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RESPONSE OF *Stevia rebaudiana* Bertoni TO FOLIAR APPLICATION OF GA_3 AND IBA
1. Morphological and yield traits

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ABSTRACT
The field experiment was carried out during the two successive seasons 2007/08 and 2008/09 aiming to investigate all the factors that may affect the morphological traits of stevia plants; *Stevia rebaudiana* Bertoni. Two different types of growth regulators; GA_3 and IBA with three concentrations 0, 250 and 500 ppm, in addition to two sprays. The most remarkable results could be summarized, with regard to the adopted concentrations or number of sprays, GA_3 treatments generally caused elevation in the averages of plant height and the number of branches per plant as compared with IBA treatments. Plants received two sprays regardless of the type of the used growth regulators (GR's) or the used concentration were the tallest and more branched. In addition, a positive relationship could be established between averages of plant height and the number of branches per plant and the adopted concentration. The interaction between the three studied factors proved that the double spray treatment by GA_3 with 500 ppm showed a remarkable elevation in the mean values of all studied morphological and yield characters.

Key words: *GA_3 , IBA, morphology, Stevia rebaudiana, yield.*

1. INTRODUCTION
Stevia rebaudiana Bertoni is a herbaceous perennial, normally used as a natural herbal sweetener and commonly known as honey leaf. It is one of 154 species of the genus *Stevia* which belongs to family Asteraceae (Compositae). All are distributed in the New World, from the Southwestern United States to the Northern Argentine and became known by the Europeans due to its discovery by Antonio Bertoni in 1887 **(**David and Rank, 2002). Commercially the plant and its extracts are also used as a diet programme. The plant is also used to treat diabetes, hypoglycemia, candidacies, high blood pressure, skin abrasions and to inhibit the growth and reproduction of certain bacteria-like plaque. The greatest economic potential of stevia is its use as a natural alternative to artificial sweeteners (such as aspartame or sodium saccharin).

Stevia was introduced to Egypt in 1990 as a source of natural sweet product for low energy foods. Stevia has many advantages to be used in Egypt since it succeeds in poor lands with moderate water and fertilizer requirements plus its high potential for yield under warm climates. The necessary steps to expand stevia cultivation in Egypt are the development of seeds, care of seedlings and appropriate agri-practices, including information on optimized crop inputs. Understanding of the biology and agricultural practices of stevia are prerequisites for the adoption and successful cultivation of stevia to be a new economic cultivated crop in Egypt, (Attya, 2005).

Gibberellin enhancement of stem elongation in intact plant usually involves increase in both cell numbers and cell length. Studies employing GA-responsive genetic dwarfs (Basford, 1961and Loy and Liu, 1974), plants treated with growth retardants (Sachs and Kofranek, 1963) and rosette plants (Bernier *et al.*, 1964), proved convincing evidence that stimulation of cell division in the sub-apical meristematic zone is a common feature of gibberellins mediated increase in stem elongation. IBA has been identified in a number of plant species from maize (*Zea mays*) and pea (*Pisum sativum*) to (*Arabidopsis thaliana*) and concentrations of free IBA approach the levels of free IAA in a number of plants IBA, like IAA, is also found in conjugated forms, yet at significantly lower levels than IAA. (Ludwig-Muller *et al*., 1993) IBA is the preferred auxin for the induction of root formation because it is much more potent than IAA or synthetic auxins (Ludwig-Muller, 2000).

This work was carried out to investigate the effect of different concentrations of growth regulators; Gibberellic acid (GA_3) and Indole Butyric Acid (IBA) and the number of sprays as well as the different concentrations on some morphological and agronomic characters of stevia plants.

2. MATERIALS AND METHODS

The field experiment was carried out during the two successive seasons 2007/08 and 2008/09 in Agricultural Research Station, Agricultural Research Center, Giza Governorate to study the effects of one and two sprays, (30 days interval after cutting), two different types of growth regulators (GA_3 and IBA) and three adopted concentrations; 0, 250 and 500 ppm on the plant morphology and plant productivity. The used plant material was terminal cuttings 15 cm long secured from Sugar Crops Research Institute. Growth regulator treatments were sprayed early in the morning, till dripping. The following characters were studied; plant height (cm.), number of branches per plant and total leaves dry weight (g.). The yield of dry leaves was estimated by weighing air dried leaves kept in the shade for 5 days. The cutting date, plant age, season and the average day length for each of the four cuts during the experiment are presented in the following tabulation:-

Cut number	Cutting date	Plant age	Season	Ave. day length (hours)
1	25th July	90 days	Summer	13.35
2	25th October	180 days	Fall	11.44
3	25th January	270 days	Winter	10.58
4	25th April	360 days	Spring	12.11

The experiment layout was split split plot design with three replicates. The collected data were subjected to the convenient statistical analysis using the MSTATC (Anonymous, 1986) computer software.

