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Changes in growth, hormones levels and essential oil content of *Ammi visnaga* plants treated with some bioregulators

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Abstract. *Talaat IM, Khattab HI, Ahmed AM. 2013. Changes in growth, hormones levels and essential oil content of* Ammi visnaga *plants treated with some bioregulators. Nusantara Bioscience 5: 57-64.* The effects of foliar application of different concentrations of amino acids (tyrosine and phenylalanine) and phenolic acids (trans-cinnamic acid, benzoic acid, and salicylic acid) on growth, pigment content, hormones levels and essential oil content of *Ammi visnaga* L were carried out during two successive seasons. It is clear that foliar application of either amino acids or phenolics significantly promoted the growth parameters in terms of shoot height, fresh and dry biomass, number of branches and number of umbels per plant. The increment of growth parameter was associated with elevated levels of growth promoters (IAA, GA_3, total cytokinins) and low level of ABA. The greatest increase in the previously mentioned parameters was measured in plants exposed to different concentrations of phenols particularly in benzoic acid-treated plants. Such effect was concentration dependent. All treatments led to significant increments in seed yield and essential oil content. Moreover, Gas-Liquid Chromatographic analysis revealed that the main identified components of essential oil were 2,2-dimethyl butanoic acid, isobutyl isobutyrate, α-isophorone, thymol, fenchyl acetate, and linalool. Phenolics and amino acids treatments resulted in qualitative differences in these components of oil.

Keywords: *Ammi visnaga*, phenolic compounds, amino acids, hormones, growth criteria, essential oil

Abstrak. *Talaat IM, Khattab HI, Ahmed AM. 2013. Perubahan dalam pertumbuhan, kadar hormon dan kandungan minyak atsiri tanaman* Ammi visnaga *yang diperlakukan dengan beberapa bioregulator. Nusantara Bioscience 5: 57-64.* Pengaruh aplikasi daun berbagai konsentrasi asam amino (tirosin dan fenilalanin) dan asam fenolat (asam trans-sinamat, asam benzoat dan asam salisilat) terhadap pertumbuhan, kandungan pigmen, kadar hormon dan kandungan minyak atsiri *Ammi visnaga* L. telah dilakukan selama dua musim berturut-turut. Hasilnya secara jelas menunjukkan bahwa aplikasi daun dari salah satu asam amino atau asam fenolat secara signifikan meningkatkan parameter pertumbuhan dalam hal tinggi tunas, biomassa segar dan kering, jumlah cabang dan jumlah tangkai bunga per tanaman. Kenaikan parameter pertumbuhan terkait dengan meningkatnya kadar hormon promotor pertumbuhan (IAA, GA_3, total sitokinin) dan rendahnya kadar ABA. Peningkatan terbesar parameter tersebut terukur pada tanaman yang terkena berbagai kadar fenol terutama tanaman yang diperlakukan dengan asam benzoat. Efek seperti itu tergantung kadarnya. Semua perlakuan menyebabkan kenaikan signifikan dalam jumlah biji dan kandungan minyak atsiri. Selain itu, analisis Kromatografi Gas Cair mengungkapkan bahwa komponen utama yang teridentifikasi dari minyak atsiri adalah asam 2,2-dimetil butanoat, isobutil isobutirat, α-isoforon, timol, fensil asetat dan linalool. Perlakuan fenolat dan asam amino mengakibatkan perbedaan kualitatif komponen minyak atsiri ini.

Kata kunci: *Ammi visnaga*, senyawa fenolat, asam amino, hormon, kriteria pertumbuhan, minyak atsiri

INTRODUCTION

Ammi visnaga, known as Khella, is an annual or perennial herb belongs to family Apiaceae (Umbelliferae). Khella is native to the Mediterranean and is cultivated in Egypt. *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). The major components were linalool, isoamyl 2-methyl butyrate, and isopentyl isovalerate (Khadhri et al. 2011).

