INFLUENCE OF SOME GROWTH SUBSTANCES AND CHEMICAL FERTILIZATION ON FLOWERING AND CHEMICAL COMPOSITION OF MATTHIOLE INCANA L. PLANT

Eman M. Abou El-Ghait; A.O. Goma; A.S.M. Youssef, and Asmaa M.A. El-Nemr
Hort. Dept., Fac. Agric., Moshtohor, Benha University, Egypt

ABSTRACT: Two field trials were conducted during two successive seasons of 2018/2019 and 2019/2020 in the Floriculture Farm of Horticulture Department, Faculty of Agriculture, Benha University, Egypt to study the effects of spraying with some growth substances (kinetin, salicylic acid, calcium thiosulfate and potassium silicate) and chemical fertilization (N.P.K) as well as their combinations on flowering and some chemical constituents of Matthiola incana L. plants to enhance flowering quality for gardens bed ornamentation. The obtained results showed that spraying plants with 100 ppm kinetin in addition to NPK fertilization at the highest level (100 N: 200 P: 200 K kg/fed) resulted in the highest values in both seasons in case of fresh and dry weights of inflorescence and flowering portion, length and diameter of the flowering portion, number, diameter and fresh weight of florets, flowering duration, leaf total chlorophylls and total indoles content. This treatment, on the other hand, recorded the lowest values of leaves total phenols content. Conclusively, it is recommended to spray Matthiola incana L. plants with kinetin at 100 ppm supplemented with NPK chemical fertilization at 100 N: 200 P: 200 K kg/fed to obtain the best flowering quality for export.

Keywords: Matthiola incana L., growth substances, chemical fertilization, flowering and chemical constituents.

INTRODUCTION
Matthiola is a genus of the Brassicaceae Family (Crucifera) which, has 13-19 tribes, 350 genera, and 3500 species worldwide (Onyilagho et al., 2003). The common term "stock" is used to describe the species M. incana L., but it can also refer to the entire genus. It's a typical garden flower that comes in a wide range of colours. The stock is an unusual member of its family due to the beauty of the bloom and its pleasant sweet scent. Seeds are high in oils, with Omega-3-linolenic acid accounting for up to 65 percent of the oil. Omega-3-linolenic acid is one of the required fatty acids for optimal health (Heuer et al., 2005). Matthiola incana L. is mostly utilized as a potted or fresh-cut winter annual plant. From Spain to Turkey, and in the South to Egypt, this species is native to the Mediterranean region and the Canary Islands. It produces inflorescences of double and single flowers in hues of rose, purple, pink, and white, fruits ranging in size from 4 to 16 cm in diameter, erect to spreading, compressed without glands; stigma lacking noticeable horns (Gullen et al., 1995). The double flowering types are used for decoration, their flowers are beautiful, and they have a pleasant perfume (EL-Quesni et al., 2012). It's mostly used for planting in flowerbeds in various sorts of gardens, and it's become a lucrative floral crop (Hisamatsu et al., 2000).

Cytokinins are plant hormones that control the nacreous processes of growth and development. Kinetin (kin) delays senescence by inhibiting ethylene synthesis processes in flower tissues and lowering
ethylene production in carnation flowers (Bosse and Van Staden, 1989). It also inhibits the activity of protein hydrolytic enzymes like lipoxygenase (Leshem et al., 1979). When spraying gaillardia plants with kinetin compared to the control treatment, El-Kinany et al. (2019) discovered that Gaillardia pulchella var. pulchella had the highest vegetative and blooming growth metrics.

Endogenous plant growth regulator salicylic acid (SA) has been discovered to cause a wide range of metabolic and physiological reactions in plants, impacting their growth and development. Salicylic acid, being a natural and nontoxic phenolic molecule, has a lot of promise for reducing horticulture crop post-harvest losses. Salicylic acid, as a plant growth regulator, is crucial for plant growth and has been licensed for use in extending the vase life of cut flowers. These substances slows cell division and growth beneath the apex, but has no effect on the meristem (Hedayat, 2001).

Calcium (Ca) is hypothe sised to serve as an intracellular metabolic agent and as a secondary messenger in the transmission and transduction of various environmental signals (Harper et al., 2004). This nutrient may directly affect various physiological processes due to its high affinity for calmodulin and other calcium-binding proteins (Hepler and Wayne, 1985). One of the most important macronutrients for plant growth is calcium. It is not only necessary for the plant's cell walls to be built, but it also helps the plant endure saline environments. Calcium is an immobile mineral, and deficiency occurs at the plant's terminating points and growing branch heads. This can cause a delay in the plant's flowering or occur at the same time as natal growth. Mohammed and Abood (2020) suggested to spray Gerbera jamesonii with calcium nitrate (500 mg l⁻¹) and salicylic acid (75 mg l⁻¹) to address this issue. As a result of this treatment, the number of leaves, leaf area, total chlorophyll, wet and dry weight of leaves, early blooming, number of inflorescences, peduncle diameter, and vase life were increased.

Silicon, a naturally occurring chemical element, has a beneficial influence on plant development and resistance. Its features include a positive impact on plant ionic equilibrium, a reduction in the toxic effects of excessive manganese and iron, and cell wall reinforcement.

Silicon is either a required ingredient for plants to complete their life cycle or an optional component of the plant's life cycle. Many crops can benefit from adding silicon to their nutrition programs since it improves drought tolerance, strength, disease resistance, and postharvest-keeping quality (Marschner et al., 1997). In this regard, Attia and Elbohy (2019) found that spraying pot marigold plants (Calendula officinalis L.) with potassium silicate at 8 cm³/l rate significantly increased plant height, number of branches, fresh and dry herb weights (g/plant), number of flowers/plant, and leaf chemical composition when compared to control treatment.

Plant nutrition is one of the most important variables that influence plant growth in a favourable way (Sharma and Kumar, 2012). Nutrient uptake must be taken into account when producing high-quality flowers. Inorganic nutrient management is a significant aspect of determining the ornamental value of plants. The most essential goals to attain in bedding and cut-flower production are increasing flower production, floral quality, and finnes in the form of plant. The nutrition content affects flower quality (Boodley, 1975). Quality flower production and a long flowering period are aided by the use of the right fertilizer combination. The most valuable vital elements for improving ornamental quality and flower production are nitrogen, phosphorus, and potassium (Kashif, 2001). In this regard, Abou El-Ghait et al. (2020) found that NPK chemical fertilization at 6 g/pot increased plant height, branch number/plant, fresh and dry weights of
leaves/plant, number of flowers/plant, and leaf chemical composition, when compared to un-fertilized Jasminum sambac plants. In this regard, the goal of this study was to investigate how for various growth agents and chemical fertilization affect the vegetative growth and chemical composition of Matthiola incana plant.

MATERIALS AND METHODS

This trial was conducted to investigate the effects of spraying kinetin, salicylic acid, calcium thiosulfate, and potassium silicate, as well as chemical fertilization (N.P.K.), on the flowering and chemical composition of Matthiola incana L. plants in order to improve flowering and chemical composition. A field experiment was conducted in the Floriculture Farm of Horticulture Department, Faculty of Agriculture, Benha University, Egypt for two consecutive seasons of 2018/2019 and 2019/2020 to meet the goals of the study.

Plant materials:

Matthiola incana cv. Katz White seeds were obtained from the United States of America. The weight of 1000 seeds is 1.5 g, the germination rate is 93%, and the purity of the seeds is 99%. Seeds were sown in plastic trays filled with growing medium containing peat moss + perlite (1:1 by volume) on September 20th in both seasons. The seedlings were sprayed with NPK (20:20:20) at 2 g/l three times a week after being placed in a plastic greenhouse for 30 days, then transferred to a lath house for 10 days. Seedlings with a height of 15-18 cm and a weight of 10-12 g with 6-8 leaves were transplanted into the field.

Procedures for conducting experiments:

Well-uniform established seedlings of Matthiola incana cv. Katz White were planted in the field soil after 40 days from seed sowing (on November 1st of 2018 and 2019 for the first and second seasons, respectively). Before planting, the soil was ploughed, and sand was added to the soil at a rate of 4 m³/108 m², as well as calcium superphosphate. The field was divided into plots, each experimental plot unit size (1 m²) containing six plants in two rows, with three plants in each row. Within each plot, the plant spacing was 25 cm² between plants and 50 cm² between rows. The plants were planted in well-irrigated soil that was irrigated at weekly intervals with a flood irrigation system to keep soil moisture at 65-70% of field capacity. In the first and second seasons, the textural class of the utilized soil was clay loam, with EC values of 0.82 and 0.79 dS.m⁻¹ and pH values of 7.46 and 7.78, respectively.

