

IMPACT OF FERTILIZATION BY USING SOME PHENOLIC COMPOUNDS AND HUMIC ACID ON MARJORAM PLANTS SUSCEPTIBILITY TO INSECTS AND MITE INFESTATION AND PLANT FEATURES

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(Manuscript received 16 April 2019)

Abstract

Present study was conducted in the seasons of 2017 and 2018 at the Central Laboratory for Agriculture Climate, Agriculture Research Center (ARC), Dokki, Giza., to investigate the influence of some phenolic chelate compounds (Humic acid, Potassium benzoate and Salicylic acid) in three levels (1.0gm., 1.5gm. and 2.0gm. /L) on the susceptibility of marjoram plants to the infection with *Aphis gossypii* Glover, *Thrips tabaci* Lind., and *Tetranychus urticae* Koch as well as yield, growth features and essential oil contents. The results proved that the using of 2.0gm./L of salicylic acid, potassium benzoate and humic acid as fertilizers to marjoram plants, caused highly significant infestation reduction of target pests' as well as the effects on the growth characteristics in the first and second cuts in both seasons. Resulted in an increasing number of branches per plant in addition increased plant height, also, it caused significantly increasing in fresh and dry weights. The highest oil yield / plant were obtained with applying salicylic acid at 2.0g/L. Leaf area (cm²) of marjoram was increased by different foliar spraying by humic acid and salicylic acid in the 1st and 2nd cut of both seasons. Foliar application of potassium benzoate gave poor results in this concern.

Key Words: Marjoram, insects and mite, vegetative growth and yield, essential oil, phenolic chelate compounds, *Aphis gossypii*, *Thrips tabaci* (Koch), and *Tetranychus urticae*.

INTRODUCTION

Marjoram (*Majorana hortensis*, L) is a perennial herbaceous plant belonging to Lamiaceae family. It is one of the most commercially important medicinal plants. Marjoram is an important aromatic and medicinal plant. It has been cultivated in the Mediterranean countries and is still widely cultivated today. The active principles are found chiefly in the aerial parts (*Majorana*) herb. In Egypt, it is considered as an important economic agricultural export crop (Demetzos and Perdetzoglou, (2001). The major components of marjoram oil are α -Pinene, β -Pinene, limonene, 1.8 cineole, linalool, terpinene-4-ol, α -Terpinene, Linalyl acetate and eugenol, some of these components are used for scenting cosmetics and others are used for flavoring pharmaceuticals such as D-limonene and Linalool (Ostas *et al.*, 2001).

Plant phenolics are generally thought to play significant roles in plant defense against herbivores and pathogens. Many plant taxa are rich in phenolic compounds and some insect herbivores have been shown to acquire phenolics from their hosts to use them as protection against their natural enemies Marta *et al.*, (2013). The environmental problems caused by overuse of pesticides have been the matter of concern for both scientists and public in recent years. The extensive use of the synthetic insecticides lead to the biological imbalance due to the destruction of beneficial species such as parasites and predators of the pests beside the destruction of pollinating insects Koul *et al.*, (2008). Natural products of plants and plant derivatives are alternative agent to currently use for insect control because they constitute rich sources of bioactive chemicals. They are often active against insect species. They are biodegradable to non-toxic products, so that many investigators initiated large screening efforts poisonous effects to use them as insecticides (El-Shazly and Hussien, 2004 and Prows *et al.*, 2006). Humic acid could be used as organic fertilizer and growth regulator to adjusted hormone level, for plant growth improvement and enhance stress tolerance along with increasing shoot and root growth (Nardi *et al.*, 2002). Said-Al Ahl *et al.*, (2016) indicated that plant height, number of branches and oil % of dill increased significantly with humic acid. Khazaie *et al.*, (2011) humic acid showed great influence on vegetative growth, leaf biomass and essential oil production. Humic acid at 300 ml/L resulted in highest amounts of aboveground, leaf biomass and essential oil production compared to untreated plants. Serafimov and Golubanova (2015) noticed that, seedling length reduction was the greatest when potassium sorbate was used on *Lactuca sativa* L. El-Khateeb *et al.*, (2010) on *Calia secundiflora* plants stated that foliar application of humic acid had a significant effect of N, P and K contents of herb compared with control.

It has also been reported that, salicylic acid enhances plant resistance against biological and antibiotic stresses Sawada *et al.*, (2006). It is confirmed that salicylic acid reduces accumulation and leakage of toxic ions in plants (Krantev, *et al.*, (2008) and Zhou *et al.*, (2009). Stevens and Senaratna (2006) it has been reported that salicylic acid significantly enhances the average growth speed of tomato stems in 200 Mm. Bayat *et al.*, (2012) revealed that, exogenous application of salicylic acid enhanced shoot, fresh and dry weights in *Calendula officinalis*. Abdol Rahman *et al.*, (2013) indicated that the lowest concentrations of salicylic acid (0.01 and 0.1 mM) resulted significantly increased of plant height, number of branches and essential oil yield of cumin.

Therefore, this research was carried out to study the effects of the foliar spraying application of phenolic chelate compounds on the population of four Insects

& mite infestation on marjoram (*Majorana hortensis* L) and plants growth, oil yield and chemical composition.

