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Influence of Pinching and Potassium Sources on Growth and Flowers Yield of *Calendula officinalis*

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THIS study was planned to increase natural colors of *Calendula officinalis* using natural treatments. Two field experiments were carried out during the two successive seasons of 2010/2011 and 2011/2012, to study the effect of different Potassium sources (Potassium sulphate, 50% K_2SO_4+K-Mag, 50% K_2SO_4 + Salicylic Acid (SA) , 50% K_2SO_4 +K-Mag +SA, Flespar +K-mag or Potassein) and pinching (at 0.0,7.5,10.0 and 12.5 cm) on *Calendula officinalis*. Data indicated that, all Potassium sources had positive effects in increasing growth characters and flower yield. The treatments of 50% Potassium sulphate with K-Mag and Salicylic Acid were the most effective treatments for growth and carotenoids content of flowers petals. On the other hand, pinching at 10 cm from the soil surface of the main stem was the best for different growth parameters and flowers yield. The best interaction treatments were treatments of 50% Potassium sulphate with K-Mag + SA, and pinching at 10 cm achieved improving growth, flowers yield with 60% over than the control (average of two seasons), obtaining the highest content of natural pigment and saving 50% of Potassium sulphate fertilizer and its negative impacts on both human health and environment.

Keywords: *Calendula officinalis*, Potassium, Pinching, Carotenoids.

Calendula (*Calendula officinalis* L.) is one of the major medicinal plants grown in field plantations, belongs to Asteraceae (Compositae) family. The petals and pollen contain several important constituents such as triterpenoid esters (anti-inflammatory), and carotenoids (flavoxanthin and auroxanthin) which are antioxidants and the source of yellow-orange colour (Hamburger *et al*., 2003 and Bashir *et al*., 2006). The plant is used as natural colorant in foods. It is also used in pharmaceutical and cosmetic products. The plant is used in folk medicine for antiseptic and anti-inflammatory. In addition, the plant has been used to cure skin disorders and pain, and as a bactericide (Bolderston *et al*., 2006 and Bielski & Szwejkowska, 2013) .

Natural colors are gaining considerable attention since several synthetic colorants have given rise to allergic, toxic and carcinogenic effects. Flavonoids have antioxidant activities which play an important role in food preservation and

human health by combating damage caused by oxidizing agents. Carotenoids are important to humans and other animals as precursors of vitamin A and carotenoid. In addition, they act as antioxidants, immune enhancers, inhibitors of mutagenesis and transformation, inhibitors of premalignant lesions, screening pigments in primate fovea, and nonphotochemical fluorescence quenchers (Castenmiller & West, 1998, Meda *et al*., 2005 and Khalid & Teixeira da Silva 2010).

Potassium is a multifunctional versatile nutrient indispensable for plants. Potassium regulates the phosphorus metabolism in living plant systems and its main physiological function is to conserve and transfer energy during plant metabolic processes e.g. photosynthesis and respiration. This energy, in one form or another, is essential during the growth and development of plants (Winter-Sluter and Kramer 1977). Potassium is regarded as an indispensable element for crop growth, as it is involved in every metabolic process including activation of several key enzyme systems, carbohydrate metabolism, protein biosynthesis, assimilate translocation and stomatal movement (Marschner, 1995). Yassen *et al*., 2010 indicated that adding potassium fertilizer significantly increased number of branches, growth and yield in *Calendula Officinalis*. Singh *et al*. (2005 and 2007) found that application of potassium to different medicinal plants (lemongrass and rosemary) produced higher herbage compared to control plants.

Salicylic acid (SA) is a phenolic phytohormone that acts as a key regulator of the signaling network in plants under abiotic and biotic stresses. Also, SA exerts stimulatory effects on various physiological processes related to plant growth and development (Pacheco *et al*., 2013). Stimulation of growth after exposure to SA has been recorded in some plant species, (Shakirova *et al*., 2003 and Gunes *et al*., 2007). It can also contribute to stress tolerance by stimulating highly–branched metabolic responses (Horvath *et al*., 2007). Kovacik *et al*. (2009) found that treating *Matricaria chamomilla* plants with SA significantly stimulated growth.

Pinching, the terminal portion of shoots is removed early, emergence of side branches starts earlier and more number of flowers of good quality and uniform size are produced. It is safe alternative treatment which could be a potential substitute to use plant growth retardants application which widely used in recent years for compacting growth and producing more branches. Results of Omar *et al*., 1997 on *Hibiscus sabdariffa* L. showed that pinching increased number of branches and flowers. Also, Pushkar and Singh (2012) indicated that pinching increased flower yield of African marigold.

