

**EFFECT OF BIO-FERTILIZATION STRAINS AND
COMPLETE FERTILIZER OR BIOMAGIC
PRODUCT ON THYME PLANT UNDER
NORTH SINAI CONDITIONS**

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ABSTRACT: Present work was carried out during the two successive seasons (2003-2004) on thyme "*Thymus vulgaris*" at El-Shiekh Zowaied Research Station, Desert Research Center, North Sinai Governorate, to study the effect of bio-fertilization strains (*Azotobacter chroococcum*, *Bacillus megaterium* and their mixture) and complete fertilizer (kristalon) or biomagic product as well as their interaction treatments on the growth, oil yield and its constituents of thyme herb.

The obtained results show that, all growth characters; i.e., plant height, fresh and dry weights of herb and yield were significantly influenced by all treatments compared to control. Meanwhile, insignificant differences in total yield of herb dry weight were shown by interaction between all treatments. Moreover, all fertilization treatments increased significantly the volatile oil yield and influenced its constituents compared to control.

Key words: *Thymus vulgaris*, *Azotobacter chroococcum*, *Bacillus megaterium*, Bio-fertilizers, Volatile oil, Thymol, Complete chemical fertilizers.

INTRODUCTION

Thyme is the common name of *Thymus vulgaris*, belongs to Lamiaceae family. It is native to Mediterranean region, Spain and now found throughout Asia and Europe. Thyme plant is a gray dwarf shrub rarely exceeds 40 cm height, stem quadrangular erect, woody and much branched. Leaves are small oval, rolled margin and downy under surface. Flowers are small pink and arranged in a corymb. The plant has a strong characteristic smell (Fawzy, 1985). Chevallier (1996) reported that thyme plants have active constituents as volatile oil especially thymol, carvacorol, cineole, borneol and others. Flavonoids and volatile oil of thyme has a strong antiseptic agent and thymol is the most effective antifungal constituent.

Tamara (1998) found that methyl chavicol and the flavonoides in thyme oil relieve muscle spasme. Zambonalli *et al.* (1996) mentioned that essential oils of thyme, lavender and mint were tested *in vitro* against *Rizoctonia solani*, *Pythium ultimum*, *Fusarium solani* and *Colletotrichum lindemuthianum*. All these oils inhibit fungal growth. Omar *et al.* (1997)

reported that control and irradiated essential oil of *Thymus vulgaris* have the exhibited activity against fungi and bacteria. Thyme plant is a great favourite for bees and the honey obtained from it has the same properties as the plant itself (Chiej, Roberto, 1988).

In the Middle East, a popular commercial herb called "Zaatar" used as a spice in foods. It is prepared from the dried leaves of *Thymus vulgaris*, *Origanum syriacum*, *Thymus capitatus* and *Satureia thymbra* (Ravid and Putievsky, 1986).

So, thyme plant is one of the important plants which need more study in the newly reclaimed lands especially at North Sinai which has a favorable climatic conditions for producing it. Moreover, studying the agricultural practices and their effects on the herbage and the volatile oil yield must take consideration.

Bio-fertilization is one of the important factors used to produce products free from mineral contamination. On the other hand, the intensive use of chemical fertilizers cause environmental pollution problems and high rates of it led to decrease the potential activity of micro flora and the

stability of organic matter. Hence, the attention has been focused on the researches of bio-fertilizers to substitute chemical fertilizers. Bio-fertilizers are increasing the number of micro-organisms and accelerate certain microbial processes in the rhizosphere of inoculated soils or plants which can change the unavailable forms of nutrients into available ones, (Subb Roa, 1981) and Alaa El-Din (1982).

The bio-fertilizers and complete fertilization significantly increased vegetative growth; i.e, plant height, herb fresh and dry weights / plant and total yield of herb dry weight / feddan. These results agreed with Mahfouz (2003) on *Majorana hortensis*, Singh *et al.* (2005) on dahlia plants. Al-Ahl (2005) on dill, Al-Qadasi (2004) on *Ocimum basilicum*, Ebrahim (2005) on roselle, Ismail (2005) on fennel and Ismail (2002) on *Pisum sativum* L. Moreover, the volatile oil percentage and its compositions were increased with application of complete and bio-fertilizers as reported by Mahfouz (2003) on *Majorana hortensis*, Attia and Abdel-Azeem (2004) on *Mentha viridis* L., Hamed (2004) on *Origanum syriacum* and *Salvia*

officinalis, Ismail (2005) on fennel plants, Youssef *et al.* (2004) on sage plants, Al-Qadasi (2004) on *Ocimum basilicum* and Al-Humaid (2004) on fennel plants.

The present study aimed to investigate the effect of bio-fertilization strains, complete fertilizer (kristalon) and biomagic product as well as their interaction treatments on the growth, oil yield and constituents of thyme herb.

MATERIALS AND METHODS

The present work was carried out at the experimental station of Desert Research Center (D.R.C.) at El-Sheikh Zowayed, North Sinai Governorate during the two successive seasons of 2002 / 2003 and 2003 / 2004.

