



## **EFFECT OF SOME GROWTH REGULATORS AND NATURAL EXTRACTS ON YIELD AND QUALITY OF POTATO**

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### **ABSTRACT**

This experiment was carried out to study the effect of gibberellic acid (GA<sub>3</sub>), indole-3-butyric acid (IBA), garlic extract, yeast extract and green tea extract with different concentrations on potato “cv. Burren” yield, yield components and chemical composition. Results showed that the applied treatments enhanced potato plants to produce tubers with good qualities and suitable for seed- sized marketing along with decreasing the percentage of small tubers. Also, most of the used treatments increased edible tubers content of NPK and protein within the acceptable ranges for good feeding. The foliar application treatment of these substances was better than that of seed tuber soaking in the same extracts and solutions. Results obtained in this study are very promising for potato farmers under similar conditions and encourage them to use these growth regulators and natural extracts and solutions in producing their seed sized as well as commercial consumed potatoes with good qualities.

**Keywords:** Potato, plant growth regulators, GA<sub>3</sub>, IBA, yeast, green tea and garlic extracts.

### **INTRODUCTION**

Potato (*Solanum tuberosum* L.) is an important vegetable crop and it is ranked as the fourth most important food crop in the world after corn, wheat, and rice (Alva

*et al.*, 2011). Potato is a member of the family *Solanaceae* that includes several other economically important crops such as tomato, pepper, and eggplant. In Egypt, potato is one

of the most important vegetable crops not only for local consumption of tubers but also for exportation to several foreign countries, e.g., European markets, therefore, it is one of the basic resources of the Egyptian national income (Mahmoud and Hafez, 2010). In terms of human nutrition, potato is a unique supplement food due to its high content of carbohydrates, essential elements, vitamins and proteins (Khuranas, 2006).

Yeast extract is a natural component which is safe and non-pollutant. It contains many of the nutrient elements, cytokinins, large amounts of amino acids, carbohydrates, reducing sugars, enzymes and vitamins B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub>, and B<sub>12</sub> (Castelfranco and Beale, 1983, Spencer *et al.*, 1983, Fathy and Farid, 1996 and Khedr and Farid, 2000). Application of yeast extract on plants stimulates plant cells division and cells enlargement as well as synthesis of proteins, nucleic acid and chlorophylls (Kraig and Haber, 1980, Castelfranco and Beale, 1983). As a bio-fertilizer, yeast extract is also used as a soil treatment or a foliar application to many of the vegetable crops. It increases the vegetative growth, productivity, tubers quality and tubers dry matter contents of potato plants (El-Ghamriny *et al.*, 1999 and Ahmed *et al.*, 2011).

Plant growth regulators (PGR) have vital effects on potato tubers germination which is highly related to the internal hormonal balance (Stuart and

Cathey, 1961, Vreugdenhil and Struik, 1989). Gibberellins are growth promoters and to date over hundred gibberellins have been isolated and mainly are produced in plant leaves but may also be synthesized in roots and fruits ((Pallais *et al.*, 1991, Vivanco and Flores, 2000, Karam and Al-Salem, 2001, Bahrani *et al.*, 2008, Zeinalabedini *et al.*, 2009, Deng *et al.*, 2010 and Zeng *et al.*, 2010). Likely wise, gibberellic acid (GA<sub>3</sub>) 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).

Indole-3-butyric acid (IBA) is more preferable than other growth regulators. It has a low auxin activity, degrades relatively slow by degrading enzymes and persistent in nature. Application of IBA on potato plants showed its superiority over other plant growth regulators in many characteristics, e.g., plant height, number of branches and number of leaves and dry weight of foliage (Bhatia *et al.*, 1992). IBA has also significant effects on rooting, especially potato stem cuttings which are hard to root (Ercili and Guleryz, 1999 and Delker *et al.*, 2008).

The present study was planned to study the effects of gibberellic acid (GA<sub>3</sub>), indole-3-butyric acid (IBA), garlic extract, yeast extract or green tea extract on increasing total yield and yield

quality in the summer season planting.

## **MATERIALS AND METHODS**

The experiments were carried out during the two successive summer seasons of 2014 and 2015 in a private farm at Abwan village, Matay city, Minia governorate, Egypt. The experiments aim to study the effect of GA<sub>3</sub>, IBA, garlic extract, yeast extract and green tea extracts on yield and quality of potato. The cultivar Burren (a table cultivar) was selected and used in these experiments. Certified seed tubers were purchased from the Potato Producers' Co-operative Society, Minia governorate, El Minia, Egypt. Homogeneous pieces of potato seed tubers were planted in January 10<sup>th</sup> and 15<sup>th</sup> of 2014 and 2015 seasons, respectively. Seeding 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 within each row was 20.0 cm interval. The area of each experimental plot was 10.5 m<sup>2</sup> to be considered as (1/400 of a Fadden). Each experiment consisted of 16 treatments i.e., control (distilled water), GA<sub>3</sub> (at three levels i.e., 2.5, 5.0 and 10.0 ppm.), IBA (at three levels i.e., 20.0, 40.0 and 60.0 ppm.), garlic extract (at three levels i.e., 0.1, 0.2 and 0.3%), yeast extract (at three levels i.e., 0.1, 0.2 and 0.3%), and green tea extract (at three levels i.e., 0.1, 0.2 and 0.3%). Concentrations of the used substances were prepared as follow:

### **1. Garlic extract**

Forty grams of garlic (Egyptian cv.) were grinded, blinded and dissolved in 200 ml of distilled water using a mixer and then, the volume was completed to one liter using distilled water. Garlic extract with a volume of 500 ml was added to 20 liters of distilled water to obtain the 0.1% as described by **Abd El-Mageed *et al.* (2009)**.

### **2. Yeast extract**

One gram of dry yeast plus sugar cane honey was soaked in one liter of distilled water resulted in 0.1% concentration of yeast extract.

### **3. Green tea extract**

One gram of green tea was soaked in one liter of distilled water resulted in 300 ppm. Meanwhile to obtain 1000 ppm, 67.0 grams of green tea were dissolved in 20 liters of distilled water.

#### **a. Seed tuber soaking**

Cut seed tubers were immersed for 10 min before planting in the aforementioned concentrations of the used substances.

#### **b. Foliar spray**

Treatments as well as control (distilled water) were sprayed on potato plants after 45 and 60 days from planting.

The experimental design was factorial experimental in randomized complete blocks design (RCBD) with three replications. The treatments were randomly

distributed in each replicate. All recommended agricultural practices for the commercial production of potato under Minia governorate growing conditions were followed according to instructions of the Egyptian Ministry of Agriculture (Bulletin, Ministry of Agriculture, Egypt, 2009).

