

Effect of Tuber Soaking Periods with some Activators on Growth and Productivity of Potato

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ABSTRACT

Two field experiments were carried out during 2017 and 2018 summer seasons at private farm in Aga, El-Dakahlia governorate, to investigate the effect of soaking periods of some activators and their interaction on vegetative growth parameters, minerals composition and biochemical parameters in leaves, yield and tuber quality of potato (*Solanum tuberosum* L., cv. Cara). The experiment was arranged in split plot design in complete blocks randomized. This research included 12 treatments consist of 3 soaking periods of activators (1 hours, 2 hours and 3 hours) and 4 activators *i.e.*, licorice root extract (LRE) at 5 g L⁻¹, zinc (Zn) and boron (B) (100+50) mg L⁻¹, yeast extract at 5 g L⁻¹ in addition control treatment (tap water). Obtained results revealed that soaking tubers pre planting 3 hours gave the highest values of vegetative growth parameters, minerals composition and biochemical parameters in leaves, yield and most tuber quality. All activators significantly enhanced measured parameters compared to the control treatment. LRE at 5 g L⁻¹ gave the maximum values of most vegetative growth parameters, minerals composition and biochemical parameters in leaves, yield and tuber quality. Thus, It can be recommended that soaking tuber pre planting 3 hours with LRE at 5 g L⁻¹ increased potato growth, yield and quality.

Keywords: Activators, soaking periods, licorice, zinc, boron, yeast, Potato.

INTRODUCTION

Potato is one of the most important plant of family Solanaceae and important vegetables crops. In Egypt, it considered one of the Egyptian national income resource. It is a cheap provenance of carbohydrates that plays important role in human diet. Total planted area in Egypt were 409372 fed. producing 4.61 million tons (FAO, 2017).

Activators used for potato before planting as soaking to minimize buds sprouting stage, that led to enhance growth and decrease risk of early vegetative growth (Kandil *et al.*, 2012).

licorice root extract (LRE) is considered high source of biological active componends such as flavonoids and phenolic, also have nutritive value and medicinal properties (Morsi *et al.*, 2008). It contains amino acid (Asparagin), monosacaraide, tannins, starch, vitamins, some minerals, *i.e.*, Ca, Mg, Zn, P, K and Si (Arytanova *et al.*, 2001). In this regard, soaking tubers of potato before planting with liquorice extract enhanced dry matter and starch in tubers (Hamadah *et al.* 2012).

Zinc (Zn) is involved in many physiological functions in plants as it intervene in most enzymes structure and crebs cycle (Alloway, 2004), used in the formation of chlorophyll and carbohydrates, conversion of starches to sugars. It is important in the formation of phenol, RNA and auxins by synthesis of tryptophan which is precursor of IAA, which improves growth regulation and stem elongation. Also, boron (B) has important role in physiological and biochemical process as root growth by cell division, sugar movement, formation of cell wall, carbohydrate metabolism, RNA, IAA and phenol (Camacho *et al.*, 2008). In this concern, soaking chickpea

seeds with Zn plus B increased vegetative growth, yield and quality (Verma *et al.*, 2017).

Yeast extract is natural component has a high amounts of cytokines, nutrient elements, amino acids, carbohydrates and vitamins. It is considered a natural source of cytokines which stimulate cell division and enlargement as well as structure of protein. Soaking potato tubers in yeast extract before planting gave a significant increased of total yield, marketable yield, N, P, K and protein content (Dahshan *et al.*, 2017)

Thus, the aim of this study is investigated the effect of soaking tuber periods with some activators (LRE, Zn plus B and yeast extract) on potato growth, tuber yield, quality and their interaction.

MATERIALS AND METHODS

Complete blocks randomized with in split plot design with three replicates was done in 2017 and 2018 seasons. This experiment consist of 12 treatments that were the combinations between three of soaking periods (one hour, two hours and three hours) and four of some activators (LRE, Zn plus B and yeast extract and control treatment). The soaking periods were assigned in main plots, while sub plots were the application of some activators.

Tubers were divided into pieces every piece (15 g), pieces were divided into 12 groups and soaked every 4 groups in aforementioned activators for 1, 2 and 3 hours at room conditions. Tuber pieces were planted at 25 cm interval on ridges at 12-15 cm depth on 8th and 10th Jan. during 2017 and 2018 seasons respectively. The plot area was 12.6 m² consist of three ridges each one was (0.7m width X 6m length). The experimental soil sample were randomly taken for some physical and chemical properties (Table1).