3. RESULTS AND DISCUSSION

3.1. Plant height

Regardless of the cutting or seasonal effects; the single, double and triple interaction effects between the three studied factors will be discussed. It is evident from Table (1 a, b, c, d and e) that the three studied factors significantly affected the average plant height of the four cuttings in both seasons. However, significant effects were detected for the interactions between the factors under study.

3.1.1. Main effects of the studied factors

3.1.1.1. Number of sprays

Table (1 a) shows that, the plants received two sprays regardless of the type of GR or the concentration, became the tallest as compared with the single spray. The highest values of plant height (71.29 and 68.75 cm.) were observed in the 4th cut in the 1st and 2nd seasons as compared with the values of single spray (65.72 and 59.72 cm.). Generally, in the 1st season, the two sprays treatment caused increases in plant height as compared with the single were 5.9, 10.6, 20.7 and 7.8% for the four studied cuts, arranged in ascending order. This was also clear in the second season where the corresponding increase percentages in plant height were 12.4, 14.6, 10.2 and 13.1% for the same cuttings, respectively. It is also noticed that, within each cut, the double sprays caused an increase in the average plant height, especially in the 1st and 4th cuts in both seasons.

3.1.1.2. Type of growth regulator

GA_3 treatment generally caused remarkable elevation in the average plant height as compared with IBA treatment. In the 1st season, GA_3 increased the average plant height by 6.3, 1.3, 13.0 and 10.0% for the four studied cuts as compared with the IBA arranged in ascending order (Table 1 a). The same trend was obtained in the second season where the corresponding increase percentages of plant height were 5.6, 8.7, 14.0 and 11.8% for the same cuttings, respectively. It is also observed that, in both seasons within each cut, the GA_3 treatment enhanced the average plant height especially in the case of the 1*st* and 4*th* cuts. The enhancement effect of GA_3 on the average plant height is commonly reported by many workers (*e.g* Mander, 2003) who reported that, gibberellins are important plant growth hormones with agricultural applications and influence a wide range of physiological properties like germination, stem elongation and flowering.

3.1.1.3. Adopted concentration

Statistically, the plants treated with the highest concentration (500 ppm) were taller than those treated with the lowest one (0 ppm). Positive relationship was established between the average plant height and the used concentrations. Relative to the control, in the 1*st* season, two sprays by 500 ppm caused increases in plant height as compared with a single spray by 5.9, 10.6, 20.7 and 7.8% for the four studied cuts arranged in ascending order, (Table, 1 a). These findings are in agreement with the results reported by Bhattachartee *et al.,* (2000) and Abou-Bakr and El-Sgai (2001).

3.1.2. The interaction between the number of sprays and the used growth regulators

Data in Table (1 b) prove that, in both seasons, double sprays with GA_3 were the most favorable treatment for enhancing the highest average plant height, as these averages, in the 1st season were, 63.55, 38.56, 22.43 and 73.83 cm. for the four studied cuts arranged in ascending order. The corresponding recorded values for the second season were, 64.35, 32.38, 19.38 and 74.33 cm. Single spray with GA_3 showed the same trend with high magnitude as compared with single or double spray with IBA. Relative to the single spray with GA_3, the increased percentages due to double sprays were 4.3, 21.3, 3.2 and 4.8% in the 1st season and were 7.0, 19.0, 1.1 and 15.4% in the 2nd one for the four studied cuts, respectively. The interaction effects between the number of foliar applications of growth hormones were early reported by many investigators on different plant species (Ebad *et al.,* 1990).

3.1.2.1. The interaction between the number of sprays and the used concentration

Regardless of the used growth regulators, the

Table (1 a): Main effects of the number of sprays, types of GR and the adopted concentration on the average stevia plant height in 2007-08 and 2008-09 seasons

Treatments		2007-08				2008-09			
		1*st* cut	2*nd* cut	3*rd* cut	4*th* cut	1*st* cut	2*nd* cut	3*rd* cut	4*th* cut
Number of sprays	**One spray**	59.39	35.77	19.64	65.72	52.61	27.17	17.81	59.72
	Two sprays	63.11	40.03	24.77	71.29	60.09	31.82	19.83	68.75
L.S.D at 0.05		2.90	1.749	2.10	4.36	1.823	2.20	1.50	3.55
Growth regulator	**GA_3**	62.24	38.16	21.08	72.14	57.99	29.79	19.17	69.36
	IBA	58.26	37.64	18.33	64.88	54.71	27.19	16.47	61.11
L.S.D at 0.05		1.49	0.24	0.73	1.23	1.73	2.23	1.53	0.64
Concentration of growth regulator	**0 ppm**	54.78	35.86	17.42	65.00	52.68	24.71	16.50	61.54
	250 ppm	61.08	37.72	19.76	66.99	55.47	27.62	17.17	63.37
	500 ppm	64.89	40.11	21.94	73.54	60.89	33.15	19.79	67.79
L.S.D at 0.05		**1.97**	**1.26**	**0.84**	**1.40**	**1.55**	**2.53**	**1.58**	**2.01**

Table (1 b): Effect of interaction between the number of sprays and growth regulators on the average plant height of stevia plant in 2007-08 and 2008-09 seasons.