Treatments:

This study contained two factors as follows: The first one was dealing with some chemical fertilization (N.P.K.) treatments, while the second one involved some growth substances treatments.

1. Chemical fertilizer (N.P.K.):

Ammonium nitrate (33% N) was used as a source of nitrogen at four levels (zero is considered as control, 50, 75 and 100 kg/fed), calcium superphosphate (46% P₂O₅) was used as a source of phosphorous at four levels (zero is considered as control, 100, 150 and 200 kg/fed), while, potassium sulfate (48% K₂O) was used as a source of potassium at four levels (zero is considered as control, 100, 150 and 200 kg/fed). Plants were fertilized with 4 combination treatments from these previously mentioned fertilizers, control (without fertilization) for the first treatment, 50 kg/fed N + 100 kg/fed P + 100 kg/fed K for the second one, 75 kg/fed N + 150 kg/fed P + 150 kg/fed K for the third one, and 100 kg/fed N + 200 kg/fed P + 200 kg/fed K for the fourth one. Calcium superphosphate was added before planting during soil preparation. Ammonium nitrate and potassium sulfate fertilizers were added to the soil six times. The first addition of ammonium nitrate was done after 7 days from transplanting the seedlings to the soil and then other five additions doses were done at weekly intervals till the sixth addition. The first addition of potassium
sulfate was done after 21 days from transplanting seedlings to the field and the second addition was given 21 days after the first addition, while the third up to the sixth additions were given at 7 days intervals after the second addition.

2. Plant growth substances:

Kinetin at three concentrations, (zero, 50 and 100 ppm), salicylic acid at three concentrations, (zero, 100 and 200 ppm), Calcium thiosulfate at three concentrations, (zero, 2 and 3 cm$^3$/l) and potassium silicate at three concentrations, (zero, 4 and 6 cm$^3$/l) were applied. Application of kinetin, salicylic acid, calcium thiosulfate and potassium silicate were carried out as a foliar spray for six times. The first spray was done after 40 days after transplanting the seedlings to the field soil and the plants were sprayed at weekly intervals after the first spray. Untreated plants (control) were sprayed with a distilled water only. Spraying was done in the first hours of the day before the sunrise.

The experiment’s layout:

The experiment was designed as a factorial experiment in a randomized complete block design with 36 treatments representing combinations of nine different growth substances and four different rates of chemical fertilization (9 growth substances treatments x 4 chemical fertilization levels) replicated three times (each replicate consisted of five beds with six plants per bed). When necessary, common agricultural procedures (irrigation, manual weed control, etc.) were implemented.

Data recorded:

Three plants were randomly chosen at the 70% flowering stage from each plot at the end of those studies on March 1$^{st}$ for both seasons (after 155 - 160 days from seeds sowing), and the following data were recorded:

Parameters of flowering:

Number of florets/inflorescence, diameter of floret per inflorescence (cm), fresh weight of floret (g), fresh weight of inflorescence per plant (g), dry weight of inflorescence per plant (g), flowering portion height per plant (cm), diameter of flowering portion per plant (cm), fresh weight of flowering portion per plant (g) and dry weight of flowering portion per plant (g).

Determining chemical composition:

On the 1$^{st}$ of April for both seasons (after 125 - 130 days from planting the seeds), three plants were randomly chosen at 5% flowering from each plot during both seasons and the following data were recorded:

1. Pigments content (mg/100 g of fresh weight):

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

2. Total indoles and phenols contents:

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

Statistical analysis:

All obtained data during both seasons of this study were subjected to analysis of variance as a factorial experiment in R.C.B.D., LSD at 0.05 level of property method was used to compare the differences between means according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Flowering growth parameters:

1. Fresh and dry weights of inflorescence (g):

   Data listed in Tables (1 and 2) clear that all tested sprays of growth substances succeeded in increasing the fresh and dry weights of Matthiola incana inflorescence (g) as compared with un-sprayed plants in both seasons. In this regard, 100 ppm kinetin-sprayed plants gave the highest values of these parameters, followed by kinetin at 50 ppm in both seasons. On the other hand, there was a positive correlation
Table 1. Effect of some growth substances and chemical fertilization on fresh weight of inflorescence (g) of *Matthiola incana* plant during 2018/2019 and 2019/2020 seasons.

| Growth substances (B) | 1st season | Chemical fertilization (A) | 2nd season | Mean (B) |
|-----------------------|------------|-----------------------------|------------|----------|
| N.P.K (0:0:0)         | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (A) | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (A) |
| Control               | 52.52      | 74.93                       | 90.13      | 101.08   | 79.66 | 53.63 | 76.41 | 90.17 | 98.63 |
| Pot. Silic. 4 cm³/l   | 88.86      | 130.87                      | 148.58     | 171.40   | 134.92 | 88.37 | 130.20 | 144.33 | 171.22 | 133.53 |
| Pot. Silic. 6 cm³/l   | 96.26      | 131.29                      | 156.59     | 172.89   | 139.25 | 94.92 | 133.33 | 154.62 | 176.11 | 139.74 |
| Ca thio. 2 cm³/l      | 78.42      | 122.02                      | 136.74     | 145.26   | 120.61 | 79.11 | 118.14 | 137.06 | 146.40 | 120.17 |
| Ca thio. 3 cm³/l      | 87.04      | 130.10                      | 145.44     | 167.01   | 132.39 | 85.89 | 127.28 | 145.37 | 170.51 | 132.26 |
| Sal. acid 100 ppm     | 66.59      | 102.35                      | 131.55     | 144.01   | 120.61 | 68.60 | 104.35 | 134.33 | 145.13 | 113.10 |
| Sal. acid 200 ppm     | 76.46      | 116.63                      | 140.27     | 157.63   | 122.74 | 78.56 | 124.35 | 145.71 | 156.13 | 126.18 |
| Kinetin 50 ppm        | 91.66      | 130.65                      | 158.96     | 183.13   | 141.10 | 95.34 | 133.68 | 155.07 | 180.99 | 141.27 |
| Kinetin 100 ppm       | 102.05     | 137.42                      | 163.35     | 186.13   | 147.23 | 106.38 | 137.82 | 163.69 | 183.88 | 147.94 |
| Mean                  | 82.20      | 119.58                      | 141.29     | 158.72   | 83.42 | 68.60 | 104.35 | 134.33 | 145.13 | 113.10 |

LSD at 0.05: $A=12.4$, $B=18.6$, $A\times B=37.2$, $A=11.7$, $B=17.6$, $A\times B=35.1$

Pot. Silic.: potassium silicate; Ca thio.: calcium thiosulfate; Sal. acid: salicylic acid

Table 2. Effect of some growth substances and chemical fertilization on dry weight of inflorescence (g) of *Matthiola incana* plant during 2018/2019 and 2019/2020 seasons.

| Growth substances (B) | 1st season | Chemical fertilization (A) | 2nd season | Mean (B) |
|-----------------------|------------|-----------------------------|------------|----------|
| N.P.K (0:0:0)         | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (A) | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (A) |
| Control               | 8.08       | 14.58                       | 17.29      | 18.89    | 14.71 | 7.51  | 14.16 | 17.17 | 18.61 | 14.36 |
| Pot. Silic. 4 cm³/l   | 16.81      | 18.81                       | 21.78      | 25.78    | 20.79 | 16.44 | 19.28 | 22.24 | 25.62 | 20.89 |
| Pot. Silic. 6 cm³/l   | 17.22      | 19.13                       | 23.77      | 26.14    | 21.56 | 18.24 | 20.23 | 23.45 | 26.86 | 22.19 |
| Ca thio. 2 cm³/l      | 13.10      | 18.85                       | 21.09      | 22.33    | 18.84 | 15.24 | 18.94 | 20.44 | 23.52 | 19.53 |
| Ca thio. 3 cm³/l      | 14.48      | 19.36                       | 22.60      | 25.25    | 20.42 | 16.95 | 19.86 | 23.13 | 24.77 | 21.17 |
| Sal. acid 100 ppm     | 14.76      | 17.86                       | 20.27      | 21.90    | 18.69 | 13.83 | 17.85 | 21.25 | 22.34 | 18.81 |
| Sal. acid 200 ppm     | 16.49      | 18.94                       | 22.24      | 23.91    | 20.39 | 15.03 | 18.14 | 22.57 | 22.40 | 19.53 |
| Kinetin 50 ppm        | 16.99      | 19.71                       | 23.69      | 28.78    | 22.29 | 17.35 | 19.96 | 22.86 | 27.59 | 21.94 |
| Kinetin 100 ppm       | 18.42      | 20.73                       | 25.01      | 28.83    | 23.24 | 19.21 | 20.63 | 23.87 | 28.77 | 23.12 |
| Mean                  | 15.15      | 18.66                       | 21.97      | 24.64    | 15.53 | 18.78 | 21.88 | 24.49 |

