EFFECT OF COMPOST FERTILIZATION ON SOME GROWTH PARAMETERS AND YIELD OF *CALENDULA OFFICINALIS* VARIETY (COSTA YELLOW)

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ABSTRACT

Calendula officinalis is classified as one of the most important medicinal crops that deserve improvement in production and quality. This research study was conducted to investigate the effect of using compost, as an organic amendment, to replace some of the mineral fertilizers normally used. The experiments were conducted in the open field in two successive seasons 2016-2017 and 2017-2018 at Applied Research Center for Medicinal Plants, National Organization for Drug Control and Research, (NODCAR) at Kafer El- Gable, Giza. Pots which were filled beforehand with sandy soil received six treatments**:** (1) 100% Organic (Org), (2) 100% Mineral (Min), (3) 75% Min + 25% Org, (4) 50% Min +50% Org, (5) 25% Min +75% Org + (6) (control) without fertilizer. Mineral fertilization (NPK) showed the highest values of both vegetative and chemical characteristics studied of *Calendula officinalis* var Costa yellow. Application of compost at the rate of 25% or 50% showed closer values to those obtained by the recommended dose of NPK. Thus, possibility of replacing mineral fertilizers to reduce environmental impact can be substituted by 25% to 50% compost.

Keywords: Pot marigold, *Calendula officinalis*, Var. Costa Yellow, Compost, NPK Fertilization, Flowering, Flavonoids, Polyphenol.

INTRODUCTION

The use of organic fertilizers in medicin4al and aromatic plant production has several positive effects on production and quality. Use of compost showed an improvement of soil physical and chemical properties in many basic characteristics such as decreasing in pH of soil and enhancement of nutrient status (Snyman *et al*., 1998). Furthermore, organic fertilizer has positive effect on vegetative growth parameters of Marigold such as plant height, stem diameter, fresh and dry shoot weight as well as flower number per plant and flower size, (Shadanpour *et al*., 2011). In confirmation, Elhindi (2012) found that the application of composted green waste on *Calendula officinalis* increased significantly plant characteristics, i.e. plant height, fresh and dry weight of plant, number of flowers/plant and flower diameter, Chlorophyll a, b Carotenoids and NPK percentages. Also, organic fertilizers can maintain moisture and fertility of different soils (Yadav *et al*., 2013).

Mineral fertilization using nitrogen fertilization had a significant impact on number of plant parameters. Results showed that applications of N fertilizer caused in increasing yield of calendula, where that the nitrogen element has play an important role in primary constituent of building proteins, consequently of N fertilizers can substantially increase plant yields (Olson and Swallow, 1984; Grant *et al*., 1985). Selim and Abdella (2004) concluded that the N fertilization rates, (1, 2 and 4 g) urea/ pot gave high values of vegetative growth, flowers parameters and chemical constituents.Also, Rahmani *et al*. (2009) found that nitrogen had a significant effect on all plant parameters of *C. officinalis*, such as seed yield, head diameter, number of flowers carried out with application of 90 kg N ha^{-1}. Król, (2011) found a clear increase in yield of *Calendula officinalis*

'Tokaj' after the application of 80 kg N /ha, when compared to the control treatment. Also, Johnson *et al*. (2018) found that five urea N rates (0, 34, 67, 134, or 202) kg /N ha increased significantly seed yield of *C. officinalis*.

The combination between organic and mineral fertilizer showed positive effects on plant growth and yield.

Hassanain, (2003) examined the effect of four different mineral N levels (0, 50, 100 and 150 kg fed^{-1}) and four various poultry manure rates (0, 10, 15 and 20m3 fed^{-1}) on *Tagetes minuta* that showed significant results on vegetative growth, flowering, volatile oil content and chemical composition.

Hasan *et al.* (2014) concluded that the combined effect of peat moss and sheep manure as organic matter with N.P.K fertilizer (10:10:17) as one g/pot exhibited significant increases in all vegetative and flowering parameters.

