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Impact of Planting Distances and Natural Plant Extracts on Vegetative Growth, Chemical Constituents and Oil Productivity on Thyme Plant

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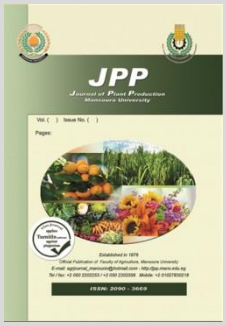

ABSTRACT

This study was carried during the two successive seasons 2017 and 2018, at the Experimental Farm of Hortic. Dep., Faculty of Agric., Benha University, Egypt to study the effects of different planting distances (20*20 and 30*30cm) with some natural extracts (licorice and aloe extracts) and their interactions on thyme plant. the results showed that the combined treatment between planting distances (20*20) cm, and F5 (Aloe 50%) gained the superiority, followed by descending order by the combination treatment of planting distances (20*20cm) and F3 (Licorice 50%) in two cuts and the two seasons. Furthermore, the combination between planting distances and fertilizations treatments enhanced the chemical compositions particularly planting distance at (30*30cm), and F3 (Licorice 50%) during the in general .However, essential oil percentage of thyme plant was increased by using the combined treatment of planting distances at (30*30 cm) and F5 (Aloe extract at 50%). GLC analysis of ~~of~~ thyme included 12 compounds were identified, the main component was β-cymene. Consequently, it is preferable to use the planting distance (30*30cm), and F5 (Aloe extract at 50%), for improving all studied traits of thyme plant.

***Keywords*: *Thymus vulgaris*, planting distance, plant extracts, and Volatile oil .**

INTRODUCTION

Thyme (*Thymus vulgaris* L.) belongs to the Lamiaceae family. Thyme is a medicinal plant use as in food, its products such as extracts, oils, and powder, have antidiabetic, antioxidant, antilipidemic, antitumor and antimicrobial actions attributed to active constituents of thyme are thymol and carvacrol in combination with other biological constituents (Khafaji 2018). The main constituents for oil of thyme were thymol, carvacrol, linalool, and p-cymene, which have already been proven to have antibacterial properties. The essential oil of thyme is the most effective, and it has antimicrobial and antioxidant properties due to its phenolic constituents (Yasuj *et al.* 2022). Also, the planting spacing is a factor that effects the nutrient absorption and photosynthesis process, which led to the growth of plant. Planting at a specific distance is high related to the nutrition and sunlight which are environmental parameters that effects productivity and biomass. The wider planting distance, the more circulation that bring nutrients to plant which increase the growth. (Aslin *et al*., 2019; El-Ghawwas *et.al*., 2011) on *Artemisia annua* they illustrated that the planting distance (60 x 40cm) improved the vegetative growth of plant, (Tadesse 2019) on *Lavandula anguistifolia* and *Rosmarinus officinalis*, and Mengistu *et al*. (2021) on *Nigella sativa*. In research has shown that extracts of plants can be used as a natural alternate to chemical fertilizers and growth stimulants. Also, Mohamed and Ghatas (2020) stated that using safety growth stimulants gave the best growth on *Salvia hispanica* L.

The licorice extracts (*Glycyrrhiza glabra*) contains some substances that have effect to promoters' growth such as minerals, (Al-Ajeeli, 2005 and Sabry *et al.*, 2009), (Fe, Zn, Ca, P, K, Mg),vitamins (B_1, B_2 and B_6), amino acids (lysine, alanine, arginine), as well as glucose and nitrogen . Also, it contains mevalonic acid which is a precursor for creating gibberellins (Saleem and Saeid, 2023). Also, reported that using aloe extracts can be used as a natural plants growth regulator due to contains some of the auxins (Dong Zhi, *et al.*, 2004). Moreover, it contains some vitamins, enzymes and amino acids (Josias, 2008 and Khater *et al.*, 2020). This study aims to evaluate the effects of planting distances and some natural extracts beside the combination between them on thyme plant.

MATERIALS AND METHODS

This study was carried out during 2017 and 2018 seasons at the Experimental Farm of Hort. Department, Fac. of Agric., Benha University, Egypt to study the effect of different plant distances (20*20 and 30*30cm) with plant extracts as (licorice and aloe) on vegetative growth characters, chemical constituents and oil productivity of (*Thymus vulgaris* L.).

Extracts preparation:

Aloe plant extract it was prepared as described by (Wilfred *et al.* 1990), weigh 100 grams of (*Aloe vera* gel) and mix in the mixer, then filter the resulting mixture, then take (100 ml) of the extract and fill it with distilled water to (1000 ml).

Licorice extract the aqueous extract of licorice roots (*Glycyrrhiza glabra*), were soaking licorice roots in water at a rate: (100 and 50 g /L) of tap water. As suggested by Abd El-Azim *et al.* (2017). Then filtering of the solution by wringing using a cloth. The treatments was arranged as follow:

1- Control (Tap of water)
2- Licorice extract at 100%
3- Licorice extract at 50%
4- Aloe extract at 100%
5- Aloe extract at 50%

Cutting was obtained from Floriculture Farm, Hortic. Department, Faculty of Agric., Benha University, in the two

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seasons. The cuttings (5-7 cm) were planted in polyethylene bags as a mixture of (1 of clay: 1 of sand) on December 5th after seedling were planted on March 21st in both seasons. Mechanical and chemical analyses of the experimental soils are presented in Table :(1). Mechanical analysis was carried out according to Jackson (1973). Whereas chemical analysis was estimated according to Black *et al.* (1982).

Table 1. Physical and chemical analysis of the experimental soil.

Parameters	Values		Parameters	Values	
A. Mechanical properties			B. Chemical analysis		
(2017)	(2018)		(2017)	(2018)	
Coarse sand	7.12 %	6.55 %	Organic matter	1.80%	1.75 %
Fine sand	11.88 %	12.99 %	$CaCO_3$	1.09 %	1.17 %
Silt	24.77 %	26.24 %	Available nitrogen	0.88 %	0.96 %
Clay	56.23 %	54.22 %	Available phosphorus	0.25%	0.33 %
Textural class	Clay loam	Clay loam	Available potassium	0.62 %	0.69%
			pH	7.44	7.66
			EC (dS/m)	0.86	0.84

Experimental layout.

The layout of this experiment was factorial experiment in Randomized Complete Block Design (RCBD) with two factors the first two planting distances (20*20 and 30*30cm) with five plant extracts. All 10 treatments were replicated three times and each replicate contain three plots area and each plot (1*1m) contained of 6 plants with spacing (20*20cm), and 4 plants with spacing (30*30cm) The plants received normal agricultural Practices whenever needed.

The second factor was natural plant extracts: The plants were treated with foliar spraying of licorice and aloe extract was applied in the early morning by spraying leaves, at intervals of three weeks between one spray and the other, and the first spray was after one month of planting, in both seasons. Licorice extract concentration (50 and 100 g / L tap water) and aloe (50 and 100 ml/L tap water).

