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Scientific Article

Response of *Ervatamia coronaria* to plant growth regulators and chemical fertilization

Hossam Ahmed Ashour [1*], Eman Zaki Othman Mohamed [1], Asmaa Badr El-din Sayed El-Atta r[1]

[1] Cairo University, Faculty of Agriculture, Ornamental Horticulture Department, Giza, Egypt.

Abstract

The present experiment was conducted to determine the effect chemical fertilization rates and foliar application of plant growth regulators PGRs (Kinetin or Napthaleneacetic Acid (NAA) and their interactions on growth, flowering, chemical composition of *Ervatamia coronaria* plants. The plants were fertilized monthly with NPK at the rate of 2, 4 and 6 g pot^{-1}, in addition to the control plants. Plants received the fertilization treatments were sprayed monthly with either Kinetin or NAA at 50, 100 ppm for each one, while the control plants sprayed with tap water. As general, the results indicated that within each level of fertilizer treatments, treating plants with different concentrations of PGRs (Kinetin or NAA) resulted in significant increase in tested vegetative growth (in terms of plant height, number of branches plant^{-1}, leaf area, number of leaves plant^{-1}, stem diameter, root length, fresh and dry weights of leaves, stems and roots), flowering parameters (*Viz* number of flowers/ plant, fresh and dry weights of flowers), chlorophylls content, total carbohydrates, N, P , K%, total indoles and total phenols, gibberellins, auxins and cytokinins compared to control, with superiority of NAA particularly the highest concentrations (100 ppm) . Under the same level of PGRs raising the fertilization rate caused a gradual and significant increase in all tested parameters compared to control. Based on the results, it can be recommended that for the highest quality growth and flowering parameters of *Ervatamia coronaria*, the plants could be sprayed with NAA at 100 ppm combined with 6 g pot^{-1} NPK.

Key words: kinetin, napthaleneacetic acid, NPK, *Tabernamontana coronaria.*

Resumo

Resposta de *Ervatamia coronaria* a fitorreguladores e adubação química.

O presente experimento foi conduzido para determinar o efeito das taxas de fertilização química e aplicação foliar de reguladores de crescimento de plantas PGRs (Cinetina ou Ácido Naftalenoacético (ANA) e suas interações no crescimento, floração, composição química de plantas de *Ervatamia coronaria*. as plantas foram fertilizadas mensalmente com NPK na dose de 2, 4 e 6 g/vaso, além das plantas controle. As plantas que receberam os tratamentos de fertilização foram pulverizadas mensalmente com cinetina ou ANA a 50, 100 ppm para cada uma, enquanto as plantas controle foram pulverizadas com água da torneira . Em geral, os resultados indicaram que, dentro de cada nível de tratamentos de fertilizantes, o tratamento de plantas com diferentes concentrações de PGRs (cinetina ou ANA) resultou em aumento significativo no crescimento vegetativo testado (em termos de altura da planta, número de ramos planta^{-1}, área foliar , número de folhas planta^{-1}, diâmetro do caule, comprimento da raiz, pesos frescos e secos de folhas, caules e raízes), parâmetros de floração (*Viz* número de flores planta^{-1}, massa fresca e seca de flores), teor de clorofilas, carboidratos totais, N, P, K%, indóis totais e fenóis totais, giberelinas, auxinas e citocininas em relação ao controle, com superioridade de ANA principalmente nas concentrações mais altas (100 ppm). Sob o mesmo nível de PGRs o aumento da taxa de adubação causou um aumento gradual e significativo em todos os parâmetros testados em relação ao controle. Com base nos resultados, pode-se recomendar que, para os parâmetros de crescimento e floração da *E. coronaria* de maior qualidade, as plantas podem ser pulverizadas com ANA a 100 ppm combinado com 6 g/vaso de NPK.

Palavras-chave: ácido naftalenoacético, cinetina, NPK, *Tabernaemontana coronaria*.

[*] Corresponding author: hossam.ahmed@agr.cu.edu.eg

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Introduction

Tabernaemontana divaricata (syn. *Ervatamia coronaria*) is evergreen shrub belonging to the Family Apocynaceae. It is native to India, has several features similar to the gardenia. It grows to a height of 6 to 10 feet tall and 5 to 8 feet wide. The leaves are 6 inches long, opposite, oblong-lanceolate to elliptic, glossy and wavy margins, dark green above and pale green beneath. The flowers are waxy white flowers with frilled petals, pinwheel-shaped, two inches across, mildly fragrant, especially at night, flowers sometimes simpler with five waxy petals. The Fruits are orange-red pods to two inches in length with a beaklike ending, pulp used as a red dye (Odenwald and Turner, 2006). In addition to utilize of *Ervatamia coronaria* for landscape activates as a flowering ornamental shrub, the plant has been reported to be traditionally used as anti-infection, anti-inflammation, analgesic, anti-tumor, ant- oxidative effect and the effect in neuronal activity (Ghani, 2012).

Mineral fertilization is regarded one of the most necessary tools simulating ornamental plants. The fertilization with NPK offering by industrial fertilizers enhances the growth of plants mainly with the most desirable utilization rate. In this concern, it has been reported by previous researches the beneficial influence of chemical NPK fertilizers rate on various ornamental plants including enhance vegetative growth and or flowering attributes (Ashour et al., 2018; Youssef et al., 2020), chemical composition such as boosting total chlorophylls, total nitrogen, phosphorus, potassium, total carbohydrates and endogenous phytohormones (Mohamed, 2018), increasing total indoles and total phenols (Dahab et al., 2017; Ashour et al., 2018) and antioxidant capacity (Zamfir et al., 2019).