Data were recorded for the yield and yield components and chemical analyses as follow:

#### **a. Yield and yield components**

Samples of 10 whole plants were randomly harvested at the maturity stage (after 110 days from planting) of the cultivar and the following data were recorded:

1. Average total yield (ton/fed)
2. Average weight of marketable tubers (>45g) ton/fed
3. Average weight of seed-sized tubers (45-60g) ton/fed
4. Average weight of unmarketable tubers (< 45g) ton/fed

#### **b. Chemical analyses**

After 85 days from planting of the cultivar. Each sample of whole plants was dried using grinded and prepared to determine the following components:

##### **1. Nitrogen (N) concentration% (in whole plant).**

Concentration was determined using Kjeldhale apparatus according to Jackson (1973).

##### **2. Plant N uptake (g)**

Nitrogen uptake was calculated by multiplying average dry weight of whole plant (g)  $\times$  N concentration in whole plant (%).

##### **3. Phosphorus (P) concentration% (in whole plant).**

Concentration was determined by the Molybdenum Blue Method using the Spectrophotometer device according to Jackson (1973).

##### **4. Plant P uptake (g)**

Phosphorus was calculated by multiplying average dry weight of whole plant (g)  $\times$  P concentration in whole plant (%).

##### **5. Potassium (K) concentration% (in whole plant).**

Concentration was measured using the Flame Photometer device according to Jackson (1973).

##### **6. Plant K uptake (g)**

Potassium was calculated by multiplying average dry weight of whole plant (g)  $\times$  K concentration in whole plant (%).

##### **7. Average protein content**

It was calculated by multiplying average N concentration in whole plant (%)  $\times$  6.25.

#### **Statistical analysis**

All obtained data were subjected to the analysis of variance (ANOVA) and means were compared using the Duncan's Multiple Range Test (D M R T) at 95% confidence according to Gomez and Gomez (1984). The MSTATC program Ver. 4 (Michigan University, USA) was used to achieve all these statistical analyses.

## RESULTS AND DISCUSSION

### 1. Yield and yield components

All of yield and yield components characteristics were affected by the applied treatments e.g. GA<sub>3</sub>, IBA, garlic, yeast and green tea extracts and/or the methods of applications as follow:

#### 1.1. Average total yield (ton/fed)

Data in (Table 1) showed that foliar application significantly increased the average total yield (15.774 and 15.108 ton/fed) compared with the seed tuber soaking treatment (15.326 and 14.743 ton/fed) in both seasons. Application of yeast at 0.2% concentration was effective and significantly improved average total yield (16.703 and 16.977 ton/fed) followed by yeast at 0.3% and 0.1% and green tea treatments at 0.2% and 0.3%, respectively. Moreover, the three levels of GA<sub>3</sub> increased the average total yield with non-significant differences. IBA and garlic extract treatments gave higher total yield than the untreated plants with non-significant differences in both seasons.

The interaction among treatments and method of applications showed significant effects on average total yield in both seasons. The highest total tuber yield was obtained from

plants received foliar spray with yeast at 0.2% concentration (16.961 and 17.248 ton/fed) compared with the control treatment (14.352 and 13.534 ton/fed) in both seasons, respectively.

#### 1.2. Average weight of marketable tubers >45g (ton/fed)

In general, average weight of table tubers >45g was affected by yeast, green tea and/or application of GA<sub>3</sub> as clear in Table (2). Data illustrated that foliar application increased the average weight of tubers >45g (14.876 and 14.196 ton/fed) compared with seed tuber soaking application (14.314 and 13.786 ton/fed). On the same time, the effect of yeast clearly showed significant effects as the average weight of marketable tubers >45 increased with increasing the yeast level up to 0.2% (15.879 and 16.171 ton/fed) followed by green tea treatments at (0.2% and 0.3%) compared with the control (13.282 and 12.503 ton/fed) in both seasons, respectively. Meanwhile, the foliar application with yeast solution at 0.2% concentration gave the highest significant values of average weight of table consumed tubers >45 (16.281 and 16.534 ton/fed) compared with control treatment (13.292 and 12.507 ton/fed) in both seasons.

Table (1): Effect of seed tuber soaking and plant foliar application with gibberellic acid, Indole-3-butyric acid, garlic, yeast and green tea extract on total yield (ton/fed.) of potato cv. "Burren" grown in two successive summer seasons of 2014 and 2015.

Treatments	The 1 <sup>st</sup> season						The 2 <sup>nd</sup> season					
	Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B		Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B	
Control	14.342	h	14.352	h	14.347	E	13.525	m	13.534	m	13.529	G
GA <sub>3</sub> (2.5)ppm	15.512	ef	14.932	fgh	15.222	C	14.289	g-k	14.507	fgh	14.398	DE
GA <sub>3</sub> (5) ppm	15.719	de	16.181	bcd	15.950	B	14.361	g-j	14.696	efg	14.528	CD
GA <sub>3</sub> (10) ppm	15.822	cde	16.315	a-d	16.069	B	14.484	f-i	14.900	ef	14.692	C
IBA (20) ppm	14.490	h	14.622	h	14.556	De	13.733	lm	13.954	j-m	13.844	F
IBA(40) ppm	14.761	gh	14.989	fgh	14.875	Cd	13.824	klm	14.584	fg	14.204	E
IBA (60) ppm	14.698	h	15.494	ef	15.096	C	14.020	h-m	14.222	g-l	14.121	EF
GE (0.1%)	14.695	h	15.533	ef	15.114	C	13.972	i-m	14.479	f-i	14.225	E
GE (0.2%)	14.451	h	14.499	h	14.475	De	13.697	m	14.044	h-m	13.871	F
GE (0.3%)	14.308	h	14.429	h	14.368	E	13.545	m	13.571	m	13.558	G
YE (0.1%)	15.365	efg	16.797	ab	16.081	B	15.111	de	15.553	d	15.332	B
YE (0.2%)	16.446	abc	16.961	a	16.703	A	16.706	bc	17.248	a	16.977	A
YE (0.3%)	16.423	abc	16.909	a	16.666	A	16.537	c	17.156	ab	16.846	A
GTE (0.1%)	15.360	efg	16.566	ab	15.963	B	15.077	de	15.165	de	15.121	B
GTE (0.2%)	16.402	abc	16.897	a	16.649	A	16.509	c	17.091	ab	16.800	A
GTE (0.3%)	16.427	abc	16.901	a	16.664	A	16.506	c	17.027	ab	16.767	A
Mean A	15.326	B	15.774	A			14.743	B	15.108	A		

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

GA<sub>3</sub> = gibberellic acid, (IBA) Indole-3-butyric acid, GE = garlic extract, YE = yeast extract and GTE= green tea extract

<sup>1</sup>Cut seed tubers were soaked for 10 min before planting.

<sup>2</sup>Potato plants were sprayed at 45 and 60 days after planting.

Table (2): Effect of seed tuber soaking and plant foliar application with gibberellic acid, Indole-3-butyric acid, garlic, yeast and green tea extract on weight of marketable tuber &gt; 45g (ton/fed) of potato cv. "Burren" grown in two successive summer seasons of 2014 and 2015.

