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Effect of Some Growth Regulators on Growth, Flowering, Seed Yield and Total Alkaloids Content of *Atropa Belladonna*

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ABSTRACT. *Atropa belladonna* is an important plant for its medicinal uses. The medicinal effect is mainly due to atropine, Hyoscyamine and scopolamine content are found in leaves, roots and ripe berries. Several growth regulators treatments on growth, flowering, seed yield and total alkaloids content of belladonna plants were carried out. Results showed that 400 ppm IAA was the most effective treatment for producing the highest plants, largest leaf number/plant, heaviest vegetative growth, largest number of flowers/plant, highest seed yield/plant and the highest total alkaloids content in leaves, stem, roots and ripe berries. Cycocel at 4000 ppm was the most effective dose for inducing early flowering, producing the highest number of branches/plant and the heaviest roots weight/plant. Taller plants (47-52 cm) were produced when the plants were sprayed with 200 ppm GA_3 compared to other treatments.

Introduction

Atropa belladona L., family Solanaceae is considered a very important medicinal plant for producing alkaloids which are used for various medical purposes. Ideal plant has a thick, fleshy root and a stout erect stem, simple at the base and branched above 1 to 1.5 meters height. The flowers are growing from the leaf axils. The fruit is a berry rather like a small cherry. The drugs are produced from the root and leaves (Baily 1947).

Many workers used growth regulators such as GA_3, IAA and CCC to influence the growth, flowering, seed yield and active ingredients of ornamental and medicinal plants. Positive effects were obtained in the aforementioned characters when IAA or

GA_3 were applied (Lang 1959, on *Hyoscyamus nigra,* Sinha and Varma 1970, on *Datura innoxia,* Rafaeel 1976, on *Hyoscyamus muticus,* El-Tabbakh *et al.* 1982, on *Helianthus annus* and Mahmoud 1987, on some saponin containing plants). On the other hand, few studies indicated a negative effect on active ingredients content by using GA_3 spray (Sciuchetti 1964, on *Datura stramonium* and Ahmed and Malik 1965, on *Hyoscyamus muticus*). In addition, CCC induced more branches, reduce plant height, enhanced or delayed flowering, increased seed yield and active ingredients content/plant (Jasa *et al.* 1972, on *Salvia splendens,* Rafaeel 1976, on *Hyoscyamus muticus* and Kater 1982, on *Cyamopsis tetragonoloba*).

The present work aimed to study the effect of some growth regulator treatments on growth, flowering, and active ingredients in belladonna growth. The most effective treatments that would allow to get the best results of the above mentioned aspects were also investigated.

Material and Methods

This experiment was conducted at the Department of Horticulture, Faculty of Agriculture, Al-Azhar University, Nasr City, Cairo, in two successive seasons 1985/1986 and 1986/1987. The work was intended to study the effect of GA_3, IAA and CCC on growth, seed yield and total alkaloids in different plant organs.

Mature seeds of belladonna plants were carefully sown on October 15*th* in shallow pots. Seedlings were then transferred individually into 8 cm clay pots. When the seedlings became strong, adapted for cultivation and formed complete 8 leaves, they were transplanted individually in 30 cm clay pots which filled with equal and homogeneous amount of Nile silt and arranged in plots of three replicates. The plants were irrigated every 3 days in the summer months and every 5 days in the winter months and were fertilized at the rate of 3 gm ammomium nitrate and 2 gm super phosphate per pot (90 kg N and 60 kg P_2O_5 per feddan, Black 1957). The fertilizers were divided into two equal amounts. The first dose was added 15 days after transplanting, whereas the second was given after one month later. Plants were treated as follows :

A. Gibberellic Acid (GA_3) Treatments: Five concentrations of GA_3 0, 50, 100, 150 and 200 ppm were prepared and sprayed on the plants in two spraying dates; the application first was one month after transplanting in 30 cm clay pots and the second was done one month later.

