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Effect of biofertilization on Siwa Oasis mint (*Mentha spicata* L. cv. Siwa) plants

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Abstract
This field experiment was conducted during the two successive seasons of 2016 and 2017 under Siwa Oasis conditions to investigate the effect of using active dry yeast (*Saccharomyces cerevisiae*) biofertilizer on productivity improvement of Siwa Oasis mint (*Mentha spicata* L. cv. Siwa) plants. The experiment layout was a split plot design. The main plots included two application methods of active dry yeast as a foliar spray and as a soil drench whereas, the sub-plots comprised of using four concentrations of active dry yeast :- 0, 2, 4 and 6 g / liter. The interaction within the tested treatments showed that, foliar spray method with the highest concentration of 6 g/liter significantly recorded the maximum increments in fresh and dry weights of herb per square meter or per feddan as well highest essential oil yield with maximum carvone content.

Keywords: Siwa mint, active dry yeast, herb, essential oil, carvone

Introduction
Siwa Oasis mint or Siwa mint (*Mentha spicata* L. cv. Siwa, Family: Lamiaceae) is a distinguished geno / chemo-type of spearmint cultivated in Siwa Oasis in the western desert of Egypt in the Sahara Desert and is characterized by a higher essential oil content than common spearmint existed in the local market and therefore, is favored by consumers for its strong aroma and sold for much higher price than any other spearmint in the local market. Since old times, the inhabitants of Siwa Oasis used this herb for preparing a traditional desert sweet tea "Siwan tea" to obtain an agreeable flavor. Morphologically, mint of Siwa Oasis is similar to local or Baladi mint but its leaves have a smaller area and a pale green color. Regarding essential oil chemical composition, carvone content is lower in Siwa mint cultivar (42.23±4.30 to 51.55±5.00 %) than in Baladi mint cultivar (61.9 to 79.68 %). Moreover, genetically, molecular markers variations were observed among them [1-6].

Nowadays, improving yield quantity and quality of Egyptian cultivars of medicinal and aromatic plants is considering a target especially under the current global climate changes problem and their negative impacts on agriculture. In this concern, productivity development of Siwa Oasis mint is important and further research should be offered to introduce this mint type for export. The Oasis of Siwa is eco-geographically isolated and is a nature reserve, so using of "Good Agricultural Practice" (GAP) is essential for agriculture production there such as using of various biofertilization techniques. Active dry baker's yeast (*Saccharomyces cerevisiae*) is considered a safe, cheap and effective biofertilizer to increase growth, yield and active constituents of medicinal and aromatic plants under desert agro-ecosystem conditions as demonstrated by several researchers i.e [7]. on cultivated *Salvia fruticosa* under Siwa Oasis conditions and stated that spraying plants with active dry yeast enhanced vegetative growth, yields of herb and essential oil as well as increased 1,8-cineole constituent content in volatile oil over control treatment [8]. on cultivated *Origanum syriacum* under North Sinai conditions reported that spraying plants with active dry yeast gave the highest values of vegetative growth parameters, oil percentage, oil yield per plant and per feddan.

Mints of Siwa Oasis are perennial plants and their herbs are harvested several times per year, and so good nutrition is required for plants to obtain the highest yield. The current literature survey on *Mentha spicata* cv. Siwa showed that, no studies were found about its response to application of active dry yeast. So, this work was conducted to estimate the best concentration of active dry yeast should be given to plants, the best applying method should be utilized and their interaction on herb yield, essential oil yield and composition to obtain the highest parameters.

Materials and Methods

This work was carried out during the two successive seasons of 2016 and 2017 in the Experimental Farm of the Desert Research Center at Khamisa Village (29.21º N and 25.40º E), Siwa Oasis, Egypt. The soil and irrigation water analyses of the experimental farm are presented in Tables (A, B and C).

Organic compost manure at 10 m^3 /feddan was added before planting in each season throughout soil preparation. The organic manure analysis is given in Table (D). Rhizomes of Siwa mint were planted in the field on March 1st for both seasons under drip irrigation system in rows 75 cm apart and at 30 cm distance within the row.

The experiment was laid out in a split plot design with four replicates. The main plots involved two application methods of active dry yeast as a foliar spray and as a soil drench while, the sub-plots included using four concentrations of active dry yeast :- 0, 2, 4 and 6 g / liter of water. Active dry yeast (*Saccharomyces cerevisiae*) was dissolved in water followed by adding sugar at the ratio of 1:1 and kept overnight for activation and reproduction of yeast [9]. Plants were treated with yeast solution after 45 days of cultivation then addition was repeated after each cut. Control plants received a distilled water. The analysis of active dry yeast is shown in Table (E). Half dose of the recommended chemical fertilizers was applied for plants according to [10]. Four cuts were taken per season on May 15th, July 10th, September 13th and November 20th. Harvest was carried out by cutting herb at 10 cm above soil surface. L.S.D. test at 0.05 was used to compare average means of treatments according to [11]. The following data were detected for each cut:-

A-Quantity parameters

1- Herb fresh weight / m^2 (g).
2- Herb fresh weight / fed. (kg).
3- Herb dry weight / m^2 (g).
4- Herb dry weight / fed. (kg).

B-Quality parameters

1- Essential oil percentage

Essential oil percentage was determined in the air dried herb by hydrodistillation for 3 hours using a Clevenger type apparatus [12].

