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Interactive Effects of Selenium and Salicylic Acid on Growth, Yield Attributes and Improves Early Blight Resistance of Two Potato Cultivars

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Abstract: Enhancing of potato growth and yield attributes via both selenium (Se) and salicylic acid (SA) now a days is a great potation especially in resistance to early blight the most dangerous disease of potatoes, which causes huge yield losses worldwide. So the present work looking for treatments required to increased resistance and productivity of potato. Therefore, the present investigation was done to study the effect of Se at (5 ppm) and SA at (200 ppm) singly or in combination as a foliar application on the growth, yield, quality and early blight disease resistance of two potato cultivars (Spunta and Leady Rosetta) during two growing seasons of 2019/2020 and 2020/2021 at the Experimental Farm of El- Kassasein, Res. Station, Hort., Res. Inst., Agric. Res. Center, Ismailia Governorate, Egypt. Spraying Spunta cultivar with Se at 5 ppm and SA at 200 ppm in combination achieved significant increase in the plant height, number of leaves/plant, number of branches / plant, dry weight of shoots, yield / plant, average tuber weight and total yield, followed by spraying with the same cultivar with Se singly. While spraying Lady Rosetta cultivar with (Se at 5 ppm + SA at 200 ppm) revealed an increased tuber quality including dry matter % (DM%), specific gravity and starch contents, whereas reduced incidence and severity percentages of early blight disease as a result of the increase of the resistance.

Key words: Potato · Cultivars Spunta and Leady Rosetta · Selenium · Salicylic acid · Growth · Yield · Early blight disease · Resistance

INTRODUCTION

Nowadays, increasing the demand for potato day by day in help to raise the living level for farmers through export and marketing value, potato (*Solanum tuberosum* L.) Potato is considered among the most important food crops worldwide [1].

The cultivated area with potato in Egypt, have enormously increased through the last decades reaching about 381379 fad., producing about 4265178 tons, with average 11, 184 tons/ fad. [2].

Early blight is the most important and destructive of potato and tomato caused by *Alternaria solani* [3, 4]. *A. solani* spore are found in the atmosphere and in the soil and the fungus is always a serious threat under favorable conditions in the potato fields. Dark and sunken concentric ring-like lesions are usually a characteristic feature of this disease [5]. The disease can occur over a wide range of climatic conditions, but it is most iprominent in areas with dew, rainfall and high relative humidity. On tomato, infection of the plants can result in a complete loss of the crop as yields are reduced by damaging foliage and fruits [6]. In potatoes early blight disease occurs in most of the production areas almost every year although it has a significant effect on yield. Only when frequent wetting of the foliage favors early and rapid symptom development. Assessing accurately the total crop losses annual of any certain disease is difficult. Values in the literature for measured crop losses due to early blight vary enormously from 5–78% [7].

There were significant differences between potato cultivars for growth indicated by Zebenay [8]; Eaton *et al*. [9]; Zebenay *et al.* [10], yield by Banjade *et al.* [11], Merga and Dechassa [12] and Zaeen *et al.* [13], tuber quality by Tessema *et al*. [14], Abou El-Goud *et al*. [15] and Naiem *et al.* [16].

Selenium (Se) is a trace element that is important for humans and animals, as well as plants, which require at low doses promote plant growth [17]. High concentrations of Se, on the other hand, may be harmful to plants; however, using Se at low concentrations has beneficial effects on plant growth. Plants absorb Se from the soil in the same way that sulphur does and Se inside plants is involved in selenium amino acids such as

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selenomethionine and selenocysteine [18]. In addition, Se plays an important role in many physiological processes in plants, i.e. hormonal balance, antioxidant reactions, enhances the activities of glutathione peroxidase that increase the resistance to biotic and abiotic stresses which affect plant growth [19].

Foliar application of Se increased plant growth, yield and its components as well as tuber quality on potato [20, 21].