Treatments		2007-08				2008-09			
Number of sprays	**Growth regulator**	**1*st* cut**	**2*nd* cut**	**3*rd* cut**	**4*th* cut**	**1*st* cut**	**2*nd* cut**	**3*rd* cut**	**4*th* cut**
One spray	**GA_3**	60.93	31.78	21.73	70.45	60.16	27.56	19.17	64.39
	IBA	57.85	25.76	19.56	61.00	52.39	26.78	16.44	55.06
Two sprays	**GA_3**	63.56	38.56	22.43	73.83	64.35	32.81	19.38	74.33
	IBA	58.67	30.50	17.11	68.76	55.83	26.83	16.50	63.17
L.S.D at 0.05		**1.36**	**1.48**	**1.03**	**1.74**	**2.45**	**3.15**	**1.23**	**0.91**

interaction between the number of sprays and the adopted concentration, significantly affected the average plant height (Table 1 c). It is evident that zero concentration (control) showed the shortest plants either with single or double sprays. However, 250 ppm concentration significantly enhanced the average plant height. While, the plants treated with the highest concentration 500 ppm were taller than those treated with 250 ppm. Positive relationship could be established between the used concentration and plant height, as the adopted concentration was higher the plant height increased. Relative to the control, in the 1st season, two spray treatments with 500 ppm caused the highest plant height as compared with single spray treatments. The average increased percentages due to double sprays with 500 ppm were 18.9, 19.4, 32.1 and 20.2% for the four studied cuts arranged in ascending order, respectively. The corresponding increased percentages in the second season were 36.9, 40.1, 25.1 and 24.8%. The same trend was obtained but with less percentage in the case of single spray with the same adopted concentration (500 ppm).

Table (1 c): Effect of interaction between the number of sprays and the concentration of growth regulator on the stevia plant height in 2007-08 and 2008-09 seasons

Treatments		2007-08				2008-09			
Number of sprays	Concentration	1st cut	2nd cut	3rd cut	4th cut	1st cut	2nd cut	3rd cut	4th cut
One spray	0 ppm	54.78	32.89	17.17	61.17	48.67	23.58	16.42	56.83
	250 ppm	60.94	34.92	18.92	64.70	52.00	26.42	18.17	59.25
	500 ppm	63.44	39.50	21.85	71.30	57.17	31.50	18.83	66.25
Two sprays	0 ppm	55.78	34.93	16.67	63.03	47.20	24.83	16.58	58.08
	250 ppm	61.22	40.53	20.61	69.27	58.95	28.83	17.37	67.50
	500 ppm	**66.33**	**41.72**	**22.03**	**75.78**	**64.62**	**34.80**	**20.75**	**72.50**
L.S.D at 0.05		**1.19**	**1.78**	**1.18**	**1.98**	**1.48**	**1.10**	**0.37**	**2.84**

3.1.2.2. The interaction between the used growth regulators and the concentration used

Data presented in Table (1 d) reveal that in both seasons, GA_3 treatments with 500 ppm concentration was the most favorable treatment for enhancing the plant height, as the average recorded values in the 1st season were 66.0, 41.9, 23.18 and 76.83 cm for the four studied cuts arranged in ascending order. The corresponding recorded values for the second season were 61.83, 34.22, 20.67 and 74.83 cm for the same cuts arranged in the same order. Positive relationship could be established between plant height and the used GA_3 concentration. IBA treatments showed same trend when used with any adopted concentrations 0, 250 and 500 ppm. The highest used 500 ppm concentration of IBA showed remarkable increase in the average plant height as, compared extent to GA_3.

3.1.2.3. The interaction between the used growth regulators, the used concentration and number of sprays

Data presented in Table (1 e) show that the triple interaction between these factors was significant in both seasons and with all studied cuts. The highest recorded plant height was associated with double

Table (1 d): Effect of the **interaction between growth regulators and the adopted concentration on stevia plant height in 2007-08 and 2008-09 seasons.**

Treatments		2007-08				2008-09			
Growth regulator	Concentration	1st cut	2nd cut	3rd cut	4th cut	1st cut	2nd cut	3rd cut	4th cut
GA_3	0 ppm	57.5	35.55	18.42	67.75	55.5	26.42	16.33	65.17
	250 ppm	63.22	39.03	21.65	71.84	58.53	28.75	18.50	68.08
	500 ppm	66.00	41.90	23.18	76.83	61.83	34.22	20.67	74.83
IBA	0 ppm	55.06	36.17	16.42	61.25	50.87	24.80	14.67	55.02
	250 ppm	58.94	37.42	17.88	62.13	52.42	26.50	15.83	58.67
	500 ppm	61.78	39.33	20.00	68.50	56.95	29.14	17.10	60.75
L.S.D at 0.05		**1.29**	**0.48**	**0.51**	**1.98**	**2.2**	**0.71**	**0.47**	**2.84**

sprays by 500 ppm GA_3 treatment.

