EFFECT OF NPK FERTILIZATION TREATMENTS AND GA_3 ON GROWTH, FLOWERING AND CHEMICAL COMPOSITION OF MARIGOLD (*CALENDULA OFFICINALIS*, L.)

By

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ABSTRACT

Field experiments were carried out at the Farm of Agric., Fac., Kafr El-Sheikh, Tanta Univ. during 2001/2002 and 2002/2003 seasons to study the effect of 7 NPK fertilization treatments and GA_3 at the levels of 0, 50 and 100 ppm on the vegetative growth, flowering and chemical composition of *Calendula officinalis*, L. plants. The obtained results can be summarized as follows:- The different NPK fertilization treatments enhanced growth and flowering characters and increased the total chlorophyll content in the leaves as well as N, P. and K percentages in the leaves in comparison with the control in both seasons. The treatment of N_3P_2K (300 kg ammonium sulphate + 200 kg calcium super phosphate + 50 kg potassium sulphate per fed.) led to the highest records of the most growth and flowering aspects, when compared to the other NPK fertilization treatments in both seasons.

GA_3 generally improved vegetative growth and flowering of *Calendulla officinalis* L. The high level of 100 ppm had the most pronounced effect in the majority of treatments.

Generally, it is recommended to use 300 kg ammonium sulphate, 200 kg calcium super phosphate and 50 kg potassium sulphate/fed. to fertilize *Calendula officinalis* as the amount to be divided into two equal portions and added after 4 and 7 weeks from transplanting with using 2foliar applications of gibberellic acid (100ppm) at the same schedule of fertilization to obtain the highest records of growth, flowering vase-life and chemical composition of marigold.

INTRODUCTION

Calendula officinalis, L. plants are very important ornamental plants cultivated outdoors as a winter annual plants. It belongs to Family Asteraceae (Fam Composite) and is used for landscaping, as a source of colour in the gardens and as cut flowers. It is considered to be one of the valuable medicinal plants as contains oleanolic acid and other compounds, which stimulate the secretion of bile and have

diaphoretic, diuretic and stimulating properties. Moreover, pigments of the flowers are used in coloring foods.

NPK fertilization is important for growth, flowering and chemical composition of plants. In this concern **Menesi (1995a and b)** on *Ammi majus* and *Ammi visnaga* stated that increasing N, P and K levels in NPK treatments produced significant increments in plant height, dry weight and seed weight/plant, N, P and K % in the leaves over control. **El-Mahrouk and Kandeel (1997)** on *Calendula officienalis* L. found that N. fertilization at the level of 4 g/plant increased plant height, fresh and dry weights of foliage and roots/plant, flowering period, vase life, inflorescence number/plant and diameter and fresh and dry weights of inflorescence. **Mohamed (1997)** found that *Cuminum cyminum* L. and *Nigella sativa* L. plants fertilized with NPK fertilization at the rates of 50, 100 and 150 kg/fed. had increases in plant height, number of umbles and fruit yield/plant, number of branches and their fresh and dry weights/plant.

Guerrero and Johnson (2000) on *Origanum majorona* pointed out that adding N, P and K increased plant height over control.

Refaat *et al.* (2001) showed that fertilizing *Majorana hortensis* with two rates of P (15 and 30 kg P_2O_5/fed.) led to increase plant height, dry weight/plant and the uptake of N, P and K compared to the control.

Atakisi *et al.* (2001) on *Salvia officinalis* found that, applying N fertilization at high rate (160 kg N/ha) resulted in a large increase in fresh and dry weight of yields.

Badran *et al.* (2001) on *Tropaeolum majus* reported that increasing the rate of N fertilization up to 90 kg N/fed. caused a gradual increase in plant height, number of branches, leaves and flowers/plant, dry weight of leaves and flowers and nitrogen % in the leaves.

Kandeel *et al.* (2002) reported that, to produce the best *Chrysanthemum parthenium* plants having the tallest plant, the highest number of branches/plant, highest leaf area/plant, heaviest fresh and dry weight of the vegetative parts, longest roots, heaviest fresh and dry weight of roots, earliest flowering, highest number of inflorescences/ plant, largest inflorescence diameter, heaviest fresh and dry weight of inflorescences/ plant as well as highest total chlorophyll, N, P and K % in the leaves they should be fertilized with 4 g ammonium sulphate (20.5% N) /pot four time during the growing

season. **Mohamed (2002)** on *Pelargonium graveolens* L. and *Rosmarinus officinalis* L found that all NPK fertilization treatments increased plant height, number of branches/plant, fresh and dry weight of herb/plant and per fed. as well as N, P and K % in the leaves

Concerning gibberellic acid **Hassan *et al.* (1991)** reported that GA_3 increased plant height and number and dry weight of leaves and flowers of *Calendula officinalis*. **Abou-Dahab *et al.* (1987)** found that GA_3 increased plant height and leaves dry weight of *Chrysanthemum frutescens*. **Abdalla *et al.* (1989)** on *Chrysanthemum morifolium* found that GA_3 increased plant height, fresh and dry weights of vegetative parts, number of flowers and dry weight of flowers in addition to a reduction in number of branches/plant. Similar findings in addition to early flowering were revealed by **Badran *et al.* (1989)** on *Luffa cylindrica*.

Khalafalla *et al.* (1998) on *Thevetia nereifolia* Juss and *Koelreuteria paniculata* Laxm. found that GA_3 application specially at the high rate (250 ppm) enhanced plant height, fresh and dry weight of shoots and roots, root length and N, P and K % in the leaves.

Badran *et al.* (2001) on *Tropaeolum majus* demonstrated that GA_3 caused an early flowering with enhancing effects on different vegetative and flowering parameters except for branches number/plant which was decreased by increasing GA_3 concentration.

