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USING STEM TIP CUTTINGS IN POTATO PRODUCTION

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ABSTRACT

Potato production and product quality are crucial matters for potato customers and growers worldwide. The potentials of producing potato tubers (Burren, Cara, Armada, Lady Balfour and Lady Rosetta) cultivars with good qualities using different asexual propagation method stem tip cuttings were investigated in this study in the laboratory and in open field successive summer seasons of 2014 and 2015. Growth regulators e.g., Indole-3-acetic acid (IAA) and Indole-3-butyric acid (IBA) in different concentrations along with a positive (rooting powder substance) and negative control (distilled water) substances were also used to enhance rooting and growth behaviour of these stem cuttings and different growth characteristics, yield and yield component of potato produced by those stem tip cuttings were studied. Results declared that rooted stem tip cuttings could be obtained from only Burren and Lady Rosetta cultivars and propagating potato by stem cuttings as an asexual means of vegetative propagation is very promising. Moreover, all used growth regulators especially in high concentrations resulted in higher values of the most studied characteristics e.g., plant height, plant fresh and dry weights, number of tubers per plant and total yield per plant comparing to the control treatment. The results of this study may encourage the Egyptian government and potato farmers to use potato stem tip cuttings as a new and cheaper method to grow potato cultivars instead of percentage of the expensive imported seed-tubers for the summer growing season.

Key words: Potato, Stem Cuttings, Plant Growth Regulators, IAA, IBA.

INTRODUCTION

Potato (*Solanum tuberosum L.*) is one of the most important vegetable crops worldwide. It is considered to be the fourth food crop in the world after corn, wheat, and rice (Alva *et al.*, 2011). Potato is a member of the *Solanaceae* family that includes several other economically important crops such as tomato, pepper, and eggplant. In Egypt, potato is an important vegetable crops not only for local consumption but also for exportation. It has a considerable importance as an exportable crop to European markets meanwhile; it is one of the national income resources (Mahmoud and Hafez, 2010).

Potato can be propagated sexually (by botanical seed, also called true potato seed) and asexually by means of tubers **(**Beukema and Van der Zaag, 1990). Propagation of potato seed stocks by stem cuttings was developed in 1960 (Jones, 1991) as a means of elimination of bacterial and fungal pathogens normally carried over by tuber propagation. Three techniques of potato multiplication i.e. stem cutting, nodal cutting and leaf bud cutting are used to produce disease-free planting material. Among these three techniques, stem cutting is the mostly used technique. Stem cuttings are used in 30% of North American and 25% of European rapid multiplication programs for potato (Jones, 1988).

At the same time, it was shown that two synthetic materials, indole-3-butyric acid (IBA) and a-naphthalene acetic acid (NAA) were even more effective than the naturally occurring or synthetic Indole-3-acetic acid (IAA)for rooting **(**Blythe *et al*., 2008). IBA and NAA are still the most widely used auxins for rooting stem cuttings and for rooting tissue-culture–produced micro-cuttings. It has been repeatedly confirmed that auxin is required for initiation of adventitious roots on stems, and indeed, it has been shown that divisions of the first root initial cells are dependent upon either applied or endogenous auxin **(**Maini 1968, Haissig 1972, Strömquist and Hansen 1980, Gasper and Hofinger 1989).

The application of rooting hormone for the rooting of leafy stem cuttings is widely recognized (Tchoundjeu and Leakey 2001, Husen 2003, Husen *et al.* 2003, Hossain and Kamaluddin 2004, Hossain and Kamaluddin 2005, Abdullah *et al.* 2005, Husen and Pal 2006). Although the rooting hormone, IBA, has a very important role in rooting various tropical tree species and the different concentrations of IBA applied lead to various rooting response for the different species (Ansari and Gupta 2000, Tchoundjeu *et al.* 2002). Thus, the present work was planned to investigate the possibility of producing stem tip cuttings from five potato cultivars and study the benefits of using potato stem tip cuttings to produce potato.

MATERIALS AND METHODS

The experiments were carried out during the two successive summer seasons of 2014 and 2015 as follow:

Seed tubers production using potato stem cuttings

In this experiment, stem tip cuttings were used as a rapid multiplication technique to produce transplants from five potato cultivars as follow:

1. Producing stem tip cuttings

Five potato cultivars (Burren, Cara, Armada, Lady Balfour and Lady Rosetta) were selected to be used in these experiments. Seed tubers (as product of the summer season and stored in potato refrigerators for about four months) of the above mentioned five cultivars were prepared and planted in plots in the open field in September16th, 17th, 19th, 20th, and 21st of 2013 and 2014 growing seasons (fall season) in a randomized complete block design. All recommended agricultural practices for the commercial production of potato under Minia governorate conditions were carried out according to the instructions of the Egyptian Ministry of Agriculture. After 45 days, shoot tips were removed from the main stems to stimulate the axillary buds of the initial plants to develop axillary shoots. After 15 days, the apical lateral shoots which composed of three to four leaves were used as stem tip shoots. Ten stem tip cuttings were considered as one replicate and five replicates were used for each treatment in randomized complete blocks design (RCBD) laboratory experiment. Data of stem tip cuttings' fresh weight and length at 0 time and after 15 days were recorded.