Table 1. Some physical and chemical properties of experimental soil during two seasons 2017 and 2018:

Seasons	Mechanical analysis (%)				Texture class	OM (%)	T. CaCO ₃ g kg ⁻¹	SP %	EC dS.m ⁻¹ 1:5	pH (1:2.5)	Available (mg kg ⁻¹ soil)		
	Coarse Sand	Fine Sand	Silt	Clay							N	P	K
2017	4.26	29.68	38.49	27.57	Clay loamy	1.46	4.11	58.3	0.98	8.04	52.1	5.3	178.3
2018	4.49	29.95	37.35	28.21	Clay loamy	1.63	4.12	57.2	1.07	8.02	51.3	5.7	169.5

SP: Saturation percentage OM: Organic matter EC: Electrical conductivity

Licorice root extract (LRE) applied at 5g L⁻¹ and prepared according to Almehehdi *et al.* (2011). It contains of 14.5% glycyrrhizin, 0.51% liquiritin, kaempferol 32.95ug/g, cinnamic acid 31.22 ug/g, apiginin 29,97 ug/g, rutin 24.41 ug/g, p-coumaric 21.67 ug/g vanillin 20.43 ug/g, phenol 18.40 ug/g and benzoic acid 14.42 ug/g (Ezzat *et al.*, 2016).

Zn at 100 mg L⁻¹ as zinc chelates from EDTA, B at 50 mg L⁻¹ as boric acid form.

Yeast extract applied at 5 g L⁻¹ and prepared according to El-Ghamriny *et al.* (1999). It contains amino acids 28.6 mg/100g dry weights, vitamins 444.48 mg/100g dry weights, micro elements 1985.48 mg/100g dry weights and macro elements 93.3 g/100g dry weight (Khedr and Farid, 2000).

A recommended dose of all soil fertilizers were added at N fertilizer 150 kg N/fed., which it divided into three similar parts, the first was added before the first irrigation after planting as ammonium sulphate (20.6 N%), while 2nd and 3rd parts were added with second and third irrigation after planting as ammonium nitrate (33.5 N%). Calcium super phosphate (15.5% P₂O₅) was added during soil preparation at rate of 75 kg P₂O₅/fed., potassium sulphate (48% K₂O) was added at rate of 95 kg K₂O/fed. and divided into two similar parts before second and third irrigation after planting. All recommendation of Egyptian Ministry of Agriculture were conducted.

Data recorded:

6 plants were randomly taken (two from each ridge) after 80 days from planting to determine the following measurements:

Vegetative growth characters:

represented as No of branches/ plant; No of leaves/ plant; plant height (cm); fresh weight (g/plant); dry matter (%) and leaves area (cm²) according to Koller (1972).

Mineral components in leaves:

- **N, P and K %:** were estimated in dry leaves by the method described in AOAC (2012).

- **Zinc (ppm):** was determined by the method described by Khazaei *et al.* (2017).

- **Boron (ppm):** was determined according to Chapman and Paratt (1961).

Biochemical parameters in leaves:

- **Chlorophyll a, b and Carotenoids (mg/g Fw):** were determined according to Lichtenthaler and Wellburn (1985).

Yield and its components:

At harvesting time after 140 days from planting; plant yield (kg) marketable and total tuber yield (ton/fed.) were recorded.

Tuber quality:

- Starch% was determined according to Somogy (1952).

- Vitamin C (mg/100 g Fw): It was determined by the method reported in AOAC (2012).

- Total Soluble Solids (TSS) % were determined by using Refract meter according to AOAC (2012).

- Total sugar % was estimated by the method reported by Malik and Srivastava (1979).

Statistical analysis:

ANOVA technique was used to analyzed data statistically according to Gomez and Gomez (1984). The treatment means were compared using Duncan Multiple Rang Test (Duncan, 1955).

RESULTS AND DISCUSSION

Results

Vegetative growth parameters:

Obtained results in Table 2 demonstrated that all vegetative parameters *i.e.*, No. of branches, No. of leaves, plant height, fresh weight, dry matter and leaves area significantly affected by soaking periods. The maximum values of the vegetative growth parameters were obtained from soaking tubers pre planting at 3 hours followed by soaking tubers 2 hours.