Abd El-Azim (2003) on *Salvia officinalis* found that supplying the plants with NPK at 150 kg amonium sulphate, 100 kg calcium super phosphate and 150 kg potassium sulphate/fed/year led to the greatest fresh and dry herb yield/fed/year.

Hamed (2004) on *Salvia officinalis* L. and *Origanum syriacum* L. var aegyptiacum found that full dose of NPK fertilization (600 kg ammonium sulphate + 200 kg calcium super phosphate + 100 kg potassium sulphate significantly increased plant height, number of branches/plant, fresh and dry weight of herb per plant and per feddan, as well as NPK and total carbohydrates percentages in the leaves.

MATERIALS AND METHODS

This work was conducted at the Experimental Farm of Faculty of Agric. Kafr El-Sheikh, Tanta Univ., during two successive seasons of 2001/2002 and 2002/2003 to study the effect of 7 NPK fertilization treatments and gibberellic acid concentrations on growth,

flowering and chemical composition of *Calendula officinalis*, L. plants.

Seeds of *Calandula officinalis* were sown on Oct 5th in both seasons in clay pots of 40cm diameter filled with a clay loamy soil. On November 5th the seedlings were transplanted into the field in plots (2m × 2 m) which contained 4 rows at a distance of 40 cm between plants as each plot contained 20 plants.

The experiment was arranged in a split plot design as this made 21 treatments and every treatment was replicated three times (3 plots) and the main plot was assigned to 7 NPK fertilization treatment namely, N_0P_0K (control), N_1P_1K, N_2P_1K, N_3P_1K, N_1P_2K, N_2P_2K and N_3P_2K.

Where :

N_1, N_2 and N_3 = 100, 200 and 300 kg ammonium sulphate (20.5% N)/ fed., respectively.

P_1 and P_2 = 100 and 200 kg calcium super phosphate (15.5% P_2O_5)/ fed., respectively.

K = 100 kg potassium sulphate (48.5% K_2O)/ fed.

The sub plot was intitled to the three gibberellic acid concentrations, i.e.: 0, 50 and 100 ppm. The amount of NPK fertilization assigned for each treatment was divided to equal doses and added 4 and 7 weeks after transplanting date. Gibberellic acid treatments were foliar sprayed at the same schedule of fertilization, while control treatment was foliar sprayed with a tap-water, All plants including control, received 100 kg potassium sulphate (48.5 k_2O) per faddan.

Irrigation and agricultural practices were done whenever plants needed.

Flowering date was calculated as number of days from sowing to the first flower open. Flowering period in the filed was recorded as number of days from first flower open to last flower wilt.

At full flowering (April 1st in the two seasons) the following data were recorded:

1- Plant height (cm) and number of branches/plant.
2- Fresh and dry weights of vegetative parts (g)
3- Fresh and dry weights of roots (g).
4- Number of flowers (inflorescences) per plant and flower diameter (cm.).
5- Fresh and dry weights of flowers/plant (g.).

6- As for the vase life, the five flowers from each replicate for each treatment were chosen at the opening stage and cut of by a sharp knife, then the were placed in tap-water directly. The tap-water was changed every 24 hours.

7- Total chlorophyll in the leaves (mg/g fresh weight): "determined according to **Moran (1982)** for the fifth leaf from the branch top".

8- Chemical analysis of the leaves after had been dried in the electric oven at 70°C for 24hr. as 0.1 g of the dried sample was ground and used to determine N, P and K% as follows "total nitrogen % was determined by the modified microkjedahl method as described by **Piper (1947)**, phosphorus % was estimated colorimetrically as recommended by **Troug and Meyer (1939)** and K was determined by using flame photometer **(Brown and Lilliland (1946))**.

The chemical and physical analyses for the used soil in both seasons are presented in Table (a & b).

Duncan's Multiple Range Test was used for the comparison between means of treatments **(Snedecor and Cochran, 1980)**.

Table (a) : Physical analysis of the experimental soil

Season	Sand %	Silt %	Clay %	Texture
2001/2002	20.27	31.24	48.49	Clay
2002/2003	22.41	33.14	44.45	Clay

Table (b): Chemical properties of the experimental soil.

Season	pH	Ec (mmhos/ cm at 25°C	Cations %			K (meq/L)	Anions %				Total N %	Total P (ppm)
			Na^{-}	Ca^{++}	Mg^{++}		SO_4^{--}	CO_3^{--}	Cl^{-}	HCO_3^{-}		
2001/2002	7.52	2.81	0.027	0.041	0.012	0.22	0.025	-	0.043	0.012	0.21	7.22
2002/2003	7.48	2.74	0.025	0.038	0.013	0.24	0.026	-	0.040	0.011	0.23	8.14

RESULTS AND DISCUSSION

1. Vegetative growth characters :

The four studied vegetative growth characters of *Calendula officinalis* L. i.e. plant height, number of branches/plant and fresh and dry weights of vegetative parts were significantly increased in both seasons due to the use of different nitrogen and phosphorus fertilization rates in comparison with those of unfertilized plants

(Table, 1) as the increase in these traits was gradual and parallel to the increase in the nitrogen and phosphorus rate. The highest values of the four vegetative traits resulted from the treatment of N_3P_2K (300 kg ammonium sulphate + 200 calcium superphosphate + 50 kg potassium sulphate/fedddan) followed by N_3P_1K then N_2P_2K. The increase in the studied vegetative traits owing to the application of nitrogen fertilizer may be due to that nitrogen led to constitute amino acids which formed the protein that participates in cell enlargement and cell division, while phosphorus has an important role in producing energy for the physiological processes as synthesizing proteins by formation of the coenzyme adenine triphosphate. Also, the increase in fresh and dry weights of vegetative parts may be due to the simulative effect of N, P and K elements especially with increasing nitrogen levels as led to improvement of plant growth in general which reflected increments in fresh and dry weights of the vegetative parts. The obtained findings are in agreement with those mentioned by **El-Mahrouk and Kandeel (1997)** on *Calendula officinalis*, **Badran *et al.* (2001)** on *Tropaeolium majus*, **Atakisi *et al.* (2001)** on *Salvia officinalis*, **Refaat *et al.* (2001)** on *Majarana hortensis* and **El-Bably (2003)** on *Antholyza aethiopica* and *Tritonia crocata*.