Treatments	The 1 <sup>st</sup> season						The 2 <sup>nd</sup> season					
	Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B		Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B	
Control	13.271	j	13.292	j	13.282	E	12.498	n	12.507	n	12.503	G
GA3 (2.5)ppm	14.484	fg	14.047	ghi	14.266	C	13.288	ghijk	13.558	fgh	13.423	DE
GA3 (5) ppm	14.693	ef	15.244	cde	14.969	B	13.415	ghij	13.712	efg	13.564	CD
GA3 (10) ppm	14.798	def	15.384	cd	15.091	B	13.550	fgh	13.915	def	13.733	C
IBA (20) ppm	13.472	hij	13.649	hij	13.560	DE	12.715	lmn	12.943	j-n	12.829	F
IBA(40) ppm	13.734	hij	14.054	gh	13.894	Cd	12.816	k-n	13.573	fgh	13.195	E
IBA (60) ppm	13.672	hij	14.553	fg	14.113	C	13.098	h-l	13.277	g-k	13.188	E
GE (0.1%)	13.670	hij	14.584	fg	14.127	C	13.052	i-m	13.523	f-i	13.288	DE
GE (0.2%)	13.396	j	13.522	hij	13.459	DE	12.679	lmn	13.038	i-m	12.859	F
GE (0.3%)	13.249	j	13.452	ij	13.350	E	12.518	n	12.557	mn	12.537	G
YE (0.1%)	14.395	fg	15.827	abc	15.111	B	14.153	de	14.639	c	14.396	B
YE (0.2%)	15.478	c	16.281	a	15.879	A	15.808	b	16.534	a	16.171	A
YE (0.3%)	15.455	c	16.219	ab	15.837	A	15.685	b	16.443	a	16.064	A
GTE (0.1%)	14.355	fg	15.629	bc	14.992	B	14.100	de	14.251	cd	14.175	B
GTE (0.2%)	15.434	c	16.152	ab	15.793	A	15.593	b	16.362	a	15.977	A
GTE (0.3%)	15.459	c	16.127	ab	15.793	A	15.611	b	16.297	a	15.954	A
Mean A	14.314	B	14.876	A			13.786	B	14.196	A		

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

GA<sub>3</sub> = gibberellic acid, (IBA) Indole-3-butyric acid, GE = garlic extract, YE = yeast extract and GTE= green tea extract

<sup>1</sup>Cut seed tubers were soaked for 10 min before planting.

<sup>2</sup>Potato plants were sprayed at, 45 and 60 days after planting.

### 1.3. Average weight of seed-sized tubers “45-60g” (ton/fed.)

Data in (Table 3) represent the average weight of seed-sized tubers as affected by yeast, green tea and variance of GA<sub>3</sub> levels. Data revealed that foliar application significantly increased the average weight of seed-sized tubers (11.880 and 10.856 ton/fed) compared with the seed tuber soaking treatment (10.685 and 10.356 ton/fed) in the two growing seasons, respectively. Using yeast at 0.2% was significantly effective in improving the average weight of seed-sized tubers (13.146 and 13.364 ton/fed) compared with the untreated plants (9.467 and 8.132 ton/fed) in both seasons, respectively. Spraying treatments at 45 and 60 days after planting showed that yeast 0.2% produced the highest values of resulted sized - tubers fresh weight (45-60g) during both seasons and the tested plants gave (13.538 and 13.649 ton/fed) in the first and second seasons, respectively. Moreover, the untreated plants gave 9.489 and 8.134 ton/fed of tubers fresh weight (45-60g).

### 1.4. Average fresh weight of unmarketable (small) tubers <45g (ton/fed)

Results recorded in Table (4) indicated that foliar application significantly decreased the average fresh weight of small tubers < 45g (0.897 and 0.913 ton/fed.) compared with seed tuber soaking (1.013 and 0.957 ton/fed.) in the two growing seasons. Also, treatment with yeast solution at 0.2% showed significant effect

(0.824 ton/fed.) in the first season and yeast solution at 0.3% (0.782 ton/fed.) in the second season compared with the untreated plants (1.065 and 1.027 ton/fed.) in the two growing seasons, respectively. Meanwhile, the interaction among treatments and methods of applications showed that foliar spray with yeast extract at 0.2% and 0.3% significantly lowered the average fresh weight of small tubers to (0.680 and 0.713 ton/fed.) respectively compared with control plants (1.060 and 1.027 ton/fed.) in the two growing seasons.

## 2. Chemical composition

It is noticed from obtained data that chemical composition of the potato tubers was significantly affected by GA<sub>3</sub>, IBA, garlic, yeast and green tea extracts and/or methods of applications as follow:

### 2.1. Nitrogen (N) concentration (%)

Data in Table (5) showed that foliar application was significantly effective in improving nitrogen concentration (2.68 and 2.63 %) compared with seed tuber soaking (2.59 and 2.53%) in the two growing seasons, respectively. Regarding the effect of studied treatment, in general application of yeast and green tea treatments had significant effect on increasing nitrogen concentration. Results showed that the highest concentration of nitrogen was obtained from plants that treated with yeast extract at 0.2% (2.91 and 2.93%) but the values were not significant compared with yeast



extract at 0.1 and 0.3% and green tea at 0.2 and 0.3%. Moreover, control treatment gave 2.17 and 2.15% of N concentration in both seasons, respectively. On the other hand, foliar application with yeast solution at 0.2% gave the highest significant percentage of nitrogen (2.93 and 2.98 %) followed by the other treatments of yeast 0.1% and 0.3% and green tea at 0.2 and 0.3% with insignificant differences. However, the control treatment showed lower N concentrations (2.18 and 2.14%) in the two seasons, respectively.

## **2.2. Plant N uptake (g/plant)**

Results in **Table (6)** showed nitrogen uptake (g/plant) as affected by GA<sub>3</sub>, IBA, garlic extract, yeast extract and green tea extract which were used as foliar application or seed tuber soaking. Data showed that foliar spray had significant effect on increasing nitrogen uptake (3.48 and 3.42g) compared with the soaking treatment (3.23 and 3.17g) in both seasons. Also, application of yeast extract at 0.2% was significantly improved nitrogen uptake in both seasons (4.20 and 4.37g) compared with the untreated plants (2.29 and 2.28 g) in the two growing seasons, respectively. On the other side, the interaction among treatments and

foliar or seed tuber soaking application on nitrogen uptake showed significant effects in both seasons. The highest significant percentage of nitrogen uptake was obtained from plants sprayed with yeast 0.2% (4.36 and 4.52g) followed by yeast (0.3 and 0.1%) and green tea extract (0.2 and 0.3%) compared with the control treatment (2.31 and 2.30g) in the two seasons, respectively.