Furthermore, phenolics are low molecular compounds ubiquitous in all tissues of higher plants with great significance in plant development. Phenolic compounds are some of the most widespread molecules among plant secondary metabolites, and are of great significance in plant development (Curir et al. 1990). However, their biological, ecological and agronomical significance in the rhizosphere is much less clear. Furthermore, these bio-molecules may contribute in soil and water conservation, weed management, mineral element nutrition, as well as the impact as signal molecule in certain symbiotic relationships, and act as defense molecules against soil pests and pathogens (Makoi1 and Ndakidemi 2007). Additionally, they serve as flower pigments, act as constitutive protection agents against biotic and abiotic stress (Deladonde et al 1996), function as signal molecules, act as allelopathic compounds, and affect cell and plant growth (Dakora 1995; Dakora and Phillips 1996; Ndakidemi and Dakora 2003), are important natural animal toxicants (Adams 1989) and some may function as pesticides (Vidhyasekaran 1988; Waterman and Mole 1989; Beier 1990). They are also functional components of the rhizosphere and its soil organic matter (Haider et al. 1975; Martin 1977). They have long been recognized as allelochemicals for weed control (Rice 1984; Putnam and Tang 1986) phytoestrogens in animals (Adams 1989) and plant defense molecules (Vidhyasekaran 1988). In the rhizosphere, they act as important precursors for the synthesis of soil humic substances (Haider et al. 1975). Salicylic acid participates in the regulation of several physiological processes in plant such as stomatal closure, nutrient uptake, chlorophyll synthesis, protein synthesis, inhibition of ethylene biosynthesis, transpiration and photosynthesis (Khan et al. 2003; Shakirova et al. 2003). SA increase cell metabolic rate (Amin et al. 2007). The biosynthesis of salicylic acid in plants starts from phenylalanine and follows one of two known paths of synthesis which involves trans-cinnamic acid then hydroxylation of benzoic acid which is a direct precursor of salicylic acid (Raskin 1992).

Moreover, amino acids as organic nitrogenous compounds are the building blocks in the synthesis of proteins (Davies 1982). Amino acids are particularly important for cell growth stimulation. They act as buffers which help to maintain favorable pH value within the plant cell. They protect the plants from ammonia toxicity. They can serve as a source of carbon and energy, as well as protect the plants against pathogens. Amino acids also function in the synthesis of other organic compounds, such as protein, amines, purines and pyrimidines, alkaloids, vitamins, enzymes, terpenoids and others (Goss 1973; Abd El-Aziz and Balbaa 2007). Furthermore, Hass (1975) stated that the biosyntheses of cinnamic acids (which are the starting materials for the synthesis of phenols are derived from phenylalanine and tyrosine.

The aim of this study is to investigate the role of some phenolic substances (salicylic acid, t-cinnamic acid and benzoic acid) and amino acids (tyrosine and phenylalanine) on the growth, endogenous hormones, photosynthetic pigments, total, soluble and insoluble carbohydrates of *A. visnaga* plants as well as the essential oil content of the seeds.

MATERIALS AND METHODS

Experimental

Two pot experiments were conducted in the greenhouse of National Research Centre (NRC), Dokki, Cairo, Egypt, during two successive seasons of 2009/2010 and 2010/2011. *Ammi visnaga* seeds were obtained from the Department of Medicinal and Aromatic Plants, Ministry of Agriculture, Giza, Egypt. Ten sterilized seeds were sown in each pot (30cm diameter) in the third week of October. Each pot was filled with 10 kg of air-dried clay soil. Physical and chemical properties of the soil used in this study were determined according to Jackson (1973) and Cottenie et al. (1982) and are presented in Table (1). Eight weeks after sowing, the seedlings were thinned and three plants per pot were left. Pots were divided into three main groups. The first group was exposed to different levels of phenolic compounds (salicylic acid, trans-cinnamic acid, and benzoic acid) at concentrations 5, 10 and 20 mg L^{-1}. The second group was sprayed with different levels of amino acids (phenylalanine and tyrosine) at concentrations 50,100 and 200 mg L^{-1}. Phenolic compounds and amino acids were applied after 30 days from the sowing date. The third group was sprayed with H_2O to serve as control. The experiments conducted under natural day conditions, with photoperiod 11 hrs ± 2 and temperature about 27°C ± 2.