B. Indole Acetic Acid (IAA) Treatments: Plants were sprayed twice with aqueous solution of IAA at concentration of 0, 50, 100, 200 and 400 ppm. The time of applications was similar to that of GA_3.

C. Cycocel (CCC) Treatments : Plants were sprayed twice with aqueous solution of CCC at concentrations of 0, 500, 1000, 2000 and 4000 ppm. The time of applications was similar to that of GA_3.

The following data were recorded :

a. Vegetative growth : Vegetative growth data were recorded at three developmental stages: a) At plant 170 days old; b) at the beginning of the flowering stage; and c) at ripe berries stage. Such data were as follows: 1) Plant height in cms; 2) Number of leaves per plant; 3) Number of branches per plant; 4) Dry weight of aerial growth in gms; and 5) Dry weight of roots in gms.

b. Flowering Data : Such data included 1) Flowering date: considered as the number of days from sowing to the opening of the first flower. 2) Flowering duration: as the whole period of flowering from the appearance of the first flower until plants ceased flowering.

c. Seed Production. Seeds weight per plant (gm) was also recorded.

d. Chemical Analysis. Total alkaloids content in stems, leaves and root were determined at the three developmental stages, as suggested by Sangster (1960) using the standard curve of Atropine.

Treatments means were separated for significant statistical differences by the mean of the Least Significant Difference (LSD) test at 5% level according to Snedecor (1956).

Results and Discussion

Effect of GA_3, IAA and CCC on *Atropa Belladonna* Plants

1. Effect on plant growth

1.1 Plant Height and Leaf Number/Plant : A constant increase in plant height and leaf number were found due to the advance in plant age till the berry ripening stage (Table 1). This trend was holding true with the three growth regulators at the different stages of plant growth.

Concerning the effect of different GA_3 concentration of plant height and leaf number, data in Table 1 indicated that 200 ppm GA_3 produced significantly taller plants with large leaf number/plant. These results may be due to stem elongation through the elongation of internodes by both cell division and cell elongation caused by GA_3 application as demonstrated by Krishnamoorthy (1981).

On the other hand, spraying IAA at different concentration for the two times increased plant height and leaves number of belladonna plants especially at the highest concentration (400 ppm).

Regarding the effect of spraying CCC, it was evident from the data in Table 1 that a gradual decrease was observed in plant height and number of leaves with the increasing of CCC concentration up to 4000 ppm. The site of such action for CCC is probably due to the inhibition of cell division of subapical meristem (Krishnamoorthy 1981). These results are in accordance with those of Sciuchetti and Born (1965) on *Datura tatula* and Sinha and Varma (1970-1974) on *Datura innoxia.*

1.2 Number of Branches/Plant : The best results for number of branches were obtained at ripe berries stage by using 4000 ppm CCC, 400 ppm IAA or 200 ppm GA_3

TABLE 1. Effect of GA_3, IAA and CCC concentrations sprayed twice on plant height (cms) and number of leaves per plant in *Atropa belladonna* plants during 1985/1986 and 1986/1987 seasons.