Concerning GA_3 plant height and fresh and dry weights of vegetative parts were significantly increased due to the application of both 50 and 100ppm concentrations. Moreover, the high GA_3 concentration gave significantly higher values than those of the low GA_3 concentration. On, the contrary, number of branches/plant was gradually decreased with significant differences being obtained between each two successive treatments as clearly indicated in Table (1). These data agreed with those obtained by **Badran *et al.* (1989)** on *Luffa cylindrica*, **Hassan *et al.* (1991)** on *Calendula officienalis* and **Badran *et al.* (2001)** on *Tropaeolum majus*.

The interactions between NPK fertilization and GA_3 concentration were significant for plant height and fresh and dry weights of vegetative parts in both seasons as illustrated in Table (1). The best results for such three traits were obtained when the plants received 300 kg ammonium sulphate + 200 kg calcium superphosphate + 50 kg potassium sulphate/ fed. and sprayed with 100 ppm GA_3 while the highest number of branches/plant was obtained from the treatment of $N_3P_2K_1$ without using GA_3. Similar results were obtained by **Badran *et al.* (2001)** on *Tropaeolum majus*.

Table (1): Effect of NPK fertilization treatments and GA_3 on some vegetative growth traits of *Calendula officinalis* L. during the two seasons.

GA_3 (ppm) / NPK Fertilization	First season 2001/2002				Second season 2002/2003			
	0	50	100	Mean	0	50	100	Mean
	Plant height (cm)							
N_0P_0K	49.73L	55.80j	56.97ij	54.17f	55.33L	59.27k	62.47j	59.02f
N_1P_1K	53.17k	58.93gh	62.97f	58.36e	59.80k	64.00i	67.57fg	63.79e
N_2P_1K	57.90hi	64.93e	57.07d	63.30c	64.13i	70.97e	74.34c	69.82c
N_3P_1K	59.93g	67.87cd	70.07a	65.97b	68.17f	75.70b	77.93a	73.93a
N_1P_2K	55.53j	63.63ef	66.93d	62.03d	63.47i	66.77gh	70.17e	66.79d
N_2P_2K	59.77g	67.80cd	69.20abc	65.59b	65.83h	73.03d	75.70b	71.52b
N_3P_2K	63.27ef	68.60bc	69.67ab	67.18a	68.43f	76.07b	76.43b	73.64a
Mean	57.04c	63.94b	66.12a		65.59c	69.40b	72.09a	
	No. of branches/plant							
N_0P_0K	7.17ik	6.97k	6.33m	6.82f	7.57gh	6.87i	6.40j	6.94e
N_1P_1K	7.83ef	7.37hi	6.77L	7.32e	8.23e	7.53gh	7.30h	7.69d
N_2P_1K	8.30c	7.67fg	7.13jk	7.70d	8.70bcd	8.23e	7.73fg	8.22c
N_3P_1K	8.67b	8.27c	7.50gh	8.14b	8.97b	8.60cd	8.27e	8.61b
N_1P_2K	8.13cd	7.70fg	7.20ij	7.68d	8.70cd	8.40de	7.87f	8.32c
N_2P_2K	8.67b	8.00de	7.30ij	7.99c	8.97b	8.53cde	8.23e	8.58b
N_3P_2K	9.10a	8.77c	7.87ef	8.14a	9.40s	8.77bc	8.74cde	8.89a
Mean	8.27a	7.75b	7.16c		8.65a	8.13b	7.75c	
	Fresh weight of vegetative parts (g)							
N_0P_0K	196.33a	214.00n	223.00m	211.11f	205.33j	229.67hi	236.33hi	223.78e
N_1P_1K	214.00n	239.00k	249.00i	234.00e	224.67ij	252.00fgh	264.67efg	274.11d
N_2P_1K	243.33j	271.33c	278.33e	264.33c	262.67efg	283.67b-e	293.00a-d	279.78b
N_3P_1K	267.67g	281.67cd	283.33c	275.89b	281.00cde	297.67abc	308.67ab	295.78a
N_1P_2K	233.33L	245.00j	256.00h	244.78d	245.33ghi	263.00efg	273.00c-f	260.44c
N_2P_2K	255.00h	280.00de	290.00b	275.00b	268.67d-g	287.67b-e	308.67ab	288.33ab
N_3P_2K	260.00f	292.33b	295.67a	286.00a	282.67cde	311.67a	298.67abc	297.67a
Mean	239.24c	260.48b	267.91a		252.91b	275.05a	283.29a	
	Dry weight of vegetative parts (g)							
N_0P_0K	58.83L	61.33k	62.20k	60.79f	64.20L	67.03k	69.67ij	66.97f
N_1P_1K	64.83j	68.33i	70.43h	67.87e	68.13jk	70.70hi	71.70h	70.18e
N_2P_1K	73.77g	77.30f	79.53e	76.87c	76.00g	79.63ef	78.00f	77.88c
N_3P_1K	76.53f	82.17c	82.10c	80.27b	79.10f	82.47d	86.43b	82.67b
N_1P_2K	71.63h	74.20g	80.10de	75.31d	71.87h	76.20g	78.07f	75.38d
N_2P_2K	77.00f	79.23e	81.73cd	79.32b	80.83e	85.03bc	83.87cd	83.24b
N_3P_2K	80.03de	86.07b	88.87a	84.99a	83.87cd	90.53a	89.37a	87.92a
Mean	71.81c	75.52b	77.85a		74.86c	78.80b	79.59a	

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test.