Salicylic acid (SA) is introduced as an important messenger molecule in the responses of plant to the different abiotic and biotic stresses SA, also, is playing an important role in the regulation of many physiological processes in plants such as effects on growth development, ion uptake, transport and membrane permeability [22]. In addition, SA is an important signal molecule that plays a serious role in plant defense against plant pathogen invasion [23-25].

In vitro experiments, salicylic acid (SA) 4% were the most effective concentrations on reducing growth of *A. solani* (84.44 and 67.77 %) and reducing spores' germination (55.31 and 81.56 %). All the tested concentrations of SA as inducer of resistance in tomato plants, which reduced number and diameter of lesion as well as percentage of disease and increase percentage of protection 7 days post treatment using detached and intact leaf techniques [3].

Previous studies reported that SA applications increase plant growth, productivity and tuber quality of potatoes [26-28]. In addition, application of salicylic acid has induced disease resistance on tomato plants against Alternaria leaf spot in glasshouse trials [29] for controlling early blight of potato plants under field conditions as well as controlling early blight of tomato plants [3]. Therefore, the aims of this study was to investigate the effect of selenium and salicylic acid as foliar application on growth, productivity and tuber quality as well as their effects on early blight disease resistance on two potato cultivars grown in winter plantations.

MATERIALS AND METHODS

Experiment Location: Implemented to field experiments for planting potato during the growing winter seasons of 2019/2020 and 2020/2021 at El-Kassasein, Res. Station, Hort, Res. Inst., Agric. Center, Ismailia Governorate, Egypt, the main target of this study the effect of selenium (Se), salicylic acid (SA) singly or in combinations as foliar application on the plant growth, yield and tuber quality and early blight disease resistance on two potato cultivars.

The used soil properties were: sandy soil in texture for the two experimental growing seasons, while it had 0.06 and 0.05 % organic matter, 8.05 and 8.01 pH, 1.92 and 1.97 mmhos/cm EC, 4.02 and 4.12 ppm available N, 3.02 and 3.06 available P and 10.66 and 9.28 available K during the 1st and 2nd seasons, respectively.

Experimental Treatments and Design: Treatments consisted of eight treatments combination including two factors, i.e., the main factors plot includes two potato cultivars (Spunta and Leady Rosetta), the second factors sub plots includes four foliar applications, i.e., (Se at 5 ppm, SA at 200 ppm, Se at 5 ppm + SA at 200 ppm and control) plants.

These treatments layout split plots system in a randomized complete block design with three replicates.

The plot area was 14 m^2. It contains two ridges with 10 m length and 0.7 m wide and 25 cm plant spacing. One ridge was used for the samples to measure the vegetative growth characters and the other ridge was used for measuring the yield and its components. In addition, one ridge was left between each two experimental units as a guard area to avoid the overlapping foliar spray treatments.

Potato Cultivation: Potato seeds tuber, i.e., Spunta and Leady Rosetta cultivars locally produced certified were purchased from Daltex Farm Company, El-Tawfikia, Behira Government, Egypt. Seeds tuber were planting on October 10th and 8 th in 2019 and 2020 growing seasons, respectively in a moist soil using full tubers.

Selenium applied as sodium selenate (Na_2SeO_3) and Salicylic acid ($C_7H_6O_3$) were purchased from El-Gomhouria for Trading Chemicals and Medical Appliances, Egypt. Plants were sprayed with salicylic acid and selenium three times at, i.e., 40, 55, 70 days after planting with the aid of a manual atomizer to achieve thorough and uniform coverage of the plants' foliage and simultaneously the untreated plants (control) were sprayed with water.

Recommended rate of N, P_2O_5 and K_2O were 120, 60 and 90 kg/fed., in the form of ammonium nitrate (33% N), calcium super phosphate (15.5% P_2O_{5+} phosphoric acid 80%) and potassium sulphate (48-52% K_2O) respectively. One third of these amounts were added at the soil preparation mixed with farmyard manure (30m^3/fed.) and the rest (two third amounts) were divided into 5 equal portions with irrigation water (fertigation) beginning after full emergency. The other normal agricultural treatments for grown potato plants were practiced.

