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Benefit Maximize by Application of Humic Acid and Magnetized Water for Controlling *Meloidogyne javanica* Infected Khella Plants in Relation to Improve growth and Active Constituents

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ABSTRACT

Pot experiments were carried out for exploration responsiveness to application of five Humic acid (HA) concentration rates (0,500,1000,1500 and 2000 ppm) and with irrigation by magnetized water (MW), solely or combined for controlling *Meloidogyne javanica* infected khella plants (*Ammi visnaga* L.) in relation to its morphological characters; yield parameters and medicinal components through two winter seasons (2012 and 2013) under shield conditions. Generally, all treatments reduced significantly number of root galls; egg-masses; soil, root population density of the *M. javanica* and increased tested plant morphological characters i.e., plant height; number of main branches; fresh weight of whole plant and yield parameters such as, number of umbels; its fresh and dry weights (g/plant), and fruit yield (g/plant).Dual application of both HA and irrigation with MW combined gave better results more than the solely one in controlling of *M. javanica* and all plant characteristics during the tested two winter seasons. Combined treatment of (HA 1500 ppm + MW) gave the highest reduction percentages in *M. javanica* population (71.0 and 71.8%) through the two successive seasons, respectively. In addition, application of the same combined treatment gave a best results of gall index (1.5 and 1.5); egg-masses production (7.0 and 8.0), in the both seasons, respectively, and a better enhancement in Khella morphological characters and its yield parameters. Highest value of khellin % explicitly was obtained by using 1000 ppm HA+MW and 1500 ppm HA +MW during the two successive winter seasons, respectively.

Key words: Control, *Meloidogyne javanica*, Humic acid, magnetized water, *Ammi visnaga*

INTRODUCTION

Khella plants (*Ammi visnaga* L.) is a member of the family Apiaceae (Umbelliferae); native to the Mediterranean and cultivated area in Egypt (Rechinger, 1972). A. visnaga is antiasthmatic, diuretic and vasodilator. It is an effective muscle relaxant and has been used for centuries to alleviate the excruciating pain of kidney stones (Chevallier, 1996). The medicinal properties of *A. visnaga* against coronary diseases and bronchial asthma are attributed to its essential oils that includes the substance 'khellin' (Rose and Hulburd, 1992; Satrani *et al.,* 2004).

Meloidogyne javanica is sedentary endoparasite; its species are among the most destructive agricultural pests, and aggressive to a wide range of crops (Elgorban *et al.,* 2014). Root-knot nematode, *M. javanica* is widely distributed on medicinal & ornamental plants and considered of economic importance to several species of medicinal plants (Park *et al.,* 1998). Information on host status of medicinal plants for *M. javanica* are important for continued sustainable production and to determine appropriate management practices (Park *et al.,* 2005).

Humic acid is an excellent natural and 100% organic way to provide plants and soil with a concentrated dose of essential nutrients, vitamins and trace elements. Humic acid not only fertilizer but also it acts as a bio-stimulant for the plant (Senn, 1991). There is the most importance need for an eco-friendly substitute for nematode management. Humic acid released during the decomposition of raw organic materials are one of many factors contributing to reduce nematode damage (Mcbride et al., 2000). A new strategy for adjusting plant parasitic nematodes is based on the activation of the plant's own defense system through various biotic and abiotic agents such as Humic acid (El-Sherif *et al.,*2015).

The most important features of humic acid lie on its ability to bind available insoluble metal ions, oxides and hydroxides, slowly releasing them to roots (Russo and Berlyn 1990) and also prevent water and nutrient from losses in light and sandy soils, as well as, increase aeration and water infiltration in clay soils.

When humic acid entered plants at early stages of development, promoted in increase cell division and root development hastening establishment. In addition, humic acid acted as a natural chelator by enhancing the availability of iron thus increased photosynthesis and sugar production translating into increased storage for defense (Nardi *et al.,* 2002) .

The magnetized water is a kind of water treated by the magnetic field or pass through a magnetic device which causes a positive changes in physical and chemical properties of the water such as pH, electrical conductivity and interfacial tension and so lead to increase of the water quality (Samadyar *et al.,* 2014). Irrigation with the magnetized water increase nutrient mobility in soil and uptake of N, P, K and Fe by plants (Hajer, *et al.,* 2006). It is also increase soil water absorption, and maximize the efficiency of fertilizers. All of these reasons lead to decrease population density of root-knot nematode and increase vegetative growth characters & yield parameters (Koizumi and Kano 2014). Because there is no considerable work hitherto all-over the world generally, and a great scarceness studies herein in Egypt, especially on the effective impact of humic acid and magnetized water and its utility for controlling *M. javanica* infected Khella plants *A. visnaga* in relation to its plant growth properties; yield parameters and medicine components, an attempt had been done to throw light explicitly on this beneficial dual combined appliance of both humic acid and magnetized water and its effectiveness to take into root-knot nematodes control.

