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SEEDLESS WATERMELON PROPAGATION BY CUTTINGS
B. Effect of BA, IBA and cutting type on transplants production from cuttings

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By
A. A. S. A. El-Eslamboly

Protected Cultivation Department, Horticulture Research Institute, Agriculture Research Center, Egypt

ABSTRACT

Cutting is one of the most important methods of vegetative propagation. The growing costs of seedless watermelon (triploid hybrids) in Egypt are very expensive because of its high seed price, seeds do not germinate well and they show less homogeneous germination and growth. For these reasons, the present investigation aimed to propagate seedless watermelon by cuttings produced from stock plants (mother plants) and to study the effects of BA and IBA concentrations and cutting types and the interactions between them on the cutting success.

Cuttings of seedless watermelon cv. Buttercup (QV 766) F_1 (yellow flesh) and SSX 7402 F_1 hybrid (red flesh) were taken from stock plants planted under optimal conditions and treated before as mother plant for cuttings at 45 and 75 days from transplant. Two types of cuttings were used. The first type was cuttings from terminal growing point of the main stem and lateral branches 10 to15cm in length and 0.45 to 0.6 cm in diameter. The second type was cuttings included one node, bud and leaf. Cuttings were taken from these mother plants, at four time intervals, *i.e.,* 105,135,165 and 195 days from transplanting. Mother plants were treated with 3 concentrations (0, 10 and 20 ppm) of BA for four times, *i.e.,* after 75, 105,135 and 165 days to maintain and improve the physiological status of the mother plants. The cuttings of all times were treated with 3 concentrations of IBA, *i.e.,* 0, 100 and 200 ppm to promote the adventitious roots formation. Cutting times 105 and 195 days were planted in speedling trays. These studies were conducted in factorial experiments in a randomized complete block design with three replicates for each, during the seasons of 2010/2011 and 2011/2012 at a nursery in Badrashein City, Giza Governorate, Egypt. The other cutting times at 135 and 165 days were taken to study the largest number of cutting which can be produced. Each hybrid and each cuttings time were conducted in a single experiment.

The results showed that BA treatments played a major role in rejuvenation, improved the physiological status of the mother plants and increased the total number of the produced cuttings in addition to the significant effect on the survival percentage, roots number and length. All IBA concentrations showed significant effect on the survival percentage and root number and length. Cuttings included one node gave a higher survival rate, number of roots and root lengths than the terminal cuttings in the first and second seasons in both cultivars under study. The interaction between IBA and type of cuttings exhibited significant effects on the cutting success as a survival percentage and the number of root formation. No significant effects were recorded for the bilateral interaction between the concentrations of both BA and IBA. In contrast the interactions between BA with cutting type gave significant effect on the survival percentage, root number and length. The interaction between IBA with cutting type had significant effects on al characters under study. No significant effects were noticed due to the triple interaction between BA, IBA concentration and cutting type on the survival percentage, while this interaction played a significant role in the improvement of the root number and length in both cultivars at the third to last date in both seasons.

Key words: *auxin, BA, cuttings, cytokinins, IBA , propagation, seedless watermelon, triploid.*

1. INTRODUCTION

Triploid watermelons (2n = 3x = 33) are referred to as seedless watermelons, they are not truly seedless, but rather have undeveloped seeds that are soft and edible. The seedless watermelons were first obtained and described in Japan by crossing female tetraploid and male diploid plants (Kihara, 1951). The triploid plants are sterile. Triploid watermelons production is more expensive than that of F_1 hybrids (as much as 5–10 times) because of the high cost of the seeds, the establishment of the crop from transplants and the necessary presence of a pollinator variety planted with the triploid variety (flowers of triploid plants lack sufficient viable pollen to induce normal fruit set) (Wehner, 2007).

For increasing the demand for seedless cultivars, cutting is a good approach for plant propagation of valuable plants such as triploid seedless hybrids.

Of the many important factors in cutting propagation, such as growth regulators, cutting type and the condition of the stock-plant (mother plants), optimal temperatures for propagation vary enormously between species. Vegetative propagation is extensively used in agriculture, horticulture and forestry for multiplying elite plants selected from natural populations or obtained in breeding programs (Hartmann *et al.*, 2002). De Klerk *et al.* (1999) reported that, the adventitious roots formation is an essential step in vegetative propagation and therefore losses occur if cuttings do not form roots. Moreover, they indicated that applied indole-3-butyric acid (IBA) increased adventitious root formation on vegetative stem cuttings of wild-type plants. Auxin uses in root formation on the cuttings by a short exposure to high auxin concentration as a solution or by dipping in rooting powder (auxin with talc) (Haissig and Davis 1994). Noticeable progress has been made recently in the research on rooting, which is not a single process but a progressive process consisting of different steps, each with its own requirements (Kevers *et al.*, 1997). Plant development is modulated by genetic and environmental factors, which have effects on auxin biosynthesis, metabolism, transport, and signaling pathway (Han *et al.*, 2009). Adventitious roots can arise naturally from stem tissue under stressful environmental conditions; they may also be induced by mechanical damage or following tissue culture regeneration of shoots (Li *et al.*, 2009). They are postembryonic roots which arise from the stem and leaves and from nonpericycle tissues in old roots (Geiss *et al.,* 2009).