Data Recorded

Plant Growth: A random sample of five plants were randomly taken from every experimental unit at 80 days from planting during both growing seasons of the study to determine plant height (cm), a number of leaves/plant and number of main (aerial) stems/plant.

Dry Weight: Plant parts (stems and leaves) were dried at 70°C till constant weight and the following data were recorded dry weight of stems/plant (g), dry weight of leaves/plant (g) and total dry weight/plant [stems + leaves (g)].

Yield and its Components: At harvest (115 days from planting) tubers from each experimental unit were weighed, counted, after that the following data were recorded: number of tubers/plant, average tuber weight (g), tuber yield per plant (g) and total yield (ton/fad). Faddan =4200m^2=0.42 ha.)

Tuber Quality at Harvest Time: Starch content (%): A.O.A.C. [1] methods were applied for the acid hydrolysis of starch to glucose and the later was determined by the method described by Smith and Dubois [30].

Dry Matter (%): One hundred grams of the grated mixture were dried at 105°C till constant weight and DM (%) was recorded.

Specific Gravity (S.G.): It was determined according to the method of Murphy and Govern [31]. The tubers were weighed in the air (a) and weighed of tuber under water (b) and then, specific gravity was calculated by the formula:

$$S.G. = \frac{a}{a-b}$$

Disease Incidence and Severity of Early Blight: Disease incidence was calculated as a percentage of infected plants after the appearance of natural disease symptoms in control plants (at both growing seasons tested). The following formula was used to calculate and express the disease incidence percentage (DI):

DI = (n/N) X 100

where n = Number of diseased plants, N= Total number of plants.

The reduction % in disease incidence (DI %) and the reduction % in disease severity were calculated according to Atia [23] as follows:

Reduction = C-T/C X100

C = Percentage of disease incidence and/ or severity in untreated plants (control).

T = Percentage of disease incidence and/ or severity in treated plants.

Disease severity was recorded using a disease scale of 0-7 according to Chirst [32] as follow:

0 = no infected, 1 = trace to 1%, 2 = 2-5%, 3 = 6-10%, 4 = 11-25%, 5 = 26-50%, 6 = 51-75% and 7 = 76-100% of the leaflet infected.

The disease severity was calculated using the following formula:

% Severity = (sum of n x v) x100/ 7N

where n= number of leave-in each symptom's category; v = numerical value of each category; N = total number of leaves.

Statistical Analysis: Recorded data was subjected to the analysis of variance according to Snedecor and Cachran [33]. Mean separation was done by Duncan [34].

RESULTS AND DISCUSSION

Plant Growth

Effect of Cultivars: Data in Tables 1 and 2 show that there were significant differences between Spunta and Lady Rosetta cultivars in plant height, number of leaves / plant, number of branches / plant, dry weight of branches, leaves and dry weight of shoots at 80 days after planting in both growing seasons.

Spunta cultivar gave higher plant height, number of leaves / plant, number of branches / plant, dry weight of branches, leaves and dry weight of shoots than Lady Rosetta cultivar in both growing seasons. The increases in dry weight of shoots / plant were about 2.47 and 3.55 g for Spunta cultivar over Lady Rosetta cultivar in the 1st and 2nd seasons, respectively.

These results are in the same line with those reported by Zebenay [8] and Eaton *et al*. [9]. They found that, there were significant differences among potato cultivars regarding to vegetative growth and dry weight.

Effect of Foliar Spray Treatments: Spraying potato plants with Se at 5 ppm and SA at 200 ppm singly or in combination increased plant height, number of leaves

Table 1: Effect of foliar spray with selenium and salicylic acid on vegetative growth parameters of potato cultivars at 80 days after planting during 2019/2020 and 2020/2021 growing seasons

