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Growth and Productivity of *Ammi visnaga* as Affected by Organic Fertilizers Rate and Antioxidants Level

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ABSTRACT

Two field experiments were conducted during two consecutive seasons of 2014 / 2015 and 2015 / 2016 at the Experimental Farm Faculty of Agriculture, Al-Azhar University to study the effect of organic fertilizers (compost at 10 or 20 and cattle manure at 15 or 30 m^3/feddan) and antioxidants (0.0, 75, 150 or 300 ppm from salicylic and citric acids, each applied individually) as well as, their combination treatments on vegetative growth parameters, fruit yield and active ingredients of khella (*Ammi visnaga*) plants under Assiut Governorate conditions. The obtained results cleared that using organic fertilization increased the values of plant height, herb dry weight per plant, fruit yield per plant and per feddan and khellin, visnagin and total chromones of khella plant. Since compost at 20 m^3 per fed. was the superior treatment in this respect. Similarly, the highest values of such parameters were occurred salicylic acid at 75 ppm during both seasons. The interaction effects among different treatments appeared that the best results were achieved by the combination treatment between organic fertilization of compost at 20 m^3 per feddan plus salicylic acid at 75 ppm. These combination treatments will promise in the development of sustainable crop production with a limited use of external inputs. That could be used by the farmers under Assiut Governorate conditions because this treatment has the most profitable rate and level with the greatest yield advantages.

***Key words**:* Khella, Organic fertilization, Antioxidants, Yield and Khellin

Introduction

Ammi visnaga, known as Khella, is an annual or perennial herb belongs to Family Apiaceae (Umbelliferae). Khella is native to the Mediterranean region and is cultivated in Egypt particularly in Minia and Assiut Governorate. *Ammi visnaga* is antiasthmatic, diuretic, lithontripic 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 seeds used as a folk medicine for diuretic and lithontripic (Uphof, 1959). Visnaga seeds contain oil that includes the substance 'khellin', which is used in the treatment of asthma. They have antispasmodic action on the smaller bronchial muscles, dilate the bronchial, urinary and blood vessels without affecting blood pressure (Bown, 1995). Essential oil of *A. visnaga* is known for its proprieties against coronary diseases and bronchial asthma (Rose and Hulburd, 1992; Satrani *et al.,* 2004).

Organic manures are important for medicinal and aromatic plants to produce the best product in both quantity and quality and it is also very safe for human health and environment. This is made by recycling organic material as plant and animals waste and food scraps in a controlled process. Continuous usage of inorganic fertilizer affects soil structure. Hence, organic manures can serve as alternative to mineral fertilizers for improving soil structure (Dauda *et al.*, 2008) and microbial biomass (Suresh *et al.*, 2004). Recently, many of such fertilizers have been used in a wide range around the world, compost is one of them.

Regarding salicylic acid (SA), this word was derived from Latin word “Salix”, meaning willow tree. It is ubiquitously distributed in the whole plant kingdom and is classified under the group of plant hormones (Raskin *et al.*, 1990). Salicylic acid (SA) is a plant growth regulator known as an endogenous signaling molecule, which is involved in various physiological processes in plants; such as, growth regulation, photosynthesis, stomatal conductance, nutrient uptake, plant water relations and mechanisms of plant resistance and tolerance to biotic and abiotic stresses (Popova *et al*., 1997; Hayat *et al.*, 2010). Citric acid (CA) is a six carbon organic acid, having a central role in CA cycle in mitochondria that creates cellular energy by phosphorylative oxidation reactions. It is created by the addition of acetyl-CoA to oxalo acetic acid that is converted to succinate and malate in next steps (Wills *et al.*, 1981). A recent study on

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sweet basil revealed that the combination of SA with CA was superior to others in many physiological traits and yield (Mirzajani, 2013).

