# Effect of kinetin and $GA_3$ treatments on growth and flowering of *Dendranthema grandiflorium* cv. Art Queen plants

By

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## ABSTRACT

A field experimental study was carried out during the two successive seasons of 2015/2016 and 2016/2017 to evaluate the effect of $GA_3$ at (control, 100, 200 and 300 mg/L) and kinetin at (control, 25, 50 and 75 mg/L) on growth, flowering and chemical composition of *Dendranthema grandiflorum* kitam cv. Art Queen plants. The obtained data showed that: All $GA_3$ and kinetin concentrations increased plant height, especially $GA_3$ at 300 mg/L in both seasons. On contrary, all applied treatments of $GA_3$ significantly decreased stem diameter to reach its maximum reduction with the highest concentration. While, the thickest stem was scored by the highest concentration of kinetin in the two seasons. The highest number of branches and leaves / plant as well as the heaviest fresh and dry weights of leaves/plant were gained by 75 mg/L kinetin-sprayed plants in the two seasons. Also, all tested $GA_3$ and kinetin treatments succeeded in increasing flowers number / plant, fresh and dry weights of flowering head as well as flower vase life, with the superiority for kinetin at 75 mg/L in the two seasons.

Furthermore, $GA_3$ and kinetin treatments increased leaf N, P, K, total carbohydrates, total chlorophylls and total indols contents, they decreased leaf total phenols content as compared with un-sprayed plants in the two seasons. However, the greatest leaves N, P, K, total carbohydrates, total chlorophylls and total indols contents were registered by the highest concentration of kinetin in the two seasons. Foliar application of kinetin at 75 mg/L was the best and ecomomic treatment which we can be recommend for almost growth and flowering characteristics of *Dendranthema grandiflorum* kitam cv. Art Queen

plants.

Key words: *Dendranthema grandiflorum* kitam cv. Art Queen, $GA_3$, kinetin, vegetative growth, flowering and chemical composition.

# I. INTRODUCTION

Chrysanthemum "*Dendranthema grandiflorum*. kitam " cv."Art Queen" belongs to family Composite "Asterace " is commonly known in Egypt as Autumn queen. It is highly attractive and charming short day plant, which behaves both as an annual as well as perennial flowering herb **(Arora, 1990)**. There are about 160 species of Chrysanthemum. Chrysanthemum is a perennial herb grown well in Egypt as one of the most important cut flowers and pot plants. The inflorescences are greatly required in markets because of its beautiful shape and longevity in vases. The inflorescences consist of several ray and disc flowers (florets) and such, is called a flower head. The Chrysanthemum plants are short day plants because of its habit of flowering only under short day conditions. They are grown both as potted plants and as cut flowers during the fall months when the other flowers are scarce to supply the flower markets. Chrysanthemum widely used in two types namely standard (one flower on the stem) and spry (multiple flowers on the stem such as cv. Art Queen).

Treatment of flowering plants with plant growth regulators (Gibberellins and cytokinins) are found to be beneficial in delaying senescence processes but the response to Gibberellins and cytokinins application varies depending on cultivar, stage of flower development and type of gibberellins and cytokinins.

Gibberellins (GAs) are a family of plant hormones controlling many aspects of plant growth and development. Gibberellic acid ($GA_3$) has been used to increase the length or height of plants, increase the number of flowers and induce flowering **Taiz and Zeiger (2004)**. According to some works, it is possible to note the efficiency of application of $GA_3$ in the field of quality flowers. **Chang and Sung (2000)** observed in rhododendron (*Rhododendron*

*pulchrum*) that the application of $GA_3$ was effective on the growth of buds and flowers per plant. **Blázquez *et al.*, (2002)** observed the early flowering by $GA_3$ application, especially short-day plants of the genus Arabidosis. The times of application and use of the concentration of 120 mg/L $GA_3$ affected the stem diameter of chrysanthemum cultivar Yoko ono **Vieira *et al.*, (2011**). **Gad *et al.*, (2016)** mentioned that $GA_3$ at 300 or 400 ppm significantly increased all the studied vegetative and flowering characteristics of Ixora coccinea plant. In this regard on Aster plant **Mohamed (2017)** on *Symphyotrichum novi-belgii* L. cv. Purple Monarch indicated that the best vegetative and flowering growth with high quality of *Symphyotrichum novibelgii* L.; plants should be sprayed with $GA_3$ at 200 ppm.

Cytokines are important plant hormones that regulate nacreous processes of plant growth and development. kinetin (kin) delayed senescence by its effect on ethylene synthesis processes in the tissue of flowers and decreases the ethylene production within the carnation flowers (**Bosse and van staden, 1989**) and decreasing of protein hydrolytic enzymes activity lipooxygenase (**Leshem *et al.*, 1979).** In this concern, **Mohamed (2017)** on Aster plant (*Symphyotrichum novi-belgii* L.) cv. Purple Monarch reported that the best vegetative growth with high quality of *Symphyotrichum novibelgii* L.; plants should be sprayed with BA at 100 ppm**. Youssef and Abd El-Aal (2014)** on *Hippeastrum vittatum* plant reported that all studied kinetin concentrations statistically enhanced flowering growth parameters.