LSD at 0.05: $A=2.04$, $B=3.06$, $A\times B=6.12$, $A=2.21$, $B=3.32$, $A\times B=6.64$

Pot. Silic.: potassium silicate; Ca thio.: calcium thiosulfate; Sal. acid: salicylic acid
between the inflorescence fresh and dry weights values and fertilization levels, so the values of these parameters increased as the level of fertilization increased until reached the maximum increase at the highest level (100 N: 200 P : 200 Kg/fed). This trend was true in both seasons.

Furthermore, data presented in Tables (1 and 2) indicated that all the interactions between growth substances and chemical fertilization levels statistically increased inflorescence fresh and dry weights of *Matthiola incana* plants as compared with untreated plants in both seasons. In this concern, the heaviest fresh (186.13 and 183.88 g) and dry inflorescence (28.83 and 28.77 g) were recorded by 100 ppm kinetin-sprayed plants supplemented with NPK fertilization at the highest level treatment in the first and second seasons, respectively.

2. **Fresh and dry weights of flowering portion (g):**

Tables (3 and 4) show that all tested sprays of growth substances succeeded in increasing the fresh and dry weights of *Matthiola incana* flowering portion as compared with un-sprayed plants in both seasons. In this concern, 100 ppm kinetin-sprayed plants gave the highest values in this concern, followed by the kinetin at 50 ppm in both seasons.

It was interesting to observe that there was a positive correlation between the fresh and dry weights of flowering portion and chemical fertilization treatments. So, as the highest level of chemical fertilization increased the fresh and dry weights of flowering portion increased up to the maximum increase at the high level of chemical fertilization in both seasons (Tables, 3 and 4). In this regard, the heaviest fresh and dry weights of the flowering portion were recorded by 100 ppm kinetin-sprayed plants and fertilized with the highest level of NPK fertilization in both seasons.

3. **Length and diameter of flowering portion (cm):**

Data exhibited in Tables (5 and 6) declare that all tested growth substances and chemical fertilization treatments as well as their interactions increased the length and diameter of the flowering portion as compared with un-treated plants in both seasons. In this concern, the increment in the length and diameter were parallel to the applied concentration of kinetin and fertilization levels, so the highest concentration of kinetin or the highest level of fertilization significantly scored the highest length and diameter of flowering portion values when compared with untreated plants in both seasons. In general, the tallest (33.33 and 22.00 cm) and thickest (9.76 and 9.93 cm) flowering portion were recorded by 100 ppm kinetin-sprayed plants joined with NPK fertilization at the highest level in the first and second seasons, respectively.

4. **Number, diameter and fresh weight of florets:**

Data presented in Tables (7, 8 and 9) clear that all tested growth substances treatments increased number, diameter and fresh weight of florets compared with un-treated plants in both seasons. In this concern, 100 ppm kinetin-sprayed plants scored the highest values of these parameters in both seasons. In parallel, number, diameter and fresh weight of floret increased with all tested levels of chemical fertilization, particularly the highest level in both seasons.

In brief, all interactions between growth substances and chemical fertilization treatments succeeded in increasing the number, diameter and fresh weight of floret as compared with control in the two seasons. In this sphere, the highest values of these parameters were scored by 100 ppm kinetin-sprayed plants supplemented with NPK fertilization at the high level in the first and second seasons, respectively.
Table 3. Effect of some growth substances and chemical fertilization on fresh weight of flowering portion (g) of *Matthiola incana* plant during 2018/2019 and 2019/2020 seasons.

| Growth substances (B) | 1st season | Chemical fertilization (A) | 2nd season | Chemical fertilization (A) |
|-----------------------|------------|---------------------------|------------|---------------------------|
|                       | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean |
| Control               | 42.96      | 59.52                    | 68.68      | 78.34          | 62.36 | 40.44          | 65.54          | 69.36          | 73.96          | 62.32 |
| Pot. Silic. 4 cm³/l   | 55.20      | 87.96                    | 92.84      | 101.30         | 84.32 | 58.04          | 81.02          | 102.14         | 104.12         | 86.32 |
| Pot. Silic. 6 cm³/l   | 57.42      | 94.26                    | 103.14     | 114.14         | 92.24 | 60.10          | 103.14         | 112.28         | 116.90         | 98.10 |
| Ca thio. 2 cm³/l      | 54.08      | 89.32                    | 91.54      | 99.76          | 83.66 | 57.28          | 87.96          | 89.40          | 101.52         | 84.04 |
| Ca thio. 3 cm³/l      | 54.86      | 92.54                    | 98.96      | 103.72         | 87.52 | 58.26          | 95.48          | 96.76          | 106.12         | 89.14 |
| Sal. acid 100 ppm     | 50.48      | 69.22                    | 81.82      | 87.32          | 72.20 | 52.42          | 73.92          | 77.34          | 86.06          | 72.42 |
| Sal. acid 200 ppm     | 53.22      | 89.74                    | 91.66      | 93.70          | 82.08 | 55.00          | 87.76          | 93.00          | 96.08          | 82.96 |
| Kinetin 50 ppm        | 63.62      | 99.08                    | 102.76     | 108.78         | 93.56 | 60.40          | 106.48         | 107.04         | 110.50         | 96.10 |
| Kinetin 100 ppm       | 64.58      | 105.02                   | 106.24     | 118.28         | 98.52 | 67.68          | 109.90         | 116.34         | 119.64         | 103.38 |
| Mean                  | 55.14      | 87.40                    | 93.06      | 100.58         | 56.62 | 90.12          | 95.96          | 101.64         |                  |

LSD at 0.05

Pot. Silic.: potassium silicate; Ca thio.: calcium thiosulfate; Sal. acid: salicylic acid

Table 4. Effect of some growth substances and chemical fertilization on dry weight of flowering portion (g) of *Matthiola incana* plant during 2018/2019 and 2019/2020 seasons.

| Growth substances (B) | 1st season | Chemical fertilization (A) | 2nd season | Chemical fertilization (A) |
|-----------------------|------------|---------------------------|------------|---------------------------|
|                       | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean |
| Control               | 5.54       | 11.04                    | 11.94      | 13.78          | 10.56 | 5.94           | 8.98           | 12.30          | 13.66          | 10.22 |
| Pot. Silic. 4 cm³/l   | 9.70       | 14.82                    | 16.06      | 17.80          | 14.58 | 10.98          | 16.44          | 17.00          | 18.12          | 15.62 |
| Pot. Silic. 6 cm³/l   | 10.16      | 16.68                    | 16.88      | 18.72          | 15.60 | 11.48          | 17.60          | 18.04          | 18.86          | 16.48 |
| Ca thio. 2 cm³/l      | 7.86       | 14.68                    | 15.64      | 17.38          | 13.88 | 9.94           | 15.64          | 16.00          | 17.70          | 14.82 |
| Ca thio. 3 cm³/l      | 9.60       | 15.86                    | 16.38      | 18.14          | 14.98 | 10.74          | 16.10          | 16.66          | 18.14          | 15.40 |
| Sal. acid 100 ppm     | 7.66       | 12.32                    | 13.04      | 14.00          | 11.74 | 9.26           | 13.82          | 13.94          | 14.88          | 12.96 |
| Sal. acid 200 ppm     | 8.14       | 14.84                    | 15.84      | 16.18          | 13.74 | 9.94           | 14.32          | 14.66          | 17.30          | 14.04 |
| Kinetin 50 ppm        | 11.16      | 16.98                    | 17.60      | 19.38          | 16.28 | 11.60          | 17.14          | 18.36          | 19.70          | 16.70 |
| Kinetin 100 ppm       | 11.40      | 17.38                    | 17.80      | 19.88          | 16.60 | 12.42          | 18.56          | 19.12          | 20.12          | 17.54 |
| Mean                  | 9.02       | 14.94                    | 15.68      | 17.24          | 10.24 | 15.40          | 16.22          | 17.60          |                  |