Treatment	Character	First season of 1985/86						Second season of 1986/87					
		Plant height (cms)			Number of leaves/plant			Plant height (cms)			Number of leaves/plant		
		*Stages			Stages			Stages			Stages		
		S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
Control		15.9	30.0	43.5	12.3	36.7	54.0	19.9	40.8	51.3	12.0	39.0	51.7
GA_3	50 ppm	14.6	39.2	48.9	12.7	45.3	63.3	18.9	48.9	54.8	12.7	45.7	62.7
	100 ppm	13.7	46.0	57.6	11.7	61.3	77.0	19.6	53.0	59.7	12.0	64.3	76.0
	150 ppm	14.6	50.1	62.0	11.7	68.0	85.7	21.9	58.2	63.7	11.7	68.3	88.7
	200 ppm	13.7	58.1	69.1	12.0	80.0	96.0	19.9	65.9	72.0	12.7	79.7	94.3
IAA	50 ppm	15.4	29.9	41.5	13.3	52.7	75.3	20.4	35.4	48.2	112.0	57.7	71.7
	100 ppm	14.5	32.3	47.1	11.7	55.7	82.0	19.7	40.7	51.0	11.7	66.7	79.7
	200 ppm	14.9	36.1	48.3	12.3	64.7	86.7	20.8	41.8	54.0	11.3	67.7	86.0
	400 ppm	16.3	43.8	52.5	13.3	69.3	91.0	18.9	45.8	57.7	11.7	76.7	93.7
CCC	500 ppm	14.4	28.3	43.0	13.3	77.3	95.0	20.8	39.0	51.7	11.7	87.3	91.7
	1000 ppm	17.9	26.3	36.8	13.7	66.0	76.7	20.2	35.8	48.8	12.0	58.0	72.3
	2000 ppm	15.1	24.6	33.9	12.7	54.3	71.7	21.3	33.9	45.9	11.3	53.7	68.7
	4000 ppm	16.1	23.3	31.7	12.0	65.3	57.3	20.4	31.7	38.1	12.7	47.0	65.0
L.S.D.		5%			5%			5%			5%		
For GA_3:													
Concent.		2.2			9.7			3.8			10.9		
Age		3.8			16.7			6.5			18.8		
For IAA:													
Concent.		2.0			7.7			2.2			12.8		
Age		3.5			13.3			3.9			22.1		
For CCC:													
Concent.		2.1			9.7			1.9			16.5		
Age		3.6			16.8			3.3			26.6		

*Stages: Before application (S_1), at the beginning of flowering (S_2) and at ripe berries (S_3).

(Table 2). The differences within concentrations at each of the three growth regulators were found significant. These findings were in harmony with the results obtained by El-Sherbeny (1973) in *Datura metel* and Sinha and Varma (1974) on *Datura innoxia.*

1.3 Dry Weights of Aerial Growth and Roots/Plant : The yields of dry weight of plant herb and roots were greatly influenced by growth regulators treatments (Table 3).

Concerning the effect of spraying GA_3 and IAA at different concentrations on dry weight of plant herb, data showed that dry weight increased constantly with increas-

TABLE 2. Effect of GA_3, IAA and CCC concentrations sprayed for two times, on the number of branches/plant in *Atropa belladonna* plants for the two seasons of 1985/86 and 1986/87.

Seasons		First season of 1985/86			Second season of 1986/87		
Treatment	Stages	Before application	At the beginning of flowering	At ripe berries	Before application	At the beginning of flowering	At ripe berries
Control		1.3	2.9	3.3	2.0	3.0	4.3
GA_3	50 ppm	1.7	3.0	4.0	2.0	3.6	5.0
	100 ppm	1.3	3.3	4.3	1.3	3.9	5.7
	150 ppm	1.7	3.8	4.7	1.7	4.3	6.3
	200 ppm	2.0	4.1	5.7	1.7	4.4	7.3
IAA	50 ppm	2.0	4.0	5.0	2.0	4.2	6.0
	100 ppm	1.3	4.4	6.3	1.3	4.6	7.0
	200 ppm	2.0	4.6	7.3	2.0	5.0	7.7
	400 ppm	1.3	5.4	8.0	1.7	5.0	9.0
CCC	500 ppm	1.7	3.5	6.3	1.7	3.7	7.3
	1000 ppm	1.3	4.0	8.3	1.7	4.2	9.3
	2000 ppm	1.7	4.4	8.7	2.0	4.3	10.6
	4000 ppm	1.3	4.9	10.0	1.3	5.1	11.6
L.S.D.		0.05			0.05		
For GA_3 :							
Concen.		0.7			0.6		
Age		1.2			1.1		
For IAA :							
Concen.		0.9			0.8		
Age		1.5			1.3		
For CCC :							
Concen.		0.7			0.6		
Age		1.2			1.0		

ing the concentrations of either GA_3 or IAA. IAA concentrations gave good results specially when 400 ppm IAA was used. Meanwhile, the results of dry weight of herb decreased by increasing CCC concentrations. On the other hand, data recorded for the dry weights of roots of the treated plants showed that dry weight of roots/plant increased with increasing the concentrations of growth regulators. At ripe stage the best results were obtained by using CCC followed by IAA and GA_3. These results are in agreement with Rofaeel (1976) on *Hyoscyamus muticus* and Sinha and Varma (1974) on *Datura innoxia.*