2. Rooting

The obtained stem tip shoots were immersed in distilled water (as negative control), commercial rooting solution powder at 0.5 g/L (as positive control), or indole acetic acid (IAA) in three concentrations (1000, 3000, 6000 ppm) and indole butyric acid (IBA) in three concentrations (1000, 3000, 6000 ppm) in order to enhance rooting. Unfortunately, only two potato cultivars; Burren and Lady Rosetta formed root (in the high concentrations of IAA and IBA) and were used in the next experiments. The other three cultivars were discarded. Then, stem cuttings of both cultivars were left for an hour before planting in the field to allow hormone penetration into their tissues. All stem cuttings were planted in seedling trays (84 beds) containing a rooting medium consists of (peat moss + vermiculite) 3:1 size: size plus a NPK fertilizer 20:20:20 with 7.5g/kg of media plus rizolix as a fungicide. After 55 days from planting the stem cuttings in the trays, samples were collected to record plant length (cm), plant weight (g), root length (cm) and roots number.

3. Production of potato seed tubers from transplants

Rooted stem cuttings were transplanted in rows of plots in the open field in 10^{th} and 15^{th} of January during 2014 and 2015 seasons, respectively as similar as what was followed with the imported seed tubers in the same summer season. It was done on one side of the row in all plots, each plot consisted of five rows (0.70 m width and 3.0 m length) and the planting distance along with the row was 20.0 cm interval. The area of each experimental plot was 10.5 m^2 to be considered as (1/400 of a feddan). The RCBD design with five replicates was used. After 110 days from transplanting, the following data were recorded:

1. Plant height (cm)
2. Average number of main stems/plant
3. Average fresh weight of the whole plant (g)
4. Average total yield (g/ plant)
5. Average number of tubers/plant

Statistical analysis

All obtained data were subjected to the analysis of variance (ANOVA) and means were compared using the Duncan's Multiple Range Test at 95% confidence according to **Gomez and Gomez (1984)**. The MSTATC program Ver. 4 (Michigan University, USA 1986) was used to achieve all these statistical analyses.

RESULTS

Production of transplants from potato stem cuttings

1. Production of stem cuttings

Results shown in Tables 1,2,8 and 9 indicated that there were insignificant differences among potato cultivars in stem cuttings fresh weight (g) and stem cuttings length (cm) at 0 time. After 15 days data showed that stem cuttings of cv. Burren treated with 6000 ppm IBA gave the highest fresh weight (21.05 and 18.25 g) in the two growing seasons. Meanwhile, the effect of treatments on stem cuttings of cv Lady Rosetta treated with 6000 ppm IBA on fresh weight was the best (17.49 and 14.29 g) in the two growing seasons comparing to the other treatments.

2. Induction of roots in the stem cuttings

Only stem tip cuttings removed from Burren and Lady Rosetta could form roots and the other three cultivars couldn't; that's why data from the first two cultivars only were recorded in this study.

2.1 Stem cuttings length

Data in **Table (2)** illustrated the stem cuttings length as affected by hormones (IBA and IAA); the obtained results showed that treating cv Burren with 6000 ppm IBA significantly increased the stem cuttings length (17.33 and 17.87 cm) in both seasons. Also, Data in **Table (9)** illustrate that stem cuttings length was affected by hormones (IBA and IAA). Obtained results showed that treated cv Lady Rosetta with 6000 ppm IBA significantly increased the stem cuttings length in both

seasons (15.34 and 13.90 cm) compared with other treatments, in both growing seasons.

2.2 Root number

Regarding the effect of treatments, data in **Table (3)** showed that applied IBA at the concentration of 6000 ppm had the highest significant effect on root number of cv Burren after 15 days (15.08 and 14.12) and (18.72 and 19.52) after 55 days compared with the other treatments in both seasons, respectively. At the same time, data in **Table (10)** showed that applied IBA with the concentration of 6000 ppm gave the highest root number of cv Lady Rosetta (12.90 and 11.46) after 15 days and (11.68 and 13.92) after 55 days compared with the other applied treatments.