Table 1. Physical and chemical properties of the soil used

Soil texture	pH	EC*	Organic C	Organic matter	Total N	Total P	Total K
			(%)				
Sandy loam	7.2	0.6	0.9	1.9	0.3	0.1	0.1

Note: EC * = Electric conductivity (salinity)

All agricultural practices were conducted according to the recommendations by the Egyptian Ministry of Agriculture as follows: fertilizers were added to all pots as follows: cattle manure (2g pot^{-1}), phosphorus (2g pot^{-1}) as calcium superphosphate (15.5% P_2O_5), nitrogen (2g pot^{-1}) as ammonium sulphate (20.5% N) and potassium (1.5 g pot^{-1}) as potassium sulphate (48% K_2O). Weeds were removed by hand and only natural pesticides were used for any plant diseases. The growth parameters of differently treated *Ammi* plants were measured after 75, 119, 180 and 210 days from sowing (stages A, B, C, and D respectively). Stage A was at the vegetative growth while stage B at the beginning of flowering and stages C and D were at early fruiting and harvest time.

Vegetative growth characters

Plant height (cm), fresh and dry weights of shoot (g $plant^{-1}$) were recorded during the vegetative stage. Plant height (cm), number of branches and umbels ($plant^{-1}$), fresh and dry weights of shoots ($plant^{-1}$) were recorded at flowering, early fruiting, and fruiting stages.

Endogenous hormones

The endogenous hormone levels were determined using the method described by Wasfy and Orrin (1975). Chlorophyll (chl) a, chl b and total carotenoids content was measured according to the method of Association of Official Agricultural Chemists (AOAC 1970).

Total and soluble carbohydrate

Total and soluble carbohydrate contents were determined according to the method described by Dubois et al. (1956). Then, the insoluble carbohydrates were calculated.

Figure 1. *Ammi visnaga* L. (Khella, bisnaga or toothpick weed)

Essential oil isolation

The ripening fruits of *A. visnaga* were collected air dried and weighed for extraction of the essential oil. Five grams of dry fruits were crushed into smaller pieces and reduced to fine powder with the aid of a mechanical grinder. The powder sample was extracted with petroleum ether (PE 40-60ºC) for 48h at room temperature. The extract was evaporated to dryness using rotary evaporation at reduced pressure. The essential oil was passed over dark anhydrous sodium sulfate to remove moisture. The fraction obtained was stored in a refrigerator at 4ºC in dark to identify the chemical constituents of oil (Adams 1995). GC-MS analysis was carried out on a Varina 3400 system equipped with a DB-5 fused silica column (30 m x 0.25 mm i.d.); Oven temperature was 40 to 240°C at a rate of 4°C min^{-1}, transfer line temperature 260°C, injector temperature 250°C, carrier gas helium with a linear velocity of 31.5 cm s^{-1}, split ratio 1/60, flow rate 1.1 mL min^{-1}, Ionization energy 70 eV; scan time 1 s ; mass range 40-350 amu.

Identification of components

The components of the oil were identified by comparison of their mass spectra with those of a computer library or with authentic compounds and confirmed by comparison of their retention Indices with those of authentic compounds. Kovats indices (Kováts 1958) were determined by co-injection of the sample with a solution containing a homologous series of *n*-hydrocarbons, at a temperature run identical to that described above.

Statistical analysis

In this experiment, one factor was considered: different concentrations of amino acids (50, 100 and 200 mg L^{-1}), phenolic compounds treatments (5, 10 and 20 mg L^{-1}) and control. The experimental design followed a complete random block design. According to Sendecor and Cochran (1990), the average of data was statistically analyzed using 1-way analysis of variance (ANOVA-1). Significant values determined according to the Least Significant Difference (LSD at 0.05 and at 0.01 p) by using the STAT-ITCF program (1982).