Seeds of thyme plants were kindly provided from Sekem company of medicinal and aromatic plants. The seeds were sown in the nursery bed on 15th October in the two seasons (2002 and 2003). Meanwhile, seedlings were transplanted in the experimental area on 15th February (2003 and 2004) for the two seasons in sandy soil. The mechanical and chemical properties of the used soil are shown in Table A.

Table A. Mechanical and chemical properties of the used soil

Characters	Values
Mechanical analysis	
Fine sand %	31.96
Coarse sand %	58.36
Silt %	7.43
Clay %	2.25
Texture class	Sandy
Chemical analysis	
pH	8.47
E.C. (mmhos / cm)	0.90
Soluble anions (meq. / l)	
CO ₃ ²⁻	—
HCO ₃ ⁻	1.91
Cl ⁻	3.00
SO ₄ ²⁻	4.74
Soluble cations (meq. / l)	
Ca ⁺⁺	4.08
Mg ⁺⁺	0.82
Na ⁺	4.50
K ⁺	0.25
Organic matter (%)	0.52
Avalable N (ppm)	12.00
Avalable P (ppm)	7.00
CaCO ₃ %	2.80

Irrigation system of the experiment was drip irrigation with drippers of (4l / hour) for one hour twice every week, by using plastic tanks on the beginning of the main line which branched to lateral lines from plastic pipes (16 mm diameter) and with 30.6 m long. The distance between lines was 50 cm and 30 cm between the plants on the row and 60 cm between the treatments. The chemical analysis of the used water is shown in Table B.

Bio-fertilization Treatments

The biological fertilization strains were obtained from Microbiology Department, (D.R.C.) and the treatments were as follows:

Azotobacter Chroococcum (A), nitrogen fixing bacteria with rate of about 10⁸ cell/ml in aqueous suspension.

Bacillus megaterium (B), phosphate dissolving bacteria with rate of about 10⁸ cell/ml.

Table B. Chemical analysis of the used irrigation water

Characters	Values
pH	8.3
E.C.(mmhos / cm)	620
Soluble cations (ppm)	
Ca ⁺⁺	41.02
Mg ⁺⁺	24.92
Na ⁺	55.00
K ⁺	2.00
Total cations	6.531
Soluble anions (ppm)	
CO ₃ ⁻⁻	23.22
HCO ₃ ⁻	86.55
SO ₄ ⁻⁻	89.00
Cl ⁻	85.50
Total anions	6.440

The mixture of the two mentioned strains (A+B) with active rate of about 10^8 cell/ml with equal volume. Every treatments had three replicates. Each one received 100 ml of aqueous suspension diluted with 10 litres of tap water and were added at the root zone after 15 days from transplanting, once every season.

The control plants were treated with tap water.

Complete Fertilizer or Biomagic Product Treatments

The used complete fertilizer with commercial name of Kristalon contained macro and micro nutrients. Kristalon fertilizer was obtained from Hydro Agri. Trade Egypt Co. 10, Road 61 New

Maadi, Cairo. The chemical composition of Kristalon fertilizer was as follows:

Macro elements: nitrogen (N) 19 %, phosphorus (P₂O₅) 19 %, Potassium (K₂O) 19% and magnesium (Mg) 1.5%.

Microelements: boron (B) 0.025 %, manganese (Mn) 0.01%, copper (Cu) 0.01 % and molybdenum (Mo) 0.001 %. The concentration used of Kristalon as foliar spray in both season was 1.5 g/l in aqueous solution as recommended by Hydro Agri. Trade Egypt Co.

The plants were sprayed using hand-held sprayer and the used volume of the solution was maintained just to cover the whole

plant foliages every 21 days from the first spray date which was after 15 days from transplanting date till the harvesting (4 sprays every cut).

The used biomagic product which a biological promoter of microbiology origin (El-Sibai, 1995). Biomagic was provided from Microbiology Department, (D. R. C.) The biomagic did not contain any of the synthetic phytohormones, but it contained many of the biological products, which affected the plant growth and productivity and increased the plant immunity to microbial diseases. Biomagic has pH of 5.5 and consists of the following:

Amino acids (1.907%); i.e., arginine, cystine, glycine, histidine, isoleucine, leucine, lysine, phenylalanine, theronine, tryptophane, tyrosine and valine.

Vitamins (0.38%); i.e., thiamin, biotene, choline, folic acid, niacin, potothinic, pyrodxine and riboflavin.

Macro elements (in mg/l); i.e., N(1125), P₂O₅ (550) and K₂O(625)

Micro elements (in mg/l); i.e., Fe (160), Zn (124), Mn (100), Mg(45), Cu (45), B(14), Mo(12), Cd (7) and Ni(4).

The used concentration of biomagic as foliar spray in both seasons was 7.5 g/l as recommended (El-Sibaie, 1995). The amount of biomagic was dissolved in aqueous solution. The plants were sprayed using hand-held sprayer and the used volume of the solution was maintained just to cover the whole plant foliages completely every 21 days from the first spray date which was after 15 days from transplanting date till the harvesting (4 sprays every cut).

The control plants were sprayed with tap water.

Interaction Treatments between Bio-fertilization Strains and Complete Fertilizer (kristalon) or Biomagic Product

There are twelve interaction treatments which were the combination between four bio-fertilization treatments and three treatments (including complete fertilizer, biomagic product and control).