Moreover, human health has received a great attention nowadays. It was documented that chemical fertilizers have a pollutant effect on the soil and plant and in turn, on the human health. Recently, great attention has focused on the possibility to use natural and safety substitution. Therefore, this study was conducted to use different natural sources of potassium fertilizer and pinching as a natural tool for improving growth, flowers yield and flowers carotenoids content of *Calendula officinalis*.

Materials and Methods

Two field experiments were carried out during two successive seasons of 2010/2011 and 2011/2012, in the Exper. Sta. and Lab. of the Vege. Crops and Ornamental Plants Dept. Fac. of Agric., Mansoura Univ., Egypt. Prior to any practices, a composite soil sample was taken from the soil surface (0-30 cm) of the experimental site, air dried, sieved by 2 mm sieve and analyzed for physical and chemical properties of soil according to Jackson (1967) and the analysis results are presented in Table 1.

TABLE 1. Physical and chemical characteristics of the soil.

Physical characteristics		Chemical characteristics	
Texture	Loam	$CaCo_3$ (%)	0.85
Coarse sand (%) Fine sand (%)	0.98 24.40	Organic matter (%)	1.17
Clay (%)	43.57	N (ppm)	56
Silt (%)	31.05	P (ppm)	2.9
Electrical conductivity ($dS.m^{-1}$)	0.49	K (mg. kg-1)	589
pH (1:2.5 soil : water)	8.23	Exchangeable sodium percentage (%)	51.9
Anion exchange capacity (meq 100 g^{-1} soil)		Cation exchange capacity (meq 100 g^{-1} soil)	
CO_3^{--}	0.02	Ca^{2+}	0.51
HCO_3^-	0.53	Mg^{2+}	0.38
CL^-	0.35	K^+	0.05
SO_4^{--}	0.49	Na^+	0.41

Seeds of *Calendula Officinalis* L. plants were kindly provided by the Dept. of Medicinal and Aromatic Plants, Ministry of Agriculture, Egypt, and sown at the end of October during both seasons in hills at 40 cm distance between hills. Thinning for one plant/hill was done 30 days after sowing. Weeds were removed by hand and the irrigation was carried out whenever plants needed. All plots were received recommended doses of N (100kg/fed. Ammonium sulphate) and P (150kg/fed. Calcium super phosphate) and farmyard manure according to the recommendations by the Egyptian Ministry of Agriculture.

The experimental unit area (plot) was 6.75 m² consist of 3 ridges. Each ridge 3 m long and 0.75 m width.

Experiment layout

The experimental design was split plot in randomized complete block design with three replicates. The main plots were assigned for different potassium treatments as follows:

- Control recommended dose of K_2SO_4 .
- 50% of recommended K_2SO_4 + K-Mag .
- 50% of recommended K_2SO_4 + Salicylic acid.
- 50% of recommended K_2SO_4 + K-Mag + Salicylic acid .
- Flespar + K-Mag .
- Potassein – N.

Potassein–N (contains 8% N and 10% P_2O_5) was provided by the General Organization for Agriculture Equalization Fund (G.O.A.E.F.), Ministry of Agriculture, Egypt. K-Mag was provided by Fac. of Agric., Cairo Univ., Egypt. Flespar was provided by Alahram Comp., Cairo, Egypt.

Salicylic acid was dissolved in absolute ethanol then added drop wise to water (ethanol/water: 1/1000, v/v). 45 days after transplanting, SA was applied (at 20 ppm) on the foliage of calendula plants with a hand sprayer two times in two week intervals.

Different pinching treatments were applied (after 10 weeks from planting) in the sub plots as follows:

- Without pinching (control)
- Pinching at 7.5 cm from soil surface.
- Pinching at 10.0 cm from soil surface.
- Pinching at 12.5 cm from soil surface.

Data recorded

At maturity (after 105 days from planting) during each growing season six plants/ replicate, were randomly selected for various vegetative data e.g. plant height (cm), branches number/plant and fresh and dry weights (g/plant). Quantitative analysis for NPK and photosynthetic pigments was done. At harvest stage flowers number per plant, flowers fresh and dry weights and total carotenoids were recorded.

Analytical Methods

NPK: Nitrogen, Phosphorus, and Potassium according to the methods described by Cottenie *et al*. (1982).