RESULTS AND DISCUSSION

Effect of amino acids and phenolic compounds on growth parameters

Foliar application of different concentrations of either phenols or amino acids stimulate gradual increases in growth parameters in terms of plant height, number of branches, number of umbels fresh and dry weights and water content of *A. visnaga* shoot throughout the experimental periods. Results also, investigated that phenols stimulate all the previous morphological parameters, particularly at 20 mg L^{-1} compared with those of amino acids (tyrosine and phenyl-alanine) throughout the experimental period (Figures 1-6). The greatest increases in all investigated morphological criteria were measured in *A. visnaga* plants exposed to 20 mg L^{-1} benzoic acid at all stages. Similar results were obtained by Balbaa and Talaat (2007) who concluded that phenylalanine treatments significantly promoted plant height, number of branches, fresh and dry weights of rosemary plants. Abd El-Aziz et al. (2007) also indicated that foliar application of tyrosine significantly promoted plant height, number of leaves and branches, fresh and dry weights of branches and shoots and stem diameter in both cuttings of *Salvia farinacea* plants. It was recorded that application of certain amino acids significantly increased the vegetative growth of *Chrysanthemum* (El-Fawakhry and El-Tayeb 2003), peppermint (Refaat and Naguib 1998), datura (Youssef et al. 2004) and *Pelargonium graveolens* (Mahgoub and Talaat 2005). Furthermore, salicylic acid caused significant increases in most growth parameters of different plant species (Abd El-Wahed et al. 2006; El-Khallal et al. 2009; Delavari et al. 2010; Dawood et al. 2012). The promotive effect of salicylic acid could be attributed to its bioregulator effects on physiological and biochemical processes in plants such as ion uptake, cell elongation, cell division, cell differentiation, sink/source regulation, enzymatic activities, protein synthesis and photosynthetic activity as well as increase the antioxidant capacity of plants (Raskin 1992; Blokhina et al. 2003; El-Tayeb 2005).

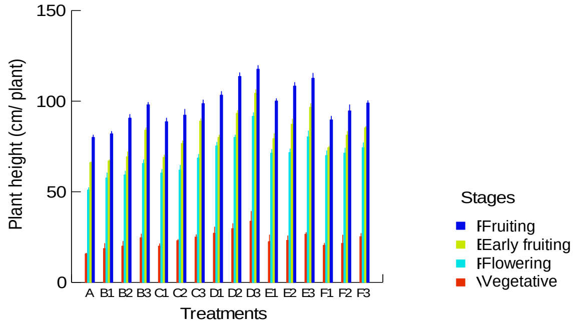
Effect of amino acids and phenolic compounds on chemical composition

The changes of chlorophylls a and b as well as carotenoids content in response to amino acids and phenolics treatments are shown in Figure 7. High pigments levels (chl a, b, carotenoids) were measured in *A. visnaga* leaves treated with phenols compared with those of amino acids. The maximum increase in chlorophylls and carotenoids are recorded in leaves treated with 20 mg L^{-1} benzoic acid. The increments in pigment level were attributed to the promotion in its synthesis and/or retardation of pigment degradation. These results are similar to those obtained by Sharma et al. (1995) who found that excised leaves of *Tropaeolum majus*, treated with t-cinnamic acid, retained more chlorophyll (60% higher at 10^{-3} M) compared to control. Moreover, the potent effects of particularly salicylic acid might be ascribed firstly to the reduction in chlorophyll loss due to its ability to increase the antioxidant capacity of the plants (Kuorzer et al. 1999) or inducing the synthesis of stabilizing substances (Nemeth et al. 2002). Salicylic acid caused significant increases in photosynthetic pigments (Figure 8). These results corroborate with those of Khodary (2004) and Gunes et al. (2005) on maize, El-Tayeb (2005) on barley, and Dawood et al. (2012) on sunflower.

The enhancing effects of SA on photosynthetic capacity could be attributed to its stimulatory effects on Rubisco activity and pigment contents (Khodary 2004) as well as increased CO_2 assimilation, photosynthetic rate and increased mineral uptake by the plant (Szepesi et al. 2005). In addition, Arfan et al. (2007), pointed out that application of salicylic acid improved the photosynthetic capacity and retain pigment content through increasing IAA and Cytokinins, therefore, inhibits their senescence. Similar results were obtained by Hassanein (2003) on *Foeniculum vulgare* plants and Abou Dahab (2006) on *Philodendron erubescens* plant. They reported that foliar application of the amino acid (tryptophan) caused an increase in photosynthetic pigments contents.

