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ORIGINAL ARTICLES

Impact of Foliar Application of Commercial Amino Acids Nutrition on the Growth and Flowering of *Tagetes Erecta*, L. Plant

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ABSTRACT

This study was conducted at the greenhouse of Biology Department, Faculty of Science, Taif University. The objective of this experiment was to evaluate the effect of amino acids applied as (Algaefol compound) at 0, 1, 2, 3 and 4 ml/L on vegetative growth; plant height, branch number, herb weight (fresh & herb), flower parameters; flower number/plant, flower diameter, flower weight (fresh & dry), first flower opening and photosynthetic pigments; chlorophyll (a), chlorophyll (b), total chlorophyll and carotenoides, N, P, K, protein and carbohydrates percentages of marigold. It was observed from the obtained data that, Algaefol treatment at 3 ml/L was the best treatments in increasing the previous characteristics compared to the other levels and control. On the other hand, there were insignificant differences between this concentration and the treatment of 4 ml/L, thus it was recommended to apply foliar application of 3 ml/L Algaefol in order to improve growth, flower yield and its quality and chemical constituents of marigold plants.

Key words: Algaefol - marigold - photosynthetic pigments - protein – carbohydrates

Introduction

Tagetes erecta, L. plant belongs to family *compositae* (*Asteraceae*), often called African marigold or marigold as a common name, is one of the most important herbaceous ornamental with aromatic plants, is valued in landscape settings and also as cut flowers (Nau, 1997). This plant reaches heights usually use as a bedding plant, cut flower, or as a coloring agent in poultry feed to obtain yellow egg yolks (Dole and Wilkins, 2005). Marigold flowers are rich source of a natural yellow to orange dye, helenien (a dipalmitate ester of a xanthophylls), which is in high demand by national and international companies. Since prehispanic times, this plant has been used for medicinal purposes. Scientific study shows that thiophenes, natural phytochemicals that include sulfur-containing rings, may be the active ingredients. They have been shown to kill gram negative and gram positive bacteria in vitro. This marigold may help protect certain crop plants from nematode pests when planted in fields (Olabiyi and Oyedunmade, 2007). The oil of the flower may be added to perfumes to infuse an apple scent into them. Today, *T. erecta* is grown to extract lutein, a common yellow/orange food color (Rosa Martha et al., 2006).

Amino acids (AA) can act as growth factors of higher plants since they are the build blocks of protein synthesis, which could be enzymes important for metabolic activities (Aberg, 1961). As an example, the role of tryptophan is well known; it has an indirect role on the growth via its influence on auxin synthesis (Phillip, 1971). AA helps to increase chlorophyll concentration in plant leading to higher degree of photosynthesis. Any factor causes increase in photosynthetic pigments will lead to increase carbohydrate content. Carbohydrates are the main repository of photosynthetic energy, they comprise structurally polysaccharides of plant, principally cellulose, hemicelluloses and pectin and lignin which consider an important structural compound of plant. Also it's associated with phenolic compounds which play a major role in plant defense (Hahlbrock and Scheel, 1989).

The role of amino acids in plant due to the correlation between these acids and plant health. Amino acids are used both for the production of new cell biomass and to produce energy. Followed by deamination into the keto acid which inter into the Tri Carboxylic acid (TCA) cycle, which play important role in plant resistance (Bush, 1993). Proline accumulation can influence stress tolerance in multiple ways. It has been shown to function as a molecular chaperone able to protect protein integrity and enhance the activities of different enzymes (Rajendrakumar, 1994 and Mansour, 2000). Organic solutes such as amino acids are used to regulate water potential when subjected to water deficits or high salts in the root zone. Glycinebetaine is used in this capacity to maintain osmotic balance between the cytoplasm and vacuole (Subbarao et al., 1995; Serrano, 1996; Hare and Cress, 1997). It is hypothesized that foliar application of

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glycinebetaine in non accumulating species can ameliorate the negative effects of drought and salinity on productivity. Exogenous glycinebetaine application is reported to improve growth and yield of tobacco under drought conditions (Makela et al., 1998).

Amino acids (AA), which account for the majority of organic nitrogen in soils and humic substances, impact plant growth and serve to explain how organic matter promotes soil productivity. Amino acids which have a high integrity with different metabolic pools in plants were used to promote plant growth (Coruzzi and Last, 2000; Schnitzer, 2001). Several commercial compounds that include amino acids in their composition are recommended to be applied to increase the growth and yield of economical crops. Foliar application of amino acids (Lysine, ornithine and tryptophan) enhanced the vegetative growth and chemical constituents of *Pelargonium graveolens* (Talaat, 2005). On *Philodendron erubescens* both diphenylamin and tryptophan significantly increased plant growth in terms of plant height, number of leaves/plant, stem diameter, root length, leaf area, as well as, plant fresh and dry weights (Abou Dahab and Abd El-Aziz, 2006). Some researchers also pointed out the importance of amino acids in increasing growth, yield and chemical composition of some economic plants (El-Shabas et al., 2005; Rawia et al., 2011).