Harvesting time

During both seasons thyme plants were harvested throughout both cuts in each harvest. The first cut was done on 30th June. While the second cut was on 30th September of both seasons 2017 & 2018.

Data recorded.

Vegetative growth:

Plant height (cm), herb fresh weight per plant (g), herb dry weight per plant (g) and number of branches were determined at the end of experiment

Chemical composition

Chlorophyll (A and B) were determined calorimetrically in leaves of thyme according to A.O.A.C. (1990) and calculated as mg/100g fresh weight.

Nitrogen, phosphorus, potassium and total carbohydrates were tested in thyme herbs according to (Horneck and Miller, 1998; Hucker and Catroux, 1980; Horneck and Hanson, 1998 and Herbert *et al.* 1971).

Micronutrients Fe, Mn, and Zn (%) were tested in the samples by atomic absorption as described by Chapman and Paratt, (1961).

Essential oil characters

Essential oil (%): was determined according to British Pharmacopeia (1963).

-GLC (analysis of the volatile oil constituents): The gas liquid chromatography analysis was carried out at the medicinal and Aromatic plant laboratory. Dokki, Giza, Egypt. By Bunzen *et al.* (1969) and Hoftman (1967).

Statistical analysis

The means of each obtained results from the studied factors were analyzed for variance (ANOVA) as factorial experiments in a complete randomized block design). The differences between the mean values of various treatments were compared by using the least significant differences (L. S. D.) at 0.05 %, as given by Snedecor and Cochran (1989) using MSTAT-C statistical software package.

RESULTS AND DISCUSSION

Effects of planting distances and some plant extracts and their interactions treatments on vegetative growth of *Thymus vulgaris* L. plants during 2017 and 2018 seasons.

Tables (2 and 3) indicate that, the characteristics of vegetative growth i.e. plant height (cm) , number of branches per plant, herb fresh and dry weights (g/ plant), and herb fresh weight (Kg/Fed)of thyme were increased using the planting distances (30*30 cm) in two cuts and in both seasons, compared to the planting distances (20*20). On the other side, these parameters mentioned afore were affected by all the different extract treatments with the superiority of F5 (aloe extract at 50 %), followed by F3 (Licorice at 50%). Moreover, the effect of combining planting distances and extracts treatments, the data showed that all combinations between planting distances and plant extracts treatments led to an increase in the parameter of the thyme plant. However, the greatest values were recorded that using the combination treatment of planting distance at (20 * 20) cm) and F5, followed by descending the co-treatment between planting distances (20 * 20cm), and F3 in the two cuts and the two seasons. The lowest values for these parameters were recorded between planting distances (30 * 30 cm) and F1 in the two plots and in both seasons. Also, the abovementioned results on the vegetative growth agreement with those recorded by Khater *et al.* (2020) on *Carum Carvi* the finest qualities, such as vegetative growth and seed production, were generated using *Aloe vera* extract. Wilson (2020) on *Solanum melongena* aqueous extracts of *Aloe vera* were the highest on the growth and development of eggplant seedlings. It can be using as a growth stimulant. El-Gohary *et al.* (2021) on *Cynara cardunculus* extracts of licorice roots had positive effects on growth and yield, Abdel-Mola *et al.* (2022) on *Pelargonium graveolens* concerning liquorice extract treatments, on vegetative growth were augmented due to aqueous LRE, Saleem and Saeid (2023) on *Brassica oleracea* led the foliar spraying of Licorice roots extract to increase of the attributes vegetative growth, The abovementioned results on the planting distance are met with those recorded by (Mohamed *et al.* 2023) on *Artemisia annua*, the best was applying the planting spacing (40*40 cm), to improve the vegetative growth and Nurzyńska-Wierdak *et al.* (2023) on *Melissa officinalis*, they stated that planting distance (40 x 40cm) improved the vegetative growth, a better planting than (30 x 30cm).

Effect of planting distances and some medicinal plant extracts (licorice and aloe extracts) and their interactions treatments on Chemical composition of *Thymus vulgaris* L. plants during 2017 and 2018 seasons.

Nitrogen, phosphorus, potassium and total carbohydrates percentage.

Results presented in Tables (4 and 5), declared that nitrogen, phosphorus and potassium percentage contents/

plant of (*Thymus vulgaris*, L.) plant was increased by using planting distances (20*20cm) in the first cut in both seasons and (30*30cm) in the second cut in both seasons.

Table 2. Effects of planting distances and some natural plant extracts and their interaction on plant height (cm) and number of branches per plant of *Thymus vulgaris* L. plants during 2017-2018 and 2018-2019 seasons.

Parameters	Plant height (cm)						Number of branches /plant					
Cutting	1st cut			2nd cut			1st cut			2nd cut		
Plant distance(A)	Plant distance (A)			Plant distance (A)			Plant distance (A)			Plant distance (A)		
Extracts Treatments(B)	20*20	30*30	Mean	20*20	30*30	Mean	20*20	30*30	Mean	20*20	30*30	Mean
	1st season											
F_1	16.13	13.43	14.78	21.600	18.167	19.883	3.000	6.000	4.500	5.600	8.267	6.933
F_2	24.40	21.30	22.85	28.100	26.700	27.400	6.200	8.233	7.217	8.800	12.967	10.883
F_3	26.80	24.43	25.62	33.367	28.700	31.033	8.233	9.667	8.950	10.633	14.800	12.717
F_4	26.00	22.77	24.38	29.067	27.867	28.467	6.767	8.700	7.733	9.900	13.667	11.783
F_5	28.03	26.60	27.32	35.933	30.167	33.050	8.767	10.500	9.633	11.733	15.767	13.750
Mean	24.27	21.71		29.613	26.320		6.593	8.620		9.333	13.093	
L.S.D at 0.05 for	A= 0.484 B= 0.765 AXB=1.082			A= 0.460 B= 0.727 AXB= 1.028			A= 0.127 B= 0.312 AXB=0.441			A= 0.384 B= 0.608 AXB=0.859		
	2nd season											
F_1	17.400	13.467	15.433	20.333	19.267	19.800	4.000	6.000	5.000	5.667	8.400	7.033
F_2	25.900	23.233	24.567	29.167	28.633	28.900	7.000	9.500	8.250	10.133	13.267	11.700
F_3	28.767	26.500	27.633	34.800	31.067	32.933	10.267	11.200	10.733	13.067	15.133	14.100
F_4	27.767	24.633	26.200	30.000	30.100	30.050	9.233	10.067	9.650	11.133	14.000	12.567
F_5	30.133	28.833	29.483	36.833	32.267	34.550	11.933	12.267	12.100	14.033	16.433	15.233
Mean	25.993	23.333		30.227	28.267		8.487	9.807		10.807	13.447	
L.S.D at 0.05 for	A= 0.499 B=0.789 AXB= 1.116			A= 0.633 B= 1.001 AXB=1.416			A= 0.283 B= 0.447 AXB= 0.633			A= 0.306 B= 0.484 AXB= 0.684		

F_1:Control, F_2: Licorice at 100 %, F3: Licorice at 50 %, F4: Aloe at 100 %, F5: Aloe at 50%.