The increments of the photosynthetic pigments in the treated *A. visnaga* leaves were concomitant with a gradual increase in total, soluble and insoluble carbohydrates (Figure 8). The maximum increases in soluble and insoluble carbohydrates were measured in the plants exposed to foliar application of phenolic compounds compared to those treated with amino acids. Moreover, such increments in the levels of total, soluble and insoluble carbohydrates were recorded in leaves exposed to 20 mg L^{-1} benzoic acid. These results are in agreement with those obtained by Goss (1973), who indicated that amino acids can serve as a source of carbon and energy when carbohydrates become deficient in the plant; amino acids are determinate, releasing the ammonia and organic acid from which the amino acid was originally formed. The organic acids then enter the Kreb's cycle, to be broken down to release energy through respiration. These results could also be explained by the findings obtained by Gamal El-Din et al. (1997) who found that treatment of lemongrass plants with 100 ppm phenylalanine in the first cut and ornithine in the second cut recorded the highest level of carbohydrate percentage compared with control. Refaat and Naguib (1998) reported that application of all amino acids (alanine, cytosine, guanine, thiamine, and L-tyrosine) increased the total carbohydrates percentage in peppermint leaves. The effect of the amino acids on the total carbohydrates content may be due to their important role on the biosynthesis of chlorophyll molecules which in turn affected carbohydrate metabolism. In this respect, Talaat and Balbaa (2010) reported that chemical analysis of the leaves of sweet basil indicated that the contents of total soluble and total carbohydrates were significantly increased as a result of foliar application of trans-cinnamic acid. Tari et al. (2002) and Dawood et al. (2012) reported that salicylic acid application resulted in a significant increase in total soluble carbohydrates content in leaves of tomato and sunflower, thus maintaining the carbohydrates pool in the chloroplasts at a high level.

Plant hormones play an important role in development processes; some of them have a key in the most plant mechanisms. Data represented in Figure 9 showed increments in gibberellins (GA_3), indole acetic acid (IAA) and cytokinins (Z & ZR) in plants treated with amino acids and phenolic compounds. High concentrations of gibberellins (GA_3), Indole acetic acid (IAA) and cytokinins (Z & ZR) were measured in *A. visnaga* leaves treated with phenolic compounds compared with amino acids. The highest values of GA_3, IAA and cytokinins were recorded in plants exposed to 20 mg L^{-1} benzoic acid. A reduction in abscisic acid (ABA) level was concomitant with such increments in growth promoters estimated in plants exposed to either phenolic compounds or amino acids. The increases in the levels of endogenous growth promoters could be attributed to the increase in their biosynthesis and/or decrease in their degradation and conjugation. On the other hand, the reduction in ABA level could be due to the shift of the common precursor isopentenyl pyrophosphate



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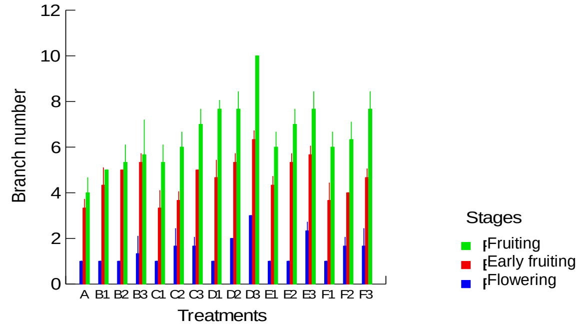

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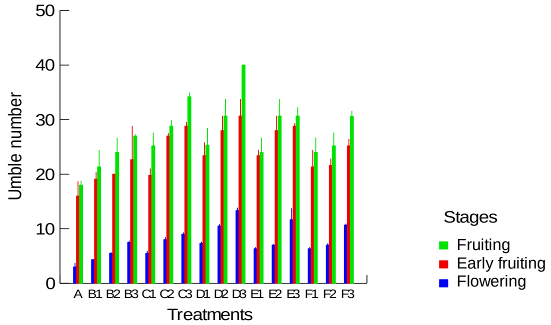

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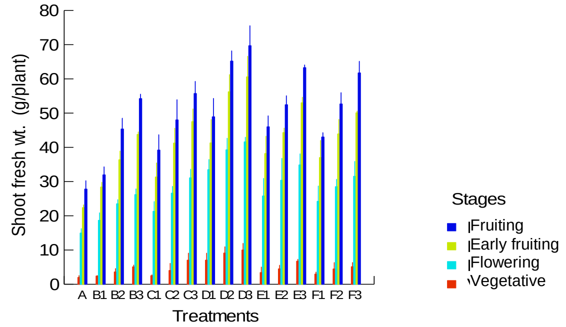

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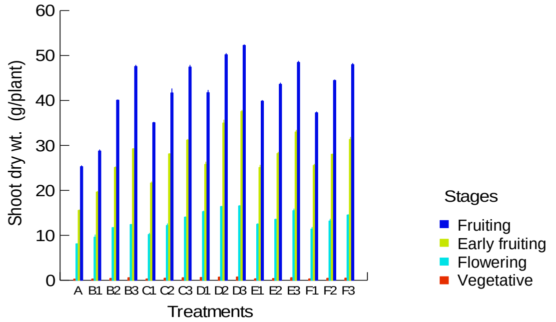