Nowadays, there are several commercial products of amino acids like Algaefol which contains macro and micro nutrients for improving plant growth. The supplementation of *Tagetes erecta* L plant by foliar application of zinc and /or iron have increased the vegetative growth and augmented the production of the herb and flowers. Similarly, the combined treatments raised plant content of N, P, K, Zn, Mn, and Fe in addition to carotinoids and carbohydrates (Khalil and El-Sherbeny, 2002). The combined application of boron with molybdenum or zinc resulted in higher rapeseed yield and quality than the application of boron with molybdenum or zinc alone (Yang et al., 2009). Flower yield, essential oil percentage, and essential oil yield in chamomile increased by foliar application of iron and zinc compared with control in calcareous soils. (Nasiri, 2010). The growth and yield of *Salvia officinalis,* L. and some *Mentha* species were improved as a result of applying macro and micro nutrients (Lotfy and Naguib, 2001;Khalil and El-Sherbeny, 2005).

Therefore the aim of the present study was to investigate the effect of different levels of amino acids nutrition applied as Algaefol compound on the growth, flowering, and some chemical constituents of marigold under the conditions of Taif city, KSA.

Materials and methods

This study was conducted during the 2012 season at the greenhouse of Biology Dep., Faculty of Science, Taif University. The mature seedlings (10 cm) of marigold (*Tagetes erecta,* L.) were obtained from commercial grower in Taif region and used to conduct this study. On the 1^{st} of March, 2012, the seedlings of marigold were cultivated in sandy soil then irrigated. The experiment was designed as Completely Randomized Block Design with three replicates. Each plot area was 2 x 1.5 m containing 3 rows. The distances between plants were 30 cm and 50 cm among rows. Amino acids were applied as Algaefol compound which contains amino acids (phynyl allanine, Treptophane, Hestidene, Methionene, Asbartic acid, Glosatic acid, Therbonene, Isolysine, Ornythene, Cetrolene, Phalene, Serene, Lithene, Alanene, Sastene, Thyrosyne, Prolene, Lythene, Argenene, Glycine), carbohydrate; Manythole, Bolysaccharene Manytole, Al-Genec acid, Bolysacrene, Lamynaric acid and Methyle bentosene), vitamins (A, B1, B2, B12, C, D, E, riboflavin, colen, orthene and panthothene), and nutrient elements and minerals (N, P, K, Fe, Mn, Zn, S, Ca, Cu, Ba, Li, Ge, Ag, Ti, Si, Mo, Mo, Al, Au, V, Ni, B, I, Rb, St, Sb, F, Co, Zr and W). Marigold seedlings were treated with Algaefol at 0, 1, 2, 3 and 4 ml/L. The Algaefol treatments were applied weekly one-week after transplanting and for 6 weeks.

All other agriculture practices needed during marigold growth; weed, pests, and diseases control were done when required. Five plants were randomly taken from each plot and the following data were recorded: Plant height (cm), number of main branches/plant, fresh and dry weight of herb (g), flower diameter (cm), flower number/plant, flower beginning (period from transplanting to the first flower opens on plant) and flower fresh and dry weight (g).

2.1. Chemical analysis:

2.1.1. Chlorophyll and carotenoids percentages:

Samples of fresh leaves were randomly collected from the mid-part of plants of each treatment in early morning for chlorophyll "a & b" determinations. Carotenoids were measured in flower petals and were extracted by using acetone 80% and calorimetrically determined according to Metzner et al., (1965). Leaf pigments were measured by a spectrophotometer at wave length of 663, 644 and 452.5 nm. Taking into consideration the dilution factor, it was possible to determine the concentration of pigment fractions (chl. A, chl. B and carotenoids) as mg/ml using the following equations:

Chlorophyll "a" = $10.3_{E663} - 0.918_{E644} = \mu g/ml$

Chlorophyll "b" = $19.7_{E644} - 3.87_{E663}$ = µg/ml
Carotenoids = $4.2_{E452.5}$ – (0.0264 Chl. A + 0.426 Chl. B) = µg/ml
Finally, the pigment fractions were calculated as mg/g fresh weight of leaves.

