.60^{b}	0.653^{d}	0.592^{d}	0.535^{c}	1.104^{f}	0.943^{f}	0.802^{f}
T_2	1.79^{d}	1.64^{d}	1.40^{e}	0.612^{e}	0.543^{e}	0.437^{e}	1.107^{e}	0.988^{e}	0.994^{e}
T_3	1.74^{e}	1.42^{e}	1.38^{f}	0.575^{f}	0.466^{f}	0.376^{f}	1.179^{c}	0.996^{c}	0.923^{c}
T_4	1.89^{b}	1.78^{b}	1.45^{c}	0.783^{b}	0.721^{b}	0.649^{b}	1.210^{b}	1.124^{b}	1.039^{b}
T_5	1.97^{a}	1.86^{a}	1.62^{a}	0.860^{a}	0.795^{a}	0.655^{a}	1.395^{a}	1.237^{a}	1.139^{a}
T_6	1.83^{c}	1.70^{c}	1.42^{d}	0.713^{c}	0.645^{c}	0.523^{d}	1.211^{d}	1.080^{d}	1.022^{d}
F test	182.91	791.67	274.42	29116.67	35793	55998.75	28273	29391.67	32700.75
LSD	0.010	0.009	0.011	0.001	0.001	0.001	0.001	0.001	0.001

*T_1= Control, T_2= Compost T_3= Compost + *Azospirillum lipoferum,* T_4 = Compost +*Azotobacter chroococcum,* T_5= Compost +*Azospirillum lipoferum* + *Azotobacter chroococcum,* T_6= Compost + Active dry *yeast.*.

Total carbohydrates percentage and Essential oil percentage:

Data in Table (10) showed that, T_5 recorded the highest values in the total carbohydrates in both seasons which recorded (7.30- 5.98 and 4.79) and (6.52- 5.71 and 4.65) respectively during the first and second season. An increase in total carbohydrates can indicate to an increase in photosynthesis, which leads to an increase in the content of photosynthetic pigments in the leaves. Carbohydrates are significant metabolites because they are the first organic complex substances generated in the leaves as a result of photosynthesis and constitute a key respiratory substrate. In addition, all the biofertilizer treatments affected oil percentage in both seasons of Lavender leaves. The increment of oil percentage obtained from T_5 in all cuts in the two seasons, followed by T_4 and sometimes by T_6. Oil content (ml/herb) recorded the same trend.

Table 10. Effect of organic and biofertilizer on essential oil percentage and oil (ml./herb) of leaves in lavender (*Lavandula officinalis* L.).

	Total Carbohydrates (% DW)			Essential oil %			Oil (ml/ herb)		
Harvest	**1st**	**2nd**	**3rd**	**1st**	**2nd**	**3rd**	**1st**	**2nd**	**3rd**
First season									
T_1	5.31^{d}	3.66^{f}	3.39^{e}	0.322^{f}	0.242^{f}	0.197^{f}	0.227^{f}	0.369^{f}	0.539^{f}
T_2	5.36^{d}	3.78^{e}	3.68^{d}	0.391^{d}	0.293^{d}	0.220^{d}	0.303^{e}	0.505^{e}	0.660^{e}
T_3	6.00^{c}	5.04^{c}	4.33^{bc}	0.351^{e}	0.245^{e}	0.200^{e}	0.413^{d}	0.755^{c}	0.698^{d}
T_4	6.62^{b}	5.70^{b}	4.75^{ab}	0.614^{b}	0.366^{b}	0.253^{b}	0.755^{b}	1.261^{b}	0.994^{b}
T_5	7.30^{a}	5.98^{a}	4.79^{a}	0.627^{a}	0.389^{a}	0.295^{a}	0.809^{a}	1.561^{a}	1.170^{a}
T_6	5.68^{cd}	4.30^{d}	3.90^{c}	0.541^{c}	0.310^{c}	0.232^{c}	0.577^{c}	0.579^{d}	0.780^{c}
F test	11.02	24153.67	5.12	46309.67	9238.75	3399.42	9636.91	40284.91	4732.89
LSD	0.407	0.011	0.440	0.001	0.001	0.001	0.004	0.004	0.006
Second season									
T_1	4.43^{f}	3.57^{f}	2.75^{f}	0.321^{f}	0.229^{f}	0.190^{f}	0.223^{f}	0.326^{f}	0.482^{f}
T_2	4.84^{e}	3.76^{e}	3.26^{e}	0.344^{d}	0.280^{d}	0.210^{d}	0.247^{e}	0.434^{e}	0.605^{e}
T_3	5.58^{c}	4.87^{c}	3.68^{c}	0.342^{e}	0.244^{e}	0.192^{e}	0.365^{d}	0.595^{c}	0.648^{d}
T_4	6.14^{b}	5.49^{b}	3.99^{b}	0.601^{b}	0.357^{b}	0.233^{b}	0.696^{b}	0.992^{b}	0.800^{b}
T_5	6.52^{a}	5.71^{a}	4.65^{a}	0.620^{a}	0.382^{a}	0.280^{a}	0.750^{a}	1.500^{a}	1.079^{a}
T_6	4.91^{d}	4.22^{d}	3.66^{d}	0.443^{c}	0.301^{c}	0.223^{c}	0.380^{c}	0.502^{d}	0.707^{c}
F test	16644.67	22544.62	11685.09	45575.42	9271.42	2775.67	5025.73	29945.63	5191.71
LSD	0.011	0.010	0.010	0.001	0.001	0.001	0.005	0.004	0.005