Auxins have the greatest effect on root formation in cuttings, IBA is artificial; the most widely used rooting hormone, used on its own or in combination with NAA. Auxins can be applied to plants as a powder, gel or liquid. Cutting is frequently treated with hormones which encourage root development. The length of time for which the cutting is dipped can also be varied. For example, basal parts of cuttings can be soaked for 24 hours in a dilute solution (*e.g.* 100 ppm), or dipped in a concentrated solution (500–10 000 ppm) for about 5 seconds (Mason, 2004). Treating different plant cuttings by dipping in IBA at 500 to1000 ppm for few seconds promote adventitious root formation, root number and root length (Robbins *et al.*, 1985). The application of IBA alone increased root fresh weight especially with the lowest concentration of IBA. Mepiquat Chloride (MC) also increased root fresh weight in the same auxin level; the response may be due to the reduction of ethylene production. IBA is used for rooting in commercial operations (Kenney *et al.*, 1969). Auxin is often described as activators, while cytokinins and gibberellins are seen as inhibitors of adventitious root formation, even when some positive effects have been observed. The widely used sources of growth hormones for cutting rooting are the IBA, NAA, IAA and commercialization root promoters. The successful formation of adventitious roots is an obligatory phase of vegetative propagation in many woody plants; this being related to the presence of auxin (McClelland *et al.,* 1990). IAA was the first used to stimulate rooting of cutting (Cooper, 1935) and soon after another auxin which also promoted rooting, IBA was discovered and was considered even more effective (Zimmerman and Wilcoxon 1935). Nowadays IBA is used commercially to root microcuttings and is more efficient than IAA (Epstein and Ludwig-Müller 1993). El-Abd (1997) reported that, all IBA treatments were effective in increasing the number, length and fresh weight of adventitious roots in cucumber cuttings as compared with the control cuttings. IBA increased ethylene production compared with Mepiquat Chloride treatments which reduced ethylene production but enhanced root elongation. Cytokinins have long been known as anti senescence agents because they have a dramatic effect on the longevity of various organs in many plants. Exogenous cytokinin treatment results in delayed leaf senescence Moreover, endogenous levels of cytokinins decline in parallel with the progression of this senescence. Senescence is regulated by phytohormones. Cytokinins (CKs) delay leaf senescence (Gan and Amasino 1995). The content of cytokinins (CKs), the plant inhibitors of the final phase of plant development, senescence, is effectively controlled by irreversible degradation catalysed by cytokinin oxidase/dehydrogenase (Mytinova *et al.*, 2006).

This study aimed to estimate the best application of watermelon plants using cuttings as a method of production and studied the effect of BA on mother plants, types of cuttings and treatments of IBA on cuttings for successful production of seedless watermelon transplants.

2. MATERIAL AND METHODS

Two types of cuttings were taken from the watermelon mother plants cultivated in the plastic house (stock plants) *i.e.*, cuttings from terminal growing point of main stem and lateral branches 10 to 15cm in length and 0.45 to 0.6 cm in diameter and cuttings included one node, bud and leaf.

Tow field experiments were conducted during 2010/2011 and 2011/2012 using two seedless watermelon hybrids. Each experiment included 18 treatments, *i.e.* two types of cuttings (shoot tip and one node cuttings) collecting from mother plants which treated with one of three concentrations (0, 10 and 20 ppm)of BA (6-Benzylaminopurine (Benzyl adenine)). These cuttings were treated with one of three concentrations of IBA (0, 100 and 200 ppm) and planted in speedling trays 84 cell.

2.1. Plant material

2.1.1. Watermelon hybrids

Two seedless watermelon (*C. lanatus*) (Buttercup (QV 766) F_1 (yellow flesh) and SSX 7402 F_1 hybrids (red flesh)) from Sakata Seed Company, Japan were used in the present study.

2. 2.Cutting preparing

Seedless watermelon seeds were sown in the greenhouse in Badrashein city on the 7th of October in 2010 (first season) and 12th of October 2011 (second season) in foam speedling trays with 84 cells. The trays were filled with a mixture of peat-moss, vermiculite and berlite at a ratio of 1:1:1 (v/v). Three hundred grams of ammonium sulphate, 400 g calcium superphosphate, 150 g potassium sulphate, 50 ml. nutrient solution and 50 gm of a fungicide were added to each 50 kg of the peatmoss.

Sixty seedlings from each of seedless watermelon hybrids were transplanted on the 12th of November, 2010 and 18th of November 2011 in a plastic house in Badrashein city as mother plants to obtain cuttings in both seasons.

Mother plants were treated with the conventional agricultural practices *i.e.*, irrigation, fertilization, pests and diseases management as recommended by the Ministry of Agriculture, Egypt. For producing good watermelon vegetative growth, all female flowers and fruits were removed. Cuttings were collected from healthy mother plants, free of pests and disease after 45, days from planting as a first collection, then the other cuttings collected every 30 days from the previous one.

After the second cutting collection (75 days) each hybrid was divided into three groups; the first group was treated with 0 ppm concentration BA (distilled water) while the second and third groups were treated with 10, 20 ppm BA respectively, this application was done after *i.e.*, 75, 105, 135 and 165 days from transplanting.

Four shoot tip cuttings and 12 cuttings that included one node were collected at 45 days from each plant, while after 75 days 8 cuttings included shoot tip and 30 one node cuttings from each cultivar were collected (El-Eslamboly, 2014). Suitable branches were chosen for preparing cuttings. These plants become suitable for collecting more cuttings after 105, 135, 165 and 195 days.

Both shoot tip and one node cuttings were divided into three groups. The first group was treated with 200 ppm of IBA. The second group was treated with 100 ppm. IBA treatment was conducted by dipping these cuttings in IBA solution followed by immersing the bases of the cutting in Mepiquat Chloride solution at the concentration of 100 ppm. The third group was treated with distilled water for 10 seconds. The treated and untreated cuttings were planted in speedling trays 84 cells filled with previously mentioned culture mixture.

Speedling trays, after being planted, were removed immediately into the shaded plastic low tunnel for healing hardening and root formation from the node region. A polyethylene sheet was laid on the floor of low tunnels and covered with a shallow layer of water. Speedling trays were placed on bricks to support the plants above the water layer. The plastic tunnel was closed to achieve a temperature of 25-32 ºC and >85% RH humidity for seven days after planting. Watermelon plants which were formed from cuttings were moved out of the tunnel and placed inside a screen house, for ten days.