Table 3. Effects of planting distances and some natural plant extracts and their interaction on herb fresh and dry weights (g/ plant) of *Thymus vulgaris* L. plants during 2017-2018 and 2018-2019 seasons.

Parameters	Herb fresh weight (g/ plant)						Herb dry weight (g/ plant)					
Cutting	1st cut			2nd cut			1st cut			2nd cut		
Plant distance(A)	Plant distance (A)			Plant distance (A)			Plant distance (A)			Plant distance (A)		
Extracts Treatments(B)	20*20	30*30	Mean	20*20	30*30	Mean	20*20	30*30	Mean	20*20	30*30	Mean
	1st season											
F_1	20.367	8.933	14.650	46.533	52.233	49.383	6.800	8.933	7.867	15.533	17.433	16.483
F_2	41.600	14.967	28.283	79.667	87.800	83.733	13.833	14.967	14.400	26.600	29.267	27.933
F_3	49.700	17.800	33.750	91.300	95.867	93.583	16.533	17.800	17.167	30.400	31.933	31.167
F_4	44.267	16.600	30.433	86.600	90.500	88.550	14.733	16.600	15.667	28.867	30.133	29.500
F_5	54.867	19.333	37.100	100.867	104.600	102.733	18.333	19.333	18.833	33.633	34.867	34.250
Mean	42.160	15.527		80.993	86.200		14.047	15.527		27.007	28.727	
L.S.D at 0.05 for	A= 1.075 B= 1.700 AXB= 2.405			A= 1.931 B= 3.053 AXB= 4.318			A= 0.722 B=1.142 AXB=1.615			A= 0.646 B= 1.021 AXB=1.444		
	2nd season											
F_1	29.300	44.200	36.750	46.567	50.833	48.700	9.733	14.600	12.167	15.567	16.933	16.250
F_2	45.367	62.500	53.933	88.300	90.367	89.333	15.100	21.400	18.250	29.433	30.233	29.833
F_3	54.300	70.767	62.533	98.333	102.367	100.350	18.100	23.533	20.817	32.767	34.100	33.433
F_4	50.400	67.400	58.900	90.467	94.600	92.533	16.833	22.400	19.617	30.167	31.500	30.833
F_5	56.133	75.767	65.950	110.233	125.	117.633	18.667	25.033	21.850	36.767	41.700	39.233
Mean	47.100	64.127		86.780	92.640		15.687	21.393		28.940	30.893	
L.S.D at 0.05 for	A= 1.496 B= 2.365 AXB= 3.344			A= 2.989 B= 4.727 AXB=6.684			A= 0.475 B= 0.751 AXB= 1.062			A= 1.002 B= 1.585 AXB=2.241		

F_1:Control, F_2: Licorice at 100 %, F3: Licorice at 50 %, F4: Aloe at 100 %, F5: Aloe at 50%.

In table (4) Data showed that nitrogen (%) greatly affected by all different extracts with superiorly of F3 (Licorice at 50 %), followed by F2 (Licorice at 100 %) in the two cuts in both seasons. the greatest values was recorded by using the combination treatment of planting distances (30*30 cm) and F3, followed descending by the combination treatment of planting distances (30*30cm) and F2 in the two cuts and seasons . Also, data showed that Phosphorus (%) greatly affected by all different extract's treatments with superiorly with superiorly F2 (Licorice at 100 %), followed by F4 (aloe extract at 100 %) in the second cut and in the second season. the greatest values was by using the combination treatment of planting distances at (20*20 cm) and F1 in the two cuts and first season. Except, (20*20 cm) and F5 in first cut in the second season and (30*30 cm) and F2 in the second cut in second season. Data shown in table (5)indicated that Potassium(%) greatly affected by all different extract's treatments, superiorly F3 (Licorice at 50 %) followed by F5 (aloe at 50 %) in first cut in both seasons. while in the second cuts and in both season with superiorly F5 (aloe at 50 %), followed by F3 (liquorices at 50 %). the highest values was recorded by using the combination treatment of planting distances (20*20cm) and F3 in the first cut in both season and (30*30 cm) and F5 in the second cut in both seasons.

In tables (5) declared that total carbohydrates percentage of dry weight of thyme (*Thymus vulgaris* L.) plant was increased by using planting distances (30*30 cm) in the two cuts and in both seasons. data showed that total

carbohydrates percentage of dry weight highly affected by all different extract's treatments in both cuts and in both seasons with superiorly of F3 (Licorice at 50 %), followed by F2 (Licorice extract at 100 %) in the first cuts in both seasons. And the greatest values was recorded by using the combination treatment of planting distances (30*30 cm) and F3, followed descendingly by the combination treatment of planting distances (20*20cm) and F3 in first cut in two seasons, except in second cut in the two seasons the greatest values was (30*30 cm) and F3 followed descendingly by (20*20 cm) and F2. While nitrogen, phosphorus , potassium and total carbohydrates percentage the lowest values of these parameters by planting distances (20*20 cm) and F1 in two cuts and in second seasons. Also, the abovementioned data on Chemical composition are met with those attained by Khater *et al.* (2020) on caraway plant, found that aloe extract produced the highest All, Chemical constituents, (Abdel-Mola *et al.* 2022) on *Pelargonium Graveolens*, found that total carbohydrate, NPK increased with licorice extracts LRE. Hasan and Kader (2022) on *Punica granatum* interaction between NPK, and Licorice extracts led to significant increase, and gave the highest value of leaves content of nitrogen, phosphor and potassium. Furthermore, (Mohamed *et al.* 2023) on *Artemisia annua* L., Nurzyńska-Wierdak *et al.* (2023) on *Melissa officinalis*, Plant spacing seemed, to be the optimum for plant.

Table 4. Effects of planting distances and some natural plant extracts and their interaction on nitrogen and phosphorus percentage /plant of *Thymus vulgaris* L. plants during 2017-2018 and 2018-2019 seasons.