Therefore, the aim of this study is to investigate the effect of organic manure (compost and cattle manure) and antioxidants (salicylic and citric acids), as well as, their combinations on vegetative growth, fruit yield, and active ingredients of khella plants.

Materials and Methods

This study was carried out during the two successive seasons 2014/2015 and 2015/2016 at the Experimental Farm, Faculty of Agriculture, Al-Azhar University branch of Assiut, to study the effect of organic fertilization (compost and cattle manure) and antioxidants (salicylic acid and citric acid), as well as, their interaction on the vegetative growth, yield and yield components and chemical constituents of khella (*Ammi visnaga*, L.) plants. The fruits of khella (*Ammi visnaga*, L.) were obtained from Medicinal and Aromatic Plants Dept., Horticulture Research, Institute, Giza, Egypt. Table 1 shows some of the physical and chemical analysis of the experimental used soil according to (Jackson, 1973).

Table 1: Physical and chemical properties of the experimental soil (average of the two seasons)

Physical analysis												Soil texture
Clay (%)				Silt (%)			Sand (%)					Loamy
35.30				39.40			25.30					
Chemical analysis												
Organic matter (%)	$CaCO_3$ (%)	pH	EC m.mohs / cm	Soluble cations (meq. / L)			Soluble anions (meq. / L)			Available		
				Mg^{++}	Ca^{++}	Cl^-	HCO_3^-	SO_4^{--}	N%	P ppm	K mg/100g	
0.57	2.53	7.87	0.95	1.9	3.4	2.2	1.5	3.4	0.12	0.14	3.5	

The experiment was consisted of 35 treatments arranged in a complete randomized split plot design with three replicates. The main plots included five treatments of organic fertilization (control without organic fertilization addition, compost at 10 or 20 m^3/feddan and cattle manure at 15 or 30 m^3/feddan) and seven treatments of antioxidant solutions (control as water spray, salicylic acid and citric acid each at 75, 150 and 300 ppm applied individually) occupied the sub-plots.

The experimental unit (plot) was 3 × 3.5 meters and containing six rows spaced at 60 cm. Fruits were sown on hills spaced in between 40 cm on one side of the ridge. The seeds of khella plant were sown of November (5th) for the two experimental seasons. After 45 days from sowing date, the growing seedlings were thinned to one plant per hill (42 plants per plot), thereabouts (16000 plant/feddan).

Cattle manure was obtained from Animal Farm, Faculty of Agriculture, Al-Azhar University Assiut and the used compost (called compost El-Saeed). Compost and cattle manure were added during preparing the soil to cultivation in the two experimental seasons. Physical and chemical properties of the used compost were moisture (25-30 %), pH (7.4), E.C. as m.mohs/cm (1.00), total N% (1.6),total P% (1.2),total K% (1.5), organic matter % (38.9), organic carbon % (22.5), C.N. ratio (1:14), Fe ppm (320), Mn ppm (32.4) and Zn ppm (150) as well as cattle manure were pH (7.4), E.C. as m.mohs/cm (6.80), total N% (1.22),total P% (0.65),total K% (1.12), organic matter % (17.3), Fe ppm (639), Mn ppm (61) and Zn ppm (270).

Salicylic acid and citric acid were obtained from El-Gomhoria Company for Chemicals, Egypt. Each of salicylic acid and citric acid were applied twice by hand sprayer. The first spray was added after 3 weeks from thinning date (January 10th) and the second one 4 weeks thereafter. The plants were sprayed till run off. All agricultural practices were performed as usual, in the region for the production of khella plants. The plants were harvested on the first week of June in both experimental seasons.

Data recorded:

Growth characters:

Plant height (cm) and total herb dry weight (g) per plant were estimated by taking 5 random guarded plants from each experimental unit.

Yield:

Fruits yield/plant (g) were determined, then total fruit yield per feddan (kg) was calculated.