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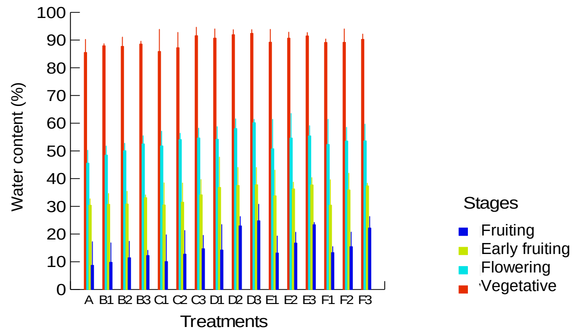

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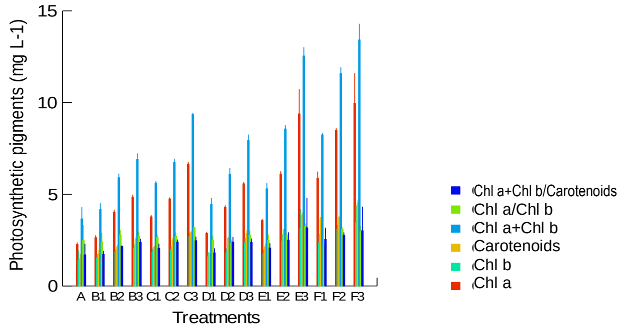

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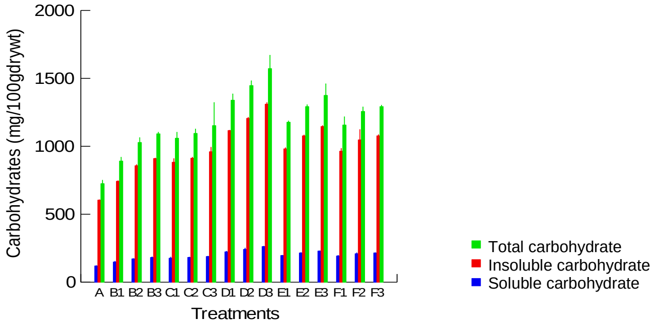

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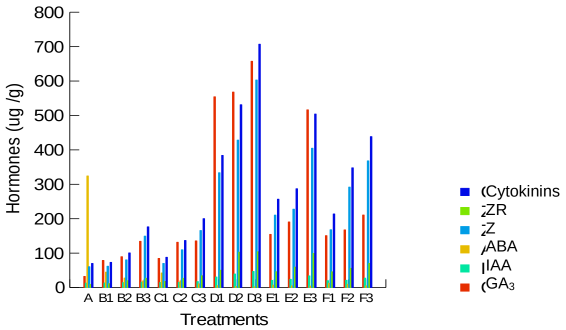

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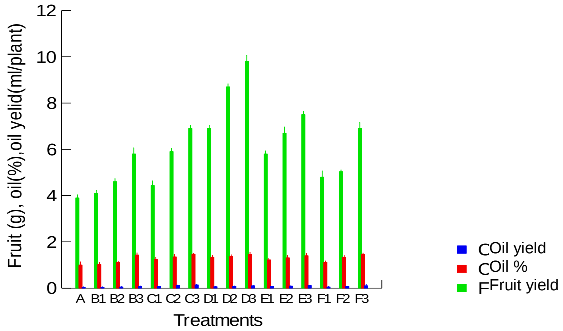

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Figure 1. Changes in the values of plant height of shoot system of *A. visnaga* plants (cm plant^{-1}) treated with different concentrations of amino acids and phenolic compounds during the vegetative, flowering, early fruiting and fruiting stages, each value is mean of ten replicates ± SD

Figure 2. Changes in the values of branch number of shoot system of *A. visnaga* plants treated with different concentrations of amino acids and phenolic compounds during the flowering, early fruiting, and fruiting stages, each value is mean of ten replicates ± SD

Figure 3. Changes in the values of umbels number of shoot system of *A. visnaga* plants treated with different concentrations of amino acids and phenolic compounds during the flowering, early fruiting, and fruiting stages, each value is mean of ten replicates ± SD