Parameters	N (%)						P (%)					
Cutting	1st cut			2nd cut			1st cut			2nd cut		
Plant distance(A)	Plant distance (A)			Plant distance (A)			Plant distance (A)			Plant distance (A)		
Extracts Treatments(B)	20*20	30*30	Mean	20*20	30*30	Mean	20*20	30*30	Mean	20*20	30*30	Mean
					1st season							
F_1	0.960	1.067	1.013	0.860	0.980	0.920	1.210	0.097	0.654	1.016	1.022	1.019
F_2	1.980	2.333	2.157	1.823	2.393	2.108	0.420	0.343	0.382	0.375	0.419	0.397
F_3	2.523	2.267	2.395	2.227	2.790	2.508	0.450	0.273	0.362	0.382	0.244	0.313
F_4	2.147	1.333	1.740	1.110	1.967	1.538	0.300	0.443	0.372	0.298	0.335	0.317
F_5	2.643	1.940	2.292	1.137	1.967	1.552	0.963	0.377	0.670	0.403	0.363	0.383
Mean	2.051	1.788		1.431	2.019		0.669	0.307		0.495	0.477	
L.S.D at 0.05 for	A= 0.0015 B= 0.0024 AXB= 0.0034			A= 0.002 B= 0.003 AXB= 0.004			A= 0.0006 B= 0.0009 AXB=0.0013			A= 0.0006 B= 0.0009 AXB=0.0013		
					2nd season							
F_1	1.407	1.180	1.293	0.970	1.240	1.105	0.140	0.260	0.200	0.220	0.212	0.216
F_2	2.877	2.650	2.763	2.210	2.877	2.543	0.537	0.413	0.475	0.410	0.455	0.433
F_3	2.940	2.727	2.833	2.880	3.163	3.022	0.570	0.363	0.467	0.418	0.263	0.341
F_4	2.213	1.987	2.100	1.550	2.207	1.878	0.367	0.543	0.455	0.430	0.388	0.409
F_5	2.647	2.210	2.428	1.770	2.207	1.988	1.017	0.460	0.738	0.337	0.374	0.356
Mean	2.417	2.151		1.876	2.339		0.526	0.408		0.363	0.338	
L.S.D at 0.05 for	A= 0.0015 B= 0.0024 AXB=0.0034			A= 0.034 B= 0.054 AXB=0.077			A= 0.002 B= 0.003 AXB=0.004			A= 0.0015 B= 0.0024 AXB= 0.0034		

F_1:Control, F_2: Licorice at 100 %, F3: Licorice at 50 %, F4: Aloe at 100 %, F5: Aloe at 50%.

Table 5. Effects of planting distances and some natural plant extracts and their interaction on potassium and total carbohydrates percentage /plant of *Thymus vulgaris* L. plants during 2017-2018 and 2018-2019 seasons.

Parameters	K (%)						Total carbohydrates(%of dry weight)					
Cutting	1st cut			2nd cut			1st cut			2nd cut		
Plant distance(A)	Plant distance (A)			Plant distance (A)			Plant distance (A)			Plant distance (A)		
Extracts Treatments(B)	20*20	30*30	Mean	20*20	30*30	Mean	20*20	30*30	Mean	20*20	30*30	Mean
					1st season							
F_1	0.123	0.116	0.120	0.188	0.213	0.200	7.167	10.620	8.893	9.783	11.070	10.427
F_2	0.305	0.298	0.301	0.377	0.403	0.390	18.267	19.063	18.665	19.977	26.063	23.020
F_3	0.389	0.287	0.338	0.388	0.381	0.385	20.247	23.440	21.843	24.827	28.230	26.528
F_4	0.287	0.276	0.281	0.311	0.372	0.341	16.400	16.937	16.668	17.543	19.757	18.650
F_5	0.317	0.317	0.317	0.325	0.412	0.369	12.233	14.667	13.450	14.147	18.223	16.185
Mean	0.284	0.259		0.318	0.356		14.863	16.945		17.255	20.669	
L.S.D at 0.05 for	A= 0.002 B= 0.003 AXB=0.004			A= 0.0006 B= 0.0009 AXB= 0.0013			A= 0.277 B= 0.437 AXB=0.619			A=0.024 B= 0.038 AXB=0.054		
					2nd season							
F_1	0.195	0.153	0.174	0.206	0.232	0.219	5.700	11.240	8.470	8.437	13.340	10.888
F_2	0.356	0.286	0.321	0.431	0.425	0.428	18.353	19.760	19.057	20.860	27.007	23.933
F_3	0.411	0.266	0.339	0.437	0.402	0.420	21.433	24.550	22.992	26.563	30.327	28.445
F_4	0.328	0.224	0.276	0.351	0.391	0.371	17.403	17.683	17.543	18.110	20.413	19.262
F_5	0.356	0.220	0.288	0.362	0.443	0.403	10.427	16.870	13.648	15.507	19.463	17.485
Mean	0.329	0.230		0.358	0.379		14.663	18.021		17.895	22.110	
L.S.D at 0.05 for	A= 0.0015 B= 0.0024 AXB= 0.0034			A= 0.002 B= 0.003 AXB=0.004			A= 0.069 B= 0.106 AXB=0.153			A= 0.024 B= 0.038 AXB= 0.054		

F_1:Control, F_2: Licorice at 100 %, F3: Licorice at 50 %, F4: Aloe at 100 %, F5: Aloe at 50%.

Zinc, Iron and Manganese percentage

Tables (6 and7) declare that zinc, Iron and Manganese percentage contents/plant of thyme (*Thymus vulgaris* L.) plant was increased by using planting distances (30*30 cm) in the two cuts and in both seasons.

Data showed that zinc (%) highly affected by all different extracts treatments in the both cuts and in the both

seasons with superiorly of F4 (aloe at 100 %), followed by F2 (Licorice at 100 %) in the first cuts in the both seasons, the greatest values were recorded by using the combination treatment of planting distances (20*20 cm) and F4 with (30*30 cm) and F2 followed descendingly by the combination treatment of planting distances (30*30 cm) and F3 in the two cuts in the first season. Except, (20*20 cm) and F4 followed descending by the combination treatment of planting distances at (30*30cm) with F4 in the two cuts in the second season.

In Iron (%) highly affected by all different extract's treatments in both cuts and in both seasons with superiorly of F4 (aloe at 100 %), followed by F2 (Licorice at 100 %) in the two cuts in both seasons. the greatest values was recorded by using the combination treatment of planting distances (30*30 cm) and F4 followed descendingly by the combination treatment of planting distances (20*20cm) and F4 in the two cuts and both seasons.

Table 6. Effects of planting distances and some natural plant extracts and their interaction on zinc and iron percentage /plant of *Thymus vulgaris*, L. plants during 2017-2018 and 2018-2019 seasons.