The purpose of this study was to investigate the effects of $GA_3$ and kinetin on growth, flowering and chemical composition of *Dendranthema grandiflorium* Kitam cv. Art Queen plants.

# MATERIALS AND METHODS

this trail was conducted to study the effects of spraying various concentration of Gibberellic acid ($GA_3$) and kinetin, on growth, flower quality, vase life and chemical composition of Chrysanthemum (*Dendranthema grandiflorum*, kitam) cv. "Art Queen". To achieve the mentioned investigation, a field experiment was carried out during two successive seasons of 2015/2016 and 2016-2017 in private farm in Moshtohor Village, El-Qalubia Governorate, Egypt.

**Plant materials:**

Chrysanthemum cuttings used in this study were purchased from the same private commercial farm. Terminal cutting bases (10-12 cm) were dipped in water then in [5g Indole butaric acid (IBA) + alcohole 100 cm + water 100 cm + talc powder 1kg] and were planted in rooting trays filled with mixture of peatmoss 200 kg + 80 kg perlite + rizolex fungicide 100g/ 150 liter of water for 15 - 21 days in nursery. Rooted cuttings of Chrysanthemum cv. Art Queen (weight 1.4 - 2.5g, length 11.2 – 13.4 cm and leaves 5.3 - 5.7) were planted.

**Experimental procedures:**

On 17 $^{th}$ November of 2015 and 2016 (for the first and second seasons), the well rotted cuttings of chrysanthemum cv. Art Queen were planted under translucent plastic quenset greenhouses, the experimental ($1m^2$) on 8 ridges keeping each 2 ridges around the line of drip irrigation pipe. the experimental unit consist of 4 lines of drip pipe. Each line contained 16 plants with planting distance 12.5 cm in each side of the drip irrigation pipe line, thus accommodating 64 plants per plot unit. Plot area was 9m x 24m =216 $m^2$ the area of greenhouse. The plants were planted in sufficient irrigated soil and were irrigated every 4 - 5 days intervals to maintain soil moisture at 65 - 70% of field capacity by drip irrigation system was used with droppers of 4.0 L/h. The plants

were grown under natural greenhouse temperature and controlled day length (16-18 lighting hours per day) with white fluorescent lamp. When the plant height was reached our target stem length (after 43-50 days from planting), lighting was stoped and after one week of plant adaptation, plants were subjected to short day light by using a black plastic film of polyethelene for about 8 - 10 hours (from afternoon till the next beginning of daylight) plants were grown under the abovementioned condition till flowering.

**Soil:**

Randomized soil sample at the depth of 20 cm were taken from the experimental area for soil analysis.

Physical and chemical analyses of the experimental soil were determined according to **Jackson (1973)** and **Black *et al.*, (1982)**, respectively. The obtained results of soil analysis are presented in Tables (a) and (b).

Table (a): Mechanical analysis of the experimental farm soil

| Parameters | Unit | Seasons | |
|---|---|---|---|
| | | 2015 | 2016 |
| Coarse sand | % | 3.97 | 4.32 |
| Fine sand | % | 16.85 | 16.03 |
| Silt | % | 24.57 | 25.77 |
| Clay | % | 54.61 | 53.88 |
| Textural class | ------ | Clay loam | Clay loam |

Table (b): Chemical analysis of the experimental farm soil.

| Parameters | Unit | Seasons | |
|---|---|---|---|
| | | 2015 | 2016 |
| $CaCO_3$ | % | 1.03 | 1.08 |
| Organic matter | % | 1.69 | 1.77 |
| Available nitrogen | % | 0.44 | 0.51 |
| Available phosphorus | % | 0.18 | 0.23 |
| Available potassium | % | 0.24 | 0.28 |
| EC | dS.m-1 | 0.82 | 0.79 |
| Ph | ---------- | 7.46 | 7.78 |

**Treatments: -**

**1-plant growth regulators**:

Gibberellic acid ($GA_3$) at four concentrations, corresponding to (control, 100, 200 and 300 mg/L) and Kinetin at four concentrations of (control, 25, 50 and 75 mg/L). Tween 20 as a sticking agent was used at the rate of 0.1 cm/L. Application of $GA_3$ and Kinetin were carried out as foliar spray for three times. The first spray was done after 17 days from planting and the second spray was given 21 days after the first spray while, the third spray was given 21 days after the second spray. Untreated plants (control) were sprayed with distilled water only. Spraying was done in the first hours of the day. All commen agricultural practices concern managing the water supply with macro and micro nutrients, supporting system, Periodic pinching, disbudding, weed control and pest control were performed as recommended in the commercial production of greenhouses cut flowers chrysanthemum plants.

**Data recorded:**

At the end of those experiments on 27th of March for both seasons (after 130 - 135 days from planting), three plants were randomly chosen from each plot during both seasons and the following data were recorded:

**1-1-vegetative growth parameters:**

Plant height (cm), Stem diameter (cm), number of branches per plant, number of leaves per plant, fresh weight of leaves per plant (g) and dry weight of leaves per plant (g).

**1-2-Flowering parameters:**

Number of flowers /plant, diameter of flower head (cm), fresh weight of flower head (g) and dry weight of flower head (g) and flower vase life (days).

