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RESPONSE OF SPEARMINT (*Mentha viridis* L.) AND GERANIUM (*Pelargonium graveolens l herit, ait*) PLANTS TO DIFFERENT WEED CONTROL PRACTICES

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ABSTRACT

Four field experiments were conducted at the experimental farm of Medicinal and Aromatic Plants Research Department, El-kanater El-khairia Qalubia Governorate and Horticulture Res. Institute, Agric., Res., Center, Giza, Egypt, during two successive seasons (2014-2015 and 2015-2016) including two studies on controlling weeds in spearmint and geranium plants. The objective of this work was to determine the efficacy of some weed control treatments (herbicides and physical methods) on weed control and yield productivity and quality of spearmint (*Mentha viridis* L.) and geranium (*Pelargonium graveolens* L. *Herit Ait.*) plants. The first study aimed to determine the effect of six weed control treatments (Anmex, 2.5 L/fed. stomp, 1.7 L/Fed. Roal, 750 cm^3/Fed. ,Select super, 0.5 L/Fed., hand hoeing and control treatment (untrested) on weeds and spearmint yield's components (herb fresh and oil).

The results showed that the density of broad weeds in the standard treatment was estimated as 0.97 & 0.45 Ton/Fed. while the annual density of weeds was 0.43 & 0.24 Ton/Fed. in the two seasons of 2014 & 2015 respectively , the best treatments for weed control were under the conditions of the experiment , the Stomp extra with a rate of 1.7 L/Fed. where the least dry weight was given to broad grass and narrow leaves , all with an increase in vegetative growth (plant high – number of branches- fresh weight and the oil yield of spearmint plant), also the treatment resulted from a Roal of 750 cm^3/Fed. gave the highest percentage in the compound Carvone in spearmint oil . In the second study six weed control treatments were conducted in the Geranium yield : Stomp extra with a rate 1.7 L/Fed. , Roal at 750 cm^3/Fed. and Select super at 0.5 L/Fed. coverage with black plastic , three times hand hoeing and control treatment (untreated treatment) to study their effected on weeds and vegetative growth (plant height – number of branches – fresh weight and percentage of volatile oil components) .The results indicted that the density of broad weeds in the standard treatment was estimated at 0.75 & 0.70 Ton/Fed., while the annual density of weeds was 0.43 & 0.3 Ton/Fed. for the two seasons 2014/2015 and 2015/2016 respectively and the addition of Stomp extra by 1.7 L/Fed. casued reduction in the dry weight of the annual grass and the highest values in the vegetative growth and oil yield , while the treatment with a Roal of 750 cm3/Fed. was the highest percentage in the compound Geraniol the main compound of the oil of Geranium. By analyzing the Spearmint and Geranium plants there was no residual effect of herbicides under the two studies . The economic analysis indicated that the economic feasibility of these treatments in terms of expected returns and farmers revenue by the Egyptian pounds.From the results it could be concluded that by using Stomp extra at 1.7 L/Fed. in controlling the annual weeds in Spearmint and Geranium plants , it gave the highest value in oil yield and vegetative growth and no residues were detected in fresh herbs of Spearmint and Geranium and also mulching with black plastic sheets as a natural substitutes for weed control instead of the herbicides.

Key words: *Controlling weeds,(Spearmint & Geranium) plants, herbicides, residual.*

1. INTRODUCTION

Spearmint and geranium are considered as two of the most important medicinal and aromatic plants grown in Egypt for local consumption processing and exportation . In 2015, the cultivated area of spearmint and geranium reached 6448 and 4880 faddans producing an average of 20.63 and 21.37 ton of herbs/faddan, respectively (Egyptian Ministry of

Agric, 2015). The demand and production for medicinal plants as natural products and recombinant proteins for medicinal purpose have substantially increased in the world market over the last decades. (Anonymous, 2012). These herbal plants are very weak competitors to weeds and there is a need to control these weeds by physical or mechanical methods to be free of herbicides residues. Among selective herbicides that can be used in these two crops are oxyfluorfen as pre-emergence (pre-em) herbicide. It gives very good weed control and when followed later in the season by sethoxydim or fluazifop-butyl also gives excellent weed control up to harvest. Meanwhile oxyfluorfen when applied as emergence, it causes phytotoxicty and becomes more so when applied as post-em. In spearmint, oxyfluorfen at 1 lb *a.i.*/acre, applied during the dormant period, was well tolerated during the growing seasons (Romanowski *et al.*, 1980). Pendimethalin at 4.0 1/ha, metolachlor at 1.0 1/ha and oxadiargyl at 0.5 kg/ha effectively controlled the weeds with no adverse effect on the raspberry plants (Rankova and Koumanov, 2004). The use of natural method by soil mulching as application of paddy straw mulch increased the herb and essential oil yields in geranium by 23% and 27% respectively, over the unmulched control at planted crops harvest (Muni and Roy,2003). Unrestricted weed growth significantly reduced geranium oil yield, by 61.6 and 70.6% in 1999 and 2000, respectively. Pre-emergence application of pendimethalin (0.75-1.00 kg/ha) or oxyfluorfen (0.25 kg/ha), successive hand-weeding, hoeing, and mulching and three hand-weeding were highly effective in reducing weed density and dry weight and gave oil yield comparable to the weed-free check. Application of oxyfluorfen (0.15 or 0.20 kg/ha) and pendimethalin (0.50 kg/ha) were less effective in controlling the weed species in geranium (Kothari *et al.*, 2002). Mulch removal in May and July led to a significant increase of summer annual weeds, especially *Cyperus sp.* and *lindernia sp* (Mineta *et al.*, 1997). Successful control of weeds with terbacil when used as a pre-emergence herbicide in Japanese mint. Wallia *et al.*, (1980) and Katoch *et al.*, 1982 observed that terbacil at 1.5 kg product/ha pre-emergence, effectively controlled both the dicot and monocot weeds in the first harvest, but thereafter weeding at 40 days intervals was most effective for yield and herb oil. Bernsier and Gallotte, (1989) reported that terbacil and bentazon are registered for pre-emergent and post-emergent use, respectively, on both Peppermint and spearmint in the USA.(El-Masry *et al.*, (1989) reported no change in oil composition after the post-emergence application of bentazon and graminol. On the other hand, literature on weed control in medicinal plants is found very scarcely. Currently, there are no recommended herbicides nor alternative physical methods to overcome the common weeds associated with spearmint and geranium. Thus the aim of the present study was to evaluate some promising herbicides and physical methods for controling weeds and to increase the quality and quantity of these medicinal and aromatic plants.

2. MATERIALS AND METHODS

Four field experiments were carried out in clay soil at the experimental farm of Medicinal and Aromatic Plants Research Department, Horticulture Research Institute, Agriculture Research Center, El-Kanater El-Khiria, Qalubia Governorate, Egypt during the period from 2014 to 2016 seasons. The objective of the study was to evaluate weed control treatments on the productivity and quality of spearmint (1^{st} and 2^{nd} experiments) and geranium (3^{rd} and 4^{th} experiments).

The main experiment and the chemical properties of the tested soil were determined according to Jackson (1967) and Piper (1950) and presented in Table (1).

Each experiment of spearmint consisted of six weed control treatments as follows:

1- Oxyfluorfen (2-chloro -1- (3- ethoxy -4- nitrophenooxy) 4- (trifluoromethyl) benzene known commercially as Roal 24% EC, was applied at 750cm^3 liter/fed. as pre-transplanting.
2- Clethodim (≠) -2- [1-(ethoxyimino) butyl] -5- [2-(ethylthio) propyl] -3-hydroxy -2-cyclohexen -1- one (i)e, known commercially as Select super 12.5% EC, was applied at 500 cm3 liter/fed. after one month from transplanting.

Table (1): Physical and chemical analyses of the soil of spearmint and geranium experiments at (0-30 cm.) depth in 2014 season.

Particle size distribution										
Sand %		Silt %		Clay %		Soil Texture		Organic matter %		
29.2		16.5		54..3		Clay		2.1		
Soluble ions (mmolc L^{-1})										
SO_4^{2-}	Cl^-	HCO^{3-}	CO_3^{2-}	K^+	Na^+	Mg^{2+}	Ca^{2+}	Ec; ds/m	pH (1:2.5)	$CaCO_3$
43.2	7.25	0.55	**0.00**	3.00	8.2	14.1	25.7	4.8	8.01	3.56

3-Pendimethalin (N-(1-ethylpropyl)-3,4 dimethyl-2,6-dinitrobenzenamin) known commercially as Stomp extra 45.5% CS was applied at rate 1.7 liter/fed. as pre-transplanting.

4-Butralin(4-(1,1-dimethylethyl)-N-(1-methylpropyl) -2,6-dinitrobenzenamin) known commercially as Amex 48% EC was applied at rate 2.5 liter/fed. as pre-transplanting for first and second experiments (spearmint).