2.3 Root length

Table (4) describes the effect of IBA and IAA on root length showed that the best effective treatment on cv Burren was the concentration of 6000 ppm of IBA after 15 days (3.56 and 4.04 cm) and (18.46 and 19.30 cm) after 55 days compared to the other treatments. On the other hand, the results in Table (11) indicated that root length was significantly affected by both IBA and IAA and the data revealed that cv Lady Rosetta showed the best values of root length (14.28 and 15.12 cm) after 55 days compared with cv Lady Rosetta (3.24 and 3.10 cm) after 15 days in the two growing seasons respectively.

2.4 Fresh weight

Results of Table (5) indicated that stem cuttings fresh weight after 55 days was significantly affected by hormones treatment (IBA and IAA). The data revealed that treated cv Burren with 6000 ppm of IBA was the best and produced the highest values after 55 days (281.22 and 289.38g) compared with other the treatments in the two growing seasons. Meanwhile, the effect of treatments on cv Lady Rosetta treated with 6000 ppm of IBA was the best and gave the highest values, too (220.34 and 213.38 g) in the two growing seasons, **(**Table 12**)**.

3. Production of potato seed tubers from transplants obtained from stem cuttings.

3.1 Plant height (cm).

The Effect of treatments on plant height after 55 and 110 days of cultivation in cv. Burren were showed in **(**Table 6**)** and the results in this Table indicated that the effects of treatment of 6000 ppm of IBA showed significant higher values after 55 days (33.59 and 34.99cm) and (52.55 and 55.19 cm) after 110 days compared with other treatments in the two growing seasons, respectively. In Table (13), data showed that the best obtained values of plant height of cv Lady Rosetta were obtained by the concentration of 6000 ppm from IBA after 55 days (27.77 and 26.93 cm) and (39.59 and 40.51cm) after 110 days in the two growing seasons, respectively.

3.2 Average number of main stems/plant.

In Table (7), application of IBA at the concentration of 6000 ppm was more effective in increasing the potato main stems/plant of cv Burren (3.08 and 2.97) comparing with the other treatments. Also, the same treatment showed the highest values of main stems/plant of cv Lady Rosetta (2.16 and 2.33) as shown in **Table (14)** comparing to the other treatments.

3.3 Average fresh weight of whole plant (g)

Data in Table (7) illustrated the average fresh weight of whole plant (g) of the potato cv Burren as affected by IBA and IAA and showed that IBA significantly increased the average fresh weight of the whole plant of cv Burren after 110 days (511.32 and 535.84g) in the two growing seasons, respectively. On the other hand, data in Table (10) showed that the application of 6000 ppm of IBA was significantly more effective and improved average fresh weight of whole plant in cv Lady Rosetta after 110 days (405.63 and 400.72 g) compared with the other treatments in the two growing seasons.

3.4 Average total yield /plant

The average total yield of potato was affected by IBA and IAA treatments as described in Table (7). Application of IBA (6000 ppm) was significantly more effective and improved the average total yield/plant of cv Burren (396.20 and 400.20 g) compared with the other treatments in both growing seasons, respectively. Also, Data in Table (14) showed the effect of the same treatment on cv Lady Rosetta, and the best and highest values were obtained by using 6000 ppm of IBA (307.00 and 302.40 g) in the two growing seasons, respectively.

3.5 Average number of tubers/plant

Data in **Table (7)** showed the average number of tubers/plant and illustrated that the highest average number of tubers/plant (4.19 and 3.69) in cv Burren was obtained by the application of 6000 ppm of IBA. Also, data in **Table (14)** showed that the number of tubers/plant of cv Lady Rosetta were significantly increased by the concentration of 6000 ppm of IBA (3.28 and 2.76) compared with the other treatments in the two growing seasons.

DISCUSSION

Potato can be propagated sexually (by botanical seed, also called true potato seed) and asexually (vegetatively) by means of tubers. (Jones, 1991). Propagation of potato seed stocks by stem cuttings was developed in 1960 as a means of elimination of bacterial and fungal pathogens normally carried over by tuber propagation. Searching for other means to propagate potato is very crucible nowadays, as the seed tubers' prices are expensive. That's why in these experiments we studied the possibilities to

propagate potato with the means of stem cuttings and enhance the growth capabilities of these cutting by using different plant growth regulators (PGR) e.g., IAA, IBA and GAs. Thimann and Koepfli (1935) reported that the synthetic Indole-3-Acetic Acid (IAA) has the capability of forming roots and demonstrated its practical use in stimulating root formation on potato cuttings. In the same year, Zimmerman and Wilcoxon (1935), claimed that the growth regulators Indole-3-Butyric Acid (IBA) and 1-Naphthalene Acetic Acid (NAA) were shown to be more effective than IAA for rooting. Since IBA has a higher activity, a broader range of effective concentration without toxicity and it was effective in more plant species. Therefore IBA was used more frequently than NAA. (Hartmann and Kester, 1968).