MATERIALS AND METHODS

1- Methodology:

This experiment was conducted at Central Laboratory for Agriculture Climate, Agriculture Research Center (ARC), in the seasons of 2017 and 2018 in Giza Governorate, to investigate the impact of using some phenolic chelate compounds and humic acid as foliar spraying on marjoram plants on vegetative growth parameters and chemical composition on two insects pests and mite infesting marjoram plants; *Aphis gossypii* Glover, *Thrips tabaci* Lind. and *Tetranychus urticae* (Koch). Potassium benzoate, salicylic acid and humic acid treatments with different concentrations applied as foliage application, the experiment was designed in randomized complete block with 10 treatments and 3 replicates as follow:

- 1- Control was sprayed with water.
- 2- Humic acid (HA) 1.00 gm /L.
- 3- Humic acid (HA) 1.50 gm /L.
- 4- Humic acid (HA) 2.00 gm / L.
- 5- Potassium benzoate (PB) 1.00 gm / L.
- 6- Potassium benzoate (PB) 1.50 gm / L.
- 7- Potassium benzoate (PB) 2.00 gm /L.
- 8- Salicylic acid (SA) 1.00 gm /L.
- 9- Salicylic acid (SA) 1.50 gm /L
- 10- Salicylic acid (SA) 2.00 gm /L

Plant materials

Marjoram seedlings (about 15 cm in height) were obtained from the farm of El-Kanater El- Khayria. Horticulture Research Institute, ARC. Seedlings were sown on 23rd and 25th March in the first and second seasons respectively, at spacing of (60×25) cm during both seasons on one side of the row. The experiment plots were 3.0 × 2.0 meters, with three rows at distance of 60 cm between rows.

Effect of treatments on some insects and mite infestation:

Phenolic chelate compounds and humic acid sprays in suggested doses were applied on seedlings at one week after germination at 7 days intervals until transplanting. Under field conditions, treatments were applied at 10 days intervals from transplanting date until the flowering stage except the control treatment. Ten leaves were randomly taken /replicate/ week and put into paper bag then tightly

closed and transferred to the laboratory to be inspected for counting insect and mites individuals by using Stereomicroscope:

- Number of *Aphis gossypii*, individuals /10 leaves.
- Number of *Thrips tabaci*. Individuals /10 leaves.
- Number of spider mite *Tetranychus urticae* movable stages /10 leaves.

II- Growth measurements:

The plants were harvested 2 times (1st and 2nd cut) on 14th June and 17th August for the two seasons 2017 and 2018 during the growing season by cut the plants and left 10 cm above the soil, and the different vegetative growth parameters were recorded in both seasons as follows: plant height (cm), number of branches/ plant, leaf area (cm²) was measured using CI-203 Handheld Laser Leaf Area Meter (CID, Bioscience) in Central Laboratory for Agricultural Climate, fresh and dry weight of herb / plant (gm), oil % and oil yield / plant ml/L.

III- Chemicals composition:

Nitrogen, phosphorus and potassium contents:

Nitrogen, phosphorus and potassium were determined as dry weight basis according to the methods described by Bremner and Mulvaney (1982), Olsen and Sommers (1982) and Jackson (1970). While, essential oil % in marjoram dry herb was determined according to British Pharmacopoeia (2002).

Essential oil composition:

The Gas Liquid Chromatography analysis (GLC) was used to analyze the essential oil samples and carried out in Laboratory of Medicinal and Aromatic Plants Research Department, Horticulture Research Institute, (HRI). (ARC) using Ds Chrom 6200 Gas Chromatograph apparatus was fitted with capillary column BPX-5, 5 phenyl (equiv.) polysilphenylene-siloxane 30 x 0.25 mm ID x 0.25 μ film. Temperature program ramp increase with a rate of 10 °C / min from 70 ° to 200°C. Flow rates of gases were nitrogen at 1 ml / min, hydrogen at 30 ml / min and 330 ml / min for air Detector and injector temperatures were 300 °C and 250 °C respectively. The obtained chromatogram and report at GC analysis for each sample were analyzed to calculate the percentage of main components of the volatile oil according to Guenther and Joseph (1978).

IV- Statistical analysis:

- This experiment was designed as complete randomized block design. The experiment included 10 treatments and 3 replicates as described by Gomez and Gomez (1984). The percentages of infestation reduction were calculated according to Schneider-Orelli's formula (Nakano *et al.*, (1981).

$$\text{Corrected \%} = \left(\frac{\text{Mortality \% in treated plot} - \text{Mortality \% in control plot}}{100 - \text{Mortality \% in control plot}} \right) * 100$$

Final data were analysis of variance (ANOVA) was performed on infesting pest and different treatments by (SAS, 1999) and appropriate error terms for the F tests of interactions were calculated separately. Comparisons of means were performed using the Duncan's multiple range test (= 0.05). Statistical analysis for horticulture was done by using the computer program MS-TATEC software version (4).

RESULTS AND DISCUSSION

I. Effect of different tested treatments:

Data in (Tables 1&2) indicated the gradual reduction percentages of pests *Aphis gossypii*, *Thrips tabaci* and *Tetranychus urticae* numbers as a result of some phenolic chelate compounds and humic acid as foliar spraying on marjoram plants in both seasons 2017- 2018. Data showed highly significant differences between the three compounds with different concentrations.

I .1 in first season:-

I.1.1 *Aphis gossypii*

Data shown in Table (1) throughout the first cut of marjoram plant indicated that salicylic acid treatment with the different concentrations used (2.0, 1.5 and 1.0 g/L of water) gave highest reduction percentages against *A. gossypii* being (6.53, 7.86 and 7.90%), respectively. The same results were achieved that in the second cuts with reduction percentages of *A. gossypii* being (8.33, 8.66 and 10%) in tested concentrations, respectively. While, potassium benzoate treatments (2.0, 1.5 and 1.0g/L) caused the intermediate efficacy, being (8.2, 8.8 and 11.56%), respectively. Finally, humic acid treatments with the tested concentration caused the lowest reduction percentages of *A. gossypii* (12.43, 13.3 and 15.9%), respectively. In the second cut, treatments (Humic acid and Potassium benzoate) may arranged discerningly as (11.33, 15.66, 16, 21.66, 21.33 and 26%) for the used tested concentrations (2.0, 1.5 and 1.0g/L), respectively, compared with control.