MATERIALS AND METHODS

Isolation, Purification and Multiplication

Pot experiments were carried out under shield conditions at the Experimental Farm, Faculty of Agriculture, Minoufia Univ., Shebin El-Kom, Egypt, during two successive winter seasons (2012&2013). Untraditional investigation aimed to scouting the fitness impact of five humic acid (HA) concentration rates (0,500,1000,1500 and 2000 ppm) and irrigation by magnetized water (MW) solely and combinedly for controlling *Meloidogyne javanica* infected khella plants in relation to its growth characters; yield parameters and medicinal components.

Nematode culture

Juveniles of the root-knot nematode, *M. javanica* were obtained from the pure culture reared on black nightshade, planted with *Solanum nigrum* in the Nematode Laboratory of the Entomology and Zoology Department, Faculty of Agriculture , Menoufia University.

Experimental preparation and design

Seeds of khella plants were obtained from Research Center of Medicinal and Aromatic plant Section, Giza, Egypt. The seeds were sown on the middle of October in each growing season in plastic pots 30 cm in diam. Each pot was filled with 4.0 kg of air-dried clay soil. Physical and chemical properties of the soil used in this study were determined according to the method which described by (Cottenie *et al.,*1982), as follows: PH 7.9, Ec 1.73 ds/m; 2.80 % organic matter, 44.24% silt, 3.84% coarse sand, 27.40% fine sand, 23.20% clay, the texture grade was a clay loam soil. The available macronutrients were 2.30% $CaCo_3$, 0.12% N and 0.25% P_2O_5. Humic acid treatments were prepared and mixed with the experimental soil with five concentration rates (0,500,1000,1500 and 2000 ppm). After sowing the seeds in pots, directly irrigated either with tap water or with magnetically treated water, which passed through magnetron tube of 2 inches in diameter and 4000 Gaus strength (Ameen and Kassim 2009). Fifteen days later, 1000 J_2 of *M. javanica* per 1kg soil were added by pipette into three holes around the base stem of each seedling.

Soil moisture level was kept at about 60% from its water capacity during the growing period by daily weighting. After one and half month from sowing date, plants were thinned to one plant/pot. All pots were received a recommended dose of NPK fertilizers, namely 2 g calcium super phosphate (15.5% P_2O_5), 2 g potassium sulphate (48% K_2O), which was added immediately after thinning, and 4 g ammonium nitrate (33.5% N), which was divided into two equal portions: the first was added immediately after thinning and the second after one and half month later. The experiment layout was randomized complete block design. Ten treatments were applied, each treatment was replicated three times. Khella plants were harvested at the first of May during maturity stage through two successive winter seasons (2012&2013).

Obtained data showed all measurements of khella plants such as: plant height (cm), number of main branches, fresh weight of whole plant (g/plant), number of umbels/plant, fresh and dry weights of umbels (g/plant) and fruit yield (g/plant).

Nematode Extraction and Enumeration:

Each composite soil sample was carefully mixed, and an aliquot of 100 cm^3 was processed for nematode extraction according to methods described by (Southey, 1970), each treatment was replicated three times. An aliquant of 1 ml each of nematode suspensions were pipetted off, placed in a Hawksley counting slide and examined by using a stereomicroscope.

Nematode counts were done after 1,2,3,4,5 and 6 months of application, and the identification to generic level were based on morphology of the adult and larval forms, according to the description of (Mai and Lyon, 1975). Roots were carefully washed, and the nematode galls were counted and rated as mentioned in Table (1), as well as one gram per root was stained by acid fuchsin lactophenol to counted root knot nematode stages inside the roots with the aid of a dissecting microscope.

Number of egg-masses root system were assessed by staining the roots with Phloxin-B solution (0.15 g/l tap water) for 20 minutes according to (Daykin and Hussey 1985).

