Effect of organic extracts on the growth and flowering of marigold plants (*Calendula officinalis* L.)

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Abstract

A nursery experiment was carried out during 2011 - 2012 at Najaf, Iraq, to determine the response of Marigold plant to organic fertilisers and their extracts. A factorial experiment was conducted involving three factors (2x4x2) namely, type of compost (the extracts of peat moss and sheep manure), concentrations of foliar application (0%, 20%, 40% and 60%), and the mixed in soil and foliar application. The results showed that the type of organic fertiliser and the application method significantly affected vegetative growth (leaf number/plant, shoot dry weight, leaf chlorophyll content, and carbohydrate leaf content), flowers parameters (length of the flower stem, flower number/plant, and flower diameter). This study showed that compared to the other fifteen treatment conditions, the application of extract of sheep manure applied at 40% concentration and as a foliar spray produced superior results on both vegetative growth and flower parameters.

Key words: Organic fertiliser, peat moss, sheep manure, Iraq.

Introduction

Marigold (*Calendula officinalis* L.) is an annual, herbaceous plant. It belongs to the family Asteraceae. Roots are a white yellowish to light brown color with a length of about 20 cm and a thickness of 7 mm and carry many root hairs. Stems are long and strong, 50 cm in length. Leaves are simple, elongated, spoon-shaped, dark green in color and 20 cm in length (Muley et al. 2009). The original home of the plant is the basin of the Mediterranean and it grows wild in southern and central Europe and the Netherlands.

Marigold is the third most important cut flower in the global market after roses and carnations. The flowers of the plant come in different colours. They are in high demand inf the holiday season during Easter and Mother's Day (Biondo & Noland 2000).

Marigold flowers are a rich source of a natural yellow to orange dye, helenien (a dipalmitate ester of axanthophylls), which is in high request by national and international companies, and this plant has been used for medicinal purposes (Ali & Hasan 2013). The plant is also used as a spice and a tea (Ćetković 2003; Isaac 1994).

Flowering of marigold plants under short photo-periods, however there is a long flowering period. The plants can be used in various situations in the home garden and in landscaping. It is one of the best plants for rock gardens, borders, flower beds and balcony plantings (Golestani et al. 2013).

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Organic farming is one of the practices to make the production system more sustainable without adverse effects on the natural resources and the environment (Kochakinezhad et al. 2014; Paull 2011; Ram et al. 2014). It not only maintains soil fertility but also conserves soil moisture (Yadav et al. 2014). Many studies have demonstrated that organic residues can be used with outstanding results (e.g. Kononova 1966; Tan 1986). Organic fertilisers and their extracts enhance soil fertility via improved nutrient retention and cycling and also plays an essential role in growth and yield (Khalid & Shafei, 2005).

The use of organic matter plays an essential role in the growth and development of Marigold plants (Elhindi 2012). It positively affects vegetative growth parameters including plant height, stem diameter, fresh and dry shoot weight, as well as flower parameters, including flower number per plant, flower height, and flower size of the plant (Shadanpour 2011), and it increases the availability and absorption of the essential nutrient elements, such as Fe_2+, Mg_2+ and NH_4+ cations, which are necessary for enzyme activation and chloroplast and chlorophyll formation (Elhindi 2012).

Adding different organic fertilisers to the soil or to a plant as a foliar application resulted in increased growth and flowering characters of *Borago officialis* plant (Ezz El-Din & Hendawy 2010). Application of organic fertilisers or their extracts also have positive effects on plant growth, dry matter yield and root development (Gharib et al. 2008; Ram et al. 2014). Addition of cow manure vermicompost at the 40% level resulted in high growth values of Marigold plant (Rahbari 2013). The purpose of this study is to determine the effects of the type of organic matter (peat moss and sheep manure), concentration of organic matter extractions, and the application method, on improving the growth, flowering and flower qualities of Marigold plants.

Materials and methods

Plants were grown at a private nursery at Najaf, Iraq during the 2011-12 season. The soil was silt loam in texture with a pH of 5.6 and a conductivity (EC) of 2 dS/m. Seeds were planted in treated soil in 150mm diameter plastic pots, 200 mm deep. Each pot contained 1kg soil with one plant. The experiment was conducted using completely randomized design (CRD) of three factors:

- 2 x types of organic matter (sheep manure and peat moss);
- 4 x concentrations of each extract (0%, 20%, 40% and 60%); and
- 2 x application methods (mixed with soil and spray).