2- Essential oil yield / m^2 (ml)

$$\text{This was calculated as follows : } \frac{\text{Oil percentage} \times \text{herb dry weight / m}^2\text{ (g)}}{100}$$

3- Essential oil yield per feddan (l)

This was calculated as follows: essential oil yield / $m^2 \times 4200$ m^2

4- Essential oil chemical composition

GC-MS analyses of extracted volatile oil of the second season were conducted using Gas Chromatography-Mass Spectrometry instrument stands at the Laboratory of Medicinal and Aromatic Plants, National Research Center, Egypt with the following specifications. Instrument: a Trace GC Ultra Gas Chromatographs (Thermo Scientific Corp., USA), coupled with a Thermo mass spectrometer detector (ISQ Single Quadrupole Mass Spectrometer). The GC-MS system was equipped with a TR-5MS column (30 m x 0.32 mm i.d., 0.25 µm film thickness). Analyses were carried out using helium as carrier gas at a flow rate of 1.3 ml/min at a split ratio of 1:10 at the following temperature program: 80ºC for 1 min; rising at 4ºC/min to 300ºC and held for 1min. The injector and detector were held at 220 and 200ºC, respectively. Diluted samples (1:10 hexane, v/v) of 1 µL of the mixtures were always injected. Mass spectra were obtained by electron ionization (EI) at 70 eV, using a spectral range of m/z 40-450. The separated components of the essential oils were identified by matching with the National Institute of Standards and Technology (NIST) published.

Means of the meteorological data of Siwa Oasis during both seasons of 2016 and 2017 are given in Table (F).

Table (A): Mechanical analysis of the soil of the experimental station.

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Soil texture
0-30	92.91	5.21	1.88	Sandy

Table (B): Chemical analysis of the soil of the experimental station.

pH	E.C. (ds/m)	O.M. (%)	Soluble anions (meq/l)				Soluble cations (meq/l)			
			CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
7.5	4.1	0.5	-	3.6	31.3	6.1	8.6	7.5	0.2	24.7

Table (C): Chemical analysis of ground water of the experimental station.

pH	E.C. (ppm)	Soluble anions (meq/l)				Soluble cations (meq/l)			
		CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
7.00	2824	-	1.57	16.68	22.73	11.43	8.98	19.80	0.77

Table (D): Chemical analysis of the used compost manure.

pH	EC (ds/m)	O.M. (%)	C/N ratio (%)	N (%)	P (%)	K (%)	Fe (%)	Mn (mg/kg)	Zn (mg/kg)	Cu (mg/kg)
8.8	4.6	20.5	11.85	1.03	0.22	2.04	3.43	606.8	85.65	43.60

Table (E): Chemical analysis of active dry yeast.

Protein	47%
Carbohydrates	33%
Nucleic acids	8%
Minerals	8%
Lipids	4%
The composition of minerals (mg/g)	

Na	0.12	Cu	8.00
Ca	0.75	Se	0.10
Fe	0.02	Mn	0.02
Mg	1.65	Cr	2.20
K	21.00	Ni	3.00
P	13.50	Va	0.04
S	3.90	Mo	0.40
Zn	0.17	Sn	3.00
Si	0.03	Li	0.17
The composition of vitamins (mg/g)			
Thiamine		6 – 100	
Riboflavin		35 – 50	
Niacin		300 – 500	
Pyridoxine HCL		28	
Pantothenate		70	
Biotin		1.3	
Cholin		4000	
Folic acid		5 – 13	
Vitamin B_{12}		0.001	

Table (F): Means of the meteorological data of Siwa Oasis for both seasons of 2016 and 2017.

Month	Temperature (°C)			Solar (MJ/m^2)	Precipitation (mm)	Humidity (%)	Wind (km/h)
	Max	Min	Mean				
March	26	11	19	25.03	0.2	40	10
April	30	15	23	27.15	0.6	35	9
May	34	19	27	28.42	0.0	32	9
June	38	22	30	29.35	0.0	32	8
July	39	23	31	30.70	0.0	35	8
August	39	24	32	28.55	0.0	37	7
September	36	22	29	24.33	0.0	40	7
October	31	18	25	19.05	0.0	48	6
November	26	12	19	15.12	0.0	55	6
December	22	8	15	13.80	0.0	58	6

Results and Discussions

I. Quantity parameters

Data presented in Tables (1, 2, 3 and 4) show the effects of active dry yeast applying methods, active dry yeast concentrations and their interaction on quantity characters.

Concerning the effect of active dry yeast applying methods, results showed that foliar application method was more effective than soil drench method for enhancing all growth and yield characters as the significantly highest values of herb fresh and dry weights per square meter or per feddan were obtained by spraying with active dry yeast solution than other treatment. As for the effect of yeast concentration, it was marked that treating plants with the highest concentration of 6 g/liter significantly increased herb fresh and dry weights per unit area over control. Also, the interaction between treatments revealed that the significantly heaviest yield per unit area was observed by foliar spray with active dry yeast at the highest concentration of 6 g/liter. These results were in a parallel line with the results achieved by [13] on coriander; [14] on *Nigella sativa*; [15] on *Thymus vulgaris*; [16] on *Borago officinalis* and [17] on *Trigonella foenum-graecum*.

The positive effect of active dry yeast on plants may be attributed to its role in enhancing the cell division rate and cell enlargement as yeast contains cytokinins that improve the accumulation of soluble metabolites and also stimulate cell proliferation and differentiation, controlling shoot and root morphogenesis and chloroplast maturation. In addition, these results may be due to also the physiological roles of vitamins and amino acids in the yeast extract which increased the metabolic processes role and levels of the indogenous hormones, i.e., IAA and GA_3. Moreover, the fermentation process that occurred in the presence of dry yeast produces CO_2 in high quantity, a factor that may increase photosynthesis and consequently plant growth, the high content of dry yeast from vitamin B and minerals might play a considerable role in orientation and translocation of metabolites from the leaves to the productive organs (Table, E). Other researchers stated that treating plants with yeast extract enabled it to mitigate the adverse environmental effects such as heat, water and salinity stresses. Furthermore, yeast spray could be beneficial for pest management. As well as, it is considered a rich source of natural antioxidants [18-28].

Table 1: Effect of active dry yeast applying methods, active dry yeast concentrations and their interaction on herb fresh weight / m^2 (g) during both successive seasons of 2016 and 2017.