Table (1): Rating scale levels of resistance or susceptible by gall numbers (Southey, 1970)

Number of galls/ root system	Gall index	Resistance rating
0	0	Immune
1-2	1	Highly resistant
3-10	2	Resistant
11-30	3	Moderately resistant
31-70	4	Moderately susceptible
71-100	5	Susceptible
>100	6	Highly susceptible

Chemical analysis

Total carbohydrate percentages in the dried herb were determined by using the colorimetric method of (Dubios *et al.,* 1956). Nitrogen, phosphorus and potassium percentages were determined in the dried herb by Kjeldah methods, Spectrophotometericly and Flame photometer methods, respectively, as reported by (Cottenie *et al.,* 1982).Total khellin and visnagin percentages were determined according to the methods described by (Martelli *et al.,*1984)

Statistical analysis

The obtained data were subjected to analysis of variance (ANOVA) using CoStat Software, Version 6.4 (2008). The mean differences were compared by Least Significant Difference (L.S.D. 5%)

Reduction percentages were computed according to (Abbott formula 1925).

Increase or decrease % = Control – treatment / Control x 100

RESULTS AND DISCUSSION:

In the first season (2012):

Data presented in Table (2) indicated the average numbers of *M. javanica* juveniles per 100 g soil 30, 60,90,120,150 and 180 days after the application of five humic acid (HA) rates (0,500,1000,1500 and 2000 ppm) and with irrigation by magnetized water (MW), solely and combinedly for controlling *M. javanica* infected khella plants under shield conditions.

Statistical analysis indicated that all treatments significantly suppressed the nematode population in the soil treated after 30, 60, 90,120,150 and 180 days in comparison with control treatment.

The highest reduction percentages of the nematode population in the soil, were recorded by application of combined treatment (HA 1500 ppm + MW) followed by (HA 1000 ppm + MW) with (71.0 and 62.0 %), respectively.

The obtained results are in agreement with (Mcbride *et al.,* 2000) who reported that the organic acids released during the decomposition of organic materials are one of many factors contributing to reductions in nematode damage

Table (2) : Impact of humic acid and magnetized water separately and in combination on the population density of root-knot nematode, *Meloidogyne javanica* infected Khella plants and reduction % ,under shield conditions (2012).

Treatments	Aver. no. of *Meloidogyne javanica* juveniles/ 100 g of soil						
	Days post-treatments						
	30 Days	60 Days	90 Days	120 Days	150 Days	180 Days	overall mean
Humic acid 500 ppm	854.3 c	786.5 c	712.0 c	650.1 c	594.0 c	506.3 c	683.9 c
Humic acid 1000 ppm	809.3 d	778.0 c	697.0 d	589.3 e	510.0 e	479.9 d	643.9 d
Humic acid 1500 ppm	757.0 f	701.3 f	589.0 h	512.3 g	467.5 g	406.0 f	572.2 f
Humic acid 2000 ppm	791.0 e	735.9 d	625.0 f	543.1 f	487.0 f	438.0 e	603.3 e
magnetized water	910.0 b	894.3 b	839.0 b	791.0 b	737.3b	704.9 b	812.7 b
H. acid 500 ppm+ m. water	801.0 d	719.3 e	678.5 e	603.0 d	560.0 d	483.0 d	640.8 d
H. acid 1000 ppm+ m. water	725.0 h	612.0 h	499.3 i	408.0 h	371.2 i	291.0 h	484.4 h
H. acid 1500 ppm+ m. water	707.0 i	534.3 i	404.0 j	203.3 i	113.4 j	81.3 i	340.6 i
H. acid 2000 ppm+ m. water	743.0 g	671.0 g	607.0 g	520.0 g	394.0 h	301.0 g	539.3 g
Control	969.8 a	1149.1 a	1320.0a	1465.8 a	1873.0 a	2019.9 a	1466.3 a
Reduction percentages (%)							
Humic acid 500 ppm	11.9	31.6	46.1	55.7	68.3	74.9	48.1
Humic acid 1000 ppm	16.6	32.3	47.2	59.8	72.7	76.2	50.8
Humic acid 1500 ppm	21.9	38.9	55.4	65.1	75.0	79.9	56.0
Humic acid 2000 ppm	18.4	35.9	52.6	62.9	74.0	78.3	53.7
magnetized water	6.2	22.2	36.4	46.0	60.6	65.1	39.4
H. acid 500 ppm+ m. water	17.4	37.4	48.6	58.9	70.1	76.1	51.4
H. acid 1000 ppm+ m. water	25.2	46.7	62.2	72.1	80.2	85.6	62.0
H. acid 1500 ppm+ m. water	27.1	53.5	69.4	86.1	93.9	95.9	71.0
H. acid 2000 ppm+ m. water	23.4	41.6	54.0	64.6	78.9	85.1	53.4

Means in each column followed by the same letter (s) are not significantly different at 5% level.

An alternative to pesticide application is that, it may be possible to utilize a scheme of inducible plant defenses (El-Sherif *et al.,*2015).