Chlorophyll Determinations: Chlorophyll a, b and total chlorophyll (Ch) were determined in the blade of the third leaf of the plant tip (terminal leaflet) according to the methods described by Saric *et al*. (1967).

Determination of total carotenoids: Total carotenoids (mg 100 g^{-1}) were determined by a modified method of Razmjoo (1997).

Statistical analysis

The obtained data were subjected to analysis of variances, and the significant differences among treatment means were determined by Duncans' multiple range test at P<5% as published by Duncan (1965).

Results and Discussions

Vegetative growth

It is quite clear from the data presented in Tables 2 and 3 that, potassium sources, pinching and their interactions affected significantly plant height, branches number/plant and fresh and dry weights of plants of *Calendula officinalis*.

In most cases, application of the different potassium sources promoted vegetative growth and resulted in significant increases in the values recorded for the different growth parameters, compared to the control. Maximum growth was resulted from the treatment (0.5 K_2SO_4 + K-mag +SA), while the minimum growth values were obtained from Potassein treatment.

Similar promotion of vegetative growth (Table 2) was obtained from pinching at the different heights. The favorable pinching height was pinching at 10 cm compared to the control and other pinching heights in both seasons.

Concerning the combination between the two factors, there was a significant difference between treatments. The plants fertilized with 0.5 K_2SO_4 + K-mag + SA and pinched at 10 cm resulted in a maximum plant height (68.03 and 71.50), number of branches per plant (13.67 and 14.67), plant fresh weight (769.90 and 783.87 g/plant) and plant dry weight (141.40 and 144.24 g/plant) in the two seasons, respectively (Table 3).

Results mentioned above of vegetative growth under K sources might be due to the role of K in the enhancement and development of plant tissues through the synthesis of simple sugars and starch and also, translocation of carbohydrates and protein synthesis.

The increase in number of branches might be due to the fact that it checked apical dominance and diverted extra energy to the production of more number of branches and thus more leaves (Pushkar and Singh, 2012). In addition, there is evidence of a cross-talk between the SA and auxin signaling pathways during plant vegetative growth (Rivas-San and Plasencia, 2011). The positive effect of SA could be related to the increasing in CO_2 assimilation and photosynthetic rate (Karlidage *et al*., 2009). Pacheco *et al*. (2013) on marigold mentioned that SA exerts stimulatory effects on various physiological processes related to plant growth and development.

These results are in agreement with Hashemabadi *et al*. (2012) and Yassen *et al*. (2010) on *Calendula officinalis* L. and Pal and Ghosh 2010 on African marigold. El-Masry (1996) on peppermint observed that K_2SO_4 (300g/L) produced the highest growth. Liu *et al*., (2008) indicated that adding potassium fertilizer significantly increased number of branches and yield in crops.

The results are also in similarity with Khobragade *et al*. (2012) who worked on China aster and reported a positive effect of pinching. Ryagi *et al*. (2007) on carnation mentioned that pinching increased number of lateral branches per plant.

TABLE 2. Effect of different potassium sources and pinching on vegetative growth characteristics of *Calendula officinalis* L. during 2010/2011 and 2011/2012.

Treatment	Plant height		Branches No.		Plant F.W		Plant D.W	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Potassium Sources								
Control	52.84 d	53.95 c	7.83 d	8.50 d	411.28 e	414.68 e	78.60 c	80.27 c
Potassein	48.23 e	53.73 b	7.33 e	8.00 d	324.78 f	333.27 f	61.14 d	61.99 d
0.5K_2SO_4 + K-mag	57.03 c	58.10 bc	9.67 b	10.33 b	453.43 c	464.42 c	85.68 bc	87.78 b
Felspar + K-mag	54.58 d	56.08 bc	8.67 c	9.17 c	431.50 d	433.85 d	80.69 bc	82.01 c
0.5 K_2SO_4 + K-mag + SA	64.88 a	66.92 a	11.17 a	12.00 a	615.93 a	628.71 a	118.83 a	116.14 a
0.5 K_2SO_4 +SA	59.17 b	60.59 b	10.00 b	10.58 b	482.79 b	494.02 b	88.16 b	90.31 b
Pinching								
0	49.45 d	53.85 c	6.00 c	6.61 d	344.24 d	350.64 d	64.41 d	66.26 d
7.5	58.47 b	59.82 b	9.83 b	10.56 b	502.52 b	511.89 b	94.17 b	95.35 b
10	63.98 a	65.41 a	11.22 a	11.94 a	570.55 a	578.01 a	106.00 a	108.15 a
12.5	52.59 c	53.83 c	9.39 b	9.94 c	395.83 c	405.42 c	77.50 c	57.93 c

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

TABLE 3. Effect of interaction between potassium sources and pinching on vegetative growth characteristics of *Calendula officinalis* L. during 2010/2011 and 2011/2012.