2. Fresh and dry weights of roots :

Data in Table (2) showed that the different NPK fertilization treatments had pronounced effects on fresh and dry weights of roots/plant when compared with control in the two seasons. The significantly heaviest fresh weights resulted from the treatments of N_3P_2K and N_2P_2K with non significant differences between them in the two seasons followed by N_3P_1K then N_2P_1K, while the heaviest dry weight of roots/plant resulted from the treatments of N_3P_2K, N_2P_2K and N_3P_1K in the first season. In the second one the heaviest weights resulted from N_3P_2K followed by N_2P_2K then N_3P_1K treatments as these results are in accordance with those obtained by **El-Mahrouk and Kandeel (1997)** on *Calendula officinalis* and **Kandeel *et al.* (2002)** on *Chrysanthemum parthenium.*

Table (2): Effect of NPK fertilization treatments and GA_3 on fresh and dry weights of roots of *Calendula officinalis* L. during the two seasons.

GA_3 (ppm) / NPK Treatment	First season 2001/2002				Second season 2002/2003			
	0	50	100	Mean	0	50	100	Mean
	Fresh weight of roots (g)							
N_0P_0K	33.67I	39.00h	43.67fg	38.78f	37.33k	39.33j	47.33fg	41.33e
N_1P_1K	39.00h	44.33ef	45.76de	43.00e	41.40I	46.33g	49.33de	45.56d
N_2P_1K	44.33ef	47.33bc	48.00bc	46.56c	46.67g	51.57c	54.67b	51.00b
N_3P_1K	45.33de	48.33b	48.67b	47.44b	44.67h	54.00b	56.33a	51.67b
N_1P_2K	42.67g	45.67de	47.67bc	45.33d	42.33I	47.67fg	51.67c	47.22c
N_2P_2K	46.67cd	48.67ab	50.00a	48.44a	48.67ef	53.33b	56.33a	52.78a
N_3P_2K	48.00bc	48.00bc	48.67ab	48.22a	50.33cd	54.33b	54.67b	53.11a
Mean	42.81c	45.91b	47.48a		44.43c	49.52b	52.91a	
	Dry weight of roots (g)							
N_0P_0K	9.95i	11.33h	12.47fg	11.24d	11.13m	12.40L	13.23ij	12.26g
N_1P_1K	11.35h	12.50efg	13.13c-f	12.33c	12.37L	13.47hi	14.27ef	13.37f
N_2P_1K	12.57efg	12.90def	13.57bcd	13.01b	13.67h	14.57d	14.93c	14.39c
N_3P_1K	13.20c-f	13.67bcd	14.33ab	13.37a	12.83k	14.27ef	14.17fg	13.76e
N_1P_2K	11.78gh	12.80def	13.47b-e	12.68bc	13.13j	13.97g	14.93c	14.01d
N_2P_2K	13.17c-f	13.80a-d	14.70a	13.89a	14.47bc	15.73b	16.17a	15.46b
N_3P_2K	13.16c-f	14.30ab	13.90abc	13.79a	14.90c	15.83b	16.23a	15.66a
Mean	12.17c	13.04b	13.65a		13.21c	14.32b	14.85a	

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test.

Data in Table (2) indicated also that GA_3 at 50 and 100 ppm increased fresh and dry weights of roots in both seasons over untreated plants and GA_3 at 100 ppm was much more effective. These results are in accordance with those obtained by **Abdalla *et al.* (1989), Makary (1991)** on *Chrysanthemum morifolium* and

Khalafalla *et al.* (1998) on *Thevetia nereifolia* Juss and *Koelreuteria paniculata* Laxm.

The interaction between NPK fertilization and GA_3 treatments was significant for fresh and dry weights of roots/plant. The significantly heaviest fresh and dry weight of roots resulted from treated plants with N_2P_2K and sprayed with 100 ppm GA_3 in the two seasons. Similar results were obtained by **Badran *et al.* (2001)** on *Tropaeolum majus* and **El-Sayed (1991)** and **Hassan *et al.* (1991)** on *Calendula officinalis*.

3. Flowering aspects:

Data in Table (3) showed that number of days from sowing to flowering was gradually increased in both seasons by increasing nitrogen or phosphorus rate, with significant differences between the treatments. The earliest flowering date resulted from control treatment followed by N_1P_1K and N_1P_2K then N_2P_1K and N_2P_2K. The effect of nitrogen fertilization on delaying flowering date was reported by **Abd-Alazeem (1993)** on *Tagetes minuta* and **El-Sayed (1991)** on marigold.

Data in Table (3) showed that all NPK fertilization treatments prolonged flowering period when compared with control. The highest values resulted from the treatments of N_2P_2K and N_3P_2K with non significant differences between themselves as the remainder NPK treatments gave less values in the two seasons.

Data in Table (3) indicated also that both GA_3 concentrations of 50 and 100 ppm caused significantly earlier flowering in both seasons than the untreated plants with the superiority of GA_3 at 100 ppm in this regard. The acceleration of flowering and prolonging of flowering period due to application of GA_3 at 50 and 100 ppm., may be due to the promotive effects on vegetative growth, through photosynthetic process, which in turn accounts for the carbohydrate accumulation, consequently flower bud initiation was faster than in untreated plants (**Funnell *et al.*, 1992**). These results confirm with the previous research of **Badran *et al.* (1989)** on *Luffa cylindrica*, **Karaguzel and Doran (2000)**, **Dataram *et al.* (2001)** on *Gladiolus* and **Badran *et al.* (2001)** on *Tropaeolum majus*.

