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RESPONSE OF POTATO PLANTS TO SOME GROWTH REGULATORS APPLICATION

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ABSTRACT: *Two field experiments were carried out during the winter seasons of 2005/2006 and 2006/2007 as an attempt to investigate the effect of jasmonic acid (JA) at 10 mg/l, salicylic acid (SA) at 10 mg/l, gibberellic acid (GA_3) at 20 mg/l and indol acetic acid (IAA) at 20 mg/l with different methods of application on growth, chemical composition and yield and its quality. The obtained results revealed that, growth regulators (GRs) treatments significantly increased plant height, leaf number, root length, dry weight of roots, stems and leaves as well as the concentration of chlorophyll (a + b), carotenoids, total carbohydrates, N, P and K in the leaves. Moreover, dry matter, specific gravity, starch, tuber size grades and yield and its components showed significant increases. Foliar spray treatments recorded the highest values of dry weights (stems and leaves), chl (a+b), carotenoids, total carbohydrates, N, P and K contents and total tubers yield. The dry matter, starch and specific gravity were increased with tuber seeds soaking in GRs. The interaction between GRs and their application methods had a significant effect, and the application of IAA, JA and GA_3 as tuber seed soaking and/or foliar spraying gave the relatively higher tuber yield with good quality.*

Key words: *Growth regulators, Methods of application, Jasmonic acid, Chemical and quality of potato tuber, tuber yield.*

INTRODUCTION

Potato (*Solanum tuberosum*, L.) is one of the most important and popular vegetable crops grown in Egypt for local consumption and export.

There are many factors might limit potatoes plant behaviour, which of them are growth regulators. Jasmonate has been shown to elicit both inhibitors and to be of promotive effects on plant morphology and physiology (Arteca, 1996). Thus, 1 µM JA in the growth medium enhanced axillary shoots and adventitious root growth of plant stem node cultures (Dermastia *et al.*, 1994). It has also been reported that the addition of JA to potato stem node culture medium enhanced water, Ca, P and K ions

transport (Ravnikar *et al.*, 1995 a) and induced starch accumulation (Ravnikar *et al.*, 1995 b). Besides, JA treatment in potato resulted in an increase of active cytokinin content, without drastic changes of photosynthetic pigments (Dermastia *et al.*, 1994).

Salicylic acid was found to have an antioxidant effect and could overcome the deleterious effect of different stresses on plant, so it acting as chelating agent and protect plant growth from stress (Oota, 1972). Besides, salicylic acid was reported to be of a positive effect on soybean yield (Zhao *et al.*, 1995). However, Bardisi (2004) reported that spraying garlic plants with salicylic acid at 50 ppm recorded maximum values of plant height, number of leaves / plant, diameter of both neck and bulbs, total dry weight / plant and N, P and K uptake.

Gibberellic acid and indole acetic acid were frequently reported in the literature to affect water relations and amino acids synthesis (Midan, 1978 and Midan *et al.*, 1982) and to enhance the synthesis of chlorophyll and total sugars in treated plants (Arteca, 1996). Besides, gibberellic acid was reported to directly implicate in promotion of germination (Groot *et al.*, 1988). Hassan *et al.* (2005) reported that, spraying GA_3 caused a remarked promotion in leaf mineral status, yield and fruit quality in apricot trees compared with control treatment. Desouky (2006) found that, foliar application of gibberellic acid at 200 ppm produce the best vegetative growth, flowering yield and quality of *Pelargonium grandiflorum* Willd plants.

The present investigation aims to evaluate the impact of the recent some growth regulators, along with their methods of application, on potato growth, chemical constituents and tubers yield and their quality.

MATERIALS AND METHODS

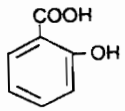
Two field experiments were conducted at the Experimental Farm, Faculty of Agriculture, Minufiya University, Shibin El-Kom during the winter seasons 2005/2006 and 2006/2007 to study the effect of some growth regulators applied either as tuber soaking or foliar spray and as the combination of both on potato growth, chemical constituents of leaves and tubers, yield as well as tuber quality .

The potato tuber seeds of Diamont cv. were kindly given by the exporters union of Horticultural Crops. Seed tubers of 35 – 50 mm in size were sown on 5th of October. in the two seasons. The experimental design was a split plot system with four replications as methods of application were arranged as main plots, while growth regulators treatments were considered as sub-

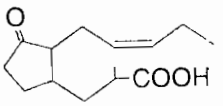
plots. Each sub-plot consisted of five rows each of 5 m long and 75 cm apart.

The experiment included 15 different treatments (5 GRs x 3 methods) as follows: [1]. Potato tuber seeds soaking treatments: potato tuber seeds were soaked for half hour before planting with the assigned concentrations of growth regulators , i.e., jasmonic acid (JA) at 10 mg/l, salicylic acid (SA) at 10 mg/l, gibberellic acid (GA_3) at 20 mg/l and indole acetic acid (IAA) at 20 mg/l. Besides the distiled water as a control. Tween 20 (5%) was used as wetting agent. The molecular structures of growth regulators are shown in Fig. (1). [2]. Foliar spray treatments. The plants were sprayed at 40 days from sowing in the above mentioned assigned concentrations of growth regulators. [3]. Potato tuber seeds soaking + foliar spraying treatments: potato tuber seeds were soaked for half hours in the above mentioned concentrations of growth regulators. Further more, plants were sprayed with the above mentioned concentrations of growth regulators at 40 days plant age.