LSD at 0.05

Pot. Silic.: potassium silicate; Ca thio.: calcium thiosulfate; Sal. acid: salicylic acid
Table 5. Effect of some growth substances and chemical fertilization on flowering portion length (cm) plant of *Matthiola incana* plant during 2018/2019 and 2019/2020 seasons.

| Growth substances (B) | 1st season | Chemical fertilization (A) | 2nd season | Chemical fertilization (A) |
|-----------------------|------------|-----------------------------|------------|-----------------------------|
|                        | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (A) | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (B) |
| Control               | 16.66 | 18.50 | 18.83 | 19.33 | 18.33 | 16.50 | 18.33 | 18.66 | 19.50 | 18.24 |
| Pot. Silic. 4 cm³/l   | 18.50 | 19.16 | 19.66 | 19.83 | 19.28 | 18.66 | 19.00 | 19.33 | 19.66 | 19.16 |
| Pot. Silic. 6 cm³/l   | 19.66 | 19.81 | 20.33 | 20.50 | 20.07 | 19.33 | 19.83 | 20.00 | 20.16 | 19.83 |
| Ca thio. 2 cm³/l      | 17.83 | 19.00 | 19.66 | 20.66 | 19.28 | 18.66 | 19.50 | 20.00 | 19.20 |       |
| Ca thio. 3 cm³/l      | 19.00 | 19.66 | 20.16 | 21.00 | 19.95 | 19.50 | 19.83 | 20.33 | 19.99 |       |
| Sal. acid 100 ppm     | 18.16 | 19.83 | 20.33 | 21.00 | 19.83 | 17.66 | 20.00 | 20.33 | 20.66 | 19.66 |
| Sal. acid 200 ppm     | 19.16 | 20.16 | 21.16 | 21.33 | 20.45 | 18.33 | 20.50 | 20.66 | 21.66 | 20.28 |
| Kinetin 50 ppm        | 19.50 | 19.83 | 20.16 | 21.16 | 20.28 | 19.83 | 20.00 | 20.50 | 21.66 | 20.49 |
| Kinetin 100 ppm       | 20.50 | 20.83 | 21.33 | 33.33 | 23.99 | 20.50 | 20.50 | 20.66 | 22.00 | 20.91 |
| Mean                  | 18.77 | 19.64 | 20.18 | 22.07 | 18.77 | 17.62 | 19.99 | 20.62 |        |       |

LSD at 0.05

\[ A=0.78 \quad B=1.19 \quad A\times B=2.34 \quad A=0.69 \quad B=1.04 \quad A\times B=2.08 \]

Pot. Silic.: potassium silicate; Ca thio.: calcium thiosulfate; Sal. acid: salicylic acid

Table 6. Effect of some growth substances and chemical fertilization on diameter of flowering portion (cm) of *Matthiola incana* plant during 2018/2019 and 2019/2020 seasons.

| Growth substances (B) | 1st season | Chemical fertilization (A) | 2nd season | Chemical fertilization (A) |
|-----------------------|------------|-----------------------------|------------|-----------------------------|
|                        | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (A) | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (B) |
| Control               | 6.88 | 8.06 | 8.20 | 8.26 | 7.85 | 6.40 | 8.00 | 8.10 | 8.43 | 7.73 |
| Pot. Silic. 4 cm³/l   | 7.76 | 8.60 | 9.26 | 9.43 | 8.76 | 8.43 | 8.66 | 9.26 | 9.43 | 8.94 |
| Pot. Silic. 6 cm³/l   | 8.10 | 8.63 | 9.50 | 9.70 | 8.98 | 8.56 | 8.73 | 9.33 | 9.50 | 9.03 |
| Ca thio. 2 cm³/l      | 7.43 | 8.50 | 8.60 | 8.66 | 8.29 | 7.56 | 8.40 | 8.66 | 9.00 | 8.40 |
| Ca thio. 3 cm³/l      | 7.83 | 8.83 | 8.96 | 9.33 | 8.73 | 8.00 | 8.76 | 9.10 | 9.16 | 8.75 |
| Sal. acid 100 ppm     | 7.00 | 8.33 | 8.33 | 8.40 | 8.01 | 7.50 | 8.38 | 8.66 | 8.70 | 8.31 |
| Sal. acid 200 ppm     | 8.06 | 8.50 | 8.66 | 9.16 | 8.28 | 7.84 | 8.60 | 8.83 | 9.00 | 8.56 |
| Kinetin 50 ppm        | 8.22 | 8.83 | 9.50 | 9.60 | 8.59 | 8.66 | 8.96 | 9.53 | 9.70 | 9.21 |
| Kinetin 100 ppm       | 8.83 | 9.16 | 9.46 | 9.76 | 9.30 | 9.10 | 9.33 | 9.83 | 9.93 | 9.54 |
| Mean                  | 7.79 | 8.60 | 8.97 | 9.14 | 8.00 | 8.64 | 9.03 | 9.20 |        |       |

LSD at 0.05

\[ A=0.27 \quad B=0.41 \quad A\times B=0.82 \quad A=0.21 \quad B=0.32 \quad A\times B=0.64 \]

Pot. Silic.: potassium silicate; Ca thio.: calcium thiosulfate; Sal. acid: salicylic acid
Table 7. Effect of some growth substances and chemical fertilization on No. of florets/inflorescence of *Matthiola incana* plant during 2018/2019 and 2019/2020 seasons.

| Growth substances (B) | 1st season | 2nd season | Chemical fertilization (A) | 1st season | 2nd season | Chemical fertilization (A) |
|-----------------------|------------|------------|-----------------------------|------------|------------|-----------------------------|
|                       | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (A) | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (B) |
| Control               | 13.33      | 15.33      | 15.66                      | 17.66      | 15.49      | 12.33                      | 15.33      | 16.00              | 16.66              | 15.08     |
| Pot. Silic. 4 cm³/l   | 17.33      | 18.00      | 18.33                      | 18.66      | 18.08      | 17.33                      | 17.33      | 18.00              | 18.00              | 17.66     |
| Pot. Silic. 6 cm³/l   | 18.00      | 18.66      | 19.00                      | 19.33      | 18.74      | 18.00                      | 18.33      | 18.66              | 19.33              | 18.58     |
| Ca thio. 2 cm³/l      | 16.66      | 17.00      | 17.33                      | 17.66      | 17.16      | 17.00                      | 17.66      | 17.66              | 18.33              | 17.66     |
| Ca thio. 3 cm³/l      | 17.33      | 17.66      | 18.33                      | 18.66      | 17.99      | 18.00                      | 18.33      | 18.66              | 19.00              | 18.49     |
| Sal. acid 100 ppm     | 16.00      | 16.33      | 16.66                      | 17.33      | 16.58      | 17.00                      | 17.33      | 17.66              | 18.00              | 17.49     |
| Sal. acid 200 ppm     | 16.66      | 17.00      | 17.66                      | 18.66      | 17.49      | 17.33                      | 17.66      | 18.00              | 18.66              | 17.91     |
| Kinetin 50 ppm        | 18.33      | 18.66      | 18.66                      | 20.33      | 18.99      | 18.33                      | 18.66      | 19.00              | 19.33              | 18.83     |
| Kinetin 100 ppm       | 18.66      | 19.00      | 19.66                      | 20.66      | 19.49      | 19.00                      | 19.33      | 19.66              | 20.33              | 19.58     |
| Mean                  | 16.92      | 17.51      | 17.92                      | 18.77      | 17.14      | 17.77                      | 18.14      | 18.62              |                     |           |
| LSD at 0.05           | A= 0.18    | B= 0.27    | A×B=0.54                   | A= 0.15    | B=0.23     | A×B= 0.46                  |           |                    |                     |           |

Pot. Silic.: potassium silicate; Ca thio.: calcium thiosulfate; Sal. acid: salicylic acid

Table 8. Effect of some growth substances and chemical fertilization on fresh weight of floret (g) of *Matthiola incana* plant during 2018/2019 and 2019/2020 seasons.