Table 2. Vegetative growth parameters of potato as affected by soaking periods of some activators during 2017 and 2018 seasons.

Characters Treatments	No. of branches /plant		No. of leaves /plant		Plant height (cm)		Fresh weight (g)		Dry matter (%)		Leaves area (cm ²)		
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	
A- Soaking periods:													
1 Hours	4.6 c	5.3 c	23.0 c	19.8 c	27.9 c	29.0 c	132.9 c	119.8 c	18.61 c	17.38 c	479.8 c	564.0 c	
2 Hours	5.8 b	6.8 b	26.7 b	27.9 b	35.4 b	36.2 b	136.4 b	126.7 b	18.83 b	18.09 b	767.4 b	768.3 b	
3 Hours	6.9 a	7.4 a	31.5 a	31.8 a	41.5 a	37.9 a	175.2 a	177.5 a	19.01 a	18.71 a	873.5 a	866.3 a	
B- Activators:													
Control	4.4 d	4.7 d	23.3 d	23.5 d	31.7 d	30.9 d	126.3 d	119.5 d	17.48 d	16.42 d	670.0 d	685.6 d	
LRE at 5 g/l	7.1 a	7.7 a	30.6 a	29.2 a	36.0 b	35.6 b	171.7 a	162.7 a	19.88 a	19.13 a	743.4 a	777.4 a	
Zn+B (100+50) mg/l	5.4 c	6.5 c	26.0 c	25.7 c	34.3 c	33.9 c	138.4 c	133.1 c	18.65 c	18.00 c	697.3 c	724.1 c	
Yeast at 5 g/l	6.2 b	7.0 b	28.3 b	27.6 b	37.6 a	37.0 a	156.2 b	150.1 b	19.25 b	18.70 b	716.8 b	744.3 b	
A × B – Means values as affected by soaking periods and activators:													
1 Hour	Control	3.2 g	3.7 f	18.0 i	17.2 i	24.3 i	25.9 g	106.3 f	100.8 h	17.26 k	15.58 h	452.0 i	527.7 j
	Licorice	6.0 bcd	6.7 d	27.7 e	22.3 g	29.0 h	30.0 e	157.3 c	139.2 e	19.66 b	18.45 d	506.0 i	587.3 h
	Zn+B	4.0 fg	5.0 e	21.7 h	19.8 h	27.7 h	28.7 f	126.3 e	113.2 g	18.47 h	17.40 f	472.7 k	562.7 i
	Yeast	5.3 de	5.7 e	24.7 fg	20.0 h	30.7 g	31.3 d	141.7 d	126.6 f	19.03 e	18.09 e	488.3 j	578.3 h
2 Hours	Control	4.3 ef	5.0 e	24.0 g	25.3 f	32.7 f	32.0 d	120.7 e	106.9 gh	17.49 j	16.46 g	727.3 h	734.0 g
	Licorice	7.0 b	7.7 bc	29.3 d	30.3 c	36.3 d	37.7 b	163.3 bc	150.3 d	19.93 a	19.05 b	803.3 e	803.7 d
	Zn+B	5.7 cd	7.0 cd	25.7 f	27.0 e	34.3 e	35.7 c	117.7 ef	111.7 g	18.63 g	17.99 e	758.3 g	758.0 f
	Yeast	6.0 bcd	7.3 bcd	27.7 e	29.0 d	38.3 c	39.3 a	144.0 d	138.0 e	19.25 d	18.88 bc	780.7 f	777.7 e
3 Hours	Control	5.7 cd	5.3 e	28.0 e	28.0 de	38.3 c	34.8 c	152.0 cd	150.7 d	17.68 i	17.21 f	830.7 d	795.0 d
	Licorice	8.2 a	8.7 a	34.7 a	35.0 a	42.7 a	39.0 a	194.3 a	198.7 a	20.04 a	19.89 a	921.0 a	941.3 a
	Zn+B	6.7 bc	7.6 bc	30.7 c	30.3 c	41.0 b	37.5 b	171.3 b	174.3 c	18.86 f	18.62 cd	861.0 c	851.7 c
	Yeast	7.1 b	8.1 ab	32.7 b	33.7 b	44.0 a	40.2 a	183.0 a	186.3 b	19.46 c	19.14 b	881.3 b	877.0 b

Different letters in the same column which indicate significant differences according to the Duncan Multiple Test (P < 0.05)

As regard to the effect of activators on vegetative growth parameters, data in the same Table show that all activators enhanced vegetative growth parameters compared to control treatment. LRE at 5 g L⁻¹ gave the highest values of No. of branches, No. of leaves, fresh weight, dry matter and leaves area, while yeast extract at 5 g L⁻¹ treatment gave the highest plants in both seasons.

