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INFLUENCE OF HUMIC ACID RATES AND APPLICATION TIMES ON VEGETATIVE GROWTH AND YIELD COMPONENTS OF CHAMOMILE (*Matricaria chamomilla*, L.) PLANTS GROWN UNDER RECLAIMED SANDY SOIL CONDITIONS

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ABSTRACT: Two field experiments were carried out at a Private Farm in Qeft District, Qena Governorate, Egypt, during the two consecutive seasons of 2016/2017 and 2017/2018. To study the effect of humic acid rates (0.0, 1.0, 2.0 and 3.0 l/fad.), sprays number (one, two, three and four times at 25, 25 and 40 , 25, 40 and 55 as well as 25, 40, 55 and 70 days after planting, respectively and their combinations on vegetative growth, flower yield components and volatile oil production of chamomile plant. The obtained results referred to that the maximum values of plant height, branch number/plant, herb dry weight/plant as well as air-dry weight of flower heads/ plant and/fad., were detected when chamomile plants were applied with the highest rate of humic acid and sprayed three times during the season, in most cases. In the same time, the treatment of humic acid rate at 3 l/faddan combined with three application times was superior treatment in volatile oil percentage in flower heads and volatile oil yield (ml/ plant and l/faddan) of chamomile compared to the other ones under study during both seasons. Generally, this combination treatment seems promising in the development of sustainable crop growth and yield advantages under Qena Governorate conditions.

Key words: Chamomile, humic acid, rates, application times, growth, yield, volatile oil.

INTRODUCTION

Chamomile (*Matricaria chamomilla*, L.) is an annual plant belongs to Family Asteraceae. Chamomile is the most important medicinal plants worldwide. This plant has been used for thousands of years in traditional Roman, Greek and Egyptian medicine to treat different diseases such as anxiety, chest colds, psoriasis and insomnia **(Andrzejewska and Woropaj-Janczak, 2014)**. Later, one third of human demands for drugs are acquired from medicinal and aromatic plants **(Agatonovic-Kustrin *et al.*, 2015)**. In addition, increasing demand of pharmaceutical factories for primary materials, more importantly, conservation of natural genetic resources and lay emphasis on the production as well as research on enhancing and processing of medicinal and aromatic plants.

Humic acid is part of the humus compounds which plays an important role in balance plant nutrition by improving physical, chemical and biological properties of soil. **Mikkelsen (2005)** reported that humic acid has a high molecular weight and high complexation ability. **Sangeetha *et al.* (2006)** indicated that humic material have two direct and indirect effects on physiological and biochemical processes in plant and on physical, chemical, and biological properties of soil.

Timing of fertilizer application highly influenced the yield and yield components of many crops (**Loecke *et al.*, 2004**). This is in interaction with other management factors such as, irrigation, application of pesticides and harvesting times (**Bush and Austin, 2001**). However, **Khazaie *et al.* (2011)** demonstrated that above ground and leaf biomass of hyssop

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showed higher values in both years at two times (38 and 85 days after transplanting) applications. Total essential oil yield of hyssop was not different in response to different application times in 2008 and 2009. The highest and lowest oil production obtained at two times application (13.38 $g.m^{-2}$) and at one time application (11.79 $g.m^{-2}$) in 2009.

So, the present investigation carried out to examine the effects of humic acid treatments (rates and sprays number) on growth characteristics, flower heads yield components and oil production of *Matricaria chamomilla*, L. plants under reclaimed sandy soil conditions.

MATERIALS AND METHODS

Two field experiments were conducted at a Private Farm in Qeft District, Qena Governorate, Egypt during the two consecutive seasons of 2016/2017 and 2017/2018. To study the effect of humic acid rates, sprays number and their combination treatments on vegetative growth, flower yield components and volatile oil production of chamomile (*Matricaria chamomilla*) plant.

Seeds of chamomile were obtained from Research Centre of Medicinal and Aromatic Plants, Dokky, Giza, Egypt. The seeds were sown in the nursery on 9th November, in the two seasons. The physical and chemical properties of the used soil were shown in Table A, according to **Chapman and Pratt (1978)**.