2.3. Experimental design and statistical analysis

This study was conducted in factorial experiment in a randomized complete block design with three replicates. Each cultivar and each cutting times were considered as a separated experiment. Data were statistically analyzed using analysis of variance ANOVA, with the Stat soft statistical package MSTATC software program (Michigan State University, East Lansing, MI, USA). Probabilities of significance among treatments and means were compared with least significant difference LSD ($P \leq 0.05$) according to Gomez and Gomez (1984).

2.4. Studied characteristics

2.4.1. Number of cuttings collected each time.

2.4.2. Survival percentage

Survival percentages were recorded after 12 days from planting by counting the succeeded transplants and divided them on the total number of cuttings.

2.4.3. Number of roots formed on 10 cuttings after 12 days from planting**.**

2.4.4. Length of roots formed on 10 cuttings after 12 days from planting.

3. RESULTS AND DISCUSSION

3.1. Effect of Benzyl adenine on the mother plants

Table (1) shows the number of mother plants at all ages, number of cuttings taken from shoot tip or one node cutting and the total number of cuttings which can be taken from the 20 mother plants during each season.

Data presented in Table (1) revealed that untreated plants with BA (control plant) remained in good condition until 105 days, while after 105 days some plants were lost. At 135 days the plants numbers became 35 from 40 plants in both cultivars followed by losing 6 plants until 165 days. At 195 days from transplanting the number of remainder plants in control treatment were 9 and 10 in cv., Buttercup (QV 766) F_1 and SSX 7402 F_1 respectively. The plants treated with 20 ppm benzyl adenine after 75 days from transplanting and then every 30 days remained in good conditions and without any losses in plant number until 195 days. The number of plants treated with 10 ppm benzyl adenine dropped from 20 to 15 and 16 at 195 days from transplanting in Buttercup (QV 766) F_1 and SSX 7402 F_1, respectively.

Data also illustrated that the total number of cuttings that were taken from 20 mother plants were 1080 from each hybrid after 45 and 75 days in both seasons. The total numbers that were taken in the period from 105 to 195 days in control plants were 3428 and 3363 cuttings for the first and second cultivar respectively, while the treated mother plants with 10 ppm BA gave 4230 and 4360 in Buttercup (QV 766) F_1 and 4360 SSX 7402 F_1, respectively. Mother plants treated with 20 ppm BA gave 5060 cuttings for each cultivar.

Table (1): Total number of cuttings taken from mother plants of two seedless watermelon hybrids before and after treatment with BA (average of 2010 and 2011 seasons).

		2010 and 2011									
Before BA Treatment	Days from transplanting	No. of mother plants		No. of shoot tip taken from each plant	Total number of shoot tip		No. of one node take from each plant	Total number of one node cuttings		Total number of cuttings taken from 20 plant	
		Buttercup QV 766 F_1	SSX 7402 F_1		Buttercup QV 766 F_1	SSX 7402 F_1		Buttercup QV 766 F_1	SSX7402 F_1	Buttercup QV 766 F_1	SSX 7402 F_1
	45	20	20	4	80	80	12	240	240	320	320
	75	20	20	8	160	160	30	600	600	760	760
Total number of cuttings after 75 days					240	240		840	840	1080	1080
BA (0 ppm)	105	20	20	9	180	180	40	800	800	980	980
	135	18	17	9	162	153	50	900	850	1062	1003
	165	15	14	10	150	140	50	750	700	900	840
	195	9	10	9	81	90	45	405	450	486	540
Total no. of cuttings after 195 days		9	10		573	563		2855	2800	3428	3363
BA (10 ppm).	105	20	20	9	180	180	40	800	800	980	980
	135	20	20	9	180	180	50	1000	1000	1180	1180
	165	17	18	10	170	190	50	850	900	1020	1080
	195	15	16	15	225	240	55	825	880	1050	1120
Total no. of cuttings after 195 days		15	16		755	790		3475	3580	4230	4360
BA (20 ppm).	105	20	20	9	180	180	40	800	800	980	980
	135	20	20	9	180	180	50	1000	1000	1180	1180
	165	20	20	10	200	200	50	1000	1000	1200	1200
	195	20	20	15	300	300	70	1400	1400	1700	1700
Total no. of cuttings after 195 days		20	20		860	860		4200	4200	5060	5060

Several previous reports indicated that cytokinins have long been known as anti senescence agents because they have a dramatic effect on the longevity of various organs in many plants. Exogenous cytokinin treatment delayed leaf senescence. Moreover, endogenous levels of cytokinins declined in parallel with the progression of this senescence. Senescence is regulated by phytohormones (Gan and Amasino 1995). The content of cytokinins, the plant inhibitors of the final phase of plant development, senescence, is effectively controlled by irreversible degradation catalysed by cytokinin oxidase/dehydrogenase (Mytinova *et al.,* 2006). The relative ease of rooting cuttings from juvenile plants as compared to adult plants was known by 1900 (Goebel, 1900).

3.2. Effect of the single factors

3.2.1. Effect of benzyl adenine

Data in Tables (2 and 3) indicated that there was a significant increase in the survived plant percentage after 105 until 195 due to the application of BA to the mother plants after 75, 105,135 and165 days compared with the control in the first and second seasons. This was true in both cultivars. In the first season, no significant differences were recorded between the two concentrations of BA (10 and 20 ppm) for the cuttings collected at 105 days from mother plants treated at 75 days from planting, although the BA applications played big role in increasing the healthy status and improved the physiological status in the mother plants especially in the late ages as shown in Table (1).