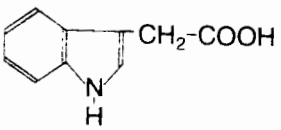
The molecular structures of the growth regulators are shown in fig (1)



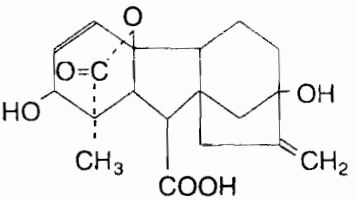
Salicylic acid (SA)



Jasmonic acid (JA)



Indol-3-acetic acid (IAA)



Gibberelic acid (GA_3)

Fig.(1) The structures of growth regulatores

Nitrogen, Potassium and Phosphrous were added in doses of 350 kg ammonium sulphate (20.6% N), 100 kg potassium sulphate (48.0% K_2O), 250 kg Calcium superphosphate (15.5% P_2O_5)per feddan. N and K were divided and equally added as side dressing at 30 and 60 days from planting. Calcium superphosphate was added during soil preparation. Other agricultural practices were done.

The plant samples were taken after 75 days from planting, five plant samples were randomly taken from each sub-plot hence the following data were recorded: 1- Vegetative growth characters: plant height (cm), number of leaves , root length and dry weight of roots, stems and leaves. 2- Chemical constituents: 2.1.photosynthetic pigments were determined in the leaves using the method described by Wettestein (1957). 2.2. Total carbohydrates in leaves were estimated colorimetrically using the phenol sulfuric acid according to the method of Dubios *et al.* (1956), 3- N, P and K concentrations: Total nitrogen was determined in dry leaves using microkjeldahl methods as described by Ling (1963), while P and K were determined as mentioned by A.O.A.C. (1990). 4- Tuber quality after harvest: 4.1. Starch content and dry matter%: starch content was determined using the method of A.O.A.C. (1990). Tuber dry matter (%) was determined by drying the tuber slices at 65°C for 72 hours according to the method of A.O.A.C. (1990). 4.2. Specific gravity of tubers was estimated by the following equation (Smith, 1976).

$$\text{Specific gravity} = \frac{\text{Weight of tubers in air}}{\text{weight of tubers in air} - \text{weight of tubers in water}}$$

4.3.Total carbohydrates in tubers was estimated colarimetrically using the phenol sulfuric acid method as described by Dubios *et al.* (1956). 5- yield and its components: Each experimental unit was harvested individually after 120 days from planting and the following yield data were recorded: 5.1. Average tuber number / plant. 5.2. Average tuber weight (g). 5.3. Total tuber yield / plant and per feddan. 5.4. The percentage of different tuber size grades: Tubers were graded according their size to large > 55; 45 – 55; 35 – 45 and < 35 mm in diameter (Fattahalla, 1997).

All obtained data were subjected to statistical analysis with the help of COSTAT-C program, and L.S.D. at 5% level was calculated according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1. Vegetative growth characters:

All growth regulators caused a significant increase in plant height, leaf number/plant, root length, dry weight of roots, stems and leaves as compared with control plants (Table 1). In this connection, GA_3 at 20 mg/l followed by IAA at 20 mg/l then jasmonic acid at 10 mg/l showed the highest records for all studied growth characters. These results agreed with the finding of Nilsamranchit *et al.* (1996), Desouky *et al.* (1999) and Desouky (2006). Broughton (1970) proposed that the increment in plant growth characters resulting from GA_3 applications might be explained by their promotive effect on cell division and cell elongation on potato. However, Saniewski *et al.* (1990) concluded that exogenous gibberellins taken up stems or those synthesized under the influence of exogenous ones, led to the elongation of all stem internodes of tulip. Besides, IAA was also noticed by Gherroucha *et al.* (2003) to be of a significant effect on wheat plant height, number of leaves and proliferate. Zaghlool *et al.* (2001) demonstrated that foliar application of salicylic acid (SA) stimulated plant growth. Malamy and Klessing (1992) reported that, SA reversing of ABA induced stomatal closure, leaf abscission and growth inhibition. Zaghlool (2002) mentioned that exogenous application of GA_3 counteract the inhibiting effect of endogenous ABA and enhancement of IAA.

Concerning the effect of the application methods, data show no significant differences among them regarding their effect on growth parameters except dry weights of stems and leaves which had a significant increase when plants foliar spray of GRs (Table 1). The interaction between GRs and their application method caused a significant effect on all tested growth characters (Table 1). Thus, the highest values of roots and hallum dry weight were recorded from GA_3 and/or IAA foliar spraying treatments. The lowest values in this respect were found in control plants. Both GA_3 and IAA were previously reported to be more effective in increasing growth of treated plants. These results are in agreement with those obtained by Nilsamranchit *et al.* (1996) and Desouky *et al.* (1999), Gherroucha *et al.* (2003), Hassan *et al.* (2005) and Desouky (2006).