T_1= Control,* T_2= Compost*,* T_3= Compost + *Azospirillum lipoferum,* T_4 = Compost +*Azotobacter chrooccocum,* T_5= Compost +*Azospirillum lipoferum* + *Azotobacter chrooccocum,* T_6= Compost + Active dry *yeast.*

lavender essential oil constant

GLC analysis of lavender essential oil samples for the second season plants from the different treatments was illustrated in Table (11). Thirteen components were found in the essential oil of leaves of lavender. Significantly affect results were found for every treatment which received biofertilizers. Linalool was the main component with the highest value of lavender essential oil. The highest percentages of linalool (52.21- 52.56 and 51.32%) were recorded from plants in T_6 which were treated with (compost + ADY). Followed by the treatment with biofertilizers gave the linalool values between (59.69 and 49.51). 1,8 cineol was the second component of the lavender essential oil which recorded (19.59- 17.59 and 18.99) in T_6 followed by the treatments with the biofertilizers**.**

Table 11. Effect of organic and biofertilizer on essential oil components in leaves of Lavender (*Lavandula officinalis* L.) in the first season.

Essential oil Components	Control			Compost			Compost + *Azospirillum* spp			Compost + *Azotobacter* spp			Compost + *Azospirillum*spp + *Azotobacter* spp			Compost + Yeast		
	1stcut	2ndcut	3rdcut	1stcut	2ndcut	3rdcut	1stcut	2ndcut	3rdcut	1stcut	2ndcut	3rdcut	1stcut	2ndcut	3rdcut	1stcut	2ndcut	3rdcut
α- pinene	3.74	3.92	3.92	4.11	5.29	4.15	2.32	2.82	2.74	3.16	4.57	3.18	3.20	6.30	5.43	6.30	5.43	4.20
Camphene	4.19	6.41	7.39	2.09	2.29	3.53	1.45	2.38	2.06	2.68	2.88	2.60	4.52	6.73	6.80	6.73	6.80	2.97
Myrcene	5.58	9.74	7.03	5.45	3.81	5.25	4.07	3.23	2.53	0.99	2.20	2.07	3.15	4.45	2.82	4.45	2.82	2.06
β- pinene	4.59	2.14	3.68	2.78	1.97	3.73	2.56	3.21	3.64	4.03	3.40	3.25	2.46	2.10	2.28	2.10	2.28	4.68
1,8 cineol	15.23	16.21	18.03	18.93	16.23	18.26	16.40	18.21	16.28	16.16	16.97	17.34	16.60	17.32	17.15	17.32	17.15	19.59
Limonene	3.05	2.62	1.13	1.21	3.23	2.71	1.48	3.40	2.01	2.55	3.85	1.90	1.26	3.42	3.63	3.42	3.63	4.21
Linalool	42.52	41.31	40.32	52.34	55.31	48.28	58.54	56.02	59.12	59.69	51.72	59.17	58.65	51.30	49.51	51.30	49.51	52.21
Camphor	7.34	8.05	7.44	3.88	3.96	3.92	4.46	3.96	3.59	2.72	1.56	1.52	2.88	2.35	1.95	2.35	1.95	2.13
Broneol	4.72	2.09	2.35	1.97	1.88	1.58	3.02	2.23	2.21	1.41	4.42	2.20	3.00	2.16	3.29	2.16	3.29	1.20
Terpine-4-01	3.66	3.31	3.98	2.57	2.75	2.60	3.73	3.76	2.87	3.02	2.32	2.97	3.21	2.90	2.81	2.90	2.81	2.63
linalyl acetate	1.36	0.92	0.98	0.59	1.56	0.82	3.98	3.93	0.95	0.76	3.59	1.70	2.63	0.84	2.22	0.84	2.22	1.05
Eugenol	1.78	1.26	1.41	1.04	1.03	1.41	2.23	2.93	0.72	1.44	1.43	1.45	1.46	1.10	2.94	1.10	2.94	1.78
β- canyoph	1.87	1.96	1.96	2.05	2.64	2.08	1.16	1.81	1.37	1.58	2.28	1.59	1.60	1.15	2.72	1.15	2.72	2.10