Treatments		Plant height		Branches NO.		F.W. g/plant		D.W. g/plant	
Potassium	Pinching	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	0	45.20 jk	46.03 ij	5.33 mn	5.67 l	285.60 jk	293.77 j	55.70 ijk	57.29 lm
	7.5	53.60 gh	55.23 defghij	8.33 hi	9.33 gh	477.40 f	358.90 f	92.15 ef	93.77 ef
	10	63.17 bc	63.83 abcdef	9.67 fg	10.67 ef	541.40 cde	529.73 def	100.45 def	102.25 def
	12.5	49.40 i	50.70 ghij	8.00 hij	8.33 hi	340.70 hi	349.33 hi	66.11 hij	67.78 hij
Potassein	0	41.70 l	60.10 abcdefgh	4.67 n	5.33 l	254.77 k	263.63 g	48.69 k	50.36 m
	7.5	51.37 hi	52.33f ghij	7.00 jk	7.67 ij	339.73 hi	348.37 hi	63.49 hijk	62.17 jkm
	10	56.90 ef	58.47 bcdefghi	9.67 fg	10.67 ef	413.00 g	422.00 g	77.24 gh	78.92 g
	12.5	42.97 kl	44.00 j	8.00 hij	8.33 hi	291.63 ijk	299.07 j	55.13 jk	56.53 lm
$0.5K_2SO_4$ + K-mag	0	49.93 i	51.67 fghij	6.33 klm	7.00 jk	340.60 hi	352.37 hi	64.28 hijk	66.61 ijk
	7.5	59.47 de	60.67 abcdefgh	10.67 cdef	11.33 cdef	499.93 def	509.83 ef	94.50 def	96.41 def
	10	65.33 ab	65.73 abcd	11.67 bcd	12.00 bcd	577.13 c	588.43 c	109.08 cd	111.17 c
	12.5	53.40 gh	54.33 defghij	10.00 ef	11.00 def	396.07 g	407.03 g	74.87 gh	76.94 gh
Felspar + K-mag	0	46.60 j	48.70 hij	5.67 klm	6.00 kl	320.63 hij	306.67 ij	56.84 ijk	57.98 klm
	7.5	57.50 ef	58.00 bcdefghi	9.67 fg	10.33 fg	491.07 ef	494.70 f	93.09 ef	93.51 ef
	10	63.40 bc	65.03 abcde	10.67 cdef	11.33 cdef	544.73 cd	554.70 cde	102.96 def	104.87 cd
	12.5	50.80 hi	52.60 efghij	8.67 fg	9.00 h	369.57 gh	379.23 gh	69.86 hij	71.69 ghi
$0.5\ K_2SO_4$ + K-mag + SA	0	61.20 cd	62.07 abcdefg	7.33 ijk	8.33 hi	366.37 f	479.70 f	88.20 fg	90.67 f
	7.5	66.53 a	69.00 ab	12.33 b	13..00 b	646.47 b	659.80 b	119.19 bc	121.41 b
	10	68.03 a	71.50 a	13.67 a	14.67 a	769.90 a	783.87 a	141.40 a	144.24 a
	12.5	63.77 bc	65.10 abcde	11.33 bcde	12.00 bcd	580.97 c	591.47 c	126.52 b	108.25 c
$0.5\ K_2SO_4$ + SA	0	52.07 hi	54.53 defghij	6.67 kl	7.33 ij	397.47 g	407.73 g	72.75 h	74.63 ghi
	7.5	62.33 c	63.67 abcdef	11.00 cdef	11.67 cde	560.50 c	572.73 cd	102.57 bef	104.82 cd
	10	67.07 a	67.90 abc	12.00 bc	12.33 bc	755.13 c	589.23 c	104.84 cde	107.44 c
	12.5	55.20 fg	56.27 cdefghij	10.33 def	11.00 def	396.07 g	406.37 g	72.49 hi	74.37 ghi

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

Flower yield and contents

The application of different potassium sources encouraged significantly the production of flowers, flowers fresh and dry weight and carotenoids content in both seasons (Table 4). The most promising effect was found with the treatment by the 0.5 K_2SO_4 + K-mag + SA. Since, this treatment gave a great number of flowers per plant (91.00 and 99.42), flowers fresh weight (159.29 and 174.04 g/plant), flowers dry weight (30.86 and 33.72 g/plant) and total carotenoids (16.20 and 17.93 mg/100g) in the first and second seasons, respectively.