In the second season (2013)

Data presented in Table (3) showed that the side effect of applied treatments on the population density of *M. javanica* infected khella plants under shield plantation conditions.

Statistical analysis indicated that all treatments significantly suppressed nematode population in the soil treated after 30, 60, 90,120,150 and 180 days in comparison with control treatment. The combined treatment of (HA 1500 ppm + MW) recorded the least mean of population density of *M. javanica* (352.7 ind's /100g) in the six months.

Highest reduction percentages of the nematode in the soil were recorded in the combined treatments of (HA 1500 ppm + MW) followed by (HA 2000 ppm + MW) with (71.8&61.5), respectively.

The role of humic acid in overcoming the harmful effects of rust diseases in *Faba bean* plant may be due to the increase in chitinase activity(Abd El-Kareem, 2007). Both HA and MW may be play a considerable role in plant growth stimulation and caused promoting for plant natural resistance against plant-parasites such as root-knot nematode and other pests.

Data presented in Table (4) indicated that all treatments decreased the gall index and egg-masses production. The combined treatment of (HA 1500 ppm + MW) recorded the highest reduction percentage in root gall index (-75.0&-75.0 %) and egg-masses production (-85.7 and -85.2 %) in the two seasons, respectively (2012&2013).

Properness; performable and beneficial application of both HA and irrigation by MW by appliance duality combined treatments gave great utility of nematodes control, which is safety and inexpensive in comparison with commercial nematicides application.

On the other hand, these treatments must be introduced and may be useful in pest management programme against different nematode species infected Khella and different other medicinal & ornamental plants.

Results indicated that application of humic acid and magnetized water each solely for controlling *M. javanica* infect Khella plants gave the lowest reduction percentages of nematodes control. While contrariwise occurred in the effectiveness when it appliance combinedly, resulted the highest reduction percentages (HA1500+MW) that reached (71.0 and 71.8%). Interpretation of such finding may be due to the accumulative effectiveness; behaviorism; own extensive properties and its interaction between them, for each of HA and MW in the case of its application duality combined treatments for controlling root knot nematode *M. javanica*.

Table (3) : Impact of humic acid and magnetized water separately and in combination on the population density of root-knot nematode, *Meloidogyne javanica* infected Khella plants and reduction % ,under shield conditions (2013).

Treatments	Aver. no. of *Meloidogyne javanica* juveniles/ 100 g of soil						
	Days post-treatments						
	30 Days	60 Days	90 Days	120 Days	150 Days	180 Days	overall mean
Humic acid 500 ppm	871.0 c	802.0 c	723.0 c	597.0 c	511.3 c	467.0 c	661.9 c
Humic acid 1000 ppm	830.0 d	789.0 d	701.0 d	557.0 d	467.3 d	401.0 d	624.2 d
Humic acid 1500 ppm	710.0 g	661.3 g	521.0 g	482.0 f	400.3 f	351.0 f	520.9 g
Humic acid 2000 ppm	731.0 f	698.0 e	512.0 h	473.0 g	421.0 e	383.0 e	536.3 f
magnetized water	934.0 b	887.0 b	806.0 b	761.0 b	697.0 b	643.3 b	788.1 b
H. acid 500 ppm+ m. water	745.0 e	697.0 e	604.0 e	491.3 e	405.3 f	347.0 f	548.3 e
H. acid 1000 ppm+ m. water	711.0 g	644.9 h	531.0 f	397.0 h	341.0 h	298.9 h	487.3 h
H. acid 1500 ppm+ m. water	671.0 h	527.3 i	383.9 i	304.0 i	167.0 i	62.9 i	352.7 i
H. acid 2000 ppm+ m. water	720.0 G	687.0 f	600.3 e	405.0 h	361.3 g	309.0 g	513.8 g
Control	1008.0 a	1216.0 a	1401.0 a	1567.0 a	1786.0 a	2184.0 a	1527.0 a
Reduction percentages (%)							
Humic acid 500 ppm	13.6	34.0	48.4	61.9	71.4	78.6	51.3
Humic acid 1000 ppm	17.7	35.1	49.9	64.5	73.8	81.6	53.8
Humic acid 1500 ppm	29.7	45.6	62.8	69.2	77.6	83.9	61.4
Humic acid 2000 ppm	27.5	42.6	63.5	69.8	76.4	82.5	60.4
magnetized water	7.3	27.1	42.5	51.4	60.9	70.5	43.3
H. acid 500 ppm+ m. water	26.1	42.7	56.9	68.7	77.3	84.1	59.3
H. acid 1000 ppm+ m. water	29.5	46.9	62.1	74.7	80.9	86.3	60.4
H. acid 1500 ppm+ m. water	33.4	56.6	72.6	80.6	90.7	97.1	71.8
H. acid 2000 ppm+ m. water	28.6	43.5	57.2	74.2	79.7	85.9	61.5

Means in each column followed by the same letter (s) are not significantly different at 5% level.