**1-3-Chemical composition measurements:**

At the end of all experiments the chemical composition measurements were recorded:

**-Total nitrogen:**

Total nitrogen was measured in sample solutions by using the modified micro-kjeldahl method as described by **Pregl (1945).**

**-Phosphorus content:**

Phosphorus was determined colourimetrically in spectronic (20) spectrophotometer using the method described by **Trouge and Meyer (1939).**

**-Potassium content:**

Potassium content was measured by flamephotometer according to **Brown and Lilland (1946).**

**-Total carbohydrates content:**

Total carbohydrates content was determined in dry powder material according to **Herbert *et al.*, (1971).**

**-Pigments content (mg/100g of fresh weight).**

Chlorophylls a, b were determined in leaf samples (mg/100g FW) by using colorimetric method **(A.O.A.C, 1990)**.

**- Total indols and phenols contents**:

Total indols and phenols contents were determined in leaf samples (mg/100g FW) by using colorimetric method **(A.O.A.C, 1990)**.

**Statistical analysis:**

All data obtained during both seasons of studies were subjected to analysis of variance as a simple experiment in a complete randomize block design. LSD method was used to difference means according to **Snedecor and Cochran (1980).**

## Results and discussion

**1- Effect of $GA_3$ and kinetin treatments on vegetative growth, flowering and chemical composition of *Dendranthema grandiflorium* cv. Art Queen plants.**

**1-1- Vegetative growth parameters:**

**1-1-a- Plant height (cm):**

Data in Table (1) revealed that all tested applications of $GA_3$ and kinetin treatments significantly increased plant height of *Dendranthema grandiflorium* cv. Art Queen plants in the two seasons as compared with control plants, with superior for $GA_3$ treatments. The tallest plants were gained by 300 mg/L $GA_3$-sprayed plants as it scored 138.20 and 147.70 cm, followed by 200 mg/L $GA_3$ sprayed plants which recorded 125.50 and 139.30 cm in the first and second seasons, respectively. Irrespective control plants, the lowest values of plant height were registered by the low concentration of kinetin (25 mg/L) which achieved 103.90 and 110.40 cm, followed in ascending order by the medium concentration of kinetin (50 mg/L) as it scored 111.20 and 112.66 cm in the first and second seasons, respectively. The remained treatments occupied an

intermediate position between the abovementioned treatments in the two seasons of this study.

**Table (1): Effect of $GA_3$ and kinetin treatments on some vegetative growth parameters of *Dendranthema grandiflorium* plant cv. Art Queen during 2015/2016 and 2016/2017 seasons**

| Parameters / Treatments | | Plant height (cm) | | Stem diameter (cm) | | No. of branches / plant | | No. of leaves / plant | | Fresh weight of leaves/plant (g) | | Dry weight of leaves/plant(g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st season | 2nd season | 1st season | 2st season | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2st season |
| Control | | 97.66 | 102.33 | 0.70 | 0.72 | 5.33 | 5.00 | 4.82 | 5.12 | 1.21 | 1.34 | 0.23 | 0.27 |
| $GA_3$ | 100mg/L | 126.00 | 130.33 | 0.61 | 0.64 | 5.00 | 5.12 | 5.73 | 5.46 | 1.61 | 1.47 | 0.31 | 0.31 |
| | 200mg/L | 125.50 | 139.30 | 0.50 | 0.58 | 4.12 | 4.41 | 6.59 | 6.83 | 1.96 | 1.92 | 0.37 | 0.41 |
| | 300 g/L | 138.20 | 147.70 | 0.47 | 0.56 | 3.96 | 4.26 | 7.16 | 7.92 | 2.21 | 2.37 | 0.42 | 0.49 |
| Kinetin | 25 mg/L | 103.90 | 110.40 | 0.78 | 0.83 | 6.66 | 6.21 | 5.82 | 6.24 | 1.92 | 1.93 | 0.36 | 0.41 |
| | 50 mg/L | 111.20 | 112.66 | 0.91 | 0.94 | 6.99 | 7.86 | 6.83 | 7.89 | 2.26 | 2.61 | 0.45 | 0.55 |
| | 75 mg/L | 112.00 | 114.50 | 1.14 | 1.18 | 7.66 | 8.34 | 7.31 | 8.21 | 2.41 | 2.72 | 0.48 | 0.57 |
| L.S.D at 0.05 | | 5.36 | 8.29 | 0.14 | 0.24 | 0.81 | 0.74 | 1.19 | 1.30 | 0.68 | 0.57 | 0.126 | 0.12 |

**1-1-b- Stem diameter (cm):**

Data in Table (1) showed that all investigated concentrations of Kinetin succeeded in increasing stem diameter of *Dendranthema grandiflorium* cv. Art Queen plants as compared with other treatments and control in the two seasons. The thickest stem was gained by 75 mg/L kinetin sprayed plants as it scored 1.14 and 1.18 cm, followed by 50 mg/L kinetin sprayed plants which gave 0.91 and 0.94 cm in the first and second seasons, respectively. On the reverse, all tested concentration of $GA_3$ decreased stem diameter when compared with other treatments and control in the two seasons, especially those received $GA_3$ at the highest concentration (300 mg/L) which induced the lowest values in this concern as it scored 0.47 and 0.56 cm, followed in ascending order by 200 mg/L $GA_3$ sprayed plants as it registered 0.50 and 0.58 cm, in the first and second seasons, respectively.