Table (1). Some vegetative growth characters of potato plants as affected by some growth regulators, along with their methods of applications, during the two growing seasons.

Seasons		2005/2006 Season						2006/2007 Season					
Characters / Treatments		Plant height (cm)	Leaf number / plant	Root length (cm)	d.wt. of roots (g/plant)	d.wt. of stems (g/plant)	d.wt. of leaves (g/plant)	Plant height (cm)	Leaf number / plant	Root length (cm)	d.wt. of roots (g/plant)	d.wt. of stems (g/plant)	d.wt. of leaves (g/plant)
M	GR												
Seed tuber soaking	Control	75.0	75.00	11.0	5.21	14.67	28.30	72.0	76.00	10.0	6.00	18.87	38.04
	JA	77.0	76.67	11.0	5.74	17.37	33.32	75.0	86.33	11.0	6.55	20.31	45.43
	SA	76.0	77.67	10.0	5.73	16.16	31.39	73.0	81.67	12.0	6.32	19.48	44.30
	GA3	80.0	92.00	13.0	6.40	18.52	32.75	87.0	95.00	14.0	6.55	23.38	48.54
	IAA	82.0	90.00	12.0	6.40	17.51	32.83	84.0	93.00	13.0	6.20	22.55	47.34
Foliar spraying	Control	77.0	79.0	9.5	5.89	14.00	28.21	72.0	75.0	10.0	5.30	18.37	38.39
	JA	81.0	80.0	13.0	6.55	15.75	33.48	78.0	81.0	12.0	5.40	20.02	45.45
	SA	82.0	82.0	10.0	6.20	16.71	30.54	77.0	85.0	12.0	5.41	18.38	44.10
	GA3	90.0	98.0	14.0	7.80	28.06	40.00	91.0	100.0	14.0	8.40	33.30	55.56
	IAA	84.0	95.0	12.0	7.55	27.68	39.28	87.0	98.0	13.0	8.40	32.16	54.59
Seed tuber soaking and foliar spraying	Control	75.0	74.0	9.3	5.30	15.30	30.41	74.0	75.0	9.0	5.60	20.37	39.07
	JA	78.0	82.0	11.3	6.31	17.31	36.20	80.0	85.0	10.67	5.40	21.42	48.28
	SA	78.0	76.0	11.0	6.38	16.15	34.25	79.0	83.0	12.67	5.40	21.18	46.31
	GA3	86.0	100.4	15.0	7.73	21.38	33.73	83.0	105.0	15.0	8.40	26.52	48.94
	IAA	88.0	98.0	14.0	7.44	20.00	32.45	85.0	100.0	15.0	8.40	25.16	48.21
Means of methods (M)	Soaked	78.0	82.27	11.40	5.90	16.85	31.72	78.2	86.4	12.0	6.32	20.92	44.73
	Foliar	82.6	86.80	11.66	6.80	20.44	34.30	81.0	87.8	12.2	6.58	24.45	47.62
	S and F	81.0	86.08	12.13	6.63	18.03	33.41	80.2	89.6	12.47	6.64	22.93	46.16
Means of growth regulators (G)	Control	75.67	76.00	9.88	5.47	14.66	28.97	72.67	75.33	9.67	5.63	19.20	38.50
	JA	78.70	79.56	11.77	6.20	16.81	34.33	77.67	83.22	11.22	5.78	20.58	46.39
	SA	78.67	78.56	10.33	6.10	16.34	32.06	76.33	83.22	12.22	5.71	19.68	44.90
	GA3	85.33	96.80	14.00	7.30	22.65	35.49	87.00	100.00	14.33	7.78	27.73	51.01
	IAA	84.67	94.33	12.67	7.13	21.73	34.85	85.33	97.00	13.67	7.67	26.62	50.05
L.S.D. 5%	M	n.s.	n.s.	n.s.	n.s.	2.26	2.00	n.s.	n.s.	n.s.	n.s.	1.64	1.20
	G	1.4	3.88	1.1	1.0	1.60	2.14	1.64	3.24	1.31	1.20	2.10	1.26
	M × G	2.41	6.56	1.9	1.2	2.58	3.90	2.78	5.46	1.60	1.50	4.42	1.60

M : Methods of application
GR : Growth regulators

2. Chemical constituents:

2.1. Photosynthetic pigments:

All studied GRs treatments increased the concentration of Chl. (a + b) and carotenoids as compared to control plants (Table 2). The best results in this concern, were obtained from GA_3 treatment followed by IAA then SA. These results coincide with those of Midan, (1982) and Desouky *et al.* (1999), working on onion and pelagonium respectively. Mohamed (1993) found that the effect of GA_3 spray treatment on pigments revealed the existence of high chlorophyll and carotenoid concentrations which might be relates to the increased photosynthetic activity in apple leaf. The method of GRs application seems also to significantly affect chlorophyll (a + b) and carotenoids (Table 2). The highest concentration of bio-chemical constituents being achieved by the foliar spraying of GRs. These results were insistently observed in both growing seasons. Results could be easily explained as foliar spraying with GRs directly affected plant leaves metabolism, the part received the active ingredients of sprayed GRs.