2. The Effect on Flowering (Date and Period)

Plants treated with GA_3 and CCC in different concentrations started flowering earlier, but the flowering period was reduced by about (2-7 days) for GA_3 and about (4-13 days) for CCC respectively; flowering was earlier by increasing the concentra-

TABLE 3. Effect of GA_3, IAA and CCC concentrations sprayed for two times, on the dry weight of aerial growth and roots/plants (gms) in *Atropa belladonna* plants for the two seasons of 1985/1986 and 1986/1987.

Treatment	Character	First season of 1985/86						Second season of 1986/87					
		Aerial growth (gms)			Roots (gms)			Aerial growth (gms)			Roots (gms)		
		*Stages			Stages			Stages			Stages		
		S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
Control		1.5	8.3	19.7	0.3	8.2	12.0	2.2	10.8	20.6	0.4	8.0	12.3
GA_3	50 ppm	1.7	11.0	22.7	0.4	9.3	13.7	2.2	12.0	23.0	0.4	9.8	13.0
	100 ppm	1.6	12.4	31.3	0.3	9.5	14.7	2.1	14.3	31.0	0.5	9.9	14.3
	150 ppm	1.7	15.1	37.3	0.3	11.8	16.7	1.9	17.7	41.7	0.4	12.8	17.3
	200 ppm	1.6	20.7	44.3	0.4	13.1	19.7	2.0	20.7	46.3	0.4	14.2	22.3
IAA	50 ppm	1.9	15.5	29.7	0.3	11.6	14.3	1.8	16.3	30.0	0.4	12.4	14.3
	100 ppm	1.8	16.2	33.3	0.4	13.3	16.3	2.2	17.0	38.0	0.3	12.8	21.3
	200 ppm	1.7	19.4	43.0	0.4	14.1	21.7	2.0	19.3	47.0	0.5	15.3	26.3
	400 ppm	1.8	19.8	54.3	0.5	15.2	24.7	1.9	19.7	55.3	0.3	15.8	28.3
CCC	500 ppm	1.8	23.8	44.0	0.4	15.7	22.0	2.1	18.9	32.7	0.5	13.4	20.7
	1000 ppm	2.2	15.5	33.7	0.5	16.1	25.0	2.2	15.0	31.3	0.4	14.1	24.3
	2000 ppm	1.9	14.3	30.3	0.3	17.3	28.3	2.3	14.2	25.0	0.3	15.4	27.7
	4000 ppm	2.0	9.5	24.0	0.4	18.4	35.3	1.9	10.0	19.7	0.4	19.5	39.3
L.S.D.		0.05			0.05			0.05			0.05		
For GA_3 : Concent.		2.5			1.5			4.6			1.8		
Age		4.3			2.6			7.9			3.2		
For IAA : Concent.		2.4			1.0			2.5			3.0		
Age		4.1			1.7			4.3			5.2		
For CCC : Concent.		2.2			1.7			2.9			6.0		
Age		3.8			3.0			4.2			10.5		

*Stages: Before application (S_1), at the beginning of flowering (S_2) and at ripe berries (S_3).

tions in both growth regulators (Table 4). Meanwhile IAA concentrations extended the flowering period by about (1-7 days) compared with the untreated plants. The mode of action of IAA on flowering could be explained by its mediating role through the formation of ethylene according to the findings of Krishnamoorthy (1981); Jase *et al.* (1972) on *Salvia splendens* and Mahmoud (1987) on mullein plants confirmed the above mentioned results.