Phytochemical screening studies indicated that marigold plant had rich constituents of phenolic compounds, carbohydrates, tocopherols, terpenoids, and carotenoids (Kishimoto *et al*., 2005; Re *et al*., 2009; Shahrbabaki *et al*., 2013). In similar studies, it was reported that flowers of *Calendula officinalis* contain a high concentration of pigments such as carotenoids (Neukirch *et al*., 2004; Roopashree *et al*., 2008; Hussein *et al*., (2011).

Therefore, it was thought as a good idea, in this research study, to use a combination of mineral fertilization and compost in experimental trails to find out their effects on vegetative parameters and internal chemical constituents of *Calendula officinalis*, Var. 'Costa Yellow'

MATERIALS AND METHODS

Location and Duration: Experiments were conducted in the open field during two successive seasons of 2016-2017 and 2017-2018 at the Applied Research Center for Medicinal Plants, National Organization for Drug Control and Research, (NODCAR) at kafer EL- Gable, Giza, Egypt.

Plant Material: *Calendula officinalis* variety Costa yellow was purchased from the Flora Nova Company, in U.K. In October of both seasons, seeds were sown in a prepared growing medium of peat moss: vermiculite (2:1 by volume). Seedlings were transplanted in the beginning of November by pricking them into 30 cm plastic pots filled with clean washed sand, peat moss and vermiculite (2:1:1 by volume) as one seedlings per pot.

Fertilization Treatments: Compost was purchased from Nile Compost Company as fully decomposed vegetative materials. Analysis of compost utilized in this research study is listed below in Table (1). Mineral fertilizer Folcare Fort was purchased from Abu Dhabi fertilizer industries company, U.A.E. Analysis of Mineral Fertilization utilized in this research study is listed below in Table (2).

Table (1): Chemical analysis of the used compost

Characters	pH	O.C %	C/N ratio	Macro-elements %			Micro-elements (ppm)			
				N	P	K	Fe	Mn	Zn	Cu
Value	6.7	26.1	19/1	1.45	0.58	0.78	547.3	38.7	53.1	26.8

Table (2): Composition of (Folcare Fort) compound fertilizer.

Compound	N	P	K	Mg	Si	Fe	Cu	Mn	B	Mo
%	20	20	20	1	1.40	0.12	0.05	0.06	0.02	0.001

Six fertilization treatments were applied as: 100% Organic fertilizer (Org), 100% Mineral fertilizers (Min), 75% Min + 25% Org, 50% Min + 50% Org, 25% Min + 75% Org and Control (without fertilizers)**.**

Data Recorded:

1- Vegetative aboveground parameters:

1-Plant height (cm) and aboveground part, i.e. fresh and dry weights (g/plant) at the end of the growing season.

2- Flower number /plant, diameter (cm)

3- Flower fresh and dry weight/plant (g/plant) were collected starting from flowering till plant harvesting at the end of growing seasons. The plants were dried in the oven (65 °c) until a constant weight was obtained.

2- Chemical analysis of internal components

a- Chlorophyll a, b and total carotenoids: Chlorophyll a, b and total carotenoids contents were determined chlorometrically in fresh leaf samples mg/g fresh matter according to Saric *et al.* (1976). Chlorophyll a, b and total carotenoids valued were calculated according to the following formulas:

$$\text{Chl. a (mg/l)} = 9.784\ E\ 660 - 0.99\ E\ 640$$

$$\text{Chl. b (mg/l)} = 21.426\ E\ 640 - 4.65\ E\ 660$$

$$\text{Carotenoids (mg/l)} = 4.695\ E\ 440 - 0.268\ (a + b)$$

b- Total carbohydrates: Total carbohydrates was estimated in the aboveground herb according to a method established by Chaplin and Kennedy (1994).

c- Polyphenols: Total polyphenol content was determined spectrophotometry, using Gallic acid as standard, according to the method described by Aliyu *et al.* (2009).

d- Flavonoids: The total flavonoid content of dried flowers was measured by a colorimetric assay according to Makky *et al.* (2012).

e-* N, P and K elements*: Nitrogen content (N) was determined by the modified micro-Kjeldahl method as described by FAO (1980). As for phosphorus (P) content it was estimated as recommended by Chapman and Parkar (1961). Potassium (K) was determined using a flam-photometer (Jeneway SN: 20158051101 Japan) according to Brown and Lilleland (1946).