Chamomile transplants (42 days old and about 10 cm lengths) were transplanted on 21th December in both seasons. Seedlings were transplanted on one side of each ridge in 60 cm width and 20 cm apart. Each plot consists of six ridges; each one is 2 m long. The area of the experimental unit was 7.20 m^2.

The current investigation was achieved to study the following points:

Studying the Effects of Humic Acid Rates on Chamomile Plants

Control (tap water), 1, 2 and 3 l/fad.

Studying the Effects of Sprays Number on Chamomile Plants

One spray at 25 days after planting, tow sprays at 25 and 40 days after planting, three sprays at 25, 40 and 55 days after planting and four sprays at 25, 40, 55 and 70 days after planting (Schedule 1).

Studying the Combined Effects Between Humic Acid Rates and Sprays Number Treatments on Chamomile Plant

Each treatment of humic acid rate was combined with one of spray number to from 16 treatments.

The statistical layout of this experiment was split-plot experiment between humic acid (four rates) and sprays number (four treatments) in randomized complete blocks design with three replicates. Every plot was 3.60 × 2.00 m. Three plants from each replication were randomly selected for determining growth characters, flower heads yield and volatile oil production.

Vegetarian humic acid fertilizer (Grow Tech. for Agricultural Development Company) contains 86% humic acid. Humic acid rates were applied as foliar spray during the vegetative period starting 25 days intervals from transplanting time every 15 days.

All agricultural practices (fertilization, irrigation, *etc.*) were performed as usual, in the region for the production of chamomile plants.

Data Recorded

A random sample of three plants from each sub plot was taken; the 1st and 2nd cuts were done 70 and 110 days after planting and the following data were recorded:

Growth parameters

Plant height (cm), number of branches /plant and herb dry weight /plant (g) was determined in the two cuts during both seasons.

Flower heads yield components

Flower heads number/plant, flower heads air-dry weight/plant (g) and flower heads air-dry weight/faddan (kg) were recorded after every cut during both seasons.

Schedule 1. The rates and application times of humic acid during the growing season

kg/fad.	Application times (kg/fad.) as foliar spray			
	1	2	3	4
1	1	0.5	0.335	0.25
2	2	1.0	0.670	0.50
3	3	1.5	1.000	0.75
Control	-	-	-	-

Table A. Physical and chemical properties of experimental farm soil (average of the two seasons)

Mechanical analysis			Soil texture
Clay (%)	Silt (%)	Sand (%)	Sandy
9.45	5.70	84.85	

Chemical analysis											
pH	E C m.mohs/cm	Soluble cations (meq. / l)				Soluble anions (meq. / l)			Available (ppm)		
		Mg^{++}	Ca^{++}	K^{+}	Na^{+}	Cl^{-}	HCO_3^{-}	SO_4^{--}	N	P	K
7.80	0.78	2.8	3.6	2.3	0.9	1.5	0.5	5.0	0.04	8.30	0.2

Volatile oil production

At harvest time (at the end of every cut), about 10 g of each air dried sample (flower heads) was taken. Both samples were mixed and the sample was taken to represent each growing season, then it was separated triturated and steam-hydro distilled for 3 hours. The extraction of oils was carried out according to method of **European Pharmacopoeia (1983)**. Also, volatile oil yield per chamomile plant (ml) and per faddan (l) was calculated.

Statistical Analysis

Data of the present work were statically analyzed and the differences between the means of the treatments were considered significant when they were more than the least significant differences (LSD) at the 5% level by using computer program of Statistix Version 9 (**Analytical Software, 2008**).

RESULTS AND DISCUSSION

Growth Parameters

It is evident from the obtained results in Tables 1, 2 and 3 that plant height, number of branches/ plant and herb dry weight/plant of *Matricaria chamomilla* increased by increasing humic acid rate, in most cases. Moreover, the humic acid rates 3 l/faddan gave significant increases in this regard compared to control and other treatments at both cuts in the two seasons, in most cases.