Yeast applying methods	Yeast concentrations	1st cut	2nd cut	3rd cut	4th cut
Foliar spray	0 g/l	84.45	103.33	202.06	317.46
	2 g/l	116.49	140.06	275.39	363.64
	4 g/l	168.74	199.50	329.76	430.04
	6 g/l	189.47	231.13	390.77	491.08
Mean		139.79	168.51	299.50	400.56
Soil drench	0 g/l	86.52	100.20	197.50	311.04
	2 g/l	91.34	116.72	249.30	335.34
	4 g/l	135.45	158.15	304.05	407.52

	6 g/l	159.93	180.47	353.08	431.69
Mean		118.31	138.89	275.98	371.40
Over all means of concentrations	0 g/l	85.49	101.77	199.78	314.25
	2 g/l	103.92	128.39	262.35	349.49
	4 g/l	152.10	178.83	316.91	418.78
	6 g/l	174.70	205.80	371.93	461.39
LSD at 0.05	Applying methods	3.35	7.21	7.42	9.59
	Concentrations	4.73	10.20	10.49	13.57
	Interaction	7.69	12.42	14.83	17.19

Table 2: Effect of active dry yeast applying methods, active dry yeast concentrations and their interaction on herb fresh weight / fed. (kg) during both successive seasons of 2016 and 2017.

Yeast applying methods	Yeast concentrations	1st cut	2nd cut	3rd cut	4th cut
Foliar spray	0 g/l	354.69	433.99	848.65	1333.33
	2 g/l	489.26	588.25	1156.64	1527.29
	4 g/l	708.71	837.90	1384.99	1806.17
	6 g/l	795.77	970.75	1641.23	2062.54
Mean		587.11	707.72	1257.88	1682.33
Soil drench	0 g/l	363.38	420.84	829.50	1306.37
	2 g/l	383.63	490.22	1047.06	1408.43
	4 g/l	568.89	664.23	1277.01	1711.58
	6 g/l	671.71	757.97	1482.94	1813.10
Mean		496.90	583.14	1159.13	1559.87
Over all means of concentrations	0 g/l	359.04	427.42	839.08	1319.85
	2 g/l	436.45	539.24	1101.85	1467.86
	4 g/l	638.80	751.07	1331.00	1758.88
	6 g/l	733.74	864.36	1562.09	1937.82
LSD at 0.05	Applying methods	13.98	30.28	31.15	40.29
	Concentrations	19.77	42.82	44.05	56.98
	Interaction	28.96	50.56	62.30	80.59

Table 3: Effect of active dry yeast applying methods, active dry yeast concentrations and their interaction on herb dry weight / m^2 (g) during both successive seasons of 2016 and 2017.

Yeast applying methods	Yeast concentrations	1st cut	2nd cut	3rd cut	4th cut
Foliar spray	0 g/l	25.04	32.10	56.08	82.04
	2 g/l	34.15	43.52	77.19	94.15
	4 g/l	50.12	61.15	92.03	111.11
	6 g/l	56.80	71.05	109.13	127.60
Mean		41.53	51.96	83.61	103.73
Soil drench	0 g/l	25.20	31.07	55.20	80.17
	2 g/l	27.80	36.80	69.76	87.09
	4 g/l	40.35	49.22	85.24	105.46
	6 g/l	47.18	55.40	98.18	112.14
Mean		35.13	43.11	77.10	96.22
Over all means of concentrations	0 g/l	25.12	31.59	55.64	81.11
	2 g/l	30.98	40.16	73.48	90.62
	4 g/l	45.24	55.19	88.64	108.29
	6 g/l	51.99	63.23	103.66	119.87
LSD at 0.05	Applying methods	1.01	2.24	2.08	2.50
	Concentrations	1.43	3.16	2.94	3.53
	Interaction	2.03	4.47	4.15	4.99

Table 4: Effect of active dry yeast applying methods, active dry yeast concentrations and their interaction on herb dry weight / fed. (kg) during both successive seasons of 2016 and 2017.

Yeast applying methods	Yeast concentrations	1st cut	2nd cut	3rd cut	4th cut
Foliar spray	0 g/l	105.17	134.82	235.54	344.57
	2 g/l	143.43	182.78	324.20	395.43
	4 g/l	210.50	256.83	386.53	466.66
	6 g/l	238.56	298.41	458.35	535.92
Mean		174.42	218.21	351.16	435.65
Soil drench	0 g/l	105.84	130.49	231.84	336.71
	2 g/l	116.76	154.56	292.99	365.78
	4 g/l	169.47	206.72	358.01	442.93
	6 g/l	198.16	232.68	412.36	470.99
Mean		147.56	181.11	323.80	404.10
Over all means of concentrations	0 g/l	105.51	132.66	233.69	340.64
	2 g/l	130.10	168.67	308.60	380.61

	4 g/l	189.99	231.78	372.27	454.80
	6 g/l	218.36	265.55	435.36	503.46
LSD at 0.05	Applying methods Concentrations Interaction	4.28 6.05 8.55	9.39 13.28 18.78	8.74 12.36 17.47	10.47 14.81 20.94

II. Quality parameters

A. Essential oil percentage and yield

As shown of data presented in Tables (5, 6 and 7), the highest essential oil percentage and yield were detected during summer months while the lowest ones were detected during spring and autumn months. These variations may be attributed to the variable meteorological patterns under Siwa Oasis conditions (Table, F). Similar results were found by [29] on common spearmint who stated that high temperature and light intensity resulted in higher essential oil content during summer months. Also, obtained data showed that biofertilization had remarkable effects on essential oil accumulation as follows:-. concerning the influence of yeast applying methods, foliar spray was superior than soil drench in improving all parameters as the significantly highest records were obtained through spraying. With respect to the influence of concentrations, it was found that the concentration of 6 g/liter significantly increased essential oil percentage and yield. Relating to the interaction within treatments, the significantly maximum increments were observed by foliar spray of yeast solution at 6 g/liter. The stimulatory effect of active dry yeast on volatile oil accumulation may be due to its positive role in building up more metabolites necessary for inducing the volatile oil synthesis in the plants. This enhancement influence for yeast on essential oil productivity was in harmony with those results stated by [30] on *Ocimum basilicum*; [7] on *Salvia fruticosa* and [31] on *Carum carvi*.

