

## RESPONSE OF *SYNGONIUM PODOPHYLLUM* PLANT TO SOME SYNTHETIC CYTOKININ TYPES AND CONCENTRATIONS AS A FOLIAR APPLICATION

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**ABSTRACT:** This investigation was executed to assess the effects of three synthetic cytokinins [6-benzylaminopurine (BAP), 6-( $\gamma,\gamma$ -dimethylallylamino) purine (2iP) and furfurylamino-purine (kinetin)] at three concentrations for each type (100, 200 and 300 mg/l), beside the control one (tap water) on vegetative growth and some chemical analysis of *Syngonium podophyllum* plants. Two pot experiments were executed during the two successive seasons of 2019 and 2020 in a commercial farm in Belqas Khamis, Dakahlia Governorate, Egypt. The obtained results generally revealed that spraying of the three types and concentrations of synthetic cytokinins significantly enhanced plant height, number of leaves/plant, leaf area, foliage fresh and dry weight, root length, root fresh and dry weight compared to the control plants. Moreover, spraying of synthetic cytokinins was superior and significantly increased N%, P%, K%, total carbohydrates, total phenolics, chlorophylls and carotenoids content in leaves. Meanwhile, spraying of 2iP at 200 mg/l gave the highest values for most of the vegetative growth characters (plant height, leaves number and foliage fresh weight) and chemical composition (chlorophyll a, b, a+b, carotenoids, total carbohydrates and N, P and K contents in leaves) compared to other treatments. However, applying of kinetin at 200 mg/l gave higher values of foliage fresh and dry weight and chlorophyll a than other concentrations. Besides, spraying of BAP at 100 mg/l gave the highest roots fresh and dry weight. While spraying of BAP at 200 mg/l gave the highest value of total phenolics content compared to other treatments. Generally, the examined cytokinin types and concentrations could be arranged for their positive effects on *Syngonium podophyllum* descendingly as 2iP at 200 mg/l, BAP at 100 or 200 mg/l and kinetin at 200 mg/l.

**Key words:** *Syngonium podophyllum*, growth regulators, cytokinins, 6-BAP, 2iP and kinetin.

### INTRODUCTION

Arrowhead vines (*Syngonium podophyllum*, L.) is an enduring evergreen plants and herbaceous vine. It is perceived by its simple leaves which are organized and sagging roughly and is one of the most popular and versatile leaf plants, which belongs to the family Araceae, native to African and South American. *Syngonium* is

an indoor plant ordinarily utilized as hanging baskets and if upstanding development is wanted; trellis or other help is required. Additionally, plants can be utilized as ground covers. Also, plants can be utilized in different places like workplaces, clinics, shops, windows, meeting rooms, commercial buildings, and residences (Abd El-Aziz *et al.*, 2007).

The foliar application involves spraying and absorption of various substances on leaves and stems of plants. It is noted that foliar application leads to increased yield, protection against diseases and pests, increased development of resistance to the dry season besides yield quality (Durrani *et al.*, 2010).

Plant growth regulators (PGRs) are characterized as naturally or synthetically constituent materials without a nutritive value, but they influence formation or metabolism processes in higher plants, which are applied for the growth and development regulation of plants and are significant measures to improve agricultural production. PGRs are utilized in agriculture to control plant development and gain specified benefits, like diminishing sensitivity to biotic and abiotic stress, bettering morphological construction, quantitative and qualitative expansions in the crop, in addition, to make plant constituents amendments (El-Bably and Rashed 2017).

Cytokinins are used to enhance axillaries branching, cell division, chloroplast improvement, control of apical dominance, shoot and root growth (Khandaker *et al.*, 2018). Besides, cytokinins modify some of the significant formative cycles, including the development last stage of leaf known as senescence, which is related to chlorophyll breakdown, photosynthetic deterioration and oxidative damage. There is plentiful proof that cytokinins can delay the senescence-accompanying changes (Hönig *et al.*, 2018).

6-Benzylaminopurine (BAP) is one of the first synthetic cytokinins utilized as a plant growth regulator in farming. It could raise a whole number of vines and leaves per arrowhead after 60 and 90 days from application. The number of branches increasing could assist the planting producers to give more different choices of cultivars (Sardoei *et al.*, 2018). Moreover, BAP application increments the leaves number, development of new shoots, prompts early blossoming and gets a better-quality spike in *Phalaenopsis* hybrid (Mishra

*et al.*, 2018). Similar findings were reported by (Nambiar *et al.*, 2012) in *Dendrobium* hybrid, as they reported that application of BAP at 150-200 ppm improved the leaves number. Foliar spray method of BAP at lower concentrations gave significant impact on different characteristics like leaves number, length of leaf and shoot, proliferation of tiller, number and width of rhizomes whose can be induced to improve the ginger plant growing (Bezabih *et al.*, 2017).

Kinetin (Kin) is a synthetic cytokinin, which plays a significant role in enhancing the nutrient's movement and transport towards high metabolites areas, just as in enhancing cell division, (Taiz and Zeiger, 2010). Utilizing a mix of (kinetin + salicylic acid + yeast suspension) as a spray on *Aloe vera* L. enhanced the production of active medical compounds by enhancing vegetative growth, number, width and thickness of leaves, photosynthesis, absorption and transport of nutrient elements, as well as the activation of certain significant enzymes (Abd-UI Razzaq and Mohammed, 2019). Similar findings were reported by Yousef *et al.* (2004) whose showed that foliar application of kinetin to *Matthiola incana* L. had a significant positive effect on plant growth.