Table (4): Increase or decrease of gall index and egg-masses production on Khella as influenced by treatments application in the two seasons (2012 and 2013).

Treatments	1st season		2nd season	
	Root gall index	Egg-masses production	Root gall index	Egg-masses production
Humic acid 500 ppm	5.0 ab	41.0 b	4.5 b	36.0 b
Humic acid 1000 ppm	4.0 bc	31.0 c	3.5 bcd	27.0 c
Humic acid 1500 ppm	3.0 cd	24.0 d	3.0 cd	23.0 c
Humic acid 2000 ppm	4.0 bc	30.0 c	3.5 bcd	26.0 c
Magnetized water	5.0 ab	38.0 b	4.0 bc	34.0 b
H. acid 500 ppm+ m. water	3.0 cd	22.0 d	2.5 de	18.0 d
H. acid 1000 ppm+ m. water	2.0 de	12.0 e	2.5 de	17.0 d
H. acid 1500 ppm+ m. water	1.5 e	7.0 f	1.5 e	8.0 e
H. acid 2000 ppm+ m. water	2.0 de	13.0 e	3.0 cd	19.0 d
Control	6.0 a	49.0 a	6.0 a	54.0 a
LSD 5%	0.9	3.4	0.9	3.4
Increase or decrease (%)				
Humic acid 500 ppm	-16.6	-16.3	-25.0	-33.3
Humic acid 1000 ppm	-33.3	-36.7	-41.7	-50.0
Humic acid 1500 ppm	-50.0	-51.0	-50.0	-57.4
Humic acid 2000 ppm	-33.3	-38.8	-41.7	-51.9
magnetized water	-16.6	-22.0	-33.3	-37.0
H. acid 500 ppm+ m. water	-50.0	-55.1	-58.3	-66.7
H. acid 1000 ppm+ m. water	-66.6	-75.5	-58.3	-68.5
H. acid 1500 ppm+ m. water	-75.0	-85.7	-75.0	-85.2
H. acid 2000 ppm+ m. water	-66.6	-73.5	-50.0	-64.9

Means in each column followed by the same letter (s) are not significantly different at 5% level.

Morphological Characteristics

After six months from sowing, responsiveness of khella plants growth to the application of different rates of humic acid (HA) was determined by means of measuring height, number of main branches and fresh weight of whole plant. Data in Table (5) markedly indicated that, all HA treatments significantly increased plant growth parameters with various extents. In this respect, application of HA at 1500 ppm ranked the first. The increments in growth parameters may be due to that HA is extremely important component because it constitutes a stable fraction of carbon, thus regulating the carbon cycle and release of nutrients, including nitrogen, phosphorus, and sulfur. Similar findings obtained by (Mohammadipour *et al.,* 2012) on *Calendula officinalis.*

Table (5): Effect of Humic acid, irrigation with both tap & magnetized water and their interaction on vegetative growth characters of *Ammi visnaga* L. during the two growing winter seasons (2012 and 2013).

Treatments	First season (2012)						Second season (2013)					
	HA 0 ppm	HA 500 ppm	HA 1000 ppm	HA 1500 ppm	HA 2000 ppm	Mean	HA 0 ppm	HA 500 ppm	HA 1000 ppm	HA 1500 ppm	HA 2000 ppm	Mean
Plant height (cm)												
TW	81.74	84.39	88.67	91.06	89.75	87.12	83.62	84.93	90.60	95.23	91.43	89.16
MW	86.54	91.62	97.53	105.41	102.33	96.68	89.70	95.21	100.33	115.56	104.79	101.11
mean	84.14	88.00	93.10	98.23	96.04	-	86.66	90.07	95.46	105.39	98.11	-
L.S.D.at 5%	W= 4.51	H= 3.57	W*H=4.99				W= 5.77	H=5.23	W*H= 7.32			
Number of main branches												
TW	6.35	6.89	7.48	8.15	7.78	7.33	6.69	7.15	7.50	7.95	7.46	7.35
MW	7.10	7.41	8.00	8.65	8.52	7.93	7.45	8.12	8.69	9.29	8.84	8.47
mean	6.72	7.15	7.74	8.40	8.15	-	7.07	7.63	8.09	8.62	8.15	-
L.S.D.at 5%	W= NS	H= 1.12	W*H= 1.57				W= 0.89	H=1.1	W*H=1.54			
Fresh weight of whole plant												
TW	188.83	195.62	212.54	225.29	219.71	208.39	192.05	206.37	217.11	234.40	228.51	215.68
MW	211.81	223.54	245.07	256.92	238.43	235.15	218.15	225.35	251.70	259.92	246.67	240.35
mean	200.32	209.58	228.80	241.10	229.07	-	205.10	215.86	234.40	247.16	237.59	-
L.S.D.at 5%	W= 7.87	H= 5.64	W*H=7.89				W= 8.61	H= 7.25	W*H= 10.15			