TABLE 4. Effect of different potassium sources and pinching on flowers number, fresh& dry weight and carotenoids content of *Calendula officinalis* L. during 2010/2011 and 2011/2012.

Treatment	Flowers No.		Flowers F.W.		Flowers D.W		T. Carotenoids	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Potassium Sources								
Control	59.25 e	63.92 e	91.84 e	99.05 e	17.86 d	19.32 d	15.48 a	16.66 e
Potassein	50.25 f	45.67 f	73.20 f	79.67 f	14.87 e	15.54 e	15.19 a	16.35 f
0.5K2SO4 + K-mag	69.75 c	75.00 c	115.09c	123.75c	19.92 c	21.26 c	15.00 a	17.64 b
Felspar + K-mag	64.08 d	68.57 d	102.57d	110.05d	30.89 a	32.74 a	15.57 a	17.04 d
0.5 K2SO4 + K-mag + SA	91.00 a	99.42 a	159.29a	174.04a	30.86 a	33.72 a	16.20 a	17.93 a
0.5 K2SO4 +SA	76.08 b	80.92 b	129.38b	137.58b	25.36 b	26.52 b	15.74 a	17.38 c
Pinching								
0	52.00 d	58.98 d	85.20 d	96.38 d	17.37 d	19.74 d	13.95 b	15.19 d
7.5	71.83 b	76.56 b	117.39b	125.09b	24.62 b	26.12 b	16.31 a	17.71 b
10	82.50 a	88.61 a	135.02a	145.07a	28.07 a	30.36 a	17.29 a	19.24 a
12.5	67.28 c	71.17 c	109.96c	116.21c	22.01 c	23.18 c	14.43 b	16.54 c

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

Similar trend of positive effect was noticed with pinching data presented in the same table. The maximum recorded values were of plants pinched at 10 cm, while the minimum values were of the control plants in the two seasons, respectively.

There was favorable effect of the interaction between potassium sources and pinching. The maximum number of flowers per plant (112.33 and 126), flowers

fresh weight (196.64 and 220 g/plant), flowers dry weight (38.17 and 42,81g/plant) and total carotenoids (17.41 and 20.12 mg/100g) were resulted from the treatment (0.5 K_2SO_4 + K-mag + SA and pinching at 10 cm), followed by the treatment (0.5 K_2SO_4 + SA) in the first and second seasons, respectively (Table 5). However the plants treated with Potassein without pinching gave the least values in both seasons.

The increase in number of flower, weight of flower and yield of flower per plant under pinching might be due to the fact that it checked apical dominance and diverted extra energy into the production of more number of branches and flowers (Pushkar and Singh, 2012). Moreover, the increase in number of flowers per plant might be attributed to the development of large number of auxiliary shoots as a result of cessation of terminal growth (Gowda and Jaynthi, 1991).

These results are in agreement with those of Bayat *et al*. (2012) who stated that SA increased flowers number of calendula. Pacheco *et al*. (2013) on marigold reported that SA application increased biomass accumulation, number of inflorescences and flavonoid content.

Similar results were obtained by Hashemabadi *et al*. (2012) on *Calendula officinalis* L., Moradinejad (1995) and Daneshkhah *et al*. (2007) on rose and Pal and Ghosh (2010) on African marigold. Yassen *et al*. (2010) on calendula demonstrated that the yield of flowers increased with different sources of potassium. El-Masry (1996) on peppermint found a significant increase in biomass and essential oil yield with KCl and K_2SO_4.

The results are in agreement with those of Pushkar and Singh (2012) who reported that pinching increased flower yield of African marigold. Also, Khobragade *et al*. (2012) concluded that maximum number of flowers and more weight of flowers per plant in China aster was found significantly higher in the pinched plants than the un-pinched ones.

Chlorophylls and nutrient contents

Potassium sources significantly induced variable chlorophyll content (mg/g), nitrogen, phosphorus and potassium percentages in both seasons as presented in Table 6.The (0.5 K_2SO_4 + K-mag + SA) treatment gave considerably the highest values of total chlorophylls (0.82 and 0.87 mg/g), N% (2.36 and 2.55), P% (0.34 and 0.37) and K% (2.03 and 2.30) in the two seasons, respectively followed by the treatment (0.5 K_2SO_4 + SA) in the two seasons, respectively (Table 6).