I.1.2- *Thrips tabaci*

Data shown in Table (1) throughout the first cut of marjoram plant indicated that salicylic acid treatment with the different concentrations used (2.0, 1.5 and 1.0 g/L of water) gave highest reduction percentages against *T. tabaci* being (0.50, 0.63 and 0.67%), respectively. The same results were achieved that in the second cut with reduction percentages of *T. tabaci* being (9.00, 10.66 and 12.66%) in tested concentrations, respectively. While, potassium benzoate treatments (2.0, 1.5 and

1.0g/L) caused the intermediate efficacy, being (0.7, 0.766 and 0.97%), respectively. Finally, humic acid treatments with the tested concentration caused the lowest reduction percentages of *T. tabaci* (1.1, 1.33 and 1.73%), respectively. In the second cut, treatments (Potassium benzoate and Humic acid) may arranged dissentingly as (13.66, 10.33, 12.33, 14.66, 18.66 and 19.66%) for the used tested concentrations (2.0, 1.5 and 1.0g/L), respectively, compared with control.

1.1.3- *Tetranychus urticae*

Data shown in Table (1) throughout the first cut of marjoram plant indicated that salicylic acid treatment with the different concentrations used (2.0, 1.5 and 1.0 g/L of water) gave highest reduction percentages against *T. urticae* being (0.8, 1 and 1.2%), respectively. The same results were achieved that in the second cut with reduction percentages of *T. urticae* being (7.33, 8.33 and 9.33%) in tested concentrations, respectively. While, potassium benzoate treatments (2.0, 1.5 and 1.0g/L) caused the intermediate efficacy, being (1.57, 1.6 and 1.90 %), respectively. Finally, humic acid treatments with the tested concentration caused the lowest reduction percentages of *T. urticae* (1.37, 1.67 and 1.67%), respectively, compared with in control. In the second cut, treatments (Potassium benzoate and Humic acid) may arranged descending as (15.33, 15.66, 16.33, 15.66, 16 and 19%) for the used tested concentrations (2.0, 1.5 and 1.0g/L), respectively, compared with control.

These results are agreement with Bodenhausen, (2007) revealed that the foliar application of potassium benzoate and salicylic acid reduced the infestation numbers of *T. urticae*, *T. tabaci*, *A. ipsilon* and *A.gosspyii* in comparison numbers with the corresponding untreated treatments with humic acid in the first season 2017.

Table 1. Effect of using some phenolic chelate compounds on the reduction of insects and mite on marjoram (*Majorana hortensis* L) plants during two growth intervals in 2017.

| Treatments | Reduction of pests | | | | | |
|----------------------------|-----------------------|---------------------|----------------------|---------------------|----------------------------|---------------------|
| | <i>Aphis gosspyii</i> | | <i>Thrips tabaci</i> | | <i>Tetranychus urticae</i> | |
| | 1 st cut | 2 nd cut | 1 st cut | 2 nd cut | 1 st cut | 2 nd cut |
| Humic acid 1.00g/L | 15.90 a | 11.33 d | 1.73 a | 19.66 a | 1.67 a | 19.00 a |
| Humic acid 1.5 g/L | 13.30 b | 15.66 c | 1.33 ab | 18.66 ab | 1.67 a | 16.00 a |
| Humic acid 2.0 g/L | 12.43 bc | 16.00 c | 1.1b c | 14.66 abc | 1.37 b | 15.66 a |
| Potassium benzoate 1.0 g/L | 11.56 c | 26.00 a | 0.97 cd | 12.33 cde | 1.90 a | 15.33 a |
| Potassium benzoate 1.5 g/L | 8.80 d | 21.30 b | 0.77 cd | 10.33 de | 1.60 a | 16.33 a |
| Potassium benzoate 2.0 g/L | 8.20 d | 21.6 b | 0.70 cde | 13.66 bc | 1.57 a | 15.66 a |
| Salicylic acid 1.00 g/L | 7.90 de | 10.00 e | 0.67 e | 12.66 bcd | 1.20 bc | 9.33 b |
| Salicylic acid 1.5 g/L | 7.86 de | 8.66 e | 0.63 de | 10.66 de | 1.00 bc | 8.33 b |
| Salicylic acid 2.0 g/L | 6.53 e | 8.33 e | 0.50 e | 9.00 e | 0.80 c | 7.33 b |
| F value | 74.81*** | 56.21*** | 9.03*** | 6.32*** | 8.70*** | 14.22*** |
| LSD at: 0.05 | 1.01 | 0.25 | 0.41 | 0.47 | 0.36 | 0.34 |

I.2- second season:**I.2.1 *Aphis gossypii***

Data shown in Table (2) throughout the first cut of marjoram plant indicated that salicylic acid treatment with the different concentrations used (2.0, 1.5 and 1.0 g/L of water) gave highest reduction percentages against *A. gossypii* being (5.13, 7.8 and 8.6%), respectively. The same results achieved that in the second cuts with reduction percentages of *A. gossypii* being (25.00, 29.00 and 31.33%) in tested concentrations, respectively. While, humic acid treatments (2.0, 1.5 and 1.0g/L) caused the intermediate efficacy, being (7.53, 8.6 and 9.70 %), respectively. Finally, potassium benzoate treatments with the tested concentration caused the lowest reduction percentages of *A. gossypii* (7.80, 8.63 and 10.76%), respectively, compared red with in control. In the second cut, treatments (Humic acid and Potassium benzoate) may arranged discerningly as (12.33, 24, 42.66, 22.33, 43.33 and 35.33%) for the used tested concentrations (2.0, 1.5 and 1.0g/L), respectively, compared with control.