The interactions between NPK fertilization and GA_3 treatments were significant for flowering date and flowering period. The earliest flowering resulted from the treatment of N_0P_0K (control) and spraying plants with 100 ppm GA_3. The longest flowering period was obtained from the treatment of N_1P_2K for plants sprayed with 50 ppm

GA_3 in the first season while in the second one this resulted from the treatment of N_3P_2K and spraying with 50 ppm GA_3.

Table (3): Effect of NPK fertilization treatments and GA_3 on some flowering characteristics of *Calendula officinalis* L. during the two seasons.

GA_3 (ppm) / NPK treatment	First season 2001/2002				Second season 2002/2003			
	0	50	100	Mean	0	50	100	Mean
	Flowering date (days)							
N_0P_0K	106.67g	101.33ij	96.00L	101.33f	98.33ghi	92.67L	89.67m	93.56f
N_1P_1K	108.00fg	104.33h	98.67k	103.67e	104.00cd	98.00hij	94.33k	98.78d
N_2P_1K	110.67d	107.33fg	102.67hi	106.89d	108.67b	100.00fg	97.00ij	101.89c
N_3P_1K	123.67a	113.33c	108.67ef	115.22a	116.67a	104.33c	99.67fgh	106.89a
N_1P_2K	108.00fg	104.33h	100.67g	104.33e	102.33de	96.67ij	90.67m	96.56e
N_2P_2K	114.67c	108.33fg	108.00fg	110.33c	107.67b	100.33n	96.33g	101.44c
N_3P_2K	119.00d	110.67d	110.33de	113.33b	113.67a	102.67cde	101.00ef	105.78b
Mean	112.95a	107.09b	103.57c		107.33a	99.23b	95.52c	
	Flowering period (days)							
N_0P_0K	49.00m	58.33l	60.67jk	56.00e	55.67k	60.00j	62.00l	59.22e
N_1P_1K	58.00l	68.33fg	67.33gh	64.56d	63.00l	70.33f	72.33de	68.56d
N_2P_1K	63.67l	72.33b	71.00bcd	69.00b	68.00g	73.67cde	73.00cde	71.56b
N_3P_1K	61.67j	70.33def	71.00bcd	67.56c	65.33h	73.00cde	72.00e	70.11c
N_1P_2K	59.33kl	73.33a	72.00abc	68.22bc	65.67h	72.33de	73.67cde	70.56c
N_2P_2K	65.67efg	72.33ab	70.33cde	70.44a	70.00f	74.67bc	74.00bcd	72.89a
N_3P_2K	66.33h	70.00def	69.00e-g	68.40bc	68.33g	75.00a	73.67cde	72.33ab
Mean	60.95b	69.24a	68.76a		65.34b	71.29a	75.52a	
	No. of flowers/plant							
N_0P_0K	54.00m	77.67j	82.00i	71.22f	48.67m	68.67k	71.33j	62.87f
N_1P_1K	68.33L	82.33i	84.67h	98.44e	63.00L	78.67h	81.33fg	74.33e
N_2P_1K	74.33k	88.00ef	91.67cd	84.57c	68.67k	81.00fgh	82.67ef	77.44d
N_3P_1K	85.67gh	93.67bc	99.00a	92.79a	78.67h	87.33c	86.00cd	84.00b
N_1P_2K	73.00k	87.33fg	90.00de	83.44d	68.33k	80.33fgh	82.67ef	77.11d
N_2P_2K	78.67j	91.33d	94.33b	88.11b	76.00i	85.33cd	84.33de	81.89c
N_3P_2K	85.67gh	95.33b	98.00a	93.00a	80.00gh	90.00b	97.67a	89.56a
Mean	74.24c	87.95b	91.38a		69.05c	81.62b	83.00a	
	Flower diameter (cm)							
N_0P_0K	6.20gh	7.07efg	8.17b-e	7.15c	6.37L	7.57j	8.07i	7.33f
N_1P_1K	6.72fgh	7.87b-g	8.27a-f	6.62b	7.27k	8.13hi	8.43g	7.95e
N_2P_1K	7.03d-g	8.37a-e	8.87a-c	8.09ab	7.53j	8.67f	9.10de	8.43c
N_3P_1K	7.33c-g	8.80a-e	10.13a	8.76a	8.37g	9.27d	9.67a	9.10a
N_1P_2K	7.07efg	8.33a-e	8.80a-e	8.07ab	7.34k	8.36gh	8.73f	8.12d
N_2P_2K	7.27d-g	8.73a-e	9.23abc	8.41ab	8.08i	9.03e	9.40bc	8.84b
N_3P_2K	8.03b-g	9.03a-d	9.40ab	8.82a	8.56g	9.23cd	9.50ab	9.03a
Mean	7.09b	8.31a	8.55a		7.62c	8.60b	8.99a	

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test.

It appears from data in Table (3) that, all NPK fertilization treatments had pronounced effects on number of flowers per plant. The significantly highest number resulted from the treatments of N_3P_2K and N_3P_1K with non significant differences among themselves in the first season, while, in the second one this resulted from the treatment of N_3P_3K and the control gave the least value in the two seasons.

It was observed from data in Tables (3 and 4) that all NPK fertilization treatments increased flower diameter, fresh and dry weights of flowers/plant and vase-life of flower when compared to the control in both seasons as the increment was significant in most cases. The treatment of N_3P_2K gave the best values in this concern when compared to the other treatments. This may be due to that nitrogen and phosphorus enhanced cell division and cell enlargement. These nutrients may participate directly or indirectly in plant anabolism resulting in more plant metabolites necessary for plant growth and flowering. Also, prolonging vase-life was perhaps accompanied by the increase in fresh weight and accumulation of more dry matter and enhancing of water balance due to increasing water uptake and reducing water loss.

