EFFECT OF WATER REQUIREMENT AND ORGANIC FERTILIZATION ON GROWTH AND YIELD OF MARIGOLD (*Calendula officinales* L.) PLANTS UNDER SANDY SOIL CONDITIONS.

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ABSTRACT

The present study was carried out at the Experimental Farm of El-Quassassin Hort. Res. Station, Ismailia Governorate, Hort. Res. Institute, Agric. Res. Center, Ministry of Agric., Egypt. during the two successive seasons (2010/2011) and (2011/2012**)** to investigate the effect of water requirements (1150, 2300 and 3450 m^3 / fed.) and fertilization treatments (mineral fertilizers NPK (control) at the rate of 300 kg / fed ammonium sulphat, 300 kg / fed super phosphate and 200 kg / fed potassium sulphate), (three sources of organic manure, i.e., poultry manure (PM), compost (C) and cattle manure (CM) at 10,15 and 20 m^3 / fed) respectively and their interactions between them on growth, dry ray flowers yield and active ingredient of marigold **(***Calendula officinales* L**.)** plant using drip irrigation system under sandy soil condition.

Irrigated marigold plants by 3450 m^3 / fed water recorded maximum values of plant growth parameters ,i.e., plant height, number of branches / plant, plant fresh and dry weights, yield of dry ray flowers / fed, carotenoides and olenolic acid in flowers of marigold plant as compared to other irrigation treatments. While, the lowest values of these parameters were obtained with 1150 m^3 /fed water. On the other side, water use efficiency (WUE) was the highest with 1150 m^3 /fed irrigated water in both seasons.

Plant growth parameters and the yield of dry ray flowers/ fed, WUE, carotenoides and olenolic acid content in flowers were increased significantly with plant fertilization with poultry manure (PM) at 10 m^3 / fed.

Interaction treatment between water quantity at 3450 m^3 / fed and poultry manure (PM) at 10 m^3 / fed or the same rate of irrigation combined with mineral fertilizers was the superior treatments for enhancing plant growth, yield of dry ray flowers and chemical constituents in flowers of marigold plants in both seasons. While the interaction between 1150 m^3 / fed water and poultry manure (PM) at 10 m^3 / fed was the best treatment for increasing water use efficiency (WUE) in both seasons.

It could be concluded that irrigated marigold plants by 3450m^3 water/ fed combined with 10m^3 /fed poultry manure (PM) was the best treatment for enhancing plant growth parameters, yield of dry ray flowers, carotenoides and olenolic acid in flowers. On the other side, water use efficiency (WUE) was the higher when irrigated plants with 1150 m^3 water / fed combined with 10 m^3 /fed poultry manure.

Keywords: Calendula officinales L. plant, irrigation requirements, organic manure, ray flowers, WUE, chemical content.

INTRODUCTION

Marigold (C*alendula officinalis* L.), is an annual medicinal and ornamental plant belong to family Asteraceae with yellow and orange flowers and a native to Mediterranean region (Anderson, 2013).

Calendulas produced for ornamental use include cut flowers and potted flowering plants. Cut flowers may be grown either in the field or in the greenhouse (Hamrick, 2003). which have antioxidant activities and play important role in human health (Meda *et al*., 2005). The main constituents of Marigold are include carbohydrates, phenolic compounds, lipids, steroids, terpenoids, tocopherols, carotenoids, quinones and vitamin C (Shahrbabaki *et al*., 2013), potted flowering plants are grown almost exclusively in the greenhouse in a soilless substrate (Fornes *et al*., 2007).

Irrigation is an important and effective factor on growth and flowering traits, because it is associated with many environmental factors, which influence plant growth and development. Availability of sufficient amount of moisture optimizes the metabolic process in plant cells and increases the effectiveness of the mineral nutrients (Saif *et al*., 2003). Yousef (2002) found that, increasing irrigation amount from 934 to 2802 m^3 /fed /season resulted in significant increase in chamomile plant growth parameters. Pirzad and Shokrani (2012) mentioned that, the maximum capitulate diameter in *Calendula officinalis* L. was observed in control treatment (without irrigation disruption). Also, Rahmani *et al*. (2012) found that maximum petal yield (809.8 kg ha^{-1}), extract yield (218.6 kg ha^{-1}), petal/flower weight ratio (33.6 %) and flower quality (45.9) was recorded in irrigation (40 mm evaporation from class A pan as compared to 80 and 120 mm evaporation from class A pan). Metwally *et al.* (2013) indicated that water regimes of 75 % of field water capacity increased certain growth characters i.e. plant height, leaf area (cm^2), flower diameter (cm) and spike stem diameter. Yousef, *et al*. (2013) found that the highest growth parameters and yield components of *Echinacea purpurea* were obtained when plants were grown under the highest irrigation water quantity (3816 m^3 /fed), treated with the highest biofertilizer level and 1500 g /fed nitrobein + 1500 g /fed phosphorein. Increasing both irrigation water quantities and biofertilizers treatments caused progressive increase in both NPK % and total carbohydrates %, while reversed trend was obtained for phenolic compounds %.