Experimental Design:

Treatments were arranged in a randomized complete block design (RCBD) with three replicates for each treatment. Each block contained the six fertilizer treatments that were allocated randomly. Each replicate contained five pots, each pot containing one plant.

Statistical Analysis:

Data were statistically analyzed using the analysis of variance (ANOVA) described by Snedecor and Cochran (1990). The method of Duncan's multiple range tests was applied for the comparison between means according to Waller and Duncan (1969).

RESULTS AND DISCUSSION

1- Plant Height

Results presented in Table (2) indicate that fertilization treatments showed significant effect on plant height. The use of mineral fertilization at 100% dose gave the tallest plant height among different treatments (39.77 and 40.93 cm) in respect order of 1st and 2nd season. All treatments showed significant increase in plant height when compared to the control (29.23 and 30.73 cm) in the same respect order.

A mixture of 50% min+50% org gave significant increases in plant height (38.70 and 39.73 cm) in 1st and 2nd season, respectively when compared to other remaining treatments except 100% mineral fertilizer treatment.

The results agree with those found by Hussein *et al*. (2011) and Weam (2017).

The increase in plant height with Mineral fertilization may be attributed to the macro elements, particularly nitrogen which promotes plant growth by enhancing the number and length of the internodes, that eventually result in a progressive increase in plant height as mentioned by Sharma (1973) and Turkhede and Prasad (1978)

2- Fresh weight/plant

Results presented in Table (2) clearly indicate that fertilization treatments showed significant effect on aboveground fresh weight/plant. The use of mineral fertilization at 100% dose gave the highest fresh weight among different treatment 377 and 386.3 g/plant in respect order of 1st and 2nd season. All treatments showed significant increase in aboveground fresh weight when compared to the control 263 and 279.3 g/plant in the same respect order. A mixture of 50% min+50% org gave significant increase in fresh weight 362.3 and 365.7 g/plant in1st and2nd season respectively when compared to other treatments except 100% mineral fertilizer treatment.

These results are in agreement with the results reported by Matter (2015). Such increment in aboveground fresh weight/plant may be attributed to the fact that nitrogen is one of the most important macronutrients required by the plant. All proteins consist of nitrogen-containing amino acids, it is used in the synthesis of purine and pyrimidine, the components of nucleic acid for (DNA and RNA). It has a big role in growth because it encourages the formation of large surface leaves and more branches, hence a higher of aboveground fresh weight (Lal, 2018). Furthermore, nitrogen plays an important role in synthesis of the plant constituents through the action of different enzymes (Jones *et al.*, 1991).

3-Dry weight/plant

The data illustrated in Table (2) showed that fertilization treatment showed significant effect on aboveground dry weight/plant.

The use of mineral fertilization at 100% dose gave the highest aboveground dry weight among different treatment 58.4 and 59.5 g/plant in respect order of 1st and 2nd season and a mixture of 50% min+50% org gave significant increase only in the first season 57.0 g/plant.