**1-1-c- Number of branches /plant:**

Data in Table (1) indicated that all studied concentrations of $GA_3$ and Kinetin affected the number of branches/plant of *Dendranthema grandiflorium* cv. Art Queen in the two seasons. Anyhow, it was found that there was a negative correlation between the values of branches number /plant and the concentration of $GA_3$. So, as the concentration of $GA_3$ increased the values of branches number /plant decreased until reached to the maximum decrease at the high level (300 mg/L) in both seasons. However, 300 mg/L $GA_3$ sprayed plants induced the lowest values of branches number /plant as it scored 3.96 and 4.26 branches /plant, followed in ascending order by the medium level of $GA_3$ (200 mg/L) which recorded 4.12 and 4.41 branches /plant in the first and second seasons, respectively. On contrary, it was found that there was a positive relationship between the values of branches number /plant and kinetin concentration. Hence, as the concentration of kinetin increased, the values of branches number were increased till reached to the highest increase at the high level of kinetin in the two seasons. Therefore, 75 mg/L kinetin- sprayed plants

showed to be the most effective one for producing the highest branches number /plant as it gave 7.66 and 8.34 branches /plant, followed in descending order by 50 mg/L kinetin-sprayed plants which scored 6.99 and 7.86 branches /plant in the first and second seasons, respectively. The rest treatments come in-between the aforementioned treatments in the two seasons of this study.

**1-1-d- Leaves number /plant:**

Data in Table (1) declared that all used treatments of $GA_3$ and kinetin increased leaves number /plant as compared with un-treated plants in the two seasons. The increases in leaves number /plant of *Dendranthema grandiflorium* cv. Art Queen plants was proportionally with the increase of $GA_3$ and kinetin concentrations. The highest number of leaves/plant was scored by 75 mg/L kinetin- sprayed plants as it scored 7.31 and 8.21 leaves /plant, followed in descending order by 300 mg/L $GA_3$ sprayed plants which registered 7.16 and 7.92 leaves /plant in the first and second seasons, respectively. Moreover, kinetin at 50 mg/L and $GA_3$ at 200 mg/L significantly increased leaves number /plant in the two seasons. Regardless control plants, the lowest leaves number /plant values were detected by $GA_3$ at 100 mg/L and kinetin at 25 mg/L in the two seasons.

The remained treatments of $GA_3$ and kinetin (medium concentration) came in between the abovementioned treatments in the two seasons of this study.

**1-1-e- Fresh weight of leaves/plant (g):**

Data presented in Table (1) clear that all examined concentrations of kinetin and $GA_3$ increased fresh weight of leaves/plant of chrysanthemum plants with significant differences in most cases as compared with control in the two seasons. However, kinetin treatments were more effective in this concern as it induced the heaviest fresh weight of leaves/plant, particularly those received kinetin at 75 mg/L, followed by kinetin at 50 mg/L in the two seasons. Besides, all tested concentration of $GA_3$ increased the fresh weight of

leaves/plant, especially the highest concentration (300 mg/L) of $GA_3$ in the two seasons of this study.

**1-1-e- Dry weight of leaves/plant (g):**

Data in Table (1) indicated that leaves dry weight / plant showed the same trend of the results of leaves fresh weight / plant, with some little differences in the signification in the two seasons. All examined concentrations of kinetin and $GA_3$ increased the dry weight of leaves/plant of *Dendranthema grandiflorium* plants in the two seasons. Moreover, kinetin treatments showed its superiority in this concern as it induced the heaviest dry weight of leaves/plant, especially those received kinetin at 75 mg/L, followed by kinetin at 50 mg/L in the two seasons. Besides, all tested concentrations of $GA_3$ increased dry weight of leaves/plant, particularly those received $GA_3$ at 300 mg/L in the two seasons of this study.

The aforementioned results of $GA_3$ are in conformity with those obtained by of **Osman and Sewedan (2014)** on *Solidago canadensis* (Tara), **Bharathi and Sekar (2015)** on chrysanthemum (*Chrysanthemum morifolium* Ramat), **Gupta *et al.*, (2015)** on China aster (*Callistephus chinensis* L. Nees), **Henschke *et al*., (2015)** on *Helleborus orientalis* 'Red Hybrids', **Mahananda *et al.*, (2015)** on chrysanthemum (*Chrysanthemum coronarium L.*), **Faisal and Abdel-Moniem (2015)** on *Euphorbia milii* var. longifolia, **Gad *et al.*, (2016)** on *Ixora coccinea* plant, **Gaurav *et al.*, (2016)** on *Dendranthema grandiflora* Tzvelev, **Kudmate *et al.*, (2016)** on chrysanthemum plants, **Muhammad *et al.*, (2016)** on *Chrysanthemum morifolium* and **Mohamed (2017)** on aster plant (*Symphyotrichum novi-belgii* L.) cv. Purple Monarch.

The aforementioned results of kinetin go on line with **Reda *et al.*, (2010)** on chamomile plant, **Henschke *et al*., (2015)** on *Helleborus orientalis* 'Red Hybrids', **Mara (2017)** on *Echinacea Hybrids* and **Mohamed (2017)** on aster plant (*Symphyotrichum novi-belgii* L.) cv. Purple Monarch.