The experimental design was factorial experiment between bio-fertilization strains and complete fertilization treatments in complete randomized block design with three replicates. Each replicate contained 24 plants. All the plants

received normal agricultural practices when they needed.

Harvesting

Harvesting was carried out in two cuts every season. The first cut was done on May 15th (after 90 days from transplanting date) and the second cut was done on August 15th (after 180 days from transplanting date) by cutting the vegetative parts of plants (5 cm above the soil surface) leaving 2 branches for regrowth.

Recorded Data :

Vegetative Characters

A random sample of four plants from each replicate was taken from the first cut, on May 14th at 89 days after transplanting before harvesting and at the second cut on August 14th at 179 days after transplanting before harvesting and the following data were recorded:

- Plant height (cm),
- Herb fresh weight per plant (gm),
- Herb dry weight per plant (gm)and
- Total yield of herb dry weight per fed (ton).

Chemical Constituents

- Volatile oil percentage (ml / 100gm fresh herb) was determined according to British pharmacopoeia (1963)

-Volatile oil yield per feddan (l.)

-Volatile oil analysis by Gas Liquid Chromatography (G.L.C.) according to Bunzen *et al.* (1969) and Hoftman (1967).

Mechanical and chemical analyses of soil samples representing the experimental soil area were achieved according to the method described by Pipper (1950) are shown in Table A.

The chemical analysis of irrigation water are presented in Table B according to Rainwater and Thatcher (1960).

Statistical Analysis

Data obtained were exposed to the proper statistical analysis of variance according to Steel and Torrie (1980).

RESULTS AND

DISCUSSION

Effect of Bio-fertilization Strains and Complete Fertilizer or Biomagic Product as well as Their Interaction Treatments on Growth Characters

Plant height (cm)

From data presented in Table 1 results show that the addition of *Azotobacter* (A) and *Bacillus* (B) individually

Table 1. Effect of bio-fertilization strains and complete fertilizer or biomagic product as well as their interaction treatments on plant height (cm) of thyme plants in both cuts during the two seasons

Bio-fertilization strains treatments (BF)	Fertilization treatments (F)							
	1 st cut				2 nd cut			
	Control	Kristalon	Biomagic	$\bar{X}(BF)$	Control	Kristalon	Biomagic	$\bar{X}(BF)$
2003 season								
Control	15.92	18.67	19.42	18.00	16.33	19.25	19.58	18.39
Azotobacter (A)	20.92	23.33	23.67	22.64	21.10	23.42	23.42	22.65
Bacillus (B)	20.67	22.75	23.00	22.14	19.25	22.42	22.10	21.26
(A + B)	22.42	25.42	25.75	24.53	22.50	25.00	25.83	24.44
$\bar{X}(F)$	19.96	22.60	22.90		19.80	22.52	22.73	
L.S.D. at 5 %	For(BF)=0.62	For(F)=0.54	For(BF)×(F)=N.S.		For(BF)=0.86	For(F)=0.74	For(BF)×(F)=1.49	
L.S.D. at 1 %	For(BF)=0.85	For(F)=0.73	For(BF)×(F)=N.S.		For(BF)=1.17	For(F)=1.01	For(BF)×(F)=2.00	
2004 season								
Control	16.25	18.33	19.33	17.98	16.17	18.75	19.58	18.16
Azotobacter (A)	19.25	22.08	22.42	21.25	20.33	22.92	22.92	22.05
Bacillus (B)	17.50	20.17	20.50	19.39	19.17	22.08	22.42	21.22
(A + B)	20.58	23.75	24.00	22.78	21.83	24.75	25.25	23.61
$\bar{X}(F)$	18.39	21.08	21.56		19.37	22.12	22.29	
L.S.D. at 5 %	For(BF)=0.56	For(F)=0.48	For(BF)×(F)=N.S.		For(BF)=0.82	For(F)=0.71	For(BF)×(F)=1.43	
L.S.D. at 1 %	For (BF)=0.7	For(F)=0.66	For(BF)×(F)=N.S.		For(BF)=1.12	For(F)=0.97	For(BF)×(F)=1.95	

or the mixture of A+B gave highly significant increase in plant height compared to control. Moreover, the tallest plants were obtained from the treatment of mixture A+B, which increased the plant height with highly significant difference compared to other treatments. Also, plant height gradually increased by the addition of B, A and A+B treatments. These results hold true in the first and second cuts of the two seasons.

Data in Table 1 reveal that spraying thyme plants with complete fertilizer or biomagic gave highly significant increase in plant height compared to control. Furthermore, the tallest plants were obtained from biomagic treatment then gradually decreased with complete fertilizer followed by control treatment. Since, there was no significant difference observed between the biomagic and complete chemical fertilizer treatments. These results were in the same line in the two cuts of the two seasons.

Meanwhile, data in Tables 1 indicate that all of the interaction treatments between bio-fertilization strains A, B and A+B with complete fertilizer or

biomagic gave insignificant increase in plant height in the first cut, but in the second cut it recorded a significant increase compared to control in both seasons. Furthermore, the interaction between A+B and biomagic treatments recorded the tallest plants, compared to other interaction treatments and control. These results are in harmony with those found by Mahfouz (2003) on *Majorana hortensis*, who recorded that the highest value of plant height was found at the treatment of bio-fertilizers plus dose of N and P. Singh *et al* (2005), on dahlia plants, reported that the inoculation with bio-fertilizers increased the plant height values compared to uninoculated treatment. Ebrahim (2005) on roselle found that all of treatments of complete fertilizer recorded an increase in plant height compared to control.