All treatments showed significant increase in aboveground dry weight when compared to the control 40.9 and 40.0 g/plant in the same respect order. The results are similar to those reported by Matter (2015) and Satish and Manju (2018). Aboveground dry weight/plant may be attributed to the fact that Nitrogen is one of the most important macronutrients required by the plant that leads to an increase in aboveground fresh weight/plant, as proved earlier, and thus reflected on the obtained dry weight. *C. officinalis* is a short growing cycle that require intense and fast implementation and assimilation of nutrients. Nutrient availability in case of higher application of mineral fertilizer did not exhaust the plant to increase availability of nutrients through segregates of some organic acids or enzymes (Miller, 2014). Phosphorous and other mineral presence in organic form may result in slow availability as well as low mineral supply may cause combition between plant and soil microorganisms on available amount (López-Arredondo *et al*., 2013).

Table (2): Effect of mineral and compost fertilization ratios on *Calendula officinalis* var. "Costa yellow" plant height (cm) and aboveground fresh and dry weight g/plant in two growing seasons 2016-17 and 2017-18.

Treatments	Plant height (cm)		Aboveground fresh weight/plant (g)		Aboveground dry weight/plant (g)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
100%org	38.07c	38.7c	352.0c	366.7b	54.3b	57.7b
100%min	39.77a	40.93a	377.0a	386.3a	58.4a	59.5a
75%min+25%org	36.03d	37.33d	342.7d	350.0c	51.7c	54.5c
50%min+50%org	38.70b	39.73b	362.3b	365.7b	57.0a	57.3b
25%min+75%org	34.80e	360e	329.7e	344.3d	53.2bc	52.2d
Control	29.23f	30.73f	263.0f	279.3e	40.9d	40.0e

Values within the same column followed by the same letters are not significantly different, using Duncan's Multiple Range Test at 5% level.

4- Number of flowers/plant:

Results in Table (3) revealed that fertilization treatments showed significant effect on number of flowers/plant. The use of mineral fertilization at 100% dose gave the highest number of flowers 84.0 and 88.0 in respect order of 1st and2nd season followed by 50% min+50% org that gave 73.6 flower/plant when compared to other treatments. Notably, all treatments showed significant increases in number of flowers when compared to the control 31.7 and 33.9 flower/plant in the same respect order. Such results are in the same line with those obtained by Seham (2015) and Beata (2012). The increment in number of flower / plant treated with nitrogen fertilization stimulated the formation of branches, which accordingly increased the number of flower heads as pointed out by Letchamo (1993). Nutrient availability and supply to plants with the increase in plant production of carbon skeleton that help in the supply of ATP, Fdx and NADH as products of photosynthesis, respiration and photorespiration pathways are thus essential for nutrient assimilation (Masclaux-Daubresse *et al*., 2010). Therefore, NPK are required in sufficient quantities to attain better growth and promote flowering (Pandey and Mishra, 2005).

Also, P-deficient plants show suppressions in leaf expansion (Fredeen *et al*., 1989) and number (Lynch *et al*., 1991). In the later stages of growth, typically after flowering in an annual plant, the degradation of proteins in the leaves exceeds the synthesis of new proteins (Pilbeam, 2015).

5-Flower diameter

Results presented in Table (3) clearly indicate that fertilization treatment showed significant effect on flower diameter.

The use of mineral fertilization at 100% dose gave bigger flower diameter among different treatment 4.28 and 4.38 cm in respect order of 1st and 2nd season when compared with the remaining treatments expect 75% min+25% org. Notable reduction in flower diameter was noticed by the increase in organic fertilizer percentage. These results are similar to those reported by Beata (2012); Seham (2015); Hanan and Hashem (2016).

It has been shown that flowers (sepal/petal tissues) switch from being a sink to a source during senescence and the changes such as decline of fresh mass, dry mass and soluble carbohydrates are often linked to PCD (Zhou *et al*., 2005).

Thus, expansion of flower is a continuous process connected with the increase in nutrient supply up to its genetic limitation of maximum development.

