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Growth Parameters and Photosynthetic Pigments of Marigold under Stress Induced by Jasmonic Acid

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Abstract

In this research, the effects of different concentrations of jasmonic acid (JA) on growth parameters of flower diameter, number of flowers, dry flower weight, plant height, 1000-seed weight and also, photosynthetic pigments in marigold (*Calendula officinalis* L.) were investigated. To achieve this aim, marigold planted in pots and jasmonic acid were sprayed on the shoots at concentrations of 0.75, 150 and 225 µM. Data were compared by Duncan test. The results showed that different concentrations of jasmonic acid significantly affected the dry flower weight, plant height and 1000-seed weight. The maximum plant height and 1000-seed weight were reached by 150 µM jasmonic acid, while 225 µM was recorded the dry flower weight.

Keywords: jasmonic acid, marigold, medicinal plants, morphological, phytochemical

Introduction

Marigold (*Calendula officialis* L.) is an annual plant belonging to the Asteraceae family, which often it is used as an ornamental and medicinal plant (Chalchat *et al.*, 1991). According to Dorwal (2012), this plant contains important compounds such as saponins, flavonoids, carotenoids, xanthophylls, essential oils, mucilage and phenolic acids.

Because of diverse sources of biological activities such as anti-inflammatory and anti-spasmodic effects, marigold is used. Also, it is used in gastric disease, eye and skin damage and some burns (Chakraborthy and Ghorpade, 2010).

Jasmonic acid is a plant growth regulator that plays key roles in plant growth and development, and responses to environmental stress (Creelman *et al.*, 1997; Kozlowski *et al.*, 1995). Studies on different plants showed that foliar application of Jasmonic acid increased growth of arabidopsis, and tomato compared with control plants (Boughton *et al.*, 2005; Devoto and Turner, 2005; Traw and Bergelson, 2003).

Baldi and Dixit (2007) also stated that the use of methyl jasmonate in plants as elicitor on artemisia increased biomass. Moreover, several reports on the positive effect of Jasmonic acid on increasing the growth of shoots and number of flowers in *Phaseolus lunatus* and improving flowering in *Lemna minor* were mentioned (Heil, 2004; Krajncic *et al.*, 2006).

As Sorial *et al.*, (2010) found in their research, number of stalk, leaf dry weight, shoot dry weight and chlorophyll content in basil plants are increased under treatment of this hormone.

Swiatek *et al.* (2003) found that jasmonic acid is effective on cell size and cell division.

Ding *et al.* (2002) stated that low concentrations of methyl jasmonate significantly increased plant resistance and thus it improves growth. The present reports indicate that jasmonates are necessary to promote flowers and sexual development in plants. Therefore, in the presence of jasmonate may have occurred early flower development and caused enhancement in production cycles and then increasing flower yield (Delker *et al.*, 2006).

Considering Jasmonic acids as growth regulator effective on phytochemical, and morphological attributes, and since these attributes are directly or indirectly effective on the medicinal properties of marigold, therefore, the purpose of the experiment design is to find some relations between the effects of hormonal treatments and phytochemical and morphological changes to achieve optimal effective concentration on desired traits.

Material and methods

To perform this experiment, Jasmonic acid purchased from Sigma (J2500) and the seeds of marigold were obtained from the Pakan Bazr Company. The experiment was completely randomized design with four levels of hor-

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mone including concentrations of 0, 75, 150 and 225 µM jasmonic acid.

Each treatment has 15 replicates. 4-5 leaf stage seedlings from seeds, transferred in pots filled with peat, leaves soil, potting soil. Plants were sprayed three times with hormone. Traits such as flower diameter, number of flowers, dry flower weight, plant height, 1000 seed weight, carotenoids, chlorophyll *a* and *b* were examined in this present study. Measurement of chlorophyll and carotenoids was performed by Porra (2002) method.