Chemical analysis:

Khellin and visnagin percentages in fruits were estimated according to Egyptian Pharmacopoeia (1984) with Memphis modification and the yield of khellin and visnagin per plant was calculated. Total chromones percentage was calculated by using the sum of khellin and visnagin percentages and the total of chromones yield per plant was calculated.

Statistical analysis:

All collected data of the two seasons were subjected to analysis of variance and means of treatments were compared with the least significant difference (LSD) test at P≤0.05. The statistical calculations were performed with statistix software version 9 (Analytical Software, 2008).

Results and Discussion

Vegetative Growth Parameters:

Effect of organic fertilizers rate:

The treatments of organic fertilizers significantly increased plant height of *Ammi visnaga* plants compared to unfertilized control during the two seasons (Table 2). The high level of cattle manure (30 m^3/fed.) and compost (20 m^3/fed.) were more effective in increasing plant height than their low levels resulting in significant increase in the first season. One the other side, cattle manure at 30 m^3/fed. showed higher significant increase than compost at 10 m^3/fed. in the second season.

Concerning the herb dry weight (Table 3), it was observed that the organic fertilizers significantly increased it compared to control in both seasons. The compost at 20 m^3/fed. was more pronounced than 10 m^3/fed. in the first season, meanwhile, no significant differences among the other rates of the organic fertilizers were found.

These results are in agreement with those reported by Younis *et al.* (2004) on *Ammi visnaga* plant, Sharaf and Khattab (2004) on fennel plant, Sakr (2005) on *Cassia acutifolia* plant and Atteia *et al.* (2009) on *Thymus vulgaris* L.

Table 2: Effect of organic fertilization rate and antioxidants level on plant height (cm) / plant of *Ammi visnaga* during 2014/2015 and 2015/2016 seasons.

Organic fertilization rate m^3/*fed. (O.F.)	Antioxidant level (A.O.)							
	Control	Salicylic acid (ppm)			Citric acid (ppm)			Means (O.F.)
	0.0	75	150	300	75	150	300	
First season								
Control	129.67	147.33	141.00	139.33	140.33	147.67	149.33	142.10
Cattle manure 15	134.00	149.33	149.33	142.00	142.00	149.00	152.00	145.38
Cattle manure 30	136.33	157.33	156.00	148.33	152.33	153.33	157.00	151.52
Compost 10	136.67	152.67	154.33	147.00	150.00	152.00	155.67	149.76
Compost 20	140.67	158.67	158.00	150.00	156.00	156.33	158.00	153.95
Means (A.O.)	135.47	153.07	151.73	145.33	148.13	151.66	154.40	
L.S.D at 5 %	(O.F.) = 2.66		(A.O.) = 1.44			(O.F.) (A.O.) = 3.22		
Second season								
Control	126.70	130.77	132.73	133.80	124.97	120.40	125.17	127.79
Cattle manure 15	139.17	148.73	151.13	150.80	133.93	133.33	138.67	142.25
Cattle manure 30	140.17	150.47	166.23	155.30	139.73	147.83	141.33	148.72
Compost 10	123.83	156.20	143.87	138.13	149.17	137.57	129.00	139.68
Compost 20	124.97	161.37	146.00	135.70	157.57	153.47	140.57	145.66
Means (A.O.)	130.97	149.51	147.99	142.75	141.07	138.52	134.95	
L.S.D at 5 %	(O.F.) = 8.30		(A.O.) = 6.78			(O.F.)(A.O.) = 15.16		

**Fed.: 4200 m^2*

Effect of antioxidants level:

The treatments of antioxidants significantly increased plant height of *Ammi visnaga* compared to control in the two seasons, except citric acid at 300ppm in the second season (Table 2).Apparently , plant height was decreased with increasing the concentration of both antioxidants from 75 to 300 ppm ,

meanwhile, citric acid showed adverse trend in the first season. Mostly, the differences among antioxidant concentrations were not significant.