The aforementioned results of $GA_3$ regarding vegetative growth measurements may be due to the effect $GA_3$ on cell elongation by induction of enzymes that weaken the cell walls. Also, the mechanism by which gibberellins might stimulate cell elongation is that the hydrolysis of starch resulting from the production of $GA_3$ induced α-amylase which might increase the concentration of sugars, thus raising the osmotic pressure in the cell sap so that water enters the cell and tends to stretch it (**Macleod and Millar, 1962)**. Whereas, the effect of kinetin might be due to the role of kinetin on promoting protein synthesis, increasing cell division and enlargement (**Cheema and Sharma, 1982**). Moreover, these results might be explained according to the role of kinetin on promoting proteins, soluble and non-soluble sugars synthesis, or may be due to the ability of kinetin for making the treated area to act as a sink in which nutrients from other parts of the plant are drawn (**Salisbury and Ross, 1974**).

**1-2- Flowering growth parameters:**

**1-2-a- Flowers number/plant:**

Data obtained on the number of flowers per plant at the end of the first and second seasons as affected by $GA_3$ and kinetin treatments are presented in Table (2). The results showed that the flower number of cv. Art Queen plants was increased progressively with the increasing of kinetin and $GA_3$ concentration in both seasons. Whereas, the greatest number of flowers /plant was scored by the highest concentration of kinetin which recorded 26.16 and 23.12 flowers / plant, followed by 50 mg/L kinetin-sprayed plants as it induced 24.36 and 21.36 flowers /plant in the first and second seasons, respectively. In addition, $GA_3$ at 300 and 200 mg/L significantly increased flowers number/plant in the two seasons without significant differences between them. The remained treatments came in between in the two seasons of this study.

**Table (2): Effect of $GA_3$ and kinetin treatments on some flowering parameters of *Dendranthema grandiflorium* plant cv. Art Queen during 2015/2016 and 2016/2017 seasons**

| Parameters / Treatments | | No. of flowers /plant | | Diameter of flower (cm) | | Fresh weight of flower head (g) | | Dry weight of flower head (g) | | Vase life (days) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season | 1nd season | 2nd season |
| Control | | 18.26 | 16.31 | 7.83 | 8.12 | 7.32 | 7.41 | 0.95 | 0.89 | 19.82 | 18.31 |
| $GA_3$ | 100 mg/L | 20.30 | 17.26 | 7.90 | 9.50 | 7.86 | 8.21 | 1.11 | 1.03 | 21.61 | 21.21 |
| | 200 mg/L | 23.12 | 18.13 | 8.12 | 9.81 | 8.41 | 9.33 | 1.13 | 1.21 | 22.40 | 23.20 |
| | 300 mg/L | 24.16 | 19.21 | 8.19 | 9.96 | 8.69 | 9.61 | 1.14 | 1.05 | 23.11 | 24.16 |
| Kinetin | 25 mg/L | 21.91 | 18.11 | 8.21 | 9.81 | 7.96 | 8.40 | 1.12 | 1.26 | 22.31 | 23.20 |
| | 50 mg/L | 24.36 | 21.36 | 8.92 | 10.16 | 8.54 | 9.73 | 1.19 | 1.29 | 24.16 | 25.16 |
| | 75 mg/L | 26.16 | 23.12 | 9.13 | 10.34 | 9.13 | 10.12 | 1.27 | 1.31 | 25.20 | 27.11 |
| L.S.D at 0.05 | | 2.31 | 1.84 | 0.84 | 1.03 | 0.91 | 1.14 | 0.114 | 0.143 | 1.29 | 2.30 |

**1-2-b- Diameter of flower head (cm):**

According to data presented in Table (2) on diameter of flower head as affected by $GA_3$ and kinetin treatments, it could be concluded that all tested concentrations of $GA_3$ and kinetin succeeded in increasing the diameter of flower head as compared with un-treated plants in the two seasons. The largest flower head was gained by 75 mg/L kinetin-sprayed plants as it scored 9.13 and 10.34 cm, followed by 50 mg/L kinetin-sprayed plants as it recorded 8.92 and 10.16 cm, in the first and second seasons, respectively. Furthermore, $GA_3$ at 300 mg/L and kinetin at 25 mg/L increased the diameter of flower head, without significant differences between them in the two seasons of this study. The rest treatments ($GA_3$ at 200 and 100 mg/L) recorded an insignificant increases in flower head diameter between them and control plants in the two seasons.

**1-2-c- Fresh weight of flower head (g):**

Data in Table (2) revealed that all tested treatments of kinetin and $GA_3$ increased the fresh weight of flower head over control, with superiority for kinetin treatments in the two seasons. The heaviest fresh weights of flower head were recorded by kinetin at the highest concentration, followed in descending order by kinetin at the medium concentration and $GA_3$ at the highest concentration, without significant differences between them in the

two seasons. Additionally, $GA_3$ at 200 mg/L significantly increased the fresh weight of flower head in the two seasons. Irrespective control plants, the lowest values of this parameter were gained by $GA_3$ at 100 mg/L, followed by kinetin at 25 mg/L without significant differences between them and control plants in the two seasons.