Table 12. Effect of organic and biofertilizer on essential oil components in leaves of Lavender (*Lavandula officinalis* L.) in the second season.

Essential oil Components	Control			Compost			Compost + *Azospirillum* spp			Compost + *Azotobacter* spp			Compost + *Azospirillum* spp + *Azotobacter* spp			Compost + Yeast		
	1stcut	2ndcut	3rdcut	1stcut	2ndcut	3rdcut	1stcut	2ndcut	3rdcut	1stcut	2ndcut	3rdcut	1stcut	2ndcut	3rdcut	1stcut	2ndcut	3rdcut
α- pinene	8.66	9.37	8.76	5.20	5.28	5.24	5.77	5.28	4.90	4.04	2.88	2.84	4.20	3.67	3.27	3.44	4.93	5.11
Camphene	3.17	5.39	6.37	1.06	1.27	2.51	0.43	1.36	1.04	1.66	2.23	1.58	3.50	5.71	5.78	1.95	1.43	1.19
Myrcene	4.55	8.72	6.01	4.43	2.79	4.23	3.05	2.21	1.51	1.23	1.17	1.05	2.13	3.42	1.80	1.04	1.32	1.54
β- pinene	3.56	1.11	2.66	1.75	0.94	2.70	1.54	2.19	2.62	3.01	2.38	2.23	1.44	1.08	1.26	3.66	1.66	3.14
1,8 cineol	18.21	15.32	16.03	21.91	19.21	21.24	19.38	21.19	19.26	19.14	19.95	20.32	19.58	20.30	20.12	22.56	20.57	21.97
Limonene	2.03	1.60	0.11	0.19	2.20	1.69	0.45	2.37	0.99	1.52	2.82	0.88	0.23	2.40	2.61	3.18	1.70	1.82
Linalool	42.69	41.48	40.50	52.52	55.49	48.45	54.72	52.20	56.29	59.87	58.97	59.35	58.82	51.48	49.69	52.39	52.74	51.41
Camphor	6.32	7.03	6.42	2.86	2.94	2.90	3.43	2.94	2.56	1.70	0.54	2.10	1.86	1.33	0.93	1.10	2.59	2.77
Broneol	3.70	1.07	2.32	0.95	0.86	0.56	2.00	1.21	1.19	0.39	3.40	1.18	1.97	1.13	2.26	0.18	1.76	1.09
Terpine-4-01	3.99	3.77	3.42	2.53	2.55	2.54	2.67	2.55	2.46	2.92	2.89	2.94	2.83	2.91	2.90	2.09	2.46	2.51
linalyl acetate	3.72275	4.2573	3.7995125	5.13128	5.189565	5.16042	5.56049	5.186483	4.908555	4.25662	3.386745	3.358436	4.37943	3.9803	3.683	4.786	4.928378	5.061101
Eugenol	0.76	0.24	0.39	0.02	0.01	0.38	1.21	1.02	0.68	0.42	0.41	1.12	0.44	1.76	1.91	0.75	0.30	0.86
β- canyoph	0.85	0.94	0.94	1.03	1.62	1.05	0.13	0.89	0.35	0.56	1.26	1.02	0.58	0.13	1.69	1.08	2.70	0.61