Different application time numbers of humic acid showed impact (P> 0.05) on chamomile plant growth parameters in the two cuts during both seasons (Tables 1, 2 and 3). The highest values in plant height were detected at four times with no significant differences in the second season compared with the other treatments under study. Moreover, the number of branches and herb dry weight/chamomile plant

Table 1. Effect of humic acid rate, number of spraying and their combinations on plant height (cm) of chamomile plant in the two cuts during the two seasons of 2016/2017 and 2017/2018

Humic acid rate as l/fad. (HR)	Humic acid sprays number (HN)									
	One time	Two times	Three times	Four times	Mean (HR)	One time	Two times	Three times	Four times	Mean (HR)
	First season (2016/2017)									
	First cut					Second cut				
Control	66.33	82.33	72.33	75.67	**74.17**	70.67	80.00	76.33	80.33	**76.83**
1	77.00	77.67	69.33	87.00	**77.75**	83.33	80.67	75.00	87.33	**81.58**
2	65.33	77.33	71.00	67.00	**70.17**	70.00	80.00	78.00	70.00	**74.50**
3	72.00	75.67	93.00	77.00	**79.42**	74.67	69.33	101.67	80.33	**81.50**
Mean (HN)	**70.17**	**78.25**	**76.42**	**76.67**		**74.67**	**77.50**	**82.75**	**79.50**	
LSD at 5%	HR = 8.98		HN= 6.70	HR× HN= 14.62		HR = NS		HN= 5.12	HR× HN= 12.29	
	Second season (2017/2018)									
	First cut					Second cut				
Control	65.00	67.33	65.00	64.67	**65.50**	70.00	76.67	76.33	76.00	**74.75**
1	65.00	68.67	64.67	69.00	**66.83**	73.00	75.67	72.00	75.67	**74.08**
2	69.00	67.67	70.00	72.00	**69.67**	75.33	74.33	77.67	78.33	**76.42**
3	74.00	73.33	69.67	71.00	**72.00**	80.67	77.67	76.33	76.33	**77.75**
Mean (HN)	**68.25**	**69.25**	**67.33**	**69.17**		**74.75**	**76.08**	**75.58**	**76.58**	
LSD at 5%	HR = 2.98		HN= NS	HR× HN= 6.31		HR = NS		HN= NS	HR× HN= 7.42	

Table 2. Effect of humic acid rate, number of spraying and their combinations on number of branches/plant of chamomile plant in the two cuts during the two seasons of 2016/2017 and 2017/2018

Humic acid rate as l/fad. (HR)	Humic acid sprays number (HN)									
	One time	Two times	Three times	Four times	Mean (HR)	One time	Two times	Three times	Four times	Mean (HR)
	First season (2016/2017)									
	First cut					Second cut				
Control	10.00	12.33	14.33	12.33	**12.25**	12.00	14.67	16.00	13.33	**14.00**
1	12.67	11.33	13.33	10.67	**12.00**	12.67	15.00	18.00	15.00	**15.17**
2	11.67	11.67	14.00	12.67	**12.50**	13.33	15.00	19.33	15.00	**15.67**
3	13.33	13.00	17.00	14.67	**14.50**	13.33	18.33	18.00	16.00	**16.42**
Mean (HN)	**11.92**	**12.08**	**14.67**	**12.58**		**12.83**	**15.75**	**17.83**	**14.83**	
LSD at 5%	HR = 1.39		HN= 2.34	HR× HN= 4.29		HR = 2.04		HN= 1.25	HR× HN= 2.97	
	Second season (2017/2018)									
	First cut					Second cut				
Control	11.67	14.33	16.67	15.00	**14.42**	14.33	17.00	19.00	17.00	**16.83**
1	12.33	14.00	16.00	13.33	**13.92**	15.00	18.00	21.33	18.33	**18.17**
2	13.00	15.33	17.67	14.67	**15.17**	16.67	17.33	22.33	19.00	**18.83**
3	13.00	16.00	19.00	18.33	**16.58**	15.33	20.00	22.67	18.00	**19.00**
Mean (HN)	**12.50**	**14.92**	**17.33**	**15.33**		**15.33**	**18.08**	**21.33**	**18.08**	
LSD at 5%	HR = 1.49		HN= 1.21	HR× HN= 2.57		HR = 1.82		HN= 0.77	HR× HN= 2.25	