6-Flower dry weight/plant:

The data illustrated in Table (3) show that all fertilization treatments showed significant effect on flowers dry weight when compared to the control 12.0 and 13.7 g/plant. The use of mineral fertilization at 100% dose gave the highest flowers dry weight among different treatment 41.4 and 43.8 g/plant in respect order of 1st and 2nd season when compared to all other remaining treatments expect 75% min+25% org in the 2nd season.The results are in agreement with those of Beata (2012) and Seham (2015). The higher uptake of these mineral nutrients and their translocation to different parts might have helped in the production of higher total dry matter and flower yield (Ahmed *et al.*, 2017).

Table (3). Effect of mineral and compost fertilization ratios on *Calendula officinalis* var. costa yellow on number of flowers/plant, flower diameter (cm) and flowers dry weight (g/plant) in two growing seasons 2016-2017 and 2017-2018.

Treatments	Number of flowers/plant		Flower diameter (cm)		Flowers dry weight (g/plant)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
100%org	54.4d	57.3cd	3.42c	3.54c	24.1c	25.8c
100%min	84.0a	88.0a	4.28a	4.38a	41.4a	43.8a
75%min+25%org	73.6ab	75.9b	3.97ab	4.07ab	34.5b	38.0ab
50%min+50%org	69.5bc	72.1b	3.83b	3.93b	32.5b	34.0b
25%min+75%org	63.0cd	65.0bc	3.48c	3.65c	28.6c	29.8c
Control	31.7e	33.9e	2.81d	2.91d	12.0d	13.7d

Values within the same column followed by the same letters are not significantly different, using Duncan's Multiple Range Test at 5% level.

7-Total Carbohydrates:

Results in Table (4) indicated that fertilization treatments showed significant effect on total carbohydrates content. The use of mineral fertilization at 100% dose gave the highest carbohydrates content among different treatments 28.7 and 29.3 mg/g in respect order of 1st and2nd season. All treatments showed significant increase in carbohydrates content when compared to the control 16.7 and 17.10 mg/g in the same respect order. A mixture of 75% min + 25% org gave significant increase in carbohydrates content 27.9 and 28.2 mg/g in respect order of 1st and2nd season respectively when compared to other treatments except 100% mineral fertilizer treatment. The results are in agreement with those of Hanan and Hashem (2016). Nutrient assimilation affect carbohydrates i.e. high N concentration in leaves also implies a high concentration of chlorophyll and of enzymes involved in CO_2 assimilation, especially Rubisco (Satish and Manju, 2018). In photosynthesis of a green plant, light is collected primarily by chlorophylls, pigments that absorb light. Several research studies have investigated the relationship between phosphorus content and photosynthesis processes.

The photosynthesis mechanism can describe bravely by consuming the energy of The H+ -e -potential, electrons are transferred from a reduced substance to the ATP and ADP formed by photosynthesis, as we see in the famous equation that the standard free energy for the synthesis of ATP is dependent mainly on phosphors

$$\Delta G = \Delta G^{\circ} + RT \mathrm{In} \frac{[ATP]}{[ADP].[P]}$$

The standard free energy for the synthesis of ATP. The photosynthesis reactions are used for the synthesis of organic matter; especially important is the synthesis of carbohydrates from CO_2 via the Calvin cycle (Hans, 2004)

$$CO2 + H2O \xrightarrow{light} [CH2O] + H2O + O2\uparrow$$

8-Total polyphenols:

Results presented in Table (4) clearly indicate that fertilization treatment showed significant effect on total polyphenol in flowers.

The use of mineral fertilization at 100% dose gave the highest of total polyphenol among different treatment 34.0 and 35.13 mg/g dry weight in respect order of 1st and 2nd season. All treatments showed significant increase in total polyphenol when compared to the control 14.57and 14.63 mg/g dry weight in the same respect order. A mixture of 75% Min + 25% Org gave significant increase in total polyphenol 31.40 and 31.77 mg/g dry weight in respect order of 1st and 2nd season respectively when compared to other treatments except 100% mineral fertilizer treatment. Our results confirm those of Abou-Sreea *et al*. (2016), Erian *et al*. (2016) and Abou-Sreea *et al*. (2017). Most phenolis are derivatives of phenylalanine formed by the shikimic acid pathway. With nitrogen supplementation, as a mineral fertilizer it can therefore contribute in building amino acids such as phenylalanine, tyrosine, or tryptophan. Majority of simple phenolic are derived from phenylalanine (Satish and Manju, 2018)