Soil temperature:

Bacterial growth was affected by soil temperature, which appeared with parallel changes in the plant growth response.While the lowest temperatures developed various populations as explained in figure (1). A simple technique of using a complete temperature curve, allowing for large scale measurements in field situations with small temperature differences (Barcenas-Moreno, *et al*., 2019). A temperature rise could increase soil respiration and soluble carbon and nitrogen consumption, as well as different impact on bacterial diversity and structure at different elevations (Lin *et al*., 2017). There may be lead to an increase in microbial activity, especially when treated with T_5, which improved all the vegetative and productive characteristics of the lavender plants.

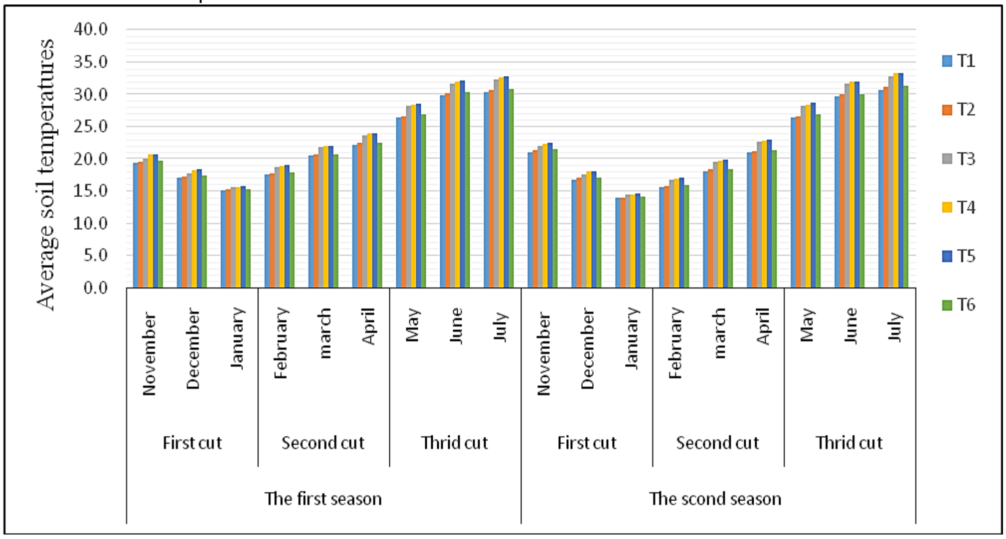

Fig. 1. The average soil temperatures of months during the two seasons.

Economic Evaluation:

In this study, the entire fixed cost is computed once for both seasons, and the variable costs are estimated for one season and multiplied by two to represent the overall cost, as shown in Table (13) and Figures (2).

- Total yield for the two seasons multiplied by an average market price =Total income.
- The profit = total income - total cost
- The profit % = Income / Cost (B/C) ratio

The value reflects the economic feasibility of the proposed treatments.
When the B/C ratio < 1 (the proposed treatment is not suitable)
the B/C ratio > 1 (the project is profitable).

Table 13. Economic evaluation (the fixed cost) of N_2 fixing bacteria application and active dry yeast on net return of Total Yield of oil in Lavender (*Lavandula officinalis* L.)

Treatments	Input			Output			
	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
T_1 Control	1200	25850	27050	217000	189950	8.61	5
T_2 Compost	9000	23000	32000	276000	244000	8.25	6
T_3 Compost+*Azospirillum* spp.	9000	25625	34625	348000	313375	9.88	4
T_4 Compost+ *Azotobacter* spp.	9000	25625	34625	550000	515375	15.28	2
T_5 Compost+ *Azospirillum* spp. + *Azotobacter* spp	9000	25625	34625	687000	652375	18.83	1
T_6 Compost+ ADY	9000	23111	32111	387000	354889	12.05	3
***Fixed cost**	irrigation cost Compost					1200 EGP/Fed. 7800 EGP/Fed	
***Variable cost**	Seedling cost: 20000 seedling/fed. Workers Chemical fertilizers :**ammonium nitrate** 33%, **super phosphate 15.5 % P_2O_5, Potassium sulphate as K_2O** Yeast: 4 gm/l. as15 L/fed. (5 times/ season)					20000 EGP/Fed. 3000 EGP/Fed. 2850 EGP/Fed. 2625 EGP/fed.	
*Revenue	lavender oil					111 EGP/fed	