Parameters	Zn (%)						Fe (%)					
Cutting	1st cut			2nd cut			1st cut			2nd cut		
Plant distance(A)	Plant distance (A)			Plant distance (A)			Plant distance (A)			Plant distance (A)		
Extracts Treatments(B)	20*20	30*30	Mean	20*20	30*30	Mean	20*20	30*30	Mean	20*20	30*30	Mean
	1st season											
F_1	0.010	0.018	0.014	0.011	0.013	0.012	0.011	0.048	0.029	0.012	0.011	0.012
F_2	0.012	0.028	0.020	0.015	0.029	0.022	0.059	0.043	0.051	0.060	0.043	0.052
F_3	0.015	0.026	0.021	0.016	0.027	0.021	0.029	0.025	0.027	0.029	0.026	0.027
F_4	0.028	0.022	0.025	0.029	0.023	0.026	0.078	0.079	0.079	0.078	0.079	0.079
F_5	0.025	0.022	0.023	0.025	0.022	0.024	0.039	0.055	0.047	0.040	0.055	0.048
Mean	0.018	0.023		0.019	0.023		0.043	0.050		0.044	0.043	
L.S.D at 0.05 for	A= 0.0015 B= 0.0024 AXB= 0.0034			A= 0.0006 B= 0.0009 AXB= 0.0013			A= 0.0005 B= 0.0008 AXB= 0.0011			A= 0.0005 B= 0.0008 AXB=0.0011		
	2nd season											
F_1	0.008	0.019	0.014	0.009	0.015	0.012	0.011	0.013	0.012	0.020	0.018	0.019
F_2	0.012	0.023	0.017	0.013	0.023	0.018	0.062	0.030	0.046	0.062	0.024	0.043
F_3	0.016	0.022	0.019	0.016	0.022	0.019	0.033	0.028	0.031	0.033	0.028	0.031
F_4	0.029	0.028	0.028	0.029	0.029	0.029	0.080	0.080	0.080	0.079	0.080	0.080
F_5	0.025	0.027	0.026	0.025	0.027	0.026	0.042	0.048	0.045	0.042	0.048	0.045
Mean	0.018	0.024		0.018	0.023		0.046	0.040		0.047	0.040	
L.S.D at 0.05 for	A= 0.0006 B= 0.0009 AXB= 0.0013			A= 0.0006 B= 0.0009 AXB= 0.0013			A= 0.0006 B= 0.0009 AXB= 0.0013			A= 0.0004 B= 0.0008 AXB= 0.0012		

F_1:Control, F_2: Licorice at 100 %, F3: Licorice at 50 %, F4: Aloe at 100 %, F5: Aloe at 50%.

Table 7. Effects of planting distances and some natural plant extracts and their interaction on manganese percentage /plant of *Thymus vulgaris*, L. plants during 2017-2018 and 2018-2019 seasons.

Parameters	Mn (%)					
Cutting	1st cut			2nd cut		
Plant distance(A)	Plant distance (A)			Plant distance (A)		
Extracts Treatments(B)	20*20	30*30	Mean	20*20	30*30	Mean
	1st season					
F_1	0.007	0.009	0.008	0.007	0.009	0.008
F_2	0.012	0.013	0.013	0.013	0.014	0.013
F_3	0.011	0.013	0.012	0.011	0.013	0.012
F_4	0.019	0.020	0.019	0.019	0.020	0.020
F_5	0.015	0.017	0.016	0.016	0.018	0.017
Mean	0.013	0.014		0.013	0.015	
L.S.D at 0.05 for	A= 0.0005 B= 0.0008 AXB=0.0011			A= 0.0007 B= 0.0011 AXB=0.0015		
	2nd season					
F_1	0.010	0.010	0.010	0.006	0.010	0.008
F_2	0.016	0.014	0.015	0.016	0.015	0.016
F_3	0.014	0.014	0.014	0.014	0.015	0.014
F_4	0.050	0.020	0.035	0.050	0.020	0.035
F_5	0.019	0.019	0.019	0.019	0.019	0.019
Mean	0.022	0.015		0.021	0.016	
L.S.D at 0.05 for	A= 0.0007 B= 0.0011 AXB=0.0015			A= 0.0008 B= 0.0012 AXB= 0.0017		

F_1:Control, F_2: Licorice at 100 %, F3: Licorice at 50 %, F4: Aloe at 100 %, F5: Aloe at 50%.

In manganese (%) it was significantly affected by the superiority of F4 (aloe at 100 %), followed by F5 (aloe at 50 %) in the two plots in the both seasons, while the greatest values was recorded by using the combination treatment of planting distances (30*30 cm) and F4 followed descendingly by the combination treatment of planting distances (20*20cm) and F4 in the two cuts in the first season while the greatest values was (20*20 cm) and F4 followed descending by the combination treatment of planting distances (30*30cm) and F4 in the both cuts in the second season. the abovementioned data are met with those stated by Mohamed *et al.* (2023) on *Artemisia annua* L. Plant reported that spacing seemed, to be the optimum for plant, and Khater *et al.* (2020), on caraway plants found that with aloe extract produced the highest, all chemical constituents.

Chlorophyll A, B and Carotenoid's contents

The data in tables (8 and 9), declared that chlorophyll (A and B), and Carotenoid's contents (mg/g F.W.) of thyme (*Thymus vulgaris* L.) plant were increased by using planting distances at (30*30 cm) in both cuts and seasons, data showed that Chlorophyll (a), (b) and Carotenoid's greatly affected by each different plant extracts treatments in both cuts and in two seasons with superiorly of F3 (Licorice at 50 %), followed by F2 (Licorice at 100 %) in the two cuts in both seasons, the greatest values was recorded by using the combination treatment of planting distance at (30*30cm) and F3 followed descending by the combination treatment of planting distance at (20*20cm) and F3 in the two cuts and both seasons. On the reverse, the lowest values of these parameters scored by between planting distance at (20*20 cm) and F_1 in two cuts and in both seasons. Also, the abovementioned results are met with those attained by Ibrahim (2021) on *Firebomb* declared that the high concentration of licorice roots extract, gave the highest total chlorophyll content, and Abdel-Mola *et al.* (2022) on *Pelargonium graveolens*, found that chlorophyll (a & b) increased with licorice extracts LRE. .

Table 8. Effects of planting distances and some natural plant extracts and their interaction on chlorophyll (a) (mg/g F.W.) and chlorophyll (b) content (mg/g F.W.) Of *Thymus vulgaris* L. plants during 2017-2018 and 2018-2019 seasons.