Figure 4. Changes in the values of fresh weight of shoot system of *A. visnaga* plants (g plant^{-1}) treated with different concentrations of amino acids and phenolic compounds during the vegetative, flowering, early fruiting and fruiting stages, each value is mean of ten replicates ± SD

Figure 5. Changes in the values of dry weight of shoot system of *A. visnaga* plants (g plant^{-1}) treated with different concentrations of amino acids and phenolic compounds during the vegetative, flowering, early fruiting and fruiting stages, each value is mean of ten replicates ± SD

Figure 6. Changes in the percentage of water content of *A. visnaga* shoots treated with different concentrations of amino acids and phenolic compounds during the vegetative, flowering, early fruiting and fruiting stages, each value is mean of ten replicates ± SD

Figure 7. Changes in the values photosynthetic pigments of *A. visnaga* plants (mg L^{-1}) treated with different concentrations of amino acids and phenolic compounds during the vegetative stage, each value is mean of ten replicates ± SD

Figure 8. Changes in the percentage of total, soluble and insoluble carbohydrates of *A. visnaga* plants (%) treated with different concentrations of amino acids and phenolic compounds during the vegetative stage; each value is mean of ten replicates ± SD

Figure 9. Changes in the values of phytohormone contents of *A. visnaga* Plants (µg g^{-1}) treated with different concentrations of amino acids and phenolic compounds during the vegetative stage

Figure 10. Changes in the values of fruit yield (g), oil percentage (%) and oil yield (ml plant^{-1}) of *A. visnaga* plants treated with different concentrations of amino acids and phenolic compounds, each value is mean of ten replicates ± SD

Table 2. The constituents of essential oil of *A. visnaga* plants

			Treatments (ppm)															
No.	**Components (%)**	**KI**	**0**	**Tyrosine**			**Phenylalanine**			**Benzoic acid**			**Trans-cinnamic acid**			**Salicylic acid**		
				50	100	200	50	100	200	5	10	20	5	10	20	5	10	20
1	α-Thujene	931	-	2.5	1.3	1.0	1.2	1.9	-	1.1	-	3.9	2.2	0.4	0.9	1.5	1.2	3.9
2	Myrcene	991	-	2.0	0.4	8.0	3.6	3.6	-	1.2	-	3.7	1.9	0.4	1.6	2.1	1.4	4.9
3	Isobutyl isobutyrate	1004	22.9	20.6	35.3	15.9	18.9	18.6	24.1	14.8	24.3	9.9	11.4	24.4	22.6	6.4	16.5	15.6
4	Linalool	1029	5.7	2.9	0.6	1.3	3.3	1.3	-	0.8	-	4.5	2.1	0.3	1.1	1.1	2.5	2.6
5	2,2-Dimethylbutanoic acid	1108	28.9	35.4	55.4	30.4	20.6	38.8	50.5	35.0	25.9	21.1	27.4	36.5	34.6	59.0	34.4	38.2
6	α-Isophorone	1121	13.4	17.9	0.9	3.0	2.7	1.2	9.2	11.9	16.7	9.6	13.8	19.3	21.1	6.4	11.3	13.8
7	Fenchyl acetate	1220	6.3	3.8	0.3	2.5	7.8	5.0	-	1.0	-	4.8	7.0	0.2	3.2	3.7	4.7	3.5
8	Bornyl acetate	1289	-	1.7	0.4	7.8	2.6	5.1	-	0.8	-	4.3	5.3	0.5	2.3	0.9	0.8	2.0
9	Thymol	1290	13.2	8.5	1.8	13.1	9.3	2.8	-	2.1	15.2	7.0	8.0	0.8	1.7	6.7	3.7	5.7
10	Geranyl acetate	1381	-	-	0.3	1.4	4.9	2.6	9.1	11.5	-	5.2	3.8	11.2	2.7	0.9	6.9	4.5
11	Lavandulyl acetate	1439	-	-	0.2	0.7	7.6	3.0	-	1.4	-	3.7	2.7	0.7	1.1	2.2	0.9	-
12	Citronellyl propionate	1446	-	-	0.6	5.6	7.9	3.3	-	1.0	-	5.3	1.6	-	1.2	3.1	2.4	-
13	Croweacin	1460	9.6	4.7	1.5	6.7	8.1	11.0	7.1	10.4	15.0	5.9	7.2	2.8	3.3	6.0	8.7	5.3
14	α-Damascone	1689	-	-	0.4	1.5	2.1	1.0	-	3.2	2.9	5.7	2.7	2.4	0.9	-	2.2	-
15	(Z,E)-farnesol	1701	-	-	0.6	1.1	1.4	0.8	-	3.8	-	5.4	2.9	0.1	1.7	-	2.4	-
Total identified			100	100	100	82.6	100	100	100	100	100	100	100	100	100	100	100	100
Monoterpene compounds			100	100	99.4	98.9	98.6	99.2	100	96.2	100	94.6	97.1	99.9	98.3	100	97.6	100
Sesquiterpene compounds			-	-	0.6	1.1	1.4	0.8	-	3.8	-	5.4	2.9	0.1	1.7	-	2.4	-