6-( $\gamma,\gamma$ -Dimethylallylamino) purine (2iP) is an adenine-based cytokinin that is generally considered to be the second most potent of all the cytokinins behind Z125 (zeatin). Moreover, 2iP is a bacteria-derived riboside cytokinin used to grow plant tissues such as tobacco and soybean callus and is considered a precursor of the cytokinin zeatin. In addition, 2iP application increased average of number and leaves length of *Phoenix dactylifera* L. (Almeer, 2020).

Ornamental plants of a kind *Syngonium podophyllum* are usually grown in pots for mercantile purposes. In this case, the roots are not allowed to grow freely (Di Benedetto, 2011) and this limitation would be related to a restricted creation of cytokinins (O'Hare *et al.*, 2004) which thus

adversely influences the growth of the aerial part (Kyozyuka, 2007). So, this research aims to improve the vegetative growth and chemical contents of *Syngonium podophyllum*, which is one of the most important indoor plants as a response to foliar spraying by some synthetic cytokinins types and concentrations.

## MATERIALS AND METHODS

### Experimental location:

This experiment was carried out at a commercial Farm in Belqas Khamis, Dakahlia Governorate, Egypt located at 31.29 latitudes, 31.39 longitudes in the North Middle Nile Delta area during the two consecutive periods of 2019 and 2020 under saran house (63% shading).

### Culturing process:

Uniform rooted cuttings of *Syngonium podophyllum* (18-20 cm length) planted in 10 cm plastic pots were purchased from a commercial nursery (Abnaa Shaesha) at El-Mansoura city, Egypt. Rooted cuttings were transplanted on 15<sup>th</sup> March during the 2019 and 2020 seasons individually in 15 cm in diameter black plastic pots, filled with a mixture of peat moss and vermiculite (2:1, v/v) with humidity of about 70% and pH of 5.9. Plants were transplanted again on 1<sup>st</sup> May in 25 cm in diameter plastic pots filled with 2.5 kg from the same potting mixture after supplying with 2 g/pot NPK (Nutri-Leaf, 20:20:20). All plants were fertilized monthly after two weeks from the transplanting by 1 g/pot NPK as a drench starting from 15<sup>th</sup> May to 1<sup>st</sup> September (four times). All other agricultural operations, such as irrigation, etc., are carried out regularly under normal conditions. The average temperature was 36 and 17 °C for the maximum and minimum, respectively starting from May to September.

### Growth regulators preparation and procedure:

Three different cytokinins were used as foliar spray; 6-benzylaminopurine (6-BAP, C<sub>12</sub>H<sub>11</sub>N<sub>5</sub>), 6-( $\gamma,\gamma$ -dimethylallylamino)

purine (2iP, C<sub>10</sub>H<sub>13</sub>N<sub>5</sub>) and 6-furfurylaminopurine (kinetin, C<sub>10</sub>H<sub>9</sub>N<sub>5</sub>O). Stock solution (1000 mg/l) from each cytokinin was prepared by dissolving 0.05 g of the powder in 5 ml of 1.0 N KOH with the addition of tween-20 at the concentration of 0.1% as a surfactant, vortexed until no powder was visible, and then brought to a final volume of 50 ml with 45 ml of deionized water. Then, three dilutions from each cytokinin were prepared (100, 200 and 300 mg/l), plus the control one (tap water). Plants were sprayed monthly with different concentrations of cytokinins after 15 days from transplanting, starting from 15<sup>th</sup> May by 250 ml of each cytokinin solution for each treatment.

### Experimental design:

Pots were laid out as a simple experiment in a completely randomized block design under saran house. Since, ten treatments were as follows: BAP (100, 200 and 300 mg/l), 2iP (100, 200 and 300 mg/l), kinetin (100, 200 and 300 mg/l) and the control. All treatments contained three replicates, each replicate consisted of four pots and every pot contained one plant.

### Data Recorded:

#### Vegetative growth:

Data were recorded for vegetative growth after 135 days from the transplanting process on 15<sup>th</sup> September. Plant height (cm) was calculated from the topsoil in planting pots to the highest point of the plant, the number of leaves/plant, leaf area (cm<sup>2</sup>) of the third base leaf, foliage fresh weight (g), foliage dry weight (g), root length (cm), roots fresh and dry weight (g).

#### Chemical analysis:

Chemical determinations were achieved in parallel with the vegetative characteristics as chlorophyll a, b, total and carotenoids were determined as per Costache *et al.* (2012), proline contents were assessed utilizing the protocol of Bates *et al.* (1973), total phenolics content was estimated by a colorimetric method according to

Chaovanalikit and Wrolstad (2004), total carbohydrates percentage was achieved according to Herbert *et al.* (1971), nitrogen percentage was evaluated by modified Micro Kjeldahl technique as depicted by Pregl (1945), phosphorus percentage was evaluated on the way of Rao *et al.* (1997) and potassium percentage was measured following Black (1965).