I.2.2- *Thrips tabaci*

Data shown in Table (2) throughout the first cut of marjoram plant indicated that salicylic acid treatment with the different concentrations used (2.0, 1.5 and 1.0 g/L of water) gave highest reduction percentages against *T. tabaci* being (0.43, 0.6 and 0.8%), respectively. The same results achieved that in the second cuts with reduction percentages of *T. tabaci* being (1.33, 2.66 and 3.66%) in tested concentrations, respectively. While, humic acid treatments (2.0, 1.5 and 1.0g/L) caused the intermediate efficacy, being (1.1, 1.2 and 1.4%), respectively. Finally, potassium benzoate treatments with the tested concentration caused the lowest reduction percentages of *T. tabaci* (2.53, 1.33 and 1.83%), respectively, compared with control. In the second cut, treatments (Humic acid and Potassium benzoate) may arranged dissentingly as (5.33, 6.00, 7.00, 6.33, 8.33 and 10.00 %) for the used tested concentrations (2.0, 1.5 and 1.0g/L), respectively, compared with control.

Table 2. Effect of using some phenolic chelate compounds on the reduction of insects and mite on marjoram (*Majorana hortensis* L) plants during two growth intervals in 2018.

| Treatments | Reduction of pests | | | | | |
|-----------------------------|-----------------------|---------------------|----------------------|---------------------|----------------------------|---------------------|
| | <i>Aphis gossypii</i> | | <i>Thrips tabaci</i> | | <i>Tetranychus urticae</i> | |
| | 1 st cut | 2 nd cut | 1 st cut | 2 nd cut | 1 st cut | 2 nd cut |
| Humic acid 1.0g/L | 9.70 b | 42.66 a | 1.40 cb | 7.00 c | 2.20 a | 25.33 a |
| Humic acid 1.5 g/L | 8.60 c | 24.00 e | 1.20 cd | 6.00 d | 2.06 b | 19.33 b |
| Humic acid 2.0 g/L | 7.53 d | 12.33 f | 1.10 de | 5.33 e | 1.23 cd | 17.00 b |
| Potassium benzoate 1.00 g/L | 10.76 a | 35.33 b | 1.83 b | 10.00 a | 1.56 c | 25.33 a |
| Potassium benzoate 1.5 g/L | 8.63 c | 43.33 a | 1.33 c | 8.33 b | 1.40 c | 24.00 a |
| Potassium benzoate 2.0 g/L | 7.80 d | 22.33 e | 2.53 a | 6.33 cd | 0.96 de | 20.00 b |
| Salicylic acid 1.00 g/L | 8.60 c | 31.33 c | 0.8 ef | 3.66 f | 1.23 cd | 11.33 c |
| Salicylic acid 1.5 g/L | 7.80 d | 29.00 dc | 0.6 gf | 2.66 g | 0.86 de | 10.00 c |
| Salicylic acid 2.0 g/L | 5.13 e | 25.00 de | 0.43 g | 1.33 h | 0.43 e | 8.60 c |
| F value | 122.94*** | 83.91*** | 30.01*** | 9.51*** | 19.39*** | 37.32*** |
| LSD at: 0.05 | 0.42 | 0.31 | 0.33 | 0.27 | 0.35 | 0.34 |

I.1.3- *Tetranychus urticae*

Data shown in Table (2) throughout the first cut of marjoram plant indicated that salicylic acid treatment with the different concentrations used (2.0, 1.5 and 1.0 g/L of water) gave highest reduction percentages against *T. urticae* being (0.43, 0.86 and 1.23%), respectively. The same results were achieved that in the second cuts with reduction percentages of *T. urticae* being (8.60, 10.00 and 11.33%) in tested concentrations, respectively. While, potassium benzoate treatments in two tested cuts caused the intermediate efficacy, being (0.96, 1.40 and 1.56%), (1.57 %, 1.60% and 1.9%), respectively. Finally, humic acid treatments with the tested concentration caused the lowest reduction percentages of *T. urticae* (1.23, 2.06 and 2.2%), respectively. In the second cut *T. urticae* being (17, 19.33 and 25.33%), respectively, compared with control.

Population' densities in 2017 was less at 1st cut than the 2nd cut. The second season was the opposite of the first season. These results are in agreement with Mahmoud and Mahfouz (2015) results that revealed the foliar spray application of humic acid and salicylic acid reduced the As soon as (Pettersson *et al.*, (1994) reported that cereal crops treated with a slow release formulation of methyl salicylate had been avoided by many insects, (Pickett *et al.*, 2006) showed that salicylic acid caused a reduction in aphid population within five weeks after application.

II. Vegetative growth:

II.1 Plant height and number of branches/plant:-

Data shown in table (3) represent the effect of humic acid, potassium benzoate and salicylic acid at 1.00, 1.5 and 2.0 g/L treatments on vegetative growth characteristics of marjoram (*Majorana hortensis* L) . Both plant height and number of branches/plant were significantly increased in the most treatments of foliar fertilization compared with the untreated plants (control). The highest plant elongation's being (54.31 and 45.34 cm) and (53.78 and 46.21 cm) were recorded for the plants received humic acid at the highest rate of foliar fertilization; (2.0 g/L) in the 1st and 2nd cut in both seasons respectively, followed by (51.34 and 43.57 cm) and (52.65 and 44.31cm) were obtained with plants received salicylic acid at 2.0 g/L at both cuts in the two seasons, respectively. Whereas, foliar fertilization of potassium benzoate resulted the least values compared with Ha and SA. Low plant elongation by using potassium benzoate by concentration (2g/L.) as foliar fertilization agrees with those of Serafimov, and Golubnova (2015) on *Lactuca sativa* L.