W= watering H= Humic acid w*H= Interaction

The same data clearly indicated that, watering khella plants with magnetized water (MW) raised growth parameters in comparison with those irrigated with tap water(TW) in the two experimental seasons. These results could be explained through the finding of (Midan and Tantawy 2013) who mentioned that irrigation snap beans with magnetized water increased soil content from available N,P and K and consequently improved its absorption by roots, which was reflected in promoting vegetative growth characters.

Also, there are significant effects of all interactions treatments between HA and irrigation with MW on vegetative growth parameters. The combined treatment of MW with HA at rate of (1500 ppm) produced the highest mean values of plant height; number of main branches and fresh weight of whole plant during the both seasons.

Table (6): Effects of Humic acid, irrigation with both tap & magnetized water and their interaction on yield parameters of *Ammi visnaga* L. during the two growing winter seasons (2012 and 2013).

	First season (2012)						Second season (2013)					
Treatments	HA 0 ppm	HA 500 ppm	HA 1000 ppm	HA 1500 ppm	HA 2000 ppm	Mean	HA 0 ppm	HA 500 ppm	HA 1000 ppm	HA 1500 ppm	HA 2000 ppm	Mean
Number of umbels/plant												
TW	14.49	15.26	15.34	18.02	16.65	15.95	15.77	16.40	17.86	19.94	19.36	17.86
MW	16.56	18.08	19.17	22.41	20.37	19.31	18.22	20.81	23.65	25.73	21.32	21.94
mean	15.52	16.67	17.25	20.21	18.51	-	16.99	18.60	20.75	22.83	20.34	-
L.S.D.at 5%	W= 2.58 H= 2.04 W*H= 2.86						W= 3.01 H= 2.87 W*H=4.02					
Fresh weight of umbels(g/plant)												
TW	56.40	58.35	63.67	67.25	65.72	62.27	57.51	61.84	65.11	70.25	68.42	64.62
MW	63.33	66.92	73.58	76.89	71.40	70.42	64.37	70.53	77.29	79.75	75.82	73.55
mean	59.86	62.63	68.62	72.07	68.56	-	60.94	66.18	71.20	75.00	72.12	-
L.S.D.at 5%	W=6.74 H=5.87 W*H=8.22						W=6.41 H=5.99 W*H= 8.39					
Dry weight of umbels (g/plant)												
TW	33.18	35.93	39.56	41.55	40.17	38.07	37.11	38.37	43.82	45.66	44.19	41.83
MW	38.95	40.60	46.29	47.51	43.76	43.42	39.68	44.15	48.75	51.09	46.05	45.94
mean	36.06	38.26	42.92	44.53	41.96	-	38.39	41.26	46.28	48.37	45.12	-
L.S.D.at 5%	W= 4.52 H=4.34 W*H= 6.08						W= 2.65 H= 2.34 W*H=3.28					
Fruit yield (g/plant)												
TW	11.86	12.95	14.35	15.05	14.78	13.79	12.67	13.37	15.13	15.80	15.41	14.47
MW	14.13	14.76	16.80	17.15	15.82	15.73	13.65	15.43	16.87	17.85	16.27	16.01
mean	12.99	13.85	15.57	16.10	15.30	-	13.16	14.40	16.00	16.82	15.84	-
L.S.D.at 5%	W=1.52 H=1.13 W*H=1.58						W=1.16 H=1.04 W*H=1.45					

W= watering H= Humic acid w*H= Interaction

Yield parameters

Concerning the effect of HA, data presented in Table (6) reported that, yield and yield components such as number of umbels/plant, fresh and dry weights of umbels (g/plant) as well as fruit yield (g/plant) were significantly affected by application of different HA rates and reached its maxima by using 1500 ppm HA in the two seasons. These enhancements in the yield components referred to the favorable effectiveness of HA which has many beneficial effects on soil structure; soil microbial populations and increase modify mechanisms involved in plant growth stimulation, cell permeability and nutrient uptake. The present results are agree with those of (Khalid *et al.,* 2015) on *Foeniculum vulgare*.