Organic fertilization is added to soils to improve their physical and chemical properties in the form of compost, animal manure. They increase the soil fertility by their composition from macro and micro elements, organic acids, sugars and organic matter, also are considerable useful habitat for several beneficial microorganisms, (El-Mahrouk, 2000). Also, organic fertilizer is softy for human health and environment. It is made by recycling organic materials in a controlled process, (Herrera *et al*., 1997). In this regard, Khalid, *et al*. (2006) showed that, solarized soil with different levels of cattle manure resulted in a significant increase in growth and yield characters, compared with the treatments of cattle manure only on *Calendula officinalis* L. plant.

The interaction between cattle manure levels and soil solarization increase the content of essential oil, flavonoides, crotenoides, N, P, K, Fe, Zn and Mn compared with the treatment of cattle manure only.

Also, Kumar and Sharma (2013) showed significant response especially well rotten farmyard manure against vermicompost. Flower yield (206.8 q ha^{-1}), carotenoid content in fresh petal (166.0 g) and dried petal (16.5 g) was responded by farm yard manure, whereas, vermicompost

showed maximum dry weight of single flower (1.38 g) and dried petal yield (12.8 q ha^{-1}) on marigold plants. Also, Idan *et al.* (2014) showed that on marigold plants, significant effect on fresh weight of flower, number of flowers per plant, flower yield/plant/plot/hectare were recorded maximum in treatment with poultry manure at 20 ton/ha as compared to the same rate of FYM or compost. Khodadadi, *et al*. (2013) found that the maximum shoot fresh weight and shoot dry weights were achieved on kitchen wastes vermicompost (KWV) at 3 % and Cow manure vermicompost (CMV) at 4.5 %, respectively of *Calendula officinalis* L. plant. The highest value of flower fresh weight was in CMV at 3%. The highest amount of flower dry weight was obtained in CMV at 4.5 %. Flower number and total phenolic content were maximum in CMV at 4.5 %.

Thus, the present work aimed to study the effect of water requirements and fertilization treatments to obtain high yield and best quality of ray flowers of marigold plant under sandy soil conditions and using drip irrigation system.

MATERIALS AND METHODS

This investigation was carried out at the Experimental Farm of El-Quassassin, Hort. Res. Station, Ismailia Governorate, Hort. Res. Inst. Agric. Res. Center, Ministry of Agric., Egypt, during the two successive seasons (2010/2011) and (2011/2012). The present study was conduced to investigate the effect of water requirements and fertilization treatments and their interactions on the plant growth, flowering characteristics and chemical constituents of Marigold (*Calendula officinales* L) plant under sandy soil conditions.

The seeds of Marigold (*Calendula officinales*, L) were obtained from the Medicinal and Aromatic Plans (MAP) Dept. of, Hort. Res. Inst., Agric. Res. Center, Egypt. The seeds were sown in the nursery on 15th Sept. in the both seasons, after 45 days from planting when the seedlings had grown to approximately 10cm in height were transplanted in the field on 1st Nov. in both seasons at 30cm apart plants and 60cm between lines. The experimental unit was 10.8 m^2 (three dripper lines at 6 m length x 0.6 m width) every unit contained 60 plants (about 23000 plants per fed approximately).

The physical and chemical analysis of the soil was analyzed according to **Jackson (1973)** were presented in Table (A).

The irrigation treatments started on Nov. 5th and stopped on May 1st in the two seasons of study (175 days). The water was added using water counter and pressure counter. Irrigation was twice weekly. A guard area; 1.5 m in width was left between each two experimental units to avoid the overlapping infiltration of both irrigation and fertilization treatments.

Drip irrigation system was used in this experiment with drippers of 2 liter /hr. discharge for each at 0.5bar. The amount of applied water irrigation liter/plant and m^3 /fed for every irrigation treatments during the growth period are shown in Table (B). Chemical analysis of the irrigation water is shown in Table (C).

Table (A): The physical and chemical analysis of the experimental soil during (2010/2011 and 2011/2012) seasons.

Properties	1st season	2nd season
1- Physical analyses :		
Saturation percent %	25	25
Field capacity %	11	11
Wilting point %	6	6
Available water %	5	5
2- Mechanical analyses :		
Sand (%)	87.13	87.02
Silt (%)	7.24	7.42
Clay (%)	5.63	5.56
Soil texture	Sandy	Sandy
3- Chemical properties :		
3-1- Salt analysis :		
EC dS_m^{-1}	1.6	1.5
pH	7.08	7.09
Cations (meq/l) :		
Ca^{2+}	5.7	5.4
Mg^{2+}	2.6	2.6
Na^{+}	7.0	7.02
K^{+}	0.8	0.7
Anions (meq/l) :		
Cl^{-}	7.6	7.4
CO_3^{2-}	0	0
HCO_3	2.8	2.9
SO_4^{2-}	5.6	5.1
3-2- Available elements :		
Nitrogen (mg/kg)	7.1	7.3
Phosphorus (mg/kg)	2.1	2.8
Potassium (mg/kg)	13.4	13.9
3-3- Organic matter (OM) (%)	0.01	0.03

Table (B): Irrigation treatments and water amount added per plant and per fed during the plant growth season.

