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Potato Growth and Yield Attributes as Affected by Boron and Selenium Foliar Application

Alkharpotly, A.[1]; A. Roshdy[2] and E. Mady[3]
[1]Horticulture Department, The Faculty of Agriculture and Natural Resources, Aswan University, Aswan, Egypt
[2]Horticulture Department, The Faculty of Agriculture, Damanhour University, Damanhour, Egypt
[3]Horticulture Department, The Faculty of Agriculture, Al-Azhar University, Nasr City, Cairo, Egypt
[*]Corresponding author: alkharpotly@agr.aswu.edu.eg

ABSTRACT

Enhancing potato growth and yield attributes *via* both Boron (Br) and Selenium (Se) is a great potential nowadays. Therefore, the present investigation was done to study the effe ct of Boron and Selenium singly or in combination as foliar application on plant growth, yield and quality of two potato cultivars 'Lady Rosetta and Caruso' during both seasons of 2016/2017 and 2017/2018. The experimental layout was split plots system in a randomized complete blocks design with three replications. Cultivars were arranged as the main plots and concentrations of Boron and Selenium singly or in combination were assigned as sub-plots. Boron was sprayed in three concentrations 0, 50, and 100 mg/l whereas Selenium was used at 0, 5, and 10 mg/l concentrations twice at 55 and 70 days after planting. The study indicated that plant growth and yield of potato plants were significantly enhanced by Boron and Selenium treatments. Plant height, tuber dry weight, number of tubers/plant, tuber yield/plant, tuber yield/feddan, tuber TSS %, ascorbic acid, tubers sugars (i.e. starch, reducing, non-reducing and total sugars), leaf total chlorophyll, leaf and tubers contents of N, P, K, Br and Se of both potato cultivars ' Lady Rosetta and Caruso' were significantly enhanced by Boron (100 mg/l) combined with Selenium (5 mg/l) foliar application at 55 and 70 days after planting during both seasons of the study.

Keywords: *Solanum tuberosum*, Boron, selenium, foliar application, growth and yield, tuber quality.

INTRODUCTION

Potato (*Solanum tuberosum* L.) belongs to the family Solanaceae is an important vegetable crop prevailing across the world with large scale production, consumption, and affordability with easy market availability. It is one of the most financially rewarding and profitable crops for the farmers due to its higher yield potential within a short time span (Sati *et al*., 2017). Egypt is one of the fresh potato exporters worldwide and produced 4,611,000 tons in 2014 (Agriculture and Agri-Food Canada, 2017). Potato is used as vegetable, stock feed, and in industries for manufacturing starch, alcoholic beverages, and other processed products. The wide flexibility in planting and harvesting dates makes potato most suitable for intensive cropping system. As a short duration crop, potato is highly responsive to high inputs and capable of producing high yield under wide range of climatic and soil conditions.

Boron (Br) plays an important role in cell wall synthesis, cell division, cell development, auxin metabolism, good pollination and fruit set, seed development, sugar transport, synthesis of amino acids and proteins, nodule formation in legumes and regulation of carbohydrate metabolism (Jafari-Jood *et al*., 2013). In the case of root crops such as potato and sugar beet where translocation of photosynthates from source to sink is needed for a longer period, a steady and prolonged supply of Boron throughout their growing period may be necessary (Sarkar *et al.*, 2007). Recently, it was suggested that Boron might improve the overall quality of fresh and minimally processed potato (Ierna *et al*., 2017; Sarkar *et al.*, 2018; Singh *et al.*, 2018). El-Banna and Abd El-Salam (2005) showed that treated potato plants with different foliar spraying rates of Br (50 and 75 ppm) or/plus molybdenum (25 and 50 ppm) twice at 60 and 75 days after planting. They reported that foliar spraying of potato plants with Br at 75 ppm + Mo at 50 ppm) significantly increased plant height, number of stems/plant, leaf area, number of tuber/plant, fresh weight of vegetative growth, total tuber yield, dry matter %, recorded the highest concentrations of N, K and Br in plants. Also, El-Dissoky and Abdel-Kadar (2013) reported that that foliar spray of Br levels up to 60 mg/l, significantly, affected potato growth parameters (i.e. plant height, No. of leaves/plant, fresh weight of plant, dry weight of plant and leaf area). Also, total tuber yield, dry shoot yield and average weight of tubers, significantly, increased by Br foliar application. Quality of potato tuber parameters (i.e. dry matter, protein and starch percentage) significantly increased with foliar Br application, also the uptake of N, P, and K significantly increased by foliar Br application. Potato variety 'Valor' appeared superiority in plant growth, total tuber yield, dry shoot yield and total NPK uptake compare to 'Spunta' variety. However, the increment of P uptake, Br concentration, tuber dry matter %, protein % and starch % was not significant. Jafari-Jood *et al*. (2013) illustrated that spraying of boron significantly improved growth parameters of potato plants (plant height, leaves per plant and shoot weight) as compared with control, furthermore combined application of boron and manganese improved the growth trails of potato plants more than which recorded by single application of boron or manganese.

Selenium (Se) is an essential trace element for many organisms and has an affect on plant, human, and animal health. However, it has not been demonstrated to be required by higher plants (Li *et al*., 2008; Fairweather-Tait *et al*., 2011; Chilimba *et al*., 2012). The Se in humans is mainly derived from diets. Nevertheless, Se deficiency in soils is overall distributed around the world (Cartes *et al*., 2011), which directly affects plant Se contents. Hence, increasing Se content in crops and vegetables to overcame or control deficiency in human diets and its threating human health risks (Schrauzer and Meginness, 1978). In recent years, some reports were published about increasing Se content in crops and vegetables to meet people's demand for selenium (Chilimba *et al*., 2012; Ducsay and Ložek, 2006; Xia *et al*., 2012). Researchers have identified that appropriate Selenium supply could not only increase Se content in plants but also promote growth and development and increase resistance and antioxidant capacity of plants exposed to abiotic stressful environment, such as drought, salt, ultraviolet, and cold stresses (Hartikainen and Xue, 1999; Djanaguiraman *et al*., 2005; Kong *et al*., 2005; Hawrylak-Nowak *et al*., 2010; Chu *et al*; 2010; Yao *et al*., 2010). The main reason is that Se is an essential component of several proteins such as the antioxidant enzyme glutathione peroxidase (GSH-Px), which can effectively remove oxygen free radicals (Hartikainen *et al*., 2000; Ríos *et al*., 2009). Supplementation of fertilizers with Se stimulates the plant yield (Hartikainen, 2005). Yassen *et al.* (2011) demonstrated that Selenium foliar application at 20 and 40 g/fed. promoted plant growth, tuber yield and quality over the control treatments.

This study was conducted to investigate the effect of foliar application with Boron and Selenium on growth, yield and quality of two processing potato cultivars 'Lady Rosetta and Caruso'.

MATERIALS AND METHODS

1. Experimental sites and arrangement:

Two field experiments were done during the winter potato growing seasons of 2016/2017 and 2017/2018 in the farm of Chipsy Egypt Co. for Food Industries at the Nubaria region - the east of 71 Km, Alex - Cairo Desert Road, Beheira Governorate, Egypt. Before planting, random soil samples of 0- 30 cm depth from different places of the planting field were collected and analyzed for some important chemical and physical properties as given in Table (1) according to Wilde *et al*., 1985.

2. Potato cultivation

Locally produced certified potato seed tubers of 'Lady Rosetta and Caruso' cultivars were tested. Planting took place on October 1st of both seasons in a wet soil using whole seed tubers.