Plant growth regulators (PGRs) have been recognized as one of the main factors simulating plants growth and their primary and secondary metabolites, Cytokinins include kinetin which known by its efficiency to induce cell division in certain plant tissues, it can also control the apical dominance of many plants and induce the lateral buds to develop into an entire new plant (Arteca, 1996). Foliar spray of kinetin has used to boost the growth and flowering of ornamental plants (El-Bably et al., 2017; Abou-El-Ghait et al., 2018). It has been reported to enhance photosynthetic pigments, total carbohydrate, (Elbohy, 2018), promote contents of macronutrient and total indols (Abou-El-Ghait et al., 2018), as well as enhance endogenous phytohormones (Youssef and El-Aal, 2014). Naphthalene acetic acid (NAA) is an organic component which is synthetic plant hormone in the auxin family. It is recognized to promote cell elongation, cell division, elongation of shoot, vascular tissue, photosynthesis, membrane permeability and water absorption also participate in many physiological processes such as delayed senescence, leaf chlorophyll content, induce flowering and boost growth (Heisler and Byrne, 2020). Foliar application of NAA on some ornamental plants have been reported to promote growth and flower yield attributes (Khudus et al., 2017; Sekhar et al., 2020), photosynthetic pigments, total carbohydrate, polyphenols and flavonoids content, antioxidant activity and enhance nutrient status in plant orangs (Atteya and El Gendy 2018), in addition it was found to be preferable to mitigate the damaging effects of salinity (Abou-El-Ghit, 2015).

Although the precious roles of plant growth regulators (PGRs) and NPK fertilizers on ornamental plants and their useful impact on enhancing growth and flowering traits has been earlier studied. However, there are no appropriate available data about their activity on the growth and performance of *Ervatamia coronaria* plants. Therefore, the objective was to evaluate the influence of NPK fertilization rates and PGRs (Kinetin or NAA) and their interactions on growth, flowering, and chemical composition of *Ervatamia coronaria* (Jacq.) plants.

Material and Methods

A pot experimental study was conducted at the experimental nursery of the Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, Giza, Egypt during the two successive seasons of 2019 and 2020. This study was aimed to investigate the influence of chemical fertilization rates and foliar application of different plant growth regulators (PGRs) such as Kinetin, NAA (Napthaleneacetic Acid) and their interactions on growth, flowering, chemical composition of *Ervatamia coronaria* (Jacq.) plants.

Plant material

On 1st March, in both seasons, uniform seedlings of *Ervatamia coronaria* having 2 branches and 20-25cm height were obtained from a commercial nursery and repotted in plastic pots of 30 cm diameter (one seedling/pot) packed with 8 kg of the mixture of clay + sand (2:1: v v^{-1}). The physical and chemical properties of soil mixture used in the study were performed according to (Jackson, 1973) as shown in Table 1 at Soil, Water and Environment Research Institute, Agriculture Research Centre (A.R.C).

Table 1. Some physical and chemical characteristics of soil mixture used in the study during the two seasons.

Parameter	***2019***	***2020***
Soil texture	Clay loam	Clay loam
Clay (%)	45.5	44.6
Silt (%)	30.4	33.0
Fine sand (%)	20.0	19.4
Coarse sand (%)	4.1	3.6
Field capacity (%)	55.50	59.33
pH	7.52	7.44
EC (dS/m)	1.82	1.75
CEC (meq/100g)	38.55	36.38
Organic matter (%)	1.40	1.55
$CaCO_3$ (%)	1.55	1.65
K^+ (ppm)	85.11	79.15
Mg^{++} (ppm)	30.44	33.54
Available N (ppm)	69.34	71.75
Available p (ppm)	28.35	23.45
Available Fe (ppm)	2.51	2.62

pH: soil acidity, EC: Electrical conductivity, CEC: cation exchange capacity : $CaCO_3$: calcium carbonate; K: potassium; Mg: magnesium; N: Nitrogen; P: phosphorous; Fe: iron.

Experimental procedures

On 15th of March the plants were fertilized monthly as a dressing application for nine times with chemical NPK in forms of Kirstalon (NPK, 19-19-19) at the rate of 2, 4 and 6 g pot^{-1}, in addition to the control plants which received no fertilization. In both seasons, plants received the different fertilization treatments were foliar sprayed every month with either Kinetin or Napthaleneacetic Acid (NAA) at concentrations of 50, 100 ppm for each one, while the control plants sprayed only with tap water. Each of Kirstalon, Kinetin and Napthaleneacetic Acid were obtained from Tecknogreen company, Egypt. PGRs treatments were sprayed using automatic atomizer after adding Tween 20 at 1.0 mL L^{-1} as wetting agent and the foliage of plants were sprayed to reach the point of runoff (100 mL plant^{-1}). Agricultural practices like regular irrigation, hand picking of weeds, insect and disease control were also carried out.

Experimental layout

The layout of the experiment was factorial 4x5 in randomized complete blocks design with 20 treatments. The first factor was 4 fertilization treatments (including the control). The second factor was 5 PGRs (including the control), each treatment consisting of 9 pots arranged in 3 replicates, each consisting of 60 plants (3 plants from each treatment).