3. Effect on Seed Yield

GA_3 (50 ppm) was the most suitable concentration for producing a significant yield of seeds per plant (Table 4). Regarding CCC treatments, 500 ppm CCC produced

TABLE 4. Effect of GA_3, IAA and CCC concentrations sprayed for two times, on number of days to 1*st* flower appearance (days), flowering period (days) and seed yield/plant (gms) in *Atropa belladonna* plants for the two seasons of 1985/86 and 1986/87.

Treatment	Character	First season of 1985/86			Second season of 1986/87		
		First flower appearance (days)	Flowering period (days)	Seed yield/plant (gms)	First flower appearance (days)	Flowering period (days)	Seed yield/plant (gms)
Control		212.7	67.3	6.2	211.3	66.0	8.0
GA_3	50 ppm	210.0	65.7	13.0	209.0	64.0	14.4
	100 ppm	208.3	62.7	10.0	207.0	61.0	12.5
	150 ppm	205.3	61.7	7.7	204.7	58.3	9.5
	200 ppm	203.0	60.3	4.2	203.0	57.0	5.2
IAA	50 ppm	215.0	68.3	7.5	213.0	67.0	10.9
	100 ppm	217.3	72.2	8.2	214.7	71.3	11.5
	200 ppm	218.3	74.0	11.5	215.3	71.7	15.0
	400 ppm	212.0	74.7	13.8	219.0	72.0	15.8
CCC	500 ppm	210.7	63.3	10.2	208.3	61.0	10.5
	1000 ppm	209.0	60.0	7.7	207.3	58.7	9.5
	2000 ppm	205.3	57.3	6.8	203.3	55.3	9.2
	4000 ppm	200.7	54.7	5.7	200.0	53.7	7.7
L.S.D.		0.05	0.05	0.05	0.05	0.05	0.05
For GA_3 Concent.		3.0	3.4	2.5	2.9	2.7	5.3
For IAA: Concent.		7.0	2.9	2.8	6.6	2.3	4.2
For CCC Concent.		2.9	2.9	1.1	3.8	2.4	n.s.

higher seed yield compared to other CCC concentrations. Concerning the effect of IAA, it was obvious that seed yield per plant increased significantly by increasing IAA concentration up to 400 ppm.

4. The Effect on the Active Ingredients Content

4.1 Percentage of Total Alkaloids Content in Leaves and Stems

There were a gradual increase in the percentage of total alkaloids in leaves and stems took place with increasing plant age (Table 5). This increase reached its maximum at the beginning of the flowering stage, but the total alkaloids decreased again in leaves and stems till the end of the plant life. The decrease in total alkaloids might be due to the decrease in the rapid reduction in the plant metabolic activities during the last stage of growth as concluded by Tedder *et al.* (1970). The same trend holds true for three growth regulators.

TABLE 5. Effect of GA_3, IAA and CCC concentrations sprayed for two times, on percentage of total alkaloids content in the leaves and stems in *Atropa belladonna* plants for the two seasons of 1985/1986 and 1986/1987.