B. Essential oil constituents

Data presented in Tables (8 and 9) and illustrated in Figs. (1 and 2) declare the effects of interaction within treatments on essential oil chemical composition.

The GC-MS analysis indicated that carvone was the dominant component in volatile oil (44.36-58.69%) followed by d-limonene (11.48-27.60%) and then 1,8-cineole (3.70-14.55%). The aforementioned data pointed out that volatile oil composition was affected and varied according to harvesting time as the oil of summer cut had higher carvone content than autumn cut. Furthermore, carvone constituent was affected by agronomic practices as foliar spray of yeast at 6 g/liter resulted in the highest carvone percentage over control treatment which recorded the lowest values. So, these data proved that, although Siwa mint is not a rich carvone chemotype in comparison to other spearmint chemotypes, the utilization of biofertilizers could enhance its qualitative characters. These results were in agreement with [29] who observed that agronomical practices affected carvone content of common spearmint. Also, the chemical composition of Siwa mint oil was in harmony with the published reports by [3] who mentioned that oil chemotype of Siwa mint is characterized by lower carvone content in comparison with oil from the local type of spearmint and weather conditions slightly affected its characteristics, but not its main genetically controlled characters [5]. Stated that Siwa mint volatile oil has lower carvone content than local spearmint and this result can probably be attributed to the differences in genotypes and other environmental conditions.

So, the used biofertilizer improved oil quality and consequently improved herb value. In this concern [32], reported that spearmint oil is used for flavoring, reducing fever, relaxation, treating asthma, digestive disorders, analgesic, antibacterial, antifungal, antioxidant and carvone is the major component responsible for spearmint aroma.

Table 5: Effect of active dry yeast applying methods, active dry yeast concentrations and their interaction on essential oil percentage during both successive seasons of 2016 and 2017.

Yeast applying methods	Yeast concentrations	1st cut	2nd cut	3rd cut	4th cut
Foliar spray	0 g/l	1.50	1.76	1.90	0.79
	2 g/l	1.54	1.83	2.17	0.84
	4 g/l	1.69	1.90	2.20	0.89
	6 g/l	1.74	2.30	2.41	0.93
Mean		1.62	1.95	2.17	0.86
Soil drench	0 g/l	1.48	1.72	1.93	0.78
	2 g/l	1.51	1.80	2.02	0.81
	4 g/l	1.54	1.85	2.11	0.84
	6 g/l	1.70	2.13	2.35	0.89
Mean		1.56	1.88	2.10	0.83
Over all means of concentrations	0 g/l	1.49	1.74	1.92	0.79
	2 g/l	1.53	1.82	2.10	0.83
	4 g/l	1.62	1.88	2.16	0.87
	6 g/l	1.72	2.22	2.38	0.91
LSD at 0.05	Applying methods Concentrations Interaction	0.01 0.02 0.03	0.02 0.04 0.05	0.02 0.03 0.04	0.02 0.02 0.03

Table 6: Effect of active dry yeast applying methods, active dry yeast concentrations and their interaction on essential oil yield / m^2 (ml) during both successive seasons of 2016 and 2017.

Yeast applying methods	Yeast concentrations	1st cut	2nd cut	3rd cut	4th cut
Foliar spray	0 g/l	0.38	0.57	1.07	0.65
	2 g/l	0.53	0.80	1.68	0.79
	4 g/l	0.85	1.16	2.03	0.99

	6 g/l	0.99	1.63	2.63	1.19
Mean		0.69	1.04	1.85	0.91
Soil drench	0 g/l	0.37	0.53	1.07	0.63
	2 g/l	0.42	0.66	1.41	0.71
	4 g/l	0.62	0.91	1.80	0.89
	6 g/l	0.80	1.18	2.31	1.00
Mean		0.55	0.82	1.65	0.81
Over all means of concentrations	0 g/l	0.38	0.55	1.07	0.64
	2 g/l	0.48	0.73	1.55	0.75
	4 g/l	0.74	1.04	1.92	0.94
	6 g/l	0.90	1.41	2.47	1.10
LSD at 0.05	Applying methods	0.02	0.04	0.05	0.03
	Concentrations	0.02	0.06	0.07	0.05
	Interaction	0.03	0.09	0.09	0.06

Table 7: Effect of active dry yeast applying methods, active dry yeast concentrations and their interaction on essential oil yield / fed. (l) during both successive seasons of 2016 and 2017.

Yeast applying methods	Yeast concentrations	1st cut	2nd cut	3rd cut	4th cut
Foliar spray	0 g/l	1.60	2.39	4.49	2.73
	2 g/l	2.23	3.36	7.06	3.32
	4 g/l	3.57	4.87	8.53	4.16
	6 g/l	4.16	6.85	11.05	5.00
Mean		2.89	4.37	7.78	3.80
Soil drench	0 g/l	1.55	2.23	4.49	2.65
	2 g/l	1.76	2.77	5.92	2.98
	4 g/l	2.60	3.82	7.56	3.74
	6 g/l	3.36	4.96	9.70	4.20
Mean		2.32	3.45	6.92	3.39
Over all means of concentrations	0 g/l	1.58	2.31	4.49	2.69
	2 g/l	2.00	3.07	6.49	3.15
	4 g/l	3.09	4.35	8.05	3.95
	6 g/l	3.76	5.91	10.38	4.60
LSD at 0.05	Applying methods	0.06	0.19	0.18	0.13
	Concentrations	0.09	0.26	0.26	0.19
	Interaction	0.13	0.37	0.37	0.27

Table 8: Effect of the interaction within treatments on constituents of volatile oil (2nd cut – summer cut).