This treatment proved to be the most reliable one to achieve the tallest stevia plants. Regardless of the seasons and the cutting effects, the used triple treatments could be ranked according to its enhancement effect on the average stevia plant height as follows; double sprays by GA_3 500ppm (29.2%) followed by single spray GA_3 500 ppm (22.6%), double sprays by GA_3 250ppm (17.8%) then single spray by GA_3 250 ppm (11.4%). IBA treatment showed the same trend with very low magnitude as compared with GA_3.

3.2. Number of branches per plant

3.2.1. Main effects of the studied factors

3.2.1.1. Number of sprays

It is clear from Table (2 a) that, the main effect of the number of sprays was significant in both seasons in all cuts. The double sprays led to the highest number of branches/plant as compared with the single spray. In both seasons, the highest numbers of branches/plant were recorded in the first and fourth cuts. The average increased percentages in the number of branches per plant due to the number of sprays, regardless of the cutting, were 15.3 and 17.1% for the first and second seasons, respectively. This result is reflecting the role of the number of sprays on promoting the vegetative growth including branching. Moreover, the highest number of branches/ plant found in the fourth cut (spring cut), was due to the high number of sprouts emerging from under the ground in the spring time giving high numbers of new branches/ plant.

3.2.1.2. Type of growth regulator

The adopted GA_3 application was more likely to increase the number of branches/plant than IBA application (Table 2 a). Therefore, the increase in the number of branches/ plant by using GA_3 was suggested to be the result of increased Stem Apical Meristem (SAM) volume, which is mainly brought from the promotion of the cell division of the pith meristem and peripheral meristem in SAM. It is known that gibberellic acid promotes the longitudinal growth due to both cell elongation and cell division. The increased number of branches has been reported to be positively related to the diameter of SAM (Yamagishi, 1992). He also pointed out that there was a close correlation between the number of branches and the diameter of SAM. El-Shaarawy *et al.* (1982) on roselle plants suggested that GA_3 treatments increased the average number of branches and this was in accordance with the present findings. On the contrary Sakr and El Kady (1981) reported that GA_3 treatments did not affect the total number of branches in faba bean plants.

Table (1 e): Effect of the interaction between number of sprays, growth regulator and the adopted concentration on stevia plant height in 2007-08 and 2008-09 seasons.

Treatments			2007-08				2008-09			
Number of sprays	Growth regulator	Concentration	1st cut	2nd cut	3rd cut	4th cut	1st cut	2nd cut	3rd cut	4th cut
One spray	GA_3	0 ppm	58.89	32.11	17.42	54.83	55.00	22.00	16.67	60.67
		250 ppm	61.44	34.83	20.42	69.40	55.50	27.33	19.50	61.50
		500 ppm	64.44	40.34	21.36	76.55	57.33	33.33	20.33	71.00
	IBA	0 ppm	58.67	33.67	18.92	57.50	52.33	25.17	14.77	57.00
		250 ppm	60.45	35.00	17.42	60.00	55.50	25.50	16.83	58.00
		500 ppm	62.44	38.67	22.33	65.50	57.00	29.67	18.33	55.17
Two sprays	GA_3	0 ppm	56.11	36.00	19.42	56.67	57.40	27.67	16.00	60.67
		250 ppm	65.00	41.23	22.88	75.00	56.33	32.00	17.50	74.67
		500 ppm	69.56	41.44	25.00	77.11	66.33	38.77	22.00	78.67
	IBA	0 ppm	55.45	36.67	15.92	57.00	56.00	22.00	15.17	62.83
		250 ppm	57.44	39.83	18.34	64.27	61.57	25.67	14.83	66.33
		500 ppm	63.11	40.00	19.07	74.28	62.90	30.83	19.50	69.33
L.S.D. 0.05			**3.93**	**2.01**	**1.67**	**2.80**	**3.11**	**1.94**	**1.82**	**4.01**

3.2.1.3. Adopted concentrations

It is obvious from Table (2 a) that in both seasons and all cuts, the number of branches per plant was increased with increasing the used concentrations from 0 to 500 ppm. Direct positive relationship could be established between the used concentration and the number of branches/plant. Relative to the control and regardless of the cuttings, the average increased percentages in the number of branches per plant due to 250 ppm treatment were 20.1 and 14.6% for the 1^{st} and 2^{nd} seasons, respectively. However, for 500 ppm, the

Table (2 a): Main effect of the number of sprays, growth regulators and the adopted concentrations on the number of branches / stevia plant in 2007-08 and 2008-09 seasons.