Table 3. Effect of humic acid rate, number of spraying and their combinations on herb dry weight/plant (g) of chamomile plant in the two cuts during the two seasons of 2016/2017 and 2017 /2018

Humic acid rate as l/fad. (HR)	Humic acid sprays number (HN)									
	One time	Two times	Three times	Four times	Mean (HR)	One time	Two times	Three times	Four times	Mean (HR)
	First season (2016/2017)									
	First cut					Second cut				
Control	13.02	16.97	29.14	21.14	**20.07**	13.77	10.08	32.52	23.47	**21.96**
1	20.35	21.12	32.32	29.41	**25.80**	22.01	23.84	35.71	30.41	**27.99**
2	22.78	25.09	36.67	29.38	**28.48**	23.52	25.46	39.76	32.19	**30.23**
3	23.20	26.18	41.63	32.43	**30.86**	25.18	30.04	44.01	34.01	**33.31**
Mean (HN)	**19.83**	**22.34**	**34.94**	**28.09**		**21.12**	**24.35**	**38.00**	**30.02**	
LSD at 5%	HR = 0.96		HN= 0.90		HR× HN= 1.83	HR = 1.15		HN= 1.09		HR× HN= 2.21
	Second season (2017/2018)									
	First cut					Second cut				
Control	14.47	17.12	29.83	22.13	**20.89**	10.00	18.43	28.62	22.63	**21.92**
1	21.67	21.36	32.26	28.71	**26.00**	20.75	23.73	32.45	29.54	**26.62**
2	21.71	25.64	35.49	29.98	**28.20**	20.21	25.55	39.82	33.16	**29.68**
3	24.22	27.33	40.82	31.77	**31.03**	25.74	28.65	44.51	31.42	**32.58**
Mean (HN)	**20.52**	**22.86**	**34.60**	**28.15**		**21.18**	**24.09**	**36.35**	**29.19**	
LSD at 5%	HR = 0.97		HN= 0.82		HR× HN= 1.71	HR = 1.07		HN= 0.76		HR× HN= 1.69

was significantly increased in response to different application times in the two cuts during both seasons, also, the best treatment in this connection was that of adding humic acid three times /season compared to the other ones under study.

Increasing humic acid rates from 0 to 3 l/faddan induced highest combination with three addition number treatment on growth parameters (plant height, number of branches/ plant and herb dry weight/plant) of chamomile plant in the two cuts during the two tested seasons, in most cases (Tables 1, 2 and 3). Generally, under each addition number of humic acid, increasing humic acid rates gradually increased abovementioned parameters.

These results might be due to the role of humic acid which is a product contains many elements which improve the soil fertility and increase the availability of nutrient elements by holding them on mineral surfaces and consequently affect plant growth leading to taller, more branches and leaves and heaviest plants (**Akinci *et al*., 2009**).

These results are in similar with those stated by **Ahmed *et al*. (2011)** on roselle, **Mohammadipour *et al*. (2012)** on marigold, **Hendawy *et al*. (2015)** *Mintha piperita* var. *citrate*, **El-Khateeb *et al*. (2017)** on marjoram and **Yousif (2018)** on garlic.

However, in this respect, **Mohammed *et al*. (2019**) indicated that the maximum value for each of plant height, branch and leaf number/ plant and total dry weight/plant of stevia plant were detected when plants were applied with the highest rate of humic acid.