Compound (%)	Control	Foliar spray With yeast At 2 g/liter	Soil drench with yeast at 2 g/liter	Foliar spray With yeast At 4 g/liter	Soil drench with yeast at 4 g/liter	Foliar spray With yeast at 6 g/liter	Soil drench with yeast at 6 g/liter
α-Pinene	1.33	2.04	1.11	2.31	2. 72	1.42	2.36
Camphene	0.52	0.08	0.09	0.32	0.08	0.19	-
α-Ocimene-x	-	-	0.65	-	1.73		
α-Myrcene	1.65	-	1.60	1.62	-	0.88	-
Sabinene	0.67	-	1.75	0.74	-	0.40	0.08
2-α-Pinene	0.39	-	0.22	2.09	1.03	1.35	0.22
1,3,8-p-Menthatriene	0.34	-	0.09	1.41	-	1.39	0.04
α-Terpinene	0.36	-	-	0.20	0.31	0.13	-
ç-Terpinene	1.11	0.34	0.27	1.92	1.25	1.15	-
D-Limonene	13.77	27.63	18.32	11.48	17.06	12.27	25.96
α- Terpinolene	0.39	-	0.87	1.00	0.05	1.63	-
α-Copaene	0.69	-	0.39	0.80	0.61	-	0.07
α-Elemene	0.91	0.21	0.32	1.20	0.10	1.18	0.17
Trans caryophyllene	0.63	0.44	0.76	-	0.23	1.11	0.39
α-Cubebene	0.97	0.18	0.10	-	0.80	0.25	-
α –Cadinene	0.59	0.04	0.10	0.94	0.66	0.70	-
α-Muurolene	0.92	-	0.05	-	1.00	1.24	-
α-Bourbonene	0.56	0.50	0.98	0.99	0.63	0.72	0.36
Germacreden-D	0.87	-	0.08	0.60	0.32	0.64	0.12
Bicyclogermacrene	0.73	-	0.30	0.62	0.50	0.12	-
Cadina-1,3,5-triene	-	-	-	-	0.44	0.57	-
α-Guaiene	0.48	0.07	0.50	-	0.54	-	0.05
Aromadendrene	0.61	0.07	0.92	-	-	-	-
α-Selinene	0.45	-	-	-	0.09	-	-
Junipene	-	-	-	-	0.50	-	-
Patchoulene	0.68	-	-	-	0.51	-	-
Calamenene	0.61	-	0.76	0.40	0.90	-	0.23
α-Chamigrene	0.61	-	-	-	-		0.08
Valencene	0.83	-	-	-	-	-	-
α-Gurjunene	-	-	-	-	0.50	0.51	-
α- Humulene	-	-	0.16	0.70	0.30	0.76	-

(+)-epi-bicyclosesquiphellandrene	-	0.19	-	-	0.52	-	0.28
Carvone	51.74	52.67	52.32	54.00	53.55	58.69	55.61
Cis-dihydrocarvone	-	-	-	0.80	0.50	-	0.12
Carvenone	-	-	0.44	-	0.64	0.16	0.50
Carvone oxide	-	0.44	0.15	2.23	0.08	0.57	0.34
Eucarvone	0.37	0.20	0.06	0.25	0.51	0.15	0.04
Cis-dihydrocarveol	1.22	0.22	1.37	0.25	-	-	0.50
Trans-carvyl acetate	-	-	0.12	0.23	0.05	0.65	0.18
Dihydrocarvyl acetate	-	-	0.07	0.47	0.27	0.55	-
Trans sabinene hydrate	-	-	0.89	0.40	0.62	-	-
1,8-Cineole	9.59	12.34	10.77	3.70	8.63	5.80	8.73
4-Terpineol	0.65	0.34	0.59	0.69	0.24	0.54	0.04
Isoborneol	1.07	0.04	-	-	0.27	-	0.07
Trans-ρ-mentha-2,8-dienol	0.93	0.27	0.11	0.24	0.07	-	0.50
p-Menth-8-en-2-ol	1.14	0.16	-	0.70	0.16	2.12	1.10
Cubenol	0.40	0.18		0.82	-	0.25	0.25
Himachalol	-	-	-	0.60	0.15	-	0.10
Carotol		0.07	0.40	0.51	-	-	-
Eugenol		0.28	0.36	0.63	-	0.16	0.18
α-Cadinol	-	0.19	0.89	0.80	0.40	0.18	0.11
(+) Spathulenol	0.35	0.11	0.19	0.22	0.29	-	0.09
α- Acorenol	-	-	-	-	-	0.19	-
α-Santalol	-	-	0.19	0.50	-	-	0.3
ç-Eudesmol	-	-	-	0.69	0.60	-	-
Verbenol	-	-	-	0.19	0.31	-	0.2
Trans-3-Caren-2-ol	-	-	-	-	-	-	-
p-Methallylphenol	-	0.28	-	0.50	0.20	-	-
3,5-Dimethylanisole	-	-	-	0.20	-	-	-
L-Menthone	0.53	0.21	0.08	-	-	0.36	0.57
Isomenthone	0.34	0.11	0.34	-	0.50	0.14	0.06
Cis-jasmone	-	-	0.10	0.55	-	0.22	-
Caryophyllene oxide	-	0.10	0.17	0.49	0.79	0.17	-
Pulegone	-	-	-	-	0.51	0.33	-
Piperitenone	-	-	-	-	-	0.16	-
Total identified compounds	100	100	100	100	100	100	100
Total hydrocarbon compounds	31.67	31.79	30.39	29.34	30.66	28.61	30.41
Total oxygenated compounds	68.33	68.21	69.61	70.66	69.34	71.39	69.59