Data in Tables (2 and 3) illustrated that, significant differences were noticed in the number of roots and roots length in the plant cuttings due to treating the mother plants with BA. The cuttings were collected from mother plants aged 195 showed significant differences among all level from BA in the survival percentage, number of roots and roots length. BA applications may recover the plant from the aging to the Juvenile phase. Hartmann *et al.* (2002) reported that, the cuttings were taken from the juvenile or young plants are easily of rooting compared with the cuttings were taken from adult plants. Preece (2003) revealed that treating cuttings or stock plants with rejuvenating chemicals such as BA would be ideal, but phase change may be too complex for this solution. If such chemicals or other methods were developed, it would further revolutionize vegetative propagation of woody and other important plant species.

3.2.2. Effect of Indole-3-butyric acid

Concerning the effect of the application of IBA levels, survival percentage, number of roots and roots length were significantly affected by IBA levels. In this concern, it was clear that using IBA significantly promoted survival percentage by treated the cuttings with 100 or 200 ppm of IBA. Treating cuttings with distilled water as a control showed the lowest value of survival percentage, number of roots and root length. In contrast, the highest value was recorded by treating these cuttings with 200 ppm IBA. Auxins are known to play a central role in adventitious root formation (Kawase, 1971).

IBA application gave a significant effect on the number of roots formed on the plant cuttings and roots length. Number of roots was significantly increased by increasing the IBA concentration from 0 to 200 ppm. The highest values were observed when using 200 ppm IBA. In contrast, the lowest values were recorded for control. Obtained results were nearly similar in both cultivars at 105 and 195 days during the two seasons. IBA applications lead to significantly increase in root length in both hybrids (Buttercup (QV766) F_1 and SSX 7402 F_1). These results were true in both seasons and in both cuttings times (105 and 195). The highest value in root length (9.81) was recorded when treating the Buttercup (QV766) with 200 ppm IBA in 105 days in the first season. The control treatment had lowest value in root length (6.41) at 105 days in the second season.

3.2.3. Effect of cutting type

Types of cutting had highly significant effect on the survival rate, number of roots and root length. Cuttings included one node showed significant increment in survival percentage, number of root and root length than the shoot tip cuttings which had lower values in survive percentage, number of roots and root length. In respect to, the effect of the cutting types, data in the same tables revealed that using one node cuttings in propagation gave a higher survival percentage than using the terminal cuttings. Survival percentage of one node cuttings ranged between 97.78 and 95.72 for both cultivars Buttercup (QV 766) F_1 and SSX7402 F_1 after 105 days. Also the same trend was observed for the cultivars after 195 days in both seasons in both cutting times under study, while the survival percentage when using the terminal cuttings ranged between 66.19 and 71.08. One node cuttings had a higher root length (11 cm) than shoot tip cuttings which had root length

Table (2): Effect of BA concentrations, IBA concentrations and cutting types on the survival percentage, the number of roots and average root length on cuttings from mother plants after105 days on two seedless watermelon hybrids in two seasons.

	Survival plant %				Number of roots				Root length			
	Buttercup QV 766 F_1		SSX 7402 F_1		Buttercup QV 766 F_1		SSX 7402 F_1		Buttercup QV 766 F_1		SSX 7402 F_1	
BA ppm	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
0	78.33	80.54	76.95	78.68	7.04	7.35	7.17	7.47	7.96	8.00	7.95	6.50
10	87.54	83.00	85.14	85.31	6.97	7.84	7.19	7.90	8.95	8.36	8.63	7.01
20	86.35	87.12	85.91	87.48	7.83	8.35	8.08	8.62	10.34	8.31	10.13	7.63
LSD at 0.05	2.07	1.21	1.10	1.56	0.47	0.38	0.30	0.34	0.46	0.27	0.25	0.13
IBA ppm												
0	80.08	80.14	79.11	81.18	6.48	7.32	6.68	7.30	8.36	7.84	8.14	6.41
100	85.79	83.87	83.78	84.42	7.35	7.92	7.61	8.07	9.08	8.20	9.11	7.17
200	86.35	86.66	85.10	85.88	8.01	8.31	8.17	8.62	9.81	8.62	9.45	7.57
LSD at 0.05	2.07	1.21	1.10	1.56	0.47	0.38	0.30	0.34	0.46	0.27	0.25	0.13
Cutting types												
Shoot tip	70.37	70.60	69.61	71.08	5.27	6.40	5.47	6.70	6.99	6.96	6.94	5.30
One nodes	97.78	96.51	95.72	96.57	9.29	9.30	9.50	9.29	11.18	9.48	10.86	8.79
LSD at 0.05	2.51	2.99	1.22	2.28	1.30	1.23	1.17	1.23	1.87	1.22	1.20	1.12

Table (3): Effect of BA concentrations, IBA concentrations and cutting types on the survival percentage, the number of roots and average root length on cuttings from mother plants after 195 days on two seedless watermelon hybrids in two seasons.

	Survival plant %				Number of roots				Root length			
	Buttercup QV 766 F_1		SSX 7402 F_1		Buttercup QV 766 F_1		SSX 7402 F_1		Buttercup QV 766 F_1		SSX 7402F_1	
BA ppm	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
0	75.16	75.29	75.48	78.28	6.97	7.18	7.63	7.52	7.32	7.60	8.20	6.55
10	80.87	83.72	82.46	82.76	7.33	7.32	7.60	7.61	8.01	8.47	9.04	7.09
20	87.54	84.68	85.63	86.12	8.19	7.98	8.72	8.80	9.73	9.57	9.86	7.77
LSD at 0.05	1.72	1.34	1.94	2.84	0.56	0.53	0.27	0.31	0.31	0.28	0.42	0.20
IBA ppm												
0	77.30	77.78	77.22	78.88	6.73	6.75	7.36	7.34	7.52	7.88	8.43	6.52
100	81.59	82.22	81.19	82.79	7.61	7.64	8.10	8.10	8.57	8.72	9.11	7.27
200	84.68	83.69	85.16	85.49	8.16	8.08	8.49	8.48	8.98	9.05	9.56	7.61
LSD at 0.05	1.72	1.34	1.94	2.84	0.56	0.53	0.27	0.31	0.31	0.28	0.42	0.20
Cutting types												
Shoot tip	67.67	67.14	66.19	68.67	5.49	5.43	5.84	6.11	6.63	6.61	7.00	5.19
One nodes	94.71	95.32	96.19	96.10	9.50	9.56	10.13	9.84	10.08	10.49	11.07	9.08
LSD at 0.05	1.40	1.10	1.59	1.68	1.22	2.11	1.22	1.20	2.23	1.23	1.34	2.16

ranged between 5.19 and 7.0 cm.