The data recorded

Vegetative growth and flowering parameters

On 15th December, in both seasons, the experiment was terminated and the vegetative growth parameters were registered including plant height (cm), number of branches plant^{-1}, leaf area (cm^2), number of leaves plant^{-1}, stem diameter (mm, at 5 cm above soil surface), root length (cm), fresh and dry weights of leaves, stems and roots plant^{-1}, additionally flowering parameters including number of flowers plant^{-1}, as well as fresh and dry weights of flowers (g plant^{-1}) were also registered. Dry weight plant^{-1} was evaluated by drying plant at 70 °C until constant weight.

Chemical constituents

Total chlorophylls were determined in fresh leaf samples by using chlorophyll meter Model SPAD 502 (Netto et al., 2005). The total carbohydrates concentration (% of dry matter) was estimated in dried leaves samples as described by Dubois et al. (1956). N, P and K %: Dried leaves samples were digested to extract nutrients and the extract was analyzed to determine concentrations of N, P and K (% of dry leaves) which were determined according to Estefan et al. (2013). Nitrogen concentration was determined by using the micro-Kjeldahl method. Phosphorus was determined calorimetrically by using the chlorostannous molybdophosphoric blue colour method in sulphuric acid. Potassium was determined by using the flame photometer apparatus (CORNING M 410, Germany). phenol and indole contents were determined in fresh samples (2 g) of leaves, which were crushed and extracted with 80% ethanol at 0 ˚C for 72-hours, the ethanol being changed every 24-hours, as described by

Selim et al. (1978). Endogenous phytohormones were quantitatively determined in *Ervatamia coronaria* leaves using High- Performance Liquid Chromato-graphy (HPLC) according to Le et al. (2020).

Statistical analysis

The means of all obtained results were subjected to two-ways analysis of variance (ANOVA) in randomized complete blocks design. Combined analysis of the two growing seasons was carried out. Means of data were compared by using Duncan's multiple range tests at 5% level Snedecor and Cochran (1989).

Results and Discussion

Vegetative growth parameters

The data in Table 2, Table 3 and Figure 1 revealed that within each level of fertilizer treatments, treating plants with different concentrations of the two PGRs (Kinetin or NAA) resulted in significant ($p < 0.05$) increase in tested vegetative growth (in terms of plant height, number of branches plant^{-1}, leaf area, number of leaves plant^{-1}, stem diameter, root length, fresh and dry weights of leaves, stems and roots) compared to control.

Table 2. Plant height, number of branches, leaf area, number of leaves and stem diameter of *Ervatamia coronaria* as affected by the interaction between plant growth regulators (PGRs) and fertilizer treatments (mean of two seasons).

PGRs*	Fertilizer treatments	Plant height (cm)	Number of branches plan^{t-}1	leaf area (cm^2)	number of leaves plant^{-1}	Stem diameter (mm)
Control	0	79.70±1.09k	5.33±0.19j	31.40±0.07j	55.82±1.01h	6.00±0.25l
	2 g / pot	83.04±1.17j	8.39±0.31i	34.41±0.61i	63.99±0.59gh	7.88±0.38k
	4 g / pot	85.11±1.18h-j	8.78±0.59hi	35.85±0.19i	76.20±3.23c-e	8.61±0.06jk
	6 g / pot	85.87±0.44g-i	9.17±0.42g-i	36.18±0.38i	78.93±1.98b-d	8.82±0.19j
Kinetin at 50 ppm	0	83.84±0.41-j	9.61±0.49f-h	39.68±2.03h	64.57±3.77f-h	9.82±0.50i
	2 g / pot	86.69±0.79f-h	10.28±0.22ef	41.45±0.90gh	73.75±4.05d-f	9.94±0.29hi
	4 g / pot	86.99±1.19f-h	10.83±0.19de	43.65±0.79e-g	76.85±1.75cd	10.74±0.37gh
	6 g / pot	88.12±0.56e-g	10.78±0.20de	44.66±0.77d-f	81.51±0.93b-d	11.05±0.19e-g
Kinetin at 100 ppm	0	86.26±0.56fg-i	9.83±0.26fg	40.94±1.30gh	66.07±0.204fg	10.52±0.20g-i
	2 g / pot	86.86±1.01f-h	11.00±0.35de	43.58±0.93e-g	75.47±1.42de	11.65±0.27d-f
	4 g / pot	88.42±0.88d-f	11.17±0.17cd	44.99±0.60c-f	77.38±2.13cd	11.67±0.17de
	6 g / pot	88.42±0.65d-f	11.45±0.15b-d	46.12±0.60b-e	82.56±0.73b-d	12.05±0.15cd
NAA at 50 ppm	0	85.83±0.96g-i	10.28±0.48ef	42.39±1.96f-h	67.22±2.94e-g	10.55±0.51g-i
	2 g / pot	87.42±0.79f-h	10.830.19de	44.54±1.28d-f	75.81±1.19c-e	10.85±0.22fg
	4 g / pot	90.82±0.62b-d	10.95±0.15de	45.67±0.27c-e	76.43±0.78c-e	11.05±0.06e-g
	6 g / pot	91.67±1.37bc	11.56±0.34b-d	46.62±1.37b-d	81.79±1.39b-d	11.60±0.36d-f
NAA at 100 ppm	0	90.33±0.44c-e	11.39±0.31b-d	46.00±1.27b-e	79.87±1.40b-d	12.59±0.31bc
	2 g / pot	93.27±0.71b	11.89±0.20a-c	47.75±0.68bc	84.92±1.88bc	13.03±0.17ab
	4 g / pot	95.88±0.44a	12.11±0.28ab	48.80±1.12ab	88.05±1.55ab	13.31±0.28ab
	6 g / pot	97.42±1.17a	12.61±0.20a	50.70±0.82a	95.35±2.36a	13.81±0.20a

*NAA= Naphthaleneacetic acid

Each value represents the mean ± standard error of three replicates. Means in a column with different letters indicate a significant difference for each variable at 5% level using Duncan multiple rang test.