As for the interaction effect between soaking periods and activators, data illustrated in the same Table reveal that the integration soaking tubers 3 hours by using LRE at 5 g L⁻¹ gave the highest values of No. of branches, No. of leaves, fresh weight, dry matter and leaves area, while there were insignificant effect between soaking tubers 3 hours plus LRE or yeast extracts on fresh weight and between soaking tubers 3 hours plus LRE or soaking tubers 2 hours plus LRE on dry matter in the first season. There were insignificant effect between soaking tubers 3 hours plus LRE or yeast extracts on plant height in both seasons.

Minerals component in leaves:

With respect to the effect of soaking periods, data listed in Table 3 indicated that soaking periods

significantly affected on N, P, K, Zn and B in potato leaves. The maximum values of the minerals component in leaves were obtained from soaking tubers 3 hours pre planting, followed by soaking 2 hours, while the lowest values were came from plants soaked 1hour.

Data in the same Table exhibited that N, P, K, Zn and B in leaves significantly increased as concerning to application with activators compared to the control treatment. LRE at 5 g L⁻¹ gave a superiority of all activators in N, P and K content, while Zn+B at (100+50) ppm application gave the highest values of Zn and B content.

Data in the same Table clarify the interaction effect between soaking periods and activators revealed that the combination between soaking tubers 3 hours by using LRE at 5 g L⁻¹ gave the highest values of N, P and K, while combination between soaking tubers 3 hours by using Zn+B gave the highest values of Zn and B contents.

Table 3. Minerals composition contents of potato leaves as affected by soaking periods of some activators during 2017 and 2018 seasons.

Characters Treatments	N (%)		P (%)		K (%)		Zn ppm		B ppm		
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	
A- Soaking periods:											
1 Hours	2.54 c	2.28 c	0.262 c	0.236 c	2.80 c	2.58 c	45.06 c	42.72 c	29.65 c	27.43 c	
2 Hours	2.62 b	2.50 b	0.270 b	0.258 b	2.91 b	2.75 b	45.88 b	43.63 b	30.38 b	28.66 b	
3 Hours	2.72 a	2.60 a	0.279 a	0.267 a	3.02 a	2.90 a	46.98 a	45.49 a	31.49 a	30.50 a	
B- Activators:											
Control	2.00 d	2.03 d	0.205 d	0.190 d	2.18 d	2.03 d	40.41 d	38.17 d	24.64 d	22.63 d	
LRE at 5 g/l	3.16 a	2.89 a	0.322 a	0.297 a	3.50 a	3.29 a	47.64 b	45.83 b	32.26 b	30.57 b	
Zn+B (100+50) mg/l	2.53 c	2.33 c	0.263 c	0.250 c	2.82 c	2.65 c	50.53 a	48.39 a	35.40 a	33.76 a	
Yeast at 5 g/l	2.82 b	2.59 b	0.292 b	0.276 b	3.16 b	3.00 b	45.30 c	43.40 c	29.71 c	28.50 c	
A × B – Means values as affected by soaking periods and activators:											
1 Hour	Control	1.95 k	1.93 i	0.196 k	0.174 h	2.07 l	1.88 j	39.67 j	36.73 g	24.17 i	21.73 i
	Licorice	3.05 c	2.64 d	0.313 c	0.279 d	3.39 c	3.12 c	46.87 ef	44.80 c	31.40 ef	29.13 ef
	Zn+B	2.45 i	2.18 g	0.255 h	0.232 f	2.71 i	2.50 g	49.20 bc	47.00 b	34.17 bc	32.17 b
	Yeast	2.71 f	2.38 f	0.283 f	0.258 e	3.04 f	2.81 e	44.50 h	42.33 d	28.87 h	26.70 g
2 Hours	Control	1.96 k	2.13 gh	0.205 j	0.193 g	2.18 k	2.05 i	40.37 ij	38.10 f	24.47 i	22.23 i
	Licorice	3.18 b	2.93 b	0.322 b	0.301 b	3.48 b	3.29 b	47.67 de	45.57 c	32.17 de	30.63 cd
	Zn+B	2.53 h	2.33 f	0.264 g	0.256 e	2.82 h	2.64 f	50.13 b	48.07 b	35.17 b	33.13 b
	Yeast	2.82 e	2.62 d	0.291 e	0.280 d	3.18 e	3.02 d	45.33 gh	42.80 d	29.73 gh	28.63 f
3 Hours	Control	2.11 j	2.04 h	0.213 i	0.202 g	2.28 j	2.14 h	41.20 i	39.67 e	25.30 i	23.93 h
	Licorice	3.25 a	3.11 a	0.330 a	0.312 a	3.63 a	3.47 a	48.40 cd	47.13 b	33.27 cd	31.93 bc
	Zn+B	2.62 g	2.49 e	0.270 g	0.263 e	2.92 g	2.82 e	52.27 a	50.10 a	36.87 a	35.97 a
	Yeast	2.92 d	2.76 c	0.303 d	0.290 c	3.26 d	3.17 c	46.07 fg	45.07 c	30.53 fg	30.17 de