Respecting herb dry weight (Table 3), it was noticed that the treatments as antioxidant significantly increased it compared to control, except salicylic acid at 150 ppm , it decreased the dry weight in the first season. However, salicylic acid at 75 and citric acid at 150 ppm significantly increased the dry weight compared to control in the second season. Clearly, salicylic acid at 75 ppm was the most effective treatment in increasing herb dry weight in comparison with the other treatments resulting in significant increases, in most cases.

Similar results regarding herb fresh weight reported by Ali (2004) on *Tagetes minuta*, Abd El-Lateef (2007) on borage plants, Milad and Mohamed (2009) on *Calendula officinalis* and Badran *et al.* (2013) on guar plants.

Table 3: Effect of organic fertilization rate and antioxidants level on herb dry weight (g)/plant of *Ammi visnaga* during 2014/2015 and 2015/2016 seasons

Organic fertilization rate m^3/*fed. (O.F.)	Antioxidant level (A.O.)							
	Control	Salicylic acid (ppm)			Citric acid (ppm)			Means (O.F.)
	0.0	75	150	300	75	150	300	
	First season							
Control	43.00	93.67	80.67	78.00	60.33	67.67	79.00	71.76
Cattle manure 15	94.00	101.67	82.00	73.33	64.33	71.00	81.67	81.14
Cattle manure 30	51.00	116.67	84.33	76.00	79.00	81.33	82.00	81.47
Compost 10	51.33	101.00	80.00	76.33	67.33	77.67	79.67	76.19
Compost 20	64.00	141.67	97.33	89.67	70.33	83.33	85.00	90.19
Means (A.O.)	60.67	110.93	48.87	78.67	68.26	76.20	81.47	
L.S.D at 5 %	(O.F.) = 3.23		(A.O.) = 2.87			(O.F.)(A.O.) = 6.42		
	Second season							
Control	83.07	103.23	98.97	121.40	109.43	118.93	101.63	105.24
Cattle manure 15	126.03	150.37	144.97	127.40	137.73	142.87	129.17	136.93
Cattle manure 30	117.00	179.13	148.00	131.03	136.33	147.40	134.40	141.90
Compost 10	143.37	164.90	139.60	119.00	133.97	139.23	136.37	139.49
Compost 20	123.20	172.97	139.33	121.83	143.37	147.07	156.80	143.51
Means (A.O.)	118.53	154.12	134.17	124.13	132.17	139.10	131.67	
L.S.D at 5 %	(O.F.) = 14.92		(A.O.) = 16.88			(O.F.)(A.O.) = 37.74		

**Fed.: 4200 m^2*

Effect of the combination between organic fertilizers rate and antioxidant level treatments:

Results in Tables 2 and 3 indicate that, the interaction between the two studied factors, was significant on plant height and herb dry weight in both seasons. However, the highest values of plant height and herb dry weight per plant were obtained by using compost at 20 m^3/feddan in combination with salicylic acid at 75 ppm compared to the other combinations in the first and second seasons. Likewise, increasing organic fertilizer rate under salicylic or citric acid level herb dry weight per khella plant was increased.

These results are in harmony with those reported by Abd El-Naeem (2008) on caraway plants, Marzok (2011) on clove basil and Abd El- Naeem (2012) on mint plants.

Yield components:

Effect of organic fertilizers rate:

The presented data in Tables 4 and 5 shows that all organic fertilizer treatments highly significantly increased fruit yield per plant and per feddan compared to control in the two seasons. Clearly, the maximum values of fruit yield of *Ammi visnaga* per plant (g) as well as, per feddan (kg) were given by using compost at 20 m^3/ feddan compared to other ones. In addition, increasing cattle manure fertilizer rate from 15 to 30 m^3/ feddan increased above mentioned parameter in the first and second seasons. Also, fruit yield per feddan was increased with increasing compost fertilizers rate.