Fertilisation by NPK at the level of 1 g/pot was applied for all treatments. At the end of the experiment on March 15, 2012, the following data were recorded:

(1) Number of leaves (leaves/plant);
(2) Dry weight of shoot (g);
(3) Total chlorophyll content in leaves (mg/100 g fresh weight) by acetone (Goodwin 1976);
(4) Carbohydrates content in leaves (mg/ mg dry weight) were estimated according to Duboies (1956);
(5) Length of flower stem (cm);
(6) Number of flowers (flowers per plant);
(7) Flower diameter (mm);
(8) Number of petals (petals per flower).

Data were analyzed by using factorial experimental design according to Steel & Torrie (1980), through analysis of variance (ANOVA) technique by using SAS software at P<0.05 level of probability. Differences between means were determined using the least significant difference (LSD) test.

Results and Discussion

Number of leaves

The type of organic matter and the application method significantly (P<0.05) affected the number of leaves per plant. The sheep manure increased the number of leaves by 36% over the control. Using the extract of sheep manure as a foliar application at the 40% level maximized the number of leaves to 76% over the control (Table 1). This increase could be due to the content of sheep manure of organic N and the immobilization process rather than that the organic matter increased the availability of some nutrients in the soil (Sabey & Hat, 1975). According to Hocking & Steer (1982), nitrogen plays an important role in protein components and enzymes and organizes hormone activity which is important in cell division and stimulates biological processes. This may account for the higher number of leaves in the plants that were treated by sheep manure.

Table 1. Effects of organic matter (OM) and application method with different concentrations on number of leaves per plant*.

Type of OM	Concentration (%)	Application method		Average of concentration	Average of OM
		Soil Mix.	Spray		
Peat moss	0	23.67 def	21.00 f		
	20	25.67 de	23.67 def	21.92 d	25.54 b
	40	25.33 de	32.00 b		
	60	30.33 bc	22.67 def	26.58 bc	
Sheep manure	0	22.00 ef	21.00 f		
	20	26.33 cd	30.67 bc	31.17 a	28.50 a
	40	30.33 bc	37.00 a		
	60	36.00 a	24.67 de	28.42 b	
Average of application method		27.46 a	26.59 a		
LSD (0.05) OM=1.3, Conc.=2.6, Application method=1.3, Interaction=3.7					

*Within a column of a table, reported quantities are significantly different where accompanied by different letters (p<0.05).

Shoot dry weight

Table 2 shows the effect of organic matter on shoot dry weight (SDW). The application of sheep manure showed an increase (P<0.05) of 14% over the peat moss treatment. Addition of the sheep manure at the 40% level showed the highest increase of 79% as compared to the control. Shoot DW was significantly (P<0.05) affected by the interaction between organic matter, the application method and the concentration, which may be due to the humus in the sheep manure which carries a negative charge and associated cations and soil particles making fixed aggregations, reducing soil bulk density, enhancing soil structure and water-air relationship that will positively affect the activity of soil organisms leading to enhance root growth, which could result in better extraction of water and nutrients from the soil occupied by the roots (FAO, 1977).

Table 2. Effects of OM and application method with different concentrations on Shoot dry weight (g) of plant*.

Type of OM	Concentration (%)	Application method		Average of concentration	Average of OM
		Soil Mix.	Spray		
Peat moss	0	5.85 bc	6.11 bc	5.57 b	6.20 b
	20	6.19 bc	5.29 bc		
	40	7.00 bc	6.87 bc	5.81 b	
	60	7.01 bc	5.28 bc		
Sheep manure	0	5.97 bc	4.36 c	8.02 a	7.09 a
	20	5.91 bc	5.84 bc		
	40	7.28 b	10.95 a	7.17 a	
	60	9.52 a	6.88 bc		
Average of application method		6.84 a	6.45 a		
LSD (0.05) OM=0.4, Conc.=1.3, Application method=0.4, Interaction=2.4					

*Within a column, reported quantities are significantly different where accompanied by different letters (p<0.05).