**Statistical analysis:**

Data were undergone to the analysis of variance (ANOVA) as a simple experiment in a completely randomized block design using the COSTAT (1986) v. 6.303 program. Comparison between means were achieved by Duncan's multiple range test according to Snedecor and Cochran (1989) at 0.05 prospect level.

**RESULTS**

**Impact of BAP, 2iP and kinetin foliar application on vegetative growth:**

The response of plant height (cm) leaves number/plant, leaf area (cm<sup>2</sup>), foliage fresh weight (g), foliage dry weight (g), root length (cm), roots fresh and dry weight (g) of syngonium plants to different types of cytokinins as a foliar application were shown in Tables (1), (2) and (3) and Fig. (1). Data in Table (1) indicated that arrowhead

(*Syngonium podophyllum*, L.) plants sprayed with 2iP at 200 mg/l had the highest values of plant height (47.67 and 47.77 cm) in the first and second season, respectively. Plants sprayed by BAP at 200 mg/l came in the second order for this character (41.00 and 42.33 cm in both seasons, respectively). On the other hand, applying BAP at the highest concentration (300 mg/l), recorded the shortest plants in both seasons (27.00 and 26.33 cm), followed by the control treatment. Generally, it was noticeable that the highest concentrations of both BAP and 2iP were accompanied by a decrease in the plant height compared to kinetin. In addition, a higher number of leaves were recorded for plants sprayed with BAP at 200 mg/l (9.67 and 10.00), followed by 9.67 and 9.33 resulted from plants treated by Kin at 100 mg/l, then 9.00 and 9.33 obtained when using 2iP at 200 mg/l, respectively in both seasons without any significant differences among them. While the least number of leaves was 6.67 and 6.67 for untreated plants, respectively in both seasons. As for leaf area, data presented in Table (1) clearly showed that during both seasons spraying the syngonium plant with all cytokinin types and concentrations significantly enhanced this parameter. Since the highest leaf area (61.90 and 62.52 cm<sup>2</sup>) was obtained from

**Table 1. Impact of BAP, 2iP and Kin on plant height (cm), leaves number and leaf area (cm<sup>2</sup>) of *Syngonium podophyllum* plant after 135 days from the beginning of the experiment during 2019 and 2020 seasons.**

Cytokinins treatments (mg/l)	Plant height (cm)		Leaves number		Leaf area (cm <sup>2</sup> )	
	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season
Control	30.00 ef	28.23 g	6.67 c	6.67 d	38.19 f	38.99 f
BAP 100	39.00 bc	40.13 c	8.33 a-c	8.00 c	41.24 ef	41.74 f
BAP 200	41.00 b	42.33 b	9.67 a	10.00 a	42.72 ef	42.94 ef
BAP 300	27.00 f	26.33 h	8.00 a-c	7.67 cd	52.38 bc	51.50 b-d
2iP 100	29.67 ef	30.50 f	7.67 a-c	7.33 cd	46.41 de	47.31 de
2iP 200	47.67 a	47.77 a	9.00 ab	9.33 ab	55.93 b	54.12 bc
2iP 300	32.67 de	30.50 f	7.67 a-c	8.00 c	61.90 a	62.52 a
Kin 100	31.83 d-f	30.73 f	9.67 a	9.33 ab	44.30 de	41.28 f
Kin 200	34.67 cde	35.33 e	7.00 bc	6.67 d	48.95 cd	49.25 cd
Kin 300	36.67 bcd	37.50 d	8.00 a-c	8.33 bc	56.64 b	55.87 b

Means within columns followed by different letters are significantly different ( $p < 0.05$ ). BAP: 6-Benzylaminopurine; 2iP: 6-( $\gamma,\gamma$ -Dimethylallylamino) purine; Kin: Kinetin.

**Table 2. Impact of BAP, 2iP and Kin on foliage fresh weight (g), foliage dry weight (g) and roots length (cm) of *Syngonium podophyllum* plant after 135 days from the beginning of the experiment during 2019 and 2020 seasons.**

Cytokinins treatments (mg/l)	Foliage fresh weight (g)		Foliage dry weight (g)		Root length (cm)	
	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season
Control	33.30 d	31.73 e	4.41 cd	4.25 h	104.00 a	103.07 a
BAP 100	50.45 ab	51.62 b	6.30 b	6.33 b	80.33 bc	81.73 de
BAP 200	46.50 b	46.73 c	5.88 b	6.10 d	67.67 cd	64.80 g
BAP 300	32.97 d	32.40 e	4.36 cd	4.37 g	85.33 a-c	86.77 bc
2iP 100	32.72 d	31.67 e	3.67 d	3.81 i	48.83 d	51.20 h
2iP 200	55.33 a	54.45 a	6.22 b	6.28 bc	76.33 bc	74.97 f
2iP 300	40.24 c	39.27 d	4.92 c	4.87 f	80.33 bc	80.13 e
Kin 100	46.97 b	47.93 c	5.87 b	5.52 e	84.67 a-c	84.97 cd
Kin 200	55.35 a	55.75 a	7.34 a	7.63 a	89.33 a-c	90.03 b
Kin 300	51.16 ab	51.36 b	6.25 b	6.24 c	98.33 ab	99.57 a

Means within columns followed by different letters are significantly different ( $p < 0.05$ ).  
BAP: 6-Benzylaminopurine; 2iP: 6-( $\gamma,\gamma$ -Dimethylallylamino) purine; Kin: Kinetin.