In addition, it is evident that, yield and yield components were enhanced by the application of MW as compared with TW in the winter seasons of 2012 and 2013. The availableness of irrigation with MW may be due to the increase in pigments, photosynthetic rate, IAA, and protein biosynthesis (Hozayn and Abdul qados, 2010). Also watering with MW enhancement surface tension, polarity, conductivity, hydrogen bonding, pH and solubility of salts in soil. These results could be also supported by (Ameen and Kassim 2009) on *Jerbera jamesonii*

Table (7): Effects of Humic acid, irrigation with both tap & magnetized water and its interaction on chemical composition and active constituents of *Ammi visnaga* L. during the two growing seasons (2012 and 2013).

	First season (2012)						Second season (2013)					
Treatments	HA 0 ppm	HA 500 ppm	HA 1000 ppm	HA 1500 ppm	HA 2000 ppm	Mean	HA 0 ppm	HA 500 ppm	HA 1000 ppm	HA 1500 ppm	HA 2000 ppm	Mean
N (%)												
TW	2.34	2.87	3.21	3.14	2.94	2.90	2.15	2.56	2.91	2.72	2.70	2.60
MW	2.88	3.33	3.52	3.24	3.05	3.20	2.62	2.81	3.19	3.18	2.90	2.94
mean	2.61	3.10	3.36	3.19	2.99	-	2.38	2.68	3.05	2.95	2.80	-
P (%)												
TW	0.28	0.34	0.39	0.39	0.35	0.35	0.30	0.28	0.35	0.40	0.38	0.34
MW	0.36	0.38	0.37	0.43	0.41	0.39	0.39	0.41	0.42	0.42	0.37	0.40
mean	0.32	0.36	0.38	0.41	0.38	-	0.34	0.34	0.38	0.41	0.37	-
K (%)												
TW	2.22	2.31	2.96	2.64	2.71	2.56	2.85	2.92	3.14	3.07	2.96	2.98
MW	3.12	3.35	3.41	3.18	3.17	3.24	2.92	3.30	3.73	3.58	3.62	3.43
mean	2.67	2.83	3.18	2.91	2.94	-	2.88	3.11	3.43	3.32	3.29	-
Total Carbohydrate (%)												
TW	12.15	12.62	13.03	13.42	13.51	12.94	12.29	12.41	12.85	13.22	13.74	12.90
MW	12.61	13.14	13.09	13.52	13.87	13.24	13.11	13.24	13.73	13.80	14.01	13.57
mean	12.38	12.88	13.06	13.47	13.69	-	12.70	12.82	13.29	13.51	13.87	-
Total khlellin %												
TW	0.98	1.04	1.17	1.11	1.03	1.06	0.87	1.10	1.15	1.22	1.16	1.10
MW	1.21	1.26	1.32	1.25	1.28	1.26	1.19	1.17	1.21	1.28	1.26	1.22
mean	1.09	1.15	1.24	1.18	1.15	-	1.03	1.13	1.18	1.25	1.21	-
Total visnagin (%)												
TW	0.32	0.36	0.34	0.28	0.30	0.32	0.25	0.31	0.30	0.27	0.27	0.28
MW	0.23	0.21	0.25	0.20	0.21	0.22	0.21	0.24	0.26	0.26	0.20	0.23
mean	0.27	0.28	0.29	0.24	0.25	-	0.23	0.27	0.28	0.26	0.23	-

Generally, combined treatments of HA and MW gave enhancement of the yield and yield components, that recorded the highest mean value in dual treatment of MW+1500 ppm HA.

Total khellin and visnagin contents

Data in Table (7) showed that increasing in HA rates till 1000 ppm means increments in khellin and visnagin contents and then decreased gradually by increasing HA rates up to 2000 ppm. Such quality improvements with HA are in agreements with those obtained by (Khalid *et al.,* 2015) on *Foeniculum vulgare* who emphasized that, the application of HA caused an increment in essential oil percentage and its main constituents i.e., trans-Anethole, Limonene and Fenchone.

Treated khella plants with MW revealed progressive increases in total khellin content. On the other hand, there was a decline in total visnagin content compared with control plants during both seasons. These results are fortified by those of (Ali *et al.,* 2011) on *Capsicum annuum* whom reported that, magnetic treatments led to a remarkable increase in vit.C and capsaicin contents compared with control plants.