3. The experimental treatments and design

Treatments consisted of two factors i.e. two potato cultivars (Lady Rosetta and Caruso) and three Boron concentrations i.e. control, 50, and 100 mg/l with three concentrations of selenium i.e. control, 5, and 10 mg/l singly or in combinations as a foliar application. Control plants were sprayed with distilled water. Boron was applied as boric acid and Selenium as sodium selenite (Na_2SeO_3) and were purchased from El-Gomhouria Co. for Trading Chemicals and Medical Appliances, Alexandria, Egypt. The experimental layout was split plots system in a randomized complete blocks design with three replications. Cultivars were arranged as the main plots and Boron; Selenium concentration were assigned as sub-plots. Each sub plot consisted of two ridges; each ridge was 12.00 m length and 0.80 m widthand 0.25 m between plants at the same row. The area of the smallest experimental unit was 19.20 square meters. Potato plants were sprayed with the assigned treatments twice during the growing seasons at 55 days after planting and after 70 days after plantation. The recommended agricultural practices for commercial production were followed. Harvesting was accomplished after 120 days of planting during both years.

Table 1. Some physical and chemical properties of the experimental site during both seasons of the experimentation (2016/2017 and 2017/2018).

Soil properties	Season 2016/2017	Season 2017/2018
Mechanical Analysis:		
Clay (%)	11.28	11.30
Silt (%)	18.00	17.70
Sand (%)	70.72	71.00
Textural class	Sandy loam	Sandy loam
Chemical analysis:		
pH (1:2 soil suspension)	7.60	7.70
EC at 25° C (dS/m)	3.70	3.60
Soluble cations in (1:5) soil: water extract (meq/l)		
Ca^{++}	3.40	3.50
Mg^{++}	7.82	7.75
K^{+}	0.96	0.95
Na^{+}	22.47	20.80
Soluble anions in (1:5) soil: water extract (meq/l)		
HCO_3^-	14.00	14.10
Cl^-	19.70	18.10
SO_4^{--}	0.68	0.80
$CaCO_3$	9.40	9.30
Organic matter (O.M.)	2.86	2.80
Available N (mg/kg soil)	82.60	83.20
Available P (mg/kg soil)	7.85	7.36
Available K (mg/kg soil)	157	160
Boron (mg/kg soil)	1.66	1.94
Selenium (mg/kg soil)	0.24	0.27

-The physical and chemical analyses were carried out at Soil and Agricultural Chemistry Departement, The Faculty of Agricultur (Saba Basha), Alexanderia University, Egypt.

4. Experimental data collections

Ten plants from each treatment in each replication were randomly selected and tagged for records on growth and total yield as well tuber quality parameters.

1. Vegetative growth:

Number of main stems per hill was determined after 85 days of planting, using the average number of main branches of 10 plants. Plant height (cm) was recorded in centimeter units, from the base to the terminal growing point of tagged plants after 85 days from planting date using a meter scale.

2. Yield and its component measurements:

Number of tubers per plant was determined just after harvesting time (120 days of planting) using the average number of tubers of 10 plants.

Average tuber fresh weight (g) was determined immediately after harvesting, by dividing the weight of tuber by tuber number of 10 plants.

Tuber dry weight random tuber samples of 100 g of fresh weight were dried in an electrical oven at 70˚C till the constant weight, then the obtained value of tuber dry weight was calculated in (g/plant).

Average tuber yield per plant (g) was calculated using the average tuber weight of 10 plants.

Total tuber yield per feddan (ton): was calculated by weighting the yield of the plot, then converted into tons per feddan.

3. Tuber quality:

Specific gravity was determined using the method described by Dinesh *et al*. (2005):

$$\text{Specific gravity} = \frac{\text{weight of tuber in air}}{\text{weigh of tuber in air} - \text{weight of tuber under water}}$$

Total soluble solids content (TSS %) was estimated in the juice of the fresh tubers using a hand refractometer according to AOAC (1992). Ascorbic acid content (mg/l00g f.w.) was determined by the procedure given by Krik and Sawyer (1991). Starch, reducing, non-reducing and total sugars (% d.w.) were determined for each tuber sample according to the method described by Malik and Singh (1980).

4. Plant chemical composition:

Total leaf chlorophyll content (mg/100g f.w.) was determined in the fourth top leaf (75 days after planting) according to the method of Moran and Porath (1980).

Leaves and tubers' Br, Se, N, P, and K contents were determined as follows: leaves chemical contents were determined at 85 days after planting in the fourth top leaves of 10 random plants per plot, meanwhile tuber chemical composition was determined at harvesting period (120 days of planting). The collected samples were washed with tap water, followed by distilled water, then located in the oven to dry at 85^{o} C to constant weight, thereafter ground in a mill and stored for the elemental analysis. Powder of plant materials were wet digested with H_2SO_4 -H_2O_2 digest (Lowther, 1980) for the following determinations. The Boron concentration was determined colorimetric by Azomethine-H method at spectrophotometer at wave length 420 nm (Wolf, 1971). The concentrations of Se were analyzed by electrothermal atomic absorption spectrometery, Perkin elmer Model 5100 as described by Kumpulainen *et al.* (1983). The N content was determined colorimetrically according to Chapman and Pratt (1978). The P content was determined in digested samples colorimetrically as described by Singh *et al*. (2005). The K content was measured using flame photometer method of Jackson (1973).

5. Statistical Analysis :

All obtained data of the present study were statistically analyzed according to the design used by the MSTAT-C computer software program (Bricker, 1991) and were tested by analysis of variance. The Duncan s multiple range test at 0.05 level of probability was used to compare the differences among the means of the various treatment combinations as illustrated by Duncan (1955) and Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Vegetative growth

As for the main effect of potato cultivars, average values listed in Table (2) indicated that insignificant differences in no. of stems/hill and plant height were noted between the two studied potato cultivars, Lady Rosetta and Caruso, during both seasons.

In terms of the main effect of foliar application with Boron and Selenium the postulated results showed clearly that applied various concentrations exhibit insignificant ($p \leq 0.05$) effect on no. stem/hill during both seasons. Nevertheless, plant height trait affected significantly due to foliar application of Br and Se, especially at 100 mg/l Br plus 5 mg/l Se, where recorded the highest average values, i.e., the tallest plants compare to the control which recorded the shortest one. The other treatments achieved an intermediate average value. The obtained results are in parallel, more or less, with those recorded by Bari *et al*. (2001), Boghdady *et al*. (2017), Muthanna *et al*. (2017) and Shedeed *et al*. (2018). Plant height increment could be accounted for the mode of action of Br and Se physiological promotive effects which enhance plant photosynthetic activity and concomitant vigour plant growth (Nowak *et al*., 2010; Chu *et al*; 2010; Yao *et al*., 2010). Also, Br roles in cell wall synthesis, cell division, cell development, auxin metabolism (Jafari-Jood *et al*. (2013). Also, the results showed that potato plant height decreased when Se concentration increased up to 10 mg/l plus 100 mg/l Br. This finding is in agreement with Barbara Hawrylak-Nowak (2008) who revealed that disturbances of growth and reduction of plant's biomass at the presence of high selenium concentrations in the nutrient solution may have resulted from the disturbance of mineral balance of plants.

Concerning the interaction effects, the obtained results showed that the highest plants' average values were due to the combination of Br at 100 mg/l + Se at 5 mg/l for both cultivars, while no differences were noted for the interaction effect of the studied treatments regarding no. of stems/hill, generally.

Yield characteristics

Pertaining the main effect of cultivars, the gained results tabulated in Table (3) illustrated that during both growing seasons, 'Caruso' cultivar produced more tubers/plant, yield/plant, and yield/feddan. Whereas, 'Lady Rosetta' cv., produced the heaviest tuber fresh weight (g) and tuber dry weight (g/plant).