**Table 3. Impact of BAP, 2iP and Kin on roots fresh and dry weights (g) of *Syngonium podophyllum* plant after 135 days from the beginning of the experiment during 2019 and 2020 seasons.**

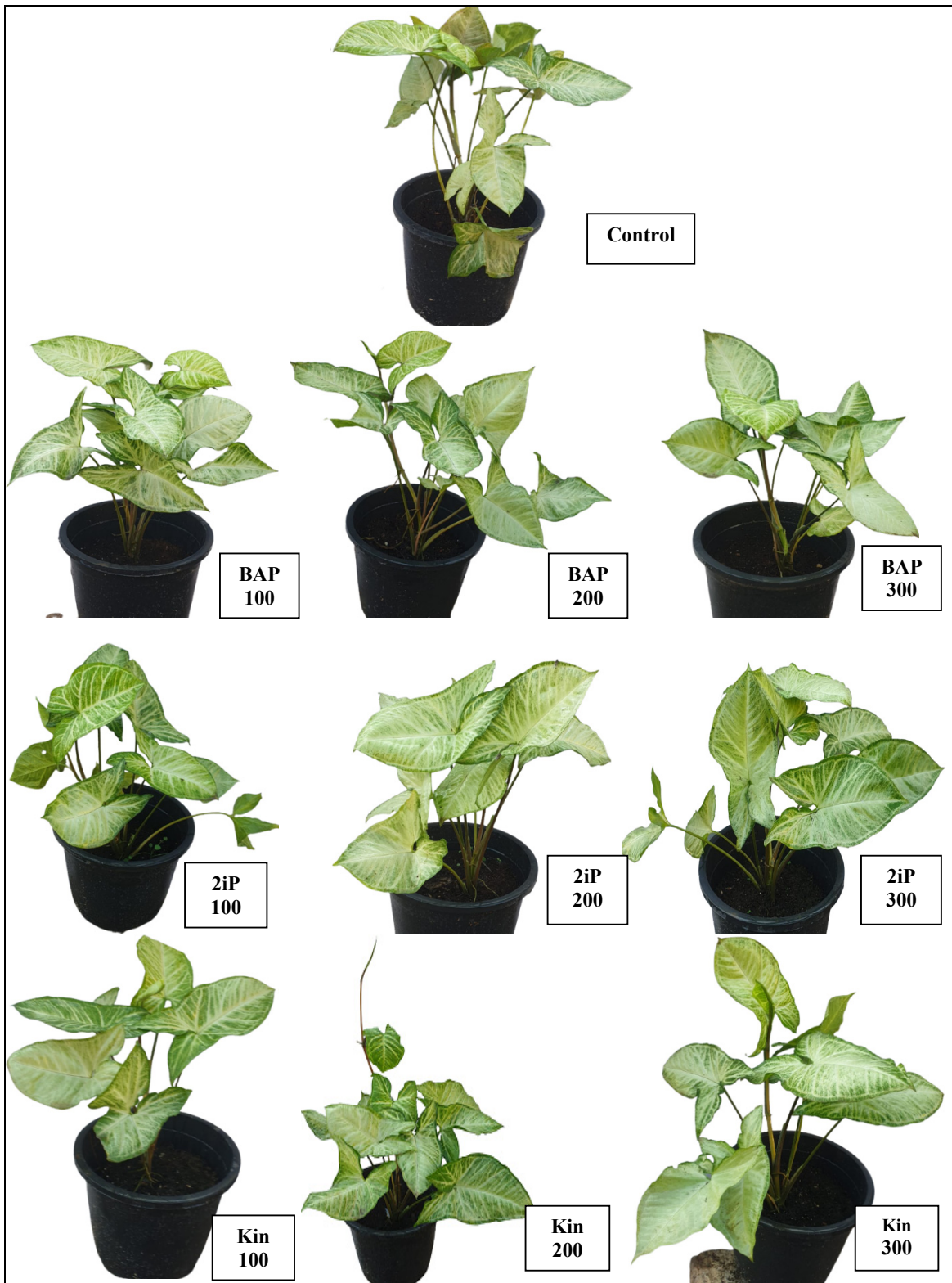
Cytokinins treatments (mg/l)	Roots fresh weight (g)		Roots dry weight (g)	
	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season
Control	54.45 cd	55.67 c	9.97 bc	9.39 e
BAP 100	74.52 a	76.14 a	13.20 a	14.17 a
BAP 200	67.88 b	65.58 b	13.17 a	13.54 b
BAP 300	50.24 d	48.92 f	9.71 bc	9.77 d
2iP 100	42.79 e	43.86 g	8.45 bc	8.43 f
2iP 200	43.18 e	41.95 h	7.84 c	7.76 g
2iP 300	52.18 cd	53.17 d	8.47 bc	8.52 f
Kin 100	51.80 cd	50.86 e	9.52 bc	9.39 e
Kin 200	54.46 cd	55.75 c	8.99 bc	9.22 e
Kin 300	55.85 c	56.45 c	10.66 ab	11.39 c

Means within columns followed by different letters are significantly different ( $p < 0.05$ ).  
BAP: 6-Benzylaminopurine; 2iP: 6-( $\gamma,\gamma$ -Dimethylallylamino) purine; Kin: Kinetin.

syngonium plants which were sprayed by 2iP at 300 mg/l when compared with other treatments. The control plants tabulated the lowest leaf area (38.19 and 38.99 cm<sup>2</sup>) in both seasons respectively as compared with most of the other treatments. In general, the use of high concentration (300 mg/l) of the three studied cytokinins has increased the leaf area.