5- Hand hoeing three times with 15 days intervals, which begins after one month from transplanting.

6- Unweeded check (control)

In the first season (2014-2015), spearmint cuttings were planted on March 24th and spaced at 25cm. The plants were harvested on July 7th and October 15th for the first and second cuts, respectively.

In the second season (2015-2016), spearmint was planted on March 30th and the plants were harvested on July 7th and October 8th for the first and second cuts, respectively.

2.1. geranium experiments

Each experiment of geranium consisted of six weed control treatments as follows:

1- Oxyfluorfen, commercially known as Roal 24% EC, was applied at 750 cm^3 liter/fed. as pre-transplanting.

2- Clethodim, commercially known as Select super 12.5% EC, was applied at 500 cm^3 liter/fed. after one month from transplanting.

3- Pendimethalin, commercially known as Stomp extra 45.5% CS applied at rate 1.7 liter/fed. as pre-transplanting.

4- Mulching with one layer of black plastic sheets 80 U diameter.

5- Hand hoeing three times with 15 days intervals, beginning 1 month after transplanting.

6- Unweeded check (control).

In the first season (2014-2015), terminal cuttings of geranium were planted on November 11th and spaced at 25cm. The plants were harvested on May 16th and October 4th for the first and second cuts, respectively.

In the second season, geranium cuttings were transplanted on November 10th. The plants were harvested on May 20th and October 4th for the first and second cuts, respectively.

The treatments of spearmint and geranium experiments were arranged in a randomized complete block design with four replicate according to Gomez and Gomez (1984). The plot area was 10.5 m^2 (3.5m length × 3m width). The agriculture practices *i.e.,* fertilization; irrigations; pest and diseases control were managed in accordance with the local recommendation for both crops. The soil texture of the experiment sites was clay in these two field experiments. The collected data on the two crops were recorded as follows:

2.1.1.Weed characters

Weeds were hand pulled at random from one square meter from of all the plots of spearmint and geranium at 15 days from last treatment, classified into three categories (grassy, broad-leaved and total weeds) and dried in an oven at 70 °C until constant weight then the dried weeds were weighed. Weeds control was evaluated in the form of percentage reduction (R%) in the dry weight of each individual species of weeds as well as the total weeds. Percentage reduction (R%) was calculated according to Topps and Wain (1957) formula as R%= (A-B) / A*100

Where: A= the dry weight of weeds in the control.

B= the dry weight of weeds in the treated plot.

2.1.2.Growth characters and yield components

At the harvest time, samples of spearmint and geranium plants were randomly collected from each plot to study the following characters:

1- Plant height (cm).

2- Number of branches/plant.

3- Herb fresh weight (g/plant) of aerial parts.
4- Yield of fresh herb/fed. was calculated according to plant fresh weight for plant × 25000 (No. of plants/fed).
5- Volatile oil percentage was determined in fresh herb according to the British Pharmacopoeia (1963).
6- Volatile oil yield (ml/plant) = herb fresh weight per plant × oil % in fresh herb.
7- Oil yield/ fed. was calculated by multiplying oil yield g/plant × 25000 (No. of plants/fed.).

2.1.3 Oil constituents of spearmint and geranium

Oil samples of the two corps used in this investigation were obtained using steam distillation in the second cut of the second season (Guenther 1961) and analyzed using Gas liquid Chromatography(GLC), to determine their constituents according the methods described by Bunzen *et al.* (1969) and Hoftman (1967).

2.1.4. Herbicides residues

The herbicides residues of Amex, Stomp, Roal and Select super in fresh herb were analyzed by GLC according to Nguyen *et.al.* (2008).

2.1.5. Economic feasibility of weed control in both crops (spearmint and geranium)

Economic evaluation due to weed control treatments was calculated according to Heady and Dillon (1961) as follows :
Gross income = yield of oil/fed(kg) × price of kg oil.
Gross margin = gross income – total cost.
Benefit / cost ratio = gross income / total cost.

2.1.6.Statistical analysis:

Mean values of each experiment were subject to the analysis of variance to test the significance as described by Gomez and Gomez (1984). Duncan means separation test and correlation were detected by using Mstat C ver.4 software.

3. RESULTS AND DISCUSSIONS

3.1. Effect of weed control treatments on weeds and spearmint yield and its components.

3.1.1. On weeds

The existed weed flora species in the experimental field during 2014 and 2015 seasons were *Amaranthus viridis, Partulaca olracea, Bidens bipinnata, Ammi majus, Capsella bursa-pastoris, Euphorbia geniculate* and *Rumex dentatus* as annual broad leaf weeds with infestation rates 0.97 and 0.45 ton dry weight ./fed in the first and the second seasons, respectively and *Seratia viridis, Digitatria sanguinalis. Echinochloa colonum* and *Phalris minor* as annual grassy weeds with infestations rates 0.43 and 0.24 ton dry weight ./fed. in both seasons, respectively.

Results in Table (2) showed significant decreases in the dry weight of the two categories of annual weeds as mentioned above by all weed control treatments in both seasons. The effectiveness of the weed control treatments on reducing the dry weight of the broadleaf weed, grassy weeds and their total could be arranged in a descending order as follows: Stomp at 1.7 l/fed by 93.9, 89.9 and 92.7%, respectively; Amex at 2, .5 l/fed by 93.9, 89.5 92.6%, respectively; Roal at 750 cm^3/fed by 93.4, 89.2 and 92.1%,

Table (2): Effect of weed control treatments on dry weight of grassy, broad leaf and their total g/m^2 during 2014 and 2015 seasons.

Seasons	2014						2015					
Weed control treatments Rate/fed	The dry weight of the annual weeds (g/m)						The dry weight of the annual weeds (g/m)					
	Grassy weeds	Reduction %	Broad leaf weeds	Reduction %	Total Weeds	Reduction %	Grassy weeds	Reduction %	Broad leaf weeds	Reduction %	Total Weeds	Reduction %
Roal at 750 cm^3	11.0b	89.2	15.3b	93.4	26.3c	92.1	5.3bc	90.8	8.7b	91.8	14.0e	91.4
Select at 500 cm^3	5.7c	94.4	225.3a	0.03	231.0b	30.7	4.7c	91.9	99.0a	0.07	103.7b	36.8
Stomp at 1.7 l	10.3b	89.9	14.0b	93.9	24.3c	92.7	4.7c	91.9	8.7b	91.8	13.4c	91.9
Amex at 2.5 l	10.7b	89.5	14.0b	93.9	24.7c	92.6	5.3bc	90.8	8.3b	92.2	13.6c	91.7
Hoeing three times	11.3b	88.9	16.0b	93.1	27.3c	91.8	5.7b	90.2	9.7b	90.9	15.4c	90.7
Control	102.0a	-	231.3a	-	333.3a	-	57.7a	-	106.3a	-	164.0a	-

respectively; hand hoeing at three times by 93.1, 88.9 and 91, 3.7%, respectively, and Select at 500 cm^3/fed by 0.03, 94.4 and 30.7%, respectively, compared to the untreated check in the first season. Similar results were obtained in the second season. Where the dry weight of broadleaf weeds, grasses and their total reached 91.8, 91.9 and 91.9%, respectively, by Stomp extra at 1.7 l/fed.; 92.2, 90.8 and 91.7% respectively by Amex at 2.5 l/fed.; 91.8, 90.8 and 91.4 respectively, by Roal at 750 cm^3/fed.; 90.9, 90.2 and 90.7%, respectively, by hand hoeing at three times and 0.07, 91.9 and 36.8%, respectively, by Select super at 500 cm^3/fed. Compared to the untreated control. Romanowski *et al.* (1980) found that Pendimethalin at 4.0 l/ha effectively controlled weeds without adverse effect on the raspberry plants.

3.1.2.Growth characters and yield of spearmint.

The growth of spearmint plants positively responded to weed control treatments. Thus, the values of plants height (cm), branches No. and fresh weight (gm/plant) increased due to weed control treatments (Table 3). The highest increase in this respect was noticed in the case of Stomp at 1.7 l/fed. where the values were 58.3, 50.0cm, 20.0, 18.3 branches/plant, 193.6, 172.6gm/plant, 4.84 and 4.32 ton/fed. for plant height, branches No., fresh weight gm/plant and herb yield ton/fed in the 1^{st} and 2^{nd} cut for the first season respectively, the highest response of spearmint growth after Stomp application was followed by Roal at 750 cm^3/fed. On the other hand, the least growth was in the case of the control plants (untreated with any weed control method).

The same trend was evident in the 2^{nd} season as indicated in (Table) 3. The application of Stomp at 1.7 l/fed gave the best result for spearmint growth. In the 1^{st} and the 2^{nd} cut in the second season. This treatment induced the highest growth in terms of plant height,branches No.,fresh weight gm/plant and yield of fresh herb/fed.