Treatments		2007-08				2008-09			
		1st cut	2nd cut	3rd cut	4th cut	1st cut	2nd cut	3rd cut	4th cut
Number of sprays	One spray	19.70	5.72	9.69	16.45	20.17	9.33	10.33	22.83
	Two sprays	22.74	7.45	12.10	17.18	21.88	11.89	12.83	26.78
L.S.D at 0.05		0.52	0.36	0.21	0.38	0.93	1.04	2.59	2.76
Growth regulator	GA_3	23.15	7.89	11.85	17.79	23.90	12.83	12.83	26.94
	IBA	21.30	6.27	9.94	15.84	21.15	10.39	10.33	22.67
L.S.D at 0.05		0.31	0.23	0.86	0.69	0.94	1.13	0.91	1.42
Concentration of growth regulator	0 ppm	19.25	5.99	8.90	13.75	17.89	9.25	9.92	20.17
	250 ppm	23.47	7.45	9.83	16.78	19.03	10.33	11.08	25.17
	500 ppm	26.95	8.82	11.95	19.92	26.15	13.25	13.75	29.08
L.S.D at 0.05		**0.34**	**0.41**	**0.53**	**1.14**	**3.32**	**0.79**	**1.06**	**1.88**

corresponding obtained increase percentages were 41.2 and 43.6% for the two seasons in the same order. These results disagree with the findings reported by Reda (1990) who suggested that, using GA_3 at any adopted concentration reduced significantly the average number of branches per pea plant.

3.2.2. The interaction between the number of prays and the used growth regulator

The effect of the interaction between the number of sprays and growth regulator type on branch number/plant was significant in both seasons and all cuts (Table 2 b). In the 1^{st} season, the highest value (26.52 branch/ plant) was recorded on plants received two GA_3 sprays. While in the 2^{nd} season the highest value (29.00 branch/ plant) of the number of branches per plant was recorded with plants received two GA_3 sprays, in the 4^{th} cut. Generally, double sprays by GA_3 treatments were likely more effective in enhancing the number of branches per plant as compared with those treated by IBA. This was further enhanced by increasing the number of sprays. The results indicated that GA_3 application had more important role on increasing the number of branches per plant by increasing the number of applications.

3.2.2.1. Effect of the interaction between the number of sprays and the concentration of growth regulator

It is obvious that, regardless of the used type of growth regulators, applying growth regulator at 500 ppm concentration gave the highest number of branches per plant with either one or two sprays (Table 2 c). The first and the last cuts showed the highest number of branches per plant when received a double spray at 500 ppm concentration being 27.05 and 31.67 branch/ plant, respectively. Relative to the control and over the four cuttings, in the case of single spray by 250 ppm, the average increased percentages in number of branches were, 20.5 and 15.7%, for the 1^{st} and 2^{nd} seasons, respectively. However, in the case of single spray by 500 ppm, the values were 39.8 and 31.2% for the same seasons in the same order. The magnitude of this interaction was nearly doubled when two sprays were applied. Moreover, double applications by 500 ppm resulted in increases in the number of ppm resulted in increases in the number of branches/plant

Table (2 b): Effect of interaction between the number of sprays and growth regulators on the number of branches / stevia plant in 2007-08 and 2008-09 seasons.

Treatments		2007-08				2008-09			
Number of sprays	Growth regulator	1st cut	2nd cut	3rd cut	4th cut	1st cut	2nd cut	3rd cut	4th cut
One spray	GA_3	23.78	7.73	9.86	18.41	21.64	9.56	11.50	25.33
	IBA	20.63	5.71	9.52	15.95	19.69	8.11	9.44	21.22
Two sprays	GA_3	26.52	9.06	11.83	19.17	24.11	12.11	14.44	29.00
	IBA	21.96	6.83	10.36	15.74	20.66	10.67	11.22	24.67
L.S.D at 0.05		**0.64**	**0.58**	**0.36**	**0.31**	**0.69**	**0.28**	**0.21**	**0.65**

by 52.8 and 47.0%.

3.2.2.2. Effect of the interaction between growth regulator type and the used concentrations.

As shown in Table (2 d), and regardless of the number of applications, GA_3 treatments with 500 ppm concentration produced the highest number of branches per plant. Moreover, the first and the last cuts resulted in relatively the highest number of branches per plant. The two growth regulators GA_3 and IBA showed significant effect in the average number of branches plant at any used concentration. The average increased percentage in such trait due to 500 ppm GA_3 treatment as compared with 500 ppm IBA treatment were, 15.64 and 13.40%, for the first and second seasons, respectively. These results reveal the dominant role of growth regulator type with the used concentration on the number of branches per plant since 500 ppm concentration always produces the highest number of branches / plant.

3.2.2.3. Effect of the interaction between the **number of sprays, type of growth regulator and the used concentration**

Triple interaction was used for assigning the best combination of the three studied factors that affected the average number of branches per plant. Data presented in Table (2 e) prove the significant effect of the interaction between the experimental three factors in both seasons and all cuts. Relative to the control, plants that received two sprays of GA_3 at 500 ppm showed the highest number of branches, being 26.89 as compared with 20.89 for the control in the 1st season(1st cut). The corresponding recorded values in the second season, were 31.00 and 19.00 branches per plant in the 4th cut.