As regards to the interaction effect, the highest values in Chl. (a + b) and carotenoids were obtained in plants received GA_3 and/or IAA as foliar spraying. Gibberellic acid and IAA were previously mentioned by Midan (1978) to activate chlorophyll synthesis. Additionally, GA_3 may increase chlorophyll content through enhancing the accumulation of fresh and dry matter in treated plants (Poskuta *et al.*, 1975).

2.2. Total carbohydrates:

The total carbohydrates in potato plant leaves was significantly increased using all of the tested GRs comparing to control (Table 2). Gibberellic acid and IAA both at 20 mg/l and salicylic acid at 10 mg/l, generally achieved the highest contents. The enhancing effect of GA_3 , IAA and salicylic acid on carbohydrates content is quite expected as these compounds promote chlorophyll content in plant leaves. Brown and Ho (1986) showed that gibberellic acid stimulated 6-amylase which promote the conversion of starch to sugar and other hydrolytic enzymes promoting hydrolysis of storage reserves. Zhao *et al.* (1995) stated that SA increased photosynthetic rate in soybean.

Concerning the effect of application methods on total carbohydrates, foliar spraying achieved the highest values. Foliar spraying was previously noticed to enhance chlorophyll content, thus its favourable effect on carbohydrates content being logic.

Table (2). Photosynthetic pigments, total carbohydrates and mineral concentrations in potato leaves as affected by some growth regulators, along with their methods of applications, during the two growing seasons.

Seasons		2005/2006 Season						2006/2007 Season					
Characters Treatments		Chl. a + b (mg/g d.wt)	Carotenoid (mg/g d.wt)	Total carb. (mg/g d.wt)	N %	P %	K %	Chl. a + b (mg/g d.wt)	Carotenoid (mg/g d.wt)	Total carb. (mg/g d.wt)	N %	P %	K %
M	GR												
Seed tuber soaking	Control	5.27	3.70	194.78	2.5	0.41	2.7	7.10	3.86	192.33	2.6	0.52	2.7
	JA	5.50	4.07	212.57	3.4	0.47	4.2	7.80	4.28	213.94	3.5	0.58	4.0
	SA	6.92	4.49	205.60	3.0	0.43	3.0	7.52	4.39	219.98	3.0	0.55	3.0
	GA3	9.51	5.83	249.15	3.2	0.47	3.3	10.70	5.47	254.89	3.2	0.57	4.0
	IAA	8.27	4.57	245.41	2.9	0.46	3.2	9.32	4.81	230.09	3.1	0.56	3.3
Foliar spraying	Control	6.60	3.22	195.44	2.6	0.42	2.9	7.00	4.07	210.62	2.7	0.54	2.7
	JA	6.80	4.21	224.63	3.7	0.49	3.7	6.05	4.55	235.55	3.8	0.62	4.1
	SA	9.16	4.09	232.34	3.4	0.45	3.1	9.58	4.63	252.58	3.5	0.56	3.0
	GA3	11.50	5.62	293.19	3.5	0.48	3.5	11.20	5.78	310.39	3.7	0.60	4.0
	IAA	10.23	5.84	284.77	2.9	0.46	3.3	10.88	5.95	303.20	3.6	0.59	3.3
Seed tuber soaking and foliar spraying	Control	5.93	3.03	190.49	2.5	0.40	2.7	5.96	3.82	197.12	2.5	0.50	2.7
	JA	6.26	3.33	212.76	3.4	0.46	3.3	6.39	4.04	225.75	3.3	0.56	3.5
	SA	7.00	3.81	227.83	2.8	0.42	2.9	6.63	4.14	233.25	3.0	0.53	2.9
	GA3	7.53	4.87	249.80	3.2	0.45	3.1	7.67	5.28	255.19	3.3	0.55	3.3
	IAA	9.51	3.17	255.59	3.1	0.45	3.0	9.07	4.78	265.54	3.2	0.54	3.0
Means of methods (M)	Soaked	7.09	4.53	221.50	3.0	0.45	3.3	8.49	4.56	222.25	3.1	0.56	3.4
	Foliar	8.86	4.60	246.10	3.22	0.46	3.3	8.94	5.00	262.47	3.5	0.58	3.4
	S and F	7.25	3.64	227.30	3.0	0.44	3.0	7.14	4.41	235.37	3.1	0.54	3.1
Means of growth regulators (G)	Control	5.93	3.32	193.60	2.53	0.41	2.8	6.69	3.92	200.00	2.6	0.52	2.7
	JA	6.19	3.87	216.70	3.50	0.47	3.7	6.75	4.29	225.08	3.5	0.59	3.9
	SA	7.69	4.13	221.92	3.10	0.43	3.0	7.91	4.39	235.27	3.2	0.55	3.0
	GA3	9.51	5.44	264.05	3.30	0.47	3.3	9.86	5.51	273.49	3.4	0.57	3.8
	IAA	9.34	4.53	261.92	3.00	0.46	3.2	9.76	5.18	266.28	3.3	0.56	3.2
L.S.D. 5%	M	0.46	0.85	7.87	n.s.	n.s.	0.09	0.49	0.80	1.79	n.s.	n.s.	n.s.
	G	0.59	0.31	13.59	0.25	0.011	0.09	0.69	0.60	5.02	0.23	0.02	0.24
	M × G	0.60	0.41	20.44	n.s.	n.s.	1.0	0.72	0.80	23.30	n.s.	n.s.	n.s.