The values were 86.3, 67cm, 19.7, 18.7 branches/plant, 294, 271 gm/plant, 7.35 and 6.80 ton/fed for the 1^{st} and the 2^{nd} cut respectively. Also, the annual herb yield recorded the highest values in this respect 9.16 and 14.15 ton/fed in the 1^{st} and the 2^{nd} season respectively.

As indicated previously in the 1^{st} season, Roal also gave high response followed the Stomp treatment with regard the spearmint growth. The recorded values were 84, 63.3cm, 17.7, 16.3 branches/plant, 272, 256 gm/plant, 6.80 and 6.40 ton/fed. In the 1^{st} and the 2^{nd} cut respectively, Also, the control (untreated plants) gave the least growth as tabulated in (Table 3).

3.2.3. Essential oil of spearmint

It was noticed that spearmint essential oil production was enhanced by weed control treatments (Table) 4. This enhancement hold true in the two seasons. Stomp application was found to be the effective treatment in this respect. So, the values of the essential oil content (%), yield (ml/plant), and yield oil l/fed. recorded a significant increase due to Stomp application, in comparison with the untreated plants (control). The recorded values of Stomp treatment in the 1^{st} and the 2^{nd} cut in the first season were0.45,0.33%,0.87,0.56ml/plant, 21.75 and 14 l/fed.

The results of the 1^{st} season were confirmed in the 2^{nd} season. Accordingly, Stomp treatment gave the best results in the 1^{st} and the 2^{nd} cut as shown in Table (4). The highest essential oil content, oil yield ml/plant and yield per fed. were recorded in case of Stomp treatment. The values were 0.37, 0.29%, 1.1, 0.79 ml/plant, 27.50 and 19.75 l/fed. The annual yield of essential oil of spearmint plants showed the same trend *i.e.* Stomp treatment producted the highest oil yield in the two seasons 35.75 and 47.25 L/fed., respectively.

The least record was obtained in the case of the control plants.

3.1.4. Chemical composition of spearmint essential oil

Volatile oil samples were taken from the oil obtained in the 2^{nd} cut of the second season and analyzed using gas liquid chromatography (GLC), to determine the oil components *i.e.* α, β-pinene, Limonene, Cymene, Cineol, Terpinene, Carvone, β-caryophyllene an Eugenol, as shown in Table (5) and Figs (1-6). Actually, Carvone was the main component of spearmint essential oil, its presence in the oil is Limonene dependent, so the obtained results showed that the application of Roal at 750 cm^3/fed. gave the highest percentage of Carvone (71.22 %) while Limonene was absent. On the other hand the lowest percentage of Carvone(49.08 %) was obtained in case of Amex at 2.5 l/fed. whereas, the Limonene content attained(10.52 %) due to this treatment.

3.1.5. Residues analysis

From Figs (7-14) and Table (6) the Gas Liquid Chromatography showed no signal to the

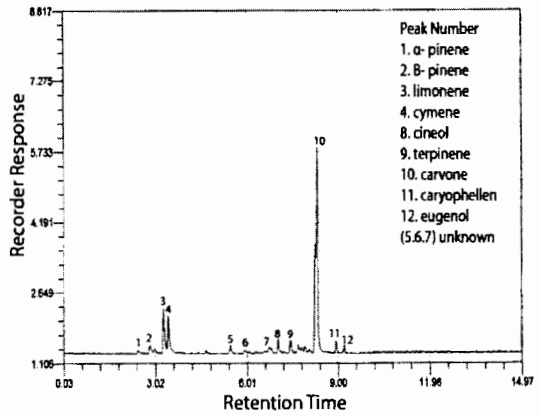

Fig 1: Chromatogram of Spearmint essential oil (control)

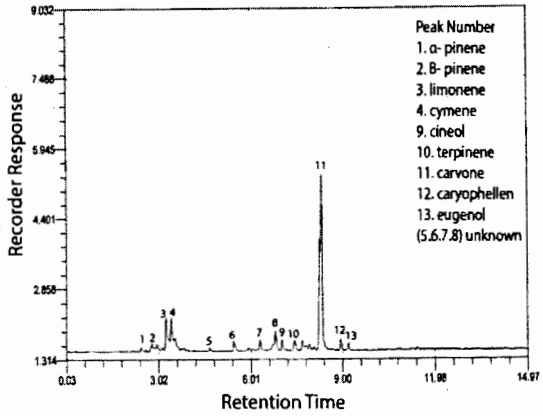

Fig 2: Chromatogram of Spearmint essential oil (Hoeing three times)

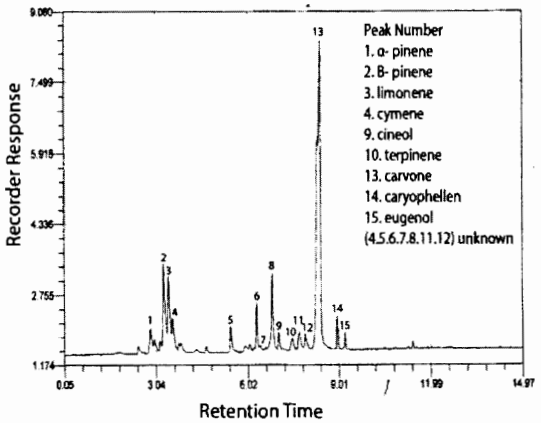

Fig 3: Chromatogram of Spearmint essential oil (Roal a 750 cm^3)

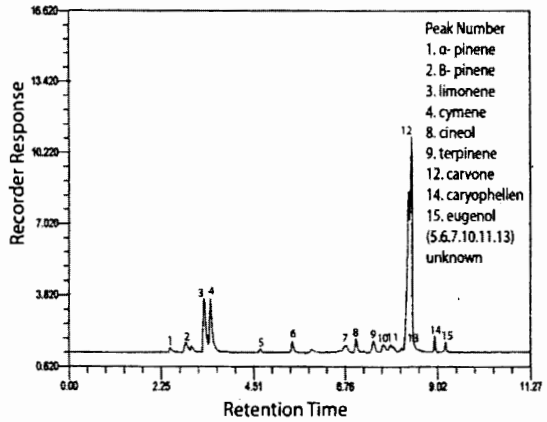

Fig 4: GLC (Amex at 2.51/fed)

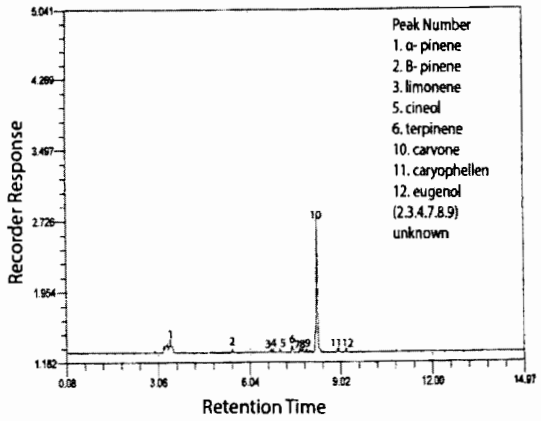

Fig 5: (Stomp at 1.7 l/fed)

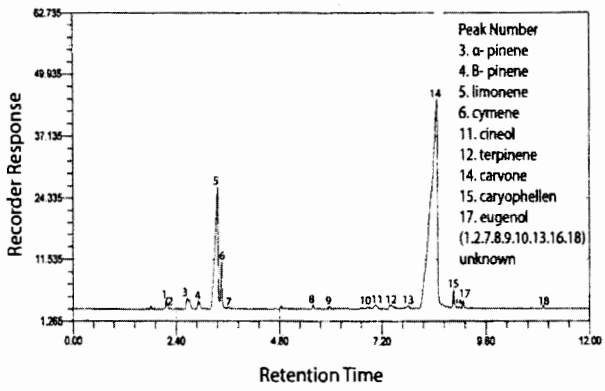

Fig 6: (Select super at 500 cm^3)

Table (3): Effect of weed control treatments on growth characters and yield of spearmint during 2014-2015 and 2015-2016.