Samples of fresh leaves were randomly collected from the mid-part of plants of each treatment in early morning; the samples were dried in an oven at 70 Ċ until a constant weight then ground to fine powder for the following determinations:
- Total carbohydrates: total carbohydrates percentage in the leaves according to (El-Enany, 1986).
- Nitrogen and protein: in leaves were determined in the digestion using the micro-Kjeldhl method (Black et. Al., 1965). The protein percentage in leaves, seeds and fruits was calculated using the conversion factor of 6.25 based on the assumption that the protein contains 16 % nitrogen according to Ranganna (1978).
- Phosphorus percentage; was calorimetrically determined using the stannous chloride phosphomolibdic-sulforic acid system and measured at 660 nm wavelength according to Jackson (1978).
- Potassium percentage; was determined using a flame photometer as described by Jackson (1978). The obtained data were subjected to statistical analysis using Michigan Statistical Program Version C (MSTATC). Least significant difference (L.S.D.) value at 0.05 and 0.01 for comparison between means of treatments were used as mentioned by Snedecor and Cochran (1973).

3. Results:

3.1. Vegetative growth characteristics:

Data presented in Table (1) clearly indicate that different Algaefol levels significantly affected plant height, branch number and herb weight (fresh & dry) of marigold plant. The Algaefol treatment at 3 ml/L significantly increased the plant height and branch number, as well as, herb weight (fresh & dry) compared to the control. By applying that treatment the plant height, branch number, fresh and dry weight were (47.33 cm and 5.33 branch/plant, 102.67 g/plant and 20.33 g/plant, respectively) compared to (35.67 cm and 2.67 branch/plant, 82.00 g/plant and 17.00 g/plant, respectively) for the control. On the other hand, there were no significant differences between 2 ml and 3 ml/L treatments in this concern.

Table 1: Effect of different levels of Algaefol compound on vegetative growth of *Tagetes erecta*, L. plant.

Algaefol levels	Plant height (cm)	Branch number/ plant	Fresh weight/plant (g)	Dry weight/plant (g)
Control	35.67	2.67	82.00	17.00
1 g/L	39.67	3.33	89.33	18.67
2 g/L	46.00	4.33	97.00	20.00
3 g/L	47.33	5.33	102.67	20.33
4 g/L	47.31	5.30	101.00	20.33
L.S.D. 0.05	1.93	0.62	3.62	0.69
0.01	3.20	1.02	6.01	1.15

3.2. Flower parameters:

Flower parameters of marigold as affected by Algaefol treatments were presented in Table (2). The obtained results indicate that the flower number/plant, flower diameter and flower weight (fresh & dry) was gradually increased with increasing Algaefol level and reached its maximum value (5.83 flower/plant, 6.67 cm, 8.67 g/plant and 1.5 g/plant, respectively) by applying 3 ml/L treatment. Meanwhile, all the previous characters decreased thereafter by the highest level of Algaefol. On the other hand, flower beginning (as the first flower emergence) was accelerated (35.33 day from transplanting compared with 41.67 day for control) with Algaefol at 3 ml/L in comparison with the other treatments.

Table 2: Effect of different levels of Algaefol compound on flower characters of *Tagetes erecta*, L. plant.

Algaefol levels	Flower number/plant	Flower diameter (cm)	Flower beginning (Days)	Flower fresh weight g/plant	Flower dry weight g/plant
Control	2.33	4.67	41.67	4.67	0.86
1 g/L	3.33	5.33	40.00	6.33	1.06
2 g/L	4.67	5.82	38.00	7.67	1.27
3 g/L	5.83	6.67	35.33	8.67	1.50
4 g/L	5.13	6.33	36.33	8.00	1.40
L.S.D. 0.05	0.41	0.39	1.16	0.31	0.007
0.01	0.66	0.64	1.92	0.51	0.011

3.3. Photosynthetic pigments (mg/g fresh weight):

The chlorophyll content of marigold leaves was gradually increased with increasing Algaefol levels from 1 to 3 ml/L, however, applying the highest level decreased the chlorophyll content compared to 3 ml/L treatment. The treatment of 3 ml/L significantly enhanced the chlorophyll content (a, b and total chlorophyll) compared to the control or other levels used (Table 3). By applying that treatment the chlorophyll content was (0.70, 0.36 and 1.06 mg/g F.W.) for chlorophyll a, b and total chlorophyll, respectively. Concerning carotenoids in flowers, the same trend was observed. The highest carotenoids content was 331.67 mg/g fresh weight of flowers was obtained with Algaefol at 3 ml/L compared to control (312.00 mg/g fresh weight of flowers).

Table 3: Effect of different levels of Algaefol compound on photosynthetic pigments of *Tagetes erecta*, L. plant.