One node cuttings had highest values of root number (10.13) as compared to the terminal cuttings (5.43).

3.3. Effect of the bilateral interaction

It is clear from data in Tables (4 and 5) that the interaction between BA and IBA concentrations were not significant in all studies traits. On the other hand, the interaction between BA and cutting types was significant in all traits of study. These results were true in both Buttercup (QV766) F_1 and SSX 7402 F_1 in the first and second seasons and in the first and second cuttings times.

As for the effect of the interaction, data in Tables (4 and 5) revealed that the interaction between IBA concentrations and type of cuttings had significant effects on survival percentage in both seasons. The highest survival percentage (98.09) resulted from one node cuttings of the Buttercup (QV766) F_1 mother plants aged 105 days with 100 ppm IBA in the first season. In contrast, the lowest survival percentage (59.84) was obtained from the terminal cuttings from SSX 7402 F_1 mother plant aged 195 days by using zero IBA in the first season.

It was clear that one node cuttings were more effective than shoot tip cuttings in all BA concentrations in producing watermelon transplants. In respect to survival percentage, number of roots and root length, the interaction between IBA concentrations with cutting types

Table (4): Effect of bilateral interaction between BA concentrations with IBA concentrations, BA concentrations with cutting types and IBA concentrations with cutting types on the survival percentage, the number of roots and average root length on cuttings from mother plants, after 105 days, of two seedless watermelon hybrids in two seasons.

BA × IBA concentrations ac		Survival %				Number of roots				Root length			
		Buttercup QV 766 F_1		SSX 7402 F_1		Buttercup QV 766 F_1		SSX 7402 F_1		Buttercup QV 766 F_1		SSX 7402 F_1	
		2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
0 ppm	0 ppm	73.33	77.09	73.25	75.57	6.13	6.76	6.35	6.68	7.45	7.65	7.23	5.83
	100 ppm	80.95	80.76	78.02	79.27	7.50	7.40	7.39	7.49	7.65	8.19	8.08	6.65
	200 ppm	80.72	83.77	79.58	81.20	7.50	7.90	7.78	8.26	8.77	8.16	8.54	7.03
10 ppm	0 ppm	82.62	79.12	80.76	82.73	6.05	7.18	6.11	7.13	8.07	8.11	7.58	6.28
	100 ppm	89.05	83.31	86.86	86.74	6.97	7.98	7.36	8.00	9.27	8.22	9.09	7.20
	200 ppm	90.95	86.58	87.80	86.47	7.88	8.37	8.11	8.58	9.52	8.74	9.22	7.55
20 ppm	0 ppm	84.28	84.20	83.34	85.24	7.27	8.01	7.57	8.10	9.57	7.76	9.62	7.12
	100 ppm	87.38	87.54	86.47	87.24	7.58	8.39	8.08	8.74	10.32	8.20	10.17	7.64
	200 ppm	87.38	89.63	87.93	89.97	8.63	8.67	8.61	9.03	11.15	8.97	10.60	8.12
LSD at 0.05		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BA × Cutting types													
0 ppm	Shoot tip	58.89	64.73	58.74	61.61	5.14	5.65	5.06	5.97	6.23	6.80	6.26	4.67
	One node	97.78	96.35	95.16	95.76	8.94	9.06	9.29	8.98	9.68	9.19	9.64	8.33
10 ppm	Shoot tip	77.30	69.62	74.86	74.06	5.03	6.37	5.19	6.59	6.66	7.21	6.54	5.29
	One node	97.78	96.38	95.41	96.57	8.90	9.32	9.20	9.21	11.24	9.50	10.71	8.74
20 ppm	Shoot tip	74.92	77.47	75.23	77.59	5.63	7.19	6.15	7.55	8.07	6.87	8.03	5.95
	One node	97.78	96.78	96.60	97.38	10.02	9.52	10.01	9.69	12.62	9.75	12.23	9.31
LSD at 0.05		4.35	1.72	2.12	2.21	2.53	2.40	1.30	0.84	1.65	1.38	1.34	1.17
IBA × Cutting types													
0 ppm	Shoot tip	62.38	65.85	63.23	66.84	4.40	5.71	4.64	5.84	6.27	6.53	6.21	4.54
	One node	97.78	94.43	95.00	95.52	8.57	8.92	8.71	8.77	10.46	9.15	10.07	8.28
100 ppm	Shoot tip	73.49	70.84	71.57	71.59	5.34	6.44	5.57	6.80	6.99	6.91	7.10	5.43
	One node	98.09	96.89	95.99	97.24	9.36	9.41	9.65	9.35	11.17	9.50	11.12	8.90
200 ppm	Shoot tip	75.24	75.12	74.03	74.82	6.07	7.06	6.19	7.47	7.70	7.44	7.51	5.94
	One node	97.46	98.20	96.18	96.94	9.94	9.56	10.14	9.77	11.92	9.80	11.39	9.20
LSD at 0.05		4.35	1.72	2.12	2.21	2.53	2.40	1.30	0.84	NS	NS	NS	NS

Table (5): Effect of bilateral interaction between BA concentrations and IBA concentrations, BA concentrations with cutting types and IBA concentrations with cutting types on the survival percentage, the number of roots and average root length on cuttings from mother plants, after 195 days, of two seedless watermelon hybrids in two seasons.