Time (minute /irrigation)	Water amount (L/ plant/ week)	Water quantity (L/ plant/ season)	Water quantity (m^3/fed)
30	2	50	1150
60	4	100	2300
90	6	150	3450

Table (C): The chemical analysis of the used irrigation water.

Characters	$ECdS_m^{-1}$	pH	Cations (meq / l)				Anions (meq / l)			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
Value	0.387	8.35	1.8	1.0	0.86	0.17	0.00	2.70	1.00	0.14

The mineral fertilizers were NPK: {300 Ammonium sulphat (20.5% N)- 300 Super phosphate (15.5% P_2O_5) -200 Potassium sulphate (48% K_2O) } were divided in to four equal doses, the first dose was applied after one month from transplanting, and the other three doses were applied after 15 days intervals. Organic fertilizers such as poultry manure (PM), compost (C) and cattle manure (CM) at the rate of 10, 15 and 20 m^3/fed., respectively and added 15 days before transplanting during soil preparation beside the rows in

channel and covered by sand. Organic fertilizers were obtained (PM and CM) from a private farm at El-Quassassin Ismailia Governorate. While compost was obtained from Arab Organization for Industrialization (A.O.I). The chemical composition of organic fertilizers are shown in Table **(E).**

Table (E): Chemical composition of cattle manure, poultry manure and compost.

Fertilizer characteristics	Cattle manure (CM)		Poultry manure (PM)		Compost (C)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Weight of 1m^3 (kg/m^3)	491	470	685	526	570	560
Moisture content (%)	19.50	19.10	16.90	19.60	17.3	15.6
Organic matter (%)	34.20	32.40	45.70	54.60	48.92	43.82
Organic carbon (%)	24.2	20.9	38.2	34.6	27.3	30.9
Total nitrogen (%)	1.82	1.94	3.42	2.96	2.64	2.30
Total phosphorus (%)	0.37	0.42	1.07	0.92	1.65	1.04
Total potassium (%)	0.86	1.09	1.97	2.30	2.53	1.80
C/N ratio (%)	13.3	10.7	11.2	11.7	10.3	13.4
Fe (ppm)	710.8	932.4	926.8	1457.3	850.6	1071.4
Zn (ppm)	186.9	259.7	290.3	250.4	267.2	210.3
Mn (ppm.)	187.2	167.4	124.9	170.6	210.4	154.2
Cu (ppm)	56.7	34.1	92.4	100.2	102.3	76.4
E.C. (mmoh/cm)	6.8	7.5	5.3	4.9	5.2	4.6
pH	7.9	8.1	7.2	7.5	7.2	7.6

The experiment included 12 treatments, which were the combinations between three irrigation requirements and four fertilization treatments.

a. Irrigation requirements (m^3/fed.)

1- 1150
2- 2300
3- 3450

b. Fertilization treatments

1- NPK (control)
2- Poultry manure (PM).
3- Compost (C).
4- Cattle manure (CM).

These treatments were arranged in a split plot design with three replicates. Irrigation water quantities were arranged in the main plots and the fertilization treatments were randomly distributed in the sub plots.

The following data were recorded:

A random samples of three plants were taken in every experimental unit at the middle of March in both seasons to evaluate the following characters.

Vegetative growth:

1- Plant height (cm).
2- Branches (number / plant).
3- Plant fresh weight (g).
4- Plant dry weight (g).

Yield of dry ray flowers: was determined (g /plant) and (kg /fed) in all picking stages in both growing seasons.

Water use efficiency (WUE) : was determined by dividing the dry ray flowers /fed by the water quantity/ fed and expressed as kg dry ray flowers/ m^3 water (Begg and Turner 1976).

Chemical analysis:

1.**Total carotenoides:** (mg /100g FW) were determined according to the procedure described by Mazumdar and Majumder (2003).

2- **Oleanolic acid:** content was estimated according to EL-Gaingihi *et al*., (1982).

Statistical analysis:

The obtained data were tabulated and statistically analyzed according to Steel and Torrie (1980) using L.S.D. at 5 % for comparison between means of different treatments.

RESULTS

Plant growth parameters

Concerning the water requirements**,** data in (Table, 1) show the effect of irrigation water quantities on plant height, number of branches / plant, both fresh and dry weights of marigold plant during 2010/2011 and 2011/2012 seasons under sandy soil conditions. It can be concluded that such characters were significantly increased with increasing water quantity from 1150 up to 3450 m^3 water/fed in both seasons.

It is obvious from such data that irrigated marigold plants by 3450 m^3 water/fed recorded maximum values of plant growth parameters as compared to other irrigation treatments. On other hand, the lowest values of plant growth parameters were obtained with 1150 m^3 /fed water in both seasons.