On the other hand, the results presented in Tables (3) also, indicated that the highest values from number of branches/plant (17.85, 16.35 and 13.75) and (39.25, 34.17 and 31.84) were obtained from humic acid, potassium benzoate and salicylic

acid at 2.0 g/L in the 1st and 2nd cuts in the first season, respectively compared with control (11.20 and 21.54) of two cuts in the first season, respectively. In the second season, data indicated the similar trend had been obtained as in the first one. Also, the results show that the humic acid had the superior effect on plant height and number of branches per plant. It is known that, humic acid used for plant nutrition, enhance root, plant growth and development as well as yield due to its action on physiological and metabolic processes Eyheraguibe *et al.*, (2008). The present results come in agreement with Said-Al Ahl *et al.*, (2016) on dill plants.

Table 3. Effect of using some phenolic chelate compounds on plant height, numbers of branches/plant and leaf area (cm²) of marjoram (*Majorana hortensis* L) plants of two cuts during two seasons 2017 and 2018.

| Treatments | First season 2017 | | | | | |
|-----------------------------|---------------------|---------------------|---------------------|---------------------|------------------------------|---------------------|
| | Plant height (cm) | | No. of branches/p | | Leaf area (cm ²) | |
| | 1 st Cut | 2 nd Cut | 1 st Cut | 2 nd Cut | 1 st Cut | 2 nd Cut |
| Control | 40.21 | 34.25 | 11.20 | 21.54 | 2.00 | 2.10 |
| Humic acid 1.0g/L | 44.11 | 37.25 | 11.50 | 25.22 | 2.00 | 2.35 |
| Humic acid 1.5 g/L | 50.24 | 42.31 | 15.34 | 31.47 | 2.70 | 3.00 |
| Humic acid 2.0 g/L | 54.31 | 45.34 | 17.85 | 39.25 | 3.27 | 3.72 |
| Potassium benzoate 1.00 g/L | 40.57 | 35.33 | 11.00 | 22.64 | 2.00 | 2.25 |
| Potassium benzoate 1.5 g/L | 42.81 | 38.56 | 14.01 | 29.38 | 2.66 | 2.80 |
| Potassium benzoate 2.0 g/L | 45.65 | 41.84 | 16.35 | 34.17 | 2.37 | 2.59 |
| Salicylic acid 1.00 g/L | 42.38 | 37.38 | 11.30 | 22.00 | 2.00 | 2.31 |
| Salicylic acid 1.5 g/L | 46.33 | 40.25 | 13.05 | 28.61 | 3.55 | 3.82 |
| Salicylic acid 2.0 g/L | 51.34 | 43.57 | 13.75 | 31.84 | 3.90 | 3.95 |
| LSD at: 0.05 | 4.72 | 4.88 | 4.04 | 4.76 | 1.29 | 1.54 |
| Treatments | Second season 2018 | | | | | |
| | Plant height (cm) | | No. of branches/P | | Leaf area (cm ²) | |
| | 1 st Cut | 2 nd Cut | 1 st Cut | 2 nd Cut | 1 st Cut | 2 nd Cut |
| Control | 39.70 | 33.78 | 10.95 | 22.33 | 1.85 | 2.20 |
| Humic acid 1.0g/L | 45.22 | 38.45 | 12.47 | 26.21 | 2.15 | 2.51 |
| Humic acid 1.5 g/L | 51.30 | 43.11 | 14.78 | 32.27 | 2.80 | 3.60 |
| Humic acid 2.0 g/L | 53.78 | 46.21 | 17.21 | 38.14 | 3.79 | 3.81 |
| Potassium benzoate 1.00 g/L | 41.24 | 35.79 | 11.94 | 22.45 | 2.11 | 2.29 |
| Potassium benzoate 1.5 g/L | 43.81 | 39.55 | 14.02 | 30.11 | 2.79 | 2.88 |
| Potassium benzoate 2.0 g/L | 46.51 | 42.35 | 16.00 | 35.36 | 2.50 | 2.74 |
| Salicylic acid 1.00 g/L | 42.71 | 38.76 | 11.42 | 22.11 | 2.18 | 2.66 |
| Salicylic acid 1.5 g/L | 47.42 | 41.42 | 12.99 | 27.43 | 3.01 | 3.80 |
| Salicylic acid 2.0 g/L | 52.65 | 44.31 | 13.81 | 32.01 | 3.80 | 3.85 |
| LSD at: 5 % | 4.04 | 5.23 | 2.40 | 4.39 | 1.40 | 1.44 |

II.2 Effect on leaf area (cm²)

The results presented in Tables (3) showed that leaf area (cm²) of marjoram was increased by different foliar fertilization with humic acid and salicylic acid in the 1st and 2nd cuts in both seasons, the higher rate (2.0 g/L) of salicylic acid gave the largest significantly leaf area (3.90 and 3.95 cm²) and (3.80 and 3.85 cm²) in both cuts in the first and second seasons, respectively), compared with control plants (2.00 and 2.10 cm²) and (1.85 and 2.20 cm²). Mady (2009) two concentrations of SA at 100 and 200 ppm increased leaf area of tomato, which is in line with the results of the present study. The effect of humic acid had similar results of SA. The results of the present investigations are in close agreement also with the findings of Moshtaghi *et al.*, (2011) and Azad *et al.*, (2014) that reported that, the foliar application of humic acid (Ha) individually increased the leaf areas of olive more than untreated plants.