After the reaction between fresh leaf tissue and methanol, absorption were measured by spectrophotometer (Model uv-1800 PC) at a wavelength of 665.2 nm for chlorophyll *a*, 652.4 nm for chlorophyll *b* and 470 nm for carotenoids. The content of chlorophyll *a, b* and carotenoids were calculated from the following formula:

Chlorophyll $a = (16.72 \times A_{665.2}) - (9.16 \times A_{652.4})$

Chlorophyll $b = (34.09 \times A_{652.4}) - (15.28 \times A_{665.2})$

Carotenoid $= [(1000 \times A_{470}) - 1.63 \times \text{Chlorophyll } a - (104.96 \times \text{Chlorophyll } b)]/221$

After flower harvest, they were weighted by digital scale (model A&D company limiled) and to measure dry weight were dried in oven (model BM120) at 40 °C for 72 h (Omidbaigi, 1997). Analysis of variance, mean comparison using Duncan's multiple range test at the five percent level and drawing graph were done by SPSS software.

Results

Mean comparison results indicated that plants treated with 225 µM had dedicated highest flower diameter (5.26 cm). While no significant difference was observed between any of the treatments ($p \leq 0.05$) and the lowest flower diameter (5.06 cm) was obtained in plants treated with 150 µM jasmonic acid (Fig. 1).

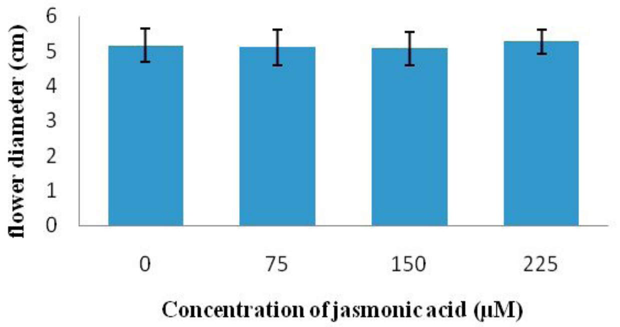

Fig. 1. Effect of different concentration of jasmonic acid on flower diameter

As it can be seen in Fig. 2, with the increasing of concentration of jasmonic acid from 0 to 150 µM, the number of flowers has increased through ascending trend. The application of jasmonic acid at 150 µM produced the highest number (24). There was no statistically difference between different treatments different treatments ($p \leq 0.05$).

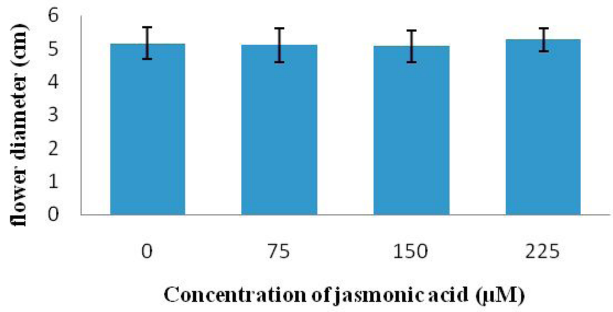

Fig. 2. Effect of different concentration of jasmonic acid on number of flower

Plants treated with 225 µM jasmonic acid caused the highest flower dry weight (0.44 g) that had no significant difference ($p \leq 0.05$) with control plants and plants treated with 150 µM, whereas significant difference ($p \leq 0.05$) is observed between this level and the plants treated with 75 µM jasmonic acid (Fig. 3).

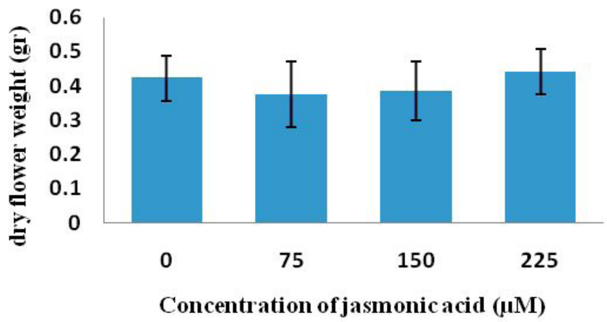

Fig. 3. Effect of different concentration of jasmonic acid on dry flower weight

Plant height has a ascending trend from control up to 150 µM. As the highest value of plant height (34.36 cm) was obtained in plants treated with 150 µM that have a significant difference ($p \leq 0.05$) with control plant (29.18 cm) (Fig. 4).