	Plant height (cm)		Number of leaves / plant		Number of main (aerial) stems/plant	
Treatments	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season
			Effect of cultivars			
Spunta	59.91 a	60.47 a	52.83 a	54.83 a	4.28 a	4.41 a
Lady Rosetta	48.49 b	52.25 b	45.86 b	45.71 b	4.08 a	4.08 a
			Effect of foliar spray treatments			
Control	45.50 c	53.00 c	42.87 d	44.16 d	3.16 b	3.33 c
Se	58.61 a	58.75 a	53.11 b	52.94 b	4.33 a	4.33 b
SA	54.93 b	55.61 b	46.90 c	48.50 c	4.49 a	4.50 b
Se+ SA	57.76 a	58.09 a	54.50 a	55.49 a	4.73 a	4.83 a

Se= selenium at 5 ppm, SA= salicylic acid at 200 ppm

Values having the same alphabetical letter(s) did not significantly difference at the 0.05 level of significance, according to Duncan's multiple range test

Table 2: Effect foliar spray with selenium and salicylic acid on dry weight of branches and leaves of potato cultivars at 80 days after planting during 2019 /2020 and 2020 /2021 growing seasons

	Dry weight of branches (g)		Dry weight of leaves (g)		Dry weight of shoot (g)	
Treatments	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season
			Effect of cultivars			
Spunta	11.81 a	14.85 a	17.29 a	20.44 a	29.12 a	35.29 a
Lady Rosetta	11.06 a	13.38 b	15.57 b	18.35 b	26.65 b	31.74 b
			Effect of foliar spray treatments			
Control	7.63 c	9.92 c	12.00 d	13.51 c	19.65 d	23.43 c
Se	13.09 a	16.52 a	17.64 b	22.47 a	30.75 b	38.99 a
SA	11.02 b	13.33 b	15.26 c	19.39 b	26.30 c	32.72 b
Se+ SA	14.00 a	16.70 a	20.81 a	22.22 a	34.85 a	38.93 a

Se= selenium at 5 ppm, SA= salicylic acid at 200 ppm

Values having the same alphabetical letter(s) did not significantly difference at the 0.05 level of significance, according to Duncan's multiple range test

/ plant, number of branches / plant, dry weight of branches, leaves and dry weight of shoots compared to the control as shown in Tables (1 and 2). Foliar spray with Se +SA significantly increased plant height, number of leaves / plant, number of branches / plant, dry weight of branches, leaves and dry weight of shoots without significant differences with Se in case of dry weight of branches in both growing seasons tested and dry weight of leaves and dry weight of shoots /plant in the 2nd season. The increases in dry weight of shoots per plant were about 15.18 and 15.49 g for Se+SA, 11.1 and 15.56 g for Se, 6.65 and 9.29 for SA over the control in the 1st and 2nd seasons, respectively.

From the previous results, it could be concluded that, spraying potato plants with Se+SA increased vegetative growth followed by spraying with Se alone.

The influence of Se on plant growth at mostly depends on its concentration, Se at low concentrations; it can promote plant growth through enhancing the antioxidant contents by increasing the activity of superoxide dismutase (SOD) and preventing the decline of tocopherols [35]. Salicylic acid play an important role in the regulation of many physiological processes in plants such as effects on growth development [22]. These results are in accordance with that obtained results by Ali and Abdel-Halim [21] for selenium effect; Suleiman *et al*. [27] and El-Areiny *et al.* [28] for salicylic acid effect on potato.

Effect of the Interaction: The interaction between two cultivars (Spunta and Lady Rosetta) and spraying with Se, SA singly or in combination increased vegetative growth compared to the interaction between two cultivars and spraying with water at 80 days after planting in both growing seasons (Tables 3 and 4).

The interaction between Spunta cultivar and spraying with Se+SA increased plant height, number of leaves /plant, number of branches / plant, dry weight of branches, leaves and dry weight of shoots, followed by the interaction between Spunta cultivar and spraying with Se in both growing seasons. In general, spraying Spunta cultivar with Se+SA increased vegetative growth of plant in both growing seasons.