Herb fresh weight /plant(gm)

Regarding to herb fresh weight per plant as affected by bio-fertilization strains and complete fertilizer (kristalon) or biomagic, it could be noticed from Table 2 that the best treatment was the addition of A+B which gave the highest herb fresh weight per plant and it was significantly increased

compared to other ones under study. Moreover, herb fresh weight per plant gradually increased by using the treatments B followed by A and A+B. Since, the addition of A, B or A+B individually led to highly significant increase in this regard compared to control, in both cuts of the two seasons.

Recorded data in Table 2 reveal that the treatment of biomagical gave significant increase in herb fresh weight per plant compared to the complete fertilizer and control treatments. Meanwhile, spraying thyme plants with complete fertilizer or biomagical gave a significant increase in herb fresh weight per plant compared to control. In the same time, herb fresh weight per plant gradually increased by using complete fertilizer followed by biomagical. These results hold true in the two cuts of the two seasons.

The interaction between A+B and biomagical treatment recorded the highest herb fresh weight and gave highly significant increase compared to other interaction treatments and control. In addition, the interaction treatments between A,B and A+B with complete fertilizer or biomagical gave highly

significant increase in herb fresh weight per plant compared to control in both two cuts every season. These results are in agreement with those reported by Al-Qadosi (2004) on *Ocimum basilicum*, Ismail (2002) on pea, Al-Ahl (2005) on dill and Ismail (2005) on fennel plants.

Herb dry weight / plant (g)

Thyme herb dry weights as affected by fertilization treatments are shown in Table 3. It could be noticed that, the highest value of herb dry weight per plant was obtained from the addition of A+B treatment and gave a significant increase compared to other treatments in the two cuts during the two seasons. In the same time, the maximum herb dry weight per plant obtained from A+B treatment, then gradually decreased by using A followed by B treatments. Moreover, the addition of A, B or A+B treatments recorded highly significant increase in this respect compared to control.

Moreover, data in Table 3 show that thyme herb dry weight per plant increased gradually by using complete fertilizer treatment followed by biomagical treatment.

Table 2. Effect of bio-fertilization strains and complete fertilizer or biomagig product as well as their interaction treatments on herb fresh weight / plant (g) of thyme plants in both cuts during the two seasons

Bio-fertilization strains treatments (BF)	Fertilization treatments (F)							
	1 st cut				2 nd cut			
	Control	Kristalon	Biomagic	\bar{X} (BF)	Control	Kristalon	Biomagic	\bar{X} (BF)
2003 season								
Control	26.11	48.64	52.79	42.51	36.33	81.00	100.50	72.61
Azotobacter (A)	37.17	60.00	65.65	54.27	46.50	87.83	112.83	82.39
Bacillus (B)	32.37	51.21	56.20	46.60	41.17	82.00	98.33	73.83
(A + B)	44.90	73.42	82.15	66.82	50.33	123.82	134.33	102.83
\bar{X} (F)	35.14	58.32	64.20		43.58	93.66	111.50	
L.S.D. at 5 %	For(BF)=1.79	For(F)=1.55	For (BF) ×(F)=3.11		For(BF)=2.99	For(F)=2.59	For (BF) ×(F)=5.18	
L.S.D. at 1 %	For(BF)=2.44	For(F)=2.11	For (BF)x(F)=4.23		For(BF)=4.07	For (F)=3.52	For (BF)x(F)=7.05	
2004 season								
Control	26.15	58.64	62.98	49.25	40.64	85.36	104.55	76.85
Azotobacter (A)	47.17	69.95	75.91	64.34	50.61	92.48	117.24	86.78
Bacillus (B)	42.22	61.13	65.86	56.40	45.58	86.33	102.29	78.07
(A + B)	57.10	83.39	92.10	77.53	54.56	128.15	138.25	106.99
\bar{X} (F)	43.16	68.27	74.21		47.85	98.08	115.58	
L.S.D. at 5 %	For (BF)=1.86	For (F)=1.61	For (BF) ×(F)=3.22		For(BF)=3.08	For(F)=2.67	For (BF) ×(F)=5.34	
L.S.D. at 1 %	For(BF)=2.53	For(F)=2.19	For (BF)x(F)=4.39		For(BF)=4.19	For(F)=3.63	For (BF)x(F)=7.26	

Since, spraying the plants with biomagic only gave the highest herb dry weight per plant with a significant increase compared to other treatments. In addition, thyme plants sprayed with complete fertilizer led to highly significant increase in this respect compared to control in the two cuts of the two seasons.

Meanwhile, the interaction between the treatments A, B and A+B with the complete fertilizer or biomagic led to a nonsignificant difference between them. Furthermore, the interaction treatment between A+B and biomagic was the best treatment which gave the maximum herb dry weight per plant compared to other interaction treatments and control. These results hold true in the first and the second cuts of the two seasons.