**1-2-d- Dry weight of flower head (g):**

Data in Table (2) cleared that all studied of kinetin and $GA_3$ treatments increased the dry weight of flower head as compared with control. The superiority was for kinetin treatments in the two seasons. The highest values of dry weight of flower head was recorded by kinetin at 75 mg/L, followed in descending order by kinetin at 50 mg/L and $GA_3$ at 300 mg/L, without significant differences between them in the two seasons. Additionally, $GA_3$ at 200 mg/L significantly increased the fresh and dry weights of flower head in the two seasons. Irrespective control plants, the lowest values of this parameter were scored by $GA_3$ at 100 mg/L, followed by kinetin at 25 mg/L with not significant differences between them and control plants in the two seasons.

**1-2-e- Vase life of flower (days):**

Data in Table (2) indicated that all studied concentration of $GA_3$ and kinetin increased the vase life of *Dendranthema grandiflorium* cv. Art Queen flowers when compared with un-

treated plants in the two seasons, with superiority for the highest concentration of Kinetin and $GA_3$ treatments. The highest values of vase life were scored by 75 mg/L kinetin- sprayed plants as it recorded 25.20 and 27.11 days, followed in descending order by 50 mg/L kinetin-sprayed plants which scored 24.16 and 25.16 days/flower longevity in the first and second seasons, respectively. Also, $GA_3$ at the highest concentration significantly increased this parameter in the two seasons of this study. Regardless control plants, the lowest values of flower vase life were registered by $GA_3$ at 100 mg/L which recorded 21.61 and 21.21 days, followed in ascending order by kinetin at 25 mg/L as it scored 22.31 and 23.20 days, in the first and second seasons, respectively.

The aforementioned results of $GA_3$ are in conformity with those reported by **Kadam *et al.*, (2013)** on Chrysanthemum, **Jamal Uddin *et al.*, (2014)** on gerbera plant, **Gupta *et al.*, (2015)** on China aster (*Callistephus chinensis* L. Nees.), **Mahananda *et al.*, (2015)** on chrysanthemum (*Chrysanthemum coronarium L.*), **Gad *et al.*, (2016)** on *Ixora coccinea* plant, **Gaurav *et al.*, (2016)** on *Dendranthema grandiflora* Tzvelev, **Kudmate *et al.*, (2016)** on chrysanthemum plants, **Muhammad *et al.*, (2016)** on *Chrysanthemum morifolium* and **Temim *et al.*, (2017)** on pelargonium plants.

The results of kinetin are in conformity with those obtained by **Reda *et al.*, (2010)** on chamomile plant, **Sellam *et al.*, (2016)** on *Centaurea moschata*.L, **Mara (2017)** on *Echinacea Hybrids* and **Mohamed (2017)** on aster plant (*Symphyotrichum novi-belgii* L.) cv. Purple Monarch.

The effects of $GA_3$ on flower growth measurements may be due to gibberellins play a role in flowering, probably it is further elaborated into florigen by the plant. Hence, gibberellins can not be the same substance as florigen but at least it may act as its precursor. The propounder of (Florigen concept) florigen but made up of two substances, namely gibberellins and anthesins. The latter are considered to be nitrogen rich compounds (**Macleod and Millar, 1962**). Furthermore, $GA_3$ increase the length of flower stalk (bolting) the process that strictly must proceeded flowering appearance process (**Devlin and Witham, 1983**).

Furthermore, the obtained results of kinetin might be due to the role of kinetin on promoting protein synthesis, increasing cell division, enlargement and chlorophyll synthesis (**Cheema and Sharma, 1982**). Moreover, these results might be explained according to the role of kinetin on promoting proteins, soluble and non-soluble sugars synthesis, or may be due to the ability of kinetin for making the treated area to act as a sink in which nutrients from other parts of the plant are drawn that will be

reflected on enhancing the flowering growth (**Salisbury and Ross, 1974**).

**1-3- Chemical composition parameters:**

**1-3-a- Leaf total carbohydrates %:**

Data in Table (3) revealed that all examined concentrations of kinetin and $GA_3$ treatments increased leaf total carbohydrates % of Art Queen plants when compared with control plants in the two seasons. The leaf total carbohydrates % was linearly increased with the increment of kinetin or $GA_3$ concentrations, so the highest leaf total carbohydrates % was scored by 75 mg/L kinetin-sprayed plants which gave 17.21 and 18.13%, followed by 50 mg/L kinetin- sprayed plants which registered 16.84 and 17.36% in the first and second seasons, respectively. Furthermore, $GA_3$ at the highest concentration significantly gave the high increments in this concern as it scored 15.73 and 16.18%, followed by kinetin at the lowest concentration as it registered 14.82 and 15.21%, in the first and second seasons, respectively. Irrespective control plants, the lowest values of this parameter were gained by 100 mg/L $GA_3$ sprayed plants as it scored 13.21 and 13.62% in the first and second seasons, respectively.

**1-3-b- Leaf total chlorophyll (mg/100g fw):**

Data presented in Table (3) indicated that all tested concentration of kinetin and $GA_3$ increased leaf total chlorophyll

(mg/100g fw) of *Dendranthema grandiflorium* cv. Art Queen plants as compared with untreated plants in the two seasons.