Parameters	Chlorophyll A (mg/g fresh weight)						Chlorophyll B (mg/g fresh weight)					
Cutting	1st cut			2nd cut			1st cut			2nd cut		
Plant distance(A)	Plant distance (A)			Plant distance (A)			Plant distance (A)			Plant distance (A)		
Extracts Treatments(B)	20*20	30*30	Mean	20*20	30*30	Mean	20*20	30*30	Mean	20*20	30*30	Mean
	1st season											
F_1	0.512	0.645	0.578	0.718	0.813	0.766	0.512	0.645	0.578	0.718	0.813	0.766
F_2	0.912	0.915	0.913	0.948	0.978	0.963	0.912	0.915	0.913	0.948	0.978	0.963
F_3	0.937	0.940	0.938	1.010	1.040	1.025	0.937	0.940	0.938	1.010	1.040	1.025
F_4	0.840	0.843	0.842	0.911	0.941	0.926	0.840	0.843	0.842	0.911	0.941	0.926
F_5	0.816	0.819	0.817	0.884	0.914	0.899	0.816	0.819	0.817	0.884	0.914	0.899
Mean	0.803	0.832		0.894	0.937		0.803	0.832		0.894	0.937	
L.S.D at 0.05 for	A= 0.0007 B= 0.0011 AXB=0.0015			A= 0.0024 B= 0.0038 AXB=0.0054			A= 0.0015 B= 0.0024 AXB= 0.0034			A= 0.0024 B= 0.0038 AXB= 0.0054		
	2nd season											
F_1	0.631	0.737	0.684	0.793	0.854	0.823	0.631	0.737	0.684	0.793	0.854	0.823
F_2	0.937	0.967	0.952	1.080	1.110	1.095	0.937	0.967	0.952	1.080	1.110	1.095
F_3	0.997	1.027	1.012	1.160	1.190	1.175	0.997	1.027	1.012	1.160	1.190	1.175
F_4	0.923	0.953	0.938	0.968	0.998	0.983	0.923	0.953	0.938	0.968	0.998	0.983
F_5	0.865	0.895	0.880	0.924	0.954	0.939	0.865	0.895	0.880	0.924	0.954	0.939
Mean	0.870	0.916		0.985	1.021		0.870	0.916		0.985	1.021	
L.S.D at 0.05 for	A= 0.0024 B= 0.0038 AXB=0.0054			A=0.0024 B= 0.0038 AXB=0.0054			A=0.0024 B=0.0038 AXB=0.0054			A=0.0024 B= 0.0038 AXB=0.0054		

F_1:Control, F_2: Licorice at 100 %, F3: Licorice at 50 %, F4: Aloe at 100 %, F5: Aloe at 50%.

Table 9. Effect of planting distances and some natural plant extracts and their interaction on carotenoids (mg/g fresh weight) of *Thymus vulgaris*, L. plants during 2017-2018 and 2018-2019 seasons.

Parameters	Carotenoids (mg/g fresh weight)					
Cutting	1st cut			2nd cut		
Plant distance(A)	Plant distance (A)			Plant distance (A)		
Extracts Treatments(B)	20*20	30*30	Mean	20*20	30*30	Mean
	1st season					
F_1	0.205	0.218	0.212	0.214	0.236	0.225
F_2	0.282	0.286	0.284	0.285	0.289	0.287
F_3	0.296	0.300	0.298	0.298	0.302	0.300
F_4	0.275	0.268	0.272	0.267	0.271	0.269
F_5	0.252	0.256	0.254	0.254	0.258	0.256
Mean	0.262	0.266		0.264	0.271	
L.S.D at 0.05 for	A= 0.0015 B= 0.0024 AXB= 0.0034			A=0.002 B= 0.003 AXB= 0.004		
	2nd season					
F_1	0.235	0.244	0.239	0.240	0.342	0.291
F_2	0.279	0.283	0.281	0.281	0.285	0.283
F_3	0.294	0.298	0.296	0.330	0.301	0.316
F_4	0.262	0.266	0.264	0.262	0.274	0.268
F_5	0.251	0.255	0.253	0.251	0.255	0.253
Mean	0.264	0.269		0.273	0.291	
L.S.D at 0.05 for	A= 0.0006 B= 0.0009 AXB=0.0013			A= 0.024 B= 0.066 AXB=0.096		

F_1:Control, F_2: Licorice at 100 %, F3: Licorice at 50 %, F4: Aloe at 100 %, F5: Aloe at 50%.

Effect of planting distances and some natural plant (licorice and aloe) and their interactions on chemical composition and essential oil yield of *Thymus vulgaris* L. plants during 2017 and 2018 seasons.

Essential oil (%)

Tables (10) declares that essential oils % (per plant) of thyme (*Thymus vulgaris* L.) plant was increased by using planting distances especially (30*30 cm) in the two cuts and both seasons. Plant extracts treatments, data showed that Essential oils (%) (Per plant) greatly affected by each different extract's treatments in two cuts and in both seasons with superiorly of F5 (aloe at 50 %), followed by F3 (Licorice at 50 %) in the two cuts in both seasons. The greatest values was recorded by using the combination treatment of planting distances (30*30 cm) and F5 followed descendingly by the combination treatment of planting distances (20*20cm) and F5 in two cuts in both seasons. While the lowest values of these treatment scored by between planting distances (20*20 cm) and F1 in the two cuts and in both seasons. Also, the abovementioned results are met with those attained by, (Khater *et al.* 2020) on *Pelargonium Graveolens*, found that with aloe extract produced the highest oil yield and oil percentage, Abdel-Mola *et al.* (2022) on *Carum* Carvi, parameters on oil yield was augmented due to the high dose with aqueous LRE, Toaima *et al.* (2022) on *Ocimum basilicum* L. Hassan (2023) on *Carum carvi*, licorice extract gave the highest, ratio of carvone, and limonene.

Essential oil constituents

Tables (11 and 12) and Figs. (1-10) showed that the effects of fertilizers treatments and plant distances at (30*30 cm) and (20*20 cm) on the compounds of essential oils from thyme (*Thymus vulgaris* L.) plant, The volatile oil compounds of thyme 12 constituents were such as (α-thujene, camphene, α-pinene, sabinene, γ-terpinene, linalool, P-cymene, terpinenolene, borneol, bornyl acetate, carvacrol, thymol). In the two cuts and in both seasons, the main component was β-cymene ranged from (29.572 to 39.643%), followed by thymol ranged from (15.978 to 24.229%), borneol ranged from (1.852 to 16.722%), terpinenolene ranged from (3.912 to 6.427), α-thujene ranged from (4.048 to 6.055), bornyl acetate ranged from (2.388 to 6.998), carvacrol ranged from (2.404 to 4.726), sabinene ranged from (1.436 to 5.758), camphene ranged from (2.789 to 3.845), α-pinene ranged from (1.841 to 4.230), γ-terpinene ranged from (1.46 to 2.291) and linalool ranged from (1.466 to 2.325). the abovementioned data on chemicals composition are met with those stated by (Nadjafi *et al.* 2014) on *thymus vulgaris* L., and *Salvia officinalis* L., and Punetha *et al.* (2022) on *thymus vulgaris* L., Yasuj *et al.* (2023) on thyme (*thymus vulgaris*, L.), the quantity of β-cymene increased considerably, by a considerable decline was in temperature conditions were detected during storage.

Table 10. Effect of planting distances and some natural plant extracts and their interaction on essential oil percentage in fresh herb/plant of *Thymus vulgaris*, L. plants during 2017-2018 and 2018-2019 seasons.