Different letters in the same column which indicate significant differences according to the Duncan Multiple Test (P < 0.05)

Biochemical parameters in leaves:

It is clear from data listed in Table 4 that increasing soaking periods for potato tubers pre planting significantly increased biochemical parameters in potato leaves *i.e.* chlorophyll a, chlorophyll b, chlorophyll a+b and carotenoids. In this concern, soaking tubers 3 hours pre planting gave the highest values of this parameters.

Data listed in the same Table showe that biochemical parameters in leaves significantly increased with using activators compared to control treatment. LRE at 5 g L⁻¹ gave the highest values of aforementioned parameters.

The interaction effect between soaking periods and activators showed that the combination between soaking tubers 3 hours by using LRE at 5 g L⁻¹ gave the highest values of biochemical parameter, followed by soaking tubers 2 hours by using LRE at 5 g L⁻¹.

Tuber yield and its components:

Data presented in Table 5 clarify that soaking periods significantly affected on potato yield and its components. The maximum values of plant yield, marketable and total tuber yield were obtained from soaking tubers 3 hours pre planting.

All activators significantly increased potato yield and its components compared to control. The highest values of plant yield, marketable and total tuber yield were

obtained from LRE at 3 g L⁻¹. It enhanced marketable yield (22.12 and 24.84%) in 1st and 2nd seasons respectively.

As regard to the interaction effect between soaking periods and activators on plant yield, marketable and total

tuber yield of potato, data in the same Table indicate that soaking tubers 3 hours pre planting with LRE at 5 g L⁻¹ gave the highest yield of potato without any significant with the yeast treatment in both seasons of study.

Table 4. Biochemical parameters of potato leaves as affected by soaking periods of some activators during 2017 and 2018 seasons.