Table 3. Root length, fresh and dry weight of leaves, stems of *Ervatamia coronaria* as affected by the interaction between plant growth regulators (PGRs) and fertilizer treatments (mean of two seasons).

PGRs*	Fertilizer treatments	Root length (cm)	Leaves fresh weight (g plant^{-1})	Leaves dry weight (g plant^{-1}	Stems fresh weight (g plant^{-1})	Stems dry weight (g plant^{-1})
Control	0	14.42±0.55j	62.23±2.16i	39.00±2.16i	84.1±0.42j	43.13±1.60i
	2 g / pot	17.58±0.18i	67.12±2.56hi	54.98±3.20h	89.18±1.99ij	46.69±1.59hi
	4 g / pot	19.58±0.24h	70.21±0.51g-i	61.22±0.48gh	89.7±0.59h-j	46.72±1.87g-i
	6 g / pot	20.65±0.26gh	78.98±1.6f-i	62.97±1.59g	94.41±3.36g-j	50.49±0.97f-i
Kinetin at 50 ppm	0	21.89±0.79g	71.74±1.39g-i	64.83±1.04g	105.1±1.97e-h	55.29±1.04d-f
	2 g / pot	24.21±0.58f	71.45±2.97g-i	72.52±2.50f	98.53±3.14f-j	52.97±1.68e-h
	4 g / pot	26.12±0.88de	74.39±1.19g-i	79.29±1.68de	98.68±1.05f-j	53.92±0.58e-h
	6 g / pot	26.61±0.34c-e	80.73±1.57d-h	81.9±1.65b-e	105.31±2.05e-g	57.55±1.12c-f
Kinetin at 100 ppm	0	24.09±1.20 f	75.06±0.99g-i	77.39±1.73ef	103.91±1.28f-i	52.22±0.64e-h
	2 g / pot	26.96±0.33b-e	81.03±0.97d-h	87.00±2.32ab	105.91±0.58e-g	55.16±2.20d-f
	4 g / pot	27.70±0.37b-d	84.88±3.13c-g	87.17±1.42ab	105.83±3.16e-g	54.83±1.68d-g
	6 g / pot	28.42±0.37b	92.86±2.78b-f	90.40±1.24a	112.81±2.59d-f	57.56±1.32c-f
NAA at 50 ppm	0	24.30±0.34f	79.88±3.58e-h	77.68±4.30d-f	105.86±1.67e-g	54.85±0.87d-g
	2 g / pot	25.56±0.83ef	92.93±2.42b-f	80.20±1.87c-e	108.79±1.17e-g	58.80±0.64c-e
	4 g / pot	25.72±0.41ef	96.24±1.65a-f	81.93±0.51b-e	119.96±1.48c-e	62.48±2.79b-d
	6 g / pot	26.79±0.27b-e	96.87±3.53a-e	86.63±3.02ab	124.96±2.17b-d	65.09±0.72bc
NAA at 100 ppm	0	26.94±0.93b-e	97.80±1.81a-d	80.02±2.63c-e	134.20±2.18a-c	69.53±1.13b
	2 g / pot	28.24±0.65bc	101.1±2.79a-c	83.78±1.42b-d	136.99±2.38ab	69.89±1.22b
	4 g / pot	30.36±0.74a	104.2±3.70ab	86.14±2.38a-c	139.20±2.59ab	89.23±1.66a
	6 g / pot	31.43±0.62a	112.3±1.70a	90.48±1.71a	143.88±1.37a	95.92±0.91a

*NAA= Naphthaleneacetic acid

Each value represents the mean ± standard error of three replicates. Means in a column with different letters indicate a significant difference for each variable at 5% level using Duncan multiple rang test.

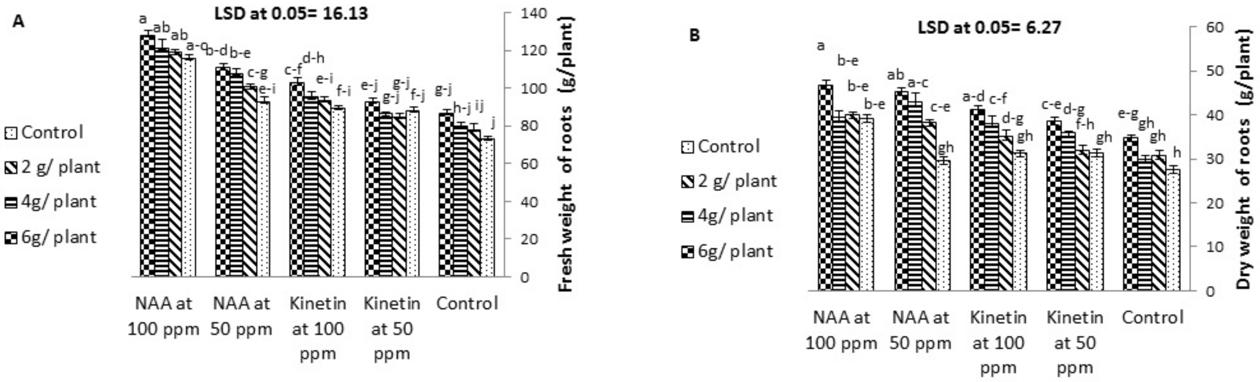

Figure 1. Fresh weight of roots (A), dry weight of roots (B) of *Ervatamia coronaria* as affected by the interaction between plant growth regulators (PGRs) and fertilizer treatments (mean of two seasons). Column with different letters indicate a significant difference at 5% test. Vertical bars indicate to standard error (SE) of three replicates.