Plant growth regulators have vital effects on potato seed tuber viability and plant growth which is highly related to hormonal balance (Stuart and Cathey, 1961 and Vreugdenhil and Struik, 1989). Gibberellins are growth promoters and to date over one hundred of gibberellins have been isolated and mainly produced in the leaves but may also be synthesized in the root and fruits (Vivanco and Flores, 2000). Gibberellic acid (GA_3) is a key factor in controlling seed dormancy and germination in many crops including potatoes (Amen, 1968, Wareing and Saunders, 1971, Taylorson and Hendricks, 1977, Bhargava, 1997, Kucera *et al*., 2005 and Pawlowski, 2009). It is often used to break seed dormancy and to improve seed germination in many plant species, (Pallais *et al*., 1991, Karam and Al-Salem, 2001, Bahrani *et al*., 2008, Zeinalabedini *et al*., 2009, Deng *et al*., 2010 and Zeng *et al*., 2010). We did not include GAs in this study because there are lots of researches focused on GAs and their effects on plants growth and productivity.

In this study, we used both IBA and IAA in different concentrations as it was mentioned above. Both growth regulators had significant and positive effects on potato stem cuttings viability and gave healthy and productive plants. Indole-3-butyric acid (IBA) is more preferable than other growth substances as, it has low auxin activity and degraded relatively slowly by auxin degrading enzymes and it is persistent in nature. The application of IBA recorded its superiority over other plant growth regulators for plant height, number of branches and number of leaves; therefore, it gave the highest dry weight of foliage (Bhatia *et al*., 1992). IBA has also significant effect on rooting, especially cuttings which are considered hard to root (Ercili and Guleryz, 1999 and Delker *et al*., 2008).

All the growth regulators are not equally suitable for rooting performances. Among the growth regulators, Indole Butyric Acid is the most commonly and widely used to achieve high percentage of rooting success for potato and some ornamental species (Kundu

et al., 1987). The same results were obtained in our experiments. Jones, (1988) reported that stem cuttings were used in 30% of North American and 25% of European rapid multiplication programs for potato. Beukema and Van der Zaag, (1990). Indole-3-acetic acid (IAA) was identified as a naturally occurring compound having considerable auxin activity (Haissig and Davis 1994).

Bryan (1981) reported that each potato stem cutting yielded 400 to 1000 gm of tubers when grown under field conditions. Berezovskii, (1982) mentioned that treating potato stem cuttings with 0.01% 2,4 D for 3-4 min was superior to the treatment with 70 mg of IAA for 6 hours in root establishment and tubers yield/plant. Moreover, Hepbum and Matthews (1986) reported that both IBA and NAA significantly stimulated more roots per rooted cuttings than the untreated cuttings but NAA significantly reduced the number. Similar results were obtained in this study.

In another study, El- Gamal (1992) dipped stem cuttings pre-planting in potassium of indole butyric acid solution at 6000 ppm for one minutes and mentioned that this treatment succeeded to stimulate adventitious roots and affected the production and growth parameters of potato e.g., fresh and dry weights of roots. The same treatment also was the best procedure to record the highest value of root numbers. Also, El-Boraie (1998) found that IBA at 4000 ppm gave the highest rooting percentage of terminal and sub terminal cuttings of *Jasminum sambac*, root length, number and dry weight of roots increased with IBA treatments as compared with control.

Table (1): Effect of using IBA, IAA and standard rooting hormone on stem fresh weight after 0 and 15 days from cutting removed of potato stem cuttings of Burren cv in 2014 and 2015 growing summer seasons.

Treatments		The 1st season				The 2nd season			
		Stem cuttings fresh weight(g) at 0 time		Stem cuttings fresh weight (g) after 15 days		Stem cuttings fresh weight (g) at 0 time		Stem cuttings fresh weight (g) after 15 days	
Control (water)		16.70	ab	15.42	e	16.56	a	15.38	d
Rooting hormone		16.46	b	17.04	d	16.98	a	16.64	bc
IBA	(1000) ppm	16.84	ab	18.44	c	17.30	a	16.94	bc
	(3000) ppm	17.50	ab	19.99	b	17.34	a	17.43	b
	(6000) ppm	17.74	a	21.05	a	17.88	a	18.25	a
IAA	(1000) ppm	16.72	ab	17.25	d	17.14	a	17.02	bc
	(3000) ppm	17.30	ab	18.38	c	17.16	a	16.44	c
	(6000) ppm	17.66	ab	19.60	b	16.62	a	17.41	b

Values having the same letter(s) did not differ at 0.05 level of significance according to Duncan's Multiple Range Test.