Leaf chlorophyll content

The effect of the type of organic matter and the application method on chlorophyll content in leaves is presented in Table 3. The extract of sheep manure increased (P<0.05) chlorophyll by 3% compared with the peat moss treatment. Chlorophyll content in leaves showed a significant (P<0.05) interaction between organic matter, application method and concentration. Due to this interaction, Marigold gave the highest Chlorophyll content in leaves with sheep manure applied sprayed at 40% (76.91 mg/100 g fresh weight). According to Elhindi (2012) organic matter includes essential nutrients for plant growth which has a positive effect for chlorophyll molecules and chloroplast formation. Organic acids and carbon dioxide have a role in enhancing the availability of some nutrients such as Mg which plays an important role in the formation of the chlorophyll molecule.

Table 3. Effects of OM and application method with different concentrations on total chlorophyll leaf content (mg/100 g fresh weight) of plant*.

Type of OM	Concentration (%)	Application method		Average of concentration	Average of OM
		Soil Mix.	Spray		
Peat moss	0	57.01 f	56.06 f	57.11 c	62.14 b
	20	57.28 f	62.75 cd		
	40	64.81 c	64.38 c	60.16 b	
	60	72.68 b	62.18 cd		
Sheep manure	0	56.28 f	59.11 def	66.86 a	63.74 a
	20	57.59 ef	63.04 c		
	40	61.35 cde	76.91 a	67.63 a	
	60	73.87 ab	61.77 cd		
Average of application method		62.61 a	63.27 a		
LSD (0.05) OM=1, Conc.=2.5, Application method=1, Interaction=3.9					

*Within a column, reported quantities are significantly different where accompanied by different letters (p<0.05).

Carbohydrate leaf content

Organic matter increased (P<0.05) leaf carbohydrate content (Table 4). Sheep manure gave the highest rate (6.08 mg/g dry weight). Leaf carbohydrate content was significantly (P<0.05) affected by the interaction between organic matter, application method and concentration. The magnitude of this increase was maximized in sheep manure at 40% concentration level as foliar application. It is believed that the fulvic acid consists of carbohydrate and amino acids (Chen et al. 2002) thus have these materials ready for absorption via the leaf surface. This result is in accordance with the findings of Tisdale et

al. (1985) who reported that the addition of humic extracts increases the production of carbohydrates.

Table 4. Effects of OM and application method with different concentrations on Carbohydrate leaf content (mg/ g dry weight) of plant*.

Type of OM	Concentration (%)	Application method		Average of concentration	Average of OM
		Soil Mix.	Spray		
Peat moss	0	4.17 e	4.37 e	4.22 c	5.17 b
	20	4.63 e	5.57 cd		
	40	5.40 cd	4.67 e	5.27 b	
	60	7.03 bc	5.53 cd		
Sheep manure	0	3.90 e	4.43 e	6.19 a	6.08 a
	20	4.93 d	5.93 cd		
	40	5.63 cd	9.07 a	6.83 a	
	60	8.13 ab	6.63 bcd		
Average of application method		5.48 b	5.78 a		
LSD (0.05) OM=0.3, Conc.=1, Application method=0.3, Interaction=1.8					

*Within a column, reported quantities are significantly different where accompanied by different letters (p<0.05).

Length of flower stem

Flower stems of the plants was significantly (P<0.05) influenced by the type of organic matter and the application method (Table 5). Peat moss addition increased the flower stem by 30% as compared to sheep manure. This may be because the organic extracts include organic N and increase the nutrient availability. This result coincides with that of Sabey & Hart (1975) who showed that the organic extract increased the nutrient availability

Table 5. Effects of OM and application method with different concentrations on Length of flower stem (cm) per plant*.

Type of OM	Concentration (%)	Application method		Average of concentration	Average of OM
		Soil Mix.	Spray		
Peat moss	0	14.93c	16.90bc	15.64a	23.27a
	20	16.53bc	17.77abc		
	40	17.17bc	19.23abc	18.10a	
	60	19.67abc	17.93abc		
Sheep manure	0	15.10bc	15.63bc	19.63a	17.93b
	20	16.07bc	16.03bc		
	40	18.70abc	23.43a	19.01a	
	60	21.03ab	17.40bc		
Average of application method		17.40a	18.04a		
LSD (0.05) OM=4, Conc.= 5, Application method=4, Interaction=6					

*Within a column, reported quantities are significantly different where accompanied by different letters (p<0.05).

Number of flowers per plant

The type of organic matter and the application method had a significant effect on the number of flowers per plant. The highest number (14.67) of flowers was in the pots treated with sheep manure. The number of flowers exhibited the maximal response with sheep manure applied at 40% as a foliar spray (Table 6).