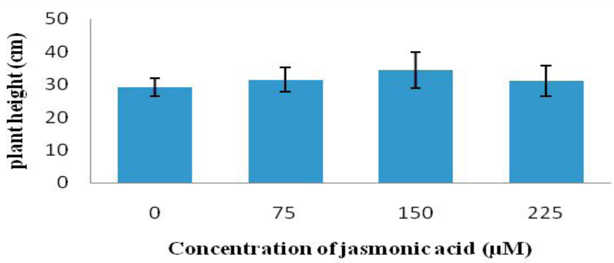

Fig. 4. Effect of different concentration of jasmonic acid on plant height

Moisture content (%) has the descending trend from 0 to 225 µM (Tab. 1). Biomass was enhanced with increasing concentration of jasmonic acid as in 225 µM the highest content was obtained (19.52).

In terms of seed weight, the highest value (13.05 g) was obtained at 150 µM jasmonic acid and control plant was recorded the lowest value (10.80 g).

Plants treated with 150 µM had no significant difference with 75 µM. while significant difference is observed between this level with control plants and 225 µM.

Tab. 1. Means comparison of studied attributes in treatment with jasmonic acid

Concentration of hormone (µM)	Moisture (%)	Biomass (g)	1000 seed weight (gr)	Carotenoid of leaf (µg ml-1)	Chlorophyll a (µg ml-1)	Chlorophyll b (µg ml-1)
0	83.16 a	16.83 a	10.803 b	0.86 a	3.01 a	1.06 a
75	82.90 a	17.09 a	11.9 ab	0.91 a	3.12 a	0.89 a
150	81.11 a	18.88 a	13.05 a	0.90 a	3.26 a	1.07 a
225	80.47 a	19.52 a	11.34 b	0.82 a	2.96 a	1.074 a

In each column, means with the same letter has no significant difference.

Considering that statistically nonsignificant difference was found between treatments in terms of carotenoids, but the highest carotenoids content (0.91 µg ml^{-1}) was obtained at 75 µM and plants treated with 225 µM were recorded the lowest carotenoids content (0.82 µg ml^{-1}).

According to the results, with the increasing of the concentration of Jasmonic acid, chlorophyll *a* increased up to 150 µM.

It is remarkable that there was no significant difference between treatments ($p \leq 0.05$). However, significant differences ($p \leq 0.05$) between treatments in terms of chlorophyll b did not exist, but the highest value (1.074 µg ml^{-1}) was obtained at 225 µM and concentration of 75 µM was accounted for the lowest (0.89 µg ml^{-1}) (Tab. 1).

Tab. 2 also indicates that there is significant positive correlation ($p \leq 0.01$) exist between flower diameters, flower dry weight and also between chlorophyll a and carotenoids. Diameter and flower number have a significant negative correlation ($p \leq 0.01$). It is remarkable that there is significant positive correlation ($p \leq 0.05$) between plant height and flower number.

Also, flower dry weight along with moisture content and biomass has significant negative and positive correlation ($p \leq 0.05$) respectively. In addition, a significant negative correlation ($p \leq 0.05$) is observed between chlorophyll b and carotenoids.

Tab. 2. Correlation coefficients between studied attributes of *Calendula officinalis* in