**Table (3): Effect of $GA_3$ and kinetin treatments on some chemical constituents of *Dendranthema grandiflorium* plant cv. Art Queen during 2015/2016 and 2016/2017 seasons**

| Parameters / Treatments | | Total carbohydrates (%) | | Total chlorophyll (mg/100g fw) | | Nitrogen % | | Phosphorus % | | Potassium % | | Total indols (mg/100g fw) | | Total phenols (mg/100g fw) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season |
| Control | | 12.13 | 11.89 | 136.00 | 147.00 | 2.16 | 2.23 | 0.126 | 0.118 | 1.34 | 1.39 | 140.20 | 147.20 | 162.80 | 176.50 |
| $GA_3$ | 100 mg/L | 13.21 | 13.62 | 142.00 | 160.00 | 2.24 | 2.37 | 0.131 | 0.128 | 1.41 | 1.48 | 158.40 | 161.40 | 154.20 | 163.40 |
| | 200 mg/L | 15.16 | 15.36 | 151.00 | 171.00 | 2.36 | 2.49 | 0.146 | 0.142 | 1.52 | 1.57 | 177.90 | 182.80 | 141.10 | 142.60 |
| | 300 mg/L | 15.73 | 16.18 | 158.00 | 176.00 | 2.39 | 2.51 | 0.152 | 0.148 | 1.59 | 1.64 | 186.50 | 191.40 | 138.50 | 131.80 |
| Kinetin | 25 mg/L | 14.82 | 15.21 | 156.00 | 162.00 | 2.29 | 2.41 | 0.129 | 0.121 | 1.48 | 1.56 | 152.40 | 159.60 | 158.70 | 167.50 |
| | 50 mg/L | 16.84 | 17.36 | 178.00 | 181.00 | 2.41 | 2.52 | 0.134 | 0.132 | 1.63 | 1.72 | 173.40 | 178.80 | 149.60 | 148.20 |
| | 75 mg/L | 17.21 | 18.13 | 184.00 | 189.00 | 2.46 | 2.59 | 0.139 | 0.136 | 1.74 | 1.81 | 181.70 | 188.60 | 141.40 | 136.70 |
| L.S.D at 0.05 | | 1.42 | 1.36 | 5.14 | 11.26 | 0.121 | 0.116 | 0.012 | 0.014 | 0.14 | 0.12 | 11.20 | 12.94 | 9.36 | 11.08 |

Anyway, the increase of leaf total chlorophyll (mg/100g fw) is proportionally increased with the increases of kinetin or $GA_3$ concentrations. Hence, the maximum leaf total chlorophyll (mg/100g fw) was scored by 75 mg/L kinetin sprayed plants which gave 184.00 and 189.00 mg/100g fw, followed in descending order by 50 mg/L kinetin- sprayed plants which gave 178.00 and 181.00 mg/100g fw in the first and second seasons, respectively. Moreover, $GA_3$ at the 300 mg/L significant increases in this respect as it registered 158.00 and 176.00 mg/100g fw, followed by kinetin at the lowest concentration as it registered 156.00 and 162.00 mg/100g fw, in the first and second seasons, respectively. Irrespective control plants, the lowest values of this parameter were gained by 100 mg/L $GA_3$- sprayed plants as it scored 142.00 and 160.00 mg/100g fw in the first and second seasons, respectively.

**1-3-c- Leaf nitrogen %:**

Data tabulated in Table (3) clear that leaf nitrogen % of *Dendranthema grandiflorium* cv. Art Queen plants was significantly increased by using all studied treatments of kinetin and $GA_3$, especially those received kinetin at 75 mg/L as it scored 2.46 and 2.59 %, followed by 50 mg/L kinetin- sprayed plants which registered 2.41 and 2.52 % in the first and second seasons, respectively. Moreover, $GA_3$ at 300 and 200 mg/L statistically increased leaf nitrogen % without significant differences between them in the two seasons. On the opposite, the lowest values of this parameter were scored by control plants which recorded 2.16 and 2.23% in the first and second seasons, respectively. The rest treatments came in- between in the two seasons.

**1-3-d- Leaf phosphorus %:**

Data presented in Table (3) showed that leaf phosphorus % of Art Queen plants was greatly increased by using all tested concentrations of $GA_3$ and kinetin, with superiority for $GA_3$ treatments as compared with control plants in the two seasons. However, the highest leaf phosphorus % were registered by 300 mg/L $GA_3$ sprayed plants which scored 0.152 and 0.148%, followed by

$GA_3$ at 200 mg/L as it scored 0.146 and 0.142 % in the first and second seasons, respectively. In addition, kinetin at 75 and 50 mg/L increased leaf phosphorus % in the two seasons. Irrespective control plants, the lowest values of leaf phosphorus % were detected by 25 mg/L kinetin-sprayed plants in the two seasons.

**1-3-e- Leaf potassium %:**

Data in Table (3) cleared that all used concentrations of $GA_3$ and kinetin increased leaf potassium % of *Dendranthema grandiflorium* cv. Art Queen plants when compared with un-treated plants. The greatest leaf potassium % of Art Queen plants were gained by 75 mg/L kinetin- sprayed plants as it scored 1.74 and 1.81 %, followed by 50 mg/L kinetin - sprayed plants which registered 1.63 and 1.72% in the first and second seasons, respectively. Also, $GA_3$ at 300 mg/L gave the highest increment in this concern compared with other $GA_3$ concentrations as it recorded 1.59 and 1.64% in the first and second seasons, respectively. Regardless control plants, the lowest values of this parameter were gained by $GA_3$ and kinetin at the lowest concentration without significant differences between them and control in both seasons of this study.