As shown in the same table different pinching treatments affected significantly on chlorophyll content (mg/g), nitrogen, phosphorus and potassium percentages in both seasons. The maximum chlorophyll content (0.86 mg/g), N (0.2.81%), P (0.39%) and K (2.56%) were of plants pinched at 10 cm in the first season. The results of the second season followed the same trend of the first one.

TABLE 5. Effect of interaction between potassium sources and pinching on flowers number, fresh& dry weight and carotenoids content of *Calendula officinalis* L. during 2010/2011 and 2011/2012.

Treatments		Flowers No.		Flowers F.W.		Flowers D.W.		Total Carot.	
Potassium	Pinching	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	0	44.33 op	51.00 l	68.71 o	79.05 m	13.38 m	15.41 jk	13.79 efg	14.67 t
	7.5	62.33 jk	66.33 hi	96.61 kl	102.73 ij	18.83 ij	20.05 ghi	15.98 abcdef	17.28 k
	10	72.33 gh	76.33 ef	112.12 ghi	118.32 h	21.83 fg	23.07 fg	17.37 abcd	18.63 e
	12.5	58.00 kl	62.00 ij	89.90 l	96.10 jk	17.41 jk	18.74 hij	14.81 bcdef	16.07 o
Potassein	0	40.67 p	42.33 m	60.37 b	62.95 n	11.74 n	12.27 k	13.32 fg	14.36 u
	7.5	53.33 lm	58.33 jk	77.33 n	84.62 lm	15.08 lm	16.50 ij	15.80 abcdef	17.06 l
	10	56.33 l	62.67 hij	81.65 mn	90.87 kl	15.92 kl	17.75 hij	17.10 abcde	18.27 g
	12.5	50.67 hi	55.33 kl	73.47 no	80.23 m	14.32 lm	15.64 jk	14.58 cdef	15.70 q
0.5K2SO4 + K-mag	0	54.00 lm	61.33 ij	89.10 lm	101.20 ij	14.36 lm	16.76 hij	14.13 def	15.70 q
	7.5	72.00 gh	74.66 f	118.80 fg	123.20 gh	21.11 fgh	22.59 fg	16.65 abcdef	18.09 h
	10	84.33 d	91.33 c	139.15 d	105.70 de	24.73 e	25.32 ef	18.23 a	19.76 b
	12.5	68.67 hi	72.67 fg	113.30 gh	119.90 h	19.47 hi	20.36 gh	11.03 g	17.01 l
Felspar + K-mag	0	46.00 no	54.00 kl	73.60 no	86.40 lm	22.18 f	25.87 ef	13.86 efg	15.03 s
	7.5	68.00 hi	72.67 fg	108.80 hi	116.43 h	32.94 b	34.80 b	16.25 abcdef	17.51 j
	10	79.67 de	81.67 de	127.50 e	130.70 fg	38.14 a	42.69 a	17.73 abc	19.17 e
	12.5	62.67 jk	66.67 hi	100.37 jk	106.67 i	30.28 c	27.59 de	15.17 abcdef	16.47 n
0.5 K2SO4 + K-mag + SA	0	65.33 ij	76.00 ef	114.33 gh	133.07 f	22.18 f	25.73 ef	14.36 def	15.89 p
	7.5	97.00 b	102.67 b	169.80 b	179.66 b	32.88 b	34.80 b	16.74 abcde	18.45 f
	10	112.33 a	126.00 a	196.64 a	220.61 a	38.17 a	42.81 a	17.41 abcdef	20.12 a
	12.5	89.33 c	93.00 c	156.40 c	162.82 c	30.19 c	31.54 bc	15.66 abcdef	17.28 k
0.5 K2SO4 + SA	0	61.67 jk	68.00 gh	105.07 ij	115.60 h	20.35 ghi	22.40 fg	14.26 def	15.48 i
	7.5	78.63 ef	84.67 d	133.03 de	143.93 e	26.89 d	27.97 de	16.47 abcdef	17.87 i
	10	90.00 c	93.67 c	153.07 c	159.23 cd	29.64 c	30.52 cd	15.96 ab	19.48 c
	12.5	74.33 fg	77.33 ef	126.37 ef	131.53 ef	24.57 e	25.18 ef	15.39 abcdef	16.70 m

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

TABLE 6. Effect of different potassium sources and pinching on total chlorophylls content and N P K percentages of *Calendula officinalis* L. during 2010/2011 and 2011/2012.