As for syngonium foliage fresh, dry weight and roots length, data presented in Table (2) indicated that all these

characteristics were significantly affected by applications of cytokinin types and concentrations as a foliar spray. In both seasons, the highest values of foliage fresh weight (55.35 and 55.75 g), (55.33 and 54.45 g) were obtained from syngonium plants treated with Kin and 2iP at 200 mg/l respectively. On the second rank, applying Kin at 300 mg/l and BAP at 100 mg/l also record higher values than most other treatments (51.16 and 51.36 g) and (50.45 and 51.62 g) respectively in both seasons without any significant differences between



**Fig. 1.** Impact of BAP, 2iP and Kin on vegetative growth of *Syngonium podophyllum* plant after 135 days from the beginning of the experiment during 2019 season.

it and the previous superior treatments. Whereas the lowest foliage fresh weights in both seasons were obtained from the control, BAP at 300 mg/l and 2iP treatments without significant difference between them. In parallel, the use of kinetin at a concentration of 200 mg/l led to pronounced significant values (7.34 and 7.63 g) for foliage dry weight of syngonium plants, comparing with all the other treatments in both seasons, respectively. While the lowest values in this respect were recorded by applying 2iP at 100 mg/l and the control treatments.

Although the maximum root length values in both seasons were obtained from the control treatment (104.00 and 103.07 cm), applying Kin at 300 mg/l, Kin at 200 mg/l, Kin at 100 mg/l as well as BAP at 300 mg/l, gave high root length values without significant differences between them and the previous one (control). While the shortest roots length was obtained from plants sprayed with 2iP at 100 mg/l (48.83 and 51.20 cm) in both seasons, respectively.

Data illustrated in Table (3) indicated that during both seasons roots fresh weight per plant was significantly affected by application of some cytokinin concentrations as a foliar spray. Plants treated with BAP at 100 mg/l gave the highest roots fresh weight per plant (74.52 and 76.14 g) when compared with the remaining treatments during both seasons, respectively. The second-order resulted from spraying BAP at 200 mg/l (67.88 and 65.58). Also, it was obvious that there were no significant differences between the control and plants sprayed with 2iP at 300 mg/l, Kin 100, 200, or 300 mg/l during the first season. Moreover, insignificant differences between the control plants and plants treated with Kin at 100 and 200 mg/l were obtained in the second season. The lightest weights (42.79 and 43.86 g), (43.18 and 41.95 g) were obtained from plants sprayed with 2iP at 100 and 200 mg/l in both seasons, respectively. In parallel, the treatments that gave the highest values of the roots fresh weight

recorded the highest roots dry weight. Since applying BAP at 100 or 200 mg/l recorded pronounced significant values in roots dry weight compared to control and other treatments.

#### **Impact of BAP, 2iP and Kin foliar application on chemical contents:**

As for the influence of the studied cytokinins on chlorophyll a, b, a+b and total carotenoids in *Syngonium podophyllum* leaves, it was clear from data in Table (4) that applying BAP, 2iP and Kin significantly enhanced these characteristics as compared with the control plants. In addition, the highest chlorophyll a, b, a+b and total carotenoids contents in both seasons were achieved using the 2iP at 200 mg/l. The second highest significant chlorophyll a, b, a+b and total carotenoids contents in the leaves was achieved by using 2iP at 300 mg/l and the third one recorded for using Kin or BAP at 300 mg/l.

On the other side, data in Table (5) cleared that the highest total phenolics contents in both seasons were achieved using BAP at 200 mg/l (11.38 and 10.66 mg GAE/g DM). Also, applying BAP at 100 or 300 mg/l recorded superior total phenolics values, comparing the rest treatments. In contrast, the control plants and the others which sprayed with all Kin concentrations tabulated the lowest values in that respect. Moreover, spraying syngonium with 2iP at 200 mg/l significantly increased the total carbohydrates percentage in leaves as compared with the control plants. In addition, applying BAP at 200 mg/l, followed by 2iP at 300 mg/l, BAP at 300 mg/l and Kin at 200, 300 mg/l, is listed in descending order for this trait. While non-significance differences between the remaining treatments and the control one. On the other hand, the control plants significantly enhanced the proline content ( $\mu\text{g/g fw}$ ) in syngonium leaves as compared with all cytokinin types and concentrations treatments.