Regarding**,** the effect of fertilization treatments (mineral fertilizer (NPK) poultry manure (PM) at 10 m^3/fed, compost (C) at 15 m^3/fed and cattle manure (CM) at 20 m^3/fed) on plant height, number of branches/ plant, both fresh and dry weights of marigold plant in both seasons (Table 1). It can be noticed that plant height, number of branches/ plant, both fresh and dry weight of marigold plant were increased significantly with fertilization with poultry manure at 10 m^3/fed, without significant differences with mineral fertilizer with respect to plant height in the second season. On the other side, fertilization of marigold plants with mineral fertilizer came in the second rank. On the other hand, application of cattle manure at 20 m^3 /fed recorded the lowest values of all plant growth traits in both seasons.

As for the interaction between water requirements and fertilization treatments on plant height, number of branches /plant, fresh and dry weights of marigold plant in both seasons. It is evident from the data in (Table 2) that the interaction treatments between irrigation quantity and fertilization treatments had significant effect on number of branches in the 2nd season and both fresh and dry weights of plant in both seasons.

The maximum number of branches/ plant and both fresh and dry weights were obtained with the interaction between 3450 m^3 water/fed and fertilization of marigold plants with PM at 10 m^3/fed in both seasons. While, the interaction treatments did not reflect any significant effect on plant height in both seasons and number of branches in the 1st season.

1

Yield of dry ray flowers /plant and /feddan

Irrigation water requirements had significant effect on the yield of dry ray flowers /plant and /fed of marigold plants during both seasons (Table **3**). Increasing of irrigation water quantity up to 3150 m^3/fed, significantly increased yield of dry ray flowers /plant and /fed and recorded the maximum yield (30.85 and 43.52 g /plant) and (739.08 and 1034.34 kg/fed) in the 1st and 2nd seasons, respectively, but irrigation water quantity at 1150 m^3/fed gave the lowest yield of dry ray flowers (14.50 and 22.95 g /plant) and (349.32 and 548.24 kg/fed) in the 1st and 2nd seasons, respectively.

On the other side, irrigation of marigold plants with 2300 m^3/fed gave the intermediate values between them.

The relative increases in the yield of dry ray flowers/ fed were 111.6 and 88.7 % for water quantity at 3450 m^3/ fed, 59.3 and 52.2 % for 2300 m^3 /fed over the water quantity of 1150 m^3/fed in the both seasons, respectively.

As for the effect of fertilization treatments on the yield of dry ray flowers in both seasons (Table 3), data show significant effect on the yield of dry ray flowers per plant and per fed in both seasons. The yield of dry ray flowers of marigold plants significantly increased with organic fertilizer treatments especially PM at 10 m^3/fed with no significant differences with mineral fertilizers at different cutting stages in both seasons.

The maximum yield of dry ray flowers per plant and per fed were obtain when applied (PM) at 10 m^3/fed (30.53 and 44.33 g/plant) and (726.05 and 1045.98 kg/fed) followed by mineral fertilizers (29.10 and 42.58 g/ plant) and (693.65 and 1007.48 kg/fed) in the 1st and 2nd seasons, respectively. On the other hand, the lowest yield of dry flowers were obtained with (CM) at 20 m^3 /fed (15.88 and 24.27 g / plant) and (378.00 and 575.94 kg / fed) in the 1st and 2nd seasons, respectively.

The relative increase in total yield of ray flowers/fed were 4.7 and 3.8 % for PM at 10 m^3/fed over the fertilization with mineral fertilizers in the 1st and 2nd seasons, respectively. On the contrary, The relative decreases in the yield of dry ray flowers/ fed were 43.4 and 41.4 % for compost at 15 m^3/fed and 45.5 and 42.8.0 % for CM at 20 m^3/fed than the fertilization with mineral fertilizers in the 1st and 2nd seasons, respectively.

The interaction between irrigation water quantity and fertilization treatments had significant effect on the yield of dry ray flowers /plant and / fed in both seasons, (Table 4). Irrigation water quantity at 3450 m^3/fed with PM at 10 m^3/fed gave the highest values of the yield of dry ray flowers (42.12 and 57.03 g/plant) and (982.72 and 1330.78 kg/fed) in the 1st and 2nd seasons, respectively, with no significant differences with the same treatment of water combined with mineral fertilizers (40.32 and 55.10 g/plant) and (940.72 and 1285.67 in the 1st and 2nd seasons, respectively). On the other hand, the treatment of irrigation at 1150 m^3/fed combined with 20 m^3/fed CM recorded the lowest total yield of ray flowers (10.00 and 15.88 g/plant) and (233.33 and 370.61 kg/fed) in the 1st and 2nd seasons, respectively.

3

4

The relative increases in the yield of dry ray flowers/ fed were 117.3 and 91.3 % for the interaction between 3450 m^3/fed water and PM at 10 m^3/ fed over the interaction between 1150 m^3/fed water and NPK mineral fertilizers in the 1st and 2nd seasons, respectively.