These results are in harmony with those of **El-Sayed (1991)** on marigold, **Hassan *et al.* (1991)** on *Calendula officinalis*, **Badran *et al* (2001)** on *Tropaeolum majus*, **Kandeel *et al.* (2002)** on *Chrysanthemum parthenum* and **El-Bably (2003)** on *Antholyza aethiopica*, *Agapanthus africana* and *Tritonia crocata*.

Concerning GA_3 data in Tables (3 and 4) indicated that both GA_3 at 50 and 100 ppm significantly increased flowering characters of *Calandula officinalis* (number of flowers/plant, flower diameter, fresh and dry weights of flowers/plant and vase-life) when compared to untreated plants in the two seasons. The largest number of flowers/plant and flower diameter resulted from the application of GA_3 at 100 ppm followed by GA_3 at 50 ppm then untreated plants in the two seasons.

The significantly heaviest fresh and dry weights resulted from the treatment of 100 GA_3 in the two seasons followed by GA_3 at 50 ppm., while the least values resulted from untreated plant (control).

The effect of GA_3 on flowering characters may be due to that GA_3 enhanced the vegetative growth as well as photosynthetic process. So more accumulation of carbohydrates, may force the shoots to flower besides the enhancing effect of GA_3 on cell division and enlargement.

Table (4): Effect of NPK fertilization treatments and GA_3 on flowers fresh and dry weights and vase-life of *Calendula officinalis* L. during the two seasons.

GA_3 (ppm) / NPK treatment	First season 2001/2002				Second season 2002/2003			
	0	50	100	Mean	0	50	100	Mean
	Fresh weight of flowers (g)							
N_0P_0K	230.33m	256.67L	274.33k	253.78g	255.30o	277.33n	284.00m	272.25g
N_1P_1K	284.67j	310.67h	323.00g	306.11f	293.00L	317.67j	326.77i	312.11f
N_2P_1K	319.67g	347.67e	377.67bc	348.33d	332.30h	353.77e	384.33b	356.87d
N_3P_1K	343.67e	376.00c	391.00a	370.22b	348.67f	382.00bc	395.33a	375.30b
N_1P_2K	303.00i	322.33g	343.67e	323.00e	311.00k	333.70h	354.77e	333.10e
N_2P_2K	328.33f	371.33d	381.67b	360.00c	342.00g	377.71d	394.77a	371.44c
N_3P_2K	376.67c	373.67cd	390.67a	380.00a	350.67cd	393.00a	393.77a	388.92a
Mean	312.33c	336.91b	345.57a		323.00c	347.90b	361.80a	
	Dry weight of flowers (g)							
N_0P_0K	43.67g	44.67fg	54.33f	44.56d	48.33L	51.33k	53.33j	51.00g
N_1P_1K	52.67e	54.33cd	55.67b	54.22c	56.77i	63.33fg	64.33f	61.42f
N_2P_1K	55.67c	57.33b	56.33bc	56.44b	59.33h	66.67d	67.00d	64.33d
N_3P_1K	57.33b	60.00a	60.67a	59.33a	59.33h	67.33d	69.67c	65.44c
N_1P_2K	54.33d	56.33bc	57.67b	56.11b	59.00h	64.76ef	66.00de	63.20e
N_2P_2K	57.33b	60.33a	60.67a	59.44a	62.30g	70.00c	72.33b	68.25b
N_3P_2K	61.33a	60.00a	61.00a	60.78a	63.77fg	71.77b	74.00a	69.80a
Mean	54.62c	56.14b	56.76a		58.40c	56.00b	66.67a	
	Vase-life (days)							
N_0P_0K	8.13L	8.87j	8.40k	8.48d	8.78L	9.27j	9.12k	9.05f
N_1P_1K	9.30i	9.58fgh	9.49ghi	9.46c	9.90h	10.28m	9.77i	9.99e
N_2P_1K	9.75ef	10.21b	9.83de	9.93b	10.25g	10.92c	10.40ef	10.52c
N_3P_1K	9.55gh	9.97cd	10.00cd	9.84b	10.02h	10.68d	10.41ef	10.37d
N_1P_2K	9.42hi	9.67efg	9.53gh	9.54c	10.31fg	10.78cd	10.53e	10.54c
N_2P_2K	9.74f	9.96cd	9.80de	9.84b	10.70d	11.14b	10.91c	10.92b
N_3P_2K	10.12bc	10.76a	10.15bc	10.34a	10.92c	11.32a	11.09b	11.11a
Mean	9.44c	9.86a	9.60b		10.13c	10.63a	10.32b	

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test.

As for vase-life data in Table (4) proved that GA_3 treatments gave longer vase-life than control in both seasons. The significantly longest vase-life was obtained from the treatment of 50 ppm. while, control gave the shortest vase-life. The effect of GA_3 of increasing vase-life may be due to that it increases flowers content of carbohydrates, so reflected on the flower longevity.