Table (2): Effect of using IBA, IAA and standard rooting hormone on stem length after 0 and 15 days from cutting removed of potato stem cuttings of Burren cv in 2014 and 2015 growing summer seasons.

Treatments		The 1st season				The 2nd season			
		Stem cuttings length (cm) at 0 time		Stem cuttings length (cm) after 15 days		Stem cuttings length (cm) at 0 time		Stem cuttings length (cm) after 15 days	
Control (water)		14.38	b	14.02	d	15.06	b	14.14	d
Rooting hormone		15.06	ab	15.31	c	15.28	ab	14.38	d
IBA	(1000) ppm	15.28	ab	15.37	c	15.62	ab	16.01	c
	(3000) ppm	15.40	ab	16.29	b	15.84	ab	17.17	ab
	(6000) ppm	15.82	a	17.33	a	16.14	a	17.87	a
IAA	(1000) ppm	14.66	b	14.55	d	15.44	ab	15.61	c
	(3000) ppm	14.88	ab	15.24	c	15.48	ab	15.63	c
	(6000) ppm	15.36	ab	16.31	b	15.74	ab	16.86	b

Values having the same letter(s) did not differ at 0.05 level of significance according to Duncan's Multiple Range Test.

Table (3): Effect of using IBA, IAA and standard rooting hormone on number of roots after 15 and 55 days from cutting treatments of potato stem cuttings of Burren cv in 2014 and 2015 growing summer seasons.

Treatments		The 1st season				The 2nd season			
		Root number after 15 days		Root number after 55 days		Root number after 15 days		Root number after 55 days	
Control (water)		0.00	d	0.000	d	0.00	d	0.000	d
Rooting hormone		0.00	d	0.000	d	0.00	d	0.000	d
IBA	(1000) ppm	0.00	d	0.000	d	0.00	d	0.000	d
	(3000) ppm	13.16	b	14.80	b	12.96	b	15.62	b
	(6000) ppm	15.08	a	18.72	a	14.12	a	19.52	a
IAA	(1000) ppm	0.00	d	0.000	d	0.00	d	0.000	d
	(3000) ppm	0.00	d	0.000	d	0.00	d	0.000	d
	(6000) ppm	11.84	c	13.30	c	11.66	c	13.14	c

Values having the same letter(s) did not differ at 0.05 level of significance according to Duncan's Multiple Range Test.

Table (4): Effect of using IBA, IAA and standard rooting hormone on root length after 15 and 55 days from cutting treatments of potato stem cuttings of Burren cv in 2014 and 2015 growing summer seasons.

Treatments		The 1st season				The 2nd season			
		Root length (cm) after 15 days		Root length (cm) after 55 days		Root length (cm) after 15 days		Root length (cm) after 55 days	
Control (water)		0.00	d	0.000	d	0.00	c	0.000	d
Rooting hormone		0.00	d	0.000	d	0.00	c	0.000	d
IBA	(1000) ppm	0.00	d	0.000	d	0.00	c	0.000	d
	(3000) ppm	2.01	b	15.22	b	2.38	b	14.66	b
	(6000) ppm	3.56	a	18.46	a	4.04	a	19.30	a
IAA	(1000) ppm	0.00	d	0.000	c	0.00	c	0.000	d
	(3000) ppm	0.00	d	0.000	c	0.00	c	0.000	d
	(6000) ppm	1.53	c	14.62	b	1.73	b	13.62	c

Values having the same letter(s) did not differ at 0.05 level of significance according to Duncan's Multiple Range Test.

Table (5): Effect of using IBA, IAA and standard rooting hormone on whole plant fresh weight after 55 and 110 days of potato plants of Burren cv in 2014 and 2015 growing summer seasons.

Treatments		The 1st season				The 2nd season			
		whole plant fresh weight (g) after 55 days		whole plant fresh weight (g) after 110days		whole plant fresh weight (g) after 55 days		whole plant fresh weight (g) after 110days	
Control (water)		0.0000	d	0.0000	d	0.0000	d	0.0000	d
Rooting hormone		0.0000	d	0.0000	d	0.0000	d	0.0000	d
IBA	(1000) ppm	0.0000	d	0.0000	d	0.0000	d	0.0000	d
	(3000) ppm	169.40	b	308.00	b	161.40	b	293.46	b
	(6000) ppm	281.22	a	511.32	a	289.38	a	535.84	a
IAA	(1000) ppm	0.0000	d	0.0000	d	0.0000	d	0.0000	d
	(3000) ppm	0.0000	d	0.0000	d	0.0000	d	0.0000	d
	(6000) ppm	134.26	c	247.78	c	145.18	c	215.41	c

Values having the same letter(s) did not differ at 0.05 level of significance according to Duncan's Multiple Range Test.