Flower Heads Yield Components

Results tabulated in Tables 4, 5 and 6 shows that increasing humic acid rates gradually increased number of flower heads/ plant as well as flower heads air-dry/plant (g) and/faddan (kg). Furthermore, all humic rates (1. 2 and 3 l/fad.) significantly increased flower heads yield component compared to control in the two cuts during both seasons.

Number of flower heads/chamomile plant as well as flower heads air-dry /plant and /faddan

Table 4. Effect of humic acid rate, number of spraying and their combinations on flower heads number /plant of chamomile plant in the two cuts during the two seasons of 2016/2017 and 2017 /2018

Humic acid rate as l/fad. (HR)	Humic acid sprays number (HN)									
	One time	Two times	Three times	Four times	Mean (HR)	One time	Two times	Three times	Four times	Mean (HR)
	First season (2016/2017)									
	First cut					**Second cut**				
Control	68.67	76.67	80.00	78.00	**75.83**	70.00	91.33	115.67	113.67	**97.67**
1	72.67	86.00	112.33	95.00	**91.50**	100.00	129.33	137.67	118.33	**121.33**
2	79.33	97.00	121.33	104.00	**100.42**	107.33	137.33	147.33	141.00	**133.25**
3	86.00	132.00	171.67	123.00	**128.17**	125.00	143.67	212.33	176.67	**164.42**
Mean (HN)	**76.67**	**97.92**	**121.33**	**100.00**		**100.58**	**125.42**	**153.25**	**137.42**	
LSD at 5%	HR = 3.75		HN= 3.82		HR× HN= 7.59	HR = 3.81		HN= 5.98		HR× HN= 11.02
	Second season (2017/2018)									
	First cut					**Second cut**				
Control	97.00	99.67	113.67	112.00	**105.58**	110.67	119.33	125.00	122.00	**119.25**
1	102.00	128.33	148.67	130.00	**127.25**	135.67	171.33	191.00	174.67	**168.17**
2	108.67	147.67	184.00	152.00	**148.08**	136.33	185.67	210.67	179.00	**177.92**
3	108.33	176.33	230.00	188.33	**175.75**	142.00	192.33	243.67	192.33	**192.58**
Mean (HN)	**104.00**	**138.00**	**169.08**	**145.58**		**131.17**	**167.17**	**192.58**	**167.00**	
LSD at 5%	HR = 8.97		HN= 7.23		HR× HN= 15.37	HR = 4.88		HN= 5.06		HR× HN= 10.01

Table 5. Effect of humic acid rate, number of spraying and their combinations on flower heads air-dry weight/plant (g) of chamomile plant in the two cuts during the two seasons of 2016/2017 and 2017/2018

Humic acid rate as l/fad. (HR)	Humic acid sprays number (HN)									
	One time	Two times	Three times	Four times	Mean (HR)	One time	Two times	Three times	Four times	Mean (HR)
	First season (2016/2017)									
	First cut					**Second cut**				
Control	1.98	2.29	2.30	2.20	**2.19**	2.15	2.71	3.44	3.34	**2.91**
1	2.09	2.42	3.09	2.74	**2.58**	2.80	3.85	4.02	3.44	**3.53**
2	2.26	2.77	2.71	2.96	**2.67**	3.12	4.01	4.42	4.10	**3.91**
3	2.39	3.67	4.73	3.75	**3.64**	3.77	4.40	6.50	5.32	**5.00**
Mean (HN)	**2.18**	**2.79**	**3.21**	**2.91**		**2.96**	**3.74**	**4.59**	**4.05**	
LSD at 5%	HR = 0.19		HN= 0.15		HR× HN= 0.32	HR = 0.11		HN= 0.16		HR× HN= 0.30
	Second season (2017/2018)									
	First cut					**Second cut**				
Control	2.36	2.41	2.76	2.58	**2.53**	3.54	3.80	3.97	3.75	**3.77**
1	2.41	3.08	3.56	3.20	**3.06**	4.25	5.41	5.92	5.44	**5.25**
2	2.65	3.60	4.51	3.73	**3.62**	4.35	5.89	6.73	5.57	**5.63**
3	2.61	4.30	5.64	4.60	**4.29**	4.47	6.08	7.72	6.08	**6.08**
Mean (HN)	**2.51**	**3.35**	**4.12**	**3.53**		**4.15**	**5.29**	**6.08**	**5.21**	
LSD at 5%	HR = 0.16		HN= 0.16		HR× HN= 0.33	HR = 0.25		HN= 0.17		HR× HN= 0.39