Total yield of herb dry weight / fed (t)

From data presented in Table 4 results show that the total yield of herb dry weight per fed. gradually increased by adding of B treatment followed by A and A+B treatments. The highest yield of herb dry weight per fed. was observed from the addition of the mixture between A+B treatment and gave a significant increase compared to other treatments in the two seasons. Moreover, the addition of A, B and A+B recorded

a significant increase in this regard compared to control.

Moreover, spraying the plants with biomagic gave a significant increase in total yield of herb dry weight per fed in the first season, but it showed highly significant increase in the second season compared to complete fertilizer and control. In the same time, total yield of herb dry weight per fed. increased by using complete fertilizer followed by biomagic treatments. Also, the plants treated with biomagic and complete fertilizer led to highly significant increase compared to control in the two seasons.

Table 4 indicate that the interaction treatment between A+B and biomagic recorded insignificant increase in total yield of herb dry weight per fed. compared to other interaction treatments and control. In addition, all of the interaction treatments between A, B and A+B with complete fertilizer or biomagic led to an increase in total yield of herb dry weight per fed compared to control. These results took the same trend in the two seasons. These results are in harmony with those recorded by Ismail (2002) on pea, Al-Qadosi (2004) on sweet basil, Attia and Abdel-Azeem (2005) on *lawsonia inermis* leaves and Ebrahim (2005) on roselle plants.

Table 3. Effect of bio-fertilization strains and complete fertilizer or biomagic product as well as their interaction treatments on herb dry weight /plant (g) of thyme plants in both cuts during the two seasons

Bio-fertilization strains treatments(BF)	Fertilization treatments (F)							
	1 st cut				2 nd cut			
	Control	Kristalon	Biomagic	\bar{X} (BF)	Control	Kristalon	Biomagic	\bar{X} (BF)
2003 season								
Control	6.08	9.96	12.46	9.50	7.79	15.97	16.53	13.43
Azotobacter (A)	8.28	13.67	15.48	12.47	8.80	17.71	23.94	16.82
Bacillus (B)	6.84	11.40	11.36	9.87	7.98	17.70	20.39	15.36
(A + B)	9.35	15.41	17.66	14.14	10.62	27.79	30.11	22.84
\bar{X} (F)	7.64	12.61	14.24		8.79	19.79	20.24	
L.S.D. at 5 %	For (BF)=1.34	For (F)=1.16	For (BF)×(F)=N.S.		For(BF)=2.93	For(F)=2.54	For (BF)×(F)=N.S.	
L.S.D. at 1 %	For (BF)=1.83	For (F)=1.58	For (BF)x(F)=N.S.		For(BF)=3.98	For (F)=3.45	For (BF)x(F)=N.S.	
2004 season								
Control	6.14	12.02	14.86	11.01	8.71	16.87	16.43	14.00
Azotobacter (A)	10.52	15.94	17.90	14.78	10.01	18.65	23.31	17.32
Bacillus (B)	8.91	13.62	13.37	11.96	8.84	18.65	19.89	15.79
(A + B)	11.84	17.51	19.80	16.38	11.51	28.76	29.05	23.11
\bar{X} (F)	9.35	14.77	16.48		9.76	20.73	22.17	
L.S.D. at 5 %	For (BF)=1.53	For (F)=1.33	For (BF)×(F)=N.S.		For(BF)=2.98	For(F)=2.58	For (BF)×(F)=N.S.	
L.S.D. at 1 %	For(BF)=2.09	For(F)=1.81	For (BF)x(F)=N.S.		For(BF)=4.05	For(F)=3.50	For (BF)x(F)=N.S.	

Table 4. Effect of bio-fertilization strains and complete fertilizer or biomagic product as well as their interaction treatments on total yield of herb dry weight / fed (t) of thyme plants in both cuts during the two seasons

Bio-fertilization strains treatments(BF)	Fertilization treatments (F)							
	1 st cut				2 nd cut			
	Control	Kristalon	Biomagic	\bar{X} (BF)	Control	Kristalon	Biomagic	\bar{X} (BF)
2003 season								
Control	0.158	0.259	0.296	0.237	0.202	0.415	0.430	0.349
Azotobacter(A)	0.216	0.355	0.402	0.324	0.229	0.460	0.622	0.437
Bacillus (B)	0.178	0.296	0.324	0.266	0.207	0.460	0.530	0.399
(A + B)	0.243	0.401	0.459	0.368	0.276	0.722	0.783	0.594
\bar{X} (F)	0.265	0.327	0.370		0.228	0.514	0.591	
L.S.D. at 5 %	For(BF)=0.034	For (F)=0.030	For (BF)×(F)=N.S.		For (BF)=0.076	For(F)=0.065	For (BF)×(F)=N.S.	
L.S.D. at 1 %	For(BF)=0.047	For (F)=0.041	For (BF)×(F)=N.S.		For (BF)=0.103	For (F)=0.089	For (BF)×(F)=N.S.	
2004 season								
Control	0.160	0.313	0.386	0.286	0.226	0.438	0.427	0.363
Azotobacter(A)	0.273	0.414	0.465	0.384	0.260	0.485	0.606	0.450
Bacillus (B)	0.232	0.341	0.348	0.307	0.230	0.485	0.517	0.411
(A + B)	0.308	0.455	0.515	0.426	0.299	0.748	0.755	0.601
\bar{X} (F)	0.243	0.380	0.428		0.253	0.539	0.576	
L.S.D. at 5 %	For(BF)=0.042	For (F)=0.036	For (BF)×(F)=N.S.		For (BF)=0.077	For (F)=0.067	For (BF)×(F)=N.S.	
L.S.D. at 1 %	For(BF)=0.057	For(F)=0.050	For (BF)×(F)=N.S.		For (BF)=0.105	For(F)=0.091	For (BF)×(F)=N.S.	