## **2.3. Phosphorus (P) concentration (%/ whole plant).**

Data in **Table (7)** showed that foliar application had significant effect on increasing P % (0.42 and 0.36%) compared with tuber seed tuber soaking treatment (0.38 and 0.35%) in both seasons, respectively. Regarding the effect of used treatments, the highest significant increase in P % was obtained from plants that treated with yeast solution at 0.2% (0.57 and 0.40%) compared with the control treatment (0.33 and 0.31%) in both seasons. The interaction effect showed that foliar spray with yeast solution at 0.2% gave the highest significant P % content in plants (0.59 and 0.43%) while the untreated plants gave 0.33 and 0.31 P % in the two growing seasons, respectively.

Table (3): Effect of seed tuber soaking and plant foliar application with gibberellic acid, Indole-3-butyric acid, garlic, yeast and green tea extracts on weight of seed-sized tuber (45-60 g) ton/ fed. of potato cv. "Burren" grown in two successive summer seasons of 2014 and 2015.

Treatments	The 1 <sup>st</sup> season						The 2 <sup>nd</sup> season					
	Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B		Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B	
Control	9.445	j	9.489	j	9.467	D	8.130	m	8.134	m	8.132	G
GA3 (2.5)ppm	9.883	j	10.545	hi	10.214	C	9.872	jk	9.998	ij	9.935	D
GA3 (5) ppm	11.684	ef	12.152	de	11.918	B	10.281	ghi	10.571	fg	10.426	C
GA3 (10) ppm	11.253	fg	12.553	cd	11.903	B	10.398	gh	10.520	fg	10.459	C
IBA (20) ppm	9.525	j	10.531	hi	10.028	C	8.136	m	8.453	m	8.295	G
IBA(40) ppm	9.587	j	11.016	ghi	10.302	C	9.452	l	9.507	kl	9.480	E
IBA (60) ppm	9.533	j	11.320	fg	10.427	C	9.709	jkl	10.369	ghi	10.039	D
GE (0.1%)	9.540	j	11.102	gh	10.321	C	9.889	jk	10.066	hij	9.978	D
GE (0.2%)	9.533	j	10.493	i	10.013	C	8.137	m	9.427	l	8.782	F
GE (0.3%)	9.497	j	10.522	hi	10.009	C	8.137	m	9.424	l	8.780	F
YE (0.1%)	10.981	ghi	13.319	ab	12.150	B	10.869	f	11.742	e	11.306	B
YE (0.2%)	12.753	c	13.538	a	13.146	A	13.078	cd	13.649	a	13.364	A
YE (0.3%)	12.718	c	13.524	a	13.121	A	13.090	bcd	13.475	ab	13.282	A
GTE (0.1%)	10.883	ghi	12.933	bc	11.908	B	10.600	fg	11.611	e	11.106	B
GTE (0.2%)	12.087	de	13.538	a	12.812	A	12.963	d	13.389	abc	13.176	A
GTE (0.3%)	12.052	de	13.500	a	12.776	A	12.951	d	13.358	abc	13.155	A
Mean A	10.685	B	11.880	A			10.356	B	10.856	A		

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

GA<sub>3</sub> = gibberellic acid, (IBA) Indole-3-butyric acid, GE = garlic extract, YE = yeast extract and GTE= green tea extract

<sup>1</sup>Cut seed tubers were soaked for 10 min before planting.

<sup>2</sup>Potato plants were sprayed at 45 and 60 days after planting.

Table (4): Effect of seed tuber soaking and plant foliar application with gibberellic acid, Indole-3-butyric acid, garlic, yeast and green tea extracts on small &lt;45 g (ton/fed) of potato cv. "Burren" grown in two successive summer seasons of 2014 and 2015.

Treatments	The 1 <sup>st</sup> season						The 2 <sup>nd</sup> season					
	Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B		Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B	
Control	1.071	a	1.060	a	1.065	A	1.027	a	1.027	a	1.027	A
GA3 (2.5)ppm	1.029	ab	0.885	e	0.957	C	1.001	a-e	0.949	c-i	0.975	BC
GA3 (5) ppm	1.026	ab	0.937	de	0.981	BC	0.946	d-i	0.983	a-f	0.965	C
GA3 (10) ppm	1.025	ab	0.931	de	0.978	BC	0.934	fghi	0.985	a-f	0.959	C
IBA (20) ppm	1.017	abc	0.973	bcd	0.995	BC	1.017	ab	1.012	ab	1.015	AB
IBA(40) ppm	1.026	ab	0.935	de	0.981	BC	1.008	a-d	1.010	abc	1.009	AB
IBA (60) ppm	1.026	ab	0.941	de	0.983	BC	0.922	ghi	0.946	e-i	0.934	C
GE (0.1%)	1.025	ab	0.949	cde	0.987	BC	0.920	ghi	0.956	b-i	0.938	C
GE (0.2%)	1.055	a	0.977	bcd	1.016	AB	1.018	ab	1.006	a-e	1.012	AB
GE (0.3%)	1.059	a	0.977	bcd	1.018	AB	1.027	a	1.014	ab	1.020	A
YE (0.1%)	0.970	bcd	0.969	bcd	0.970	BC	0.958	b-h	0.914	hi	0.936	C
YE (0.2%)	0.967	bcd	0.680	g	0.824	D	0.898	hij	0.714	k	0.806	DE
YE (0.3%)	0.968	bcd	0.690	g	0.829	D	0.852	j	0.713	k	0.782	E
GTE (0.1%)	1.004	a-d	0.937	de	0.971	BC	0.977	a-g	0.914	hi	0.945	C
GTE (0.2%)	0.968	bcd	0.745	fg	0.856	D	0.916	ghi	0.730	k	0.823	D
GTE (0.3%)	0.969	bcd	0.773	f	0.871	D	0.895	ij	0.730	k	0.813	DE
Mean A	1.013	A	0.897	B			0.957	A	0.913	B		

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

GA<sub>3</sub> = gibberellic acid, (IBA) Indole-3-butyric acid, GE = garlic extract, YE = yeast extract and GTE= green tea extract

<sup>1</sup>Cut seed tubers were soaked for 10 min before planting.

<sup>2</sup>Potato plants were sprayed at 45 and 60 days after planting.

Table (5): Effect of seed tuber soaking and plant foliar application with gibberellic acid, Indole-3-butyric acid, garlic, yeast and green tea extracts on Nitrogen concentration (%) in whole plant of potato cv. "Burren" grown in two successive summer seasons of 2014 and 2015.