As for as, the effect of potassium benzoate on the leaf area (cm²), data showed that, no significant effect of Pb. on the leaf area in both seasons. The highest values (2.66 and 2.50 cm²) and (2.79 and 2.88 cm²) were obtained from plants applied with 1.5 g/L. The same results nearly were obtained by Serafimov and Golubanova (2015) on *Lactuca sativa* L.

II.3 Fresh and dry weights of herb/plant

Regarding the effect of different foliar fertilization on fresh and dry weights of herb, the data in Tables (4) indicate that application of humic acid at a the rate of 2.0 g/L to marjoram plants gave significantly increased in fresh and dry weighs compared with untreated plants or other treatments (184.35 and 216.34 g/plant) and (179.78 and 220.41 g/plant) for fresh weight in the 1st and 2nd cuts in the two seasons respectively, and (44.28 and 76.25 g/plant) and (43.45 and 78.52 g/plant) for dry weight in the first and second cuts in both seasons, respectively, followed by (170.51 and 210.17 g /plant) and (169.85 and 212.41 g/plant) for fresh weight that obtained from plants treated with salicylic acid at 2.0 g/L in the two cuts in both seasons, respectively and (41.55 and 70.33 g/plant) and (42.54 and 71.29 g/plant) dry weight in the first and second cuts in the two seasons, respectively. Moreover, fresh and dry weights of plant treated with potassium benzoate, showed the same trend. These finding are in agreement with those of (Nia, *et al.*, (2014). Who reported that humic acid application of HA at 1.5 l/ha, gave the highest fresh and dry weight in *Rosmarinus officinalis*.

II.4 Essential oil % and oil yield per plant (ml)

Concerning the effect of foliar fertilization's treatments on the percentage of essential oils contents and oil yield/plant (ml) of marjoram plants. Data in Table (4) showed that, all the foliar treatments increased the percentage of essential oils

contents and oil yield/plant (ml) comparing with the untreated plants (control). It is clear that highly significant differences occurred between the percentage of essential oils contents and oil 's production/plant (ml) produced by plants treated by salicylic acid at 2.0 g/L (1.89 and 1.95 %) and (1.88 and 1.96 %) in the 1st and 2nd cuts during both seasons, respectively. Similar increases in the on the percentage of essential oils contents and oil yield/plant (ml) as a result of salicylic acid or humic acid treatments were reported by Khazaie *et al.*, (2011) who mentioned that, the using of concentrations from 0 to 300 ml/L humic acid gave highest production of total essential oil of hyssop plants also Abdol Rahman *et al.*, (2013) on cumin and Farhood *et al.*, (2017) noticed that coriander plants treated with salicylic acid had higher seed oil content and yield compared with untreated plants.

Table 4. Effect of using some phenolic chelate compounds on fresh and dry weight (g)/ plant, percentage of essential oils contents and oil yield /plant (ml) of marjoram (*Majorana hortensis* L) plants of two cuts during two seasons 2017 and 2018.

| Treatments | First season 2017 | | | | | | | |
|-----------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|----------------------|---------------------|
| | Fresh weight (g) | | Dry weight (g) | | Essential oil % | | Oil yield/plant (ml) | |
| | 1 st Cut | 2 nd Cut | 1 st Cut | 2 nd Cut | 1 st Cut | 2 nd Cut | 1 st Cut | 2 nd Cut |
| Control | 136.24 | 171.55 | 30.22 | 57.31 | 1.04 | 1.03 | 2.00 | 2.80 |
| Humic acid 1.0g/L | 151.11 | 185.41 | 35.22 | 61.22 | 1.54 | 1.65 | 2.33 | 3.06 |
| Humic acid 1.5 g/L | 160.28 | 197.28 | 36.25 | 69.33 | 1.55 | 1.67 | 2.48 | 3.29 |
| Humic acid 2.0 g/L | 184.35 | 216.34 | 44.28 | 76.25 | 1.60 | 1.75 | 2.95 | 3.79 |
| Potassium benzoate 1.00 g/L | 136.58 | 173.84 | 30.56 | 58.00 | 1.00 | 1.00 | 2.10 | 2.03 |
| Potassium benzoate 1.5 g/L | 143.35 | 179.63 | 32.47 | 58.22 | 1.54 | 1.63 | 2.21 | 2.93 |
| Potassium benzoate 2.0 g/L | 162.87 | 205.84 | 38.61 | 66.38 | 1.80 | 1.81 | 2.93 | 3.73 |
| Salicylic acid 1.0 g/L | 140.28 | 179.58 | 31.54 | 60.84 | 1.77 | 1.70 | 2.48 | 3.05 |
| Salicylic acid 1.5 g/L | 146.51 | 183.57 | 34.81 | 65.64 | 1.86 | 1.80 | 2.73 | 3.30 |
| Salicylic acid 2.0 g/L | 170.51 | 210.17 | 41.55 | 70.33 | 1.89 | 1.95 | 3.22 | 4.10 |
| LSD at 5% | 8.27 | 9.04 | 3.01 | 4.86 | 0.18 | 0.19 | 0.34 | 0.39 |
| Treatments | Second season 2018 | | | | | | | |
| | Fresh weight (g) | | Dry weight (g) | | Essential oil % | | Oil yield/plant (ml) | |
| | 1 st Cut | 2 nd Cut | 1 st Cut | 2 nd Cut | 1 st Cut | 2 nd Cut | 1 st Cut | 2 nd Cut |
| Control | 140.10 | 175.20 | 31.47 | 53.12 | 1.04 | 1.09 | 2.07 | 2.02 |
| Humic acid 1.0g/L | 155.35 | 190.11 | 36.54 | 62.11 | 1.50 | 1.66 | 2.33 | 3.16 |
| Humic acid 1.5 g/L | 159.80 | 200.30 | 37.22 | 67.54 | 1.53 | 1.68 | 2.44 | 3.37 |
| Humic acid 2.0 g/L | 179.78 | 220.41 | 43.45 | 78.52 | 1.61 | 1.77 | 2.89 | 3.90 |
| Potassium benzoate 1.00 g/L | 141.00 | 177.31 | 31.48 | 53.22 | 1.48 | 1.64 | 2.09 | 2.91 |
| Potassium benzoate 1.5 g/L | 145.42 | 180.21 | 33.89 | 59.14 | 1.51 | 1.65 | 2.20 | 2.97 |
| Potassium benzoate 2.0 g/L | 166.35 | 207.35 | 39.62 | 68.54 | 1.79 | 1.79 | 2.98 | 3.71 |
| Salicylic acid 1.0 g/L | 143.50 | 180.25 | 32.54 | 56.71 | 1.66 | 1.71 | 2.38 | 3.08 |
| Salicylic acid 1.5 g/L | 147.20 | 185.20 | 35.22 | 61.68 | 1.75 | 1.82 | 2.58 | 3.37 |
| Salicylic acid 2.0 g/L | 169.85 | 212.41 | 42.54 | 71.29 | 1.88 | 1.96 | 3.21 | 4.16 |
| LSD at: 0.05 | 6.64 | 7.55 | 3.77 | 4.05 | 0.19 | 0.21 | 0.41 | 0.42 |