Treatment	Character	First season of 1985/86						Second season of 1986/87					
		Total alkaloids (%)						Total alkaloids (%)					
		Leaves			Stems			Leaves			Stems		
		*Stages			Stages			Stages			Stages		
		S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
Control		0.130	0.395	0.363	0.110	0.238	0.143	0.133	0.391	0.357	0.113	0.234	0.138
GA_3	50 ppm	0.120	0.356	0.323	0.105	0.312	0.125	0.128	0.348	0.318	0.112	0.207	0.123
	100 ppm	0.127	0.323	0.297	0.107	0.184	0.101	0.123	0.317	0.290	0.113	0.179	0.097
	150 ppm	0.125	0.281	0.262	0.109	0.151	0.082	0.130	0.280	0.257	0.117	0.145	0.077
	200 ppm	0.129	0.251	0.225	0.107	0.133	0.053	0.125	0.247	0.219	0.115	0.125	0.050
IAA	50 ppm	0.122	0.398	0.364	0.106	0.250	0.163	0.132	0.398	0.360	0.114	0.241	0.160
	100 ppm	0.125	0.450	0.383	0.108	0.278	0.194	0.130	0.443	0.378	0.112	0.277	0.190
	200 ppm	0.129	0.515	0.427	0.105	0.307	0.242	0.125	0.505	0.422	0.116	0.300	0.240
	400 ppm	0.127	0.553	0.475	0.109	0.353	0.299	0.122	0.549	0.473	0.110	0.345	0.294
CCC	500 ppm	0.123	0.397	0.396	0.110	0.245	0.150	0.129	0.394	0.359	0.113	0.242	0.147
	1000 ppm	0.124	0.438	0.373	0.107	0.263	0.187	0.125	0.423	0.369	0.117	0.259	0.183
	2000 ppm	0.128	0.487	0.414	0.108	0.299	0.238	0.128	0.482	0.401	0.118	0.290	0.230
	4000 ppm	0.123	0.513	0.467	0.105	0.230	0.259	0.130	0.501	0.450	0.112	0.313	0.249

* Stages: Before application (S_1), at the beginning of flowering (S_2) and at ripe berries (S_3).

The total alkaloids content in the leaves and stems was increased proportional to the increase of IAA doses from 50 to 400 ppm and of CCC doses from 500 to 4000 respectively. On the other hand, there was a clear reduction in total alkaloids content in leaves and stems as a result of GA_3 treatment; this reduction was increased with increasing GA_3 concentrations.

In general, 400 ppm IAA was the most effective dose for producing the highest total alkaloids content in leaves and stems for all three growth regulators concentrations used. These results were in agreement with those of Sciuhetti and Born (1965) on *Datura tatula;* Shah and Saojc (1968) on *Datura metel* and Rofaeel (1976) on *Hyoscyamus muticus.*

4.2 Percentage of Total Alkaloids Content in Roots: Total alkaloids content in roots increased as the plant age advanced till the beginning of flowering stage, then decreased again till the end of plant life (Table 6). This decrease in total alkaloids might be due to the decrease in the rapid reduction in the plant metabolic activities during the last stage of growth as explained by Tedder *et al.* (1970).

Roots alkaloids percentage negatively responded to the increase of GA_3 or CCC concentrations (Table 6). It decreased gradually by increasing GA_3 or CCC doses, whereas total alkaloids content in roots increased constantly with the increase of

TABLE 6. Effect of GA_3, IAA and CCC concentrations sprayed for two times, on percentage of total alkaloids content in the root and ripe berries in *Atropa belladonna* plants for the two seasons of 1985/86 and 1986/87.

Treatment	Stages	First season of 1985/86				Second season of 1986/87			
		Before application on (plants) 170 days old)	At the beginning of flowering (%)	At ripe berries (%)	Total alkaloids in ripe berries (%)	Before application on (plants 170 days old)	At the beginning of flowering (%)	At ripe berries (%)	Total alkaloids in ripe berries (%)
Control		0.113	0.167	0.148	0.240	0.113	0.170	0.135	0.237
GA_3	50 ppm	0.110	0.160	0.143	0.223	0.110	0.158	0.122	0.218
	100 ppm	0.107	0.143	0.125	0.207	0.108	0.132	0.104	0.200
	150 ppm	0.103	0.121	0.107	0.186	0.105	0.110	0.083	0.183
	200 ppm	0.109	0.108	0.075	0.153	0.102	0.081	0.065	0.148
IAA	50 ppm	0.108	0.180	0.153	0.246	0.105	0.189	0.143	0.240
	100 ppm	0.105	0.219	0.168	0.275	0.107	0.223	0.158	0.269
	200 ppm	0.107	0.273	0.180	0.340	0.103	0.286	0.179	0.339
	400 ppm	0.109	0.310	0.217	0.385	0.109	0.320	0.215	0.379
CCC	500 ppm	0.108	0.157	0.133	0.240	0.110	0.145	0.120	0.243
	1000 ppm	0.106	0.133	0.120	0.264	0.107	0.129	0.100	0.260
	2000 ppm	0.107	0.112	0.101	0.314	0.103	0.101	0.075	0.303
	4000 ppm	0.110	0.097	0.073	0.342	0.113	0.070	0.053	0.338