Generally and regardless of the cuttings and relative to the control, two sprays of GA_3 at 500 ppm caused increases in the average number of branches per plant ranged between 42.12 to 64.75% for the 1st and 2nd seasons, respectively. It is obvious from Table (2 e) that, in both seasons, the control exhibited less number of branch/ plant comparing with the treated plants. Moreover, the plants treated with GA_3 were more branched than those treated with IBA at the same concentration.

Table (2 c): Effect of interaction between the number of sprays and adopted concentration on the number of branches / stevia plant in 2007-08 and 2008-09 seasons.

Treatments		2007-08				2008-09			
Number of sprays	Concentration	1st cut	2nd cut	3rd cut	4th cut	1st cut	2nd cut	3rd cut	4th cut
One spray	0 ppm	17.61	6.22	8.11	14.92	16.03	7.50	8.83	22.00
	250 ppm	23.39	6.73	9.64	16.73	17.42	9.00	9.83	26.67
	500 ppm	26.11	8.21	11.32	19.90	26.25	11.50	12.33	28.50
Two sprays	0 ppm	18.89	5.75	9.69	12.58	18.75	9.00	9.00	20.33
	250 ppm	23.56	8.17	10.01	16.83	20.65	11.67	12.33	23.67
	500 ppm	28.78	10.42	12.59	19.94	27.05	14.00	15.17	31.67
L.S.D at 0.05		0.48	0.59	0.76	0.66	0.45	0.50	0.38	0.46

Table (2 d): Effect of interaction between growth regulators and the adopted concentration on number of branches / stevia plant in 2007-08 and 2008-09 seasons.

Treatments		2007-08				2008-09			
Growth regulator	Concentration	1st cut	2nd cut	3rd cut	4th cut	1st cut	2nd cut	3rd cut	4th cut
GA_3	0 ppm	21.78	6.67	8.68	13.42	18.12	9.50	9.33	21.00
	250 ppm	23.67	8.34	9.76	15.89	22.25	11.00	10.33	23.83
	500 ppm	26.00	10.67	12.10	21.62	26.33	12.00	16.17	31.83
IBA	0 ppm	19.72	5.30	9.11	14.08	17.67	9.00	10.50	22.50
	250 ppm	23.28	6.55	9.90	17.67	19.82	10.67	11.03	26.50
	500 ppm	23.89	7.96	10.81	18.23	25.97	12.50	11.83	26.33
L.S.D at 0.05		0.48	1.42	0.50	1.48	0.57	0.61	1.24	2.71

3.3. Total yield of dry leaves per plant (g)

3.3.1. The main effects

3.3.1.1. Number of sprays

Table (2 e): Effect of interaction between the number of sprays, growth regulators and the adopted concentrations on the number of branches per stevia plant in 2007-08 and 2008-09 seasons.

Treatments			2007-08				2008-09			
Number of sprays	Growth regulator	Concentration	1st cut	2nd cut	3rd cut	4th cut	1st cut	2nd cut	3rd cut	4th cut
One spray	GA_3	0 ppm	20.67	7.33	8.00	14.33	15.07	8.33	8.67	21.67
		250 ppm	23.55	7.68	9.61	16.28	14.67	10.00	9.33	25.00
		500 ppm	26.50	8.17	10.94	20.67	27.17	12.67	14.33	29.67
	IBA	0 ppm	17.55	5.11	8.22	15.50	17.00	6.67	9.00	23.33
		250 ppm	23.22	5.78	9.68	17.18	20.17	8.00	10.33	28.33
		500 ppm	23.67	6.25	10.68	17.23	24.77	10.33	10.57	30.67
Two sprays	GA_3	0 ppm	20.89	6.00	9.37	13.50	21.17	10.67	10.00	19.00
		250 ppm	23.78	9.00	9.90	16.50	21.83	12.00	11.33	22.67
		500 ppm	26.89	11.18	11.97	22.57	29.33	13.67	18.00	31.00
	IBA	0 ppm	18.89	5.50	9.01	13.67	18.33	11.33	12.00	18.67
		250 ppm	23.33	7.33	10.12	18.17	19.47	11.33	13.33	24.67
		500 ppm	26.11	9.67	10.23	19.22	23.33	12.33	14.50	26.33
L.S.D. 0.05			**0.68**	**1.92**	**0.57**	**0.85**	**3.61**	**1.58**	**1.37**	**1.83**

Data presented in Table (3 a) prove that, applying two sprays always resulted in high yield as compared with one spray, being 9.54 and 10.94% increases in the yield of dry leaves per plant in both seasons. It is worthy to mention that the control plants that received tap water showed low yield of dry leaves as compared with the plants received either one or two sprays of growth regulators.