M : Methods of application
GR : Growth regulators

Besides, the interaction between GRs and their methods of application recorded a significant effect on total carbohydrates in plant leaves (Table 2). Foliar spraying with GA_3 and/or IAA gave superior records comparing to other treatments. Gibberellin was also reported by Arteca (1996) to stimulate photosynthesis and photosynthesates accumulation. Mohamed (1993) reported that GA_3 spray treatment induced increases of individual sugars and starch concentrations as well as the specific activity of aldose 6-P reductase and sucrose synthetase in apple leaves.

3. N,P and K concentrations:

All the tested GRs treatments caused obvious increments in N, P and K (%) as compared with the untreated plants. On the other hand, control plants had the lowest percentage of such elements. The highest percentage of elements was produced by using jasmonic acid followed by GA_3. Such results would be reasonably explained by the finding of Ravnikar *et al.* (1995 b) and Desouky *et al.* (1999) on potato and pelargonium plants, respectively. These results are in agreement with those obtained by Ravnikar *et al.* (1995 a) who reported that the addition of JA to potato stem node culture medium enhanced Ca, P and K ions transport. Such results would be reasonably explained by the finding of Desouky *et al.* (1999) on pelargonium plants, Hassan *et al.*, (2005) on canino apricot trees and Desouky (2006) on *Pelargonium grandiflorium*. As for, the effect of seed tuber soaking treatments, foliar spraying or the combination of both, data show no significant differences among them regarding their effect on mineral concentrations. Generally, the interaction of GRs and their method of application caused non-significant effect on the tested mineral concentration (Table 2).

4. Potato tubers quality:

4.1. Starch and dry matter contents:

Jasmonic acid, SA, GA_3 and IAA caused an increase in starch and dry matter contents in potato tubers (Table 3). In general, jasmonic acid at the rate of 10 mg/l recorded the maximum values of starch and dry matter contents in tubers. Obtained results go along with those of (Ravnikar *et al.*, 1995 b). As regards to the effect of methods of GRs application on starch and dry matter content in potato tubers, the obtained data clear that soaking tuber seeds in all tested GRs caused an increase in these biochemical constituents. Pre-planting soaking tubers produced the less amounts of

Table (3). Some chemical constituents and some tubers quality parameters as affected by some growth regulators, along with their methods of applications, during the two growing seasons.

Seasons		2005/2006 Season				2006/2007 Season			
Characters Treatments		Starch %	Dry matter%	Specific gravity	Total carbohydrates (mg/g dry weight)	Starch %	Dry matter%	Specific gravity	Total carbohydrates (mg/g dry weight)
M	GR								
Seed tuber soaking	Control	10.46	16.55	1.057	122.8	11.23	16.10	1.050	127.1
	JA	16.15	22.38	1.087	181.4	15.53	21.28	1.086	184.8
	SA	14.80	19.37	1.078	140.9	14.57	18.85	1.070	145.1
	GA3	12.12	18.28	1.066	151.1	14.70	18.85	1.067	155.1
	IAA	14.70	19.26	1.077	170.9	14.34	18.56	1.069	175.0
Foliar spraying	Control	11.12	16.99	1.058	124.3	10.77	16.21	1.054	127.8
	JA	13.75	19.31	1.066	210.6	14.60	19.64	1.065	213.7
	SA	12.39	18.18	1.063	160.6	12.45	19.22	1.065	164.4
	GA3	13.14	19.16	1.068	174.2	11.85	19.22	1.062	174.4
	IAA	12.28	17.90	1.064	201.4	14.13	16.22	1.075	205.0
Seed tuber soaking and foliar spraying	Control	10.43	16.40	1.055	119.8	10.14	16.07	1.055	123.6
	JA	13.25	18.77	1.070	185.6	11.59	17.64	1.061	177.3
	SA	12.31	17.74	1.062	140.4	13.36	19.22	1.072	144.7
	GA3	13.76	19.03	1.071	154.1	13.39	19.22	1.060	145.0
	IAA	11.79	16.27	1.060	174.8	12.22	16.22	1.060	149.1
Means of methods (M)	Soaked	13.65	19.17	1.073	153.4	14.07	18.73	1.068	157.4
	Foliar	12.54	18.31	1.064	174.2	12.76	18.10	1.064	177.1
	S and F	12.31	17.64	1.064	154.9	12.14	17.67	1.062	147.9
Means of growth regulators (G)	Control	10.67	16.65	1.057	122.3	10.71	16.13	1.053	126.2
	JA	14.38	20.15	1.074	192.5	13.91	19.52	1.071	191.9
	SA	13.17	18.43	1.068	147.3	13.46	19.10	1.069	151.4
	GA3	13.0	18.82	1.068	159.8	13.31	19.10	1.063	158.2
	IAA	12.92	17.81	1.070	182.3	13.56	17.00	1.068	176.4
L.S.D. 5%	M	0.997	n.s.	0.005	3.33	1.07	n.s.	0.006	2.90
	G	1.26	1.3	0.006	3.07	1.08	0.92	0.006	3.00
	M × G	1.61	1.7	0.010	5.21	1.23	1.00	0.012	5.30