These results are in accordance with those found by Ariafar *et al*. (2013) on black cumin and Acimovic (2013) on caraway for yield per plant. Also, Younis *et al.* (2004) on *Ammi visnaga* and Rekaby (2013) on coriander have reported similar results for yield per feddan.

Table 4: Effect of organic fertilization rate and antioxidants level on fruit yield /plant (g) of *Ammi visnaga* during 2014/2015 and 2015/2016 seasons

Organic fertilization rate m^3/*fed. (O.F.)	Antioxidant level (A.O.)							
	Control	Salicylic acid (ppm)			Citric acid (ppm)			Means (O.F.)
	0.0	75	150	300	75	150	300	
	First season							
Control	21.33	28.67	26.33	25.67	25.67	26.67	27.67	26.00
Cattle manure 15	24.00	32.00	30.67	30.33	30.67	31.00	31.00	29.95
Cattle manure 30	26.67	33.67	31.33	30.33	30.67	31.00	31.33	30.71
Compost 10	22.67	35.67	34.00	33.00	34.33	34.67	35.67	32.86
Compost 20	24.33	40.33	35.67	33.33	34.33	34.67	34.33	33.86
Means (A.O.)	23.80	34.10	31.60	30.53	31.13	31.60	32.00	
L.S.D at 5 %	(O.F.) = 0.81		(A.O.) = 0.42		(O.F.)(A.O.) = 0.94			
	Second season							
Control	25.73	30.27	31.23	30.33	26.40	29.47	29.56	29.00
Cattle manure 15	30.60	35.33	33.83	33.40	31.80	33.30	33.80	33.15
Cattle manure 30	35.60	41.67	41.33	41.87	39.87	41.73	40.17	40.32
Compost 10	32.90	39.60	39.97	38.40	35.43	36.27	39.07	37.38
Compost 20	39.80	45.30	44.73	41.70	42.87	43.67	44.43	43.21
Means (A.O.)	32.93	38.43	38.22	37.14	35.27	36.89	37.41	
L.S.D at 5 %	(O.F.) = 2.33		(A.O.) = 1.77		(O.F.)(A.O.) = 3.96			

**Fed.: 4200 m^2*

Table 5: Effect of organic fertilization rate and antioxidants level on fruit yield /fed. (Kg) of *Ammi visnaga* during 2014/2015 and 2015/2016 seasons

Organic fertilization rate m^3/*fed. (O.F.)	Antioxidant level (A.O.)							
	Control	Salicylic acid (ppm)			Citric acid (ppm)			Means (O.F.)
	0.0	75	150	300	75	150	300	
	First season							
Control	341.33	458.67	421.33	410.33	410.67	426.67	442.67	416.00
Cattle manure 15	384.00	512.00	490.67	485.33	490.67	496.00	496.00	479.24
Cattle manure 30	426.67	538.67	501.33	485.33	490.67	496.00	501.33	491.43
Compost 10	362.67	570.67	544.00	528.00	549.33	554.67	570.67	525.71
Compost 20	389.33	645.33	570.67	533.33	549.33	554.67	549.33	541.71
Means (A.O.)	380.80	545.07	505.60	488.46	498.13	505.60	512.00	
L.S.D at 5 %	(O.F.) = 12.89		(A.O.) = 6.79		(O.F.)(A.O.) = 15.18			
	Second season							
Control	411.73	484.27	499.73	485.33	422.40	471.47	473.07	464.00
Cattle manure 15	489.60	565.33	541.33	534.40	508.80	532.67	540.80	530.42
Cattle manure 30	569.60	666.67	661.33	669.87	637.87	667.73	642.67	645.10
Compost 10	526.40	633.60	639.25	614.40	566.93	580.27	625.07	591.16
Compost 20	636.80	724.80	715.73	667.20	685.87	698.67	710.93	691.43
Means (A.O.)	526.83	614.93	611.47	594.24	564.37	590.16	598.51	
L.S.D at 5 %	(O.F.) = 37.24		(A.O.) = 28.26		(O.F.)(A.O.) = 63.19			