Algaefol levels	Photosynthetic pigments			
	Chlorophyll (a) mg/g F.W.	Chlorophyll (b) mg/g F.W.	Total Chlorophyll mg/g F.W.	Total carotenoids mg/g F.W.
Control	0.53	0.23	0.76	312.00
1 g/L	0.57	0.26	0.83	317.00
2 g/L	0.65	0.31	0.96	323.00
3 g/L	0.70	0.36	1.06	331.67
4 g/L	0.67	0.34	1.01	329.67
L.S.D. 0.05	0.01	0.004	0.01	3.86
0.01	0.03	0.007	0.02	6.39

3.4. Nutrients (N, P and K), protein and carbohydrates percentages in leaves:

It was observed from the obtained data that leaf chemical constituents; N, P and K, protein and carbohydrates percentages were affected as a result of treating marigold plants by different Algaefol levels. Generally, the treatment of 3 ml/L was the superior treatment in increasing the percentages of the previous constituents compared with the other treatments. The percentages of N, P and K, protein and carbohydrates were 3.83, 0.54, 2.63, 21.14 and 3.96 %, respectively compared to 2.91, 0.34, 2.16, 18.21 and 3.53 % percentages, respectively as a result of foliar application of marigold by Algaefol at 3 ml/L.

Table 4: Effect of different levels of Algaefol compound on Nutrients content (N, P and K %), protein and carbohydrates percentages of *Tagetes erecta*, L. leaves.

Algaefol levels	N (%)	P (%)	K (%)	Protein (%)	Carbohydrates (%)
Control	2.91	0.34	2.16	18.21	3.53
1 g/L	2.83	0.39	2.26	17.67	3.69
2 g/L	3.29	0.47	2.45	20.58	3.63
3 g/L	3.38	0.54	2.63	21.14	3.96
4 g/L	3.13	0.46	2.55	19.54	3.81
L.S.D. 0.05	0.16	0.002	0.05	6.35	0.08
0.01	0.27	0.004	0.09	10.53	0.13

4. Discussion:

Growth parameters, flower characteristics and chemical constituents of marigold plants were positively affected by applying Algaefol treatments especially with 3 g/L. This promotion could be explained through the effective role of AA in stimulating plant growth by increasing cell division, as well as, optimized uptake of nutrients and water (Atiyeh et al., 2002; Chen et al., 2004) also, regulate hormone level, improve plant growth and enhance stress tolerance (Piccolo et al., 1992). In addition, AA stimulate plant growth by the assimilation of major and minor elements, enzyme activation and/or inhibition, changes in membrane permeability, protein synthesis and finally the activation of biomass production (Ulukan, 2008). AA which included in Algaefol such as methionine is linked to the biosynthesis of growth regulating substances (Maxwell and Kieber, 2004) and there is a link of tryptophan to the biosynthesis of auxins and other related natural products in plants (Tao et al., 2008).

AA have a chelating effect on micronutrient when applied, that make the absorption and transportation of micronutrients inside the plant is easier due to its effect on cell membrane permeability. Some of these micronutrients play roles in plant resistance by regulating the levels of auxins in plant tissues by activating the auxin oxidase system (Marschner, 1986). Amino acids help to increase chlorophyll concentration in plant leading to higher degree of photosynthesis and that was very clear from our data presented in Table (3). Any factor causes increase in photosynthetic pigments will lead to increase carbohydrate content as shown in Table (4). Carbohydrates are the main repository of photosynthetic energy, they comprise structurally polysaccharides of plant, principally cellulose, hemicelluloses and pectin and lignin which consider an important structural compound of plant. Also associated with phenolic compounds which play a major role in plant defense

(Hahlbrock and Scheel, 1989). And hence, this was reflected in enhancing the growth and flowering of marigold plants. The positive increment in the growth and flower yield components of marigold in response to amino acids is in agreement with those obtained by (Talaat, 2005; Rawia et al., 2011).

Otherwise, the Algaefole compound contains macro and micro nutrients which may play an important role in growth promotion and flower development. The stimulating effect of nutrients on plant growth may be due to its beneficial role in chlorophyll production (Hu and Sparks, 1991), protein synthesis and structure of many enzymes in plant cells (Marschner, 1995) which in turn enhance physiological processes in the plant, resulting in development of more tissues and organs (Taiz and Zeiger, 2002), and activating the cell division and enlargement (El-Tohamy and El-Greadly, 2007). From the previous results it could be concluded that foliar application of marigold plants with Algaefol (higher nutritional value) at 3 g /L was recommended. By applying that treatment the vegetative growth, flowering quality and chemical constituents of plants were improved.

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