Table 6. Effect of humic acid rate, number of spraying and their combinations on flower heads air-dry weight/faddan (kg) of chamomile plant in the two cuts during the two seasons of 2016/2017 and 2017/2018

Humic acid rate as l/fad. (HR)	Humic acid sprays number (HN)									
	One time	Two times	Three times	Four times	Mean (HR)	One time	Two times	Three times	Four times	Mean (HR)
First season (2016/2017)										
	First cut					**Second cut**				
Control	66.00	76.33	76.67	73.33	**73.08**	71.76	90.46	114.76	111.34	**97.08**
1	69.55	80.78	102.89	91.23	**86.11**	93.54	128.42	133.96	114.96	**117.72**
2	75.33	92.45	90.33	98.67	**89.20**	103.86	133.64	147.20	136.74	**130.36**
3	79.78	122.34	157.67	125.11	**121.23**	125.56	146.50	216.78	177.44	**166.57**
Mean (HN)	**72.67**	**92.97**	**106.89**	**97.09**		**98.68**	**124.76**	**153.18**	**135.12**	
LSD at 5%	HR = 6.25		HN= 5.05		HR× HN= 10.72	HR = 3.82		HN= 5.34		HR× HN= 10.00
Second season (2017/2018)										
	First cut					**Second cut**				
Control	78.73	80.42	92.17	86.18	**84.38**	118.01	126.70	132.42	125.03	**125.54**
1	80.30	102.74	118.62	106.60	**102.06**	141.68	180.47	197.20	181.45	**175.20**
2	88.32	120.17	150.29	124.21	**120.75**	145.00	196.43	224.32	185.65	**187.85**
3	86.92	143.36	187.90	153.32	**142.87**	148.95	202.57	257.26	202.57	**202.83**
Mean (HN)	**83.56**	**111.67**	**137.25**	**117.58**		**138.41**	**176.54**	**202.80**	**173.67**	
LSD at 5%	HR = 5.46		HN= 5.50		HR× HN= 10.96	HR = 8.50		HN= 5.87		HR× HN= 13.21

significantly increased with two and three times application compared to control in the two cuts during both seasons (Tables 4, 5 and 6). In the other words, the best treatment in increase flower heads yield component was that the treatment of three times addition compared with the other ones under study.

In addition, under each addition number of humic acid flower heads yield component parameters was gradually increased with increasing humic acid rates. In the same time, the combination treatment between humic acid rate of 3 l/faddan and three times of humic acid addition as foliar spray was superior in this respect compared to the other ones under study in the two cuts during the first and second seasons (Tables 4, 5 and 6). Also, under each humic acid rates number of flower heads/plant as well as flower heads air-dry per plant and per faddan was gradually increased by increasing humic acid application number up to 2 times then it was decreased.

The results are in conformity with the findings of **Karakurt *et al.* (2009)** on pepper, **Azarpour *et al.* (2011)** on cowpea and **Khater and Abd El-Azim (2016)** on *Plantago psyllium* plants. However, **Abdellatif *et al.* (2017)** pointed out that application of humic acid (HA) during the summer season targeted great results on tomato plant growth and productivity. Humic acid at 14.4 kg.ha^{-1} increased the flowering parameters (number of flower clusters and flowers per plant) as well as yield characters (fruit number per plant and fruit weight, which resulted in higher early and total yield) in both seasons. Also, humic acid foliar application could increase seed number/siliqua, biological yield and seed yield/hectare of canola cultivars (**Barekati *et al.*, 2019**).