IAA doses. IAA at 400 ppm gave the highest percentage of total alkaloids content in roots compared to the other growth regulators. Similar results were reported by Sciuchatti and Born (1965) on *Datura tatula* and Sinha and Varma (1970, 1974) on *Datura innoxia*.

4.3 Percentage of Total Alkaloids Content in Ripe Berries. Percentage of total alkaloids content in ripe berries responded differently for the three growth regulators (Table 6). It was evident that the percentages increased progressively by increasing doses of IAA and CCC but on the contrary, it decreased gradually by increasing GA_3 concentration. Similar results were recorded by Sinha and Varma (1970) in *Datura innoxia*.

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تأثير بعض منظمات النمو على النمو والإزهار ومحصول البذور ومحتوى القلويدات الكلية لنبات أتروبا بلادونا

بيومي منصور ، نبيل طعيمة ، محمد الفاتح زويل و إبراهيم أمين*
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المستخلص . يعتبر نبات الأتروبا أحد النباتات الطبية الهامة التابعة للعائلة الباذنجانية ، حيث يحتوى على عديد من القلويدات الطبية التي لها تأثير علاجي . ويهدف البحث إلى دراسة تأثير بعض منظمات النمو على النمو وإنتاج البذور ومحتوى النبات من القلويدات الكلية لكل جزء من أجزاء النبات . وقد أجرى هذا البحث خلال موسمين ناجحين ٨٥/١٩٨٦م ، ٨٦/١٩٨٧م وقد شملت الدراسة المعاملات التالية :

١ - الرش مرتين بحمض الجبرلين بتركيزات صفر ، ٥٠، ١٠٠، ١٥٠، ٢٠٠ جزء/المليون .

٢ - الرش مرتين بحمض الأندول أسيتيك بتركيزات صفر ، ١٠٠، ٢٠٠، ٤٠٠ جزء/المليون .

٣ - الرش مرتين بالسيكوسيل بتركيزات صفر ، ٥٠٠، ١٠٠٠، ٢٠٠٠، ٤٠٠٠ جزء/المليون .

وتم تسجيل البيانات في ثلاث مراحل لنمو النبات عند عمر ١٧٠ يوم ، عند بداية التزهير ، وعند نضج الثمار وكانت أهم النتائج كمايلي :

١ - وجد أن هناك زيادة مطردة في ارتفاع النبات وعدد الأوراق والأفرع الجانبية والوزن الجاف للمجموع الخضري والمجموع الجذري لكل نبات تبعا لتقدم النبات في العمر حتى مرحلة نضج الثمار .

٢ - كانت أفضل تركيزات الجبرلين هي ٢٠٠ جزء/المليون حيث أعطت أكثر النباتات طولا (٤٧-٥٢,٦ سم) وكذلك أكبر عدد من الأوراق وتبكير في الإزهار ٩ أيام عن الكنترول .

٣ - كان أكثر التركيزات مناسبة هي الرش بحمض الأندول أسيتيك بتركيز ٤٠٠ جزء/المليون حيث أعطى أعلى ارتفاع ، أكبر عدد من الأوراق ، أكبر وزن للمجموع الخضري ، أعلى محصول بذور ، أعلى محتوى من القلويدات في الأوراق والسيقان والجذور والبذور .

٤ - تركيز ٤٠٠٠ جزء/المليون من السيكوسيل كان أكثر مناسبة في التبكير في الإزهار ١٢ يومًا عن الكنترول ، زيادة عدد الأفرع وكذلك وزن الجذور .