Table (6): Effect of using IBA, IAA and standard rooting hormone on plant height after 55 and 110 days of potato plants of Burren cv in 2014 and 2015 growing summer seasons.

Treatments		The 1st season				The 2nd season			
		Plant height (cm) after 55 days		Plant height (cm) after 110 days		Plant height (cm) after 55 days		Plant height (cm) after 110 days	
Control (water)		0.000	d	0.000	d	0.000	d	0.000	d
Rooting hormone		0.000	d	0.000	d	0.000	d	0.000	d
IBA	(1000) ppm	0.000	d	0.000	d	0.000	d	0.000	d
	(3000) ppm	25.52	b	39.16	b	27.45	b	36.87	b
	(6000) ppm	33.59	a	52.55	a	34.99	a	55.19	a
IAA	(1000) ppm	0.000	d	0.000	d	0.000	d	0.000	d
	(3000) ppm	0.000	d	0.000	d	0.000	d	0.000	d
	(6000) ppm	21.06	c	32.48	c	22.67	c	27.17	c

Values having the same letter(s) did not differ at 0.05 level of significance according to Duncan's Multiple Range Test.

Table (7): Effect of using IBA, IAA and standard rooting hormone on main stem/plant, total yield/plant (g) and number of tubers/plant after 110 days from planting of potato plants (Burren cv) in 2014 and 2015 growing summer seasons.

Treatments		The 1st season						The 2nd season					
		main stems/plant		total yield /plant		number of tubers/plant		main stems/plant		total yield /plant		number of tubers/plant	
Control (water)		0.00	d	0.0000	d	0.00	d	0.00	d	0.0000	d	0.00	d
Rooting hormone		0.00	d	0.0000	d	0.00	d	0.00	d	0.0000	d	0.00	d
IBA	(1000) ppm	0.00	d	0.0000	d	0.00	d	0.00	d	0.0000	d	0.00	d
	(3000) ppm	2.16	b	198.15	b	2.79	b	2.03	b	202.40	b	2.05	b
	(6000) ppm	3.08	a	396.20	a	4.19	a	2.97	a	400.20	a	3.69	a
IAA	(1000) ppm	0.00	d	0.0000	d	0.00	d	0.00	d	0.0000	d	0.00	d
	(3000) ppm	0.00	d	0.0000	d	0.00	d	0.00	d	0.0000	d	0.00	d
	(6000) ppm	1.95	c	149.60	c	2.06	c	1.41	c	145.20	c	1.52	c

Values having the same letter(s) did not differ at 0.05 level of significance according to Duncan's Multiple Range Test.

Table (8): Effect of using IBA, IAA and standard rooting hormone on stem fresh weight after 0 and 15 days from cutting removed of potato stem cuttings of Lady Rosetta cv in 2014 and 2015 growing summer seasons.

Treatments		The 1st season				The 2nd season			
		Stem cuttings fresh weight (g) at 0 time		Stem cuttings fresh weight (g) after 15 days		Stem cuttings fresh weight (g) at 0 time		Stem cuttings fresh weight (g) after 15 days	
Control (water)		14.08	a	13.43	d	11.00	a	10.74	e
Rooting hormone		13.76	a	13.55	d	11.46	a	11.90	d
IBA	(1000) ppm	14.36	a	15.18	c	11.74	a	12.84	c
	(3000) ppm	14.56	a	16.62	ab	11.78	a	13.67	b
	(6000) ppm	14.98	a	17.49	a	12.30	a	14.29	a
IAA	(1000) ppm	14.52	a	13.92	d	11.40	a	11.94	d
	(3000) ppm	14.12	a	13.54	d	11.44	a	11.92	d
	(6000) ppm	14.82	a	16.29	b	11.50	a	13.74	b

Values having the same letter(s) did not differ at 0.05 level of significance according to Duncan's Multiple Range Test.

Table (9): Effect of using IBA, IAA and standard rooting hormone on stem length after 0 and 15 days from cutting removed of potato stem cuttings of Lady Rosetta cv in 2014 and 2015 growing summer seasons.

Treatments		The 1st season				The 2nd season			
		Stem cuttings length (cm) at 0 time		Stem cuttings length (cm) after 15 days		Stem cuttings length (cm) at 0 time		Stem cuttings length (cm) after 15 days	
Control (water)		12.66	b	12.39	d	11.20	b	9.64	e
Rooting hormone		13.32	ab	12.88	d	11.30	b	10.74	d
IBA	(1000) ppm	14.18	ab	13.88	c	11.92	ab	11.70	c
	(3000) ppm	14.40	ab	15.32	a	11.94	ab	13.14	b
	(6000) ppm	14.54	a	15.34	a	12.64	a	13.90	a
IAA	(1000) ppm	13.98	ab	12.65	d	11.52	b	11.72	c
	(3000) ppm	14.12	ab	12.97	d	11.90	ab	10.86	d
	(6000) ppm	14.24	ab	14.50	b	11.92	ab	13.11	b

Values having the same letter(s) did not differ at 0.05 level of significance according to Duncan's Multiple Range Test.