Although, with any one of the two types of PGRs, raising the application rate resulted in a steady increase in the recorded mean values compared to control, however NAA was superior (in most cases) in its effect than Kinetin and among the different concentrations of NAA, the highest on (100 ppm) was the most effective one for increasing of studied parameter. Similar increases in vegetative growth parameters due to Kinetin treatments are in harmony with the finding of El-Bably et al. (2017) on *Clivia miniata*; Abou-El-Ghait et al. (2018) on *Dendranthema grandiflorium*; Elbohy (2018) on *Spathiphyllum wallisii*; El-Kinany et al. (2019) on gaillardia varieties, whereas the valuable pronounced increase in vegetative growth attributes due to NAA treatments are coincided with Bairwa and Mishra (2017) on *Tagetes erecta*; Sendhilnathan et al. (2017) on *Jasminum sambac*; Atteya and El Gendy (2018) on *Tagetes patula*; Dheeraj and Saravanan (2018) on *Calendula officinalis*; Dhanasekaran (2019) on *Jasminum sambac*; Sekhar et al. (2020) on *Jasminum nitidum*.

The stimulatory impact of NAA on morphological traits may be due its capability to enhance membrane permeability and water absorption that accompanied through elements uptake, synthesis of chlorophyll and carbohydrates contents that obtain the highest growth of plants (Atteya and El Gendy 2018).

Results in Table 2, Table 3 and Figure 1 also showed that, under the same level of PGRs, raising the fertilization rate caused a gradual and significant increase in tested vegetative growth parameters compared to control. Accordingly, the highest values were scored with the highest rate (6 g plant^{-1}), whereas the lowest values were obtained from control. The augmentation in growth parameters owing to fertilization treatments is matched well with those of Ashour et al. (2018) on *Euryops pectinatus*; Mohamed (2018) on *Dypsis cabadae*; Youssef et al. (2019) on *Swietenia mahagoni*; Zamfir et al. (2019) on *Murraya exotica*; Ghatas (2020); Youssef et al. (2020) on *Cupressus macrocarpa*; Wiendi et al. (2021) on *Eleutherine bulbosa*.

Flowering parameters

It is clear from data in Figure 2 that within each level of fertilizer treatments spraying *Ervatamia coronaria* plants with any rate of Kinetin or NAA caused a significant increase in flowering parameters (*Viz* number of flowers plant^{-1}, fresh and dry weights of flowers) as compared to untreated control plants. With any one of the tested PGRs, raising the application rate resulted in a steady increase in the recorded mean values compared to control. NAA was eminent in its effect particularly the highest on (100 ppm) since recorded the highest mean values of studied traits.