| Growth substances (B) | 1st season | 2nd season | Chemical fertilization (A) | 1st season | 2nd season | Chemical fertilization (A) |
|-----------------------|------------|------------|-----------------------------|------------|------------|-----------------------------|
|                       | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (A) | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (B) |
| Control               | 1.93       | 2.33       | 2.27                       | 2.48       | 2.25       | 1.87                       | 2.08       | 2.40               | 2.56               | 2.22     |
| Pot. Silic. 4 cm³/l   | 2.30       | 3.31       | 3.09                       | 3.41       | 3.02       | 2.21                       | 3.01       | 3.17               | 3.44               | 2.95     |
| Pot. Silic. 6 cm³/l   | 2.35       | 3.14       | 3.37                       | 3.42       | 3.07       | 2.39                       | 3.31       | 3.33               | 3.53               | 3.14     |
| Ca thio. 2 cm³/l      | 2.16       | 2.78       | 2.93                       | 3.13       | 2.75       | 2.17                       | 2.87       | 3.00               | 3.33               | 2.84     |
| Ca thio. 3 cm³/l      | 2.28       | 3.00       | 3.12                       | 3.61       | 3.00       | 2.18                       | 3.03       | 3.10               | 3.27               | 2.89     |
| Sal. acid 100 ppm     | 1.86       | 2.45       | 2.52                       | 2.60       | 2.35       | 1.93                       | 2.47       | 2.56               | 2.76               | 2.43     |
| Sal. acid 200 ppm     | 2.18       | 2.87       | 3.09                       | 3.12       | 2.81       | 2.08                       | 2.84       | 2.91               | 3.25               | 2.77     |
| Kinetin 50 ppm        | 2.36       | 3.39       | 3.42                       | 3.49       | 3.16       | 2.32                       | 3.55       | 3.56               | 3.63               | 3.26     |
| Kinetin 100 ppm       | 2.41       | 3.50       | 3.51                       | 3.59       | 3.25       | 2.48                       | 3.59       | 3.60               | 3.73               | 3.35     |
| Mean                  | 2.20       | 2.97       | 3.03                       | 3.20       | 2.18       | 2.97                       | 3.07       | 3.27               |                     |           |
| LSD at 0.05           | A= 0.11    | B= 0.17    | A×B=0.34                   | A= 0.13    | B=0.20     | A×B= 0.40                  |           |                    |                     |           |

Pot. Silic.: potassium silicate; Ca thio.: calcium thiosulfate; Sal. acid: salicylic acid
Table 9. Effect of some growth substances and chemical fertilization on diameter of floret (cm) of *Matthiola incana* L. plant during 2018/2019 and 2019/2020 seasons.

| Growth substances (B) | 1st season | Chemical fertilization (A) | 2nd season |
|-----------------------|------------|-----------------------------|------------|
|                        | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (A) | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (B) |
| Control               | 4.23       | 4.66                        | 4.76       | 4.86                      | 4.62       | 3.93           | 4.40       | 4.66                       | 4.83                   | 4.45     |
| Pot. Silic. 4 cm³/l   | 4.80       | 5.30                        | 5.76       | 6.23                      | 5.52       | 4.60           | 5.23       | 6.00                       | 6.20                   | 5.50     |
| Pot. Silic. 6 cm³/l   | 5.06       | 5.66                        | 5.83       | 6.33                      | 5.72       | 4.86           | 5.46       | 6.16                       | 6.26                   | 5.68     |
| Ca thio. 2 cm³/l     | 4.76       | 5.23                        | 5.33       | 5.66                      | 5.24       | 4.66           | 5.26       | 5.93                       | 6.06                   | 5.47     |
| Ca thio. 3 cm³/l     | 4.86       | 5.46                        | 5.70       | 6.06                      | 5.52       | 4.90           | 5.30       | 6.10                       | 6.16                   | 5.61     |
| Sal. acid 100 ppm    | 4.66       | 4.96                        | 5.16       | 5.60                      | 5.09       | 4.60           | 4.66       | 5.33                       | 5.60                   | 5.04     |
| Sal. acid 200 ppm    | 4.70       | 5.10                        | 5.50       | 6.00                      | 5.32       | 4.76           | 4.96       | 5.70                       | 5.86                   | 5.32     |
| Kinetin 50 ppm       | 4.83       | 5.56                        | 6.13       | 6.23                      | 5.68       | 4.90           | 5.56       | 6.26                       | 6.33                   | 5.76     |
| Kinetin 100 ppm      | 5.23       | 5.76                        | 6.26       | 6.30                      | 5.88       | 5.13           | 5.66       | 6.43                       | 6.50                   | 5.93     |
| Mean                  | 4.79       | 5.29                        | 5.60       | 5.91                      | 4.70       | 5.16           | 5.84       | 5.97                       |                        |         |

LSD at 0.05  
A= 0.14  
B= 0.21  
AxB= 0.42  
A= 0.18  
B= 0.27  
AxB= 0.54

Pot. Silic.: potassium silicate; Ca thio.: calcium thiosulfate; Sal. acid: salicylic acid

5. Duration of flowering:

Data in Table (10) indicate that kinetin at both concentrations achieved the highest flowering duration, followed by potassium silicate at 6 cm/l in both seasons. Opposite untreated plants scored the lowest values of this parameter in most cases by salicylic acid at 100 ppm in the two seasons. The remained treatments occupied an intermediate position between the aforementioned treatments in both seasons. Concerning the effect of chemical fertilization, data in Table (10) show that the duration of flowering was increased in the two seasons, due to the three used levels of chemical fertilization over those of control plants, with superiority for the high level (100 N : 200 P : 200 K kg/fed) in the two seasons. As for the interaction effect between growth substances and chemical fertilization treatments, data in the same Table (10) reveal that all the combinations between growth substances and chemical fertilization succeeded in increasing the flowering duration of Matthiola plant in both seasons. Generally, the combined treatment between kinetin at 100 ppm and chemical fertilization at the highest level gave the highest flowering duration as it scored 65.00 and 66.66 days, in the first and second seasons, respectively.

The obtained results might be due to the role of kinetin in promoting protein synthesis, increasing cell division and enlargement (Cheema and Sharma, 1982). Moreover, these results might be explained according to the role of kinetin in 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).

Chemical constituents:

1. Leaves total chlorophylls and indoles contents (mg/100 g fw):

Data listed in Tables (11 and 12) show that all tested treatments of growth substances, chemical fertilization and their combinations succeeded in increasing leaves
Table 10. Effect of some growth substances and chemical fertilization on duration of flowering (day) of *Matthiola incana* plant during 2018/2019 and 2019/2020 seasons.

| Growth substances (B) | 1st season | Chemical fertilization (A) | 2nd season | Chemical fertilization (A) |
|-----------------------|------------|-----------------------------|------------|-----------------------------|
|                       | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (A) | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (B) |
| Control               | 25.66      | 28.33                      | 35.00      | 38.33                      | 29.33     | 26.66         | 28.66          | 33.66          | 39.33          | 32.07      |
| Pot. Silic. 4 cm³/l   | 32.66      | 38.33                      | 42.33      | 46.66                      | 39.99     | 38.00         | 40.33          | 43.66          | 47.00          | 42.24      |
| Pot. Silic. 6 cm³/l   | 38.88      | 41.00                      | 44.00      | 48.66                      | 43.13     | 41.00         | 43.00          | 47.66          | 49.33          | 45.24      |
| Ca thio. 2 cm³/l     | 34.66      | 35.00                      | 38.00      | 43.66                      | 37.83     | 34.00         | 36.66          | 39.33          | 42.66          | 38.16      |
| Ca thio. 3 cm³/l     | 36.66      | 38.66                      | 41.33      | 45.00                      | 40.41     | 38.66         | 39.66          | 43.00          | 45.66          | 41.74      |
| Sal. acid 100 ppm    | 29.00      | 32.66                      | 35.00      | 39.66                      | 34.08     | 30.00         | 32.00          | 36.33          | 38.33          | 34.16      |
| Sal. acid 200 ppm    | 33.33      | 35.66                      | 38.66      | 41.00                      | 37.16     | 33.33         | 35.66          | 39.00          | 41.00          | 37.24      |
| Kinetin 50 ppm       | 40.00      | 47.00                      | 50.00      | 55.33                      | 48.08     | 42.00         | 48.00          | 51.33          | 58.00          | 49.83      |
| Kinetin 100 ppm      | 43.66      | 54.33                      | 58.66      | 65.00                      | 55.41     | 45.66         | 52.00          | 60.00          | 66.66          | 56.08      |
| Mean                 | 34.94      | 38.99                      | 42.55      | 47.03                      | 39.55     | 34.08         | 36.59          | 43.77          | 47.55          | 34.16      |