It could be concluded that, the increment in fresh and dry weights of thyme herb may be due to the effect of complete and bio fertilizers which enhanced growth of the herb resulting from cell division and elongation in the meristimatic zones.

Effect of Bio-fertilization Strains and Complete Fertilizer or biomagic Product as well as Their Interaction Treatments on Chemical Constituents of Thyme Plants

Volatile oil percentage

The volatile oil percentage of thyme herb as affected by different fertilization treatments were shown in Table 5. It indicate that the addition of A, B and A+B treatments led to an increase in oil percentage compared to control. Also, the volatile oil percentage gradually increased by using B, A and the mixture between them A+B. In the same time, the maximum oil percentage was obtained from plants treated with A+B compared to the other treatments. These results were found in the two cuts of the two seasons.

Data in Table 5 reveal that spraying the plants with complete fertilizer or biomagic recorded an increase in oil percentage compared to control. Furthermore,

volatile oil percentage gradually increased by using complete fertilizer followed by biomagic treatment. The best treatment was spraying the plants with biomagic which gave the highest oil percentage compared to other ones. These results hold true in the first and second cuts during the two seasons.

The results in Table 5 show that the interaction treatments between A, B and A+B with complete or biomagic fertilizers recorded an increase in oil percentage compared to untreated plants. Moreover, the interaction treatments between A+B and biomagic gave the highest percentage of volatile oil compared to other interaction treatments and control.

It could be noticed from Table 5 the percentage of volatile oil in thyme herb in the second cut is better than the first cut in the two seasons of study.

Volatile oil yield per fed (l.)

The total volatile oil yield per feddan as affected by fertilization treatments was shown in Table 6. It is clear that the highest value of volatile oil yield per feddan resulted from A+B treatment and showed highly significant increase compared to A, B or control.

Table 5. Effect of bio-fertilization strains and complete fertilizer or biomagic product as well as their interaction treatments on volatile oil percentage of thyme plants in both cuts during the two seasons

Bio-fertilization strains treatments (BF)	Fertilization treatments (F)							
	1 st cut				2 nd cut			
	Control	Kristalon	Biomagic	$\bar{X}(BF)$	Control	Kristalon	Biomagic	$\bar{X}(BF)$
2003 season								
Control	0.23	0.33	0.36	0.31	0.34	0.43	0.43	0.40
Azotobacter (A)	0.44	0.51	0.53	0.49	0.53	0.63	0.62	0.59
Bacillus (B)	0.42	0.47	0.50	0.46	0.46	0.54	0.53	0.51
(A + B)	0.55	0.59	0.65	0.60	0.62	0.70	0.72	0.68
$\bar{X}(F)$	0.41	0.47	0.51		0.49	0.57	0.58	
2004 season								
Control	0.26	0.36	0.39	0.33	0.35	0.45	0.47	0.42
Azotobacter (A)	0.47	0.54	0.57	0.53	0.51	0.62	0.63	0.59
Bacillus (B)	0.44	0.50	0.53	0.49	0.46	0.54	0.55	0.52
(A + B)	0.58	0.62	0.68	0.63	0.63	0.70	0.74	0.69
$\bar{X}(F)$	0.43	0.51	0.54		0.49	0.58	0.60	

Total volatile oil yield per fed. gradually increased by using B followed by A and A+B treatments. In the same time, all treatments of A, B or A+B led to highly significant increase compared to control. These results were recorded in both cuts of the two seasons.

Moreover, the results in Table 6 indicate that the highest value of total oil yield per feddan obtained by spraying the plants with biomagic, then decreased by using complete fertilizer. In the same time, the best treatment was that of spraying the plants with biomagic and it gave highly significant increase in the total volatile oil yield per feddan compared to complete fertilizer and control treatments for both cuts of the two seasons.

The data in Table 6 reveal that the interaction treatments between A+B and biomagic recorded highly significant increase in total oil yield per feddan and gave the maximum value in this respect compared to the other interaction treatments and control. Furthermore, the interaction treatments between all of A, B and A+B with complete fertilizer or biomagic recorded highly significant increase compared to control. These results hold true in the two seasons. These results are

coincided with those reported by Mahfouz (2003) on *Majorona hortensis* and Hamed (2004) on *Origanum syriacum* who found that the highest oil percentage and yield at the treatment of biofertilizer plus full dose of N and P compared to control, Attia and Abdel-Azeem (2004) on *Mentha viridis* and Ismail (2005) on fennel. They found that the treatments of nitrogen and complete fertilizers increased the oil percentage compared to control.