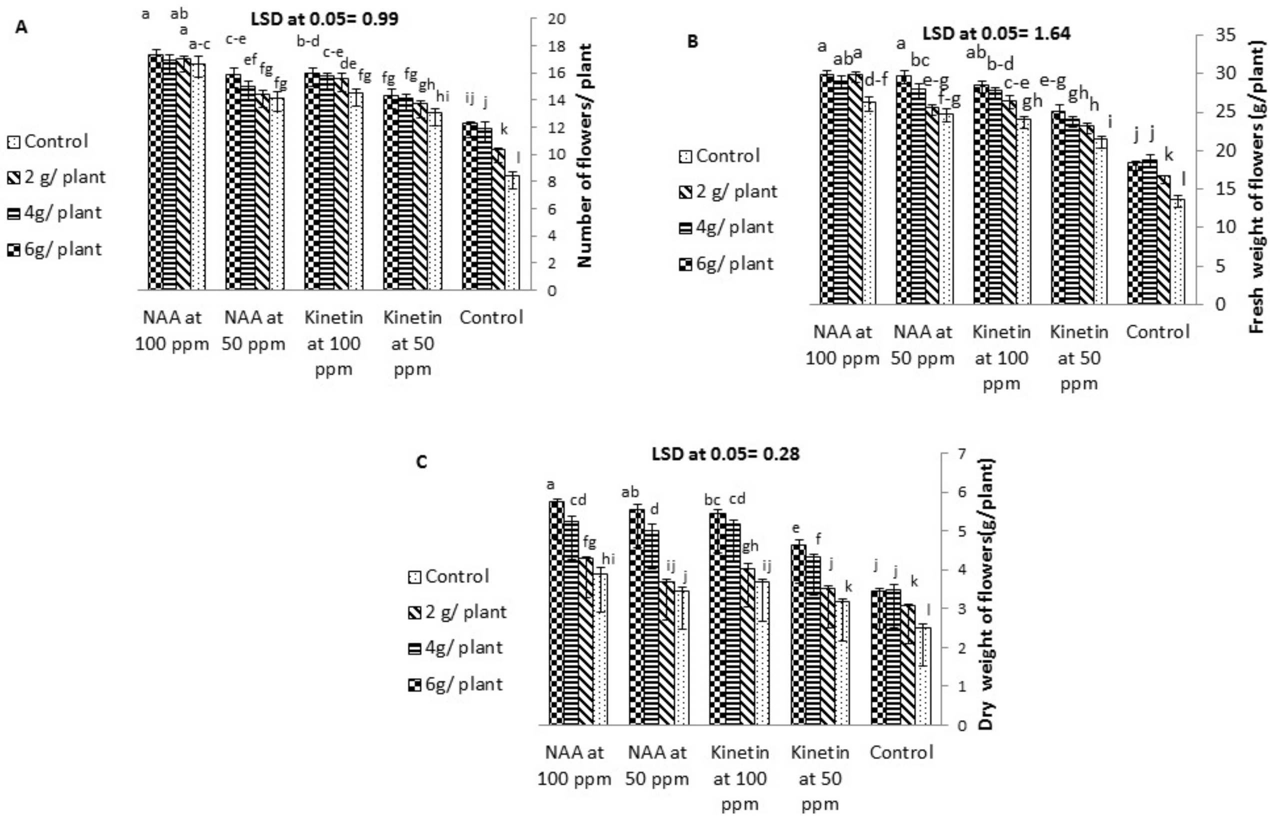

Figure 2. Number of flowers/ plant (A), fresh weight of flowers plant^{-1} (B) and dry weight of flowers plant^{-1} (C) of *Ervatamia coronaria* as affected by the interaction between plant growth regulators (PGRs) and fertilizer treatments (mean of two seasons). Column with different letters indicate a significant difference at 5% test. Vertical bars indicate to standard error (SE) of three replicates.

The results of increasing flowering parameters owing to Kinetin treatments are in conformity with previous researches (El-Bably et al., 2017; Abou-El-Ghait et al., 2018; Elbohy, 2018; El-Kinany et al., 2019), while the results of increasing flowering attributes owing to NAA treatments are in good accordance with those elicited by earlier studies (Bairwa and Mishra, 2017; Khudus et al., 2017; Sendhilnathan et al., 2017; Atteya and El Gendy, 2018; Dheeraj and Saravanan, 2018; Pahare and Das, 2020; Sekhar et al., 2020).

Results in in Figure 2 also indicated that, under the same level of PGRs, raising the fertilization rate resulted in steady and significant increase in flowering parameters compared to control, Accordingly, the highest values were registered by the highest rate (6 g plant^{-1}), whereas the lowest values were obtained from control. The obtained increase in flowering parameters as a result of fertilization treatments is quite in line with those obtained by previous reports including Mumtaz et al. (2017) on *Rosa* Gruss-an-teplitz; Ashour et al. (2018) on *Euryops pectinatus*; Wiendi et al. (2021) on *Eleutherine bulbosa*.

The stimulatory effect of NPK fertilization on inceasing the vegetative growth and flowering parameters compared to the control may be due to the important role of N, P and K in the different physiological processes within the plant, which in turn influence the plant growth traits. Nitrogen is an essential component of proteins, nucleic acids, porphyries, alkaloids, some vitamins and co-enzymes, phosphorus is an essential component of nucleic acids and phospholipids, promotes root growth, while potassium plays an essential role in metabolism such as photo synthesis (Devlin, 1975).

Chemical constituents

Chlorophylls content and total carbohydrates, N, P and K%

The data in Table 4 displayed that within each level of fertilizer treatments, in most cases plants foliar sprayed with the tested PGRs (Kinetin or NAA) had significantly higher values of chlorophylls content, total carbohydrates, N, P and K% in their leaves than those of control. Generally, raising the application rate of any type of the two studied PGRs (Kinetin or NAA) caused steady increase in the recorded mean values compared to control, with superiority of NAA particularly the highest on (100 ppm) which recorded the highest mean values of tested parameter.

Table 4. Total chlorophylls, total carbohydrates, N, P, and K% of *Ervatamia coronaria* as affected by the interaction between plant growths regulators (PGRs) and fertilizer treatments (mean of two seasons).