These results are in agreement with those of **Hassan *et al.* (1991)** on *Calaendula officinalis*, **Abdella *et al.* (1989)** on *Chrysanthemum morifolium*, **Badran *et al.* (2001)** *Tropaelum majus*,

Karaguzel and Doran (2000) and Dataram *et al.* (2001) on *Gladiolus* **and Attia (2004)** on *Zantedeshia aethiopica* **and** *Hedychium caronarium.*

The interaction between NPK fertilization and GA_3 treatments was significant for flowering characters of *Calendula officinalis* in most cases during the two seasons. The highest number of flowers, widest flower diameter and the heaviest fresh weight of flowers resulted from the treatments of N_3P_2K and N_2P_2K and sprayed with 100 ppm GA_3. However, the heaviest dry weight of flowers /plant resulted from N_3P_2K and N_3P_1K treatments for plants sprayed with 50 and 100 ppm GA_3 with non significant differences between them in the first season while in the second one was obtained when plants received N_3P_2K and prayed with 50 or 100 ppm GA_3. As for vase-life, the longest vase-life was obtained from the treatment of N_3P_2K and plants sprayed with 50 ppm GA_3.

4. Chemical composition :

Data of the effect of different levels of NPK and GA_3 treatments on the total chlorophyll, N, P and K% in the leaves of *Calendula officinalis* during both seasons are presented in Table (5) which reveal that the different NPK fertilization treatments significantly increased the total chlorophyll in the leaves over control in both seasons. The treatment of N_3P_2K recorded the highest record in the leaves when compared to the other treatments during the two seasons.

As for N, P and K% in the leaves, data in Table (5) indicate that all NPK fertilization treatments significantly increased N, P and K% in the leaves over control during both seasons. The highest values of N and K% in the leaves resulted from the treatment of N_3P_2K in the two seasons, while the highest value of P% in the leaves was obtained from N_3P_2K and N_2P_2K treatments with non significant differences between the two treatments during both seasons.

The increase in chlorophyll content due to the application of NPK fertilization treatments especially at the high level of nitrogen might be attributed to the known function of some elements like nitrogen which was found in such important molecules as prophyrin. The prophyrin structure was found in metabolically important compounds in the chlorophyll (**Devlin 1979**).

The increase in N% in the leaves as a results of using N, P and K fertilization may be due to the promotive effect of the nitrogen on

plant growth, hence more nutrients might be absorbed to build up the plant organs and metabolites.

Table (5): Effect of NPK fertilization treatments and GA_3 on chemical composition of *Calendula officinalis* L. during the two seasons.

GA_3 (ppm) / NPK Treatment	First season 2001/2002				Second season 2002/2003			
	0	50	100	Mean	0	50	100	Mean
	Total chlorophyll (mg/g fresh weight)							
N_0P_0K	0.933j	0.940j	0.963ij	0.947f	1.093L	1.140k	1.100L	1.111f
N_1P_1K	0.900j	0.973i	0.953ij	0.972e	1.187ij	1.207hi	1.173j	1.189e
N_2P_1K	1.127g	1.067h	1.037h	1.077d	1.267e	1.247f	1.217gh	1.243c
N_3P_1K	1.253bc	1.197ef	1.167f	1.206b	1.313d	1.247f	1.247ef	1.269b
N_1P_2K	1.107g	1.123g	1.110g	1.113c	1.237fg	1.300hij	1.190ij	1.209d
N_2P_2K	1.243cd	1.180f	1.163f	1.196b	1.313d	1.267b	1.233fg	1.271b
N_3P_2K	1.307a	1.287ab	1.217cd	1.270a	1.360e	1.287a	1.243ef	1.297a
Mean	1.137a	1.110b	1.087c		1.263a	1.228b	1.200c	
	N %							
N_0P_0K	1.747j	1.727j	1.827i	1.767g	1.947m	1.783n	2.053m	1.928f
N_1P_1K	2.147g	2.097h	2.053h	2.099f	2.247hik	2.163jkl	2.120kl	2.177e
N_2P_1K	2.443d	2.310e	2.303e	2.352d	2.547cde	2.357fgh	2.300ghi	2.401c
N_3P_1K	2.600ab	2.447d	2.440d	2:496b	2.723ab	2.523bc	2.440ef	2.562b
N_1P_2K	2.263e	2.310e	2.213f	2.262e	2.373fg	2.257g-j	2.190ijk	2.273d
N_2P_2K	2.523c	2.437d	2.447d	2.369c	2.663c	2.473f	2.440f	2.536b
N_3P_2K	2.637a	2.533c	2.567bc	2.579a	2.790a	2.640bcd	2.540de	2.657a
Mean	2.337a	2.266b	2.246b		2.470a	2.314b	2.298b	
	P %							
N_0P_0K	0.227k	0.267j	0.287i	0.260f	0.267i	0.323g	0.350f	0.313f
N_1P_1K	0.270j	0.300i	0.323gh	0.298e	0.303h	0.360ef	0.377de	0.347e
N_2P_1K	0.300i	0.320h	0.330gh	0.317d	0.330g	0.377de	0.387cd	0.364d
N_3P_1K	0.337fg	0.340fg	0.330gh	0.336c	0.353f	0.387cd	0.417ab	0.382b
N_1P_2K	0.347ef	0.357de	0.367cd	0.357b	0.353f	0.377de	0.393bc	0.374c
N_2P_2K	0.357de	0.373cd	0.383ab	0.371a	0.370de	0.397bc	0.410ab	0.392a
N_3P_2K	0.347ef	0.380bc	0.390a	0.372a	0.383cd	0.400bc	0.423a	0.399a
Mean	0.312c	0.334b	0.344a		0.337c	0.374b	0.391a	
	K %							
N_0P_0K	2.510k	2.723j	2.813i	2.682f	2.627o	2.580n	2.963L	2.813f
N_1P_1K	2.783i	3.017g	3.107f	2.969e	2.910m	3.140j	3.243h	3.098e
N_2P_1K	2.967h	3.137f	3.193e	3.099d	3.087k	3.270gh	3.323ef	3.227c
N_3P_1K	3.107f	3.270cd	3.290L	3.222b	3.247h	3.347de	3.440c	3.344b
N_1P_2K	3.053g	3.133f	3.220e	3.136c	3.000L	3.190i	3.300fg	3.163d
N_2P_2K	3.147f	3.237de	3.293c	3.226b	3.157ij	3.373d	3.430c	3.320b
N_3P_2K	3.193e	3.357d	3.407a	3.319a	3.267gh	3.537a	3.490b	3.431a
Mean	2.966c	3.125b	3.189a		3.042c	3.244b	3.313a	

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test.