Volatile oil constituents

The oil samples obtained from different treatments during the second cut of the second season were subjected in GLC analysis. The percentages of the main components were calculated and presented in Tables 7,8 and 9. Results show that thyme oil contained thymol, carvacrol, limonene, linalool, α -pinene, β -pinene, cineole, methyl chavicol, camphor, borneol as well as terpeniol as main components, these results are in agreement with the results obtained by Guenther (1961).

It is obvious from the results presented in Table 7 that the treatment of the mixture between Azotobacter and Bacillus A+B exhibited maximum value of thymol percentage compared to the other treatments (control, Azotobacter A and Bacillus each alone).

Table 6. Effect of bio-fertilization strains and complete fertilizer or biomagic product as well as their interaction treatments on total volatile oil yield /fed (l.) of thyme plants in both cuts during the two seasons

Bio-fertilization strains treatments (BF)	Fertilization treatments (F)							
	1 st cut				2 nd cut			
	Control	Kristalon	Biomagic	$\bar{X}(BF)$	Control	Kristalon	Biomagic	$\bar{X}(BF)$
2003 season								
Control	1.65	4.25	5.03	3.64	3.31	9.10	10.92	7.78
Azotobacter (A)	4.42	9.98	9.10	7.83	6.41	14.47	18.11	12.99
Bacillus (B)	3.47	6.33	7.28	5.69	4.85	11.53	13.69	10.02
(A + B)	6.41	11.44	13.87	10.57	8.06	22.62	25.05	18.58
$\bar{X}(F)$	3.98	8.00	8.82		5.66	14.43	16.92	
L.S.D. at 5 %	For(BF)=0.40	For(F)=0.34	(F)=0.69×For (BF)		For(BF)=0.91	For (F)=0.79	For (BF)×(F)=1.59	
L.S.D. at 1 %	For(BF)=0.54	For(F)=0.47	For (BF)x(F)=0.94		For (BF)=1.25	For (F)=1.08	For (BF)x(F)=2.16	
2004 season								
Control	1.82	5.46	6.41	4.56	3.81	10.05	12.74	8.87
Azotobacter (A)	5.72	9.71	10.85	8.76	6.67	15.00	18.63	13.43
Bacillus (B)	4.85	7.89	9.01	7.25	5.46	12.13	14.56	10.72
(A + B)	8.58	13.52	16.29	12.80	8.93	23.14	26.78	19.62
$\bar{X}(F)$	5.24	9.15	10.64		6.22	15.08	18.18	
L.S.D. at 5 %	For(BF)=0.54	For(F)=0.47	(F)=0.94×For (BF)		For (BF)=0.70	For (F)=0.60	For (BF)×(F)=1.21	
L.S.D. at 1 %	For(BF)=0.74	For(F)=0.64	For(BF)x(F)=1.28		For(BF)=0.95	For(F)=0.82	For(BF)x(F)=1.64	

Furthermore, thymol percentage increased gradually by using of B, A and A+B treatments.

Also, in the same Table, results indicate that carvacrol, limonene, linalool, α -pinene and β -pinene were gradually increased by addition of B, A and A+B individually. Moreover, the maximum values in this respect was observed by using the mixture of A+B treatment compared to the other treatments.

The obtained results in the same Table show that all of cineole, methyl chavicol, camphor, borneol and terpeniol were gradually decreased by using B, A, and A+B treatments. Also, the highest values in this regard was obtained from control treatment, but the mixture between A+B treatment exhibited the minimum value compared to the other treatments.

As for complete fertilizer or biomagic product treatments, data in Table 8 reveal that, spraying kristalon (complete fertilizer) and biomagic individually gave an increase in thymol percentage compared to control. In the same time, biomagic treatment gave the maximum value of thymol percentage compared to complete fertilizer (kristalon) and control treatments.

The data recorded in the same Table show that the highest values of carvacrol, limonene, linalool, α -pinene and β -pinene were obtained from biomagic treatment, then gradually decreased by using kristalon followed by control treatments. Since, the maximum percentages were obtained from biomagic treatment compared to the other treatments.

As shown in Table 8, data indicate that cineole, methyl chavicol, camphor, borneol and terpeniol decreased by using complete fertilizer (kristalon) followed by biomagic treatments. Moreover, these components were gradually decreased until reaching the lowest percentages by using biomagic treatments. Furthermore, the minimum values of cineole, methyl chavicol, camphor, borneol and terpeniol were obtained from biomagic treatments, then gradually increased with kristalon followed by control treatments.

From the results of Table 9, it is clear that, the interaction treatments between bio-fertilization strains A, B and A+B and complete fertilizer (kristalon) or biomagic gave an increase in thymol percentage compared to control. Furthermore, the highest value in this respect was obtained by using the mixture between A+B with biomagic comparing with the other interaction ones under the study.