Table 3: Effect of the interaction between potato cultivars and foliar spray with selenium and salicylic acid on vegetative growth parameters at 80 days after planting during 2019/2020 and 2020/2021growing seasons

Treatments		Plant height (cm)		Number of leaves / plant		Number of main (aerial) stems/plant	
Cultivars	Spray treatments	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season
Spunta	Control	50.00 e	53.00 c	47.66 c	48.66 cd	3.00 c	3.00 c
	Se	63.66 b	63.50 a	56.33 a	58.00 b	4.66 ab	4.66 a
	SA	60.66 c	61.23 b	49.33 bc	51.00 c	4.66 ab	5.00 a
	Se+ SA	65.33 a	64.18 a	58.00 a	61.66 a	4.81 a	5.00 a
Lady Rosetta	Control	41.00 f	53.00 c	38.08 e	39.66 e	3.33 c	3.66 b
	Se	53.57 d	54.00 c	49.90 bc	47.88 cd	4.00 b	4.00 b
	SA	49.20 e	50.00 d	44.48 d	46.00 d	4.33 ab	4.00 b
	Se+ SA	50.20 e	52.00 cd	51.00 b	49.33 c	4.66 ab	4.66 a

Se= selenium at 5 ppm, SA= salicylic acid at 200 ppm

Values having the same alphabetical letter(s) did not significantly difference at the 0.05 level of significance, according to Duncan's multiple range test.

Table 4: Effect of interaction between potato cultivars and foliar spray with salicylic acid and selenium on dry weight of branches and leaves of potato at 80 days after planting during 2019 /2020 and 2020 /2021growing seasons

Treatments		Dry weight of branches (g)		Dry weight of leaves (g)		Dry weight of shoots (g)	
Cultivars	Spray treatments	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season
Spunta	Control	8.93 d	10.61 d	13.04 f	15.56 d	22.00 e	26.17 g
	Se	13.41 ab	17.43 a	18.41 bc	22.62 a	31.80 b	40.05 b
	SA	10.36 cd	13.47 c	15.40 de	20.10 bc	25.80 d	33.57 e
	Se+ SA	14.55 a	17.92 a	22.32 a	23.48 a	36.90 a	41.40 a
Lady Rosetta	Control	6.33 e	9.23 e	10.97 g	11.46 e	17.30 f	20.69 h
	Se	12.78 ab	15.61 b	16.88 cd	22.32 ab	29.70 c	37.93 c
	SA	11.69 bc	13.20 c	15.12 e	18.68 c	26.80 d	31.88 f
	Se+ SA	13.45 a	15.49 b	19.31 b	20.97 ab	32.80 b	36.46 d

Se= selenium at 5 ppm , SA= salicylic acid at 200 ppm

Values having the same alphabetical letter(s) did not significantly difference at the 0.05 level of significance, according to Duncan's multiple range test

The increases in dry weight of shoots / plant were about 14.9 and 15.23 g as for the interaction between Spunta cultivar and spraying with Se+SA and 9.8 and 13.88 g for spraying Spunta with Se over the spraying Spunta with water (control) in the 1st and 2nd seasons, respectively and 15.5 and 15.77 for spraying Lady Rosetta with Se+SA and 12.4 and 17.24 g for spraying Lady Rosetta with Se over the spraying Lady Rosetta with water (control) in the 1st and 2nd seasons, respectively.

Results are agreement with Germ [36]. They showed that spraying potato plants with Se at 10 mg /l caused higher fresh and dry weight in Bard cultivar than Adora cultivar, also, Alkharpotly *et al.* [20] they found that Caruso potato cultivar gave the higher plant than Lady Rosetta under selenium foliar spray.

Yield and its Components

Effect of Cultivars: Spunta cultivar gave higher yield /plant, average tuber weight and total yield /fad. than Lady Rosetta in both growing seasons, whereas Lady Rosetta gave higher number of tubers/ plant (Table 5).

The increase in total yield /fad. were about 3.267 and 5.509 ton/fad. for Spunta cultivar over Lady Rosetta cultivar in the 1st and 2nd seasons, respectively. The increase in total yield for Spunta cultivar may be due to the increase in average tuber weight were about 169.67 g as average two growing seasons), yield / plant (735.44 g as average two growing seasons) and increased in shoot dry weight/ plant (Table 2).