Water use efficiency WUE (kg dry ray flowers / m^3 water)

Data presented in (Table, 5) showed that irrigation water quantity had significant effect water use efficiency of marigold plants in both seasons**.** The highest WUE was obtained by decreasing irrigation water quantity up to 1150 m^3 water/fed and simultaneously reduced gradually the water use efficiency by increasing irrigation water quantity up to 3450 m^3/fed. Irrigated marigold plants with 1150 m^3/fed recorded the maximum WUE efficiency (0.304 and 0.477 kg dry ray flowers/m^3 water) in the 1st and 2nd seasons, respectively). On the other hand, irrigation of plant with 3450 m^3 water/fed recorded the minimum WUE (0.215 and 0.300 kg dry ray flowers/m^3 water) in the 1st and 2nd seasons, respectively).

As regards the effect of fertilization treatments, it is evident from the data in Table (5) that fertilization of marigold plants had a significant effects on water use efficiency in both seasons. Fertilization with PM at 10 m^3/ fed recorded the maximum increment of water use efficiency (0.337 and 0.498 kg dry ray flowers /m^3 water) in the 1st and 2nd seasons, respectively, when compared the other fertilization treatments in both seasons. While, the lowest WUE was obtained by application of 20 m^3/fed CM (0.174 and 0.267 kg dry ray flowers/m^3 water) in the 1st and 2nd seasons, respectively.

Table (5): Effect of water requirements, fertilization treatments and their interaction on water use efficiency (kg ray flowers / m^3 water) of *Calendula officinalis* L. flowers during (2010/2011 and 2011/2012) seasons.

Fertilization / Irrigation	Water use efficiency (kg ray flowers / m^3 water)				
	NPK	**PM** at **10 m^3 / fed**	**C** at **15 m^3 / fed**	**CM** at **20 m^3 / fed**	**Mean A**
2010/2011 season					
1150	0.393	0.411	0.207	0.203	0.304
2300	0.299	0.314	0.182	0.172	0.242
3450	0.273	0.285	0.153	0.147	0.215
Mean B	0.322	0.337	0.181	0.174	--
LSD at 5 %	A= 0.011		B=0.027	AB= 0.041	
2011/2012 season					
1150	0.605	0.644	0.335	0.322	0.477
2300	0.453	0.464	0.273	0.261	0.363
3450	0.373	0.386	0.222	0.219	0.300
Mean B	0.477	0.498	0.277	0.267	---
LSD at 5 %	A = 0.018		B = 0.024	AB = 0.036	

NPK in the form of ammonium sulphat 20.5% N, super phosphate 15.5% P_2O_5 and potassium sulphate 48% K_2O at 300, 300 and 200 kg/fed. respectively;
PM= poultry manure, C= compost and CM= Cattle manure.

It is quite clear from the data in (Table, 5) that the interaction between irrigation water quantity and fertilization treatments had significant effect on WUE in both seasons.

Addition of 1150 m^3 water to marigold plants during the growing season and fertilized with PM at 10 m^3/fed gave the maximum WUE (0.411 and 0.641 kg dry ray flowers/m^3 water) in the 1st and 2nd seasons, respectively. On other hand, the minimum WUE (0.147 and 0.219 kg dry ray flowers/m^3 water) was obtained when applied 3450 m^3 water and fertilized plants with CM at 20 m^3/fed. in the 1st and 2nd seasons, respectively.

Carotenoides and olenolic acid contents in flowers :

The effect of irrigation water quantity (1150, 2300 and 3450 m^3 water / fed) on carotenoides and olenolic acid contents in marigold flowers are shown in (Table, 6). It is evident that irrigation quantity had significantly increased carotenoides and olenolic acid contents in marigold flowers in both seasons. Increasing water quantity from 1150 up to 3450 m^3/fed significantly increased carotenoides and olenolic acid contents in marigold flowers. The highest contents of carotenoides and olenolic acid in flowers were obtained by irrigated plants with 3450 m^3water/fed in both seasons, without significant differences between 2300 m^3 water/fed. with respect carotenoides in both seasons and olenolic acid content in the 2nd season.

On the other hand, the lowest contents of these parameters were obtained by irrigated plants with 1150 m^3/fed. in both seasons. NPK in the form of ammonium sulphat 20.5% N, super phosphate 15.5% P_2O_5 and potassium sulphate 48% K_2O at 300, 300 and 200 kg / fed. respectively;

PM= poultry manure, C= compost and CM= Cattle manure.

The effect of fertilization treatments on carotenoides and olenolic acid contents in marigold flowers is show in (Table 6).

The data show that, fertilization treatments had a significant effect on carotenoides and olenolic acid contents in marigold flowers. Fertilization of marigold plants with PM at 10 m^3/fed increased carotenoides and olenolic acid contents in marigold flowers in both seasons without significant differences with mineral fertilizer in the two seasons.

As for the effect of interaction treatments on carotenoides and olenolic acid contents in marigold flowers, data in Table 6 that interaction between irrigation rates and fertilization treatments had significant effect on carotenoides and olenolic acid contents in marigold flowers in two seasons. Irrigated plants with 3450 m^3 water/fed and fertilized plants with 10 m^3/ fed PM recorded the highest values of carotenoides and olenolic acid without significant effect with mineral fertilizer regarding olenolic acid in the 2nd season.

Table (6): Effect of water requirements, fertilization treatments and their interaction on carotenoides and olenolic acid of *Calendula officinalis* L. flowers during (2010/ 2011 and 2011/2012) seasons.