II.5- Essential oil composition

The effect of different foliar fertilization of humic acid, potassium benzoate and salicylic acid with different constitutions on oil composition shown in Table (5). Thirteen compounds, accounting for more than 90.83% of the total volatiles in most marjoram samples were detected and identified. It was clear that, Terpine-4-ol was the most abundant compound in all analyzed oils, followed by Linalyl acetate, β Phylanderene, and Sabinene. (Ostas *et al.*, (2001). The highest percentage of Terpine-4-ol (28.4 %) was obtained from using humic acid at 2 g/l. Similar results are in agreement with EL-Khateeb *et al.*, (2017) GLC analysis indicated that essential oil extracted from marjoram plants treated, humic acid at high level (5 ml/l) and were found to be rich in cis sabinene hydrate, whereas terpinen-4-ol was found was found to be rich in oil of plants treated with humic acid at 2.5 ml/l. to be rich in oil of plants treated with humic acid at 2.5 ml/l or brassinolide at 50 ppm.

Table 5. Effect of using some phenolic chelate compounds on chemical composition of marjoram oil of the 2nd cut during second season 2018.

| Compounds % | Treatments | | | | | | | | | |
|----------------------|------------|------|-------|-------|-------|-------|------|-------|------|-------|
| | Contro | Ha1 | Ha2 | Ha3 | Pb1 | Pb2 | Pb3 | Sa1 | Sa2 | Sa3 |
| α -Pinene | 0.57 | 1.71 | 1.55 | 1.39 | 1.21 | 1.33 | 1.37 | 1.40 | 1.40 | 1.80 |
| Sabinene | 6.45 | 9.51 | 8.55 | 9.99 | 7.55 | 8.12 | 7.97 | 8.90 | 8.78 | 8.88 |
| Myrecene | 2.90 | 2.78 | 2.36 | 2.74 | 2.25 | 2.33 | 2.50 | 2.15 | 2.55 | 2.46 |
| α -Terpinene | 3.55 | 4.98 | 5.11 | 5.30 | 6.22 | 6.80 | 6.52 | 6.80 | 6.80 | 6.65 |
| α - | 1.29 | 0.29 | 1.30 | 1.50 | 1.44 | 1.21 | 1.58 | 1.64 | 1.77 | 1.70 |
| β Phylanderene | 9.25 | 10.0 | 10.22 | 10.2 | 10.00 | 10.00 | 10.2 | 10.45 | 10.4 | 10.38 |
| Limonene | 2.05 | 1.88 | 2.55 | 2.33 | 2.57 | 2.2.6 | 2.61 | 2.80 | 2.90 | 2.76 |
| Linalool | 4.85 | 2.29 | 5.00 | 5.72 | 6.22 | 6.21 | 7.35 | 6.55 | 7.80 | 7.70 |
| Linalyl acetate | 12.79 | 16.4 | 17.2 | 16.9 | 11.55 | 11.5 | 10.4 | 17.50 | 17.8 | 17.88 |
| Terpine-4-ol | 26.46 | 26.2 | 27.85 | 28.4 | 20.1 | 21.55 | 24.8 | 22.30 | 23.4 | 25.51 |
| Thymol | 1.00 | 0.89 | 1.00 | 0.90 | 0.78 | 0.68 | 0.77 | 0.88 | 0.88 | 0.76 |
| α -Terpineol | 3.55 | 3.01 | 3.00 | 2.90 | 3.33 | 3.50 | 3.41 | 4.11 | 3.70 | 3.90 |
| β - | 3.01 | 2.47 | 1.70 | 2.00 | 1.55 | 1.44 | 1.97 | 1.01 | 0.96 | 0.45 |
| Total | 77.72 | 82.5 | 87.39 | 90.27 | 74.77 | 74.67 | 81.4 | 86.49 | 89.3 | 90.83 |