Characteristics / Weed Control Treatments rate/fed	2014-2015 Season									
	Plant height (cm)		No. of branches/plant		Herb fresh yield gm/plant			Herbage yield fed. (ton/fed)		
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	Total	1st cut	2nd cut	Total
Roal at 750 cm^3	52.0b	48.0d	17.7b	16.7c	173.7b	155.5b	329.2b	4.34b	3.89a	8.19b
Select super at 500 cm^3	43.7c	36.7e	17.3c	14.0d	56.0e	53.7d	109.7e	1.40e	1.34c	2.74e
Stomp at 1.7 l	58.3a	50.0a	20.0a	18.3a	193.6a	172.6a	366.2a	4.84a	4.32a	9.16a
Amex at 2.5 l	50.7b	46.0b	18.7b	17.0b	117.6d	114.4c	232.0c	2.94d	2.86b	5.80d
Hoeing three times	50.0b	43.0c	16.7c	15.7c	125.7c	117.3c	243.0d	3.14c	2.93b	6.07c
Control	35.0d	33.0f	13.0d	12.7e	33.0f	30.1e	63.1f	0.83f	0.75d	1.64f
	2015-2016 season									
Roal at 750 cm^3	84.0b	63.3b	17.7bc	16.3b	272.0b	256.1b	528.1b	6.80b	6.40b	13.2b
Select super at 500 cm^3	72.0d	56.3d	18.0b	13.3d	239.1e	196.8e	435.9e	5.98e	4.92e	10.9e
Stomp at 1.7 l	86.3a	67.0a	19.7a	18.7a	294.1a	271.9a	566.0a	7.35a	6.80a	14.15a
Amex at 2.5 l	83.3b	61.3c	18.0b	14.0c	247.0d	238.6c	485.6c	6.18d	5.97c	12.15c
Hoenig three times	78.0c	58.0d	17.0c	13.3d	262.5c	200.9d	463.4d	6.56c	5.02d	11.58d
Control	50.7d	40.3e	10.3d	10.0e	45.5f	43.7f	89.2f	1.11f	1.05f	2.16f

Table (4): Effect of weed control treatments on essential oil of spearmint during 2014 and 2015 seasons.

Characteristics / Weed Control Treatments rate/fed	2014-2015 Season							
	Volatile oil %		Volatile oil yield (ml/plant)			yield oil (l/fed)		
	1st cut	2nd cut	1st cut	2nd cut	Total	1st cut	2nd cut	Total
Roal at 750 cm^3	0.33b	0.3a	0.57b	0.47b	1.04b	14.25b	10.0b	26.0b
Select super at 500 cm^3	0.33b	0.3b	0.18d	0.17d	0.35d	4.58d	4.25d	8.75d
Stomp at 1.7 l	0.45a	0.33a	0.87a	0.56a	1.43a	21.75a	14.0a	35.75a
Amex at 2.5 l	0.32bc	0.27c	0.38c	0.31b	0.69c	9.5c	7.75c	17.25c
Hoeing three times	0.31c	0.25c	0.39c	0.29c	0.68c	9.75c	7.25c	17.0c
Control	0.29d	0.25c	0.09e	0.07d	016e	2.25e	1.75e	4.0e
	2015-2016 season							
Roal at 750 cm^3	0.35a	0.29a	0.96b	0.75a	1.71b	24.00b	18.75a	42.75b
Select super at 500 cm^3	0.33b	0.24b	0.79d	0.49c	1.28d	19.75d	12.25c	32.00e
Stomp at 1.7 l	0.37a	0.29a	1.1a	0.79a	1.89a	27.50a	19.75a	47.25a
Amex at 2.5 l	0.37a	0.29a	0.9bc	0.68b	1.58c	22.50c	17.00b	39.50c
Hoenig three times	0.33b	0.25b	0.88c	0.50c	1.38d	22.00c	12.50c	34.50d
Control	0.29c	0.21c	0.10e	0.08d	0.18e	2.5e	2.00d	4.5f

four herbicides used (not detected). These four herbicides (Butralin, Pendimethalin, Oxyfluorfen and Clethodim) were degraded in the spearmint plants and the GLC coul not read any values. The residues level of the four herbicides depended on the nature of plant . Moreover, some herbicides were rapidly degraded in the open field by sunlight and its stability in the soil having many species of microorganisms and different levels of acidity and alkalinity in addition the hoeing of of the soil.

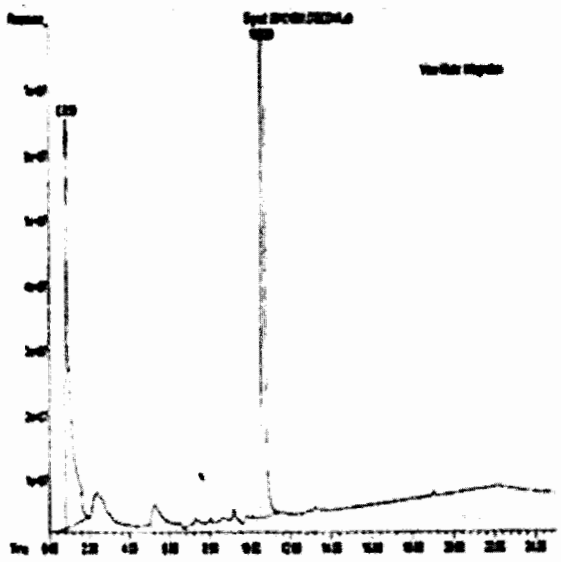

Fig (7) : **Standard of Stomp extra**

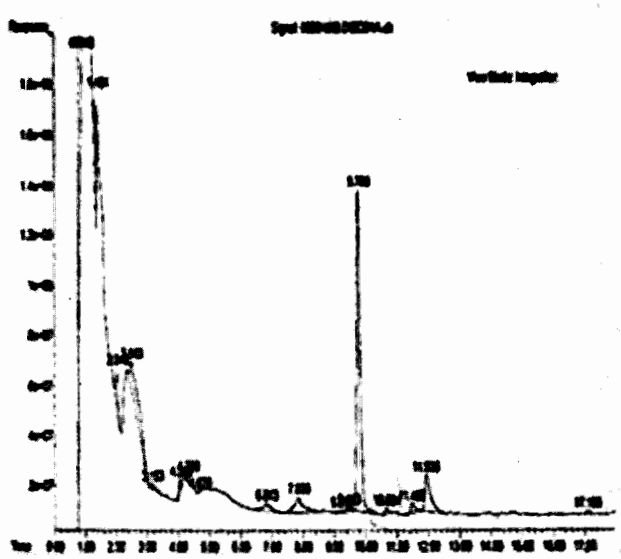

Fig (8) : **Residual of Stomp extra in spearmint**

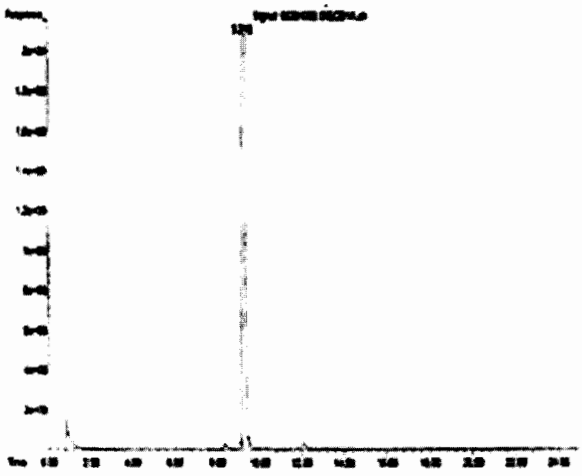

Fig (9): **Standard of Amex**

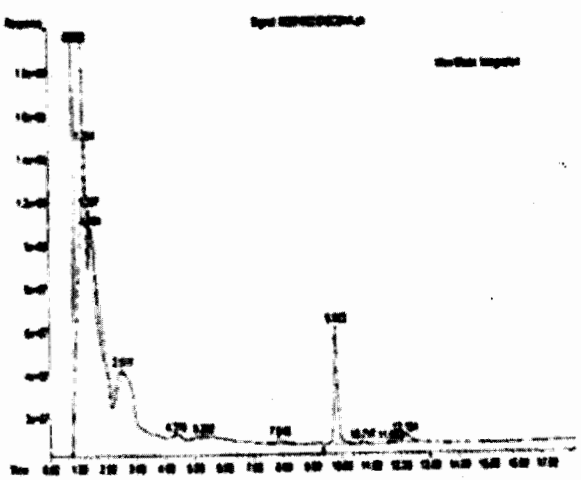

Fig (10): **Residual of Amex in spearmint**

Table (5): Chemical composition of oil in spearmint as affected by weed control treatments.

Weed Control Treatments rate/fed	α-pinene	β-pinene	Limonene	Cymene	Cineol	Terpinene	Carvone	β- caryophyllene	Eugenol
Roal at 750 cm^3	-	-	-	0.49	4.73	4.78	71.22	2.63	2.54
Select super at 500 cm^3	1.78	0.92	18.35	3.48	0.66	0.81	69.52	1.39	0.64
Stomp at 1.7 l	0.95	3.52	10.32	11.11	2.71	2.43	55.7	1.61	1.27
Amex at 2.5 l	-	4.38	10.52	6.7	1.48	1.55	49.08	2.28	1.14
Hoeing three times	0.95	3.47	7.85	14.04	5.97	2.59	52.33	2.3	2.45
Control	0.85	3.48	9.49	9.68	3.16	9	53.57	2.29	2.02

Table (6): Calibration of butralin, pendimethalin, and Oxyfluorfen and Clethodim parameters:

Herbicides name	Residual (ppm)	Max. Residue Level [mg/kg]
Pendimethalin	ND	0.005
Butralin	ND	0.02
Oxyflorfen	ND	0.3
Clethodim	ND	0.02

ND = Not detected

3.1.6. Determination of economics for weed control in the spearmint plants

Data in Table (7) show that the total cost of the weeded check was3.59 and 3.70 thS L.E. in 2014 and 2015 seasons, respectively, which is considered the fixed cost (land preparation, transplantation fertilization irrigation, insect control, harvesting and transportation) , in addition; to the cost of the treatments on the others. In both seasons, Stomp at 1.7 l/fed. gave the highest values of gross income, net benefit and the percentage of benefit/cost by 17.88 & 14.03 thS LE and 4.69% and 23.63 & 19.67 thS LE and 5.97% respectively, in the first and second seasons Roal at 750 cm^3/fed. was the following treatment which increasing the respective previous economic values by 13.1 & 9.41 thS and 3.58% and 21.38 & 17.58 thS LE and 5.62%, respectively, in both seasons. Whilst, the rest treatments *i.e,* Amex at 2.5 l/fed. hand hoeing three times and Select super at 500 cm^3/fed. were still superior of the previous economic value compared to unweeded check.