**Table 4. Impact of BAP, 2iP and Kin on chlorophylls pigments (mg/g F.W.) of *Syngonium podophyllum* plant after 135 days from the beginning of the experiment during 2019 and 2020 seasons.**

Cytokinins treatments (mg/l)	Chl (a)		Chl (b)		Total chl (a+b)		Carotenoids	
	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season
Control	0.418 c	0.422 f	0.159 d	0.148 e	0.577 cd	0.571 f	0.218 d	0.216 ef
BAP 100	0.461 ab	0.459 c	0.175 cd	0.165 d	0.636 c	0.624 d	0.233 cd	0.230 d
BAP 200	0.437 bc	0.429 e	0.132 d	0.146 e	0.570 d	0.576 f	0.208 d	0.213 ef
BAP 300	0.470 a	0.471 b	0.228 bc	0.234 bc	0.698 b	0.705 bc	0.248 bc	0.245 c
2iP 100	0.450 ab	0.452 d	0.168 d	0.172 d	0.617 cd	0.624 d	0.220 d	0.219 e
2iP 200	0.465 ab	0.463 c	0.427 a	0.438 a	0.892 a	0.901 a	0.304 a	0.302 a
2iP 300	0.474 a	0.476 ab	0.261 b	0.235 b	0.736 b	0.712 b	0.267 b	0.261 b
Kin 100	0.452 ab	0.450 d	0.150 d	0.144 e	0.602 cd	0.593 e	0.217 d	0.212 f
Kin 200	0.470 a	0.472 b	0.223 bc	0.229 bc	0.694 b	0.701 c	0.251 bc	0.246 c
Kin 300	0.479 a	0.483 a	0.226 bc	0.227 c	0.704 b	0.710 bc	0.255 bc	0.254 b

Means within columns followed by different letters are significantly different ( $p < 0.05$ ).

BAP: 6-Benzylaminopurine; 2iP: 6-( $\gamma,\gamma$ -Dimethylallylamino) purine; Kin: Kinetin.

**Table 5. Impact of BAP, 2iP and Kin on total phenolics (mg GAE/g DM), total carbohydrates (%) and proline ( $\mu\text{g/g}$  F.W.) of *Syngonium podophyllum* plant after 135 days from the beginning of the experiment during 2019 and 2020 seasons.**

Cytokinins treatments (mg/l)	Total phenolics (mg GAE/g DM)		Total carbohydrates (%)		Proline ( $\mu\text{g/g}$ FW)	
	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season
Control	5.09 e	4.87 e	21.58 d	20.75 d	70.19 a	66.77 a
BAP 100	10.40 b	10.42 a	21.39 d	21.73 cd	21.27 d	22.36 e
BAP 200	11.38 a	10.66 a	22.42 d	22.78 cd	16.23 f	14.23 h
BAP 300	10.67 b	9.46 b	26.98 b	27.45 b	38.58 b	36.12 c
2iP 100	4.44 f	4.07 f	24.51 c	23.78 c	19.20 e	16.21 g
2iP 200	6.30 d	5.29 e	32.42 a	34.12 a	17.85 ef	14.85 h
2iP 300	7.51 c	7.06 c	27.75 b	26.67 b	34.86 c	33.06 d
Kin 100	7.02 c	6.21 d	22.52 d	21.41 d	37.39 b	39.48 b
Kin 200	5.16 e	6.05 d	26.47 b	26.65 b	20.98 d	22.64 e
Kin 300	5.02 ef	4.41 f	26.55 b	26.67 b	17.23 f	17.97 f

Means within columns followed by different letters are significantly different ( $p < 0.05$ ).

BAP: 6-Benzylaminopurine; 2iP: 6-( $\gamma,\gamma$ -Dimethylallylamino) purine; Kin: Kinetin.

The second highest proline contents were obtained from using Kin at 100 mg/l and BAP at 300 mg/l.

The concerned data in Table (6) showed that spraying syngonium with most concentrations of used cytokinins increased the nitrogen (N), phosphorous (P) and potassium (K) percentages in leaves compared with the control during the 2019

and 2020 seasons. Moreover, spraying 2iP at 300 mg/l gave the highest percentages of nitrogen in both seasons as compared with other treatments. While the highest percentage of P and K was recorded when 2iP at 200 mg/l in both seasons were applied. On the other hand, the lowest N, P and K percentages in leaves were recorded for the untreated plant in both seasons of study.



**Table 6. Impact of BAP, 2iP and Kin on macro-nutrients (%) of *Syngonium podophyllum* plant after 135 days from the beginning of the experiment during 2019 and 2020 seasons.**

Cytokinins treatments (mg/l)	N %		P %		K %	
	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season
Control	0.782 d	0.776 j	0.050 d	0.054 e	0.224 f	0.196 h
BAP 100	1.015 b-d	0.988 h	0.067 cd	0.056 e	0.272 d-f	0.274 f
BAP 200	0.891 cd	0.873 i	0.074 bc	0.078 d	0.268 ef	0.255 g
BAP 300	1.215 ab	1.222 d	0.086 a-c	0.088 c	0.326 b-d	0.332 d
2iP 100	1.083 a-c	1.103 f	0.078 bc	0.083 c	0.290 c-e	0.295 e
2iP 200	1.230 ab	1.246 c	0.106 a	0.103 a	0.411 a	0.388 a
2iP 300	1.312 a	1.301 a	0.091 ab	0.096 b	0.355 b	0.362 b
Kin 100	1.068 a-c	1.040 g	0.075 bc	0.077 d	0.290 c-e	0.288 e
Kin 200	1.203ab	1.207 e	0.087 a-c	0.094 b	0.328 bc	0.331 d
Kin 300	1.266 ab	1.255 b	0.086 a-c	0.084 c	0.334 bc	0.343 c

Means within columns followed by different letters are significantly different ( $p < 0.05$ ).