The increase in phosphorus percentage in the leaves may be due to their enchanting effects on phosphour absorption and/or translocation in the plants. The increase in the K% may be due to the direct or indirect effect of the used nutrients on the absorption and translocation of potassium. The increase in the N, P, K and total chlorophyll contents could be resulted from the increase in the uptake of nutrients through the root system which becomes more capable of absorbing more amounts of nutrients.

These results are in harmony with those recorded by **El-Mahrouk and Kandeel (1997)** on *Calendula officinalis*, **Menesi (1995 a and b)** on *Ammi majus* and *Ammi visnaga*, **Badran *et al.* (2001)** on *Trapaeolum majus*, **Kandeel *et al.* (2002)** on *Chrysanthemum parthenium*, **Mohamed *et al.* (2002)** on *Pelargonium graveolus* and *Rosmarinus officinalis* and **Hamed *et al.* (2004)** on *Salvia officinalis* and *Origanum syriacum* L. var. aegyptiacum.

Data in Table (5) showed that nitrogen percent was gradually decreased in both seasons by increasing GA_3 concentration but the differences were non significant between GA_3 at 50 and 100 ppm. Similar results were obtained by **Badran *et al.* (2001)** on *Tropaeolum majus*.

Also, data in Table (5) showed that P and K% in the leaves were increased by increasing GA_3 concentration. The highest values of both were obtained from the treatment of GA_3 at 100 ppm in the two seasons.

The increase in P and K% in *Calendula officinalis* leaves may be due to that GA_3 gave better growth and led to more P and K uptake. These results are in Conformity with those of many researches as **Khalafalla *et al* (1998)** on *Thevetia nereifolia* and *Koelreuteria paniculata*, **Karaguzel and Doran (2000)** on *Gladiolus*.

The interaction between NPK fertilization and GA_3 treatment was significant for chemical composition in the two seasons in most cases. The results are in harmony with those of **El-Sayed (1991)** on *Calendula officinalis* and **Abd-Alazeem (1993)** on *Tagetes minuta*.

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الملخص العربى

تأثير التسميد بالـنتروجين والفوسفور والبوتاسيوم (NPK) والرش بالجبريللين على النمو والإزهار والتركيب الكيماوى لنبات الإقحوان

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أجرى هذا البحث فى المزرعة التجريبية بكلية الزراعة بكفرالشيخ – جامعة طنطا خلال موسمى ٢٠٠١/٢٠٠٢ ، ٢٠٠٢/٢٠٠٣م لدراسة تـأثير ٧ معاملات تسميد بالـ ن، بو، فو حيث استخدم النتروجين بثلاثة مستويات (١٠٠ ، ٢٠٠، ٣٠٠ كجم جرام سلفات امونيوم/فدان والفوسفور بمسـتويين (١٠٠ ، ٢٠٠كجم سوبر فوسفات) والبوتاسيوم بمستوى واحد هو ٥٠كجـم سلفات بوتاسيوم للفدان، وتأثير الرش بالجبريللين بتركيزات صفـر، ٥٠، ١٠٠ جزء فى المليون على النمو الخضرى والإزهار والتركيب الكيمـاوى لنباتات الإقحوان.

وكانت أهم النتائج المتحصل عليها كالآتى :

١-أدت جميع معاملات التسميد بالـ ن، بو، فو الى زيادة معنوية فى كل صفات النمو الخضرى (إرتفاع النبات – عدد الأفرع للنبات – الوزن الطازج والجاف للمجموع الخضرى – اللون الطازج والجاف للجذور) والإزهار (تاريخ الإزهار – طول فترة الإزهار بالحقل – عدد الأزهار/نبات – قطر الزهرة – الوزن الطازج والجاف للأزهار – مدة حياة الزهرة بعد القطف) مما أدت الى زيادة محتوى الأوراق من الكلورفيل وكذلك النسبة المئوية من عناصر النتروجين والفوسفور والبوتاسيوم مقارنة بمعاملة الكنترول خلال الموسمين.

أدت المعاملة بالـ ن٣ بو٢ فو N_3P_2K (٣٠٠كجم سلفات أمونيوم + ٢٠٠ كجم سوبر فوسفات + ٥٠كجم سلفات بوتاسيوم/فدان) الى إعطاء أحسن النتائج لكل صفات النمو الخضرى والإزهار مقارنة بباقى المعاملات السمادية خلال الموسمين.

٢-أدت معاملات الرش بالجبريللين الى زيادة فى كل صفات النمو والإزهار لنبات الأقحوان باستثناء عدد الأفرع/نبات وكانت أفضل المعاملات هى الرش بمستوى ١٠٠ جزء فى المليون.

ومن ذلك فإنه ينصح بتسميد نبات الأقحوان بمعدلات ٣٠٠كجم سلفات أمونيوم + ٢٠٠كجم سوبر فوسفات + ٥٠كجم سلفات بوتاسيوم للفدان على أن نقسم هذه الكمية الى جرعتين متساويتين تضاف الأولى بعد ٣ أسابيع من عملية تفريد النباتات والثانية بعد ٢١ يوم من الأولى مع استخدام الرش بالجبريللين بمعدل ١٠٠ جزء فى المليون فى نفس مواعيد التسميد السابقة وذلك بغرض الحصول على أفضل صفات خضرية وزهرية لنبات الأقحوان.