Treatments	The 1 <sup>st</sup> season						The 2 <sup>nd</sup> season					
	Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B		Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B	
Control	2.18	i	2.16	i	2.17	F	2.14	l	2.16	l	2.15	F
GA <sub>3</sub> (2.5)ppm	2.57	f	2.65	def	2.61	DE	2.49	ij	2.64	gh	2.57	CDE
GA <sub>3</sub> (5) ppm	2.72	cde	2.81	abc	2.77	ABC	2.51	ij	2.75	efg	2.63	BCD
GA <sub>3</sub> (10) ppm	2.73	cde	2.77	bc	2.75	BCD	2.61	hi	2.75	efg	2.68	BC
IBA (20) ppm	2.28	ghi	2.37	g	2.32	F	2.22	kl	2.28	k	2.25	F
IBA(40) ppm	2.56	f	2.57	f	2.57	E	2.48	j	2.49	ij	2.49	E
IBA (60) ppm	2.64	ef	2.77	bc	2.71	CDE	2.50	ij	2.51	ij	2.51	DE
GE (0.1%)	2.60	f	2.77	bcd	2.68	CDE	2.50	ij	2.66	fgh	2.58	B-E
GE (0.2%)	2.20	hi	2.31	gh	2.26	F	2.16	l	2.22	kl	2.19	F
GE (0.3%)	2.20	hi	2.31	gh	2.25	F	2.15	l	2.21	kl	2.18	F
YE (0.1%)	2.65	def	2.88	ab	2.77	ABC	2.64	gh	2.77	c-f	2.71	B
YE (0.2%)	2.88	ab	2.93	a	2.91	A	2.88	abcd	2.98	a	2.93	A
YE (0.3%)	2.88	ab	2.93	a	2.91	A	2.88	abc	2.96	ab	2.92	A
GTE (0.1%)	2.65	def	2.84	abc	2.75	BCD	2.60	hij	2.76	def	2.68	BC
GTE (0.2%)	2.85	ab	2.92	a	2.89	AB	2.85	bcde	2.96	ab	2.90	A
GTE (0.3%)	2.86	ab	2.92	a	2.89	AB	2.87	abcde	2.95	ab	2.91	A
Mean A	2.59	B	2.68	A			2.53	B	2.63	A		

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

GA<sub>3</sub> = gibberellic acid, (IBA) Indole-3-butyric acid, GE = garlic extract, YE = yeast extract and GTE= green tea extract

<sup>1</sup>Cut seed tubers were soaked for 10 min before planting.

<sup>2</sup>Potato plants were sprayed at 45 and 60 days after planting.

Table (6): Effect of seed tuber soaking and plant foliar application with gibberellic acid, Indole-3-butyric acid, garlic, yeast and green tea extracts on nitrogen uptake (g/plant) of potato cv. "Burren" grown in two successive summer seasons of 2014 and 2015.

Treatments	The 1 <sup>st</sup> season						The 2 <sup>nd</sup> season					
	Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B		Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B	
Control	2.27	k	2.31	k	2.29	G	2.27	k	2.30	k	2.28	G
GA3 (2.5)ppm	2.94	i	3.12	i	3.03	EF	2.79	ij	3.10	fgh	2.95	DE
GA3 (5) ppm	3.53	fgh	3.79	def	3.66	B	3.19	fg	3.66	cd	3.43	C
GA3 (10) ppm	3.49	gh	3.72	efg	3.60	BC	3.09	fgh	3.68	cd	3.38	C
IBA (20) ppm	2.44	jk	2.63	j	2.54	G	2.38	k	2.53	jk	2.45	F
IBA(40) ppm	2.89	i	2.89	i	2.89	F	2.83	hi	2.78	ij	2.80	E
IBA (60) ppm	3.11	i	3.71	efg	3.41	CD	2.88	hi	3.25	ef	3.07	D
GE (0.1%)	3.06	i	3.37	h	3.21	DE	2.95	ghi	3.18	fg	3.07	D
GE (0.2%)	2.36	k	2.58	jk	2.47	G	2.30	k	2.46	k	2.38	FG
GE (0.3%)	2.36	k	2.56	jk	2.46	G	2.29	k	2.43	k	2.36	FG
YE (0.1%)	3.64	fg	4.04	bcd	3.84	B	3.60	cd	3.83	c	3.72	B
YE (0.2%)	4.04	bcd	4.36	a	4.20	A	4.21	b	4.52	a	4.37	A
YE (0.3%)	4.01	bcd	4.24	ab	4.13	A	4.19	b	4.41	ab	4.30	A
GTE (0.1%)	3.57	fgh	3.94	de	3.76	B	3.49	de	3.79	c	3.64	B
GTE (0.2%)	3.97	cd	4.22	abc	4.09	A	4.16	b	4.40	ab	4.28	A
GTE (0.3%)	3.99	bcd	4.21	abc	4.10	A	4.17	b	4.39	ab	4.28	A
Mean A	3.23	B	3.48	A			3.17	B	3.42	A		

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

GA<sub>3</sub> = gibberellic acid, (IBA) Indole-3-butyric acid, GE = garlic extract, YE = yeast extract and GTE= green tea extract

<sup>1</sup>Cut seed tubers were soaked for 10 min before planting.

<sup>2</sup>Potato plants were sprayed at 45 and 60 days after planting.

Table (7): Effect of seed tuber soaking and plant foliar application with gibberellic acid, Indole-3-butyric acid, garlic, yeast and green tea extracts on phosphorus concentration (%) of potato cv. "Burren" grown in two successive summer seasons of 2014 and 2015.

Treatments	The 1 <sup>st</sup> season						The 2 <sup>nd</sup> season					
	Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B		Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B	
Control	0.32	j	0.33	j	0.33	I	0.30	l	0.31	l	0.31	H
GA3 (2.5)ppm	0.33	ij	0.35	fgh	0.34	GH	0.34	d-g	0.32	jkl	0.33	EFG
GA3 (5) ppm	0.37	f	0.40	e	0.38	D	0.34	d-h	0.35	de	0.35	BCD
GA3 (10) ppm	0.36	fg	0.40	e	0.38	D	0.35	de	0.35	def	0.35	B
IBA (20) ppm	0.33	ij	0.34	g-j	0.34	GHI	0.32	jkl	0.33	g-k	0.32	FG
IBA(40) ppm	0.33	ij	0.36	fg	0.34	GH	0.35	def	0.32	i-l	0.34	DEF
IBA (60) ppm	0.35	ghi	0.37	f	0.36	EF	0.34	d-g	0.33	f-j	0.34	CDE
GE (0.1%)	0.34	g-j	0.36	fg	0.35	FG	0.34	e-i	0.33	f-j	0.34	DEF
GE (0.2%)	0.33	ij	0.34	g-j	0.34	HI	0.31	kl	0.32	h-l	0.32	GH
GE (0.3%)	0.33	ij	0.34	hij	0.34	HI	0.31	kl	0.32	h-l	0.32	GH
YE (0.1%)	0.35	ghi	0.40	e	0.37	D	0.35	def	0.36	cd	0.35	B
YE (0.2%)	0.54	b	0.59	a	0.57	A	0.38	b	0.43	a	0.40	A
YE (0.3%)	0.53	b	0.58	a	0.55	B	0.38	b	0.42	a	0.40	A
GTE (0.1%)	0.35	ghi	0.39	e	0.37	DE	0.34	d-h	0.36	cd	0.35	BC
GTE (0.2%)	0.51	c	0.59	a	0.55	B	0.37	bc	0.42	a	0.40	A
GTE (0.3%)	0.47	d	0.58	a	0.52	C	0.37	bc	0.42	a	0.40	A
Mean A	0.38	B	0.42	A			0.34	B	0.36	A		

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

GA<sub>3</sub> = gibberellic acid, (IBA) Indole-3-butyric acid, GE = garlic extract, YE = yeast extract and GTE= green tea extract

<sup>1</sup>Cut seed tubers were soaked for 10 min before planting.