BA × IBA concentrations		Survival %				Number of roots				Root length			
		Buttercup QV 766 F_1		SSX 7402 F_1		Buttercup QV 766 F_1		SSX 7402 F_1		Buttercup QV 766 F_1		SSX 7402 F_1	
		2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
0 ppm	0 ppm	70.95	71.43	70.95	74.66	6.13	6.41	6.87	7.16	6.72	7.08	7.78	5.69
	100 ppm	74.76	76.23	75.24	78.53	7.05	7.34	7.80	7.57	7.63	7.63	8.20	6.85
	200 ppm	79.76	78.22	80.24	81.64	7.72	7.79	8.23	7.82	7.62	8.10	8.62	7.11
10 ppm	0 ppm	76.43	79.87	77.62	78.70	6.27	6.46	6.95	6.53	6.60	7.55	8.22	6.50
	100 ppm	82.14	85.24	83.33	83.40	7.55	7.52	7.67	7.98	8.32	8.85	9.02	7.23
	200 ppm	84.05	86.04	86.43	86.19	8.18	7.96	8.18	8.31	9.12	9.01	9.88	7.55
20 ppm	0 ppm	84.52	82.03	83.09	83.27	7.80	7.39	8.25	8.33	9.23	9.02	9.30	7.37
	100 ppm	87.86	85.20	85.00	86.45	8.22	8.05	8.83	8.77	9.75	9.68	10.10	7.74
	200 ppm	90.24	86.82	88.81	88.64	8.57	8.50	9.07	9.31	10.20	10.02	10.18	8.19
LSD at 0.05		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BA × Cutting types													
0 ppm	Shoot tip	57.14	56.23	55.71	60.91	4.62	5.04	5.41	5.76	5.77	5.73	5.99	4.51
	One node	93.17	94.35	95.24	95.64	9.31	9.32	9.86	9.27	8.88	9.47	10.41	8.59
10 ppm	Shoot tip	67.46	72.63	69.36	69.92	5.37	5.21	5.53	5.70	6.22	6.45	6.97	5.03
	One node	94.28	94.81	95.55	95.61	9.30	9.42	9.67	9.51	9.80	10.49	11.11	9.15
20 ppm	Shoot tip	78.41	72.56	73.49	75.18	6.49	6.03	6.57	6.88	7.90	7.65	8.03	6.02
	One node	96.66	96.81	97.78	97.06	9.90	9.92	10.87	10.73	11.56	11.50	11.69	9.51
LSD at 0.05		2.43	1.89	2.75	1.18	1.37	1.19	1.39	1.30	1.40	1.40	1.62	1.28
IBA× Cutting types													
0 ppm	Shoot tip	63.02	61.63	59.84	63.18	4.71	4.66	5.11	5.45	5.66	5.93	6.30	4.46
	One node	91.59	93.92	94.60	94.58	8.76	8.85	9.60	9.23	9.38	9.83	10.57	8.58
100 ppm	Shoot tip	67.78	68.62	65.87	69.10	5.66	5.54	6.00	6.13	6.80	6.64	6.92	5.27
	One node	95.39	95.82	96.51	96.48	9.56	9.73	10.20	10.07	10.33	10.80	11.29	9.27
200 ppm	Shoot tip	72.22	71.16	72.86	73.73	6.11	6.07	6.40	6.75	7.43	7.26	7.77	5.83
	One node	97.14	96.23	97.46	97.25	10.20	10.09	10.59	10.21	10.52	10.83	11.36	9.40
LSD at 0.05		2.43	2.89	2.75	2.18	1.37	1.19	1.39	1.30	NS	NS	NS	NS

played significant effect in the survival percentage and number of roots formed on the cuttings in both cultivars, while this interaction was not significant in root length in both cultivars in the first and second season in all cutting times. These results were achieved in both cultivars in cuttings taken after 105 and 195 days.

3.2.5. Effect of the triple interaction

Data in Tables (6 and 7) although, the triple interaction was not significant on survival percentage, the interaction between BA application, IBA concentrations and cutting types played a significant role in improving the number of roots and root length as shown in both cultivars under study in the first and second cutting times in both seasons.

The interaction of BA×IBA× cutting types was significant on number and length of roots of 105 and 195 days from planting. In this respect one node cuttings obtained from mother plants treated with BA at 20 ppm and dipped in solution of IBA at 200 ppm showed the highest values of number of roots and root length in Buttercup(QV766) F_1 and SSX 7402 F_1 at 105 and 195 days in both seasons. On the contrary, the shoot tip cuttings without any treated exhibited the lowest values of survival percentage, roots number and length in the first and second cutting times in Buttercup (QV766) F_1 and SSX 7402 F_1 in both seasons.

Table (6): Effect of triple interaction among BA concentrations, IBA concentrations and cutting types on the survival percentage, the number of roots and average root length on cuttings from mother plants, after 105 days, of two seedless watermelon hybrids in two seasons.