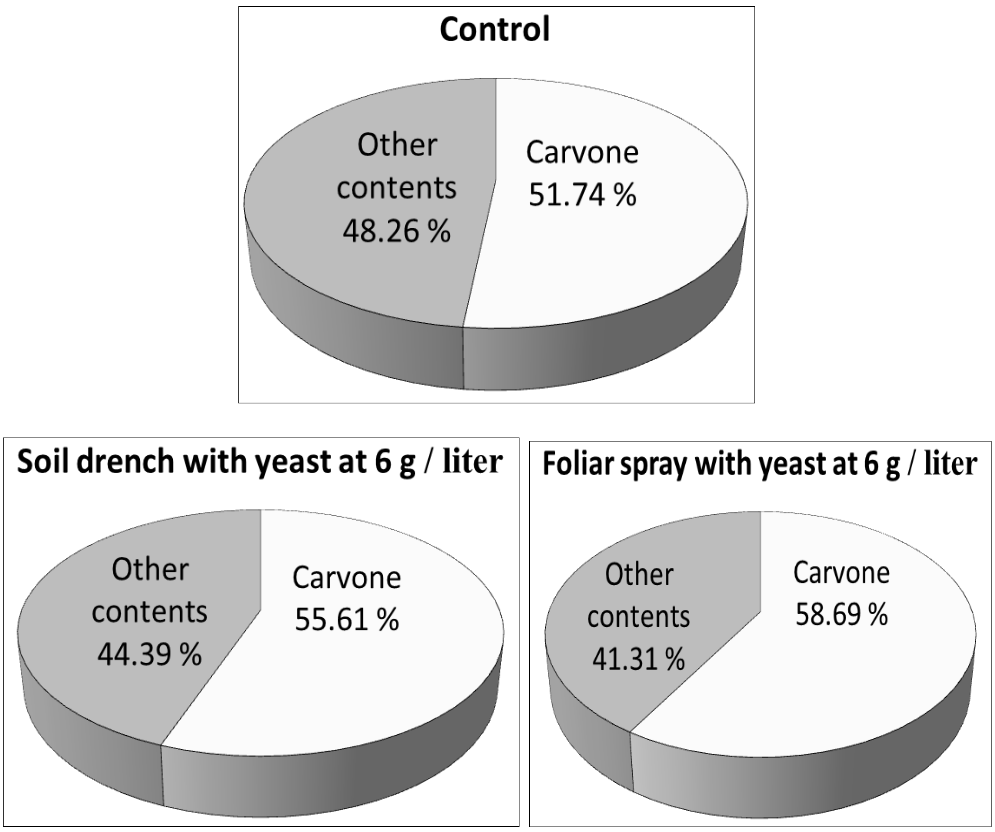

Fig 1: Effect of the interaction within treatments on carvone content of volatile oil (2^{nd} cut – summer cut)

Table 9: Effect of the interaction within treatments on constituents of volatile oil (4th cut - autumn cut).

Compound (%)	Control	Foliar spray With yeast At 2 g/liter	Soil drench with yeast at 2 g/liter	Foliar spray With yeast At 4 g/liter	Soil drench with yeast at 4 g/liter	Foliar spray With yeast At 6 g/liter	Soil drench with yeast at 6 g/liter
α-Pinene	3.22	1.82	1.55	1.14	0.88	1.31	1.57
Camphene	0.52	-	0.28	0.16	-	0.32	0.18
α-Ocimene-x	-	1.34	-	0.75	-	-	1.17
α-Myrcene	1.65	-	1.33	0.19	-	0.62	-
Sabinene	0.72	0.97	0.50	0.23	-	0.73	0.15
2-α-Pinene	2.14	0.27	1.37	1.31	1.66	1.09	0.26
1, 3, 8-p-Menthatriene	0.21	-	1.66	0.37	-	1.41	
ç-Terpinene	2.11	0.32	1.59	0.35	0.28	1.92	0.34
D-Limonene	16.97	18.54	18.64	18.40	20.59	11.48	19.77
α- Terpinolene	2.86	-	0.45	-	-	1.46	-
α-Copaene	-	-	0.18	0.27	0.52	-	0.53
α-Elemene	0.83	-	1.54	0.73	-	0.84	1.06
Trans caryophyllene	1.33	0.33	1.76	-	2.69	0.93	1.48
α-Cubebene	0.28	0.47	0.31	-	1.38	0.33	-
ç-Cadinene	0.47	1.95	0.72	0.79	1.21	0.61	0.41
α-Muurolene	0.95	2.97	0.73	0.16	-	1.05	0.66
α-Bourbonene	2.22	3.22	2.64	1.65	2.44	2.56	1.42
Germacreden-D	0.95	1.08	1.12	0.79	-	1.25	0.57
Bicyclogermacrene	-	-	-	-	-	-	0.29
Cadina-1, 3, 5-triene	0.75	-	0.92	0.14	-	0.23	0.85
α-Guaiene	0.80	-	-	0.22	-	0.22	0.13
Aromadendrene	0.23	-	-	-	0.61	-	-
α-Selinene	-	-	0.18	0.26	-	-	-
Junipene	-	-	-	-	-	0.23	-
Patchoulene	-	0.73	-	-	-	-	0.16
Calamenene	-	-	-	0.91	-	-	-
Valencene	-	-	-	1.90	-	-	-
α-Longipinene	-	-	0.20	0.50	-	-	0.40
α-Gurjunene	-	-	1.17	0.50	-	0.82	-
α- Humulene	-	-	0.23	-	-	0.20	-
(+)-epi-bicyclosesquiphellandrene	-	0.58	-	0.10	0.28	-	0.23
Carvone	44.36	45.39	44.85	50.06	47.25	51.40	50.28
Cis-dihydrocarvone	1.71	-	0.92	0.40	0.23	0.80	-
Carvenone	0.22	-	-	0.73	-	0.35	-
Carvone oxide	1.47	1.45	-	-	0.94	2.26	-
Trans carveol	-	-	0.30	0.21	-	-	-
Cis-dihydrocarveol	-	0.55	0.14	0.56	-	1.00	1.98
Trans-longipinocarveol	-	-	-	-	1.22	-	-
Cis-L-carvyl acetate	1.02	0.24	0.25	0.67	0.20	0.35	-
Dihydrocarvyl acetate	-	-	-	-	-	0.62	
Trans sabinene hydrate	-	-	0.15	-	-	-	-
1, 8-Cineole	7.96	11.78	10.10	14.43	12.05	6.70	14.55
4-Terpineol	0.79	0.39	0.53	-	0.35	1.69	0.33
Isoborneol	-	0.75	-	0.42	-	-	-
Trans-ρ-mentha-2, 8-dienol	-	-	-	-	0.83	0.24	-
p-Menth-1-en-4-ol	-	1.05	-	-	-	-	0.40
p-Menth-1-en-8-ol	-	0.90	-	-	-	-	-
Cubenol	0.31	-	0.40	-	0.42	1.40	
Himachalol	-	0.15	-	-	0.45	-	-
Carotol	-	0.21	-	0.44	1.05	-	-
α-Cadinol	0.22	0.87	0.33		-	0.52	-
Neoclovenoxid-alkohol	-	-	-		1.66	-	-
(+) Spathulenol	-	0.67	-	-	0.55	-	0.30
α-Santalol	-	0.14	-	-	0.11	-	-
Torreyol	-	-	-	-	-	-	-
ç-Eudesmol	-	-	-	-	-	-	0.27
Verbenol	0.21	-	-	-	-	1.19	-
Trans-3-Caren-2-ol	0.80	-	-	-	-	-	-
p-Methallylphenol	0.26	-	-	-	-	-	-
3, 5-Dimethylanisole	-	-	-	0.26	-		-
L-Menthone	0.84	-	1.09	-	-	0.66	-
Bornyl acetate	-	-	-		-	-	-
Isomenthone	-	-	-		-	0.30	