<sup>2</sup>Potato plants were sprayed at 45 and 60 days after planting.

Table (8): Effect of seed tuber soaking and plant foliar application with gibberellic acid, Indole-3-butyric acid, garlic, yeast and green tea extracts on phosphorus uptake (g/plant) of potato cv. "Burren" grown in two successive summer seasons of 2014 and 2015.

Treatments	The 1 <sup>st</sup> season						The 2 <sup>nd</sup> season					
	Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B		Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B	
Control	0.33	k	0.35	k	0.34	H	0.32	l	0.33	l	0.33	F
GA3 (2.5)ppm	0.38	ijk	0.41	g-j	0.40	FG	0.39	g-l	0.38	g-l	0.38	DE
GA3 (5) ppm	0.48	f	0.53	de	0.51	D	0.43	d-g	0.47	de	0.45	BC
GA3 (10) ppm	0.46	fgh	0.54	de	0.50	D	0.42	e-h	0.47	de	0.45	BC
IBA (20) ppm	0.36	jk	0.38	ijk	0.37	GH	0.34	i-l	0.37	h-l	0.35	EF
IBA(40) ppm	0.37	jk	0.40	h-k	0.39	FGH	0.40	f-i	0.36	h-l	0.38	DE
IBA (60) ppm	0.41	h-k	0.49	ef	0.45	E	0.39	g-k	0.43	d-g	0.41	CD
GE (0.1%)	0.40	h-k	0.44	f-i	0.42	EF	0.40	f-j	0.40	f-i	0.40	D
GE (0.2%)	0.35	jk	0.38	ijk	0.37	GH	0.34	jkl	0.36	h-l	0.35	EF
GE (0.3%)	0.36	jk	0.37	jk	0.37	GH	0.33	kl	0.36	i-l	0.35	EF
YE (0.1%)	0.48	f	0.56	d	0.52	D	0.48	de	0.49	cd	0.49	B
YE (0.2%)	0.76	b	0.89	a	0.82	A	0.55	b	0.65	a	0.60	A
YE (0.3%)	0.73	b	0.84	a	0.79	AB	0.56	b	0.63	a	0.60	A
GTE (0.1%)	0.47	fg	0.55	de	0.51	D	0.46	def	0.49	cd	0.48	B
GTE (0.2%)	0.70	bc	0.85	a	0.78	BC	0.55	bc	0.62	a	0.59	A
GTE (0.3%)	0.66	c	0.83	a	0.75	C	0.54	bc	0.62	a	0.58	A
Mean A	0.48	B	0.55	A			0.43	B	0.47	A		

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

GA<sub>3</sub> = gibberellic acid, (IBA) Indole-3-butyric acid, GE = garlic extract, YE = yeast extract and GTE= green tea extract

<sup>1</sup>Cut seed tubers were soaked for 10 min before planting.

<sup>2</sup>Potato plants were sprayed at 45 and 60 days after planting.

Table (9): Effect of seed tuber soaking and plant foliar application with gibberellic acid, Indole-3-butyric acid, garlic, yeast and green tea extracts on potassium content (%) of potato cv. "Burren" grown in two successive summer seasons of 2014 and 2015.

Treatments	The 1 <sup>st</sup> season						The 2 <sup>nd</sup> season					
	Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B		Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B	
Control	3.10	m	3.13	m	3.12	H	3.04	m	3.06	m	3.05	H
GA3 (2.5)ppm	3.17	ij	3.18	hi	3.18	F	3.16	l	3.29	fgh	3.23	DEF
GA3 (5) ppm	3.25	f	3.30	e	3.28	C	3.29	fgh	3.37	cde	3.33	B
GA3 (10) ppm	3.25	f	3.31	e	3.28	C	3.25	g-k	3.37	cde	3.31	BC
IBA (20) ppm	3.14	lm	3.14	lm	3.14	GH	3.10	m	3.19	kl	3.15	G
IBA(40) ppm	3.16	ijk	3.17	ij	3.17	F	3.22	i-l	3.22	jkl	3.22	EF
IBA (60) ppm	3.21	g	3.27	f	3.24	D	3.23	h-k	3.27	f-j	3.25	CDE
GE (0.1%)	3.19	gh	3.20	g	3.20	E	3.20	kl	3.31	ef	3.26	B-E
GE (0.2%)	3.14	m	3.16	jkl	3.15	G	3.09	m	3.24	h-k	3.16	FG
GE (0.3%)	3.14	m	3.15	klm	3.14	GH	3.08	m	3.24	h-k	3.16	FG
YE (0.1%)	3.35	d	3.47	b	3.41	B	3.28	f-i	3.32	def	3.30	BCD
YE (0.2%)	3.40	c	3.51	a	3.46	A	3.47	b	3.55	a	3.51	A
YE (0.3%)	3.39	c	3.51	a	3.45	A	3.39	c	3.54	a	3.47	A
GTE (0.1%)	3.34	d	3.46	b	3.40	B	3.27	f-j	3.31	fg	3.29	B-E
GTE (0.2%)	3.39	c	3.49	a	3.44	A	3.37	cd	3.54	a	3.46	A
GTE (0.3%)	3.38	c	3.50	a	3.44	A	3.37	cde	3.53	a	3.45	A
Mean A	3.25	B	3.31	A			3.24	B	3.33	A		

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

GA<sub>3</sub> = gibberellic acid, (IBA) Indole-3-butyric acid, GE = garlic extract, YE = yeast extract and GTE= green tea extract

<sup>1</sup>Cut seed tubers were soaked for 10 min before planting.

<sup>2</sup>Potato plants were sprayed at 45 and 60 days after planting.



Table (10): Effect of seed tuber soaking and plant foliar application with gibberellic acid, Indole-3-butyric acid, garlic, yeast and green tea extracts on potassium uptake (g/plant) of potato cv. “Burren” grown in two successive summer seasons of 2014 and 2015.