Table (7): Determination of economics for weed control in the spearmint plants:

Seasons	2014-2015				2015-2016			
Weed control Treatments Rate/fed	Total cost Ths. L.E.	Gross income Ths L.E.	Net Benefit Ths L.E.	B/C	Total cost Ths. L.E.	Gross income Ths L.E.	Net Benefit Ths L.E.	B/C
Roal at 750 cm^3	3.69	13.1	9.41	3.58	3.8	21.38	17.58	5.62
Select super at 500 cm^3	3.72	4.38	0.66	1.18	3.83	16.0	12.17	4.18
Stomp at 1.7 l	3.85	17.88	14.03	4.69	3.96	23.63	19.67	5.97
Amex at 2.5 l	4.02	8.63	4.61	2.15	4.13	19.15	15.62	4.66
Hoeing three times	4.19	8.5	4.31	2.03	4.3	17.25	12.95	4.01
Control	3.59	2.00	-1.59	0.58	3.7	2.25	-1.45	0.61

3.2. Effect of weed control treatments on weeds and geranium yield and its components

3.2.1. On weeds

It is notable from the data in Table (8) that the infestation rate for the whole season recorded (0.43 and 0.75 ton/fed.) and (0.3 and 0.7 ton/fed.) of the dry weight for grasses, broad leaf weeds, respectively, in both seasons approximately. Table (8) shows the means of dry weight of grassy, broadleaved and total annual weeds as affected by different herbicides and hand hoeing compared with the untreated treatment in both seasons. All herbicidal treatments and hand hoeing gave high significant reduction percentage on the dry weight of presented weeds in both seasons. Stomp extra at rate of 1.7 l/fed. reduced broad leaf, grassy and their total by 95.0 & 94.5 and 92.7%, respectively. The following treatments in the highest increasing percentage the previous respective characteristics were Roal at 750 cm^3/fed. by 92.2 & 91.9 and 92.1%, respectively; Black plastic sheet by 90.4 & 88.7 and 89.8%, respectively; hand hoeing at three times by 89.1 & 87.7 and 88.6%, respectively, and Select super at 500 cm^3 26.1& 93.9 and 50.9%, respectively, compared to the untreated control in the first season. Similar results were obtained in the second season. The reduction in the dry wt. of broadleaf weeds, grasses and their total reached 94.6, 90.6 and 93.4%, respectively, by Stomp extra at 1.7l/fed.; 94.4 & 90.6 and 93.3%, respectively by Roal at 750 cm^3/fed.; 90.5 & 90.0 and 90.4, respectively, by black plastic sheet, 90.9 & 85 and 89.1%, respectively, by hand hoeing at three times and 12.9, 89.6 and 35.8%, respectively, by Select super at 500 cm^3/fed. compared to the untreated control. These results agree with (Kothari *et al.,* 2002) who found that pre emergence application of pendimethalin (0.75-1.00 kg/ha) or oxyfluorfen (0.25 kg/ha), successive hand-weeding, hoeing, and mulching and three hand-weeding were highly effective in reducing weed density and dry weight and pendimethalin (0.50 kg/ha) were

Table (8): Effect of weed control treatments in dry weight of grassy, broad leaf and total weed g/m^2 during 2014 and 2015 seasons.

Seasons	2014						2015					
Weed control treatments Rate/fed	The dry weight of the annual weeds (g/m)						The dry weight of the annual weeds (g/m)					
	Grassy weeds	Reduction %	Broad leaf weeds	Reduction %	Total Weeds	Reduction %	Grassy weeds	Reduction %	Broad leaf weeds	Reduction %	Total Weeds	Reduction %
Roal at 750 cm^3	8.3CD	91.9	14.0C	s92.2	22.3DE	92.1	6.7C	90.6	9.3C	94.4	16.0D	93.3
Select at 500 cm^3	6.3D	93.9	132.7B	26.1	139.0B	50.9	7.3C	89.6	146.0B	12.9	153.3B	35.8
Stomp at 1.7 l	5.7D	94.5	9.0C	95.0	14.7E	94.8	6.7C	90.6	9.0C	94.6	15.7D	93.4
Amex at 2.5 l	11.7BC	88.7	17.3C	90.4	29.0CD	89.8	7.0C	90.0	16.0C	90.5	23.0C	90.4
Hoeing three times	12.7B	87.7	19.7C	89.1	32.4C	88.6	10.7B	85.0	15.3C	90.9	26.0C	89.1
Control	103.3A	-	179.7A	-	283.0A	-	71.0 A	-	167.7A	-	238.7A	-

less effective in controlling the weed species in geranium. Mineta *et al.* (1997) reported that mulch removal in May and July led to a significant increase of summer annual weeds, especially Cyperus sp.

3.2.2. Growth characters and yield of geranium

The growth of geranium plants positively responded to weed control treatments. thus, the values of plant height (cm), branches No. and fresh weight (gm/plant) increased due to weed control treatments. The highest increase in this respect was noticed in case of Stomp at 1.7 l/fed. Table (9). The values were 105, 79.7 cm, 12,14.3 branches/plant, 393.7, 365 gm/plant, 9.85 and 9.12 ton/fed. for plant height, branches No., fresh weight gm/plant and herb yield ton/fed. in the 1st and the 2nd cut for the first season respectively. The highest response of geranium growth after Stomp application was followed by Roal at 750 cm^3/fed., on the other hand, the least growth was in the case of control plants (untreated with any weed control method).

The same trend was shown in the 2nd season as emphasized in Table (9). The application of Stomp at 1.7 l/fed. gave the best results for geranium growth, in the 1st and the 2nd cut in the second season.

This treatment induced the highest growth in term of plant height, branches No., fresh weight gm/plant and yield of fresh herb/fed.

The values were 99.3, 93.7 cm, 10, 9.7, branches/plant, 651, 533 gm/plant, 16.28 and 13.33 ton/fed. for the 1st and the 2nd cut respectively.

As indicated previously in the first season, Roal gave also high response followed the Stomp treatment with regard the geranium growth and yield. The recorded values were 93.7, 92 cm, 9, 8.7 branches/plant, 540, 475 gm/plant, 13.5 and 11.88 ton/fed. in the 1st and 2nd cut respectively.

The highest annual fresh herb yield was obtained from stomp treatments with values of 18.97 and 29.61 ton/fed in the 1st and the 2nd season respectively.

Also, the control (untreated plants) gave the lowest growth as Table (9).

3.3. Essential oil of geranium plants

It is noticed that, geranium essential oil production was enhanced by weed control treatments. This enhancement holds true in the two seasons. Stomp application was found to be the effective treatment in this respect. So, the values of essential oil content, yield (ml/plant) and yield oil l/fed. recorded a significant increase due to Stomp application in comparison with the untreated plants (control).

The recorded values of Stomp treatments in the 1st and the 2nd cut in the first season were 0.18, 0.19%, 0.73, 0.71 ml/plant, 18.25 and 17.75 l/fed.

The results of the first season were confirmed in the second season. Accordingly, Stomp treatments gave the best results in the 1st and the 2nd cut as shown in Table (10).

The highest essential oil content, oil yield ml/plant and yield per fed. were recorded in case of Stomp treatments. The values were 0.17, 0.17%, 0.97, 0.71 ml/plant, 24.25 and 17.75 l/fed. the least record was obtained in the case of control plants. Also, the highest annual yield per.

Table (9): Effect of weed control treatments on growth characters and yield of geranium during 2014/2015 and 2015/2016 seasons.