M : Methods of application
GR : Growth regulators

vegetative growth, thereby it permits much more quantities of stored starch in tubers. The interaction between the two studied factors significantly increased both studied bio-chemical constituents (Table 3). So, the highest content of both starch and dry matter being obtained due to soaking tubers in Jasmonic acid.

4.2. Specific gravity:

In general, increases in specific gravity were noticed due to all of the tested GRs application (Table 3). These results are true in both growing seasons. Results could be explained as a result of increasing dry matter and starch content due to GRs.

Besides, soaking treatment being superior in increasing specific gravity comparing to spraying ones. Soaking treatment was previously reported to produce less amounts of vegetative growth and caused an increase in storage starch amounts, thereby it could increase specific gravity. However, the interaction between studied GRs and their methods of application achieved significant effect on specific gravity in potato tubers (Table 3). The highest value of specific gravity was obtained due to soaking tuber seeds in Jasmonic acid.

4.3. Total carbohydrates concentration in tubers:

The total carbohydrates in tuber was significantly Increased using all of the treated GRs compared with control (Table 3). The highest values were obtained from JA followed by IAA then GA_3 in the two growing seasons. The enhancing effect of IAA, jasmonic acid and GA_3 on carbohydrates content is quite expected as these compounds promote chlorophyll content in plant leaves (Table 2). Pavnikar *et al.* (1995 b) reported that JA enhanced axillary shoots, adventitious root growth of potato and induced accumulation of starch. As for the methods of GRs application, foliar spraying achieved the highest values in this connection. Besides, the interaction effect between GRs and their method of application on carbohydrates in the tubers data showed that foliar spraying with JA and/ or IAA gave superior records comparing to other treatments.

5. Yield and its components:

5.1. Average tuber number per plant:

Comparing to control, generally all of the tested GRs significantly increased tuber number/plant. In general, IAA at the rate of 20 mg/l followed by GA_3 at 20 mg/l achieved the highest values (Table 4). Mostafa *et al.* (2001) reported that spraying trees with GA_3 at 25 or 50 ppm tended to increase yield as number of fruits / tree. Increasing the number of tubers per plant

Table (4). Yield and its components of potato plants as affected by some growth regulators, along with their methods of applications, during the two growing seasons.