Characters / Treatments		Carotenoides (mg / plant)		Olenolic acid (mg / plant)	
		1st season	2nd season	1st season	2nd season
Effect of water requirements (m^3 / fed)					
1150		76.97	133.63	41.43	44.75
2300		129.81	209.57	47.34	51.41
3450		172.25	264.95	52.09	54.30
LSD at 5 %		10.04	13.65	3.84	4.16
Effect of fertilization treatments					
NPK (control)		168.16	265.77	49.31	52.72
PM at 10 m^3 / fed		182.42	291.17	50.54	52.65
Compost at 15 m^3 / fed		87.81	140.42	45.00	48.18
CM at 20 m^3 / fed		76.52	131.62	42.96	47.07
LSD at 5 %		11.75	10.41	0.62	0.56
Irrigation rates (m^3/ fed)	Fertilization	Effect of interaction			
1150	NPK	111.53	183.21	44.73	46.90
	PM at 10 m^3 / fed	118.66	202.57	46.40	48.06
	Compost at 15 m^3 / fed	54.15	90.88	38.56	43.00
	CM at 20 m^3 / fed	42.18	83.94	36.03	41.06
2300	NPK	171.68	277.40	49.50	54.00
	PM at 10 m^3 / fed	185.77	300.14	50.20	52.73
	Compost at 15 m^3 / fed	95.28	152.36	45.66	49.83
	CM at 20 m^3 / fed	86.36	140.25	44.00	49.10
3450	NPK	232.29	350.46	53.70	57.26
	PM at 10 m^3 / fed	256.67	386.53	55.03	57.16
	Compost at 15 m^3 / fed	121.24	186.58	50.76	51.73
	CM at 20 m^3 / fed	110.21	179.61	48.86	51.06
LSD at 5 %		20.31	18.09	1.09	0.98

DISCUSSION

Irrigation is an important and effective factor on growth and flowering traits, because it is associated with many environmental factors, which influence plant growth and development. Availability of sufficient amount of moisture optimizes the metabolic process in plant cells and increases the effectiveness of the mineral nutrients (Saif *et al*., 2003). The reduction in plant growth under condition of low water quantity level may be due to that water stress caused losses in tissue water which reduced turgor pressure in the cell, thereby inhibited enlargement and division of cells (Hsiao and Acevedo, 1974). The decrease in enlargement and division of cells decrease leaf area and hence the effective of photosynthetic surface (Jain and Misra, 1970). Water stress caused an increase in ABA/cytokine ratio, which in turn decreases plant growth (Marchner,1995). He also added that, under sufficient water conditions there were decrease in ABA and increase in cytokinin, GA and IAA reflecting good growth and dry matter content.

These results indicate the importance of water supply along plant life for increasing plant growth. These results are in harmony with these reported by Schuch *et al.* (1998) on chrysanthemum and Yousef (2002) on chamomile.

Pirzad and Shokrani (2012), Rahmani *et al*. (2012) and Metwally, *et al.* (2013) indicated that increasing irrigation water quantity increased certain growth characters, i.e., plant height (cm), leaf area (cm^2), flower diameter (cm) and spike stem diameter and yield of flowers. Organic fertilizers contains micro-organisms as *Azotobacter, Azospirilla,* ect, which stimulate plant growth and dry matter content, and absorption of nutrients and many soil bacteria and actinomycetes were found to have the ability to dissolve soil complex inorganic and organic phosphate, (Reynders and Vlassak, 1982).

These observations may be indicate that, these micro- organisms have the ability to supply the grown plants with fixed N, P and hormones, which could increase the dry matter accumulation, which in turn increase both NPK concentrations and their uptake, as well as organic manure may be play favorable role in increasing nutrients availability in most soils, thought the processes of chelating, biochemical processes and production of several organic acid during decomposition of organic manure.

In this regard, Khalid, *et al*. (2006), Kumar and Sharma (2013), Khodadadi, *et al*. (2013) and Idan *et al.* (2014) all on marigold plants. They found that addition of organic manure to plants showed significant effect on fresh weight of flower, number of flowers per plant, flower yield per plant, flower yield per plot, flower yield per hectare, especially with poultry manure at 20 ton/ha as compared to the same rate of FYM or compost.

It could be concluded that, under the same conditions, irrigated marigold plants by 3450m^3water/fed combined with 10 m^3/fed poultry manure was the best treatment for enhancing plant growth parameters, yield of dry ray flowers per fed, carotenoides and olenolic acid in flowers. On the other side, water use efficiency (WUE) was the higher when irrigated plants with 1150 m^3 water/fed combined with 10 m^3/fed poultry manure.

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تأثير كميات مياه الرى والتسميد العضوي على نمو وإنتاجية نبات الأقحوان تحت ظروف الأراضى الرملية.