Characteristics / Weed Control Treatments rate/fed	2014/2015 season									
	Plant height (cm)		No. of branches/plant		Herb fresh yield gm/plant			Herbage yield fed. (ton/fed)		
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	Total	1st cut	2nd cut	Total
Roal at 750 cm^3	97.7b	73.7b	10.7ab	13.7ab	288.3b	265.6b	553.9b	7.21b	6.64b	13.85b
Select super at 500 cm^3	75.7d	61.7d	4.7c	11.0d	190.7e	167.7e	358.3e	4.77e	4.19e	8.96e
Stomp at 1.7 l	105.0a	79.7a	12.0a	14.3a	393.7a	365.0a	758.7a	9.85a	9.12a	18.97a
Black plastic sheet	79.0c	69.3c	9.0b	13.0b	265.3c	246.0c	511.3c	6.63c	6.15c	12.78c
Hoeing three times	77.3cd	62.3d	5.3c	12.0c	225.3d	196.3d	421.6d	5.63d	4.91d	10.54d
Control	75.3d	60.0e	8.0c	9.3e	150.0f	139.3f	289.3f	3.75f	3.48f	7.23f
	2015/2016 season									
Roal at 750 cm^3	93.7b	92.0ab	9.0b	8.7b	540.0b	475.0b	1015.0b	13.5b	11.88b	25.38b
Select super at 500 cm^3	87.3c	83.0c	7.3c	3.7d	246.3e	197.3e	443.6e	6.16e	4.93e	11.09e
Stomp at 1.7 l	99.3a.	93.7a	10.0a	9.7a	651.0a	533.3a	1184.3a	16.28a	13.33a	29.61a
Black plastic sheet	91.3b	90.3b	9.0b	8.3b	443.0c	397.0c	840.0c	11.08c	9.93c	21.01c
Hoeing three times	88.3c	84.3c	8.3b	7.0c	392.3d	323.0d	715.3d	9.81d	8.08d	17.89d
Control	55.0d	54.7d	4.7d	2.3e	158.0f	142.0f	300.0f	3.95f	3.55f	7.5f

Table (10): Effect of weed control treatments on essential oil of geranium during 2014 and 2015 seasons.

Characteristics / Weed Control Treatments rate/fed	season 2014/2015							
	Volatile oil %		Volatile oil yield (ml/plant)			yield oil (l/fed)		
	1st cut	2nd cut	1st cut	2nd cut	Total	1st cut	2nd cut	Total
Roal at 750 cm^3	0.17ab	0.23ab	0.49a	0.61b	1.07b	15.00b	12.00b	27.00b
Select super at 500 cm^3	0.15b	0.17d	0.29bc	0.3c	0.59d	7.25c	7.50c	14.75c
Stomp at 1.7 l	0.18a	0.19c	0.73a	0.71a	1.44a	18.25a	17.75a	36.00a
Black plastic sheet	0.17a	0.23ab	0.57a	0.46b	1.03bc	14.25b	11.50b	25.75b
Hoeing three times	0.15b	0.27a	0.52ab	0.35c	0.87c	13.08b	8.75d	21.75b
Control	0.13c	0.13e	0.18c	0.2d	0.38e	4.5c	5.00e	9.5d
	season 2015/2016							
Roal at 750 cm^3	0.17a	0.17ab	0.93a	0.81a	1.74a	23.25a	20.25a	43.5a
Select super at 500 cm^3	0.15a	0.13c	0.37c	0.26c	0.63c	9.25c	6.5c	15.75c
Stomp at 1.7 l	0.17a	0.17ab	0.97a	0.71a	1.68a	24.25a	17.75a	42.00a
Black plastic sheet	0.15a	0.15b	0.67b	0.61b	1.28b	16.75b	15.25b	32.00b
Hoeing three times	0.17a	0.17a	0.67b	0.56b	1.23b	16.75b	14.00b	30.75b
Control	0.15a	0.13c	0.2d	0.15d	0.35d	5.00c	3.75d	8.75d

Table (11): Chemical composition of geranium oil as affected by weed control treatments.

Weed Control Treatments rate/fed	α-pinene	p-cmene	Limonene	Linalool	Citronellol	Geranoil	Citroellyl gormate	Eugenol	β-caryphellen
Roal at 750 cm^3	3.36	3.05	5.74	6.3	21.89	38.27	10.66	2.38	1.48
Select super at 500 cm^3	3.42	4.4	5.26	7.47	21.23	34.6	10.09	2.75	2.66
Stomp at 1.7 l	3.47	3.11	5.8	6.08	22.95	35.92	10.92	2.66	2.15
Black plastic sheet	3.87	3.2	6.15	6.58	23.48	34.19	10.58	2.43	1.72
Hoeing three times	-	4.32	3.97	5.66	23.51	35.08	10.46	2.56	1.79
Control	2.39	2.51	5.76	5.98	22.19	35.2	11.38	3.08	2.46

fed. was 36.0 l/fed in the 1st season and 42 l/fed. in the 2nd one, Table (10). However, Roal gave the highest oil yield in the 2nd season only 43.5 l/fed.

3.3.1. Chemical composition of geranium essential oil

Volatile oil samples were taken from the oil obtained in the second cut of the second season and analyzed using gas liquid chromatography (GLC), to determine the oil components *i.e.* α-Pinene, β-Pinene, Limonene, Linalool, Citronellol, Geraniol, Citroellyl formate, Eugenol and β-caryophyllene, as shown in Table (11) and Figs (15-20). Geraniol was the main component of geranium essential oil. The obtained results showed that the application of Roal at 750 cm^3/fed. gave the highest percentage of geraniol (38.27%). On the other hand, the lowest percentage of geraniol (34.19%) was using the black plastic sheet.

As citronellol was the second main component, hand hoeing three times (23.51%) gave the highest percentage. While the lowest percentage of citronellol (21.23%) was obtained in the case of Select super at 500 cm^3/fed.

3.4. Residues analysis

The stability of the three herbicides under the current study were applied pre-emergence (Pendimethalin and Oxyfluorfen) and post-emergence at 30 days after planting (DAP) (Clethodim). These herbicides (Butralin, Pendimethalin Oxyfluorfen and Clethodim) degraded into the spearmint plants and the GLC could not read any values.

The results in Table (12) and Figs (21-26) exhibit the residue analyses of Pendimethalin Oxyfluorfen and Clethodim herbicides. The residues level of Pendimethalin Oxyfluorfen and Clethodim herbicides in geranium plants in all the treatments were lower than maximum residue levels (MRL) which were 0.05, 0.3 and ppm, respectively. The results are in the agreement obtained by European Food Safety Authority (EFSA), (2012).

Table(12): Calibration of Pendimenthalin, Oxyfluorfen amd Clethodim geranium.

Herbicides name	Residual (ppm)	Max. Residual Levels [mg/kg]
Pendimethalin	N D	0.05
Oxyfluorfen	N D	0.3
Clethodim	N D	0.02

3.5. Determination of economics for weed control in the geranium plants.

The total cost of the weeded check was 11.96 and 12.46 LE in 2014 and 2015 seasons, respectively, considered the fixed cost (land preparation, transplantation fertilization irrigation, insect control, harvesting and transportation) in addition; to the cost of the treatments on the others as shown (Table 13).

In both seasons, Stomp at 1.7 l/fed. gave the highest values of gross income net benefits and the percentage of benefit/cost by 46.8 & 34.64