**1-3-f- Leaf total indols (mg/100g fw):**

Data presented in Table (3) emphasized that all tested concentrations of $GA_3$ and kinetin increased leaf total indols (mg/100g fw) as compared with control plants in both seasons. However, 300 mg/L $GA_3$-sprayed plants is being the most effective one for increasing leaf total indols (mg/100g fw), as it scored 186.50 and 191.40 mg/100g fw, followed in descending order by 75 mg/L kinetin-sprayed plants which gave 181.70 and 188.60 mg/100g fw, in the first and second seasons, respectively. In addition, $GA_3$ at 200 and kinetin at 50 mg/L gave higher increments in this parameter as compared with un-treated plants in the two seasons of this study. Irrespective control plants, the lowest values of this parameter were gained by 25 mg/L kinetin- sprayed plants as it

scored 152.40 and 159.60 mg/100g fw in the first and second seasons, respectively.

**1-3-g- Leaf total phenols (mg/100g fw):**

Data in Table (3) showed that all studied $GA_3$ and kinetin treatments decreased leaf total phenols (mg/100g fw) when compared with un-treated control plants in the two seasons. However, 300 mg/L $GA_3$-sprayed plants is being the most effective one for inducing the lowest values of leaf total phenols (mg/100g fw), as it scored 138.50 and 131.80 mg/100g fw, followed in ascending order by 75 mg/L kinetin sprayed plants which scored 141.40 and 136.70mg/100g fw, in the first and second seasons, respectively. Additionally, $GA_3$ at 200 and kinetin at 50 mg/L gave lower contents of this parameter as compared with un-treated plants in the two seasons of this study. Regardless control plants, the highest values of this parameter were recorded by 25 mg/L kinetin- sprayed plants as it gave 158.70 and 167.50 mg/100g fw in the first and second seasons, respectively.

The obtained results of $GA_3$ are in agreement with those obtained by **EL-Sherbeny *et al.*, (2009)** on *Calendula officinalis*. Also, **El-Naggar *et al.*, (2009)** on *Dianthus caryophyllus*, **Osman and Sewedan (2014)** on *Solidago canadensis* (Tara) and **Mohamed (2017)** on aster plant (*Symphyotrichum novi-belgii* L.) cv. Purple Monarch.

The results of kinetin go on line with that obtained by **Abd El-Gawad (2006)** on *Nigella sativa* plants, **El-Maadawy *et al.*, (2006)** on *Calendula officinalis* L., **Ibrahim *et al.*, (2010)** on croton plants. Additionally, **Reda *et al.*, (2010)** on chamomile plant, **Askari and Mortazaeinezhad (2016)** on *Rosa hybrida* L. cv. 'Yellow Finesse' and **Mohamed (2017)** on aster plant (*Symphyotrichum novi-belgii* L.) cv. Purple Monarch.

The aforementioned results of $GA_3$ regarding chemical constituents may be due to that $GA_3$ causes cell elongation by the induction of enzymes that

weaken the cell walls. Also, the mechanism by which gibberellins might stimulate cell elongation is that the hydrolysis of starch resulting from the production of $GA_3$ induced $\alpha$-amylase which might increase the concentration of sugars, thus raising the osmotic pressure in the cell sap so that water and many nutrients enters the cell and tends to stretch it and that will be reflected on improving the chemical constituents (**Macleod and Millar, 1962**).

As for the explanation of the enhancing effect of kinetin on chemical constituents content of dendranthema plants, it could be illustrated here on the basis that kinetin treatments stimulated the endogenous cytokinins synthesis as will be mentioned afterwards and there is an intimate relationship between cytokinins and chlorophyll metabolism in both excided or detached leaf disks and intact plants i.e., cytokinins retard chlorophyll degradation, preserve it and increase its synthesis (**Devlin and Witham, 1983**). Besides, cytokinins activate a number of enzymes participating in a wide range of metabolic reactions in the leaves. These reactions included the maturation of proplastid into chloroplasts. These enzymes could be divided into two groups according to their response to cytokinins. The first group of enzymes could be said to relate to chloroplast differentiation, while the second one could be related to cytokinin stimulated group (**Kulaeva, 1979**). Also, these results may explain the role of cytokinins on promoting proteins and pigments synthesis and their ability to delay senescence and withdraw sugars and other solutes from older parts of a plant to the new organs (**Salisbury and Ross, 1974**). In the same line **Leopol and Kawase (1964)** stated that cytokinins stimulate the movement of sugars, starch, amino acids and many other solutes from mature organs to primary tissues of other ones. Furthermore, it may be due to the role of kinetin on increasing the growth promoters in the plant tissues at the expense of the inhibitors. In this concern, **Kenneth (1979)** reported that total control of plant growth is vested not in a single hormonal type that of auxin but is shared by several specially

auxins, cytokinins, gibberellins and ethylene and this further subjected to namely the phenols, flavons and absicsic acid.

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