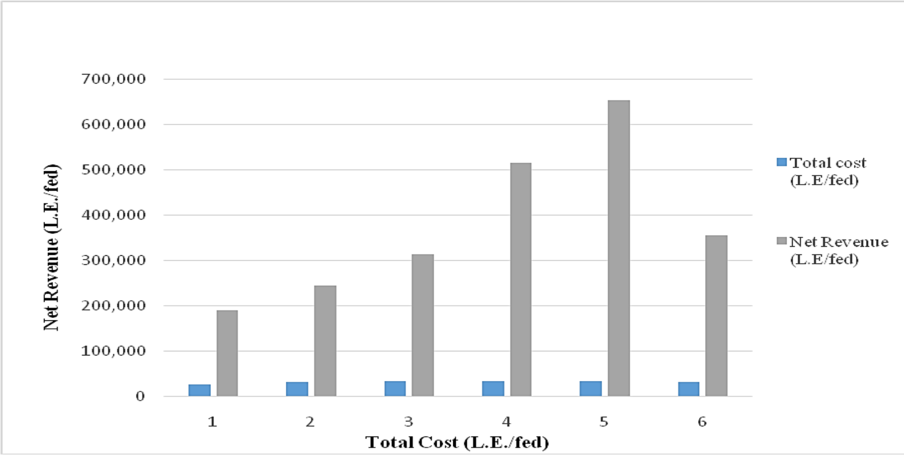

Fig. 2. Comparison the total costs and revenue of all six treatments for lavender plants with the two seasons

DISCUSSION

Soil is a major reservoir of microbial diversity and act as a natural habitat for their multiplication and their different association. These organisms have formed complex interaction networks that influence soil functions and play an important role on plant growth and development, enhance the mineral uptake, production of phytohormones, nitrogen fixation, neutralizing biotic and abiotic stress, producing volatile organic compounds and enzymes to prevent diseases (Choudhary *et al*., 2021). In addition, (Gagelidze*etal*., 2018) said that, soils have a dynamic system in which there is a continuous relationship between soil minerals, organic matter and living organisms. Bacteria are the largest group of soil microbes in terms of total number and diversity.

The present study tested the use of compost, biofertilizers such as *Azotobacter chrococcum*, *Azospirillum Lipoferum* individually or in combinations and the active dry yeast to improve growth and production of lavender (*Lavandula Officinalis* L.) plant and the essential oil. When determined the total population of microorganisms (fungi, bacteria and actinomycetes) in the soil before planting found that, the average number of microorganisms corresponds to the usual number of microbes in arable soils. Where Bacteria recorded the largest population in the soil followed by the fungi, which agreement with (Popelarova *et al*., 2008) said that, bacteria and fungi were the main types of soil microorganisms, which play an essential role in nutrient transformations.

Biological nitrogen fixation is one of the most important biological processes in nature. The utilization of biological nitrogen fixation technology can reduce the use of chemical fertilizers, prevent depletion the organic matter in the soil, reduce environmental pollutionand and increase the yield of crops. Among N_2- fixing bacteria, *Azospirillum* spp. and *Azotobacter* spp. that have a high adaptation to colonize different host plants and have been isolated from many geographical regions of the world. These two genera known to be associated with roots of various plant species and soils of several regions and may increase the crop yield up to 30% (Suliman *et al*., 2019). Nitrogen fixing bacteria (*Azospirillum* spp. and *Azotobacter* spp.) were locally isolated from the cultivated soil and grown in their specific medium, equal volumes of each bacterial strain were mixed to make the inoculum mixture, which was used as biofertilizers in this experiment to improve lavender growth.