PGRs*	Fertilizer treatments	Total chlorophylls content (SPAD)	Total carbohydrates (% DW)	N (% DW)	P (% DW)	K (% DW)
Control	0	47.31±0.69k	14.21±0.55i	1.36±0.18j	0.22±0.04l	1.19±0.03j
	2 g / pot	52.45±0.49j	16.24±0.15gh	1.73±0.02g-i	0.42±0.10k	1.45±0.03i
	4 g / pot	57.06±0.69g-i	17.93±0.76d-f	1.77±0.08f-i	0.43±0.10jk	1.50±0.04hi
	6 g / pot	57.65±0.50f-h	17.60±0.44e-g	1.67±0.04hi	0.49±0.11g-j	1.65±0.02e
Kinetin at 50 ppm	0	52.61±1.07j	15.18±0.56hi	1.65±0.06i	0.48±0.13h-k	1.48±0.02hi
	2 g / pot	56.63±1.25hi	17.59±1.33e-g	1.83±0.14f-h	0.54±0.14d-g	1.51±0.06hi
	4 g / pot	59.45±0.92d-g	18.52±0.29c-e	1.88±0.03e-g	0.50±0.13f-i	1.56±0.07e-h
	6 g / pot	61.01±0.48b-e	20.07±0.16ab	2.02±0.02de	0.57±0.16cd	1.64±0.04ef
Kinetin at 100 ppm	0	53.06±0.12j	15.12±0.03hi	1.68±0.18hi	0.49±0.14g-j	1.52±0.02hi
	2 g / pot	59.36±0.73d-h	17.21±0.64e-g	1.87±0.07e-g	0.51±0.14e-i	1.54±0.05g-i
	4 g / pot	60.60±1.15b-e	19.42±0.37a-d	2.27±0.04b	0.61±0.16c	1.64±0.03e
	6 g / pot	63.15±0.39b	20.18±0.13ab	2.24±0.01bc	0.56±0.14c-e	1.56±0.01e-h
NAA at 50 ppm	0	54.75±0.90ij	15.42±0.82hi	1.48±0.08j	0.46±0.15i-k	1.49±0.12hi
	2 g / pot	58.28±0.62e-h	18.21±0.19de	1.83±0.02f-h	0.55±0.17c-f	1.54±0.01f-i
	4 g / pot	58.60±0.41e-h	18.72±0.13b-e	1.89±0.01ef	0.54±0.15d-g	1.62±0.11e-g
	6 g / pot	60.31±1.86c-f	20.03±0.62a-c	2.11±0.06cd	0.52±0.14d-h	1.65±0.02e
NAA at 100 ppm	0	59.14±1.67d-h	16.43±0.46f-h	1.80±0.05f-i	0.56±0.18c-e	1.76±0.02d
	2 g / pot	61.46±0.94b-d	18.35±0.28de	2.24±0.03bc	0.69±0.22b	1.93±0.02c
	4 g / pot	62.59±1.58bc	20.13±0.51ab	2.55±0.06a	0.73±0.22b	2.69±0.04b
	6 g / pot	68.05±0.47a	20.39±0.60a	2.60±0.08a	0.79±0.26a	2.79±0.03a

*NAA= Naphthaleneacetic acid

Each value represents the mean ± standard error of three replicates. Means in a column with different letters indicate a significant difference for each variable at 5% level using Duncan multiple rang test.

These results are similar to those obtained by earlier studies which reported that application of Kinetin caused increase in total chlorophylls and carbohydrates content (El-Bably et al., 2017; Elbohy, 2018) and N, P or K% (Abou-El-Ghait et al., 2018). Whereas, the obvious augmentation in tested components due to NAA treatments are in conformity with earlier workers that reported positive effect of NAA in increase in total chlorophylls, carbohydrates content and N, P and K% (Sendhilnathan et al., 2017; Atteya and El Gendy, 2018)

The data shown in Table 4 also visualized that under the same level of PGRs, chlorophylls content, total carbohydrates, N, P and K% were increased steadily and significantly ($p<0.05$) as result of raising the fertilization rate compared to control, consequently, the highest values were obtained by the highest fertilization rate (6 g plant^{-1}), while the lowest values were gained from control. The present increases in tested components as a result of fertilization treatments are in harmony with the finding of Ashour et al. (2018) on *Euryops pectinatus*; Mohamed, (2018) on *Dypsis cabadae*; Youssef et al. (2019) on *Swietenia mahagoni*; Zamfir et al. (2019) on *Murraya exotica*; Ghatas (2020); Youssef et al. (2020) on *Cupressus macrocarpa*.

Total indoles and total phenols

Results in Figure 3 showed that within each level of fertilizer treatments, foliar application of any rate of PGRs (Kinetin or NAA) resulted in significant increase in total indoles and total phenols in leaves of *Ervatamia coronaria* plants compared to control. With any one of the two types of PGRs (Kinetin or NAA), raising the application rate caused a steady increase in the recorded mean values compared to control, NAA was superior in its impact than Kinetin and among the two concentrations of NAA, the highest on (100 ppm) was the most effective for increasing of total indoles and total phenols.

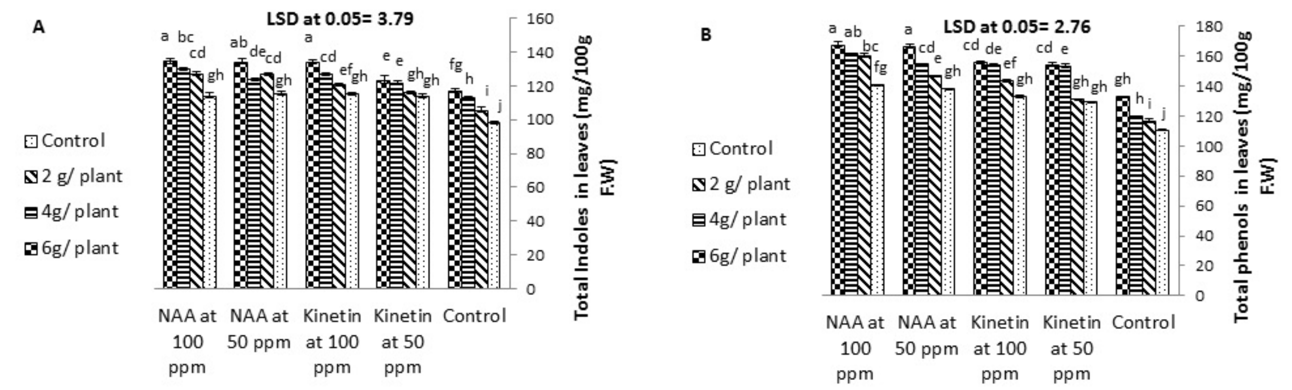

Figure 3. Total indoles (A), total phenols (B) of *Ervatamia coronaria* as affected by the interaction between plant growth regulators (PGRs) and fertilizer treatments (mean of two seasons). Column with different letters indicate a significant difference at 5% test. Vertical bars indicate to standard error (SE) of three replicates.