**Fed.: 4200 m^2*

Effect of antioxidants level:

Results in Tables 4 and 5 indicate that treating *Ammi visnaga*, L. plants with salicylic acid and citric acid significantly increased fruit yield per plant and per feddan in both seasons compared with control. It was found that the highest values of fruit yield per plant were recorded by using salicylic acid at 75 ppm followed by citric acid at 300 ppm in the first season and salicylic acid at 75 ppm followed by salicylic acid at 150 ppm and citric acid at 300 ppm in the second season. These results are in agreement with those stated by Abd El-Lateef (2007) on borage and Talaat *et al.* (2014) on *Ammi visnaga.*

This positive effect of SA was attributed to the enhancement of CO_2 assimilation, chlorophyll concentration, photosynthetic rate and increased mineral uptake by plants treated with SA which reflected yield per plant (Karlidag *et al.*, 2009).

Effect of the combination between organic fertilizers rate and antioxidant level treatments:

The data given in Tables 4 and 5 indicate that fruit yield per plant and per feddan were significantly increased by all combination treatments between organic fertilization rate and antioxidant level compared to control in both seasons. However, the combination of compost at 20 m3/ feddan and 75 ppm salicylic acid

proved to be more effective in augmenting fruit yield per plant and per feddan compared to the other combinations in the two seasons. Mostly, increasing organic fertilizer rate under salicylic or citric acid level increased fruit yield per plant and per feddan. These results are in agreement with those found by Abd El-Naeem (2008) on caraway.

Khellin, visnagin and total chromones yield per plant:

Effect of organic fertilizers rate:

The recorded data in Tables 6 and 7 and Figure 1 shows that all organic fertilization treatments (compost and cattle manure) significantly increased khellin, visnagin and total chromones yield per plant of *Ammi visnaga* plants compared to unfertilized plants in the both seasons. However, the highest values in this connection were resulted from adding compost at 20 m3/feddan. Generally, khellin, visnagin and total chromones yield per plant (g) was increased with increasing compost and cattle manure rates in the first and second seasons. However, the highest value for thymol on *Thymus vulgaris* herb was obtained from 30 m^3 compost combined with 10m^3 sheep manure treatment (Atteia *et al.*, 2009).

Table 6: Effect of organic fertilization rate and antioxidant level on khellin yield / plant (g) of *Ammi visnaga* during 2014/2015 and 2015/2016 seasons

Organic fertilization rate m^3/*fed. (O.F.)	Antioxidant level (A.O.)							
	Control	Salicylic acid (ppm)			Citric acid (ppm)			Means (O.F.)
	0.0	75	150	300	75	150	300	
	First season							
Control	0.351	0.553	0.481	0.450	0.431	0.470	0.505	0.463
Cattle manure 15	0.399	0.630	0.571	0.548	0.519	0.559	0.572	0.543
Cattle manure 30	0.497	0.674	0.589	0.553	0.525	0.566	0.588	0.570
Compost 10	0.381	0.697	0.635	0.605	0.599	0.630	0.662	0.601
Compost 20	0.448	0.787	0.693	0.677	0.649	0.669	0.678	0.657
Means (A.O.)	0.415	0.668	0.594	0.567	0.545	0.579	0.601	
L.S.D at 5 %	(O.F.) = 0.017		(A.O.) = 0.008		(O.F.) (A.O.) = 0.015			
	Second season							
Control	0.442	0.518	0.695	0.684	0.528	0.527	0.545	0.563
Cattle manure 15	0.529	0.626	0.624	0.639	0.604	0.631	0.628	0.612
Cattle manure 30	0.578	0.708	0.687	0.704	0.662	0.713	0.730	0.683
Compost 10	0.623	0.784	0.758	0.762	0.742	0.757	0.744	0.739
Compost 20	0.708	0.902	0.838	0.771	0.801	0.827	0.837	0.812
Means (A.O.)	0.576	0.707	0.720	0.712	0.667	0.691	0.697	
L.S.D at 5 %	(O.F.) = 0.043		(A.O.) = 0.015		(O.F.)(A.O.) = 0.036			