Table 6. Effects of OM and application method with different concentrations on Number of flowers per plant*.

Type of OM	Concentration (%)	Application method		Average of concentration	Average of OM
		Soil Mix.	Spray		
Peat moss	0	7.33 i	11.00 efgh	10.50c	11.92b
	20	9.33 hi	12.67 efg		
	40	14.33 cde	14.00 cdef	11.83b	
	60	16.00 bc	10.67 gh		
Sheep manure	0	12.00 efgh	11.67 efgh	15.83a	14.67a
	20	12.33 efg	13.00 def		
	40	14.67 cd	20.33 a	15.00a	
	60	18.33 ab	15.00 cd		
Average of application method		13.04 b	13.54 a		
LSD (0.05) OM=0.4, Conc.=1, Application method=0.4, Interaction=2.3					

*Within a column, reported quantities are significantly different where accompanied by different letters (p<0.05).

Increasing the number of flowers as a result of applying organic extracts (Shadanpour 2011) may be due to the significant impact of the nutrients in the organic extracts in stimulating growth regulators, including auxins and gibberellins, that play an important role in increasing the proportion of the pollination through the control of transport nutrients toward the flowers (Sergeant, 1965).

Flower diameter

Flower diameter (cm) was affected by the type of organic matter and the application method (Table 7). Marginal increase in flower diameter occurred with added sheep manure. Flower diameter of Marigold plant showed an increase of 84% due to the interaction effect between organic matter, application method and concentration (maximum at 40% sheep manure foliar application), as compared to the control treatment (water spray). The organic extracts increase plant growth and enhance the flower characteristics.

Table 7. Effects of OM and application method with different concentrations on flower diameter (mm) of plant*.

Type of OM	Concentration (%)	Application method		Average of concentration	Average of OM
		Soil Mix.	Spray		
Peat moss	0	2.40 c	2.40 c	2.37 b	3.10 a
	20	2.70 bc	2.87 ac		
	40	3.23 ac	4.30 a	2.80 b	
	60	3.47 ac	3.47 ac		
Sheep manure	0	2.43 c	2.23 c	3.73 a	3.16 a
	20	2.40 c	3.23 ac		
	40	3.27 ac	4.10 a	3.63 a	
	60	4.27 a	3.33 ac		
Average of application method		3.02 b	3.24 a		
LSD (0.05) OM=0.1, Conc.=0.8, Application method=0.1, Interaction=1.6					

*Within a column, reported quantities are significantly different where accompanied by different letters (p<0.05).

Number of petals per flower

Table 8 shows the positive impact of the type of organic matter and the application method on the number of petals per flower; the response to sheep manure and peat moss was not significantly different as a main effect (P>0.05). There was a significant

(P<0.05) interaction between organic matter, application method and concentration (maximum at 40% sheep manure foliar application), in the number of petals per flower. The number of petals showed an increase of 74% (in the 40% sheep manure foliar application treatment) compared with the control.

Table 8. Effects of OM and application method with different concentrations on Number of petals per plant*.

Type of OM	Concentration (%)	Application method		Average of concentration	Average of OM
		Soil Mix.	Spray		
Peat moss	0	23.33 fg	23.33 fg	22.33 b	27.08 a
	20	24.33 fg	25.67 ef		
	40	28.33 de	32.67 bc	24.75 b	
	60	30.33 cd	28.67 de		
Sheep manure	0	21.00 g	21.67 g	31.83 a	28.08 a
	20	24.00 fg	25.00 efg		
	40	28.67 de	37.67 a	31.42 a	
	60	36.33 ab	30.33 cd		
Average of application method		27.04 a	28.13 a		
LSD (0.05) OM=1.1, Conc.=3, Application method=1, Interaction=3.7					

*Within a column, reported quantities are significantly different where accompanied by different letters (p<0.05).

Conclusion

The outcome from this experimental study is that it is reasonable to conclude that the application of organic extracts (both peat moss and sheep manure), increased the plant characteristics measured: number of leaves per plant, shoot dry weight, leaf chlorophyll content, carbohydrate leaf content, length of flower stem, number of flowers per plant, flower diameter and number of petals per flower. These increases were higher when using sheep manure extract (except length of flower stem) rather than peat moss. For the sixteen treatments (2x4x2) in this study, compared to the other treatments, the application of sheep manure extract at a concentration rate of 40% as a foliar spray resulted in superior growth values and flower parameters of Marigold plants.

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