Cis-jasmone	-	-	-		0.15	-	-
Caryophyllene oxide	-	0.54	-		-	-	0.26
Dihydro-α-ionone	-	0.33	-	-	-	-	-
Pulegone	0.44	-	0.98	-	-	0.62	-
Piperitenone	0.18	-	0.26	-	-	0.29	-
Camphenone	-	-	0.63	-	-	-	-
Total identified compounds	100	100	100	100	100	100	100
Total hydrocarbon compounds	39.21	34.59	39.07	31.82	32.54	29.61	31.63
Total oxygenated compounds	60.79	65.41	60.93	68.18	67.46	70.39	68.37

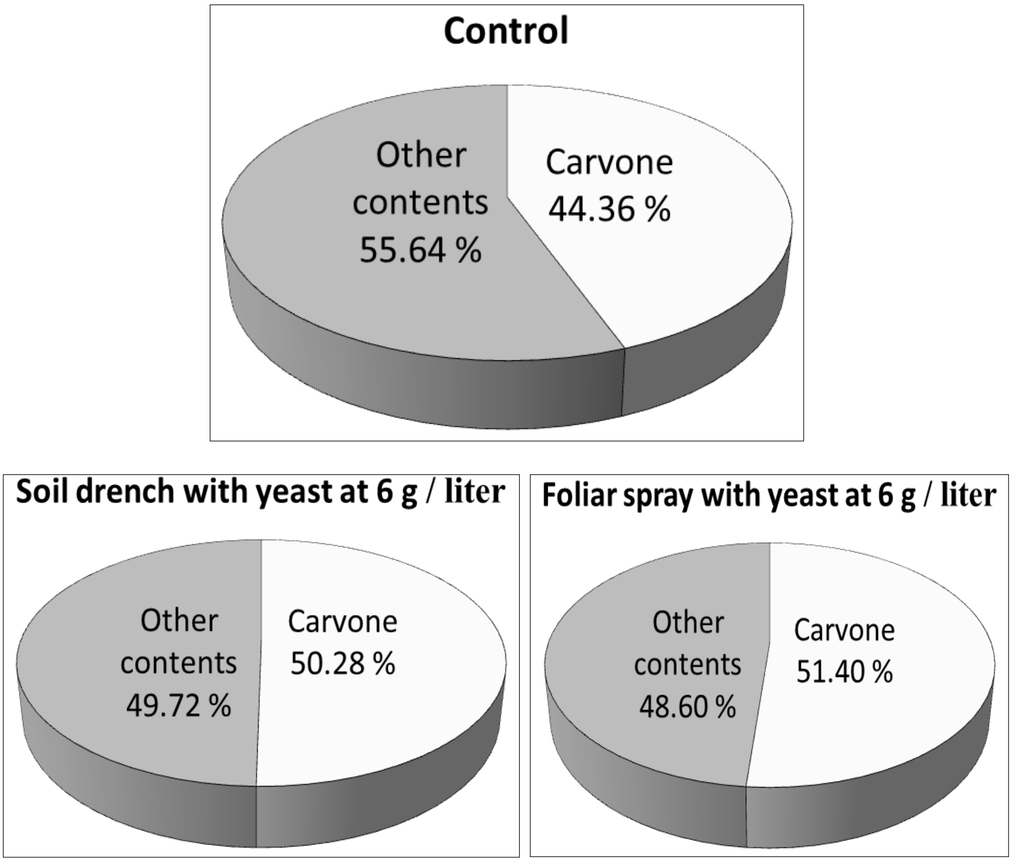

Fig 2: Effect of the interaction within treatments on carvone content of volatile oil (4th cut - autumn cut)

From the aforementioned results, it was obvious that the treatment of spraying with active dry yeast at a concentration of 6 g/liter was more effective than other treatments for improving yield characters as it gave the significantly highest increases in fresh, dry weights of herb and essential oil yield with maximum carvone level, so it could be a successful field treatment.

Conclusion
It would be recommended that mint of Siwa Oasis should be foliar sprayed with active dry yeast at concentration of 6 g/liter after 45 days of cultivation, then foliar spraying with active dry yeast should be repeated after each cut for production of the highest herbage yield distinct by rich aroma and flavor.