	Flower diameter (cm)	Number of flowers	Dry flower weight (gr)	Plant height (cm)	1000 seed weight (gr)	Carotenoids (µg ml^{-1})	Chlorophyll a (µg ml^{-1})	Chlorophyll b (µg ml^{-1})	Moisture content	Biomass
Flower diameter (cm)	1									
Number of flowers	-0.454**	1								
Dry flower weight (gr)	0.332**	-0.199^{ns}	1							
Plant height (cm)	-0.219^{ns}	0.285*	-0.091^{ns}	1						
1000 seed weight (gr)	-0.219^{ns}	0.1^{ns}	-0.057^{ns}	0.407**	1					
Carotenoids (µg ml^{-1})	-0.061^{ns}	0.031^{ns}	-0.006^{ns}	0.147^{ns}	0.214^{ns}	1				
Chlorophyll a (µg ml^{-1})	-0.53^{ns}	0.056^{ns}	-0.027^{ns}	0.090^{ns}	0.221^{ns}	0.928**	1			
Chlorophyll b (µg ml^{-1})	0.069^{ns}	0.025^{ns}	0.109^{ns}	-0.219^{ns}	-0.051^{ns}	-0.282*	-0.036*	1		
Moisture content	0.006^{ns}	-0.125^{ns}	-0.291*	-0.062^{ns}	0.034^{ns}	0.091^{ns}	-0.005^{ns}	-0.17^{ns}	1	
Biomass	-0.006^{ns}	0.125^{ns}	0.291*	0.062^{ns}	0.034^{ns}	-0.091^{ns}	0.005^{ns}	0.17^{ns}	-1**	1

** ($p<0.01$), * ($p<0.05$), ns ($p>0.05$)

Discussion

As the results showed, traits such as flower diameter, flower number and flower dry weight in plants treated with 225 μM jasmonic acid reached the highest values. These results are consistent with those obtained by (Heil, 2004; Krajncic *et al.*, 2006), who stated that jasmonic acid increases flowering in *Lemna minor* and *Phaseolus lunatus*.

Wasternack (2006) also outlined that Jasmonic acid has several roles in flowering and this hormone has effects on anther development, female organ development, chemical defence production, color production, and the attraction of pollinators.

Based on the presented results, dry flower weight at the level of 225 μM significantly was increased than 225 μM.

These findings are in accordance with other researchers who claimed that jamonates improves growth of arabidopsis, tomato, artemisia and basil (Baldi and Dixit, 2007; Boughton *et al.*, 2005; Sorial *et al.*, 2010; Traw and Bergelson, 2003).

In this present study, plant height has ascending trend up to 150 μM, and the highest value of it was obtained at 150 μM. In this context, Heil (2004) stated that the shoot the growth of *Phaseolus lunatus* L. were enhanced by jasmonic acid treatment.

These results could suggest that jasmonic acid protects plants against biotic stress and abiotic stress and enhance their resistance to damages, so it has had a positive impact on the mentioned traits (Devoto and Turner, 2005; Ding *et al.*, 2002).

Moreover, this hormone can promote the growth by effect on cell size and cell division (Sorial *et al.*, 2010; Swiatek *et al.*, 2003).

Reduction in shoot growth at high concentrations (225 μM) may be due to high concentrations of jasmonetes which could act as stress and may reduce the absorption of nutrients, that can lead to the reduction of growth (Rossato *et al.*, 2002).

In this regard, Mathew and Sankar (2012) stated that high concentrations of this hormone are associated with plant cell death. According to the results, it is observed that the highest value of chlorophyll a and b were obtained at 150 and 225 μM, respectively.

The findings were consistent with Sorial *et al.* (2010) who stated that jasmonic acid causes increment in chlorophyll in basil plant. They found that jasmonic acid treatment causes enhancement in the active cytokine (CK) that ultimately increase the chlorophyll pigments.

Saniewski *et al.* (2010) also expressed that jasmonetes controls ethylene production in plant tissues that seems by controlling ethylene production, and chlorophyll degradation is also reduced. In accordance with the obtained results, by increasing the number of flower, diameter was significantly reduced.

It seems that in case of increasing number of flowers, consumer organ increases too. Thus, each flower reaches less carbohydrate and dwindles. Positive correlation between the plant height and the number of flower can be as a result of direct relation between the plant height and the number of nods. When the plant height increases, number of nods increases too. So, more flowers form at nods.

In this connection, it has been reported that jasmonic acid increased the number of nodes and length of internode in tissue culture of *Vitis vinifera* L. (Ravnikar *et al.*, 1990). In general, considering the results of these experiments, high concentrations of jasmonic acid are proposed to achieve the desirable traits of ornamental and medicinal.

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