BAP: 6-Benzylaminopurine; 2iP: 6-( $\gamma,\gamma$ -Dimethylallylamino) purine; Kin: Kinetin.

## DISCUSSION

Most houseplants are tropical evergreen species that adapted to survive in a tropical climate which ranges from 15 °C to 25 °C (60 °F to 80 °F) year-round. The natural range of plant species, the varieties of which are used as houseplants, allows important conclusions to be drawn about their husbandry requirements. As a result of climate change, it has become important to try to protect these plants from various stress factors like changes in temperature, humidity and air content of various gases that are harmful to it.

Literature data make it conceivable to infer that cytokinins assume a significant part in the line of plant protection from unfavorable impacts; in any case, the impact of these hormones relies upon stress intensity. Under modest stress, cytokinins guarantee support of plant development, while a drop in cytokinins obstructs development under the effect of stress (Veselov *et al.*, 2017). Also, cytokinins advance cell division and cell extension in plant tissue and various research have declared fitting cytokinin types and their concentrations for each species (Ružić and Vujović, 2008).

Generally, the consequences of this research exhibited that there were positive connections between's cytokinins application as a foliar spray and most vegetative over-the-ground and root boundaries and in the inside chemical substance of *Syngonium podophyllum* L. plant.

The best vegetative parameters are affected by application with different cytokinin concentrations (Table, 1). Where, the best plant height was obtained when 2iP at a concentration of 200 mg/l was applied, followed by BAP at 200 mg/l. The maximum number of leaves for plants sprayed with BAP at 200 mg/l, followed by Kin at 100 mg/l, then 2iP at 200 mg/l respectively in both seasons with insignificant differences between them. The highest values of leaf area were recorded when syngonium plants were sprayed with 2iP at 300 mg/l. In this regard, Khandaker *et al.* (2018) reported that kinetin further developed the height of the plant, number of leaves, branches number and the area of leaf in stevia plants which might be because of the activations of apical and lateral meristems. These results are following those of Yadav (2013) who announced that big leaf area characteristics obtained in marigold leaves were when used

kinetin at 150 mg/l. These results were parallel with those reported by Liang *et al.* (2010) who showed that kinetin controls leaf development. Also, Singh (2006) found that foliar spray with kinetin at 10 mg/l at vegetative and flowering stages improved all growth characteristics as well as the produce of okra crop. While Almeer (2020) noticed that the average number of vegetative branches of the Hillawi cultivar date palm significantly increased when using BAP compared to 2iP and Kin. Similarly, results recorded by Taheri and Haghghi (2018) cleared that foliar application of BAP enhanced the plant height, shoot and root dry weight in bell pepper. In addition, the utilization of 6-Benzylaminopurine expanded the number of leaves in orchids plants (Mishra, 2018). Comparable results were found by Nambiar *et al.* (2012) in *Dendrobium* hybrid as they announced that utilization of BAP (150-200 mg/l) expanded the leaves number.

Applying Kin and 2iP at 200 mg/l, gave the highest values of foliage fresh weight of *Syngonium podophyllum* plants, followed by treatments of Kin at 300 mg/l and BAP at 100 mg/l (Table, 2). Also, treatments with 2iP produced plants which mainly large and influenced considerable the foliage fresh and dry values, particularly at medium concentrations (200 mg/l). As for foliage weights, the increase was recorded with a decline in BAP concentration. On the application with mentioned concentrations of applied cytokinins, our results suggest the roots shortened when compared with untreated plant, which is largely a positive impact caused stronger stem, with large leaves and good characteristics.

The superior root fresh and dry weights were obtained from the treatments of BAP at 100 mg/l (Table, 3). This result clears an inverse relationship between BAP concentrations and these parameters. Since, applying BAP at higher concentrations (200 or 300 mg/l), reduced the root fresh and dry weights values compared with the lowest concentration one (100 mg/l). These results

may be because of cytokinins-driven diversion of assimilates and mineral nutrients towards shoot meristems, rather than to roots (De Lojo and Di Benedetto, 2014).

Using cytokinins not only improves vegetative growth but also enhances pigments. Where all used cytokinins significantly promoted pigments content of *Syngonium* fresh leaves (Table, 4). The highest chlorophyll a, b, a+b and total carotenoids contents in both seasons were achieved using the 2iP at 200 mg/l. The second highest values in those parameters were achieved using 2iP at 300 mg/l, the third-highest were that of Kin and BAP at 300 mg/l. These results are in harmony with those of (George and Shemington, 2008) who's reported that the increases in chlorophylls formation and protein synthesis in tissues were a result of treating with synthetic cytokinins. Exogenous application of kinetin increased photosynthetic pigments contents in the leaves of corn (Kaya *et al.*, 2010). In addition, kinetin protects chlorophylls against the photo-oxidation process by enhancing the concentration of carotenoids (Petrenko and Biryukova, 1977). The application of cytokinin may increase the content of chlorophylls in leaf tissues because it reduced chlorophyll degradation and delays the aging process (Xu *et al.*, 2011).