Treatments	The 1 <sup>st</sup> season						The 2 <sup>nd</sup> season					
	Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B		Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B	
Control	3.23	j	3.35	j	3.29	G	3.22	k	3.25	k	3.24	I
GA3 (2.5)ppm	3.63	hij	3.74	hij	3.68	EF	3.54	h-k	3.88	gh	3.71	FG
GA3 (5) ppm	4.22	efg	4.44	c-f	4.33	C	4.19	ef	4.47	cde	4.33	CD
GA3 (10) ppm	4.16	fg	4.43	c-f	4.30	C	3.85	ghi	4.50	cde	4.18	D
IBA (20) ppm	3.37	ij	3.49	hij	3.43	G	3.31	jk	3.53	ijk	3.42	HI
IBA(40) ppm	3.57	hij	3.57	hij	3.57	FG	3.67	ghi	3.60	hij	3.64	G
IBA (60) ppm	3.78	hi	4.37	def	4.07	D	3.71	ghi	4.24	def	3.97	E
GE (0.1%)	3.76	hij	3.89	gh	3.83	E	3.78	ghi	3.96	fg	3.87	EF
GE (0.2%)	3.37	ij	3.54	hij	3.45	FG	3.29	jk	3.59	h-k	3.44	H
GE (0.3%)	3.37	ij	3.50	hij	3.43	G	3.28	jk	3.56	h-k	3.42	HI
YE (0.1%)	4.60	cde	4.53	c-f	4.57	B	4.47	cde	4.59	c	4.53	B
YE (0.2%)	4.76	bcd	5.23	a	4.99	A	5.07	ab	5.40	a	5.24	A
YE (0.3%)	5.06	ab	5.09	ab	5.07	A	4.93	b	5.27	a	5.10	A
GTE (0.1%)	4.50	c-f	4.81	bc	4.66	B	4.39	cde	4.53	cd	4.46	BC
GTE (0.2%)	4.71	bcd	5.04	ab	4.88	A	4.92	b	5.26	a	5.09	A
GTE (0.3%)	4.73	bcd	5.06	ab	4.89	A	4.90	b	5.25	a	5.08	A
Mean A	4.06	B	4.26	A			4.03	B	4.31	A		

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

GA<sub>3</sub> = gibberellic acid, (IBA) Indole-3-butyric acid, GE = garlic extract, YE = yeast extract and GTE= green tea extract

<sup>1</sup>Cut seed tubers were soaked for 10 min before planting.

<sup>2</sup>Potato plants were sprayed at 45 and 60 days after planting.

Table (11): Effect of seed tuber soaking and plant foliar application with gibberellic acid, Indole-3-butyric acid, garlic, yeast and green tea extracts on protein content of potato cv. "Burren" grown in two successive summer seasons of 2014 and 2015.

Treatments	The 1 <sup>st</sup> season						The 2 <sup>nd</sup> season					
	Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B		Seed tuber soaking <sup>1</sup>		Foliar application <sup>2</sup>		Mean of B	
Control	13.65	j	13.65	j	13.65	G	13.42	l	13.35	l	13.39	F
GA3 (2.5)ppm	16.09	g	16.56	d-g	16.33	DE	15.56	ij	16.50	g	16.03	CDE
GA3 (5) ppm	16.98	c-f	17.58	abc	17.28	ABC	15.69	hij	17.21	ef	16.45	BCD
GA3 (10) ppm	17.04	cde	17.33	bcd	17.19	BCD	16.31	gh	17.21	ef	16.76	BC
IBA (20) ppm	14.25	hij	14.79	h	14.52	F	13.86	kl	14.27	k	14.07	F
IBA(40) ppm	16.02	g	16.08	g	16.05	E	15.50	j	15.56	ij	15.53	E
IBA (60) ppm	16.50	efg	17.33	bcd	16.92	CDE	15.65	hij	15.69	hij	15.67	DE
GE (0.1%)	16.23	fg	17.29	bcd	16.76	CDE	15.63	hij	16.61	fg	16.12	B-E
GE (0.2%)	13.77	ij	14.42	hi	14.10	FG	13.48	l	13.90	kl	13.69	F
GE (0.3%)	13.73	ij	14.44	hi	14.09	FG	13.46	l	13.81	kl	13.64	F
YE (0.1%)	16.59	d-g	17.98	ab	17.28	ABC	16.50	g	17.31	c-f	16.91	B
YE (0.2%)	18.02	ab	18.29	a	18.16	A	18.00	abc	18.61	a	18.30	A
YE (0.3%)	18.00	ab	18.31	a	18.16	A	18.02	abc	18.48	ab	18.25	A
GTE (0.1%)	16.58	d-g	17.73	abc	17.16	BCD	16.25	ghi	17.27	def	16.76	BC
GTE (0.2%)	17.83	ab	18.25	a	18.04	AB	17.79	b-e	18.50	ab	18.15	A
GTE (0.3%)	17.85	ab	18.23	a	18.04	AB	17.94	a-d	18.46	ab	18.20	A
Mean A	16.20	B	16.77	A			15.82	B	16.42	A		

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

GA<sub>3</sub> = gibberellic acid, (IBA) Indole-3-butyric acid, GE = garlic extract, YE = yeast extract and GTE= green tea extract

<sup>1</sup>Cut seed tubers were soaked for 10 min before planting.

<sup>2</sup>Potato plants were sprayed at 45 and 60 days after planting.

#### **2.4. Plant P uptake (g/plant)**

Data shown in **Table (8)** indicated that the foliar spray application accelerated the phosphorus uptake to 0.55 and 0.47g/plant compared with tuber soaking 0.48 and 0.43g/plant in the two growing seasons, respectively. On the same time, yeast extract at 0.2% was the best among the other studied treatments (0.82 and 0.60 g) in both seasons. Meanwhile, the highest significant uptake of phosphorus was obtained from plants received foliar yeast solution at 0.2% (0.89 and 0.65 g/plant) followed by yeast (0.3 and 0.1%) and green tea solution (0.2 and 0.3%) while, control treatment gave 0.35 and 0.33 g/plant in the two growing seasons, respectively.

#### **2.5. Potassium (K) content (% / whole plant).**

Recorded data in **Table (9)** showed that foliar application had significant effect on increasing K content (3.31 and 3.33 %) compared with the seed tuber soaking application (3.25 and 3.24%) in the two growing seasons, respectively. Also, the highest significant increase in K content was obtained from plants that treated with yeast extract 0.2% (3.46 and 3.51 %) compared with the control treatment (3.12 and 3.05%) in both seasons. Regarding the interaction response, The highest significant K content was obtained from plants received foliar spray with yeast solution 0.2% (3.51 and 3.55 %) followed by yeast (0.3 and 0.1%) and green tea extract (0.2 and 0.3%) while, K

content in control plants was (3.13 and 3.06 %) in the two growing seasons, respectively.

#### **2.6. Plant K Uptake (g/plant)**

Results shown in **Table (10)** indicated that K uptake was significantly affected by GA<sub>3</sub>, IBA, garlic, yeast and green tea extracts and methods of application. Data revealed that foliar application was the best method of application and significantly increased K uptake (4.26 and 4.31g) compared with soaking application (4.06 and 4.03 g). On the same time, yeast with all used three levels of concentrations gave the highest K uptake, especially, yeast solution at 0.2% (4.99 and 5.24 g). Again, the highest significant of K uptake was obtained from plants treated with yeast at 0.2% as foliar spray (5.23 and 5.40 g) followed by the other levels of yeast (0.3 and 0.1%) and green tea (0.2 and 0.3%) treatments compared with the control plants (3.35 and 3.25 g) in the two growing seasons, respectively.