Characters Treatments	Chlorophyll a (mg/g FW)		Chlorophyll b (mg/g FW)		Chlorophyll a+b (mg/g FW)		Carotenoids (mg/g FW)		
	2017	2018	2017	2018	2017	2018	2017	2018	
A- Soaking periods:									
1 Hours	0.645 c	0.604 c	0.459 c	0.429 c	1.105 c	1.033 c	0.252 c	0.234 c	
2 Hours	0.653 b	0.622 b	0.468 b	0.447 b	1.121 b	1.069 b	0.271 b	0.236 b	
3 Hours	0.663 a	0.642 a	0.476 a	0.463 a	1.139 a	1.105 a	0.283 a	0.270 a	
B- Activators:									
Control	0.594 d	0.564 d	0.413 d	0.393 d	1.007 d	0.957 d	0.225 d	0.216 d	
LRE at 5 g/l	0.700 a	0.670 a	0.510 a	0.487 a	1.210 a	1.156 a	0.305 a	0.281 a	
Zn+B (100+50) mg/l	0.648 c	0.616 c	0.461 c	0.440 c	1.109 c	1.056 c	0.256 c	0.234 c	
Yeast at 5 g/l	0.674 b	0.641 b	0.487 b	0.465 b	1.161 b	1.106 b	0.288 b	0.252 b	
A × B – Means values as affected by soaking periods and activators:									
1 Hour	Control	0.585 k	0.547 h	0.405 j	0.377 h	0.990 l	0.924 j	0.208 i	0.203 h
	Licorice	0.691 c	0.651 c	0.503 b	0.469 c	1.194 c	1.120 d	0.287 c	0.269 c
	Zn+B	0.639 h	0.594 f	0.452 g	0.423 f	1.091 i	1.017 g	0.238 g	0.222 f
	Yeast	0.666 e	0.624 de	0.477 d	0.448 de	1.143 f	1.071 f	0.275 d	0.244 d
2 Hours	Control	0.594 j	0.565 g	0.413 i	0.392 g	1.007 k	0.956 i	0.220 h	0.212 g
	Licorice	0.700 b	0.671 b	0.512 a	0.493 ab	1.212 b	1.164 b	0.305 b	0.280 b
	Zn+B	0.648 g	0.617 de	0.461 f	0.439 e	1.109 h	1.056 f	0.267 e	0.231 e
	Yeast	0.671 e	0.636 d	0.487 c	0.466 c	1.158 e	1.101 e	0.291 c	0.222 f
3 Hours	Control	0.603 i	0.581 f	0.422 h	0.411 f	1.025 j	0.992 h	0.248 f	0.231 e
	Licorice	0.710 a	0.687 a	0.515 a	0.498 a	1.224 a	1.184 a	0.322 a	0.295 a
	Zn+B	0.657 f	0.637 d	0.470 e	0.459 cd	1.127 g	1.097 e	0.263 e	0.249 d
	Yeast	0.684 d	0.664 bc	0.496 b	0.482 b	1.180 d	1.146 c	0.299 b	0.292 a

Different letters in the same column which indicate significant differences according to the Duncan Multiple Test (P < 0.05)

Table 5. Potato yield as affected by soaking periods of some activators during 2017 and 2018 seasons.

Characters Treatments	Plant yield (kg)		Marketable yield (ton/fed.)		Total tuber yield (ton/fed.)		
	2017	2018	2017	2018	2017	2018	
A- Soaking periods:							
1 Hours	0.641 c	0.635 c	14.64 c	14.51 c	15.83 c	15.48 c	
2 Hours	0.731 b	0.709 b	16.70 b	16.20 b	17.51 b	17.12 b	
3 Hours	0.800 a	0.767 a	18.29 a	17.53 a	19.36 a	18.63 a	
B- Activators:							
Control	0.643 d	0.613 d	14.69 d	14.01 d	15.77 d	15.02 d	
LRE at 5 g/l	0.785 a	0.765 a	17.94 a	17.49 a	18.94 a	18.38 a	
Zn+B (100+50) mg/l	0.719 c	0.693 c	16.43 c	15.84 c	17.52 c	16.89 c	
Yeast at 5 g/l	0.748 b	0.743 b	17.10 b	16.97 b	18.03 b	18.02 b	
A × B – Means values as affected by soaking periods and activators:							
1 Hour	Control	0.589 h	0.577 h	13.47 h	13.18 h	14.46 g	14.13 g
	Licorice	0.713 ef	0.689 e	16.29 ef	15.74 e	17.52 de	16.71 d
	Zn+B	0.605 h	0.602 gh	13.84 h	13.77 gh	15.34 f	14.75 f
	Yeast	0.654 g	0.671 ef	14.94 g	15.33 ef	15.99 f	16.33 de
2 Hours	Control	0.637 g	0.615 g	14.57 g	14.06 g	15.43 f	15.06 f
	Licorice	0.790 c	0.782 c	18.05 c	17.88 c	18.88 c	18.50 bc
	Zn+B	0.739 de	0.692 e	16.89 de	15.81 e	17.56 de	16.89 d
	Yeast	0.758 d	0.746 d	17.31 d	17.06 d	18.15 d	18.02 c
3 Hours	Control	0.702 f	0.647 f	16.04 f	14.80 f	17.42 e	15.86 e
	Licorice	0.853 a	0.824 a	19.49 a	18.84 a	20.41 a	19.92 a
	Zn+B	0.812 bc	0.785 bc	18.57 bc	17.95 bc	19.66 b	19.03 b
	Yeast	0.834 ab	0.811 ab	19.05 ab	18.54 ab	19.94 ab	19.71 a

Different letters in the same column which indicate significant differences according to the Duncan Multiple Test (P < 0.05)

Tubers quality:

As shown in Table 6 increasing soaking tubers periods increased significantly tubers quality *i.e.* starch, TSS, and total sugar contents in both seasons, except of vitamin C.