			Survival %				Number of roots				Root length			
BA ppm	IBA ppm	Cutting type	Buttercup QV 766 F_1		SSX 7402 F_1		Buttercup QV 766 F_1		SSX 7402 F_1		Buttercup QV 766 F_1		SSX 7402 F_1	
			2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
0	0	Shoot tip	49.05	60.08	52.27	56.53	3.87	4.79	3.93	4.79	6.07	6.26	5.50	3.79
		One node	97.62	94.11	94.22	94.61	8.40	8.73	8.77	8.56	8.83	9.03	8.95	7.87
	100	Shoot tip	63.33	64.71	60.72	62.41	5.87	5.53	5.35	6.00	5.60	6.92	6.37	4.86
		One node	98.57	96.80	95.31	96.13	9.13	9.28	9.42	8.98	9.70	9.46	9.79	8.44
	200	Shoot tip	64.29	69.39	63.23	65.88	5.70	6.62	5.89	7.11	7.03	7.23	6.90	5.36
		One node	97.14	98.15	95.94	96.53	9.30	9.17	9.67	9.40	10.50	9.08	10.17	8.70
10	0	Shoot tip	67.14	63.69	66.67	69.94	4.00	5.41	4.06	5.52	5.37	7.03	5.46	4.29
		One node	98.09	94.55	94.84	95.52	8.10	8.95	8.16	8.74	10.77	9.19	9.69	8.27
	100	Shoot tip	80.48	69.59	77.94	75.86	4.80	6.51	5.28	6.79	7.23	7.02	6.96	5.50
		One node	97.62	97.02	95.78	97.61	9.13	9.44	9.44	9.20	11.30	9.42	11.21	8.91
	200	Shoot tip	84.29	75.58	79.98	76.36	6.30	7.19	6.24	7.47	7.37	7.58	7.21	6.07
		One node	97.62	97.58	95.62	96.58	9.47	9.56	9.99	9.69	11.67	9.89	11.23	9.03
20	0	Shoot tip	70.95	73.79	70.74	74.04	5.33	6.93	5.94	7.21	7.37	6.31	7.67	5.55
		One node	97.62	94.62	95.94	96.43	9.20	9.08	9.20	9.00	11.77	9.22	11.56	8.69
	100	Shoot tip	76.67	78.23	76.06	76.49	5.37	7.26	6.07	7.61	8.13	6.78	7.96	5.92
		One node	98.09	96.84	96.88	97.98	9.80	9.51	10.09	9.86	12.50	9.62	12.37	9.37
	200	Shoot tip	77.14	80.39	78.88	82.23	6.20	7.37	6.45	7.83	8.70	7.52	8.44	6.39
		One node	97.62	98.87	96.97	97.72	11.07	9.96	10.76	10.22	13.60	10.42	12.76	9.86
LSD at 0.05			NS	NS	NS	NS	1.92	1.73	2.55	1.64	2.12	2.60	2.66	2.46

Table (7): Effect of triple interaction among BA concentrations, IBA concentrations and cutting types on the survival percentage, the number of roots and average root length on cuttings from mother plants, after 195 days, of two seedless watermelon hybrids in two seasons.

BA ppm	IBA ppm	Cutting type	Survival %				Number of roots				Root length			
			Buttercup QV 766 F_1		SSX 7402 F_1		Buttercup QV 766 F_1		SSX 7402 F_1		Buttercup QV 766 F_1		SSX 7402 F_1	
			2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
0	0	Shoot tip	51.90	50.10	48.57	55.29	3.53	4.07	4.37	5.27	4.43	5.28	5.53	3.69
		One node	90.00	92.75	93.33	94.03	8.73	8.76	9.37	9.06	9.00	8.87	10.03	7.69
	100	Shoot tip	55.71	57.73	55.24	61.15	4.83	5.25	5.70	5.70	6.17	5.62	6.07	4.61
		One node	93.81	94.72	95.24	95.90	9.27	9.43	9.90	9.43	9.10	9.64	10.33	9.09
	200	Shoot tip	63.81	60.86	63.34	66.30	5.50	5.80	6.17	6.31	6.70	6.29	6.37	5.23
		One node	95.71	95.58	97.14	96.98	9.93	9.77	10.30	9.33	8.53	9.91	10.87	8.98
10	0	Shoot tip	62.86	66.05	61.43	63.20	4.37	4.22	4.73	4.48	4.83	5.32	5.80	4.04
		One node	90.00	93.69	93.81	94.21	8.17	8.71	9.17	8.58	8.37	9.78	10.63	8.95
	100	Shoot tip	68.57	75.15	70.48	70.59	5.60	5.35	5.63	5.96	6.47	6.77	6.83	5.28
		One node	95.71	95.33	96.19	96.20	9.50	9.70	9.70	9.99	10.17	10.93	11.20	9.18
	200	Shoot tip	70.95	76.67	76.19	75.97	6.13	6.06	6.23	6.65	7.37	7.25	8.27	5.78
		One node	97.14	95.41	96.66	96.42	10.23	9.87	10.13	9.98	10.87	10.77	11.50	9.31
20	0	Shoot tip	74.29	68.74	69.52	71.05	6.23	5.70	6.23	6.61	7.70	7.19	7.57	5.65
		One node	94.76	95.33	96.66	95.49	9.37	9.07	10.27	10.05	10.77	10.85	11.03	9.09
	100	Shoot tip	79.05	72.99	71.91	75.55	6.53	6.04	6.67	6.74	7.77	7.52	7.87	5.93
		One node	96.66	97.41	98.09	97.35	9.90	10.05	11.00	10.80	11.73	11.84	12.33	9.54
	200	Shoot tip	81.91	75.95	79.05	78.93	6.70	6.37	6.80	7.30	8.23	8.24	8.67	6.48
		One node	98.57	97.69	98.57	98.34	10.43	10.64	11.33	11.33	12.17	11.80	11.70	9.89
LSD at 0.05			NS	NS	NS	NS	1.95	2.44	2.73	2.66	2.70	1.75	2.63	1.62

Conclusion: The present study indicated that:

1. About 6000 transplants could be obtained in the period of 195 days from 20 plants.
2. BA showed significant effect on increasing the healthy status and improving the physiological status of mother plants and increasing the numbers of cuttings.
3. BA and cuttings types showed significant effect on survival percentage at 105 and 195 days from planting.
4. Applying IBA increased the number and length of roots per cutting and percentage of survival plants.
5. One node cuttings showed significant increment on number of roots, roots length and survival plants which reached 97%, while the shoot tip cutting reached 70%.
6. The interactions between IBA and cutting types showed significant improved in both survival percentage and roots number without any significant differences in root length.
7. The interaction between BA concentrations and cutting types had significant role on survival percentage and both roots number survival percentage and both roots number and length.
8. The best method for producing watermelon transplants from cuttings was treating the mother plant with 20 ppm BA and taken one node cuttings followed by treating these cuttings with 200 ppm IBA.