to biosynthesis of cytokinins and/or gibberellins instead of ABA (Hopkins and Huner 2004). These results are in accordance with those obtained by Shehata et al. (2000), Shehata et al. (2001) and Zaghlool (2002). The increases in IAA and GA_3 in shoot tissues of sunflower plant concurrently with the increase in growth rate due to the role of these endogenous hormones in stimulating cell division and/or the cell enlargement and subsequently growth (Taiz and Zeiger 1998). It is well known that salicylic acid induces flowering, increases flower life, retard senescence and increases cell metabolic rate. In addition, salicylic acid may be a prerequisite for synthesis of auxin and /or cytokinin. (Metwally et al. 2003; Gharib 2006). Furthermore, these increments in growth regulating substances might be a prerequisite for acceleration of growth resumption of sunflower plant. In addition, salicylic acid effects on abscisic acid (Senaratna et al. 2000), gibberellins (Traw and Bergelson 2003) regulate many physiological processes and plant growth. Moreover, Dawood et al. (2012) reported that SA caused marked increments in IAA, GA_3, zeatin and zeatin riboside, in the meantime decrease in ABA content comparing with untreated controls.

Figure 10 indicated that the fruit yield, oil yield percentage and oil yield (ml plant^{-1}) increased in plants treated with phenolic compounds and amino acids. The maximum levels of oil yield percentage (ml plant^{-1}) were recorded in seeds exposed to 20 mg L^{-1} benzoic acid. The increment in oil% and protein% might be due to the increase in vegetative growth and nutrients uptake. Similar results were reported by Gharib (2006) and Çag et al. (2009). In addition, Noreen and Ashraf (2010) mentioned that high doses of salicylic acid caused marked increases in sunflower achene oil content as well as some key fatty acids and significant decrease in stearic acid.

Table 2 represents the compounds of essential oil obtained from *A. visnaga* as detected by GC-MS. the relative levels of various constituents of oil yield were increased, decreased or disappeared in *A. visnaga* fruits of plants treated with amino acids and phenolic compounds compared with untreated control plants. 2,2-dimethylbutanoic acid, isobutyl isobutyrate, linalool, thymol, and croweacin are the major constituents of *A. visnaga* fruits. These results are similar to those obtained by Khalfallah et al. (2011) who found that the major component of essential oil in *A. visnaga* are 2, 2-dimethylbutanoic acid, isobutyl isobutyrate, croweacin, linalool, and thymol. The effect of different treatments on essential oil and its constituents may be due to its effect on enzyme activity and metabolism of essential oil production (Burbott and Loomis 1969).

SA has a role in controlling gene expression (He et al. 2005) reported that most of the genes regulated by SA are defense-related genes and many of them participate in plant responses to biotic and abiotic stresses. Therefore SA may change secondary metabolites and its pathway by effects on plastid, chlorophyll level and represent stress conditions. The SA like stress manipulated quality and quantity of essential oil of *Salvia macrosiphon*. The yield of essential oil was increased. The useful component such as Linalool was increased. Seventeen components were identified in SA-treated plants (Rowshan et al. 2010).

CONCLUSION

Finally, it is apparently clear that phenolics treatments were more effective in enhancing growth and productivity of *A. visnaga*. Moreover, the greatest increase in the growth parameters and chemical constituents obtained at 20 mg L^{-1} of benzoic acid. On the other hand, the major component of essential oil gave the best percentage (59%) was assayed in seeds exposed to salicylic acid.

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