LSD at 0.05

A = 3.17  B = 4.76  A×B = 9.51

Pot. Silic.: potassium silicate; Ca thio.: calcium thiosulfate; Sal. acid: salicylic acid

Table 11. Effect of some growth substances and chemical fertilization on total chlorophylles (mg/100 g fw) of *Matthiola incana* plant during 2018/2019 and 2019/2020 seasons.

| Growth substances (B) | 1st season | Chemical fertilization (A) | 2nd season | Chemical fertilization (A) |
|-----------------------|------------|-----------------------------|------------|-----------------------------|
|                       | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (A) | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (B) |
| Control               | 119        | 128                        | 139        | 156                        | 136       | 113           | 125            | 136            | 152            | 132        |
| Pot. Silic. 4 cm³/l   | 128        | 134                        | 151        | 168                        | 145       | 125           | 135            | 148            | 164            | 143        |
| Pot. Silic. 6 cm³/l   | 134        | 141                        | 158        | 175                        | 152       | 131           | 139            | 155            | 172            | 149        |
| Ca thio. 2 cm³/l     | 126        | 137                        | 143        | 163                        | 142       | 127           | 129            | 144            | 161            | 140        |
| Ca thio. 3 cm³/l     | 131        | 140                        | 147        | 167                        | 146       | 129           | 133            | 150            | 168            | 145        |
| Sal. acid 100 ppm    | 124        | 134                        | 148        | 165                        | 143       | 121           | 132            | 142            | 167            | 141        |
| Sal. acid 200 ppm    | 129        | 139                        | 150        | 171                        | 147       | 126           | 137            | 149            | 170            | 146        |
| Kinetin 50 ppm       | 136        | 145                        | 162        | 179                        | 156       | 134           | 141            | 160            | 176            | 153        |
| Kinetin 100 ppm      | 141        | 148                        | 168        | 186                        | 161       | 139           | 146            | 169            | 184            | 160        |
| Mean                 | 130        | 138                        | 152        | 170                        | 127       | 135           | 150            | 168            | 168            | 168        |

LSD at 0.05

A = 6.14  B = 15.7  A×B = 31.3

Pot. Silic.: potassium silicate; Ca thio.: calcium thiosulfate; Sal. acid: salicylic acid
Table 12. Effect of some growth substances and chemical fertilization on total indoles (mg/100 g fw) of *Matthiola incana* plant during 2018/2019 and 2019/2020 seasons.

| Growth substances (B) | 1st season | 2nd season | Chemical fertilization (A) |
|-----------------------|------------|------------|---------------------------|
|                       | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (A) | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (B) |
| Control               | 214        | 249        | 271          | 280          | 254          | 219        | 246          | 273          | 283          | 255        |
| Pot. Silic. 4 cm³/l   | 234        | 260        | 276          | 290          | 265          | 231        | 262          | 281          | 287          | 265        |
| Pot. Silic. 6 cm³/l   | 239        | 268        | 279          | 294          | 270          | 236        | 265          | 286          | 289          | 269        |
| Ca thio. 2 cm³/l      | 219        | 251        | 273          | 286          | 257          | 226        | 249          | 276          | 284          | 259        |
| Ca thio. 3 cm³/l      | 226        | 259        | 276          | 287          | 262          | 231        | 256          | 279          | 286          | 263        |
| Sal. acid 100 ppm     | 231        | 256        | 275          | 282          | 261          | 230        | 257          | 274          | 286          | 262        |
| Sal. acid 200 ppm     | 234        | 258        | 277          | 286          | 264          | 237        | 261          | 278          | 288          | 266        |
| Kinetin 50 ppm        | 246        | 271        | 282          | 296          | 274          | 249        | 273          | 289          | 291          | 276        |
| Kinetin 100 ppm       | 251        | 279        | 289          | 299          | 280          | 256        | 278          | 291          | 296          | 280        |
| Mean                  | 233        | 261        | 278          | 289          | 235          | 261        | 281          | 288          |              |            |
| LSD at 0.05           | A= 12.7    | B= 19.1    | A×B=38.2     | A= 11.4      | B=17.1      | A×B= 34.2  |            |              |              |            |

Pot. Silic.: potassium silicate; Ca thio.: calcium thiosulfate; Sal. acid: salicylic acid

As compared with control in both seasons. In this concern, the highest leaf total chlorophylls content (186 and 184 mg/100 g fw) and the richest leaves total indoles content (299 and 296 mg/100 g fw) were recorded by 100 ppm kinetin-sprayed plants supplemented with chemical fertilization at the highest level in the first and second seasons, respectively. Additionally, kinetin at 50 ppm and potassium silicate at 6 cm/l supplemented with the highest level of chemical fertilization induced high increments in this concern in the two seasons.

2. Leaves total phenols content (mg/100 g fw):

Data shown in Table (13) indicates that all tested growth substances treatments decreased leaves total phenols content, with superior for kinetin and potassium silicate treatments as compared with un-treated plants in both seasons. Also, the decrements of leaves’ total phenols content were parallel to the increase of chemical fertilization level to reach the maximum decrease at the highest level in both seasons. Generally, all resulted interactions between growth substances and chemical fertilization treatments statistically decreased the values of this parameter as compared with control in both seasons. In this respect, the lowest values of leaves’ total phenols content (112 and 108 mg/100 g fw) were recorded by 100 ppm kinetin-sprayed plants supplemented with NPK fertilization at the highest level, in the first and second seasons, respectively.

On contrary, the highest values of leaves’ total phenols content were gained by those sprayed plants with tap water and received no chemical fertilization treatments as they recorded 194 and 191 mg/100 g fw 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 13. Effect of some growth substances and chemical fertilization on leaves total phenols content (mg/100 g fw) of *Matthiola incana* plant during 2018/2019 and 2019/2020 seasons.

| Growth substances (B) | 1st season | Chemical fertilization (A) | 2nd season | Mean (B) |
|-----------------------|------------|---------------------------|------------|---------|
|                       | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (A) | N.P.K (0:0:0) | N.P.K (50:100:100) | N.P.K (75:150:150) | N.P.K (100:200:200) | Mean (B) |
| Control               | 194        | 176                       | 137        | 123      | 158          | 191        | 179           | 131          | 120      | 155.25   |
| Pot. Silic. 4 cm³/l   | 187        | 169                       | 132        | 120      | 152          | 186        | 154           | 129          | 115      | 146      |
| Pot. Silic. 6 cm³/l   | 186        | 163                       | 131        | 118      | 150          | 183        | 149           | 128          | 113      | 143      |
| Ca thio. 2 cm³/l     | 189        | 173                       | 134        | 121      | 154          | 189        | 162           | 130          | 119      | 150      |
| Ca thio. 3 cm³/l     | 187        | 171                       | 132        | 119      | 152          | 188        | 159           | 127          | 117      | 148      |
| Sal. acid 100 ppm    | 192        | 168                       | 134        | 119      | 153          | 187        | 168           | 129          | 118      | 151      |
| Sal. acid 200 ppm    | 191        | 165                       | 133        | 118      | 152          | 187        | 163           | 128          | 116      | 149      |
| Kinetin 50 ppm       | 186        | 159                       | 129        | 117      | 148          | 181        | 146           | 126          | 111      | 141      |
| Kinetin 100 ppm      | 181        | 156                       | 124        | 112      | 143          | 178        | 141           | 121          | 108      | 137      |
| Mean                  | 188        | 167                       | 132        | 119      | 186          | 158        | 128           | 115          |          |          |

LSD at 0.05  
A=13.3  
B= 20.0  
A×B= 40.0  
A= 11.9  
B= 17.9  
A×B= 35.7 

Pot. Silic.: potassium silicate; Ca thio.: calcium thiosulfate; Sal. acid: salicylic acid

As for the explanation of the incremental effect of kinetin on the growth and chemical constituents of Matthiola plant, it could be illustrated here on the basis that kinetin treatments stimulated the endogenous cytokinins synthesis and there is an intimate relationship between cytokinins and chlorophylls metabolism in both excised or detached leaf disks and intact plants i.e., cytokinins retard chlorophylls 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 in 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 special auxins, cytokinins, gibberellins and ethylene and this further subjected to namely the phenols, flavons and abscisic acid. The stimulating effect of fertilization treatments may be due to the role of mineral fertilization in supplying the plants with their required nutrients for more carbohydrates and proteins production which are necessary for
vegetative, flowering growth and chemical composition of the plants (Marschner, 1997).