Parameters	Oil Percentage (%)					
Cutting	1st cut			2nd cut		
Plant distance(A)	Plant distance (A)			Plant distance (A)		
Extracts Treatments(B)	20*20	30*30	Mean	20*20	30*30	Mean
	1st season					
F_1	0.223	0.253	0.238	0.300	0.340	0.320
F_2	0.517	0.533	0.525	0.557	0.583	0.570
F_3	0.600	0.620	0.610	0.647	0.673	0.660
F_4	0.557	0.577	0.567	0.600	0.623	0.612
F_5	0.643	0.670	0.657	0.697	0.717	0.707
Mean	0.508	0.531		0.560	0.587	
L.S.D at 0.05 for	A= 0.002 B= 0.003 AXB=0.004			A= 0.002 B= 0.003 AXB= 0.004		
	2nd season					
F_1	0.250	0.290	0.270	0.280	0.380	0.330
F_2	0.550	0.557	0.553	0.557	0.590	0.573
F_3	0.633	0.660	0.647	0.650	0.693	0.672
F_4	0.583	0.593	0.588	0.590	0.623	0.607
F_5	0.700	0.727	0.713	0.727	0.743	0.735
Mean	0.543	0.565		0.561	0.606	
L.S.D at 0.05 for	A= 0.002 B= 0.003 AXB= 0.004			A= 0.002 B=0.003 AXB=0.004		

F_1:Control, F_2: Licorice at 100 %, F3: Licorice at 50 %, F4: Aloe at 100 %, F5: Aloe at 50%.

Table 11. GLC analysis for the essential oil of *Thymus vulgaris*, L. plants as affected by the planting distances (30*30), and some natural plant extracts and fertilizations and their interaction in the second cut of the second season.

Tre. No. / Component	F1	F2	F3	F4	F5
α-Thujene	5.110	5.950	5.097	6.055	4.048
α- pinene	2.465	2.189	2.017	4.230	1.841
Camphene	3.065	3.167	3.385	3.361	3.327
Sabinene	5.490	3.799	5.758	2.164	3.289
β- Cymene	32.515	31.964	34.658	35.403	38.270
Linalool	1.789	1.758	1.930	1.961	1.700
γ-Terpinene	1.855	1.964	1.793	2.069	2.291
Terpinenolene	5.636	5.437	5.046	4.831	5.827
Borneol	7.801	9.931	10.612	9.959	1.852
Bornyl acetate	3.835	3.993	4.492	4.057	2.388
Thymol	16.178	17.431	20.796	19.525	24.229
Carvacrol	3.521	4.726	3.845	3.871	3.657
Total					

F_1:Control, F_2: Licorice at 100 %, F3: Licorice at 50 %, F4: Aloe at 100 %, F5: Aloe at 50%.

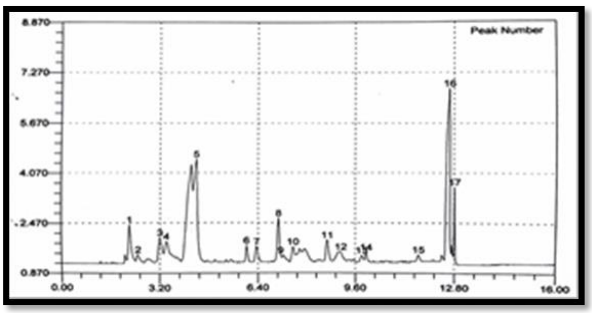

Fig. 1. Chromatogram of thyme (*Thymus vulgaris*, L.) essential oils distilled from F5 (Alovera50) on planting distance 30*30cm in the 2nd cut and 2nd

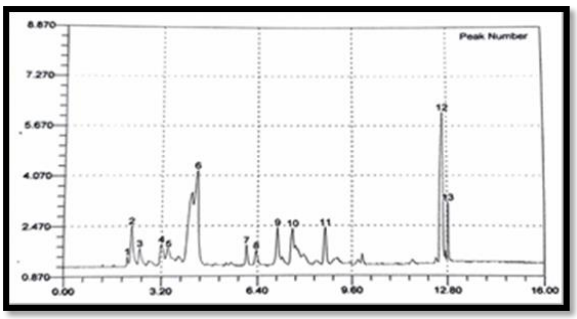

Fig. 2. Chromatogram of thyme (*Thymus vulgaris*, L.) essential oils distilled from F3 (Liquorices50) on planting distance 30*30cm in the 2nd cut and 2nd

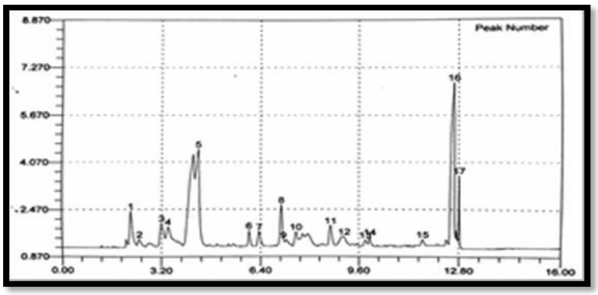

Fig. 3. Chromatogram of thyme (*Thymus vulgaris*, L.) essential oils distilled from F4 (Alovera100) on planting distance 30*30cm in the 2nd cut and 2nd

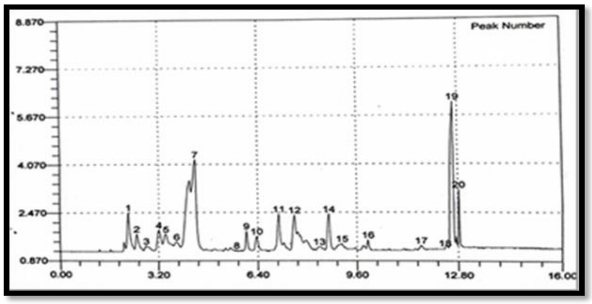

Fig. 4. Chromatogram of thyme (*Thymus vulgaris*, L.) essential oils distilled from F2 (Liquorices100) on planting distance 30*30cm in the 2nd cut and 2nd

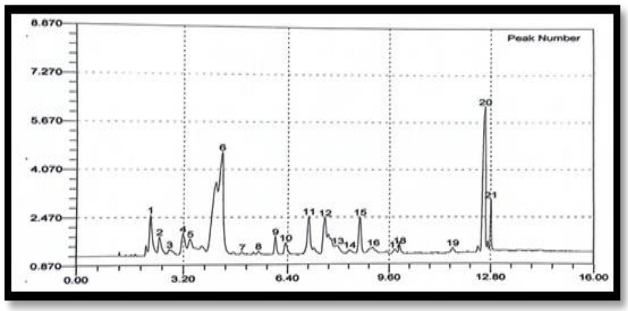

Fig. 5. Chromatogram of thyme (*Thymus vulgaris*, L.) essential oils distilled from F1 (control) on planting distance 30*30cm in the 2nd cut and 2nd

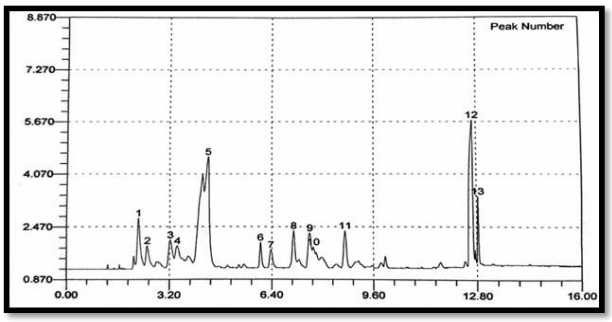

Fig. 7. Chromatogram of thyme (*Thymus vulgaris*, L.) essential oils distilled from F3 (Liquorices50) on planting distance 20*20cm in the 2nd cut and 2nd