The obtained results of increased total indoles due to Kinetin treatment have been demonstrated in previous studies (Abou-El-Ghait et al., 2018), while the augmentation in total phenols owing to NAA treatments are in good accordance with those elicited by earlier studies (Atteya and El Gendy, 2018).

Results in Figure 3 also showed that, under the same level of PGRs, raising the fertilization rate caused a gradual and significant increase in total indoles and total phenols in leaves of plants compared to control, Accordingly, the highest values were scored with the highest rate (6 g plant^{-1}), whereas the lowest values were obtained from control. The obtained increases in total indoles or total phenols owing to fertilization treatments are in good accordance with those elicited by of previous studies (Abou Dahab et al., 2017; Ashour et al., 2018; Zamfir et al., 2019).

Endogenous phytohormones

The data in Table 5 exhibited that within each level of fertilizer treatments, foliar spraying plants with different concentrations of the two PGRs (Kinetin or NAA) resulted in significant increase in phytohormones (gibberellins, auxins and cytokinins) compared to control. Generally, raising the application rate of any type of the two tested PGRs (Kinetin or NAA) caused steady increase in the recorded mean values compared to control, with superiority of NAA mostly the highest on (100 ppm) since registered the highest mean values. These results are similar to those obtained by earlier studies which reported that application of Kinetin caused increase in gibberellins, auxins and cytokinins content (Youssef and El-Aal, 2014).

Table 5. Gibberellins, auxins, cytokinins of *Ervatamia coronaria* as affected by the interaction between plant growth regulators (PGRs) and fertilizer treatments (mean of two seasons).

PGRs*	Fertilizer treatments	Gibberellins μg g^{-1} F.wt	Auxins (IAA) μg g^{-1} F.wt	Cytokinins μg g^{-1} F.wt
Control	0	91.98±0.54k	16.72±0.10m	3.22±0.08n
	2 g / pot	103.02±0.2j	20.16±0.04jk	4.91±0.57m
	4 g / pot	107.84±0.52h	21.06±0.10hi	5.11±0.02l
	6 g / pot	106.9±0.35hi	19.71±0.03k	5.73±0.58j
Kinetin at 50 ppm	0	103.64±1.44ij	19.01±0.26l	5.51±0.08k
	2 g / pot	117.14±1.25fg	21.73±0.23gh	6.41±0.07h
	4 g / pot	118.85±.38ef	20.53±0.07ij	5.42±0.02k
	6 g / pot	121.56±0.70c-e	21.94±0.13g	6.20±0.04i
Kinetin at 100 ppm	0	114.56±0.04g	25.14±0.01f	7.35±0.58f
	2 g / pot	122.06±0.36c-e	25.49±0.06f	6.93±0.02g
	4 g / pot	122.8±0.37cd	25.39±0.06f	6.79±0.02g
	6 g / pot	124.79±4.65bc	28.91±0.93c	7.21±0.23f
NAA at 50 ppm	0	115.34±0.67fg	26.97±0.13e	8.30±0.04cd
	2 g / pot	122.31±0.30c-e	27.99±0.06d	8.43±0.02c
	4 g / pot	122.21±0.97c-e	27.18±0.17e	7.74±0.05e
	6 g / pot	124.44±0.12b-d	25.63±0.02f	6.36±0.17hi
NAA at 100 ppm	0	121.07±0.38de	29.24±0.07bc	9.11±0.02b
	2 g / pot	124.92±0.79bc	29.84±0.15b	9.21±0.05b
	4 g / pot	126.49±0.94b b	28.96±0.17c	8.25±0.05d
	6 g / pot	135.05±0.96a	31.53±0.18a	9.58±0.06a

*NAA= Naphthaleneacetic acid

Each value represents the mean ± standard error of three replicates. Means in a column with different letters indicate a significant difference for each variable at 5% level using Duncan multiple rang test.

The data shown in Table 5 also showed that under the same level of PGRs, gibberellins, auxins and cytokinins were increased steadily and significantly as result of raising the fertilization rate compared to control, thus, the highest values were obtained by the highest fertilization rate (6 g plant^{-1}), while the lowest values were gained from control. The present increases in phytohormones (gibberellins, auxin and cytokinins) as a result of fertilization treatments are in conformity with that recorded by Mohamed (2018) on *Dypsis cabadae*. The favorable effect of the NPK fertilization may be due to the important role of N, P and K in the different physiological processes within the plant (such as activation of photosynthesis and metabolic processes of organic compounds) which in turn affect phytohormones synthesis and plant growth.

Conclusions

The present results reported on the vegetative growth, flowering parameters and chemical compositions of *Ervatamia coronaria*, showed that the best treatment was spraying the plants with NAA at the highest concentration (100 ppm) combined with the highest level of kristalon fertilizer (6 g plant^{-1}) which gave the best quality results for all the studied parameters. Generally, it can be recommended that for the highest quality growth and flowering parameters of *Ervatamia coronaria*, the plants could be sprayed with NAA at 100 ppm combined with 6 g plant^{-1}of kristalon chemical fertilizer.

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Author Contribution

HAA: Designed and performed the experiment, data analysis, preparation and writing the manuscript**. EZOM**: Assistance in designing of the experiment, chemical analysis, statistical analysis, preparation and writing of the manuscript. **ABESE**: Assistance in data collection, chemical analysis, statistical analysis, manuscript preparation.

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