3.3.1.2. Type of growth regulator

Data presented in Table (3 a) indicate that, in both seasons, GA_3 treatments yielded the highest dry leaves per plant compared with IBA treatments. The average increases in leaves dry weight due to GA_3 treatments, as compared with IBA treatments, were 22.22 and 22.21% for the 1st and 2nd seasons, respectively. It is worthy to mention that both used growth regulator type showed high yield of dry leaves as compared with the untreated controls, indicating the advantage of growth regulator treatments on the yield of dry leaves of stevia plant.

3.3.1.3. Adopted concentration

Statistically, significant differences in the yield were detected between the three used concentrations; 0, 250 and 500 ppm (Table 3 a). However, the control showed the lowest yield of dry leaves as compared with the treated plants. It is clear that the highest used dose 500 ppm provided prominent effect on the average of this trait. Relative to the control, the average increased percentages due to 500 ppm treatments were 33.56 and 32.89% for the 1st and the 2nd seasons, respectively. The other used concentration (250 ppm) showed similar effects with relatively low magnitude.

Table (3 a): Effect of the number of sprays, growth regulators and the adopted concentration on the total yield of leaves dry weight/ plant of stevia plant in 2007-08 and 2008-09 seasons.

Treatments		2007-08	2008-09
Number of spray	One spray	90.39	88.37
	Two sprays	99.01	98.04
L.S.D at 0.05		3.01	6.69
Growth regulator	GA_3	101.97	102.97
	IBA	83.43	84.25
L.S.D at 0.05		4.80	6.20
Concentration of growth regulator	0 ppm	78.42	79.81
	250 ppm	94.94	93.76
	500 ppm	104.74	106.06
L.S.D at 0.05		**2.63**	**4.33**

It is also noticed previously by many workers that GA_3 treatment generally enhanced relative leaf area growth rate (LAGR). Since, LAGR, with some exceptions, increased with the rate of foliar GA_3 treatment in stevia plant. It is also reported that foliar spray with 100 ppm GA_3 showed the highest values for plant height, number of branches and leaves, leaf area and dry matter in soybean plant (Deotale *et al*.1998). Leite *et al.* (2003) found that applying gibberellin increased leaf area in soybean. In addition, IBA is a synthetic auxin and is used commercially for enhancing crop production and regulation of plant growth and development of rapid growth such as shoot tissue, young leaves elongation and promotion of lateral root development (Nagel *et al*., 2001).

3.3.2. The interaction between the number of sprays and growth regulator type

Data presented in Table (3 b) show the interaction effects between the used number of sprays and the types of the applied growth regulator. Significant differences were detected between the two studied factors. Generally, in both seasons, double sprays of GA_3 treatments produced the highest yield of dry leaves (97.41 and 99.90 g.) for 1^{st} and 2^{nd} seasons, respectively. In the case of IBA treatments, the plants received double IBA applications recorded higher yield as compared with those treated by single spray. In the first season, the average increase percentage in the yield of dry leaves due to the double GA_3 sprays as compared with single spray was 7.78%. While, it was 5.58% in the case of IBA treatment. The same trend was obtained in the second season, where the increased percentages were 4.78 and 3.73% for GA_3 and IBA treatments, respectively. From the above mentioned results, it is obvious that the effect of growth regulator is more dominant than the effect of the number of sprays.

Table (3 b): Effect of the interaction between the number of sprays and growth regulator on total yield of leaves dry weight per stevia plant in 2007-08 and 2008-09 seasons

Treatments		2007-08	2008-09
Number of spray	Growth regulator		
One spray	GA_3	90.38	95.34
	IBA	82.02	86.20
Two sprays	GA_3	97.41	99.90
	IBA	86.60	89.42
L.S.D at 0.05		4.39	2.10

3.3.2.1. The interaction between the number of sprays and growth regulator concentrations

As shown in Table (3 c), regardless of the type of growth regulator, the highest concentration 500 ppm produced the highest yield of dried leaves per plant. In both seasons the highest yield per plant was recorded on plants received double sprays of 500 ppm, being 108.49 and 112.94 g for the first and the second seasons, respectively.

Table (3 c): Effect of interaction between the number of sprays and concentrations of growth regulators on the total yield of leaves dry weight per stevia plant in 2007-08 and 2008-09 seasons.

Treatments		2007-08	2008-09
Number of sprays	Concentration		
One spray	0 ppm	84.58	84.84
	250 ppm	95.59	91.10
	500 ppm	100.99	99.17
Two sprays	0 ppm	82.25	84.78
	250 ppm	95.29	96.42
	500 ppm	108.49	112.94
L.S.D at 0.05		3.23	2.84

The corresponding recorded yields due to the single spray were 100.99 and 99.17 g. Relative to the control, the average increased percentage in the mean of this trait due to single spray by 500 ppm were 19.40 and 16.89% in both seasons. While in case of double sprays with 500 ppm, the average increased yield percentages were31.9 and 33.21% for the first and second seasons, respectively. Thus, it could be stated that the double spray treatment with the high concentration was apparently more effective for producing stevia high yield.