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**** قسم النباتات الطبية والعطرية - معهد بحوث البساتين - مركز البحوث الزراعية**

أجريت هذه الدراسة في المزرعة البحثية لمحطة بحوث البساتين، مركزالبحوث الزراعية بالقصاصين بمحافظة الإسماعيلية خلال موسمين زراعيين ناجحين (٢٠١٠/٢٠١١) و(٢٠١١/٢٠١٢) وذلك لدراسة تأثير كميات مياه الري بمعدلات (١١٥٠- ٢٣٠٠- ٣٤٥٠ م/ ف) ومعاملات التسميد (الأسمدة المعدنية NPK بمعدل ٣٠٠ كجم/ ف سلفات الأمونيوم- ٣٠٠ كجم/ ف سوبر فوسفات- ٢٠٠ كجم/ ف كبريتات البوتاسيوم، وثلاثة مصادر من السماد العضوي، روث الدواجن والكمبوست وسماد الماشية بمعدل ١٠ - ١٥ - ٢٠ م٣/ ف) على التوالي وتفاعلاتها على النمو، محصول الازهار الشعاعية الجافة والمكونات الكميائية لنبات الاقحوان باستخدام نظام الري بالتنقيط بالتربة الجديدة المستصلحة.

سجل رى نباتات الاقحوان بمعدل (٣٤٥٠ م٣ مياه / ف). قيم الحد الأقصى لنمو النبات، ارتفاع النبات، وعدد الأفرع / نبات، الوزن الطازج والجاف للازهار، محصول الازهار الشعاعية الجافة / ف، الكاروتين وحمض اولينوليك اسيد في الاقحوان بالمقارنة مع معاملات الرى الاخرى. في حين تم الحصول على أدنى قيم من هذه المعاملات مع (١١٥٠م٣ مياه / ف) فى كلا الموسمين. على الجانب الآخر، كانت كفاءة استخدام المياه (WUE) فى النباتات عند معدل رى ١١٥٠ م٣ مياه/ ف هى الأعلى في كلا الموسمين.

تزداد معدلات نمو النبات والمحصول من الازهار الشعاعية الجافة وWUE والكاروتين وحمض اولينوليك في الأزهار بشكل كبير مع تسميد النباتات بسماد الدواجن (١٠ م٣ / ف).

معاملات التفاعل بين كمية المياه (٣٤٥٠ م٣ / ف. وسماد الدواجن بنسبة ١٠ م٣ / ف). أو نفس معدل الري مع الأسمدة المعدنية كان هو الأفضل لتعزيز نمو النبات، ومحصول الازهار الشعاعية الجافة / ف، والمكونات الكيميائية فى الازهار في كلا الموسمين. في حين أن التفاعل بين ١١٥٠ م٣ مياه / ف. وسماد الدواجن ١٠ م٣ / ف. كان أفضل معاملة لزيادة WUE في كلا الموسمين.

نوصى برى نباتات الأقحوان ب ٣٤٥٠ م٣ ماء / ف والتسميد بسماد الدواجن ١٠ م٣ / ف. حيث كان من أفضل المعاملات لزيادة نمو النباتات ومحصول الأزهار الجافة للفدان والكاروتين وحمض اولينوليك في الأزهار تحت نفس الظروف. على الجانب الآخر، كانت كفاءة استخدام المياه (WUE) فى النباتات هى الأعلى عند معدل رى ١١٥٠ م٣ مياه/ ف وسماد الدواجن ١٠ م٣ / ف.

الكلمات الرئيسية: الكلانديولا، كميات مياه الري ، السماد العضوي، الازهار الشعاعية، WUE، المكونات الكميائية .

Table (1): Effect of water requirements and fertilization treatments on vegetative growth of *Calendula officinalis* L. during (2010/2011 and 2011/2012) seasons.

Characters / Treatments	Plant height (cm)		Number of branches/ plant		Plant fresh weight (g)		Plant dry weight (g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Effect of water requirements (m^3 / fed)								
1150	47.33	53.33	5.37	6.27	515.97	646.51	84.43	124.38
2300	52.75	57.50	6.47	7.78	790.27	939.72	146.01	193.40
3450	55.16	62.66	7.92	8.91	785.36	1065.32	170.93	223.29
LSD at 5 %	2.35	2.86	0.82	0.42	34.26	21.46	10.87	9.57
Effect of fertilization treatments								
NPK (control)	55.00	61.66	7.34	8.60	752.46	1008.10	144.06	199.83
PM at 10 m^3/fed	58.55	63.33	8.07	9.31	837.86	1090.05	159.83	231.86
C at 15 m^3/fed	48.33	55.66	5.72	6.65	631.51	756.01	122.35	150.20
CM at 20 m^3/fed	45.11	50.66	5.22	6.06	566.97	681.25	108.92	139.54
LSD at 5 %	2.88	4.54	0.38	0.54	29.08	60.75	5.88	14.88

NPK in the form of ammonium sulphat 20.5% N, super phosphate 15.5% P_2O_5 and potassium sulphate 48% K_2O at 300, 300 and 200 kg / fed respectively; PM= poultry manure, C= compost and CM= Cattle manure.

Table (2): Effect of interaction between water requirements and fertilization treatments on vegetative growth of *Calendula officinalis* L during (2010/2011 and 2011/2012) seasons.