These differences between varieties may be return to genotypic effect of the given variety and characteristics of all variety and elements requirements of all variety that appear these differences.

In relation to the main effect of Boron and Selenium application, the given results declared, generally, that the combination of 100 mg/l Br plus 5 mg/l Se produced the highest significant values for number of tubers/plant, tuber dry weight (g/plant), total yield/plant (g), and total yield/feddan (ton) during both seasons as compared with the other treatments. This effect correlated with the same response in plant growth parameters that may be return to low concentration of Br availability and low organic matter % in soil before planting as shown in Table (1), in addition to the important roles of Br and Se in plant. Also, increased yield of Se treated plants suggested that Se may enhance the translocation of photo assimilates for tuber growth, acting as a strong sink for both Se and for carbohydrates. The positive impact of Se on the yield of potato plants could be related to its antioxidative effect in delaying senescence.

Table 2. Average values of some vegetative growth-related characters of two potato cultivars as affected by foliar application with Boron (Br), Selenium (Se) and their interactions during the winter seasons of 2016/2017 and 2017/2018.

Treatments		No. of stems/hill 2016/2017	No. of stems/hill 2017/2018	Plant height (cm) 2016/2017	Plant height (cm) 2017/2018
Potato cultivar					
Lady Rosetta		3.93 a	5.63 a	60.74 a	64.37 a
Caruso		4.20 a	5.89 a	64.93 a	60.15 a
Boron and Selenium					
Control		4.00 a	5.64 a	49.34 i	48.67 i
5 mg/l Se		3.92 a	5.57 a	63.00 e	62.84 e
10 mg/l Se		4.08 a	5.72 a	53.50 h	51.34 h
50 mg/l Br		4.17 a	5.84 a	56.33 g	54.67 g
50 mg/l Br+5 mg/l Se		4.08 a	5.87 a	71.84 b	72.67 b
50 mg/l Br+10 mg/l Se		4.09 a	5.72 a	66.17 d	65.67 d
100 mg/l Br		4.09 a	5.98 a	59.34 f	58.84 f
100 mg/l Br+5 mg/l Se		3.92 a	5.60 a	76.00 a	76.67 a
100 mg/l Br+10 mg/l Se		4.25 a	5.95 a	70.00 c	69.00 c
Interaction effects					
Cultivars	Boron and Selenium mg/l				
Lady Rosetta	Control	3.83 a	5.37 a	46.67 k	50.67 j-l
	5 mg/l Se	3.83 a	5.53 a	60.33 gh	65.00 ef
	10 mg/l Se	3.83 a	5.37 a	52.33 j	54.00 ij
	50 mg/l Br	4.00 a	5.60 a	52.33 j	56.67 hi
	50 mg/l Br+5 mg/l Se	4.33 a	6.37 a	71.00 cd	73.67 b
	50 mg/l Br+10 mg/l Se	3.67 a	5.13 a	63.33 fg	67.67 c-e
	100 mg/l Br	4.00 a	6.13 a	57.00 hi	62.00 fg
	100 mg/l Br+5 mg/l Se	3.83 a	5.60 a	75.33 ab	78.67 a
	100 mg/l Br+10 mg/l Se	4.00 a	5.60 a	68.33 de	71.00 b-d
Caruso	Control	4.17 a	5.90 a	52.00 j	46.67 l
	5 mg/l Se	4.00 a	5.60 a	65.67 ef	60.67 gh
	10 mg/l Se	4.33 a	6.07 a	54.67 ij	48.67 kl
	50 mg/l Br	4.33 a	6.07 a	60.33 gh	52.67 i-k
	50 mg/l Br+5 mg/l Se	3.83 a	5.37 a	72.67 bc	71.67 bc
	50 mg/l Br+10 mg/l Se	4.50 a	6.30 a	69.00 c-e	63.67 e-g
	100 mg/l Br	4.17 a	5.83 a	61.67 g	55.67 i
	100 mg/l Br+5 mg/l Se	4.00 a	5.60 a	76.67 a	74.67 ab
	100 mg/l Br+10 mg/l Se	4.50 a	6.30 a	71.67 cd	67.00 de

Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level.

Table 3. Averages values of some yield characters of two potato cultivars as affected by foliar application with Boron (Br), Selenium (Se) and their interactions during the winter seasons of 2016/2017 and 2017/2018.

Treatments		No. of tubers /plant 2016/2017	No. of tubers /plant 2017/2018	Tuber fresh weight (g) 2016/2017	Tuber fresh weight (g) 2017/2018	Tuber dry weight (g/plant) 2016/2017	Tuber dry weight (g/plant) 2017/2018	Total yield /plant (g) 2016/2017	Total yield /plant (g) 2017/2018	Total yield /feddan (ton) 2016/2017	Total yield /feddan (ton) 2017/2018
Potato cultivar											
Lady Rosetta		4.93b	4.48b	129.76a	135.41a	71.43a	71.06a	639.71b	606.63b	13.43b	12.74b
Caruso		5.81a	5.59a	113.44b	110.95b	70.67b	71.41a	659.11a	620.21a	13.84a	13.02a
Boron and Selenium											
Control		3.84 f	4.00 e	144.87 a	135.19 ab	64.83 i	65.20 i	555.00 i	527.65 i	11.66 i	11.08 i
5 mg/l Se		5.17 de	4.83 cd	126.94 bc	129.47 ab	70.89 e	71.16 e	651.23 e	620.27 e	13.78 e	13.03 e
10 mg/l Se		4.34 ef	4.00 e	134.06 ab	138.15 a	66.25 h	66.80 h	578.44 h	549.84 h	12.15 h	11.55 h
50 mg/l Br		4.67 e	4.50 d	129.71 b	128.75 a-c	67.75 g	68.43 g	602.79 g	573.63 g	12.66 g	12.05 g
50 mg/l Br+5 mg/l Se		6.50 ab	6.00 b	112.38 d	106.98 e	75.89 b	75.54 b	719.28 b	628.56 d	15.11 b	13.20 d
50 mg/l Br+10 mg/l Se		5.67 cd	5.17 c	119.38 d	125.70 bc	72.65 d	72.81 d	674.59 d	645.36 c	14.17 d	13.56 c
100 mg/l Br		5.17 de	4.67 d	121.36 cd	128.19 a-c	69.41 f	70.14 f	626.54 f	595.91 f	13.16 f	12.52 f
100 mg/l Br+5 mg/l Se		6.84 a	6.50 a	109.83 d	111.24 de	77.55 a	77.14 a	740.06 a	712.30 a	15.54 a	14.96 a
100 mg/l Br+10 mg/l Se		6.17 bc	5.67 d	113.54 d	119.07 cd	74.20 c	73.89 c	696.80 c	667.29 b	14.63 c	14.01 b
Interaction effects											
Cultivars	Boron and Selenium mg/l										
Lady Rosetta	Control	3.67 g	3.33 h	148.29 a	154.73 a	65.23 kl	65.60 k	544.21 k	515.25 m	11.43 k	10.82 m
	5 mg/l Se	4.67 d-g	4.33 e-h	136.99 a-d	139.64 a-d	71.11 f	70.85 ef	639.75 g	604.66 i	13.43 g	12.70 i
	10 mg/l Se	4.00 fg	3.67 gh	142.07 ab	146.52 ab	66.65 ij	67.22 i	568.29 j	537.71 l	11.93 j	11.29 l
	50 mg/l Br	4.33 e-g	4.00 f-h	136.64 a-c	140.26 a-c	68.37 h	68.67 h	591.66 i	561.04 k	12.42 i	11.78 k
	50 mg/l Br+5 mg/l Se	5.67 c-e	5.33 c-e	125.81 a-e	126.82 c-g	76.28 bc	74.73 c	713.34 d	675.96 d	14.98 d	14.20 d
	50 mg/l Br+10 mg/l Se	5.33 c-f	4.67 d-g	124.44 a-e	134.68 b-e	72.93 e	72.54 d	663.29 f	628.96 h	13.93 f	13.21 h
	100 mg/l Br	5.00 d-g	4.33 e-h	123.06 a-e	134.45 a-d	69.74 g	70.37 fg	615.29 h	582.16 j	12.92 h	12.23 j
	100 mg/l Br+5 mg/l Se	6.00 b-d	5.67 b-d	122.54 b-e	124.20 d-g	77.05 b	76.42 b	735.21 b	704.21 b	15.44 b	14.79 b
	100 mg/l Br+10 mg/l Se	5.67 c-e	5.00 d-f	121.05 b-e	129.93 b-f	74.48 d	73.12 d	686.38 e	649.66 f	14.41 e	13.64 f
Caruso	Control	4.00 fg	4.67 d-g	141.45 a-c	115.64 c-g	64.43 l	64.80 l	565.79 h	540.04 l	11.88 h	11.34 l
	5 mg/l Se	5.67 c-e	5.33 c-e	116.88 b-e	119.30 d-g	70.77 f	71.46 e	662.71 f	635.88 g	13.92 f	13.35 g
	10 mg/l Se	4.67 d-g	4.33 e-h	126.04 a-e	129.78 b-f	65.84 jk	66.37 j	588.59 i	561.96 k	12.36 i	11.80 k
	50 mg/l Br	5.00 d-g	5.00 d-f	122.78 a-e	117.24 c-g	67.13 i	68.19 h	613.91 h	586.21 j	12.89 h	12.31 j
	50 mg/l Br+5 mg/l Se	7.33 ab	6.67 ab	98.94 e	87.13 fg	75.49 c	76.35 b	725.21 c	581.16 j	15.23 c	12.20 j
	50 mg/l Br+10 mg/l Se	6.00 b-d	5.67 b-d	114.31 c-e	116.71 d-g	72.36 e	73.07 d	685.88 e	661.75 e	14.40 e	13.90 e
	100 mg/l Br	5.33 c-f	5.00 d-f	119.66 a-e	121.93 d-g	69.08 i	69.90 g	637.79 g	609.66 i	13.39 g	12.80 i
	100 mg/l Br+5 mg/l Se	7.67 a	7.33 a	97.12 e	98.28 g	78.04 a	77.87 a	744.91 a	720.38 a	15.64 a	15.13 a
	100 mg/l Br+10 mg/l Se	6.67 a-c	6.33 a-c	106.03 de	108.20 e-g	73.92 d	74.65 c	707.21 d	684.91 c	14.85 d	14.38 c

Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level.

However, when concentration of Se increased up to 10 mg/l with 100 mg/l Br the abovementioned traits decreased, this finding could be confirming the fact that selenium interaction with plants depends on its concentration. At lower rates, selenium stimulated growth of ryegrass seedlings, while at high doses it acted as pro-oxidant reducing yields and inducing metabolic disturbances (Hartikainen *et al*., 2000). Our results are in agreement with El-Banna and Abd El-Salam (2005); El-Dissoky and Abdel-Kadar (2013); Jafari-Jood *et al*. (2013); Lei *et al*. (2014). They reported that Br or Se foliar application, significantly, increased the number of purple potato tubers per plant and the total yield per plant. These findings may suggest an effect of Br and Se on the tuber formation and differentiation.

The interaction effects among potato cultivars, Br and Se foliar application showed that the application of Br at 100 mg/l + Se at 5 mg/l; produced the highest values of no. of tubers/plant, tuber dry weight, total yield/plant and the total yield/feddan for 'Caruso and Lady Rosetta' cultivars during both seasons.

Tuber quality characteristics

Results outline in Table (4) exhibited that tubers of the cultivar 'Lady Rosetta' showed higher specific gravity than the cultivar 'Caruso'. However, 'Caruso' tubers had higher values in the TSS and ascorbic acid contents in both seasons.

Respecting the main effect of Boron and Selenium application the obtained results declared that specific gravity, TSS, and ascorbic acid contents were increased during both seasons as compared to control plants. The highest average values were obtained due to foliar application level of 100 mg/l Boron combined with 5 mg/l Selenium. Mondy and Munshi (1993) also reported that Br foliar spray, significantly, improves the tuber's ascorbic acid contents. Since Boron plays an important role in carbohydrates translocation from leaves to other plant parts, higher concentrations of ascorbic acid may have been translocated to the tuber (El-Dissoky and Abdel-Kadar, 2013).

Concerning the interaction effects, tubers of 'Lady Rosetta' cv., treated with 100 mg/l Br and 5 mg/l Se had the highest specific gravity in both seasons. However, the 'Caruso' tubers cv., treated with the same levels had the highest contents of TSS and ascorbic acid in both seasons. While the lowest average values of TSS and ascorbic acid were obtained from the tubers of control treatment of 'Lady Rosetta' cv.

Table 4. Average values of some tuber quality characters of two potato cultivars as affected by foliar application with Boron (Br), Selenium (Se) and their interactions during the winter seasons of 2016/2017 and 2017/2018.

Treatments		Specific gravity		TSS % (Brix)		Vitamin C % (Ascorbic acid)	
		2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018
Potato cultivar							
Lady Rosetta		1.092a	1.074a	5.34b	5.52b	21.08b	20.92b
Caruso		1.089b	1.070b	5.67a	5.94a	21.66a	21.21a
Boron and Selenium							
Control		1.083 c	1.064 c	4.78 i	4.96 i	20.39 i	20.09 i
5 mg/l Se		1.085 c	1.067 c	5.49 e	5.73 e	21.34 e	21.10 e
10 mg/l Se		1.090 b	1.071 b	4.95 h	5.17 h	20.64 h	20.33 h
50 mg/l Br		1.092 ab	1.074 ab	5.13 g	5.36 g	20.89 g	20.59 g
50 mg/l Br+5 mg/l Se		1.093 ab	1.075 a	6.07 b	6.31 b	22.11 b	21.66 b
50 mg/l Br+10 mg/l Se		1.094 a	1.075 a	5.68 d	5.91 d	21.61 d	21.34 d
100 mg/l Br		1.093 ab	1.074 ab	5.30 f	5.54 f	21.13 f	20.84 f
100 mg/l Br+5 mg/l Se		1.095 a	1.076 a	6.26 a	6.52 a	22.35 a	22.13 a
100 mg/l Br+10 mg/l Se		1.093 ab	1.074 ab	5.88 c	6.10 c	21.86 c	21.54 c
Interaction effects							
Cultivars	Boron and Selenium mg/l						
Lady Rosetta	Control	1.086 d	1.067 de	4.62 k	4.79 l	20.13 l	19.90 o
	5 mg/l Se	1.089 b-d	1.071 b-d	5.32 g	5.50 h	21.03 h	20.92 hi
	10 mg/l Se	1.091 bc	1.072 b-d	4.77 j	4.97 k	20.38 k	20.15 n
	50 mg/l Br	1.093 ab	1.075 ab	4.98 i	5.14 j	20.63 j	20.40 lm
	50 mg/l Br+5 mg/l Se	1.094 ab	1.075 ab	5.87 d	6.09 d	21.80 e	21.67 c
	50 mg/l Br+10 mg/l Se	1.094 ab	1.075 ab	5.51 f	5.68 fg	21.30 g	21.15 fg
	100 mg/l Br	1.094 ab	1.075 ab	5.14 h	5.32 i	20.87 i	20.64 jk
	100 mg/l Br+5 mg/l Se	1.097 a	1.078 a	6.09 c	6.32 c	22.01 d	22.05 b
	100 mg/l Br+10 mg/l Se	1.094 ab	1.075 ab	5.71 e	5.88 e	21.54 f	21.41 de
Caruso	Control	1.079 e	1.061 f	4.94 i	5.13 j	20.65 j	20.27 mn
	5 mg/l Se	1.081 d	1.062 ef	5.66 e	5.95 e	21.64 f	21.28 ef
	10 mg/l Se	1.088 b-d	1.070 b-d	5.13 h	5.36 i	20.89 i	20.51 kl
	50 mg/l Br	1.091 bc	1.072 b-d	5.28 g	5.57 gh	21.14 h	20.77 ij
	50 mg/l Br+5 mg/l Se	1.092 bc	1.074 ab	6.24 b	6.52 b	22.41 b	21.65 c
	50 mg/l Br+10 mg/l Se	1.093 ab	1.075 ab	5.85 d	6.14 d	21.92 de	21.53 cd
	100 mg/l Br	1.091 bc	1.072 b-d	5.46 f	5.76 f	21.39 g	21.03 gh
	100 mg/l Br+5 mg/l Se	1.092 a-c	1.074 ab	6.43 a	6.72 a	22.69 a	22.21 a
	100 mg/l Br+10 mg/l Se	1.092 a-c	1.073 a-c	6.04 c	6.32 c	22.18 c	21.67 c

Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level.

As mentioned by Khan *et al*. (2010) who reported that potatoes with high specific gravity are preferred for preparation of chips and French fries and potatoes with very high specific gravity (1.10) may not be suitable for French fries production because they become hard or biscuit like products. Cultivar differences in specific gravity are well known (Stevenson *et al*., 1964).

However, specific gravity was higher in 'Lady Rosetta' cultivar, which resulted in higher crisp yield and lower oil percentage, which are advantageous to the processing industry (Kumar *et al*., 2007). Irene *et al.* (1964) also reported that cooking quality of potato is influenced by the genetic factors inherent in the variety.

Starch and Sugars

Referring to the potato cultivars main effect, average values depicted in Table (5) declare that the 'Lady Rosetta' cultivar had more tuber starch content in the first season only and it had more non-reducing and total sugars during both growing seasons. While 'Caruso' cv., tubers had more starch in the second season and more reducing sugars in both seasons.

Pertaining the main effect of Br and Se concentrations, the results reported that potato plants sprayed at 100 mg/l Br plus 5 mg/l Se, significantly, increased the starch contents in the tubers during both seasons compare to the other concentrations. However, Br and Se treatments were in adverse relationship with reducing, non-reducing, and total sugars characteristics, whereas control treatment showed, significantly, the highest average values during both growing seasons. These effects of Br foliar spray on starch content in the potato tubers may be attributed to role of Br on sugar transport to parts of storage (tubers), also to its role in synthesis of proteins and regulation of carbohydrate metabolism (Mengel *et al*., 2001). These results are in accordance with that obtained by Bari *et al.* (2001) and El-Banna and Abd El-Salsm (2005).

Regarding the interaction effects, 'Lady Rosetta' cv. treated at 100 mg/l Br + 5 mg/l Se produced the highest average value of tuber starch content during both seasons, while the lowest starch content was obtained from the tubers of 'Caruso' cv., in control treatment

Table 5. Average values of some tubers quality characters of two potato cultivars as affected by foliar application with Boron (Br), Selenium (Se) and their interactions during the winter seasons of 2016/2017 and 2017/2018.

Treatments		Tubers sugars (% d.w)							
		Starch		Reducing sugars		Non-reducing sugars		Total sugars	
		2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018
Potato cultivar									
Lady Rosetta		67.51 a	67.87 b	0.533 b	0.552 b	1.389 a	1.382 a	1.922 a	1.934 a
Caruso		66.58 b	66.10 a	0.560 a	0.577 a	1.337 b	1.341 b	1.897 b	1.918 b
Boron and Selenium									
Control		65.37 i	65.27 i	0.611 a	0.626 a	1.508 a	1.519 a	2.119 a	2.145 a
5 mg/l Se		67.03 e	66.95 e	0.543 b-e	0.562 cd	1.366 e	1.360 e	1.909 e	1.922 e
10 mg/l Se		65.80 h	65.69 h	0.592 ab	0.608 ab	1.477 b	1.480 b	2.069 b	2.088 b
50 mg/l Br		66.19 g	66.11 g	0.576 a-c	0.591 a-c	1.436 c	1.435 c	2.012 c	2.026 c
50 mg/l Br+5 mg/l Se		68.35 b	68.29 b	0.503 ef	0.522 ef	1.252 h	1.250 h	1.755 h	1.772 h
50 mg/l Br+10 mg/l Se		67.45 d	67.41 d	0.533 c-f	0.552 c-d	1.328 f	1.320 f	1.861 f	1.872 f
100 mg/l Br		66.61 f	66.53 f	0.560 a-d	0.576 b-d	1.400 d	1.395 d	1.960 d	1.971 d
100 mg/l Br+5 mg/l Se		68.73 a	68.78 a	0.487 e	0.508 f	1.215 i	1.213 i	1.702 i	1.721 i
100 mg/l Br+10 mg/l Se		67.91 c	67.85 c	0.517 d-f	0.538 d-f	1.288 g	1.284 g	1.805 g	1.822 g
Interaction effects									
Cultivars	Boron and Selenium mg/l								
Lady Rosetta	Control	65.81 i	66.15 i	0.594 c	0.615 b	1.547 a	1.543 a	2.141 a	2.158 a
	5 mg/l Se	67.52 e	67.87 e	0.532 g	0.552 i	1.388 fg	1.375 e	1.920 g	1.927 e
	10 mg/l Se	66.29 h	66.59 h	0.574 d	0.598 cd	1.508 b	1.493 b	2.083 b	2.091 c
	50 mg/l Br	66.66 g	67.02 g	0.563 e	0.579 ef	1.463 c	1.456 c	2.026 d	2.034 d
	50 mg/l Br+5 mg/l Se	68.82 b	69.11 b	0.491 l	0.507 l	1.271 k	1.275 hi	1.762 l	1.783 i
	50 mg/l Br+10 mg/l Se	67.93 d	68.37 d	0.519 hi	0.537 j	1.356 hi	1.341 f	1.875 i	1.878 g
	100 mg/l Br	67.10 f	67.43 f	0.545 f	0.564 gh	1.421 de	1.412 d	1.966 f	1.976 e
	100 mg/l Br+5 mg/l Se	69.11 a	69.53 a	0.477 m	0.493 m	1.240 l	1.239 jk	1.717 m	1.732 j
	100 mg/l Br+10 mg/l Se	68.36 c	68.72 c	0.505 jk	0.523 k	1.308 j	1.306 g	1.813 k	1.829 h
Caruso	Control	64.92 k	64.38 m	0.628 a	0.636 a	1.469 c	1.495 b	2.097 b	2.131 b
	5 mg/l Se	66.54 g	66.03 i	0.554 ef	0.572 fg	1.343 i	1.344 f	1.897 h	1.916 f
	10 mg/l Se	65.31 j	64.79 l	0.610 b	0.618 b	1.445 cd	1.466 c	2.055 c	2.084 c
	50 mg/l Br	65.72 i	65.20 k	0.589 c	0.603 c	1.409 ef	1.414 d	1.997 e	2.017 d
	50 mg/l Br+5 mg/l Se	67.87 d	67.46 f	0.514 ij	0.536 j	1.232 l	1.225 k	1.746 l	1.761 i
	50 mg/l Br+10 mg/l Se	66.96 f	66.45 h	0.546 f	0.566 g	1.300 j	1.298 gh	1.846 j	1.864 g
	100 mg/l Br	66.11 h	65.62 j	0.575 d	0.588 de	1.378 gh	1.378 e	1.953 f	1.966 e
	100 mg/l Br+5 mg/l Se	68.34 c	68.03 e	0.497 kl	0.523 k	1.190 m	1.187 l	1.687 n	1.710 j
	100 mg/l Br+10 mg/l Se	67.45 e	66.97 g	0.528 gh	0.552 i	1.268 k	1.261 ij	1.796 k	1.813 h

Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level.