3.3.2.2. The interaction between type of growth regulator and the used concentration

It is realized that, the interaction between type of growth regulator and the used concentrations was significant. Regardless of the number of used sprays, GA_3 treatments with high concentration 500 ppm caused the highest yield of dried leaves per plant (Table 3 d). Same with relatively lower values in case of 250 ppm concentration, where, GA_3 treatments showed a relatively high yield as compared with IBA.

Table (3 d): Effect of interaction between growth regulators and adopted concentration on total yield of leaves dry weight per stevia plant in 2007-08 and 2008-09 seasons.

Treatments		2007-08	2008-09
Growth regulator	Concentration		
GA_3	0 ppm	79.81	78.64
	250 ppm	96.54	95.83
	500 ppm	106.10	108.75
IBA	0 ppm	77.03	79.98
	250 ppm	93.34	91.70
	500 ppm	98.20	101.10

Relative to the control, the average increased percentage in the mean of such trait due to 500 ppm GA_3 were 32.94 and 38.29% in both seasons, while 500 ppm IBA treatment increased the yield percentages by 27.00 and 26.0% for the first and second seasons, respectively. The used concentrations of 250 ppm of GA_3 or IBA showed a minute promotion in the mean of such trait.

3.3.2.3. The interaction between number of sprays, type of growth regulators and the used concentrations

The triple interactions between the investigated three experimental factors in both seasons were significant (Table 3 e). Relative to the control, in both seasons, the average yield of dry leaves showed a gradual increasing as the adopted concentration increased and number of sprays.

Table (3 e): Effect of interaction between number of sprays, growth regulator and the adopted concentration on total yield of leaves dry weight per stevia plant in 2007-08 and 2008-09 seasons.

Treatments			2007-08	2008-09
Number of sprays	Growth regulator	Concentration		
One spray	GA_3	0 ppm	74.43	73.99
		250 ppm	93.32	90.58
		500 ppm	100.64	99.40
	IBA	0 ppm	76.86	77.69
		250 ppm	95.21	88.63
		500 ppm	98.37	93.94
Two sprays	GA_3	0 ppm	77.31	75.29
		250 ppm	93.36	101.07
		500 ppm	111.56	113.33
	IBA	0 ppm	77.19	74.27
		250 ppm	97.86	91.77
		500 ppm	101.41	98.73
L.S.D. 0.05			2.72	3.94

To assign the best combined treatment among the three studied factors, data proved that, double sprays by GA_3 at 500 ppm produced the highest yield 111.56 and 113.33 g. per plant in the 1^{st} and 2^{nd} seasons, respectively. Comparing the yield of plants that received two sprays of GA_3 at 500 ppm and two sprays of IBA at the same concentration, showed an increased yield by 10.0 and 14.0% for the first and the second seasons, respectively. The corresponding increased yield percentages in case of single spray were 2.0 and 5.0% for both seasons in the same order. It is also noticed that, relative to the control, over the two seasons, the average increased percentages due to 500 ppm concentrations were 34.5, 23.5% and 47.0%, 30.0% for GA_3 single and double sprays and IBA single and double sprays, respectively. This emphasized the tremendous effect of GA_3 on the yielding ability of stevia dry leaves.

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استجابة نبات الإستيفيا للمعاملة بحمض الجبريليك وحمض الإندول بيوتريك
1-الصفات المورفولوجية وصفات المحصول

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ملخص

اجريت التجربة الحقلية خلال موسمي 2007-2008 و 2008-2009 وتهدف الدراسة الي إلقاء الضوء علي العوامل التي قد تؤثر في الصفات المورفولوجية لنبات الإستيفيا. وهذه العوامل هي استخدام نوعين من منظمات النمو وهما حمض الجبريليك (GA_3) وحمض الاندول بيوتريك (IBA) بثلاثة تركيزات 0- 250 و500 جزء في المليون، و رشتين من كل منظم. و أوضحت النتائج وبغض النظر عن التركيزات المستخدمة وعدد الرشات أن المعاملة بمنظم النمو GA_3 عموما سبب ارتفاعا ملحوظا في متوسط طول النبات وعدد الأفرع مقارنة بمنظم النمو IBA . أظهرت النباتات التي رشت مرتين بمنظمات النمو بغض النظر

عن نوعه او التركيز المستخدم اظهرت ارتفاعا ملحوظا في طول وعدد الأفرع. كذلك أمكن ايجاد علاقة ايجابية بين متوسطات طول النبات وعدد الفروع والتركيزات المستخدمة. اثبت التفاعل بين العوامل الثلاثة ان استخدام GA_3 بتركيز 500 جزء في المليون في رشتين أدي الي ارتفاع ملحوظ في كل الصفات المورفولوجية وصفات المحصول.

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