Table 7. Thyme oil constituents as affected by bio-fertilization strains during the second cut of the second season

Bio-fertilization strains	Thyme oil constituents (%)											
	Thymol	Carvacrol	Limonene	Linalool	α -pinene	β -pinene	Cineol	Methyl - chavicol	Camphor	Borneol	Terpeniol	Unknown
Control	56.822	0.680	1.309	2.188	2.217	2.095	7.104	7.197	5.200	6.626	7.520	1.042
Azotobacter (A)	59.053	0.800	1.442	2.751	2.448	2.497	6.746	6.509	4.450	6.410	6.652	0.242
Bacillus (B)	57.947	0.721	1.337	2.210	2.209	2.048	6.807	6.894	5.192	6.839	6.513	1.283
(A+B)	59.776	0.917	1.757	2.976	2.596	2.699	6.638	6.102	3.856	6.548	4.383	1.752

Table 8. Thyme oil constituents as affected by complete fertilizer (kristalon) or biomagic product during the second cut of the second season

Com.fert.or biomagic	Thyme oil constituents (%)											
	Thymol	Carvacrol	Limonene	Linalool	α -pinene	β -pinene	Cineol	Methyl - chavicol	Camphor	Borneol	Terpeniol	Unknown
Control	56.359	0.613	0.982	1.919	1.623	1.808	7.089	7.539	6.135	7.435	7.725	0.773
Kristalon	58.718	0.801	1.592	2.720	2.555	2.466	6.788	6.514	4.336	6.483	6.470	0.557
Biomagic	60.122	0.924	1.811	2.964	2.924	2.732	6.595	5.973	3.554	5.900	5.856	0.645

Table 9. Thyme oil constituents as affected by interaction treatments between bio-fertilization strains and complete fertilizer (kristalon) or biomagic product during the second cut of the second season

Treatments		Thyme oil constituents (%)													
		Thymol	Carvacrol	Limonene	Linalool	α -pinene	β -pinene	Cineol	Methyl - chavicol	Camphor	Borneol	Terpeniol	Unknown		
Azotob acter (A)	Control	control	54.314	0.539	0.707	0.844	1.313	1.274	7.241	8.250	6.807	8.087	8.941	1.832	
		Kristalon	57.921	0.721	1.522	2.810	2.416	2.301	7.041	6.941	4.911	5.910	6.820	0.686	
		Biomagic	58.232	0.781	1.699	2.951	2.921	2.711	7.030	6.400	3.882	5.881	6.800	0.712	
	Bacillu s (B)	Control	Control	57.500	0.662	0.907	2.361	1.812	2.051	6.922	7.125	6.215	7.013	7.321	0.111
			Kristalon	58.722	0.782	1.650	2.911	2.627	2.641	6.715	6.381	3.895	6.211	7.025	0.490
			Biomagic	60.937	0.955	1.770	2.980	2.904	2.799	6.600	6.021	3.241	6.005	5.610	0.378
	(A+B)	Control	Control	55.701	0.540	0.825	1.700	1.517	1.805	7.171	7.801	6.797	7.527	7.520	1.096
			Kristalon	58.116	0.712	1.427	2.176	2.410	2.131	6.836	6.722	4.900	6.990	6.516	1.073
			Biomagic	60.023	0.911	1.758	2.750	2.701	2.209	6.415	6.160	3.880	6.002	5.502	1.689
(A+B)		Control	Control	57.922	0.712	1.488	2.771	1.850	2.100	7.022	6.981	4.721	7.111	7.117	0.205
			Kristalon	60.112	0.990	1.768	2.981	2.766	2.791	6.560	6.012	3.636	6.820	5.520	0.044
			Biomagic	61.295	1.050	2.015	3.176	3.171	3.207	6.333	5.312	3.211	5.712	5.511	0.007

Also, data from the same Table show that, the interaction between A+B treatment with biomagic gave the highest percentages of carvacrol, limonene, linalool, α -pinene and β -pinene if compared to the other treatments.

From the data presented in Table 9 results clear that the treatment of biofertilization strains A+B combined with biomagic produced gave the lowest percentages of cineole, methyl chavicol, camphor, borneol and terpeniol if compared with other interaction treatments and control .

From the previously mentioned results, it can be concluded that thyme plants must be treated with interaction between *Azotobacter* plus *Bacillus* and biomagic product to obtain the highest productivity of herb and volatile oil under North Sinai conditions.

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تأثير التسميد الحيوي و السماد الكامل او منتج البيوماجك على نبات
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أجريت تجربة حقلية في موسمين متتابعين ٢٠٠٣ و ٢٠٠٤ على نبات الزعرتر
Thymus vulgaris في محطة بحوث شمال سيناء بالشيخ زويد التابعة لمركز
بحوث الصحراء بغرض دراسة تأثير سلالات التسميد الحيوي (*Azotobacter*
chroococcum, Bacillus megaterium والخليط بينهما) ، و السماد الكامل
(كريستالون)، أو منتج البيوماجك والتفاعل بينهم على النمو والمحصول والمكونات
الفعالة (الزيت الطيار ومكوناته)، وقد أظهرت النتائج أن كل القياسات الخضرية (طول
النبات ، والوزن الطازج، والجاف للنبات، والمحصول الكلي للعشب الجاف / فدان)
قد استجابت معنوياً لجميع المعاملات بالمقارنة بالكنترول ، بينما لم تظهر التحليلات
الإحصائية استجابة معنوية للتفاعل بين المعاملات المختلفة على المحصول الكلي
للعشب الجاف ، وعلاوة على ذلك فإن جميع المعاملات أدت إلى زيادة معنوية في
محصول الزيت كما أثرت في مكوناته بالمقارنة بالكنترول.