**Fed.: 4200 m^2*

Table 7: Effect of organic fertilization rate and antioxidants level on visnagin yield / plant (g) of *Ammi visnaga* during 2014/2015 and 2015/2016 seasons

Organic fertilization rate m^3/*fed. (O.F.)	Antioxidant level (A.O.)							
	Control	Salicylic acid (ppm)			Citric acid (ppm)			Means (O.F.)
	0.0	75	150	300	75	150	300	
	First season							
Control	0.148	0.249	0.203	0.180	0.181	0.191	0.230	0.197
Cattle manure 15	0.173	0.284	0.239	0.231	0.223	0.231	0.263	0.235
Cattle manure 30	0.191	0.307	0.255	0.236	0.227	0.234	0.271	0.246
Compost 10	0.165	0.319	0.271	0.259	0.254	0.266	0.307	0.263
Compost 20	0.177	0.378	0.331	0.288	0.260	0.279	0.299	0.287
Means (A.O.)	0.171	0.307	0.260	0.238	0.229	0.240	0.274	
L.S.D at 5 %	(O.F.) = 0.009		(A.O.) = 0.005		(O.F.) (A.O.) = 0.011			
	Second season							
Control	0.184	0.213	0.237	0.223	0.216	0.216	0.250	0.220
Cattle manure 15	0.221	0.261	0.267	0.245	0.258	0.249	0.288	0.256
Cattle manure 30	0.241	0.295	0.294	0.291	0.293	0.277	0.337	0.290
Compost 10	0.256	0.328	0.322	0.313	0.303	0.316	0.343	0.312
Compost 20	0.299	0.368	0.365	0.321	0.346	0.339	0.391	0.347
Means (A.O.)	0.240	0.293	0.297	0.278	0.283	0.279	0.322	
L.S.D at 5 %	(O.F.) = 0.020		(A.O.) = 0.015		(O.F.) (A.O.) = 0.036			