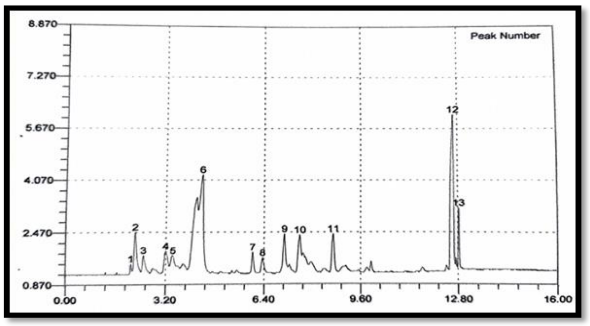

Fig. 6. Chromatogram of thyme (*Thymus vulgaris*, L.) essential oils distilled from F5 (Alovera50) on planting distance 20*20cm in the 2nd cut and 2nd

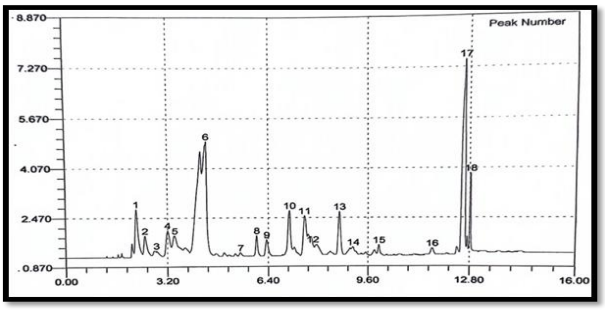

Fig. 8. Chromatogram of thyme (*Thymus vulgaris*, L.) essential oils distilled from F4 (Alovera100) on planting distance 20*20cm in the 2nd cut and 2nd

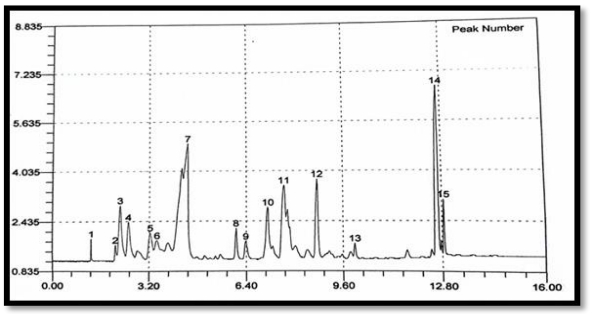

Fig. 9. Chromatogram of thyme (Thymus vulgaris, L.) essential oils distilled from F2 (Liquorices100) on planting distance 20*20cm in the 2nd cut and 2nd

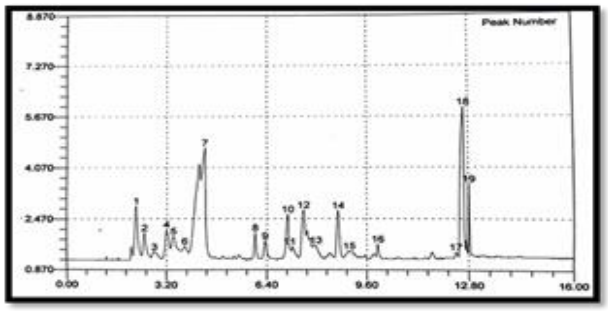

Fig. 10. Chromatogram of thyme (Thymus vulgaris, L.) essential oils distilled from F1 (control) on planting distance 20*20cm in the 2nd cut and 2nd

Table 12. GLC analysis for the essential oil of *Thymus vulgaris*, L. plants as affected by the planting distances (20*20), some natural plant extracts and fertilizations and their interaction in the second cut of the second season.

Tre. No. Component	F1	F2	F3	F4	F5
α-Thujene	5.733	6.045	5.693	5.262	5.553
α- pinene	2.840	4.009	2.444	2.237	2.313
Camphene	3.355	2.789	3.102	3.004	3.845
Sabinene	4.140	1.436	2.167	5.698	2.355
β- Cymene	32.094	29.572	36.976	32.856	39.643
Linalool	1.974	2.149	1.890	1.466	2.325
γ-Terpinene	2.001	1.657	1.867	1.686	2.126
Terpinenolene	3.912	6.427	5.463	5.373	5.011
Borneol	8.229	16.722	10.685	6.920	3.673
Bornyl acetate	4.014	6.998	6.562	4.333	6.508
Thymol	15.978	17.040	19.081	17.323	21.592
Carvacrol	3.638	2.404	3.198	4.400	4.091

Conclusively, its better to apply the planting distance at (30*30cm) and F_5 (Aloe extract at 50%), for enhancing for enhancing all studied traits of thyme plant.

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تأثير مسافات الزراعة والمستخلصات النباتية على النمو الخضري و المكونات الكيميائية وانتاجية الزيت العطري لنبات الزعتر

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الملخص

يعتبر الزعتر نباتًا بريًا مهمًا صالحًا للأكل تمت دراسته لعدة قرون لأهميته الفريدة في صناعة الأغذية والأدوية ومستحضرات التجميل. أجريت هذه الدراسة خلال موسمي٢٠١٧ و ٢٠١٨ في المزرعة التجريبية بقسم البساتين -بكلية الزراعة - جامعة بنها لدراسة تأثير الزراعة بمسافات مختلفة (٢٠ * ٢٠ سم و ٣٠ * ٣٠ سم) والمستخلصات النباتية (مستخلص عرق السوس والصبار) على النمو وانتاجية الزيت لنبات الزعتر. أظهرت النتائج ان معاملة التفاعل بين مسافات الزراعة (٢٠ * ٢٠) سم و F5 (مستخلص الصبار ٥٠٪) ، متبوعة بترتيب تنازلي بالمعاملة المشتركة بين مسافات الزراعة (٢٠ * ٢٠ سم) و F3 (مستخلص عرق السوس ٥٠٪) في كلا الحشتين والموسمين. علاوة على ذلك ، فإن الجمع بين مسافات الزراعة ومعاملات التسميد يعزز التقديرات الكيميائية خاصة مسافة الزراعة (٣٠ * ٣٠ سم) و F3 (عرق السوس ٥٠٪) في معظم الحالات. تمت زيادة نسبة الزيوت العطرية لنبات الزعتر باستخدام معاملة التفاعل لمسافات الزراعة (٣٠ * ٣٠ سم) و F5 (الصبار ٥٠٪). اشتمل تحليل GLC للزعتر على ١٢ مركبًا و المكون الرئيسي كان β-Cymene. وبالتالي يفضل تطبيق مسافة الزراعة (٣٠ * ٣٠ سم) و F5 (مستخلص الصبار ٥٠٪) لتعزيز النمو في نبات الزعتر