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اكثار البطيخ عديم البذور بواسطة العقل
ب. تاثير البنزيل ادينين واندول حمض البيوتريك وانوع العقل علي انتاج الشتلات من العقل

احمد عبدالهادي سيد عبد الوهاب الاسلامبولي

قسم بحوث انتاج الخضر تحت ظروف جوية معدلة- معهد بحوث البساتين- مركز البحوث الزراعية

ملخص

يستخدم التكاثر الخضري على نطاق واسع لاكثار العديد من المحاصيل البستانية. حيث تعتبر العقل واحدة من أهم طرق التكاثر الخضري . لم ينتشر البطيخ عديم البذور علي نطاق تجاري في مصر على الرغم من ان طعمة أكثر حلاوة بالاضافة الى وعدم وجود بذور صلبة. ويرجع ذلك إلى ارتفاع تكاليف انتاج البطيخ عديم البذور(الهجن الثلاثية) في مصر بسبب اسعار البذور المرتفعة ، وكما ان البذور لا تنبت بسهولة وكذا الإنبات والنمو غير المتجانس. تهدف الدراسة الحالية الى اكثار البطيخ عديم البذور بواسطة العقل من نباتات الأمهات ودراسة العوامل التي تتحكم في انتاج نبات كامل من العقل. حيث يعتبر تكوين الجذور العرضية الخطوة الرئيسية في التكاثرالخضري.

في هذه الدراسة تم استخدام صنفين من البطيخ عديم البذور هما الهجينين F_1 Buttercup (QV 766) (أصفر اللحم) والهجينF_1 SSX 7402 (الأحمر اللحم). تعتمد هذه الطريقة على أخذ عقل من النباتات الأم التي زرعت تحت ظروف مثلى في صوبة الامهات والتى عوملت مسبقا بأخذ عقل منها عند عمر 45-75 يوما من الزراعة فى المشتل. تم معاملة نباتات الأمهات بواسطة 3 تركيزات من البنزيل ادنيين (0و10 و20 جزء في المليون) لأربع مرات، أي بعد (75و 105و 135 و165) يوم بهدف تحسين الحالة الفسيولوجية لنباتات الأمهات و المحافظة عليها. استخدم نوعين من العقل، النوع الأول هو العقل الطرفية من الساق الرئيسي والفروع الجانبية بطول 10-15سم وبقطر 0.45 و 0.6 سم ، والنوع الثاني هو العقل ذات عقدة واحدة وورقة وبرعم . أخذت العقل من نباتات الأم بعد (105و 135 و165 و195) يوما من الشتل . وتمت معاملة جميع العقل التى اخذت بأحد الثلاث تركيزات من اندول حمض البيوتريك IBA (0و 100و 200 جزء في المليون) بهدف تشجيع تكوين الجذور العرضية.

أجريت هذه الدراسات في تجارب عاملية في تصميم قطاعات كاملة العشوائية في ثلاثة مكررات خلال الموسمين 2011/2010 و 2012/2011 م بمشتل في مدينة البدرشين محافظة الجيزة. حيث زرعت العقل التي اخذت في الميعاد الثالث 105والاخير195يوم في صواني الزراعة. وذلك لدراسة تأثير تركيزات BA و IBA وأنواع العقل والتفاعل بين كل منهم. بينما استخدمت العقل التي اخذت في الميعادين135و165 لمعرفة أكبرعدد من العقل يمكن انتاجة .

تم تحليل التجربة احصائيا على اعتبار أن عوامل الدراسة هى انواع العقل ، تركيزات البنزيل ادنيين BA وتركيزات حمض البيوتريكIBA.

وتلخصت النتائج فيما يلي:-

لعبت المعاملة بالبنزيل ادنيين دورا كبيرا في تحسين الحالة الفسيولوجية لنباتات الأمهات وزيادة العدد الإجمالي للعقل التي يمكن أن تنتج بالإضافة إلى تأثير كبير على نسبة نجاح العقل ومعدلات البقاء وكذا كل من أطوال واعداد الجذور .

وأظهرت تركيزات اندول حمض البيوتريك IBA تأثيرات معنوية في معدلات البقاء وأعداد وأطوال الجذور. اعطت العقل ذات عقدة واحدة أعلى معدل للبقاء على قيد الحياة من العقل الطرفية .وأظهرت نفس النتائج في عدد الجذور وطول الجذور في الموسمين في كلا الصنفين تحت الدراسة.

أظهر البنزيل ادنيين واندول حمض البيوتريك وكذا أنواع القطع كل منهم بمفردة تأثيرات كبيرة على نجاح العقل حيث اعطت تأثير معنوي علي معدلات البقاء وتكوين الجذور في حين لم تتأثر أطوال واعداد الجذور بمعاملات البنزيل ادنيين.

لم يكن هناك تأثيرات معنوية للتفاعل الثنائي بين تركيزات كل من BA و IBA وعلي العكس من ذلك أعطى التفاعلات بين تركيزات BA مع نوع العقل تاثيرا معنويا في كل الصفات تحت الدراسة في حين ان التفاعل بين IBA مع أنواع العقل تأثيرات كبيرة في معدلات البقاء واعداد الجذور. ولم يظهر تاثير معنوي في اطوال الجذور. ولم يظهر للتفاعل الثلاثي بين كل من تركيزات BA وتركيزات IBA وأنواع العقل أي تأثير معنوي في صفة نسبة النجاح الا انه ادي الي تاثير معنوي في اطوال واعداد الجذور في كلا الصنفين في المعادين 105 و 195 يوم من الشتل في كلا الموسمين.

المجلة العلمية لكلية الزراعة – جامعة القاهرة – المجلد (65) العدد الثانى (ابريل 2014) 193-203.