**Fed.: 4200 m^2*

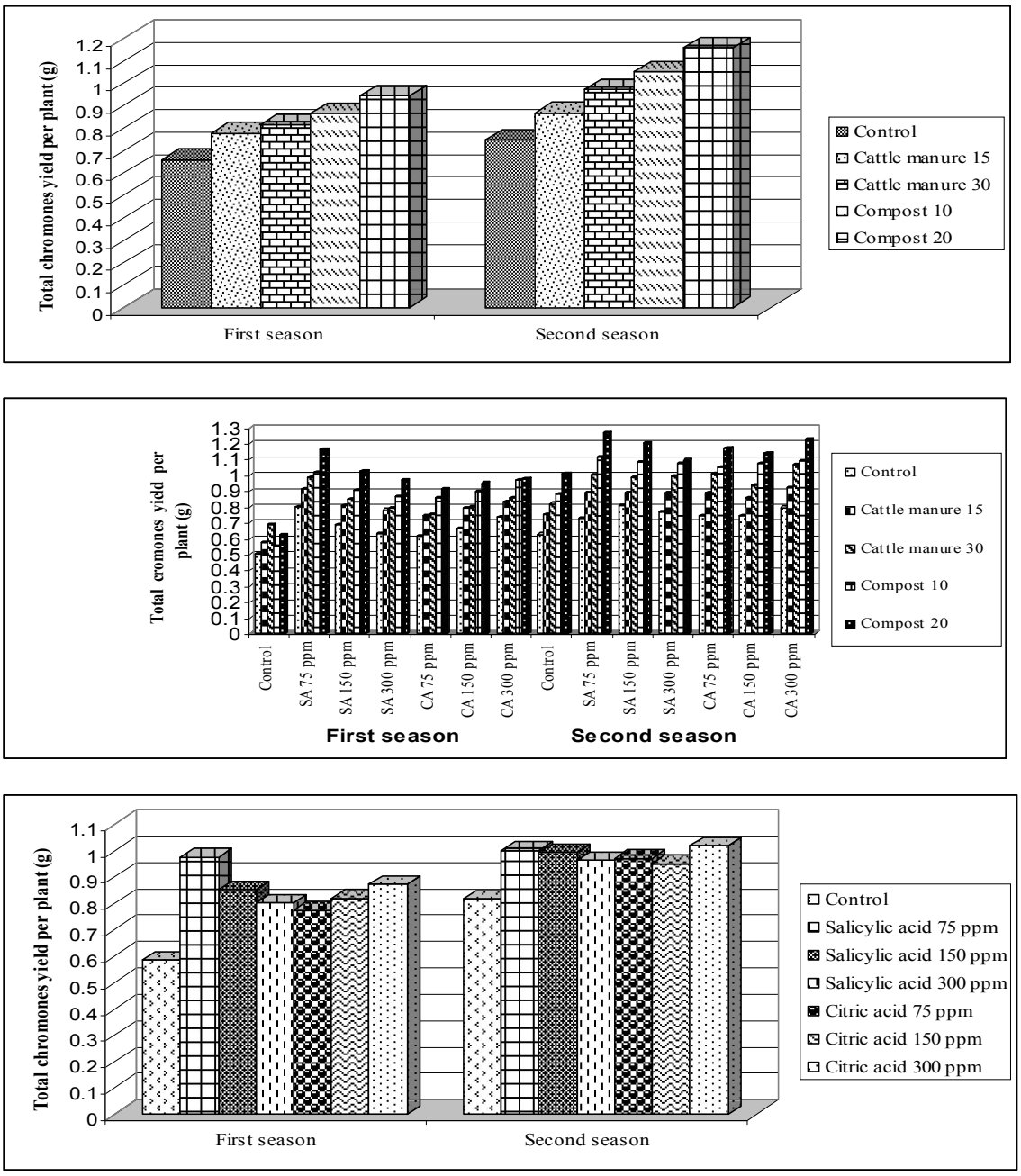

Fig. 1: Effect of organic fertilization rate and antioxidant level on total chromones yield / plant (g) of *Ammi visnaga* during 2014/2015 and 2015/2016 seasons

Effect of antioxidants level:

Data of both seasons in Tables 6 and 7 and Figure 1 indicate that salicylic acid and citric acid at all concentrations highly significant increased khellin, visnagin and total chromones yield per plant (g) compared to untreated plants during the two seasons. The best values in this regard were obtained from treating khella plants with salicylic acid at 75 ppm in the first season and 150 ppm of the same acid in the second one followed by 300 ppm citric acid in both seasons.

The synergism between applied levels of citric acid and salicylic acid is readily notable in our results, which is consistent with Badran *et al.* (2013) on guaran production of guar plants. This confirms that the response to this antioxidants takes place as an internal plant physiological response and is independent of the level be used.

Effect of the combination between organic fertilizers and antioxidant treatments:

Results in Tables 6 and 7 and Figure 1 indicate that the interaction between the two studied factors on khellin, vinagin and total chromones were significant in the both seasons. However, the highest values of khellin yield per plant were produced by using compost at 20m^3/fed. in combination with salicylic acid at 75 ppm compared to the other combination treatments in the first and second seasons. However, increasing citric acid levels under any organic manure rates gradually increased khellin, visnagin and total chromones yield per plant during both seasons.

Conclusion

In conclusion, the application of organic fertilizers (compost or cattle manure) and antioxidants (citric or salicylic acids) as substitute for inorganic fertilizers in order to grow *Ammi visnaga* plants, should not be considered as a simple objective and short term benefits, but as a mean to improve environmental conditions and human health.

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