Volatile Oil Production

Results of both seasons in Tables 7, 8 and 9 indicate that volatile oil percentage in flower heads as well as volatile oil yield per plant (ml) and per faddan (l) of *Matricaria chamomilla* gradually increased by increasing humic acid rate. Furthermore, the humic acid rates 3 l/faddan gave significant increases in this concern compared to control and other treatments at both cuts in the two seasons. Generally, all humic rates significantly increased chamomile

Table 7. Effect of humic acid rate, number of spraying and their combinations on volatile oil percentage of chamomile plant during the two seasons of 2016/2017 and 2017/2018

Humic acid rate as l/fad. (HR)	Humic acid sprays number (HN)									
	One time	Two times	Three times	Four times	Mean (HR)	One time	Two times	Three times	Four times	Mean (HR)
	First season (2016/2017)					Second season (2017/2018)				
Control	0.708	0.875	0.939	0.910	**0.858**	0.750	0.904	0.942	0.939	**0.884**
1	0.727	0.977	1.121	1.084	**0.977**	0.917	1.020	1.317	1.112	**1.091**
2	0.740	1.022	1.126	1.114	**1.000**	0.929	1.115	1.229	1.035	**1.077**
3	0.817	1.078	1.234	1.148	**1.069**	0.993	1.161	1.418	1.194	**1.191**
Mean (HN)	**0.748**	**0.988**	**1.105**	**1.064**		**0.897**	**1.050**	**1.227**	**1.070**	
LSD at 5%	HR = 0.048		HN= 0.017		HR× HN= 0.056	HR = 0.065		HN= 0.047		HR× HN= 0.10

Table 8. Effect of humic acid rate, number of spraying and their combinations on volatile oil yield/plant (ml) of chamomile plant during the two seasons of 2016/2017 and 2017 /2018

Humic acid rate as l/fad. (HR)	Humic acid sprays number (HN)									
	One time	Two times	Three times	Four times	Mean (HR)	One time	Two times	Three times	Four times	Mean (HR)
	First season (2016/2017)					Second season (2017/2018)				
Control	0.029	0.044	0.054	0.050	**0.044**	0.044	0.056	0.064	0.059	**0.056**
1	0.035	0.061	0.080	0.067	**0.061**	0.061	0.087	0.124	0.096	**0.092**
2	0.040	0.069	0.080	0.078	**0.067**	0.065	0.106	0.138	0.096	**0.101**
3	0.050	0.087	0.139	0.104	**0.095**	0.070	0.120	0.189	0.128	**0.127**
Mean (HN)	**0.039**	**0.065**	**0.088**	**0.075**		**0.060**	**0.092**	**0.129**	**0.095**	
LSD at 5%	HR = 0.003		HN= 0.002		HR× HN= 0.006	HR = 0.004		HN= 0.005		HR× HN= 0.009

Table 9. Effect of humic acid rate, number of spraying and their combinations on volatile oil yield/faddan (l) of chamomile plant during the two seasons of 2016/2017 and 2017 /2018

Humic acid rate as l/fad. (HR)	Humic acid sprays number (HN)									
	One time	Two times	Three times	Four times	Mean (HR)	One time	Two times	Three times	Four times	Mean (HR)
	First season (2016/2017)					Second season (2017/2018)				
Control	0.976	1.458	1.797	1.681	**1.478**	1.475	1.873	2.117	1.983	**1.862**
1	1.185	2.043	2.656	2.234	**2.029**	2.035	2.888	4.142	3.202	**3.067**
2	1.325	2.311	2.674	2.623	**2.233**	2.169	3.532	4.605	3.209	**3.379**
3	1.676	2.900	4.622	3.472	**3.167**	2.343	4.017	6.313	4.250	**4.231**
Mean (HN)	**1.291**	**2.178**	**2.937**	**2.502**		**2.006**	**3.077**	**4.294**	**3.161**	
LSD at 5%	HR = 0.119	HN= 0.085	HR× HN= 0.188			HR = 0.156	HN= 0.156	HR× HN= 0.311		

volatile oil production compared to control in the two cuts during both seasons.