Vegetative Growth:

Biofeertilizers have a beneficial effects in improving plant growth as they provide nitrogen, phosphorous and potassium nutrition. They also help the plant establish a greatly organized root system, thus increasing nutrients uptake and improving plant growth (Yaseen *et al*., 2020). Data revealed that, all biofertilizer treatments were significantly increased the vegetative growth parameters (plant height, number of branches/plant, fresh and dry weights of leaves) and total yield (leaves and oil) as compared to the control in all cuts of both seasons. *Azotobacter* spp. and *Azospirilum* spp. are able to fix free nitrogen from the air, so they increase the availability of nitrogen compounds in the soil in the available form to be easy to absorbed by plant roots, whereas, *Azotobacter* spp. can fix 50 to 80 kg of nitrogen / hectare / year (Rahimi *et al*., 2019). Also, (El- Naggar *et al*., 2015) on sweet basil said that, organic and biofertilization are very important methods to improve plant growth with their proper nutritional requirement without having undesirable impacts on the environment. (Mandoor *et al*., 2017) on lavender plants mentioned that, organic matter and dry yeast improved plant growth characters and the oil yield/ fed. (El-Tarawy *et al*., 2017) on caraway mentioned that, compost in combinations with active dry yeast significantly enhanced plant growth due to, active dry yeast producing various enzymes, hormones, amino acids and vit.c.

Chemical Composition:

Biofertilizers increased plant height, stem diameter, branches number, herb fresh and dry weights, oil production (oil % and yield), as well as, photosynthetic pigments (chl. a, b and carotenoids) and the percentages of N, P and K (Abdou *et al*., 2014). Regarding the total chlorophylls contents a, b and carotenoids concentrations influenced positively by organic with biofertilization as well as with active dry yeast was greater than the control. Many researchers reported the same trend (Wael *et al*., 2014) on parsley, (Rahimi *et al*., 2019) on Syrian Cephalaria and (Elsayed *et al*., 2020) on dill.

In this respect, active dry yeast is a natural safety biofertilizer, which has a role in releasing CO_2, which directly improves photosynthesis (Ali *et al*., 2018) in addition to increasing the accumulation of carbohydrates. Carbohydrates also play a role in plant defense against wounds and infections, as well as cell detoxification (Vasca- Zamifir *et al*., 2018). Phenols are very important plant components. There is a linear relationship between total phenol and antioxidants activity in plant species. Phenolic compounds have also reported to be effective hydrogen donors, making them very good antioxidants. The results showed that the use of biofertilizer had a positive effect on production of total phenolic compounds in plants. These results are consistent with those reported by (Amer *et al*., 2019) said that, photosynthetic pigments play an important role in the phenols and flavonoids formation that contribute to the antioxidant activity of sage plants.

Also, Multiple research shown that, free-living N_2- fixing bacteria such as *Azotobacter chroococcum* and *Azospirillum lipoferum* increasing the nitrogen in the soil and release phytohormones similar to gibberellic acid (GA3) and indole acetic acid (IAA), which could stimulate plant growth, nutrient absorption, and photosynthesis, which leads to an increased yields of some plants (Sumbul *et al*., 2020, Ahmed and El-shazly 2021, Din *et al*., 2021, El-Tarawy *et al*., 2017) on caraway, mentioned that compost in combinations with active dry yeast significantly enhanced plant growth. The increase in growth characters may be attributed to the different enzymes, hormones, amino acids, Vit.c etc.

Data presented that, in both seasons the organic and biofertilizer treatments significantly increased N, P, and K percentages in leaves as compared to the control. These results are coordination with the findings of (Jahanshahi *et al*., 2014) on dill plant, (Adeel *et al*., 2014) said that, application of biofertilizer (*Azotobacter* spp. and *Azospirilum* spp.) increased macro and micronutrient absorption on plant. (Abou-Aly and Mady, 2009) on wheat plant. Moreover, (Rahimi *et al*., 2019) on (*Cephalaria syriaca*).

The essential oil percentage and content in the dried leaves of lavander plants were varied from the treatments to other. The highest increase in the oil percentage was obtained from fertilized with organic and biofertilizer for all cuts in the two seasons, similar results of the positive effect of both organic and biofertilizers on the essential oil productivity were obtained by (Wael *et al*., 2014 and Amer *et al*., 2019), (Mohamed *et al*., 2015) on basel (*Ocimum bacillicum* cv.) found that, plants that received biofertilizer had the largest significant increase in essential oil output percentage/plant by improving yield qualities, Also (Zewide, 2019) said that, The application with biofertilizers as *Azospirillum* spp. and *Azotobactor* spp. gave a positive response to increase the yield and it was observed 8 to 15 percent increase in the yield of plant by inoculation with *Azotobactor* spp. and *Azospirillum* spp. alone and in the mixture. In addition, active dry yeast significantly increased lavender oil yield/ fed. compared to control according to (Sakr *et al*., 2015, and Mandoor *et al*., 2017)