Ha= Humic acid

Pb= Potassium benzoate

Sa= Salicylic acid

II.6- Percentages of Nitrogen, Phosphorous and Potassium (K) contents

The effect of different foliar fertilization treatments on the content of nitrogen, phosphorous and potassium percentage of marjoram leaves in the two seasons are presented in Table (6), in general, the high amount of humic acid of 2.0 g/l was the most effective treatment for increasing percentages of N and P contents and of marjoram shoot (giving, 2.48, 0.56 %) and (2.44, 0.65 %) of N and P contents in the two seasons, respectively while the highest percentage of K (2.25

and 2.30 %) was obtained from plants treated with potassium benzoate at 2.0 g/L compared with control in both seasons, respectively. The results of the present investigations are in close agreement with the findings El-Khateeb *et al.*, (2010) on *Calia secundiflora* plants.

Concerning the effect salicylic acid, data in Table (6), showed that significant increases in N, P and K percentages were noticed during the two tested seasons under the effect for salicylic acid applications. Using salicylic acid at 2.0 g/l was the best treatment for enhancing N, P and K percentages on shoots. The increases in N, P and K percentages were recorded in the two seasons as a result of the different foliar fertilization rates of SA are in agreement with the findings of Muhal *et al.*, (2014) reported that, foliar spray of SA significantly influenced N and P uptake of *Brassica* species.

Table 6. Effect of using some phenolic chelate compounds on N, P and K contents of marjoram (*Majorana hortensis* L) plants during two seasons 2017 and 2018.

| Treatments | N, P and K contents (%) | | | | | |
|----------------------------|-------------------------|------|------|--------------------|------|------|
| | First season 2017 | | | Second season 2018 | | |
| | N % | P % | K % | N % | P % | K % |
| Control | 2.00 | 0.23 | 1.68 | 2.05 | 0.27 | 1.74 |
| Humic acid 1.0g/L | 2.10 | 0.31 | 1.53 | 2.20 | 0.40 | 1.79 |
| Humic acid 1.5 g/L | 2.21 | 0.35 | 1.65 | 2.31 | 0.47 | 1.85 |
| Humic acid 2.0 g/L | 2.48 | 0.56 | 1.88 | 2.44 | 0.65 | 1.95 |
| Potassium benzoate 1.0 g/L | 2.00 | 0.25 | 1.80 | 2.10 | 0.27 | 2.05 |
| Potassium benzoate 1.5 g/L | 2.00 | 0.25 | 1.95 | 2.14 | 0.33 | 2.00 |
| Potassium benzoate 2.0 g/L | 2.25 | 0.34 | 2.25 | 2.19 | 0.48 | 2.30 |
| Salicylic acid 1.00 g/L | 2.02 | 0.25 | 1.68 | 2.12 | 0.29 | 1.75 |
| Salicylic acid 1.5 g/L | 2.25 | 0.28 | 1.70 | 2.18 | 0.29 | 1.79 |
| Salicylic acid 2.0 g/L | 2.31 | 0.39 | 1.75 | 2.35 | 0.42 | 1.81 |
| LSD at: 0.05 | 0.22 | 0.07 | 0.17 | 0.26 | 0.14 | 0.21 |

CONCLUSION

The foliar fertilization by different concentrations of salicylic acid, potassium benzoate, and humic acid treatments an integrated system to reduce the infestation percent of *Aphis gossypii*, *Thrips tabaci*, and *Tetranychus urticae* and increasing plant growth , yield, and essential oil of marjoram.

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تأثير التسميد ببعض المركبات الفينولية وحامض الهيوميك على حساسية البردقوش للإصابة بالحشرات و الأكاروس و الصفات النباتية

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1. معهد بحوث البساتين - مركز البحوث الزراعية

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أجريت الدراسة الحالية خلال موسمين متتاليين عام 2017 و 2018 بمحافظة الجيزة ، لدراسة تأثير بعض المركبات الفينولية (حامض الهيوميك ، بنزوات البوتاسيوم وحمض الساليسيليك) في ثلاثة مستويات (1.0 ، 1.5 ، 2.0 جرام/لتر) على قابلية نباتات المردقوش للإصابة ب (من الكرنب - تربس البصل - العنكبوت الأحمر) بالإضافة إلى تأثيره على المحصول وخصائص النمو ومحتوياته من الزيوت الأساسية.

أثبتت النتائج أنه باستخدام 2.0 جرام /لتر من حمض الساليسيليك ، بنزوات البوتاسيوم وحامض الهيوميك كسماد للنبات البردقوش ، تسبب في ظهور خفض معنوي واضح في الإصابة بالآفات المستهدفة ، وكذلك التأثير على خصائص النمو. أشارت النتائج إلى أن الرش الورقي بـحمض الهيوميك 2.0 جم. / لتر في الحشة الأولى والثانية في كلا الموسمين أدى إلى زيادة عدد الفروع لكل نبات بالإضافة إلى زيادة في ارتفاع النبات ، أيضا ، تسبب زيادة كبيرة في الأوزان الطازجة والجافة.أيضاً تم الحصول على أعلى إنتاجية / نبات مع استخدام حمض الساليسيليك 2.0جم/لتر. تمت زيادة مساحة الورقة (سم²) من البردقوش بواسطة رش ورقي مختلف بـكلاً من حمض الهيوميك وحمض الساليسيليك في الحشة الأولى والثانية من كلا الموسمين. بينما أعطى الرش الورقي من بنزوات البوتاسيوم نتائج أقل كفاءة.