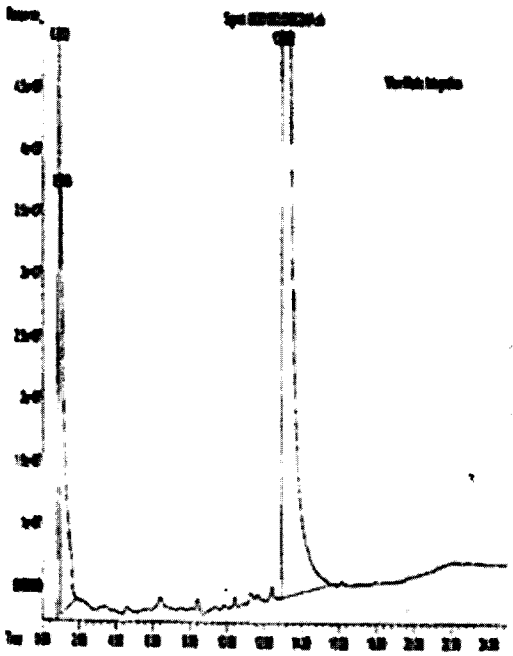

Fig (11): **Standard of Goal**

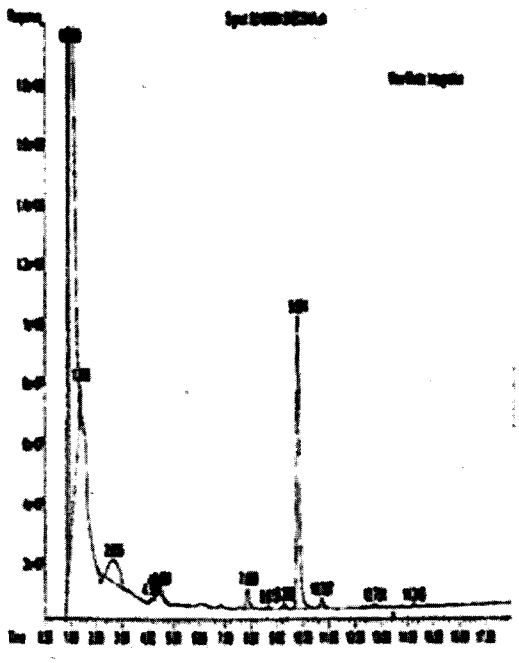

Fig (12): **Residual of Goal in spearmint**

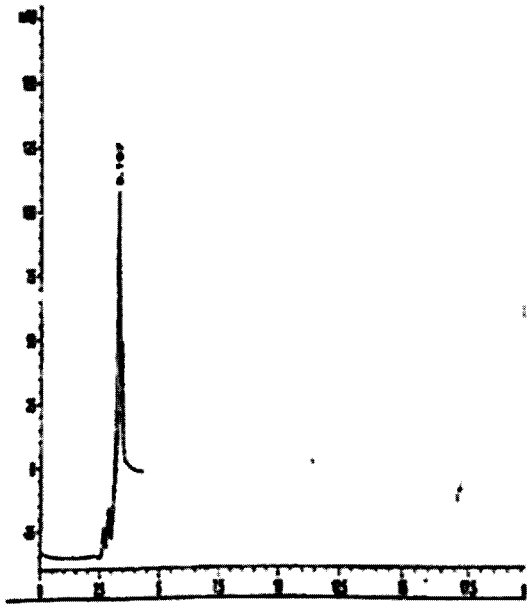

Fig (13): **Standard of select super.**

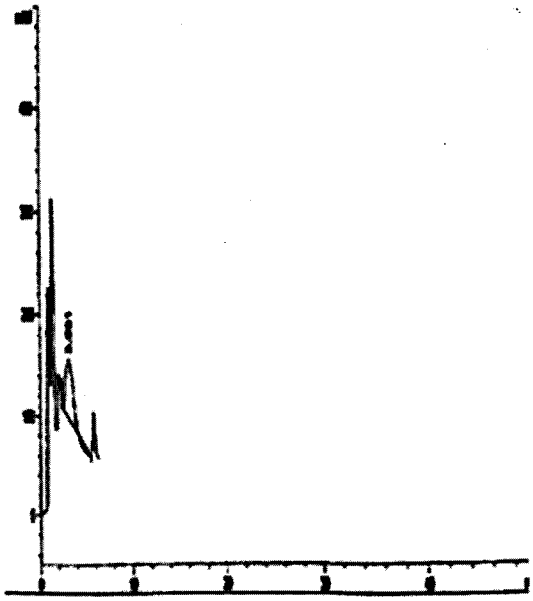

Fig (14) : **Residual of select super in spearmint**

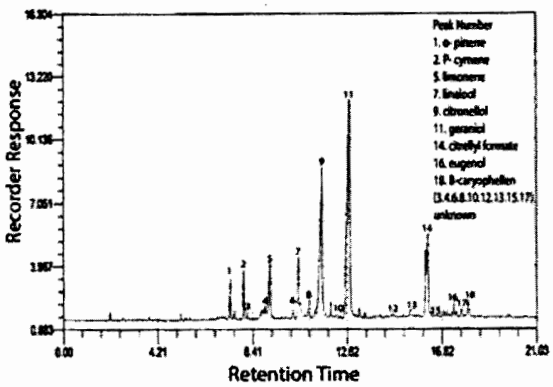

Fig (15): Chromatogram of Geranium essential oil (control)

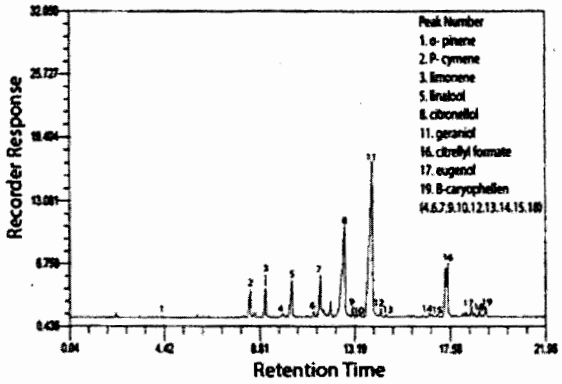

Fig (16): Chromatogram of Geranium essential oil (heoing three time)

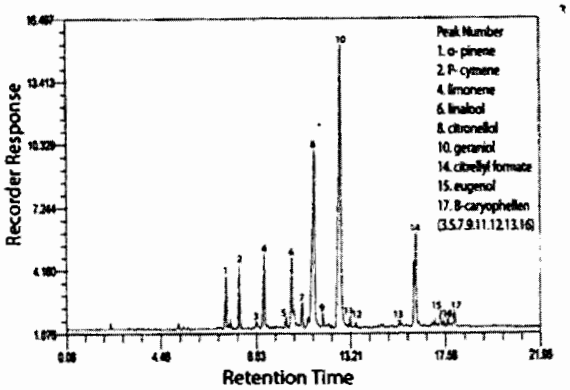

Fig (17): Chromatogram of Geranium essential oil (black plastic sheet)

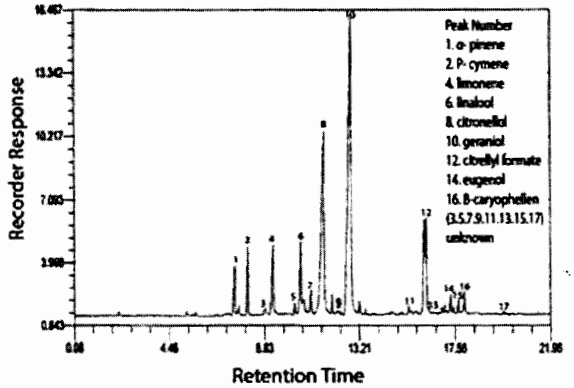

Fig (18): Chromatogram of Geranium essential oil (stomp at 1.7 l/fed)

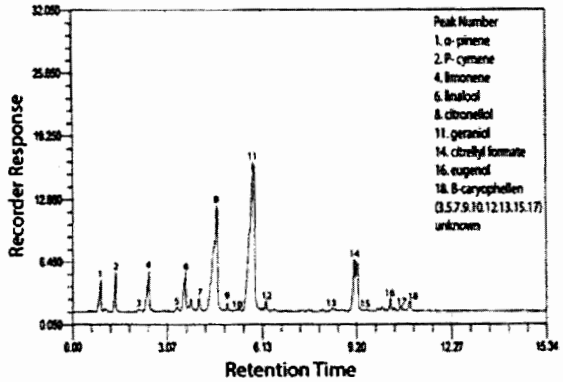

Fig (19): Chromatogram of Geranium essential oil (Roal at 750 cm^3)

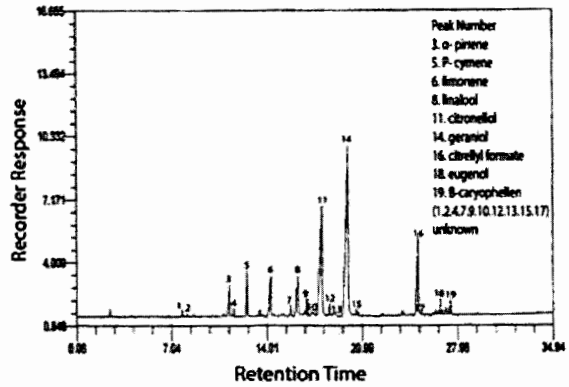

Fig (20): Chromatogram of Geranium essential oil (select at 500 cm^3)