Seasons		2005/2006 Season								2006/2007 Season							
Characters / Treatments		Tuber number /plant	Average tuber weight (g)	Total yield / plant (g)	Total yield ton/fed	Large tuber size > 55 mm	Tuber size 45 – 55 mm	Tuber size 35 – 45 mm	Small size < 35	Tuber number /plant	Average tuber weight (g)	Total yield / plant (g)	Total yield ton/fed	Large tuber size > 55 mm	Tuber size 45 – 55 mm	Tuber size 35 – 45 mm	Small size < 35
M	GR																
Seed tuber soaking	Control	6.10	87.03	516.0	10.32	52.60	16.04	29.20	2.15	6.50	81.5	528.3	10.57	54.0	15.38	28.3	2.30
	JA	6.67	117.90	784.0	15.68	67.80	24.03	7.39	0.78	6.78	115.6	780.3	15.61	69.8	21.16	8.40	0.64
	SA	6.53	90.90	628.3	12.43	55.77	25.47	18.05	0.71	7.02	86.2	601.7	12.03	69.6	19.77	9.80	0.83
	GA3	6.75	90.50	673.7	13.47	61.63	23.97	13.21	1.19	7.33	97.6	682.7	13.65	54.7	19.47	24.90	0.94
	IAA	7.25	109.50	786.7	15.73	66.70	20.84	12.23	0.231	7.98	101.0	803.3	16.07	60.8	19.3	19.16	0.74
Foliar spraying	Control	6.05	86.3	522.0	10.45	49.40	17.50	30.77	2.33	6.50	82.1	533.7	10.67	54.10	16.55	27.26	2.08
	JA	6.66	113.0	754.0	15.08	65.74	25.60	7.59	1.07	6.70	113.5	759.3	15.25	65.80	22.89	9.88	1.46
	SA	6.75	98.2	660.0	14.31	54.90	24.20	19.47	1.43	7.42	98.5	722.3	14.45	52.90	20.52	24.78	1.80
	GA3	6.68	97.3	720.7	13.21	59.30	24.20	15.72	0.79	7.68	94.0	722.7	14.45	54.00	20.23	24.56	1.21
	IAA	7.68	114.2	874.7	16.83	61.98	23.40	12.67	1.95	8.03	110.2	879.3	17.59	56.30	20.33	20.34	3.03
Seed tuber soaking and foliar spraying	Control	6.17	86.0	530.0	10.60	54.73	18.32	24.54	2.41	6.33	85.3	540.0	10.53	52.80	17.42	27.53	2.25
	JA	6.60	102.67	705.3	14.11	71.94	21.15	6.28	0.63	6.59	113.1	743.3	14.87	69.30	22.25	7.54	0.91
	SA	6.30	96.7	594.3	11.89	69.24	20.67	9.82	0.27	6.93	89.14	620.0	12.40	65.08	21.80	12.31	0.81
	GA3	6.91	99.2	650.3	13.01	65.80	22.60	10.90	0.80	7.69	86.9	666.7	13.33	62.21	22.28	14.40	1.11
	IAA	7.23	117.2	834.0	16.68	65.85	23.46	9.21	1.48	7.60	101.3	770.3	15.41	60.65	22.97	14.68	1.69
Means of method	Soaked	6.66	99.17	677.7	13.63	60.90	22.07	16.02	1.01	7.27	96.38	679.3	13.59	61.78	19.02	18.11	1.09
	Foliar	6.76	101.80	706.3	13.98	58.26	22.98	17.24	1.51	7.03	99.66	723.5	14.48	56.62	20.10	21.36	1.92
	S and F	6. 64	100.35	662.8	13.26	65.51	21.24	12.15	1.12	7.26	95.15	668.1	13.31	62.01	21.34	15.29	1.35
Means of growth regulator	Control	6.11	86.44	522.67	10.46	52.24	17.29	28.17	2.29	6.44	83.00	534.00	10.59	53.63	16.45	27.71	2.21
	JA	6.64	111.19	747.77	14.96	68.49	23.59	7.09	0.83	6.69	114.07	760.97	15.24	68. 30	22.10	8.61	1.00
	SA	6.53	95.27	627.50	12.66	60.00	23.45	15.76	0.80	7.12	91.28	648.00	12.95	62.53	20.70	15.63	1.15
	GA3	6.78	95.67	681.57	13.23	62.24	23.29	13.28	0.92	7.57	92.80	690.70	13.81	56.97	20.66	21.29	1.09
	IAA	7.39	113.63	831.80	16.41	64.84	22.57	11.37	1.23	7.87	104.17	817.63	16.36	59.25	20.87	18.06	1.82
L.S.D. 5%	M	n.s.	n.s.	25.98	0.46	2.28	1.20	2.69	0.25	n.s.	n.s.	44.75	0.70	5.19	1.20	1.98	0.04
	G	0.64	12.43	39.43	0.89	3.32	2.92	2.99	0.24	0.53	6.99	47.28	0.89	3.32	2.92	2.01	0.20
	M × G	n.s.	n.s.	54.40	1.23	4.58	3.02	4.12	0.30	n.s.	n.s.	66.76	1.23	4.58	3.09	2.69	0.04

M : Methods of application
GR : Growth regulators

could be explained as a result of stimulative growth that followed IAA and GA_3 application. IAA and GA_3 were also reported by Desouky *et al.* (1999) and Desouky (2006) to increase fruits number of such plants. There were no significant effect due to the method application of GRs on number of tubers / plant. However, the interaction between the two studied factors had no significant effect on this yield component (Table 4).

5.2. Average tuber weight:

The average tuber weight was significantly increased using all of the tested GRs. In general, jasmonic acid, IAA and GA_3 recorded the highest values of average tuber weight, as salicylic acid came the later (Table 4). The less number of tubers per plant that followed jasmonic acid application may be explained due to the increase in tubers weight as the share of every tuber from assimilates being high. The methods of GRs application exerted no-significant effect on average tuber weight. The interaction between GRs and their application methods attained also no significant effect in this respect. These results being true in both growing seasons.

5.3. Total tubers yield:

It can be noticed that total tubers yield per plant and per feddan were significantly affected by applied GRs (Table 4). The highest values of total tubers yield were obtained from plants treated with IAA followed by JA and GA_3, since salicylic acid ranked as the last. These results were insistently observed in both seasons. Indol acetic acid and GA_3 may affect total tubers yield in a positive manner via their previously mentioned positive effect on number of tubers per plant and average tuber weight. Meanwhile, jasmonic acid may cause its stimulative effect on total tubers yield through its positive effect on average tubers weight. These results are in agreement with those obtained by Abou-Raya *et al.* (2000) who mentioned that pear trees sprayed with GA_3 at full bloom increased weight and size of fruit. Moreover, it was suggested by Broughton (1970) that GA_3 increased fruit size throught stimulating both cell divistion and cell enlargement. An enhancing effect of studied phytohormons on elongation of cell, formation of parthinocarpy fruits cambial activity and building of protein and nucleic acids (RNA and DNA), were reported by Phinney and West (1961).

The application method of GRs significantly affected total tuber yield. The highest values of total yield measured per plant or per feddan were obtained in case of foliar spraying followed by seed tuber soaking.

The interaction of GRs and their methods of application showed a significant effect on total yield per plant and per feddan. The highest values of total yield per plant and per feddan were obtained in plants treated with IAA as foliar spraying.