These results are harmony with those obtained by Banjade *et al.* [11]; Merga and Dechassa [12] and Zaeen *et al.* [13]. They showed that differences between potato cultivars for yield and its components, 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.

Effect of Foliar Spray Treatments: Number of tubers/ plants, yield / plant, average tuber weight and total yield /fad. significantly increased by foliar spray of potato plants with Se, SA alone or in combination as compared to control (spraying with water) as shown in (Table 5).

Table 5: Effect foliar spray with salicylic acid and selenium on yield and its components of potato cultivars during 2019 /2020 and 2020 /2021 growing seasons

	Number of tubers/ plant		Average Tuber weight(g)		Yield / plant (g)		Total yield (ton/fad.)	
Treatments	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season
				Effect f cultivars				
Spunta	4.24 b	4.41 b	165.55 a	173.79 a	703.67 a	767.22 a	16.825 a	18.345 a
Lady Rosetta	5.83 a	5.41 a	97.32 b	99.30 b	568.54 b	538.30 b	13.558 b	12.836 b
				Effect of foliar spray treatments				
Control	4.66 b	4.66 c	125.81 c	130.07 c	564.41 c	594.95 d	13.484 c	14.218 d
Se	5.16 a	4.99 ab	132.38 b	138.42 ab	655.23 b	666.15 b	15.644 ab	15.905 b
SA	5.16 a	4.83 bc	130.61 b	136.74 b	645.86 b	641.31 c	15.436 b	15.327 c
Se+ SA	5.16 a	5.16 a	136.97 a	140.96 a	678.92 a	708.64 a	16.202 a	16.913 a

Se= selenium at 5 ppm , SA= salicylic acid at 200 ppm

Values having the same alphabetical letter(s) did not significantly difference at the 0.05 level of significance, according to Duncan's multiple range test.

Table 6: Effect of interaction between of potato cultivars and foliar spray with selenium and salicylic acid on yield and its components during 2019 /2020 and 2020 /2021 growing seasons

Treatments		Number of tubers/ plant		Average Tuber weight (g)		Yield / plant (g)		Total yield (ton/fad.)	
Cultivars	Spray treatments	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season
Spunta	Control	4.00 d	4.33 d	159.60 c	165.39 b	638.40 c	716.14 c	15.301 b	17.166 c
	Se	4.33 c	4.33 d	166.50 b	176.40 a	720.95ab	763.81 b	17.215 a	18.239 b
	SA	4.33 c	4.33 d	165.00 b	175.04 a	714.45 b	757.92 b	17.075 a	18.114 b
	Se+ SA	4.33 c	4.66 cd	171.10 a	178.33 a	740.86 a	831.02 a	17.707 a	19.862 a
Lady Rosetta	Control	5.33 b	5.00 bc	92.01 f	94.75 e	490.41 e	473.75 f	11.666 e	11.270 f
	Se	6.00 a	5.66 a	98.25 e	100.44cd	589.50 d	568.49 d	14.073cd	13.571 d
	SA	6.00 a	5.33 ab	96.21 e	98.44 de	577.26 d	524.69 e	13.797 d	12.540 e
	Se+ SA	6.00 a	5.66 a	102.83 d	103.58 c	616.98 c	586.26 d	14.696bc	13.964 d

Se= selenium at 5 ppm , SA= salicylic acid at 200 ppm

Values having the same alphabetical letter(s) did not significantly difference at the 0.05 level of significance, according to Duncan's multiple range test

For all treatments, average tuber weight ranged from 130.61 to 136.97 g in the 1st season and 136.74 to 140. 96 g in the 2nd season compared to control were about 125.81 to 130.07 g in the 1st and 2nd seasons, respectively and number of tuber / plant ranged from 5.16 to 5.16 in the 1st seasons and 4.83 to 5.16 in the 2nd season compared to control (were about 4.66 in both growing seasons).