It is quite clear in the same table that LRE, Zn+B and Yeast extract significantly increased tubers quality compared to control. The maximum values of starch, TSS, and total sugar were obtained from LRE at 5 g L⁻¹, while Zn+B at (100+50) mg/l gave superiority in vitamin C content.

Concerning to the interaction between soaking periods and activators, data in the same table illustrate that soaking tubers pre planting 3 hours with LRE at 5 g L⁻¹ gave the highest values of starch, TSS, and total sugar, while soaking tubers pre planting 2 hours combined with Zn+B at (100+50) mg/l gave the highest content of vitamin C in both seasons.

Table 6. Potato tuber quality as affected by soaking periods of some activators during 2017 and 2018 seasons.

Characters Treatments	Starch %		Vitamin C mg/100 g		TSS %		Total sugar %	
	2017	2018	2017	2018	2017	2018	2017	2018
A- Soaking periods:								
1 Hours	23.14 c	21.98 c	22.08 c	19.94 c	7.36 c	6.95 c	6.28 c	5.76 c
2 Hours	23.39 b	22.74 b	22.36 a	22.17 a	7.44 b	7.19 b	6.43 b	6.05 b
3 Hours	23.63 a	23.13 a	22.21 b	21.12 b	7.54 a	7.34 a	6.58 a	6.31 a
B- Activators:								
Control	21.77 d	21.10 d	21.26 d	20.15 d	6.83 d	6.52 d	5.41 d	4.97 d
LRE at 5 g/l	24.66 a	23.57 a	22.54 b	21.42 b	7.92 a	7.65 a	7.21 a	6.77 a
Zn+B (100+50) mg/l	23.19 c	22.56 c	22.95 a	21.71 a	7.39 c	7.10 c	6.33 c	6.00 c
Yeast at 5 g/l	23.92 b	23.24 b	22.12 c	21.03 c	7.66 b	7.38 b	6.77 b	6.41 b
A × B – Means values as affected by soaking periods and activators:								
1 Hour	Control	21.53 l	20.32 g	21.13 l	6.75 l	6.32 h	5.26 h	4.69 i
	Licorice	24.42 c	23.29 bc	22.40 f	20.31 gh	7.82 c	7.47 b	7.06 b
	Zn+B	22.93 i	21.84 e	22.81 c	20.44 g	7.29 i	6.86 e	6.19 e
	Yeast	23.68 f	22.47 d	21.97 i	19.90 i	7.58 f	7.16 d	6.62 d
2 Hours	Control	21.77 k	21.25 f	21.40 j	21.17 f	6.82 k	6.51 g	5.41 g
	Licorice	24.66 b	23.55 ab	22.68 d	22.52 b	7.91 b	7.69 a	7.23 a
	Zn+B	23.19 h	22.75 d	23.12 a	22.88 a	7.37 h	7.12 d	6.33 e
	Yeast	23.92 e	23.44 b	22.26 g	22.10 c	7.66 e	7.46 b	6.76 c
3 Hours	Control	22.03 j	21.75 e	21.25 k	20.16 h	6.93 j	6.73 f	5.55 f
	Licorice	24.91 a	23.87 a	22.54 e	21.42 c	8.02 a	7.80 a	7.36 a
	Zn+B	23.44 g	23.10 c	22.94 b	21.81 d	7.50 g	7.32 c	6.48 d
	Yeast	24.17 d	23.82 a	22.13 h	21.09 f	7.73 d	7.51 b	6.94 b

Different letters in the same column which indicate significant differences according to the Duncan Multiple Test ($P < 0.05$)

Discussion

The results of this research clarify that increasing soaking periods of activators significantly increased potato growth, leaves minerals, biochemical contents and tuber yield. These results indices may be due that potato pieces planted in moderate moisture and prevent irrigation about one month even plant emergence to prevent tubers rotting thus tubers need optimal level of moisture to stimulate sprout for emergence and commence process of cell division that leading to enhance vegetative growth (Table 2) hence increasing chlorophyll contents (Table 4) thus increased photosynthesis and translocation from leaves to tubers therefore raising potato yield (Table 5). These results are in compatible with those obtained by Sabongari and Aliero (2004) on tomato, Kandil *et al.* (2012) on potato and Hassan and Hegazy (2017) on artichoke.