Our obtained data cleared that spraying *Syngonium* plants with most concentrations of cytokinins significantly enhanced total phenolics content in the leaves as compared with the untreated plants. The maximum total phenolics content in the leaves in both seasons was achieved when applying BAP at 200 mg/l, followed by the same cytokinin type (BAP) and 2iP at 300 mg/l. these results were in the same line with those obtained by Aslam *et al.* (2016) on spinach who revealed that foliar application of plant growth regulators improved the content of individual phenolic acids in the leaves as compared with the controls. Moreover, spraying *Syngonium* with 2iP at 200 mg/l

significantly increased total carbohydrates percentage as compared with the untreated plants. the second-highest total carbohydrates content was obtained from spraying BAP at 200 mg/l, 2iP or BAP at 300 mg/l and Kin at 200, 300 mg/l. while no significant differences between the remaining treatments and the control one. While the highest proline content was achieved from the untreated plants, followed by Kin at 100 mg/l. This agreed with Aslam *et al.* (2016) since they recorded a decrease in the proline contents as a response to the plant growth regulators treatments comparing with the control.

Our findings showed that spraying syngonium with most concentrations of used cytokinins increased the N, P and K percentages compared to the control, (Table, 6). This result was supported by the findings of Ruffel *et al.* (2011), as they cleared that cytokinins appear to increase the nitrogen content in plants. Similarly, Singh and Paliwal (2017) revealed that utilization of kinetin expanded phosphorus, nitrogen and protein content in okra fruit, and this might be because of plant senescence. Also, Moatshe *et al.* (2011) found that leaf mineral content of Morula tree sprayed with BAP had significantly higher than control trees

## CONCLUSION

From our findings, it could be concluded that among the different synthetic cytokinins, the applied *Syngonium podophyllum* plants were effectively controlled beside improving the vegetative growth and chemical contents when BAP at 100 mg/l, 2iP at 200 mg/l and Kin at 200 mg/l were used as a foliar application under the conditions of this study.

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## استجابة نبات السينجونيوم للرش الورقي ببعض أنواع وتركيزات السيتوكينينات الصناعية

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تم إجراء هذا البحث لتقييم تأثير ثلاثة سيتوكينينات اصطناعية [البنزيل أمينو بيورين (BAP)، داي ميثيل أليل أمينو بيورين (2iP) و الكينيتين (kinetin)] بثلاثة تركيزات لكل نوع (١٠٠، ٢٠٠ و ٣٠٠ ملجم/لتر) بجانب معاملة الكنترول (ماء الصنبور) على النمو الخضري وبعض التحاليل الكيميائية لنباتات السينجونيوم. تم تنفيذ تجربتي أصص خلال الموسمين المتتاليين لعامي ٢٠١٩ و ٢٠٢٠ بمزرعة تجارية ببلقاس خامس، بمحافظة الدقهلية بمصر. وقد أظهرت النتائج التي تم الحصول عليها بشكل عام أن رش الأنواع الثلاثة وتركيزات السيتوكينينات الاصطناعية عزز بشكل كبير كل من طول النبات، وعدد الأوراق/النبات، ومساحة الورقة، ووزن الأوراق الرطب والجاف، وطول الجذر، ووزن الجذر الطازج والجاف وذلك بالمقارنة بنباتات الكنترول. علاوة على ذلك، تفوق رش السيتوكينينات الاصطناعية وزاد معنوياً النسبة المئوية للنيتروجين والفسفور والبوتاسيوم ومحتوى كل من الكربوهيدرات، الفينولات الكلية، الكلوروفيل والكاروتينويدات بالأوراق مقارنة بالكنترول. وكان واضحاً في الوقت نفسه، أن المعاملة باستخدام 2iP بتركيز ٢٠٠ ملجم/لتر، قد سجلت

أعلى القيم لمعظم صفات النمو الخضري (طول النبات، عدد الأوراق ووزن الأوراق الطازج) والتركيب الكيميائي (الكلوروفيل أ، ب، أ+ب، كاروتينويدات، محتوى الكربوهيدرات و النسب المئوية لـ NPK في الأوراق) بالمقارنة مع المعاملات الأخرى. ومع ذلك، فإن رش الكينتين بتركيز ٢٠٠ ملجم/لتر أعطى قيم أعلى للوزن الطازج والجاف للأوراق والكلوروفيل أ عن التراكيز الأخرى. علاوة على ذلك، أعطى رش BAP بتركيز ١٠٠ ملجم/لتر أعلى وزن طازج وجاف للجذور. بينما أعطى رش BAP بمعدل ٢٠٠ ملجم/لتر أعلى قيمة لمحتوى الفينولات الكلية مقارنة بالمعاملات الأخرى. بشكل عام، يمكن ترتيب أنواع وتركيزات السيتوكينينات التي تم دراستها تنازليا لتأثيراتها الإيجابية على نبات السنجونيوم كالتالي 2iP بتركيز ٢٠٠ ملجم/لتر ثم BAP بتركيز ١٠٠ أو ٢٠٠ ملجم/لتر وأخيرا الكينتين بتركيز ٢٠٠ ملجم/لتر.