Characters / Treatments		Plant height (cm)		Number of branches / plant		Plant fresh weight (g)		Plant dry weight (g)	
Water requirements (m^3 / fed)	Fertilization treatments	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
1150	NPK	50.66	58.00	5.73	6.93	625.10	756.63	89.60	148.93
	PM at 10 m^3/fed	54.33	58.33	6.63	7.80	693.93	819.06	102.83	159.93
	C at 15 m^3/fed	44.00	51.00	4.76	5.56	400.80	528.46	76.00	97.26
	CM at 20 m^3/fed	40.33	46.00	4.36	4.80	344.06	481.90	69.30	91.40
2300	NPK	56.00	59.66	7.43	8.60	828.46	1049.56	163.20	210.73
	PM at 10 m^3/fed	58.33	63.66	7.56	9.30	870.43	1185.70	182.73	255.66
	C at 15 m^3/fed	49.66	55.00	5.73	6.86	786.66	798.66	127.26	159.56
	CM at 20 m^3/fed	47.00	51.66	5.16	6.36	675.53	724.96	110.86	147.66
3450	NPK	58.33	67.33	8.86	10.26	803.83	1218.10	179.40	239.83
	PM at 10 m^3/fed	63.00	68.00	10.03	10.83	949.23	1265.40	193.93	280.00
	C at 15 m^3/fed	51.33	61.00	6.66	7.53	707.06	940.90	163.80	193.76
	CM at 20 m^3/fed	48.00	54.33	6.13	7.03	681.33	836.90	146.60	179.56
LSD at 5 %		NS	**NS**	**0.65**	**NS**	**50.41**	**105.26**	**10.19**	**25.81**

NPK in the form of ammonium sulphat 20.5% N, super phosphate 15.5% P_2O_5 and potassium sulphate 48% K_2O at 300, 300 and 200 kg / fed respectively; PM= poultry manure, C= compost and CM= Cattle manure.

Table (3): Effect of water requirements and fertilization treatments on yield of dry ray flowers of *Calendula officinalis* L. during (2010/2011 and 2011/2012) seasons.

Characters / Treatments	Yield of dry ray flowers (g / plant)		Yield of dry ray flowers (kg / fed)		Relative increases in total yield (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Effect of water requirements (m^3 / fed)						
1150	14.50	22.95	349.32	548.24	100.0	100.0
2300	23.28	35.10	556.31	834.26	159.3	152.2
3450	30.85	43.52	739.08	1034.34	211.6	188.7
LSD at 0.05 level	4.43	6.100	88.47	121.96	----	---
Effect of fertilization treatments						
NPK (control)	29.10	42.58	693.65	1007.48	100.0	100.0
PM at 10 m^3 / fed	30.53	44.33	726.05	1045.98	104.7	103.8
C at 15 m^3 / fed	16.48	24.97	394.85	593.05	56.9	58.9
CM at 20 m^3 / fed	15.88	24.27	378.00	575.94	54.5	57.2
LSD at 0.05 level	5.72	4.93	114.37	98.42	----	--------

NPK in the form of ammonium sulphat 20.5% N, super phosphate 15.5% P_2O_5 and potassium sulphate 48% K_2O at 300, 300 and 200 kg/fed. respectively; PM= poultry manure, C= compost and CM= Cattle manure.

Table (4): Effect of water requirements and fertilization treatments on yield of dry ray flowers of *Calendula officinalis* L. during (2010/2011 and 2011/2012) seasons.

Treatments		Yield of dry ray flowers				Relative increases in total yield (%)	
		(g / plant)		(kg / fed)			
Irrigation rates (m^3 / fed)	Fertilization	1st season	2nd season	1st season	2nd season	1st season	2nd season
1150	NPK (control)	19.38	29.827	452.28	695.72	100.0	100.0
	PM at 10 m^3 / fed	20.25	31.75	472.50	740.83	104.5	106.5
	C at 15 m^3 / fed	10.227	16.53	238.39	385.78	52.7	55.5
	CM at 20 m^3 / fed	10.00	15.88	233.33	370.61	51.6	53.3
2300	NPK (control)	29.48	44.627	687.94	1041.06	152.1	149.6
	PM at 10 m^3/fed	30.98	45.70	722.94	1066.33	159.8	153.3
	C at 15 m^3/fed.	17.98	26.93	419.61	628.44	92.8	90.3
	CM at 20 m^3/fed	16.92	25.77	394.72	601.22	87.3	86.4
3450	NPK (control)	40.327	55.10	940.72	1285.67	208.0	184.8
	PM at 10 m^3/fed.	42.12	57.03	982.72	1330.78	217.3	191.3
	C at 15 m^3/fed.	22.57	32.78	526.56	764.94	116.4	109.9
	CM at 20 m^3/fed	21.68	32.40	505.94	756.00	111.9	108.7
LSD at 5 %		10.18	8.79	175.42	170.38	----	---

NPK in the form of ammonium sulphat 20.5% N, super phosphate 15.5% P_2O_5 and potassium sulphate 48% K_2O at 300, 300 and 200 kg/fed. respectively; PM= poultry manure, C= compost and CM= Cattle manure.