The aforementioned results of growth substances are in conformity with those reported by Youssef and Mady (2013) on *Aspidistra elatior*, Abd El Gayed (2019) on *Zinnia elegans* L. plants, Attia and Elbohy (2019) on pot marigold plants (*Calendula officinalis* L.), Mara (2017) on *Echinacea hybrids*, Mohamed (2017) on aster plant (*Symphyotrichum novi-belgii* L.) cv. Purple Monarch, El-Kinany et al. (2019) on *Gaillardia pulchella* var. *pulchella*, Zheng et al. (2005) on chrysanthemum plants, Christos (2008) on oregano (*Origanum vulgare* ssp. *hirtum*), Kim et al. (2010) on *chrysanthemum morifolium*, Mirabbasi et al. (2013) on *Asiatic lily* cv. Brunello plant, Armando et al. (2016) on lisianthus (*Eustoma grandiflorum*), Abou El-Ftouh et al. (2018) on *Calendula officinalis* L., Elbohy et al. (2018) on *Zinnia elegans* plants, Mohammad Saeed et al. (2019) on *gerbera*, Abbass et al. (2020) on Freesia hybrids plants, Mohammed and Abood (2020) on *Gerbera jamesonii*, Saeed (2020) on Gazania rigens L. cv. Frosty Kiss, El-Kinany (2020) on *Viola wittrockiana* El-Ashwah (2020) on *Cortaderia selloana* plants and Abou El-Ghait et al. (2021) on *Hippeastrum vittatum* plant.

The abovementioned results of fertilization are in harmony with those attained by Abd El-All (2011) on *Aspidistra elatior*, Summan et al. (2016) on *Salvia*, Abd El Gayed and Attia (2018) on *Celosia argentea*, Attia et al. (2018) on tuberose plants, Kwon et al. (2019) on *Platycodon grandiflorum*, Al-Rubaye and Khudair (2020) on gazania plant, Ashour et al. (2020) on *Dracaena marginata* ‘Bicolor’, Abou El-Ghait et al. (2020) on jasmine plant and Abou El-Ghait et al. (2021) on *Hippeastrum vittatum* plant.

Conclusively, in order to produce good quality *Matthiola incana* plants it is preferable to spray the plants with kinetin at 100 ppm supplemented with mineral fertilization at 100 N: 200 P: 200 K kg/fed.

REFERENCES

Abbass, J.A.; Al-Zurfi, M.T.H.; Al-Abbasi, A.M.; Swadi, M.J. and Kadhim, E.S. (2020). Effect of adding wheat organic residues and salicylic acid on growth and corms production of *Freesia hybrids* plants. Plant Archives, 20(1): 574-578.

Abd El Gayed, M.E. (2019). Effect of silicon levels and methods of application on vegetative growth and flowering of zinnia (*Zinnia elegans* L.). J. Plant Product and Dev., Mansoura Univ., 24(4):929-944.

Abd El Gayed, M.E. and Attia, Eman A. (2018). Impact of growing media and compound fertilizer rates on growth and flowering of cocks comb (*Celosia argentea*) plants. J. Plant Production and Dev., Mansoura Univ., 9(11):895-900.

Abd El-All, S.G. (2011). Response of Castiron Plant (*Aspidistra elatior* Blume) to Foliar Nutrition With Greenzit and GA$_3$. M.Sc. Thesis, Fac. Agric., Benha Univ., Egypt, 300 p.

Abou El-Ftouh, Zeinab A.; Mohamed Asmaa M. and Ibrahim, A.K. (2018). Effect of saline water irrigation and foliar spraying of salicylic acid on growth, flowering and chemical composition of pot marigold (*Calendula officinalis* L.). Plant. J. Agric. Sci., Ain Shams Univ., 26(2):935-950.

Abou El-Ghait, E.M.; Goma, A.O.; Youssef, A.S.M.; Noor El-Deen, T.M. and Mohamed, Heba I. (2020). Effect of benzyladenine and chemical fertilization on growth, flowering and chemical composition of *Hippeastrum vittatum* plant. Future J. Hort., 2:21-30.

Abou El-Ghait, E.M.; Goma, A.O.; Youssef, A.S.M. and Hamoud, M.M.A. (2021). Effect of bulb size and chemical fertilization on growth, flowering, bulbs productivity and chemical composition of *Hippeastrum vittatum* plant. Future J. Hort., 2:21-30.
Al-Rubaye, B.C.H. and Khudair, T.Y. (2020). The effect of fertilization with boron and potassium on some natural and flowering traits of the gazania plants. Plant Archives, 20(2):140-144.

A.O.A.C. (1990). Official Methods of Analysis of the Association of Official Analytical Chemists, 15th Ed. Washington D.C., USA, 1298 p.

Armando, H.P.; Luis, A.V.A.; Oscar, G.V.T.; Iran, A.T.; Libia, I.T. and Manuel, J.S.A. (2016). Effects of ammonium and calcium on lisanthus growth. Hortic. Environ. Biotechnol., 57(2):123-131.

Ashour, H.A.; El-Attar, Asmaa B.E.; Abdel Wahab, M.M. (2020). Combined effects of NPK fertilizer with foliar application of benzyladenine or gibberellic acid on Dracaena marginata ‘Bicolor’ grown in different potting media. Ornamental Horticulture, 26(4):545-561.

Attia, E.K. and Elbohy, Naglaa F.S. (2019). The influence of spraying with potassium silicate and irrigation with saline water in sandy soil on Calendula officinalis L. The Future Journal of Biology, 2:39-56.

Attia, E.K.; Elbohy, Naglaa F.S. and Ashour, Nahla. A.M. (2018). Response of tuberose plants (Polianthes tuberosa L.) to chemical and bio fertilization and their effect on vegetative growth, flowering and chemical composition under sandy soil conditions. Scientific J. Flowers and Ornamental Plants, 5(3):261-273.

Boodley, J.W. (1975). Plant nutrition and flower quality. HortScience, 10:41-48.

Bosse, C.A. and Van Staden, J. (1989). Cytokinin in cut carnation flowers. V. Effect of cytokinin type, concentration and mode of application on flower longevity. Journal of Plant Physiology, 135:155-159.

Cheema, G.S. and Sharma, D.P. (1982). In vitro propagation of apple rootstocks. Proc. of the XXI Int. Hort. Cong., Hamburg, Germany, 131:75-88.

Christos, D. (2008). Foliar application of calcium and magnesium improves growth, yield, and essential oil yield of oregano (Origanum vulgare ssp. hirtum). Industrial Crops and Products, 29:599-608.

Devlin, M. and Witham, H. (1983). Plant Physiology, 4th Ed. Publishers Willard, Grant Press, Boston, 577 p.

El-Ashwah, M.A. (2020). Improving tolerance of Cortaderia selloana plants to irrigation water salinity through salicylic acid application. Scientific J. Flowers and Ornamental Plants, 7(3):349-361.

Elbohy, Naglaa F.S.; Attia, Eman K. and Noor El-Deen, T.M. (2018). Increasing quality of Zinnia elegans plants by foliar spraying with ascorbic and salicylic acids. Middle East Journal of Agriculture Research, 7(4):1786-1797.

El-Kinany, R.G. (2020). The beneficial role of salicylic acid, triacontanol and α-aminolevulinic acid on the growth, flowering and chemical composition of pansy (Viola wittrockiana Gams) under salt stress conditions. Hortscience Journal of Suez Canal University, 9(1):13-30.

EL-Quesni, F.E.M.; Mazhar, A.A.M.; Abdul El-Aziz, N.G. and Metwally, S.A. (2012). Effect of compost on growth and chemical composition of Matthiola incana L. under different water intervals. Journal of Applied Sciences Research, 8(3):1510-1516.