9-Total flavonoids:

The data illustrated in Table (4) show that fertilization treatment had significant effect on total flavonoids in flowers. The use of mineral fertilization at a 100% dose gave the highest of total flavonoid among different treatment

20.0 and 20.4 mg/g dry weight in respect order of 1st and 2nd season. All treatments showed significant increase in total flavonoid when compared to the control 12.1 and 12.3 mg/g dry weight in the same respect order. A mixture of 75% Min + 25% Org gave significant increase in total flavonoids 18.7 and 18.9 mg/g dry weight in respect order of 1st and 2nd season respectively when compared to other treatments except 100% mineral fertilizer treatment. The results are in agreement with those of Erian *et al*. (2016) and Abou-Sreea *et al*. (2016 and 2017).

Carbohydrate is a primary source for secondary metabolite compounds and participating in the whole scheme of the plant metabolism (Lal, 2018). In plants, inorganic nitrogen (i.e. NO_3^- and NH_4^+) taken up by roots is incorporated with derived organic acids into glutamine and glutamate (primary nitrogen assimilation) which is used to synthesize other amino acids (Okumoto and Pilot 2011).

Phenylalanine is a primary amino acid; its main metabolic pathway yields the most amino acids in the plant (Adams *et al* 2019). The flavonoids biosynthesis in plant is derived from the main precursor of Phenylalanine (Takos *et al*. 2006).

Table 4: Effect of mineral and compost fertilization ratios on content of total carbohydrates, polyphenol and flavonoids inside *Calendula officinalis* var. Costa yellow plants during two seasons 2016-17 and 2017-18.

Treatments	Total Carbohydrates (mg/g dw)		Total polyphenol (mg/g dw)		Total flavonoids (mg/g dw)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
100%org	24.1d	24.4e	23.9d	24.3e	15.3d	15.6d
100%min	28.7a	29.3a	34.0a	35.13a	20.0a	20.4a
75%min+25%org	27.9b	28.2b	31.4b	31.77b	18.7b	18.9b
50%min+50%org	26.9c	27.5c	29.77b	30.17c	17.3c	17.3c
25%min+75%org	24.1d	25.2d	27.2c	27.6d	15.9d	16.2d
Control	16.7e	17.1f	14.57e	14.63f	12.1e	12.3e

Values within the same column followed by the same letters are not significantly different, using Duncan's Multiple Range Test at 5% level.

10- Nitrogen %:

Results in Table (5) indicated that fertilization treatments showed significant effect on N%. The use of mineral fertilization at 100% dose gave the highest N% among different treatments 2.61 and 2.73 % in respect order of 1st and 2nd season. All treatments showed significant increase in N% when compared to the control 1.20 and 1.25 % in the same respect order. A mixture of 50%Min+50%Org N% was 2.25 and 2.34%, similarly to 75% Min + 25% Org that gave 2.35 and 2.41% in respect order of 1st and 2nd season when compared to other treatments except 100% mineral fertilizer treatment. The results are in agreement with those of Hussein *et al*. (2011) and Abou-Sreea *et al*. (2016).

The increase in plant biomass was positively correlated with the increase in N% which regrettably declines N% with an associated increase in plant biomass as represented by Pilbeam (2015).

11- Phosphorus %:

Results presented in Table (5) clearly indicate that fertilization treatment showed significant effect on phosphorus percentage.