Duality appliance of HA rates and MW and their interaction resulted increments in total khellin content in comparison with those obtained by applying HA rates with TW. Combined treatments of MW + 1000 ppm HA; MW + 1500 ppm HA gave the best results in the first and second seasons, respectively. Meanwhile, the visnagin values showed the reverse and reached to the maximum results by appliance of TW + 500 ppm HA in the two successive growing seasons.

Mineral and total Carbohydrate percentages

In dried herb of khella plants, increments in N, P, K and total carbohydrate percentages occurred parallel with increasing HA rates at its appliance. Application of HA at 1000 ppm gave the highest percentages of N and K, while its adequacy at 1500 and 2000 ppm caused the highest percentages of P and total carbohydrate, respectively in the two winter seasons. Similar results are harmony with that obtained results by (Radwan *et al.,* 2015) on wheat.

Solely treatment irrigation by MW produced the highest N, P, K and total carbohydrate percentages compared with that found by application of TW in irrigation Khella plants through both winter seasons under study. These results are in harmony of that found by (Mazrou 2013) on *Carum carvi.*

All combined treatments of HA+MW (interactions) caused increments of mineral and total carbohydrate percentages. Reached its maxima of N and K % in the treatment of HA1000 ppm + MW, while the highest % of P and total carbohydrate occurred by application of both combined treatment HA1500 and 2000 ppm + MW for each, respectively, in both seasons.

Finally, it could be recommended with appliance of the best and optimum combined treatment among Humic acid rates (1500ppm) plus magnetized water for controlling root-knot nematode *M. javanica* infected Khella plants, hence it gave the highest reduction percentages on it. Consequently, this dual treatment caused enhancement and improvement of Khella morphological characteristics; yield parameters; medicinal components such as total khellin and visnagin contents.

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معظمة الفائدة باستخدام الحمض الدبالي Humic acid والمياة الممغنطة في مكافحة نيماتودا تعقد الجذور *Meloidogyne javanica* والتي تصيب نبات الخلة وعلاقة ذلك بتحسين نموها ومكوناتها الفعالة.

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الملخص العربي

أجريت التجارب في أصص لدراسة تأثير استخدام الحمض الدبالي humic acid بخمسة معدلات وهي (صفر&500&1000&1500&2000ppm جزء في المليون) والري بالمياة الممغنطة في معاملات منفردة ومركبة لمكافحة نيماتودا تعقد الجذور *Meloidogyne javanica* والتي تصيب نباتات الخلة وعلاقة ذلك بالصفات المورفولوجية & محصول الثمار للنبات والمكونات الفعالة خلال موسمي الشتاء للعامين 2012&2013 تحت ظروف المغطاة في مزرعة التجارب بكلية الزراعة – جامعة المنوفية – شبين الكوم – مصر.

بصفة عامة أدت جميع المعاملات إلى خفض معنوي لأعداد كل من العقد النيماتودية & كتل البيض & الكثافة العددية لنيماتودا التعقد في كل من التربة والجذور مما أدى إلى زيادة في كل من الصفات المورفولوجية لنباتات الخلة مثل طول النبات & عدد الأفرع الرئيسية & الوزن الطازج للنبات ككل وكذلك مكونات المحصول مثل عدد النورات الخيمية ووزنها الطازج والجاف (جم/نبات) ومحصول الثمار (جم/نبات).

أدى تطبيق الري بالمياه الممغنطة مع الحمض الدوبالي في معاملات ثنائية إلى إعطاء نتائج جيدة وقاطعة إذا ماقورنت باستعمال كل منهما على حدة (بانفراد) في مقاومة نيماتودا تعقد الجذور *M. javanica* وكذلك تحسن في جميع صفات النباتات في موسمي الشتاء خلال عامي الدراسة.

كما أدت المعاملة الثنائية بين الحمض الدوبالي بمعدل 1500+المياة الممغنطة عن أعلى معدل نسبة إنخفاض في أعداد النيماتودا *M. javanica* خلال الموسمين المتتابعين للدراسة (71.0% & 71.8%) على التوالي إضافة إلى ذلك أعطت نفس هذه المعاملة أفضل النتائج فيما يخص العقد الجذرية (1.5&1.5) وإنتاج كتل البيض (7.0&8.0) في كلاً من الموسمين.

كما أدت هذه المعاملة الثنائية إلى تحسن ملموس في الصفات المورفولوجية للخلة ودلالات إنتاج محصولها. كما تم الحصول على أعلى قيمة للمادة الفعالة وهي الخلين عند تطبيق كل من المعاملتين: الهيوميك أسيد 1000ppm + المياه الممغنطة & الهيوميك أسيد 1500ppm + المياه الممغنطة وذلك خلال موسمي الشتاء على التوالي.