Table (10): Effect of using IBA, IAA and standard rooting hormone on root number after 15 and 55 days from cutting treatments of potato stem cuttings of Lady Rosetta cv in 2014 and 2015 growing summer seasons.

Treatments		The 1st season				The 2nd season			
		Root number after 15 days		Root number after 55 days		Root number after 15 days		Root number after 55 days	
Control (water)		0.00	d	0.00	d	0.00	d	0.000	d
Rooting hormone		0.00	d	0.00	d	0.00	d	0.000	d
IBA	(1000) ppm	0.00	d	0.00	d	0.00	d	0.000	d
	(3000) ppm	11.96	b	8.18	b	10.46	b	8.90	b
	(6000) ppm	12.90	a	11.68	a	11.46	a	13.92	a
IAA	(1000) ppm	0.00	d	0.00	c	0.00	d	0.000	c
	(3000) ppm	0.00	d	0.00	c	0.00	d	0.000	c
	(6000) ppm	9.94	c	8.30	b	8.58	c	9.16	b

Values having the same letter(s) did not differ at 0.05 level of significance according to Duncan's Multiple Range Test.

Table (11): Effect of using IBA, IAA and standard rooting hormone on root length after 15 and 55 days from cutting treatments of potato stem cuttings of Lady Rosetta cv in 2014 and 2015 growing summer seasons.

Treatments		The 1st season				The 2nd season			
		Root length (cm) after 15 days		Root length (cm) after 55 days		Root length (cm) after 15 days		Root length (cm) after 55 days	
Control (water)		0.00	d	0.00	d	0.00	d	0.000	d
Rooting hormone		0.00	d	0.00	d	0.00	d	0.000	d
IBA	(1000) ppm	0.00	d	0.00	d	0.00	d	0.000	d
	(3000) ppm	1.89	b	12.24	b	1.59	b	13.06	b
	(6000) ppm	3.24	a	14.28	a	3.10	a	15.12	a
IAA	(1000) ppm	0.00	d	0.000	d	0.00	d	0.000	d
	(3000) ppm	0.00	d	0.000	d	0.00	d	0.000	d
	(6000) ppm	1.94	c	10.08	c	1.11	c	11.04	c

Values having the same letter(s) did not differ at 0.05 level of significance according to Duncan's Multiple Range Test.

Table (12): Effect of using IBA, IAA and standard rooting hormone on fresh weight of the whole plant after 55 and 110 days of potato plants of Lady Rosetta cv in 2014 and 2015 growing summer seasons.

Treatments		The 1st season				The 2nd season			
		whole plant fresh weight (g) after 55 days		whole plant fresh weight (g) after 110days		whole plant fresh weight (g) after 55 days		whole plant fresh weight (g) after 110days	
Control (water)		0.0000	d	0.0000	d	0.0000	d	0.0000	d
Rooting hormone		0.0000	d	0.0000	d	0.0000	d	0.0000	d
IBA	(1000) ppm	0.0000	d	0.0000	d	0.0000	d	0.0000	d
	(3000) ppm	136.96	b	250.24	b	152.96	b	278.14	b
	(6000) ppm	220.34	a	405.63	a	213.38	a	400.72	a
IAA	(1000) ppm	0.0000	d	0.0000	d	0.0000	d	0.0000	d
	(3000) ppm	0.0000	d	0.0000	d	0.0000	d	0.0000	d
	(6000) ppm	94.08	c	171.08	c	90.92	c	165.34	c

Values having the same letter(s) did not differ at 0.05 level of significance according to Duncan's Multiple Range Test.

Table (13): Effect of using IBA, IAA and standard rooting hormone on plant height after 55 and 110 days of potato plants of Lady Rosetta cv in 2014 and 2015 growing summer seasons.

Treatments		The 1st season				The 2nd season			
		Plant height (cm) after 55 days		Plant height (cm) after 110 days		Plant height (cm) after 55 days		Plant height (cm) after 110 days	
Control (water)		0.000	d	0.000	d	0.000	d	0.000	d
Rooting hormone		0.000	d	0.000	d	0.000	d	0.000	d
IBA	(1000) ppm	0.000	d	0.000	d	0.000	d	0.000	d
	(3000) ppm	22.68	b	29.57	b	21.03	b	27.03	b
	(6000) ppm	27.77	a	39.59	a	26.93	a	40.51	a
IAA	(1000) ppm	0.000	d	0.000	d	0.000	d	0.000	d
	(3000) ppm	0.000	d	0.000	d	0.000	d	0.000	d
	(6000) ppm	19.56	c	25.18	c	20.02	c	25.72	c

Values having the same letter(s) did not differ at 0.05 level of significance according to Duncan's Multiple Range Test.