The use of mineral fertilization at 100% dose gave the highest of phosphorus percentage among different treatment 0.532 and 0.550% in respect order of 1st and 2nd season. All treatments showed significant increase in phosphorus percentage when compared to the control 0.236 and 0.248% in the same respect order. The results are in agreement with those of Hussein *et al*. (2011), and Abou-Sreea *et al*. (2016). P is a structural component of nucleic acids, nucleotides, phospholipids, coenzymes, and phosphoproteins. When in monoester form, P is an essential ligand in enzymatic catalysis. Phytic acid, the hexaphosphate ester of myoinositol phosphate, is the primary P storage in seeds (Hopkins 2015).

12- Potassium %:

The data illustrated in Table (5) show that fertilization treatment showed significant effect on potassium percentage. The use of mineral fertilization at 100% dose gave the highest of potassium percentage among different treatment 2.17 and 2.23% in respect order of 1st and 2nd season.

All treatments showed significant increase in potassium percentage when compared to the control 0.88 and 0.90% in the same respect order. A mixture of 50%Min+50%Org gave significant increase in potassium percentage 1.86 and 1.93% in respect order of 1st and 2nd season when compared to other treatments except 100% mineral fertilizer treatment. The results are in agreement with those of Hussein *et al*. (2011) and Abou-Sreea *et al*. (2016).

Nutrient absorption by plants is referred to usually as ion uptake or ion absorption because it is the ionic form in which nutrients are absorbed by roots (Fageria, 2013).

Uptake of K^+ is very selective and closely related to metabolic activity of plants. Potassium functions as a cofactor or activator for many enzymes of carbohydrate and protein metabolism (Fageria *et al*., 2011). Suelter (1970) and Marschner (1995) reported that there are more than 50 enzymes that either completely depend on or are stimulated by potassium ions. K^+ is a mobile ion which is preferred by plant in soluble form and very common in annual plants to be used in complex form with N and P (Fageria, 2015).

The use of organic fertilizer may be a complementary source of N, P, and K when applied in amounts that account for the composition of the manure and the nutrient-supplying potential of the soil (Chang *et al*., 1993).

Table 5.: Effect of compost fertilization ratios on nitrogen, phosphorus and potassium content as percentages inside *Calendula officinalis* var. Costa yellow plants during two seasons 2016-2017 and 2017-2018.

Treatments	N%		P%		K%	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
100%org	1.92c	2.08c	0.393bc	0.400bc	1.65c	1.71c
100%min	2.61a	2.73a	0.532a	0.550a	2.17a	2.23a
75%min+25%org	2.35b	2.41b	0.473b	0.515a	1.99ab	2.01ab
50%min+50%org	2.25b	2.34b	0.461b	0.474b	1.86b	1.93b
25%min+75%org	2.11c	2.21c	0.418b	0.436b	1.80b	1.87b
Control	1.20d	1.25d	0.236d	0.248d	0.88d	0.9d

Values within the same column followed by the same letters are not significantly different, using Duncan's Multiple Range Test at 5% level

13- Chlorophyll a and b:

Results in Table (6) indicated that fertilization treatments had a significant effect on chlorophyll a and b content in leaves of *Calendula officinalis*.

The use of mineral fertilization at 100% dose gave the highest content of chlorophyll a among different treatments 2.30 and 2.31 mg/g fresh weight, and chlorophyll b content among different treatment 1.62and 1.65 mg/g fresh weight, in respect order of 1st and 2nd season.

All treatments showed significant increase in chlorophyll a and b content when compared to the control 1.59 and 1.57 mg/g fresh weight; 0.756 and 0.78 mg/g fresh weight, in the same respect order. Elements availability, especially nitrogen due to its external application played an important role in photosynthesized pigments formation and thus the amount of chlorophyll synthesized (Król, 2011; Hussein *et al*., 2011; Elhindi, 2012; Abou-Sreea *et al*., 2017). Chlorophyll has a cyclic tetrapyrrole ring structure termed as prophyrines which N is a basic component for it (Satish and Manju, 2018).