Using activators increased all aforementioned parameters compared to the control treatment. In this concern promotive effect of LRE may be due to its contents of some nutrients that play main role in biological process as cell division, synthesis amino and nucleic acid, structure of chloroplast membrane, mevalonic acid the initiator synthesis of GA₃, glyceyrrhizin as acts like gibberellins roles that enhances cell division and elongation (Moses *et al.*, 2002), phenolic compounds, saccharaides, vitamins, folic and pantothenic acids that stimulate plant growth (Fukai *et al.*, 1998 and Arytanova *et al.*, 2001), rooting efficiency (El-dengawy *et al.*, 2017), chlorophyll content (Ramadan and Shalaby, 2016) and minerals content (Abd-Elhamied, 2017). These findings are in conformity with those reported by Hamadah *et al.* (2012), Ezzat *et al.* (2016) on potato, Faraj and Ghaloom (2012), Shafeek *et al.* (2015) on onion and Hassan and Hegazy (2017) on artichoke.

The positive effect on all parameters allied with Zn+B may be attributed to its role in building up IAA that promote cell division and cell elongation (El-Tohamy and

El-Greadly, 2007) and affect on meristematic growth which enhance plant growth with enhancing chlorophyll formation by effect on enzymatic role thus led to increase synthesis of carbohydrates and protein and their transport to storage tuber hence increase potato yield and quality. These findings are in agreement with Singh and Tiwari (2013) on tomato, Puzina (2004), Farouk (2015) on potato, Fouda and Abd-Elhamied (2017) on cowpea and Verma *et al.* (2017) on chickpea.

The promotive effect of yeast extract may be due to its contain of nutrients, vitamin b, cytokinins (Nagodawithana, 1991) that increase metabolic processes, photosynthesis process, assimilates supply and endogenous hormones which increase vegetative growth (Hamail *et al.*, 2014) and promote mineral translocation to storage parts thus reflected to increase yield and quality. These observation agrees with the reports of Dawa *et al.* (2014) on pea, El-Tohamy *et al.* (2015) on sweet potato, Ahmed *et al.* (2011) and Dahshan *et al.* (2017) on potato.

CONCLUSION

The results obtained in this research clear that soaking tubers pre planting 3 hours with LRE at 5 g L⁻¹ increased potato growth, yield and it's quality.

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تأثير فترات نقع البطاطس ببعض المنشطات على النمو والإنتاجية

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تم إجراء تجربتان حقلين خلال الموسمين الصيفيين ٢٠١٧ و ٢٠١٨ في مزرعة خاصة بمدينة أجا بمحافظة الدقهلية لدراسة تأثير فترات النقع بعض المنشطات و التداخل بينهم على صفات النمو الخضري والتركيب الكيماوى والحيوى للأوراق ومحصول وجودة البطاطس صنف كارا. نفذت التجربة في تصميم قطاعات كاملة العشوائية منشقة مرة واحدة، وإشتملت التجربة على ١٢ معاملة عبارة عن ثلاث فترات نقع للمنشطات (ساعة، ساعتان، ثلاث ساعات) وثلاث منشطات (مستخلص جذور العرقسوس بتركيز ٥ جرام/لتر، الزنك + البورون بتركيز ١٠٠+٥٠ ملليجرام/لتر و مستخلص الخميرة بتركيز ٥ جم/لتر) بالإضافة لمعاملة الكنترول (ماء الصنبور). أعطت النتائج التي تم الحصول عليها أفضل صفات النمو الخضري والمحتوى الكيماوى والحيوى للأوراق بالإضافة إلى محصول الدرنات ومعظم صفات الجودة عند معاملة نقع الدرنات بالمنشطات قبل الزراعة لمدة ثلاث ساعات. كل المنشطات أدت لتحسين الصفات المدروسة معنويا مقارنة بالكنترول، وأعطت المعاملة بمستخلص جذور العرقسوس بتركيز ٥ جرام/لتر أعلى القيم في معظم صفات النمو الخضري والتركيب الكيماوى والحيوى للأوراق والمحصول وجوته. لذلك يمكن التوصية بنقع الدرنات قبل الزراعة لمدة ثلاث ساعات بمستخلص جذور العرقسوس لزيادة صفات النمو الخضري والمحصول وجودة درنات البطاطس.