Table (14): Effect of using IBA, IAA and standard rooting hormone on main stem/plant, total yield/plant (g) and number of tubers/plant after 110 days from planting of potato plants (Lady Rosetta cv) in 2014 and 2015 growing summer seasons.

Treatments		The 1st season						The 2nd season					
		main stems/plant		total yield /plant		number of tubers/plant		main stems/plant		total yield /plant		number of tubers/plant	
Control (water)		0.00	d	0.0000	d	0.00	d	0.00	d	0.0000	d	0.00	d
Rooting hormone		0.00	d	0.0000	d	0.00	d	0.00	d	0.0000	d	0.00	d
IBA	(1000) ppm	0.00	d	0.0000	d	0.00	d	0.00	d	0.0000	d	0.00	d
	(3000) ppm	1.83	b	161.40	b	2.11	b	2.18	b	158.00	b	2.20	b
	(6000) ppm	2.16	a	307.00	a	3.28	a	2.33	a	302.40	a	2.76	a
IAA	(1000) ppm	0.00	d	0.0000	d	0.00	d	0.00	d	0.0000	d	0.00	d
	(3000) ppm	0.00	d	0.0000	d	0.00	d	0.00	d	0.0000	d	0.00	d
	(6000) ppm	1.52	c	106.60	c	1.60	c	1.38	c	95.40	c	1.34	c

Values having the same letter(s) did not differ at 0.05 level of significance according to Duncan's Multiple Range Test.

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استخدام قمم العقل الساقية لإنتاج البطاطس

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أجريت هذه التجارب فى مزرعة خاصة بقرية إبوان بمحافظة المنيا بجمهورية مصر العربية من أجل دراسة إمكانية إنتاج صنفين من البطاطس (برن Burren و ليدى روزيتا Lady Rosetta) من العقل الساقية بدلاً من إستخدام الدرنات الساقية المتعارف على إنتاج البطاطس بواسطتها ، وتم إجراء التجارب الحقلية والمعملية فى موسمين زراعيين صيفيين متواليين من عام 2014 و2015. تم أيضاً استخدام بعض منظمات النمو النباتية مثل إندول حامض الخليك IAA بتركيزات (1000 و 3000 و6000 جزء فى المليون) وإندول حامض البيوتريك IBA بتركيزات (1000 و 3000 و 6000 جزء فى المليون) وتم إستخدام مادة قياسية للتجذير (كمعاملة مقارنة موجبة) وكذلك الماء المقطر (كمعاملة مقارنة سالبة) لمعرفة تأثيرها على تجذير العقل الساقية وكذلك على نمو وإنتاجية نباتات البطاطس من الدرنات وإنتاجية الفدان من الدرنات.

أظهرت النتائج صلاحية طريقة العقل الساقية لإنتاج البطاطس خصوصا من صنفى (برن Burren و ليدى روزيتا Lady Rosetta) التى استطاعت العقل المأخوذة منها على تكوين الجذور ، فى حين لم تستطع العقل المأخوذة من الثلاثة أصناف الأخرى (Cara, Armada, Lady Balfour) على تكوين الجذور. وكذلك بينت النتائج أن المواد المستخدمة (منظمات النمو النباتية) خصوصاً بالتركيزات العالية بعضها كانت غير فعالة والبعض الآخر كانت فعالة فى تحسين النمو والقدرة على تكوين جذور وحيوية العقل الساقية وكذلك على إنتاجية الدرنات من نباتات البطاطس التى زرعت وتم إكثارها خضرياً بواسطة هذه العقل ، وكانت أفضل المعاملات هى معاملة إندول حامض البيوتريك بتركيز 6000 جزء فى المليون لصنفين البطاطس (برن Burren و ليدى روزيتا Lady Rosetta) مقارنة بباقى المعاملات التى تم إستخدامها.

تشجع النتائج المتحصل عليها من هذه التجارب الحكومة المصرية ومزارعى البطاطس ومنتجيها على إستخدام العقل الساقية كوسيلة لإنتاج البطاطس كجزء بديل لتقاوى البطاطس من الدرنات التى يتم إستيرادها بأسعار عالية لإنتاج البطاطس فى العروة الصيفية ولكن بعد مزيد من الدراسات والتجارب الأخرى.