#### **2.7. Protein content (g/plant dry weight)**

Data in **Table (11)** illustrate that protein content was affected by GA<sub>3</sub>, IBA, garlic, yeast and green tea extracts. Obtained results showed that foliar application significantly increased the protein content in both seasons (16.77 and 16.42g/plant) compared with the seed tuber soaking application (16.20 and 15.82 g/plant). Regarding the effect of treatments, still yeast had the highest significant protein content

specially, plants that treated with at 0.2% (18.16 and 18.30 g/plant) compared with the control treatment (13.65 and 13.39 g/plant) in both seasons, respectively. Meanwhile, the interaction effects showed that the highest significant values of protein content were obtained from plants received yeast 0.3% (18.31g/plant) in the first season and yeast 0.2% (18.61g/plant) in the second season compared with control treatment (13.65 and 13.35 g/plant) in the two seasons, respectively.

## DISCUSSION

Results declared that potato plants; "Burren cv." were affected by the applied treatments and the foliar one was more effective comparing to soaking potato seed tubers in the studied treatments.

In present study, greater effectiveness from adding yeast extract increased yield, yield components and chemical composition. This stimulated effect may be due to the role of cytokinins, amino acids, mineral elements, carbohydrates, reducing sugars, enzymes and vitamins B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub>, B<sub>12</sub> (Castelfranco and Beale 1983; Spencer *et al.*, 1983; Fathy and Farid, 1996 and Khedr and Farid, 2000). Furthermore, yeast as a natural source of cytokinins-stimulates division and enlargement of cells as well as the synthesis of protein, nucleic acids and chlorophylls (Kraig and Haber, 1980, Spencer *et al.*, 1983, Castelfranco and Beale 1983, Fathy and Farid, 1996 and Ahmed *et al.*, 2011). In our study, foliar

application of yeast extract has resulted in significant increases in potato yield, NPK and protein contents. Other scientists e.g., Ahmed *et al.* (2011) reported that increasing of foliar application of active yeast extract stimulated the yield of potato. These results also supported the fact that; the use of dry yeast extract as a foliar spray leads to enhancing plant growth which causes significant increases in tubers weight per plant and total tubers yield of potato.

From the results it could be concluded that the treatment with green tea has increased the studied yield parameters and chemical composition. This may be due to its contain of about 30-40 % polyphenols (as dry weight), and the average cup of green tea contains 50 to 150 mg of polyphenols (Tyler *et al.*, 1988). Furthermore, (Grohor, 1992) found that the compounds of green tea include an unusual amino acid (called theanine). And also contains caffeine, tannins, lignin, organic acids, protein, sugars, chlorophyll, volatile oils, vitamins, and minerals. But the primary constituents of interest are the polyphenols, particularly the catechin called epigallocatechin gallate (EGCG). The polyphenols are believed to be responsible for most of green tea roles in promoting human good health. Also, (Stoner and Mukhtar, 1995) mentioned that green tea polyphenols have been shown to stimulate the production of several immune system cells and have typical antibacterial properties.

Moreover, (Higdon and Frei, 2003) found that tea catechins and polyphenols are effective scavengers of reactive oxygen species *in vitro* and may also function indirectly and as antioxidants through their effects on transcription factors and enzyme activities.

The enhancing effect of applying GA<sub>3</sub> due to its responsible for stimulating the production of mRNA molecules in the cells, which in turn improves the chances of fast growth (Richards et al., 2001; Olszewki and Gubler 2002; Emongor, 2007). That's why the characteristics growth of potato plants in our experiment were significantly affected by GA<sub>3</sub> application. Supporting that, Rehman et al. (2001) stated that treating potato tubers with gibberellic acid produced high numbers of tubers. Also, Birbal et al. (2005) mentioned that GA<sub>3</sub> gave significantly higher numbers and weights of tubers sizes up to 22.1% and 18%, respectively.

Several attempts were made to understand the role of IBA in the rooting process in plants at the metabolic level (Hartmann et al., 1990). This synthetic hormone is commonly used to promote root development in asexual propagation of plants and is widely used as a root-initiation promoter in agriculture (Waisel et al., 1991). Also (Bhatia et al., 1992; Ertürk et al., 2008; Waheed et al., 2010) reported that application of IBA was superior over other plant growth regulators.

Garlic is rich in antioxidant phytochemicals that include organo sulfur compounds as well as flavonoids such as allixin, which is capable of scavenging free radicals and its extract has a positive effect in yield and defence against pests and diseases (Nishion et al., 1990; Helmy, 1992; Ahmed et al., 2005; El-Shayeb, 2009).

## CONCLUSION

Results of this study are very promising as most of the used treatments enhanced potato plants to produce tubers with good qualities and suitable for marketing medium or seed or large tubers as table types along with decreasing the percentage of unmarketable (small) tubers. The used substances especially with the foliar application treatment also increased tubers content of NPK and protein within the acceptable ranges for good feeding. From these results we are encouraged to ask potato farmers to use natural extracts in producing potato.

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تأثير بعض منظمات النمو والمستخلصات الطبيعية علي إنتاج وجودة محصول البطاطس

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أجريت هذه الدراسة في مزرعة خاصة بقرية إبان مركز مطاي محافظة المنيا بهدف دراسة تأثير بعض منظمات النمو مثل الجبرلين ، إندول حامض البيوترك والمستخلصات الطبيعية مثل مستخلص الثوم ، مستخلص الخميرة والشاي الأخضر علي محصول البطاطس صنف برن cv. "Burren" وهو أحد أصناف الاستهلاك الطازج حيث تمت الزراعة في العروة الصيفي في 10، 15 يناير من موسمي الدراسة 2014 ، 2015 وكانت المعاملات المستخدمة في التجربة هي: معاملة المقارنة (ماء مقطر) ، الجبرلين في ثلاث مستويات ( 2.5 ، 5 ، 10 جزء في المليون) ، إندول حامض البيوترك في ثلاث مستويات ( 20 ، 40 ، 60 جزء في المليون) ، مستخلص الثوم ، مستخلص الخميرة ، مستخلص الشاي الأخضر في ثلاث مستويات ( 0.1 ، 0.2 ، 0.3 %) تم استخدام المعاملات السابقة بصورة منفردة إما رشاً ورقياً عند عمر 45 و60 يوم من الزراعة أو عن طريق نفع الدرنات قبل الزراعة لمدة 10 دقائق.

وقد أظهرت النتائج أن معاملات الخميرة والشاي الأخضر بصفة عامة أدت إلي زيادة معنوية في المحصول كما زادت محتوى الدرنات من النيتروجين والفسفور والبوتاسيوم وقد كان لاستخدام معظم المعاملات رشاً علي النبات تأثيراً إيجابياً في الإنتاجية ومحتوي العناصر. وتعتبر هذه المعاملات ذات تأثير واعد بالنسبة لمزارعي البطاطس تحت نفس ظروف التجربة.