Gullen, J.; Alexander, J.C.M.; Brady, A.; Brickell, C.D.; Green, P.S.; Heywood, V.H.; Jorgensen, P.M.; JURY, S.L.; Knees, S.G.; Leslie, A.C.; Matthews V.A.; Robson N.K.B.; Walters S.M.; Wijnands D.O. and Yeo, P.F. (1995).
The European Garden Flora. Cambridge University. Great Britain, UK, 620 p.

Harper, J.F.; Breton, G. and Harmon, A. (2004). Decoding calcium signals through plant protein kinases. Ann. Rev. Plant Biol., 55:263-288.

Hedayat, M. (2001). Application of plant growth retardants in greenhouse. Proc. First Applied Sci Seminar on Flowering and Ornamental Plants. Mahallat, Iran, pp. 55-56.

Hepler, P.K. and Wayne, R.O. (1985). Calcium and plant development. Ann. Rev. Plant Physiol., 36:394-439.

Heuer, B.A.C.; Ravina, I.B. and Davidov, S. (2005). Seed yield, oil content, and fatty acid composition of stock (Matthiola incana) under saline irrigation. Australian Journal of Agricultural Research, 56(1):45-47.

Hisamatsu, T.; Koshioka, M.; Kubota, S.; Fujime, Y.; King, W.R. and Mander, L.N. (2000). The role of gibberellin biosynthesis in the control of growth and flowering in Matthiola incana. Physiologia Plantarum, 109:97-105.

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice-Hall of India Private Ltd. M-97, New Delhi, India, 498 p.

Kashif, N. (2001). Effect of NPK on Growth and Chemicals Effect on Vase-life of Zinnia. M.Sc. Thesis, PMAS Arid Agri. Univ. Rawalpindi, Pakistan, 23 p.

Kenneth, V.T. (1979). Physiology of Plant Growth and Development. McGraw-Hill Publishing Co. Ltd. New-Delhi.

Kim, Y.; Khan, A.; Hamayun, M; Kim, J.; Lee, J.; Hwang, I.; Yoon, C. and Lee, I. (2010). Effects of prohexadione calcium on growth and gibberellins contents of Chrysanthemum morifolium R. cv Monalisa White. Scientia Horticulturae, 123(3):423-427.

Kulaeva, O.N. (1979). Cytokinin action on enzyme activities in plants. In: Skoog, F. (ed.), Plant Growth Substances, Springer-Verlag Berlin, Heidelberg, New York, USA, p. 119-128.

Kwon, S.J.; Kim, H.R.; Roy, S.K.; Kim, H.J.; Boo, H.O.; Woo, S.H. and Kim, H.H. (2019). Effects of nitrogen, phosphorus and potassium fertilizers on growth characteristics of two species of bellflower (Platycodon grandiflorum). J. Crop Sci. Biotech, 22(5):481-487.

Leopol, A.C. and Kawase, M. (1964). Senescence of a trifoliate bean leaf caused by treating the primary leaves of cuttings with benzyladenine. Amer. J. Bot., 51: 294-298.

Leshem, Y.; Grossman, S.; Frimer, A. and Zir, J. (1979). Endogenous lipoxygenase control and lipid-associated free radical scavenging as a model of cytokinin action. In: Aplequist, L. and Liljenberg, C.L. (eds.), Advances in the Biochemistry and Physiology of Plant Lipids, Elsevier, Amsterdam, Netherlands, pp. 193-198.

Mara, C.G. (2017). Controlling growth in Echinacea Hybrids. Ph.D. Thesis, Virginia Polytechnic Institute and State University, USA, 132 p.

Marschner, H. (1997). Mineral Nutrition of Higher Plants, 2nd Ed. Academic Press Pub., New York, USA, 889 p.

Marschner, H.; Oberle, H.; Cakmak,I. and Romheld, V. (1990). Growth enhancement by silicon in cucumber (Cucumis sativus) plants depends on imbalance in phosphorus and zinc supply. Plant and Soil, 124:211-219.

Mirabbasi, N.; Nikbakht, A.; Etemadi, N. and Sabzalian, M.R. (2013). Effect of different concentrations of potassium silicate, nano silicon and calcium chloride on concentration of potassium, calcium magnesium, chlorophyll content and number of florets of Asiatic lily cv. Brunello. J. Sci. and Technol. Greenhouse Culture, 4(2):41-50.

Mohamed, Y.F.Y (2017). Effect of some growth stimulants on growth, flowering
and postharvest quality of aster (Symphyotrichum novi-belgii L.) cv. Purple Monarch. Middle East Journal of Agriculture Research, 6(2):264-273.

Mohammad Saeed, A.A.J.; Abdulhadi, M.D. and Salih, S.M. (2019). Response of gerbera (Gerbera jamesonii) cv. Great Smoky Mountains to foliar application of putrescine, spermidine and salicylic acid. Proc. The 4th International Conference on Agricultural Sciences, 17-18 November, Agriculture College, University of Kerbala, Iraq, pp. 1-11. doi:10.1088/1755-1315/388/1/012067

Mohammed, R.A.J. and Abood, B.M.A. (2020). Effect of bacterial inoculum, spraying with calcium nitrate and salicylic acid and in vegetative and flowering growth traits of gerbera jamesonii. Plant Archives, 20(1):633-638.

Onyilagho, J.; Bala, A.; Hallett, R.; Gruber, M.; Soroka, J. and Westcott, N. (2003). Leaf flavonoids of the cruciferous species, Camelina sativa, Crambe spp., Thlaspi arvense and several other genera of the family Brassicaceae. Biochem. System. Ecol., 31(11):1309-1322.

Saeed, A.K.A.J.M. (2020). Effect of ascorbic and salicylic acids on growth and flowering of Gazania cv. Frosty Kiss Mixed. Ornamental Horticulture, 26(4):537-544.

Salisbury, F.B. and Ross, C.W. (1974). Plant Physiology, 2nd Ed. Publishing Inc. Belmont, California, USA, 422 p.

Sharma, S. and Kumar, R. (2012). Effect of nitrogen on growth, biomass and oil composition of clary sage (Salvia sclarea Linn.) under mid hill of Northwestern Himalayas. Intl. J. Natural Prod. Resources, 3(1):79-83.

Snedecor, W.G. and Cochran, G.W. (1980). Statistical Methods, 7th Ed. Iowa State Univ. Press, Ames, Iowa, USA., 507 p.

Summan, I.; Iftikhar, A.; Khan, M.A. and Qasim, M. (2016). Modelling growth, yield and quality attributes of Salvia splendens L. in response to various nutrition regimes. Proc. The 2nd International Conference on Horticultural Sciences. Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Punjab, Pakistan, pp. 214-222.

Youssef, A.S.M. and Mady, M.A. (2013). Influence of light intensity and benzyladenine on growth performance of Aspidistra elatior Blume plant. Research Journal of Agriculture and Biological Sciences, 9(5):248-257.

Zheng, C.; Oba, S.; Matsui, S. and Hara, T. (2005). Effects of calcium and magnesium treatments on growth, nutrient contents, ethylene production, and gibberellin content in chrysanthemum plants. Journal of the Japanese Society for Horticultural Science, 74(2):144-149.
المليون بالإضافة إلى التسميد بالمستوى الأعلى من النيتروجين والبوتاسيوم والفسفور في كلا المواسم. وتم تسجيل أعلى قيم لعدد وقطر الوزن الطازج للزهرات بواسطة الرش بالكينتين بتركيز 100 جزء في المليون بالإضافة مع التسميد بالمستوى الأعلى من النيتروجين والبوتاسيوم والفسفور في كلا المواسم. أعطت المعالمة المشتركة بين الكينتين عند 100 جزء في المليون والمستوى الأعلى من التسميد الكيميائي من النيتروجين والبوتاسيوم والفسفور أطول فترة إزهار للنباتات في كلا المواسم. تم تسجيل أعلى نسبة من الكلوروفيل الكلي و الإندولات الكلية لحديقة الأوراق عند الرش بالكينتين بتركيز 100 جزء في المليون بالإضافة إلى التسميد بالمستوى الأعلى من النيتروجين والفسفور والبوتاسيوم في كلا المواسم. بوصى برش نباتات المثلج بالكينتين عند 100 جزء في المليون والتسامي بال السميد بالاسمدة الكيميائية (0.01 كجم النيتروجين: 200 كجم فوسفور: 200 كجم بروتين/فدان) للحصول على أفضل نمو زهري وجودة للأزهار من هذا النبات بغرض التصدير.