CONCLUSION

The influence of biofertilizers on morphological parameters and yield in the lavender plant *Lavandula officinalis* L. was studied in this study. When compared to chemical fertilizer, the results showed that using a combination of organic and biofertilizer significantly enhanced the quantity and quality of lavender yield and essential oil. The compost + *Azospirillum* spp. + *Azotobacter* spp. treatment is outperformed to the other treatments in terms of vegetative growth parameters, chemical compositions of the plant and essential oil of the plant followed by the compost + Active dry yeast treatment.

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تحسين النمو والمحصول والزيت الطيار لنبات اللافندر باستخدام الكمبوست السماد الحيوى في التربه الطينية

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اللافندر نبات له قيمة اقتصادية وطبية عالية. اجريت تجربه حقلية خلال موسمين زراعيين متتالين 2018/ 2019 – 2020/2019. وذلك بهدف دراسة تأثير كل من الكمبوست والتسميد الحيوى باستخدام السلالتين من البكتريا المثبته للنيتروجين (*Azospirillum* spp.،*Azotobacter* spp.) وكذلك الخميرة النشطة, على النموالخضرى والتركيب الكيميائي لنبات اللافندر المنزرع في تربة طينية وكذلك كمية الزيت وجودته. تم أضافة الكمبوست للتربة قبل الزراعة (15 طن/ فدان). اللقاح الحيوي المستخدم تم عزل السلالتين المستخدمين من التربة التي أجريت بها التجربة كل سلاله تم عزلها على البيئة المتخصصة لها لعمل اللقاحات المستخدمة بالتجربة. تم إضافة اللقاح الحيوى الى المعاملات كإضافة أرضية الى جذور النبات بصورة منفردة وفى معاملات أخرى تم خلط السلالتين معا بنسبة 1:1. تمت الاضافة عدة مرات خلال موسم النمو. الخميرة تم اضافتها على الماء الدافئ مع السكر لها 1: 1 مع تركها لمدة ساعتين لتنشطها قبل إضافتها للتربة. المعاملة الكنترول أضيف لها التسميد الكيميائي بالمعدلات الموصي بها من وزارة الزراعة. تم تقييم خصائص النمو الخضري والمحصول كميا بالمعاملات وقورنت بالمعاملة الكنترول , تم تحديد نسبة الزيت الأساسي في النبات الطازج وكذلك مكونات الزيت لتقييم جودته.

علاوة على ذلك، تم تذييل الدراسة بجدوى اقتصادية لتحدد الجدوى الاقتصادية للدراسه. أشارت النتائج الى ان استخدام الأسمدة الحيوية أدى الى زيادة معنوية في طول النبات، عدد الافرع، الوزن الرطب، الوزن الحاف، كمية المحصول، نسبة الزيت الأساسي، نسبة النيتروجين والفوسفور والبوتاسيوم في الأوراق، محتوى الكلوروفيل الكلى، البروتين، مضادات الاكسدة، الفينولات والفلافونات، الكربوهيدرات الكلية ومحتوى الاحماض الامينية الحرة ومقارنة النتائج بالمعاملة الكنترول. وأشارت النتائج الى ان المعاملة المستخدم بها مخلوط السلالتين معا مع الكمبوست أعطت أفضل نتائج في جميع الصفات التي تم قياسها. كما أدت الى زيادة نسبة الزيت العطري. أي ان اضافة التسميد العضوى (الكمبوست) مع التسميد الحيوي أدى الى انتاج نبات صحي وامن بيئيا مع تقليل مخاطر التلوث الناتج عن استخدام الأسمدة الكيميائية. وأشار التقييم الاقتصادي الى ان اتباع طريق التسميد العضوي والحيوي أعطت اعلى قيمة للعائد الصافي لنبات اللافندر.

الكلمات المفتاحية: اللافندر، الكمبوست، الازوتوباكتر، الازوسبيريللبم، الخميرة الحافة، الإنتاجية.