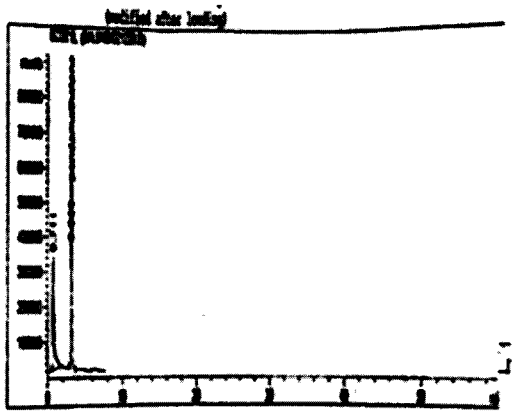

Fig (21): **Standard of Stomp extra**

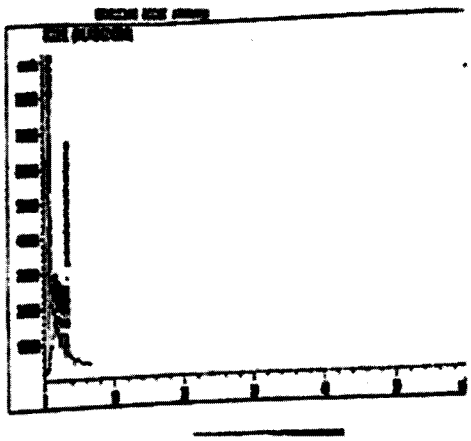

Fig (22): **Residual of Stomp extra in geranium.**

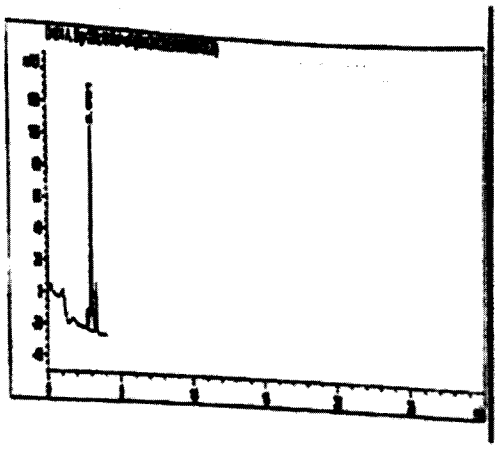

Fig (23): **Standard of Clethodim**

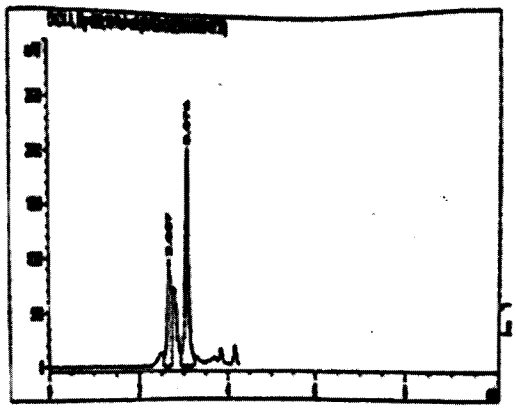

Fig (24): **Residua of Clethodim in geranium**

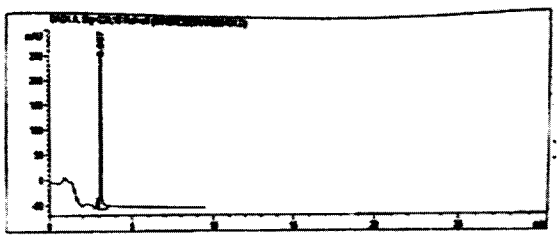

Fig (25): **Standard of Oxyfluorfen**

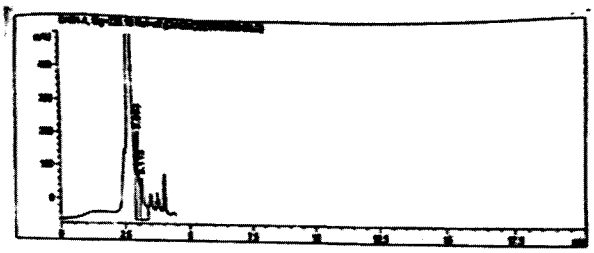

Fig (26): **Residual of Oxyfluorfen in geranium.**

Table (13): Determination of economics for weed control in geranium plants.

Seasons	2014-2015 season				2015-2016 seasion			
Weed control Treatments Rate/fed	Total cost Ths. L.E.	Gross income Ths L.E.	Net Benefit Ths L.E.	B/C	Total cost Ths. L.E.	Gross income Ths L.E.	Net Benefit Ths L.E.	B/C
Roal at 750 cm^3	12.06	35.1	33.04	2.91	12.56	65.25	52.69	5.19
Select super at 500 cm^3	12.09	19.18	7.09	1.59	12.59	20.48	7.89	1.36
Stomp at 1.7 l	12.16	46.8	34.64	3.85	12.61	54.6	41.99	4.33
Black plastic sheet	13.47	33.48	20.01	2.49	13.96	41.6	27.64	2.98
Hoeing three times	12.56	28.28	15.72	2.25	13.36	39.98	26.62	2.991
Control	11.96	12.35	0.39	1.03	12.46	13.0	0.54	1.04

thS LE and 3.85% and 54.6 & 41.99 thS LE and 4.33%, respectively, in the first and the second seasons. Roal at 750 cm^3/fed. was the following treatment which increased the respective previous economic values by 35.1 & 33.04 Ths. LE and 2.91% and 65.25 & 52.69 Ths. LE and 5.19%., respectively, in both seasons. Whilst, the rest treatments *i.e* Black plastic sheet., hand hoeing three times and Select super at 500 cm^3/fed. were still superior of the previous economic value compared to the unweeded check (Table 13).

Conclusion

It could be recommended to treat spearmint and geranium with Stomp at 1.7 l/fed. because it was the best control treatment, as the vegetative growth, herb yield and essential oil production increased while the broad leave and grassy weeds showed inhibition effect due to this treatment. Also, mulching with black plastic sheets could be as a good substitutes for weed control instead of the herbicides and can be recommended for controlling annual weeds especially in organic agriculture.

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إستجابة نباتات النعناع (*Mentha viridis* L.) والعتر (*Pelargonium graveolens l. Herit, ait*) لعمليات مكافحة الحشائش المختلفة

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ملخص

أقيمت أربع تجارب حقلية بمزرعة النباتات الطبية والعطرية بالقناطر الخيرية بمحافظة القليوبية - معهد بحوث البساتين - مركز البحوث الزراعية خلال موسمي 2015/2014 و2016/2015 شملت دراستان عن مكافحة الحشائش في محصولي النعناع والعتر. إستهدفت الدراسة الاولى معرفة تأثير ستة معاملات لمكافحة الحشائش تحت ظروف الكثافة الطبيعية للحشائش بأرض التجربة . على الحشائش ومحصول النعناع ومكوناته (العشب الطازج – الزيت) وهي معاملات أميكس بمعدل 2.5 لتر/ف وستومب أكسترا بمعدل 1.7 لتر/ف وورول بمعدل 750سم^3/ف كمبيدات أرضية تضاف قبل الشتل وسلكت سوبر بمعدل 0.5 لتر/فدان يضاف بعد شهر من الشتل والعزيق ثلاث مرات تبدأ بعد شهر من الشتل بالأضافة للكنترول. أوضحت النتائج أن كثافة الحشائش العريضة في المعاملة القياسية قدرت بحوالي 0.97 & 0.45 طن/فدان بينما كثافة الحشائش الحولية الضيقة كانت 0.43 & 0.24 طن/فدان في موسمي 2014 و 2015 ، على التوالي وكان افضل المعاملات لمكافحة الحشائش تحت ظروف التجربة هو ستومب اكسترا بمعدل 1.7 لتر/ف، حيث اعطت أقل وزن جاف للحشائش العريضة وضيقة الاوراق ومجموعهما مع زيادة في صفات النمو الخضري (ارتفاع النبات – عدد الافرع – الوزن الطازج – ومحصول الزيت لنبات النعناع) . أدت المعاملة بمبيد رول بمعدل 750سم^3/فدان اعلى نسبة مئوية في مركب carvone المركب الرئيسي لزيت النعناع تم في الدراسة الثانية اختبار ستة معاملات لمكافحة الحشائش في محصول العتر وهي ستومب أكسترا بمعدل 1.7 لتر/ف, وورول بمعدل 750 سم^3/فدان, وسلكت سوبر بمعدل 0.5 لتر/فدان والتغطية بالبلاستيك الاسود والعزيق ثلاث مرات بالاضافة الى الكنترول لدراسة تأثيرها على الحشائش والنمو الخضري (ارتفاع النبات – عدد الافرع – الوزن الطازج – والنسبة المئوية لمكونات الزيت الطيار). أشارت النتائج أن كثافة الحشائش العريضة في المعاملة القياسية قدرت بحوالي 0.75 & 0.70 طن/فدان بينما كثافة الحشائش الحوليةالضيقة كانت 0.43 & 0.3 طن/فدان موسمي 2015/2014 & 2016/2015 ، على التوالي وأن اضافة مبيد ستومب أكسترا بمعدل 1.7 لتر/ف أعطت أعلى انخفاض في الوزن الجاف للحشائش الحولية وكذلك أعلى قيم في النمو الخضري ومحصول الزيت, بينما أدت المعاملة بمبيد رول بمعدل 750سم^3/فدان اعلي نسبة مئوية في مركب Geraniol المركب الرئيسي لزيت العتر. بتحليل نباتات النعناع والعتر تبين عدم وجود اي أثر متبقي لمبيدات تحت الدراستين. أشار التحليل الأقتصادي الى الجدوى الأقتصادية لهذة المعاملات من حيث العوائد المتوقعة ودخل المزارعين بالجنية المصري. توصي الدراستين أستخدام مبيد ستومب اكسترا بمعدل 1.7 لتر/فدان في مكافحة الحشائش الحولية في محصولي النعناع والعتر حيث اعطى أعلى قيمة في محصول الزيت والنمو الخضري وعدم وجود أثر متبقي لهذا المبيد في العشب الطازج للمحصولين. كما أمكن استخدام معاملة التغطية بالبلاستيك كبديل طبيعي لاستخدام المبيدات.

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