Likewise, volatile oil percentage and volatile oil yield per plant and per faddan significantly increased with two and three number of humic acid application compared to control in the two cuts during both seasons (Tables 7, 8 and 9). The highest values in chamomile volatile oil production were obtained by the treatment of three times addition compared with the other ones under study.

Similarly, the treatment of humic acid rate at 3 l/faddan combined with three times addition was superior in volatile oil percentage in flower heads and volatile oil yield (ml/plant and l/faddan) of chamomile compared to the other ones under study in the two cuts during both seasons (Tables 7, 8 and 9). However, under each addition number of humic acid volatile oil production was gradually increased with increasing humic acid rates. Also, under each humic acid rate above-mentioned parameters were gradually increased due to increasing humic acid application number up to 2 times then it was decreased.

These results also found by **Juarez *et al.* (2011)** who indicated that the essential oil percentage and yield were higher at the highest levels of humic acid compared to control. Moreover, the increases in essential oil yield/ plant by humic acid treatments can be owing to the increase of oil (%) of dried herb and the improvement of herb yield of *Calendula officinalis* plant (**Mohammadipour *et al.*, 2012**). Also, **Bayat and Belopukhov (2019)** illustrated that the application of humic acid causes increasing of all the traits studied. The highest amount of essential oil content of sweet basil (1.1%) were observed at 6 l/ha humic acid.

Conclusion

Taking these results into account, it was generally concluded that growth, flower heads yield and its component and volatile oil production of *Matricaria chamomilla* plant are widely affected by applying humic acid rates and application times. In general, the increase in growth and productivity of plants as well as volatile oil yields is closely related to the amount of the applied 3 l/fad. in combined with three times of humic application, which led to the increase in air-dry flower heads yields that are considered as the main components of growth and development of most of aromatic plants.

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تأثير معدلات حامض الهيوميك وعدد مرات الإضافة على النمو الخضري ومكونات المحصول لنباتات شيح البابونج النامية تحت ظروف الأراضي الرملية المستصلحة

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أجريت تجربتان حقليتان في مزرعة خاصة بمركز قفط بمحافظة قنا، مصر خلال الموسمين المتتاليين لأعوام ٢٠١٦/٢٠١٧ و ٢٠١٧/٢٠١٨، لدراسة تأثير معدلات حمض الهيوميك (صفر، ١,٠ ، ٢,٠ و ٣,٠ لتر/فدان)، عدد الرشات (مرة واحدة، اثنان، ثلاث وأربع مرات) بعد ٢٥؛ ٢٥ و ٤٠؛ ٢٥ ، ٤٠ و ٥٥؛ ٢٥، ٤٠ ، ٥٥ و ٧٠يوماً، على التوالي، من تاريخ الشتل) والتداخل بينها على النمو الخضري ومحصول الرؤوس الزهرية وإنتاج الزيت العطري لنبات البابونج، وأشارت النتائج التي تم الحصول عليها إلى أن القيم القصوى لارتفاع النبات وعدد الأفرع/نبات والوزن الجاف للعشب/النبات وكذلك الوزن الجاف هوائياً للرؤوس الزهرية/نبات و/الفدان عند معاملة نباتات شيح البابونج بأعلى معدل من حمض الهيوميك ورشه ثلاث مرات خلال الموسم، في معظم الحالات، في الوقت ذاته، كانت معاملة معدل حامض الهيوميك بمعدل ٣ لتر/فدان مع رشه ثلاث مرات متفوقة في نسبة الزيت العطري بالرؤوس الزهرية وإنتاجية الزيت العطري (مللي/نبات ولتر/فدان) من شيح البابونج مقارنة بالمعاملات الأخرى قيد الدراسة خلال كلا الموسمين، عموماً، تبدو معاملة التداخل سالفة الذكر واعدة في تطوير نمو النبات وزيادة المحصول تحت ظروف محافظة قنا.

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