References

1. Bramly WJ. A Journey to Siwa in September and October, 1896. The Geographical Journal. 1897; 10(6):597-608.
2. Briggs MS. Through Egypt in War-Time. Published by T Fisher Unwin Ltd, London, 1918.
3. Edris AE, Shalaby AS, Fadel HM, Abdel-Wahab MA. Evaluation of a chemotype of spearmint (*Mentha spicata* L.) grown in Siwa Oasis, Egypt. Eur Food Res Technol. 2003; 218(1):74-78.
4. Osman YAH, Abd El Wahab MA, Afify MY. Production of Medicinal and Aromatic Plants in New Lands. (In: Arabic). Project of youth training and owners of reclaimed lands, Desert Research Center, Ministry of Agric., Egypt, 2003.
5. Hassan AHM. Identification of molecular markers for some morphological and biochemical characters in some medicinal plants. M.Sc. Thesis, Fac. Agric., Ain Shams Univ., Egypt, 2005.
6. Vale MM. Siwa: Jewelry, Costume, and Life in an Egyptian Oasis. Oxford University Press, 2015.
7. Toaima WIM. Effect of organic fertilization and active dry yeast on productivity of three-lobed sage (*Salvia fruticosa* Mill.) plants under Siwa Oasis conditions. Egyptian J Desert Res. 2014; 64:153-166.
8. Ali MYM. Effect of fertilization, irrigation and planting distances on the growth and production of *Origanum syriacum* L. plant under Sinai conditions. Ph.D. Thesis, Fac. Agric. Cairo Univ., Egypt, 2008.
9. El-Tohamy WA, El-Abagy HM, El-Greadly NHM.

Studies on the effect of putrescine, yeast and vitamin C on growth, yield and physiological responses of eggplant (*Solanum melongena* L.) under sandy soil conditions. Aust. J Basic & Appl. Sci. 2008; 2(2):296-300.

10. Swaefy HMF, Sakr WRA, Sabh AZ, Ragab AA. Effect of some chemical and bio-fertilizers on peppermint plants grown in sandy soil. Annals Agric. Sci., Ain Shams Univ. 2007; 52(2): 451-463.
11. Snedecor GW, Cochran WG. Statistical Methods, US: Iowa State Univ. Press, 1982.
12. British Pharmacopoeia, Determination of Volatile Oil in Drugs. The Pharmaceutical Press, London, 1963.
13. El-Sayed AA, Aly MK, Abd El-Gawad MH. Response of coriander plants to some phosphorus, zinc and yeast treatments. In: Proceedings of the 2nd International Conference of Horticulture Science, Kafr El-Sheikh, Tanta Univ., Egypt, 2002.
14. Naguib NY, Khalil MY. Studied on the effect of dry yeast, thiamine and biotin on the growth and chemical constituents of black cumin (*Nigella sativa* L.). Arab. Univ. J. Agric. Sci., Ain Shams Univ. 2002; 10:919-937.
15. Heikal AE. Effect of organic and biofertilization on growth production and composition of *Thymus vulgaris* L. plants. M.Sc. Thesis, Fac. Agric. Cairo Univ., Egypt, 2005.
16. Ezz El-Din AA, Hendawy SF. Effect of dry yeast and compost tea on growth and oil content of *Borago officinalis* plant. Res. J Agric. Biol. Sci. 2010; 6(4):424-430.
17. Matter FMA, Abou-Sreea AIB. Influence of application methods of bio-fertilization on vegetative growth, seed yield and chemical composition of fenugreek plants. Egypt. J Hort. 2016; 43(1):19-33.
18. Muller K, Leopold AC. Mechanism of kinetin induced transport in corn leaves. Planta. 1966; 68:185-205.
19. Armanios RR. Studies on interaction between microorganisms isolated from Egyptian soils in relation to soil fertility. Ph.D. Thesis, Fac. Agri. Cairo Univ., Egypt, 1987.
20. Nagodawithana WT. Yeast Technology. Universal Foods Corporation. Milwaukee, Wisconsin, Published by Van Nostrand Reinhold, New York, 1991.
21. Khedr ZMA, Farid S. Response of naturally virus infected tomato plants to yeast extract and phosphoric acid application. Annals Agric. Sci., Moshtohor. 2002; 38(2):927-939.
22. Amer SSA. Growth, green pods yield and seeds yield of common bean (*Phaseolus vulgaris* L.) as affected by active dry yeast, salicylic acid and their interaction. J Agric. Sci. Mansoura Univ. 2004; 29(3):1407-1422.
23. Shalaby ME, El-Nady MF. Application of *Saccharomyces cerevisiae* as a biocontrol agent against *Fusarium* infection of sugar beet plants. Acta Biol. Szeged. 2008; 52(2):271-275.
24. Abou El-Yazied A, Mady MA. Effect of naphthalene acetic acid and yeast extract on growth and productivity of tomato (*Lycopersicon esculentum* Mill.) plants. Res. J Agric. Biol. Sci. 2011; 7(2):271-281.
25. Hassan HMM. Antioxidant and immunostimulating activities of yeast (*Saccharomyces cerevisiae*) autolysates. World Appl. Sci. J. 2011; 15(8):1110-1119.
26. Khalil SE, Khalil AM. Effect of water irrigation intervals, compost and dry yeast on growth, yield and oil content of *Rosmarinus officinalis* L. plant. Am.-Eurasian J. Sustain. Agric. 2015; 9(5):36-51.
27. Mostafa GG. Improving the growth of fennel plant grown under salinity stress using some biostimulants. Am. J Plant Physiol. 2015; 10(2):77-83.
28. Link R. Landscaping for Wildlife in the Pacific Northwest. University of Washington, 2017.
29. Telci I, Sahbaz N, Yilmaz G, Tugay ME. Agronomical and chemical characterization of spearmint (*Mentha spicata* L.) originating in Turkey. Econ. Bot. 2004; 58(4):721-728.
30. El-Gamal SMA. Physiological response of sweet basil plants grown under stress conditions as affected by yeast extract, ascorbic acid and potassium. Minufiy J Agric. Res. 2005; 30(1):25-50.
31. Matter FMA, El Sayed SAA. Influence of mixed NPK fertilizers with foliar spray of active dry yeast on caraway under newly reclaimed soil conditions. Middle East J Appl. Sci. 2015; 5(2):423-430.
32. Ravindran PN. The Encyclopedia of Herbs and Spices. CABI, UK, 2017.