Treatment	T. chlorophylls		N %		P %		K %	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Potassium Sources								
Control	0.67 d	0.82 e	2.17 e	2.33 e	0.36 a	0.35 d	1.77 cd	1.92e
Potassein	0.75 e	0.80 f	2.11 f	2.27 f	0.32 a	0.34 e	1.70 d	1.98de
0.5K2SO4 + K-mag	0.78 c	0.85 c	2.27 c	2.48 c	0.34 a	0.36 b	1.82 bc	2.22ab
Felspar + K-mag	0.78 c	0.84 d	2.23 d	2.41 d	0.33 a	0.35 c	1.68 bc	2.07cd
0.5 K2SO4 + K-mag + SA	0.82 a	0.87 a	2.36 a	2.55 a	0.34 a	0.37 a	2.03 a	2.30a
0.5 K2SO4 +SA	0.79 b	0.86 b	2.31 b	2.51 b	0.34 a	0.36 b	1.92 b	2.15ab
Pinching								
0	0.72 d	0.78 d	1.86 c	2.05 c	0.30 b	0.30 d	1.23 d	1.40d
7.5	0.80 b	0.85 b	2.16 b	2.32 b	0.36 a	0.38 b	1.98 b	2.30b
10	0.86 a	0.89 a	2.81 a	3.00 a	0.39 a	0.41 a	2.56 a	2.90a
12.5	0.67 c	0.83 c	2.14 b	2.33 b	0.31 b	0.34 c	1.63 c	1.82c

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

Data shown in Table 7 pointed out significant difference between interaction treatments. The plants that received the (0.5 K_2SO_4 + K-mag + SA) treatment and pinched at 10 cm gave the highest chlorophyll content (0.887 and 0.930 mg/g), N (2.97 and 3.18%), P (0.399 and 0.417%) and K (2.69 and 3.09%) , while plants that treated with potassein without pinching had the minimum chlorophyll content (0.681 and 0.750 mg/g), N (1.75 and 1.90%), P (0.266 and 0.289%) and K (1.07 and 1.39%) in the two seasons, respectively.

Generally, nitrogen and phosphorus, contents and uptake increased in the various Potassium sources (Yassen *et al.*, 2010).

Similar results were reported by Bayat *et al.* (2012) on calendula. They mentioned that SA treated plants had greater chlorophyll reading values than untreated plants.

TABLE 7. Effect of interaction between potassium sources and pinching on total chlorophylls content and N P K percentages of *Calendula officinalis* L. during 2010/2011 and 2011/2012.

Treatments		T. chlorophylls		N%		P%		K%	
Potassium	Pinching	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	0	0.694 l	0.760 m	1.78 p	1.95 p	0.373 abcd	0.296 r	1.12 q	1.25 n
	7.5	0.781 gh	0.830 h	2.09 jk	2.25 kl	0.349 abcd	0.371 i	1.95 fgh	1.89 ij
	10	0.839 cd	0.877 e	2.73 d	2.86 d	0.423 a	0.399 d	2.46 bcd	2.81 bcd
	12.5	0.741 jk	0.799 i	2.07 kl	2.27 ij	0.302 bcd	0.327 m	1.53 klmn	1.72 ijk
Potassein	0	0.681 l	0.750 m	1.75 p	1.90 p	0.266 d	0.289 s	1.07 q	1.39l mn
	7.5	0.766 hij	0.814 i	2.03 l	2.18l m	0.343 abcd	0.364 j	1.89 ghi	2.15 gh
	10	0.825 def	0.855 g	2.61 e	2.79 e	0.371 abcd	0.394 ef	2.38 cd	2.73 cd
	12.5	0.730 k	0.786 kl	2.03 l	2.20l m	0.295 bcd	0.319 n	1.47l mno	1.65 jkl
0.5K2SO4 + K-mag	0	0.729 k	0.790 jk	1.93 n	2.14 no	0.285 cd	0.310 op	1.34 nop	1.47 klmn
	7.5	0.820 def	0.870 e	2.23 fg	2.39 gh	0.361 abcd	0.389 f	1.54 klmn	2.47 ef
	10	0.878 ab	0.920 a	2.90 b	3.13 a	0.393 ab	0.415 ab	2.66 ab	3.01 ab
	12.5	0.772 hi	0.857 f	2.21 fg	2.40 fg	0.321 abcd	0.345 k	1.72 ijk	1.92 hi
Felspar + K-mag	0	0.733 k	0.776 l	1.85 o	2.05 o	0.276 cd	0.305 q	1.19 pq	1.33 mn
	7.5	0.800 fg	0.843 g	2.15 hi	2.29 ij	0.353 abcd	0.378 i	2.06 fg	2.31 fg
	10	0.857 bc	0.894 c	2.81 c	2.97 d	0.380 abc	0.406 d	2.57 abc	2.84 abc
	12.5	0.753 jik	0.823 hi	2.13 ij	2.32 ij	0.311 bcd	0.336 l	1.61 jklm	1.79 ij
0.5 K2SO4 + K-mag + SA	0	0.778 gh	0.797 jk	1.98 m	2.17 mn	0.277 cd	0.312o	1.40m nop	1.53kl m
	7.5	0.826 de	0.884 cd	2.25 f	2.41 fg	0.365 abcd	0.392 ef	2.27 de	2.58 de
	10	0.887 a	0.930 a	2.97 a	3.18 a	0.399 ab	0.417 a	2.69 a	3.09 a
	12.5	0.778 ghi	0.872 e	2.25 f	2.44 f	0.326 abcd	0.351 j	1.79 hij	1.98 hi
0.5 K2SO4 + SA	0	0.687 l	0.799 j	1.98 no	2.10 no	0.281 cd	0.308 pq	1.27 opq	1.41l mn
	7.5	0.809 fg	0.859 f	2.19 gh	2.39 fg	0.359 abcd	0.385 g	2.15 ef	2.39 efg
	10	0.867 ab	0.908 b	2.85 c	3.07 b	0.397 ab	0.412 b	2.61 ab	2.93 abc
	12.5	0.763 hij	0.842 g	2.15 hi	2.37 gh	0.318 abcd	0.342 k	1.67 jkl	1.86 ij