In addition, the highest average values for reducing sugars were obtained from Caruso's control treatment, while the highest ones for non-reducing and total sugars were obtained from the tubers of control treatment in 'Lady Rosetta' cv. plants.

Olsen *et al*. (2003) reported that cultivars differ in their starch, sucrose, and reducing sugar accumulation. Mesquita *et al*. (2007) evaluated the effect of Boron rates (0.0, 0.75, 1.50 and 3.0 mg kg^{-1}) on the yield and tuber quality of two potato cultivars 'Asterix and Monalisa' cvs., grown on two soils, Red Latosol and Cambisol. Asterix cv., showed the highest percentages of starch in tubers on the Red Latosol soil. The reducing sugar content decreased with Boron rates on the Red Latosol soil. Likely, potato cv. 'Desiree', Boron application, also, enhanced the starch content from 10.75 to 13.07% (Khalil *et al*., 2002).

Selenium increases carbohydrate or starch accumulation in chloroplasts as reported by several investigators (Malik *et al.,* 2011; Hashem *et al*., 2013; Hajiboland *et al.,* 2015).

Leaves chlorophyll and nutrient contents

Results outlined in Table (6) exhibited that, during both growing seasons, leaves of cv. 'Caruso' had more total chlorophyll, nitrogen and phosphorus contents. On the other side, Lady Rosetta leaf Br and Se content were higher, significantly, than 'Caruso' cv. leaf content during both seasons. However, 'Caruso' leaf potassium content was, significantly, higher in the first season only. Lady Rosetta leaf potassium content was higher than 'Caruso' leaf content, but the significance level was reached in the second season only.

In terms of the main effect of Boron and Selenium foliar application, levels of 100 mg/l Br plus 5 mg/l Se treatment, significantly, enhanced leaf total chlorophyll, nitrogen, phosphorus, potassium and boron contents during both seasons compare to the other items. While, Br foliar treated at 100 mg/l plus 10 mg/l Se increased, significantly, Selenium leaf content during both seasons.

Boron and Selenium may increase chlorophyll content as this process is stimulated by optimal supplementation with Br and Se during the vegetative growth. On potato, the Br and Se application has been reported to positively influence photosynthesis (Turakainen *et al*., 2004). The positive effects of Se concentrations on the photosynthetic process may be explained *via* the improvement of the cell antioxidant activity at different levels (Schiavon *et al*., 2017).

Table 6. Average values of leaves chlorophyll and nutrient contents of two potato cultivars as affected by foliar application with Boron (Br), Selenium (Se) and their interactions during the winter seasons of 2016/2017 and 2017/2018.

Treatments		Total chlorophyll content (mg/g f.w.)		Nutrient contents of leaves (% d.w.)									
				N		P		K		Br		Se	
		2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018
Potato cultivar													
Lady Rosetta		1.019 b	0.992 b	2.17 b	2.03 a	0.179 b	0.193 b	2.36 a	2.25 a	23.49 a	24.16 a	2.51 a	2.58 a
Caruso		1.062 a	1.026 a	2.25 a	2.07 a	0.199 a	0.201 a	2.35 a	2.21 b	24.77 b	25.49 b	2.49 b	2.56 b
Boron and Selenium													
Control		0.914 f	0.894 i	1.73 i	1.59 i	0.147 f	0.156 e	1.89 i	1.76 i	19.16 i	19.68 i	1.88 i	1.93 i
5 mg/l Se		1.037 b-e	1.009 e	2.21 e	2.08 e	0.188 b-e	0.199 a-d	2.35 e	2.23 e	23.96 e	24.74 e	2.32 f	2.40 f
10 mg/l Se		0.945 ef	0.925 h	1.86 h	1.71 h	0.155 ef	0.166 de	2.02 h	1.89 h	20.10 h	20.62 h	2.48 e	2.54 e
50 mg/l Br		0.975 d-f	0.954 g	1.97 g	1.83 g	0.170 d-f	0.178 c-e	2.13 g	2.00 g	21.35 g	21.93 g	2.02 h	2.08 h
50 mg/l Br+5 mg/l Se		1.135 ab	1.092 b	2.58 a	2.39 b	0.221 ab	0.220 ab	2.70 b	2.60 b	28.42 b	29.34 b	2.68 d	2.76 d
50 mg/l Br+10 mg/l Se		1.068 a-e	1.039 d	2.31 c	2.13 d	0.198 a-d	0.208 a-c	2.46 d	2.34 d	25.25 d	25.91 d	2.97 b	3.04 b
100 mg/l Br		1.005 c-f	0.983 f	2.08 f	1.96 f	0.181 c-f	0.189 b-e	2.25 f	2.11 f	22.66 f	23.28 f	2.18 g	2.24 g
100 mg/l Br+5 mg/l Se		1.166 a	1.120 a	2.28 d	2.51 a	0.232 a	0.238 a	2.82 a	2.71 a	29.70 a	30.67 a	2.83 c	2.92 c
100 mg/l Br+10 mg/l Se		1.118 a-c	1.068 c	2.46 b	2.25 c	0.211 a-c	0.220 ab	2.58 c	2.46 c	26.59 c	27.28 c	3.15 a	3.23 a
Interaction effects													
Cultivars	Boron and Selenium mg/l												
	Control	0.889 m	0.876 k	1.68 o	1.56 j	0.139 j	0.150 i	1.93 j	1.79 l	18.95 r	19.47 q	1.91 q	1.96 p
	5 mg/l Se	1.012 hi	0.991 fg	2.18 hi	2.03 e	0.176 g	0.193 e	2.32 g	2.24 h	23.11 k	23.86 k	2.35 k	2.42 m
	10 mg/l Se	0.923 l	0.908 j	1.82 mn	1.67 hi	0.145 j	0.161 h	2.06 i	1.90 k	19.22 q	19.72 p	2.50 i	2.56 h
Lady	50 mg/l Br	0.953 kl	0.934 i	1.92 l	1.77 g	0.159 hi	0.172 g	2.18 h	2.02 j	20.53 o	21.09 o	2.06 o	2.11 n
Rosetta	50 mg/l Br+5 mg/l Se	1.110 de	1.078 c	2.53 c	2.38 b	0.211 d	0.222 b	2.66 c	2.63 b	28.08 d	28.99 d	2.66 h	2.74 g
	50 mg/l Br+10 mg/l Se	1.043 fg	1.020 e	2.29 fg	2.12 d	0.185 f	0.203 d	2.43 f	2.37 f	24.44 i	25.08 i	2.95 d	3.02 c
	100 mg/l Br	0.984 ij	0.967 h	2.04 jk	1.92 f	0.174 g	0.182 f	2.30 g	2.11 i	21.86 m	22.45 m	2.20 m	2.26 l
	100 mg/l Br+5 mg/l Se	1.145 bc	1.105 b	2.63 b	2.52 a	0.219 c	0.238 a	2.79 a	2.73 a	29.42 b	30.38 b	2.81 f	2.90 e
	100 mg/l Br+10 mg/l Se	1.108 de	1.048 d	2.42 de	2.26 c	0.202 e	0.212 c	2.56 d	2.49 d	25.76 g	26.43 g	3.16 a	3.24 a
	Control	0.938 kl	0.912 j	1.77 n	1.62 ij	0.154 i	0.161 h	1.84 k	1.72 m	19.36 p	19.89 p	1.84 r	1.89 q
	5 mg/l Se	1.062 f	1.027 e	2.24 gh	2.12 d	0.199 e	0.204 d	2.38 f	2.21 h	24.80 h	25.61 h	2.29 l	2.37 k
	10 mg/l Se	0.967 jk	0.941 i	1.89 lm	1.74 gh	0.165 h	0.171 g	1.97 j	1.88 k	20.97 n	21.51 n	2.45 j	2.51 i
	50 mg/l Br	0.997 h-j	0.973 gh	2.01 k	1.88 f	0.180 fg	0.184 f	2.08 i	1.98 j	22.17 l	22.77 l	1.98 p	2.04 o
Caruso	50 mg/l Br+5 mg/l Se	1.159 ab	1.106 b	2.62 b	2.40 b	0.231 b	0.217 c	2.73 b	2.56 c	28.75 c	29.69 c	2.69 g	2.78 f
	50 mg/l Br+10 mg/l Se	1.093 e	1.057 d	2.36 ef	2.14 d	0.211 d	0.213 c	2.48 e	2.31 g	26.06 f	26.74 f	2.98 c	3.06 b
	100 mg/l Br	1.025 gh	0.999 f	2.12 ij	2.00 e	0.188 f	0.196 e	2.20 h	2.10 i	23.46 j	24.10 j	2.15 n	2.21 m
	100 mg/l Br+5 mg/l Se	1.187 a	1.135 a	2.72 a	2.50 a	0.245 a	0.237 a	2.84 a	2.68 b	29.98 a	30.95 a	2.84 e	2.93 d
	100 mg/l Br+10 mg/l Se	1.127 cd	1.088 bc	2.49 cd	2.24 c	0.220 c	0.227 b	2.59 d	2.43 e	27.41 e	28.13 e	3.14 b	3.22 a

Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level.

The interaction effects show that 'Caruso' cv. leaves treated with 100 mg/l Br + 5 mg/l Se had the highest total chlorophyll contents followed by 50 mg/l Br + 5 mg/l Se. Leaf nitrogen and phosphorus were higher in 'Caruso' cv. treated plants with100 mg/l Br + 5 mg/l Se in the first season, while N and P were higher in 'Lady Rosetta and Caruso' cvs., treated plants with the same levels of Br and Se. Regarding leaf potassium contents, 'Caruso' cv. treated plants with 100 mg/l Br + 5 mg/l Se and 'Lady Rosetta' treated plants with the same levels had the highest K contents in the first season while Lady Rosetta 100 mg/l Br and 5 mg/l Se had the highest level of K in the second season. In terms of leaf Se content the results showed that both cultivars treated with 100 mg/l Br+10 mg/l Se gave, significantly, the highest leaf content during both seasons. While plants of both cultivars treated with 100 mg/l Br+ 5 mg/l Se brought about highest significant leaf boron contents during both seasons.

Tuber nutrient contents

Results Tabulated in Table (7) divulged that Lady Rosetta tubers had higher contents of Boron, Selenium and Potassium during both seasons. However, no significant differences were noted for tuber nitrogen contents. It is noticeable, Lady Rosetta tubers contained higher phosphorus contents in the first season only.

Regarding Boron and Selenium main effect, application of Br at 100 mg/l plus 5 mg/l Se, significantly, increased tuber contents of Boron, Phosphorus, and Potassium during both seasons.

Table 7. Average values of tuber nutrient contents of two potato cultivars as affected by foliar application with Boron (Br), Selenium (Se) and their interactions during the winter seasons of 2016/2017 and 2017/2018.

Treatments		Nutrient contents of tubers (% d.w.)									
		Br		Se		N		P		K	
		2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018
Potato cultivar											
Lady Rosetta		14.65 a	15.08 a	0.619 a	0.605 a	1.3 6a	1.29 a	0.157 a	0.165 a	1.73 a	1.63 a
Caruso		14.21 b	14.62 b	0.601 b	0.586 b	1.36 a	1.30 a	0.147 b	0.176 a	1.58b	1.53 b
Boron and Selenium											
Control		9.44 i	9.70 i	0.508 i	0.496 i	1.48 a	1.40 a	0.111 f	0.130 d	1.25 i	1.21 i
5 mg/l Se		14.67 e	15.15 e	0.584 f	0.569 f	1.36 e	1.32 d	0.151 c-e	0.172 a-d	1.65 e	1.59 e
10 mg/l Se		10.67 h	10.95 h	0.665 c	0.648 c	1.44 b	1.38 b	0.120 f	0.142 cd	1.36 h	1.27 h
50 mg/l Br		11.87 g	12.19 g	0.531 h	0.514 h	1.41 c	1.35 c	0.132 ef	0.151 b-d	1.45 g	1.35 g
50 mg/l Br+5 mg/l Se		18.29 b	18.88 b	0.607 e	0.595 e	1.28 h	1.21 g	0.185 ab	0.199 ab	1.96 b	1.89 b
50 mg/l Br+10 mg/l Se		15.88 d	16.29 d	0.691 b	0.677 b	1.33 f	1.27 e	0.162 b-d	0.181 a-c	1.77 d	1.68 d
100 mg/l Br		13.02 f	13.37 f	0.551 g	0.539 g	1.39 d	1.32 d	0.140 d-f	0.165 a-d	1.55 f	1.47 f
100 mg/l Br+5 mg/l Se		19.00 a	19.61 a	0.634 d	0.621 d	1.25 i	1.19 h	0.196 a	0.208 a	2.07 a	1.99 a
100 mg/l Br+10 mg/l Se		17.08 c	17.53 c	0.721 a	0.704 a	1.30 g	1.24 f	0.174 a-c	0.189 a-c	1.86 c	1.78 c
Interaction effects											
Cultivars	Boron and Selenium mg/l										
Lady Rosetta	Control	9.32 r	9.58 r	0.518 l	0.508 lm	1.45 b	1.37 bc	0.114 kl	0.124 l	1.32 jk	1.31 h
	5 mg/l Se	15.09 i	15.58 i	0.596 i	0.581 i	1.36 f	1.34 c-e	0.156 f	0.165 hi	1.72 ef	1.61 e
	10 mg/l Se	10.56 p	10.83 p	0.672 de	0.654 de	1.43 c	1.36 cd	0.124 j	0.137 jk	1.42 i	1.32 h
	50 mg/l Br	11.77 n	12.09 n	0.540 k	0.525 kl	1.40 d	1.33 d-f	0.137 h	0.146 j	1.52 h	1.41 g
	50 mg/l Br+5 mg/l Se	18.63 b	19.24 b	0.614 hi	0.604 h	1.29 j	1.22 ij	0.188 bc	0.192 cd	2.04 b	1.91 bc
	50 mg/l Br+10 mg/l Se	16.28 g	16.70 g	0.698 bc	0.683 bc	1.33 gh	1.27 gh	0.168 e	0.175 fg	1.85 d	1.72 d
	100 mg/l Br	12.93 l	13.28 l	0.561 j	0.551 j	1.38 e	1.31 ef	0.145 g	0.167 gh	1.62 g	1.51 f
	100 mg/l Br+5 mg/l Se	19.82 a	20.46 a	0.642 fg	0.629 fg	1.27 k	1.19 jk	0.199 a	0.200 bc	2.13 a	2.01 a
	100mg/l Br + 10 mg/l Se	17.46 e	17.91 e	0.729 a	0.709 a	1.31 hi	1.24 hi	0.179 d	0.179 ef	1.93 c	1.83 c
Caruso	Control	9.55 q	9.81 q	0.497 m	0.483 n	1.50 a	1.43 a	0.107 l	0.135 k	1.17 l	1.11 j
	5 mg/l Se	14.25 j	14.71 j	0.571 j	0.556 j	1.36 f	1.30 fg	0.145 g	0.178 ef	1.58 g	1.56 ef
	10 mg/l Se	10.78 o	11.06 o	0.658 ef	0.641 ef	1.45 b	1.40 ab	0.115 k	0.146 j	1.30 k	1.21 i
	50 mg/l Br	11.96 m	12.29 m	0.521 l	0.503 m	1.42 c	1.36 cd	0.127 ij	0.156 i	1.37 ij	1.29 hi
	50 mg/l Br+5 mg/l Se	17.94 d	18.52 d	0.599 i	0.585 i	1.26 k	1.20 i-k	0.181 cd	0.205 ab	1.88 cd	1.87 c
	50 mg/l Br+10 mg/l Se	15.47 h	15.87 h	0.684 cd	0.671 cd	1.33 g	1.27 gh	0.156 f	0.186 de	1.68 f	1.63 e
	100 mg/l Br	13.10 k	13.45 k	0.541 k	0.527 k	1.40 d	1.33 c-e	0.134 hi	0.163 hi	1.48 h	1.42 g
	100 mg/l Br+5 mg/l Se	18.17 c	18.76 c	0.626 gh	0.612 gh	1.23 l	1.18 k	0.192 ab	0.215 a	2.00 b	1.96 ab
	100 mg/l Br+10 mg/l Se	16.70 f	17.14 f	0.712 ab	0.698 ab	1.29 j	1.24 hi	0.169 e	0.198 bc	1.78 e	1.73 d

Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level

On the contrary, the highest tuber nitrogen contents were obtained from the control treatment followed by 10 mg/l Se. In the case of Selenium tuber content, the highest average value was brought about the combination between 100 mg/l Br plus 10 mg/l Se during both seasons.

The increments in the N, P, and K leaves and tubers contents have been reported earlier (El-Dissoky and Abdel-Kadar, 2013) and can be explained by the findings of Mengel *et al.* (2001) and Canada (2002). Mengel *et al.* (2001) reported such relationship between Br and the synthesis of amino acids and proteins which may affect the demand for N. Meanwhile, Canada (2002) attributed the higher P content to the influence of Br on membrane-bound ATPase activity. The high K content was explained by Mengel *et al.* (2001) based on the synergetic relationship between K and Br in the sugar and carbohydrate transport. In addition, Canada (2002) found that heavy K-demanding crops in the bulking stage of production require 60-80 ppm Boron levels in the tissue to take up their demand of potassium. Also, Selenium like heavy metals can modify uptake and accumulation of minerals which are important for plant metabolism (Pazurkiewicz-Kocot *et al*. 2003). Our results are in agreement with those of Boghdady *et al*. (2017) and Shedeed *et al*. (2018). In this context, tubers containing high percentages of Br and Se provide a vital elements for human and animal i.e. for synthesis amino acids and proteins which suffice the requirement for nitrogen (Mengel *et al*., 2001). Also, Se as a constituent of selenoproteins, i. e., many of which have important functions, including antioxidant protection, energy metabolism and redox regulation during transcription and gene expression (Kong *et al*., 2005).

The interaction effects show that the richest tuber in selenium were obtained from 'Lady Rosetta' cv. treated with100 mg/l Br and 10 mg/l Se and 'Caruso' cv. tubers treated with the same levels during both seasons. It is noticeable that cultivar of 'Caruso' tubers in the control treatment had the highest values of nitrogen during both seasons. Lady Rosetta tubers had the highest values of phosphorus due to plant's treatment with 100 mg/l Br and 5 mg/l Se, followed by Caruso' tubers that treated with the same levels in the first season. In the second season, Caruso tubers that treated with 100 mg/l Br and 5 mg/l Se had the highest contents of phosphorus followed by tubers of the same cultivar that treated with 50 mg/l Br and 5 mg/l Se. Tubers of 'Lady Rosetta' cv. that treated with 100 mg/l Br and 5 mg/l Se contained the highest values of potassium contents followed by Caruso tubers of the plants treated with the same level.The interactions among the tested cultivars, Boron, and selenium levels can be explained as a degree of gene expressions of each cultivar to the external factors (Br + Se levels).

Considering the yield, tuber quality and nutrient uptake, it may be concluded that the foliar spray of Boron (100 mg/l) in combination with Selenium (5 mg/l) at 55 and 70 days after planting is beneficial for the processing grade potato cultivars, Caruso and Lady Rosetta, in the sandy soils under the environmental conditions of Nubaria region, Behiera Governorate and other similar regions.

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خصائص نمو وإنتاجية محصول البطاطس متأثراً بالرش الورقي بالبورون والسيلينيوم

عبد الباسط الخربوطلي[1]، علاء رشدي[2] و عماد ماضي[3]

[1]قسم البساتين- كلية الزراعة والموارد الطبيعية- جامعة أسوان- مصر

[2]قسم البساتين- كلية الزراعة- جامعة دمنهور- مصر

[3]قسم البساتين- كلية الزراعة- جامعة الأزهر- مدينة نصر- القاهرة- مصر

يعتبر زيادة نمو وإنتاجية محصول البطاطس عن طريق الرش الورقي بعنصري البورون والسيلينيوم له أهمية كبيرة جداً في الوقت الحالي. لذلك تم إجراء هذا البحث لدراسة تأثير تطبيق الرش الورقي بالبورون والسيلينيوم على الصفات المورفولوجية والمحصول لنباتات البطاطس صنفي ليدي روزيتا وكاروزو خلال موسمي النمو 2017/2016 و2018/2017. استخدم نظام القطع المنشقة في تصميم القطاعات العشوائية الكاملة في ثلاث مكررات. تم توزيع الأصناف في القطع الرئيسية ثم تركيزات البورون و السيلينيوم منفردين أو كخليط في القطع تحت الرئيسة. تم الرش الورقي للبورون بثلاثة تركيزات هي الكنترول و50 و100 ملليجرام/لتر بينما تم استخدام السيلينيوم بتركيزات الكنترول و5 و10 ملليجرام/ لتر. أوضحت نتائج الدراسة إلى أن نمو ومحصول البطاطس قد تحسن معنوياً من خلال الرش الورقي بالبورون والسيلينيوم. أوضحت النتائج المتحصل عليها زيادة معنوية في ارتفاع النبات-الوزن الجاف للدرنات-عدد الدرنات للنبات-ومحصول الدرنات للنبات وللفدان- محتوى الدرنات من المواد الصلبة الذائبة الكلية-حامض الأسكوربيك-محتوى الدرنات من السكريات (النشا- السكريات المختزلة والغير مختزلة والكلية) – الكلوروفيل الكلي في الأوراق- محتوى الأوراق والدرنات من النيتروجين والفوسفور والبوتاسيوم والبورون والسيلينيوم عند الرش الورقي لصنفي البطاطس ليدي روزيتا وكاروزو بالبورون بتركيز 100 ملليجرام/لتر مخلوطاُ مع السيلينيوم بتركيز 5 ملليجرام/لتر، خلال كلا موسمي النمو.