Mitra *et al*. (1988) concluded that exogenous source of nitrogen would retard leaf senescence and improve photosynthate and nitrogen availability for seed biomass.

14- Total carotenoids

The data illustrated in Table (6) show that fertilization treatment showed significant effect on carotenoids content in leaves of *Calendula officinalis*. The use of mineral fertilization at 100% dose gave the highest total carotenoids among different treatment 0.725 and 0.717 mg/g fresh weight in respect order of 1st and 2nd season. All treatments showed significant increase in total carotenoids when compared to the control 0.498 and 0.493 mg/g fresh weight in the same respect order. The results are in agreement with those of Elhindi, (2012); and Abou-Sreea *et al*. (2017).

Table 6. Effect of compost fertilization ratio on content of chlorophyll a and chlorophyll b and total carotenoids inside *Calendula officinalis* var. Costa yellow plants during two seasons 2016-2017 and 2017-2018.

Treatments	Chlorophyll (a) (mg/g fw)		Chlorophyll (b) (mg/g fw)		Total carotenoid (mg/g fw)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
100%org	1.95d	1.97d	1.24c	1.25c	0.606d	0.605d
100%min	2.30a	2.31a	1.62a	1.65a	0.725a	0.717a
75%min+25%org	2.11b	2.11b	1.41b	1.42b	0.692b	0.688b
50%min+50%org	2.03c	2.03c	1.17d	1.33d	0.642c	0.651c
25%min+75%org	1.90e	1.89e	1.02e	0.99e	0.585e	0.585e
Control	1.59f	1.57f	0.75f	0.78f	0.498f	0.493f

Values within the same column followed by the same letters are not significantly different, using Duncan's Multiple Range Test at 5% level.

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تأثير التسميد بالكمبوست علي بعض قياسات النمو والإنتاجيه للصنف الأصفر لنبات الأقحوان

[٤]

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المستخلص

يعتبر نبات الاقحوان (Calendula officinalis) واحدا من أهم المحاصيل الطبية التي تستحق التحسين في الإنتاج والجودة. أجريت هذه التجربه البحثية لمعرفة تأثير استخدام الكمبوست كبديل عضوي من خلال استعماله بديلا لبعض الأسمدة المعدنية المستخدمة عادة، أجريت التجارب في الحقل المكشوف في موسمين متتاليين ٢٠١٦–٢٠١٧ و ٢٠١٧–٢٠١٨ في مركز الدراسات التطبيقية للنباتات الطبية التابع للهيئه القوميه للرقابة والبحوث الدوائية (NODCAR) في كفر الجبل، الجيزة. تم ملْ الاصص مسبقًا بالتربة الرملية والبيتموس. تم استخدام ستة معاملات وهي: (١) ١٠٠٪ عضوي (ORG)، (٢) ١٠٠٪ معدني (Min)، (٣)٧٥% معدني:٢٥ عضوي، (٤)٥٠% معدني:٥٠ عضوي، (٥)٢٥% معدني:٧٥% عضوي، (٦) الكنترول بدون تسميد. أظهر التسميد المعدني (NPK) أعلى القيم لكل من القياسات الخضريه والكيميائية التي تمت دراستها علي نبات الاقحوان صنف Costa yellow ولقد أظهرت المعامله السماديه العضويه بمعدل ٢٥ ٪ أو ٥٠ ٪ قيم أقرب إلى تلك التي تم الحصول عليها من الجرعة الموصى بها من NPK. وبالتالي، يمكن الاستفاده من إمكانية استبدال الأسمدة المعدنية بالكمبوست بديلا بنسبة تتراوح من ٢٥ ٪ إلى ٥٠ ٪ للحد من التأثير البيئي الضار للاسمده المعدنيه.

الكلمات المفتاحية: نبات الأقحوان- *Calendula officinalis* – الصنف الأصفر– الكمبوست– سماد NPK- التزهير– الفلافونويد– البولي فينول.