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

Potassium has been reported to be involved in maximum increase in nutrient uptake (Belorkar *et al*., 1992) and potassium content in aerial part of *Calendula officinalis* L. plant (Hashemabadi *et al.,* 2012). Total chlorophyll content in African marigold leaf tissues at active vegetative growing stage showed a gradual increase with increasing potassium level (Pal and Ghosh, 2010).

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تأثير إزالة القمة النامية ومصادر البوتاسيوم علي النمو ومحصول الأزهار في الأقحوان

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تهدف هذه الدراسة إلي زيادة الألون الطبيعية في نبات الأقحوان باستخدام الطرق الأمنــة ، حيث أجريت خــلال مـوسمين زراعيين متتاليين لعامـي ٢٠١٠/٢٠١١ و ٢٠١١/٢٠١٢ لدراسة مدي تأثير المصادر المختلفة للتسميد البوتاسي (المعدل الموصي به من سلفات البوتاسيوم (كنترول) – نصف المعدل الموصي به + البكتريا الميسرة للبوتاسيوم – نصف المعدل الموصي به + حمض الساليسلك – نصف المعدل الموصي به + البكتريا الميسرة للبوتاسيوم + حمض الساليسيلك – خام الفلسبار + البكتريا الميسرة للبوتاسيوم – البوتاسين) ، وكذلك دراسة مدي تأثير إزالة القمة النامية علي ارتفاعات مختلفة (٠ ، ٧,٥ ، ١٠ ، ١٢,٥ سم).

أظهرت النتائج التأثير الإيجابي لمصادر التسميد البوتاسي المختلفة في زيادة النمو الخضري ومحصول الأزهار، الأ أن معاملة نصف المعدل الموصي به + البكتريا الميسرة للبوتاسيوم + حمض السالسيليك كانت الأكثر إيجابية في التأثير علي النمو ومحتوي الكاروتينات في بتلات الأزهار. وعلي الجانب الآخر فإن إزالة القمة النامية علي ارتفاع ١٠ سم من سطح التربة كانت الأفضل للنمو الخضري ومحصول الأزهار . أما أفضل معاملات التفاعل فكانت التسميد بنصف المعدل الموصي به + البكتريا الميسرة + حمض السالسيليك وإزالة القمة النامية علي إرتفاع ١٠ سم ، حيث حققت تحسين في النمو ومحصول الأزهار بنسبة وصلت إلي ٦٠٪ أعلي من الكنترول (متوسط الموسمين) وكذلك الحصول علي أعلي محتوي من الصبغات الطبيعية ، بالإضافة إلي الإستغناء عن ٥٠٪ من سلفات البوتاسيوم وتلافي أثرها الضار علي الإنسان والبيئة كليهما.

الكلمات الرئيسية : الأقحوان ، البوتاسيوم ، إزالة القمة النامية ، الكاروتينات .