5.4. The percentage of tuber size grades:

All studied GRs increased the percentage of large tubers (>55 and 45–55 mm) comparing to control (Table 4). On the other hand, GRs caused a significant decrease in the percentage of medium tubers size (35–45 mm) and small potatoes (< 35 mm). These results were insistently observed in both growing seasons. Growth regulators were frequently reported to enhance photosynthesis and consequently photosynthesates accumulation, reasons that could explain the increase in the percentage of large tubers (Arteca, 1996). The application methods of GRs induced significant influence on tuber size percentage (Table 4). In general, tuber seed soaked + foliar spraying treatments significantly increased large tuber size (>55mm). The interaction between the two studied factors attained significant effect on tuber size grades (Table 4). The highest percentage of large tubers size (> 55 mm) was obtained by using JA at 10 mg/l in different application methods comparing to other treatments. Meanwhile, the highest percentage of medium (35–45 mm) or small (> 35 mm) tubers was obtained when seed tubers were soaked or foliar sprayed as well as seed tuber soaking + foliar spraying by water.

Finally, from the a forementioned results, it could be concluded that the application of plant growth regulators promoted growth characters, increased chemical constituents as well as yield and its components. Therefore, it can be recommended that the use of plant growth regulators especially jasmonic acid, indol acetic acid and gebberellic acid as foliar spray or seed tuber soaking to obtain the highest yield and good quality of potato .

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استجابة نباتات البطاطس للمعاملة ببعض منظمات النمو

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الملخص العربى :

أجريت هذه الدراسة بمزرعة التجارب بكلية الزراعة جامعة المنوفية خلال عامي ٢٠٠٥/٢٠٠٦ ، ٢٠٠٦/٢٠٠٧ لدراسة تأثير حمض الجاسمونك (١٠ مليجرام / لتر) وحمض السلسيلك (١٠ مليجرام / لتر) وحمض الجبريلليك (٢٠ مليجرام / لتر) وأندول حمض الخليك (٢٠ مليجرام / لتر) وذلك باستخدام ثلاث طرق وهى نقع الدرنات فيها قبل الزراعة بنصف ساعة أو رشها على المجموع الخضرى بعد ٤٠ يوم من الزراعة أو نقع الدرنات قبل الزراعة بنصف ساعة ثم الرش بعد ٤٠ يوم من الزراعة على المجموع الخضرى. و تم دراسة تأثيرها على صفات النمو والصفات الكيماوية بالإضافة إلى صفات الجودة والمحصول. وأجريت هذه التجربة على صنف دايمونت حيث تمت الزراعة باستخدام الدرنات الكاملة وكان متوسط وزن الدرنة ٣٥ – ٥٠ جرام تقريباً .

وكانت أهم النتائج المتحصل عليها هى :

* أظهرت النتائج أن جميع منظمات النمو المستخدمة أدت إلى زيادة معنوية فى طول النبات وعدد الأوراق وطول الجذر والوزن الجاف للجذور والسوق والأوراق كما أدت الى زيادة تركيز الكلوروفيلات الكلية والكاروتينيدات والكربوهيدرات الكلية والعناصر المعدنية فى الأوراق .
* أوضحت النتائج أن منظمات النمو المستعملة أدت إلى زيادة المادة الجافة والنشا والكثافة النوعية والكربوهيدرات الكلية فى الدرنات وعدد الدرنات ووزنها والمحصول الكلى للنبات وللفدان, كما أثرت معنوياً فى أحجام الدرنات.
* أكدت النتائج أن طرق استخدام منظمات النمو سواء كانت نقع الدرنات أو الرش على النبات

أو النقع + الرش لم تُؤثر معنويا فى معظم الصفات الخضرية بإستثناء الأوزان الجافة للسوق والأوراق حيث كانت طريقة الرش من أحسن الطرق .

* تأثرت معظم الصفات الكيماوية مثل كلوروفيل (أ + ب) والكاروتينيدات والكربوهيدرات الكلية والمحصول الكلى معنوياً بطرق تطبيق منظمات النمو حيث كانت أعلى قيم فى هذه الصفات لطريقة الرش على المجموع الخضرى .

* تأثرت قيم المحصول وبعض صفات الجودة بطرق المعاملة بمنظمات النمو وكانت طريقة نقع الدرنات قبل الزراعة فى منظمات النمو أدت إلى زيادة نسبة النشا والمادة الجافة والكثافة النوعية.

* فيما يتعلق بالتفاعل بين الهرمونات وطرق استخدامها على الصفات الكيماوية والمحصول ومكوناته وصفات الجودة اتضح أن استخدام الهرمونات وخصوصاً أندول حمض الخليك وحمض الجاسمونك أو الجبريلليك رشاً على المجموع الخضرى أو نقع للدرنات أدى إلى زيادة معنوية فى المحصول الكلى للنبات والفدان .

للحصول على نمو جيد ومحصول مرتفع ذو صفات جيدة يُوصى بإستخدام منظمات النمو النباتية وخصوصاً أندول حمض الخليك وحمض الجاسمونك و الجبريلليك رشا على المجموع الخضرى أو نقع الدرنات قبل الزراعة .