Foliar spray of potato plants with Se+SA significantly increased number of tubers / plants, yield / plant, average tuber weight and total yield /fad. with no significant differences was detected with Se alone in number of tuber / plant in both growing seasons, average tuber weight in the 2nd season and total yield in the 1st seasons. This means that spraying with the mixture of Se+SA increased number of tubers/ plant, average tuber weight, yield / plant and total yield / fad. followed by spraying with Se in both growing seasons.

The simulative effect of Se+SA on total yield may be due to that increased vegetative growth (Tables 1 and 2), number of tubers/ plant, average tuber weight and yield / plant (Table 5).

Increased yield of which sprayed with Se plants suggested that Se may enhance the translocation of photoassimilates 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 [37]. The obtained results could be attributed to the role of salicylic acid in enhancing the plant defense in potato against phytoplasma attack, reduces infection symptoms, favors photosynthates translocation and improves the yield of tubers [38].

Similar results were obtained before by Alkharpotly *et al*. [20] as for selenium effect, Metwaly and El-Shatoury [26] regarding salicylic acid effect on potato.

Effect of the Interaction: The interaction between potato cultivars and foliar spray Se and SA had significant effect on number of tubers/ plant, average tuber weight, yield / plant and total yield / fad. (Table 6). The interaction between Spunta cultivar and spraying with Se+SA increased number of tubers/ plant, average tuber weight, yield / plant and total yield / fad. with no significant differences with the interaction between Spunta cultivar and spraying with Se alone with respect to yield / plant and total yield / fad. in the 1st season and average tuber weight in the 2nd seasons.

This means that spraying Spunta cultivar with Se+SA increased yield / plant, average tuber weight and total yield.

As for number of tubers/ plant, the interaction between Lady Rosetta cultivar and spraying with Se+SA increased number of tubers/ plant with no significant differences with interaction between Lady Rosetta and spraying with both Se or SA in both growing seasons. This means that spraying Lady Rosetta with Se or SA single or in combination increased the number of tubers/ plant.

Table 7: Effect of foliar spray with selenium and salicylic acid on tuber quality of potato cultivars at harvesting time during 2019/2020 and 2020/2021 growing seasons

	DM (%)		Specific gravity (g/cm^3)		Starch (%)	
Treatments	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season
			Effect f cultivars			
Spunta	18.76 b	18.25 b	1.025 b	1.028 b	17.01 b	16.92 b
Lady Rosetta	21.89 a	22.02 a	1.143 a	1.129 a	19.37 a	19.03 a
			Effect of foliar spray treatments			
Control	18.57 c	19.05 b	1.016 c	1.023 c	16.39 b	16.45 c
Se	21.02 ab	20.48 a	1.109 ab	1.094 b	18.81 a	18.38 ab
SA	21.12 a	20.60 a	1.111 a	1.105 a	18.85 a	18.22 b
Se+ SA	20.60 b	20.43 a	1.099 b	1.093 b	18.72 a	18.87 a

Se= selenium at 5 ppm , SA= salicylic acid at 200 ppm

Values having the same alphabetical letter(s) did not significantly difference at the 0.05 level of significance, according to Duncan's multiple range test.

Table 8: Effect of interaction between potato cultivars and foliar spray with selenium and salicylic acid on tuber quality of potato at harvesting time during 2019/2020 and 2020/2021 growing seasons

Treatments		Dry matter (%)		Specific gravity (g/cm^3)		Starch (%)	
Cultivars	Spray treatments	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season
Spunta	Control	17.13 e	17.65 e	0.974 f	0.985 g	15.02 e	15.72 e
	Se	19.18 cd	18.20 e	1.058 d	1.046 e	17.81 cd	17.45 c
	SA	19.00 d	18.05 e	1.000 e	1.012 f	17.10 d	16.65 d
	Se+ SA	19.75 c	19.12 d	1.069 d	1.072 d	18.14 c	17.89 c
Lady Rosetta	Control	20.01 c	20.45 c	1.059 d	1.062 d	17.76 cd	17.19 cd
	Se	22.87 a	22.76 a	1.161 b	1.142 b	19.89 ab	18.99 b
	SA	23.24 a	23.15 a	1.223 a	1.199 a	20.52 a	20.11 a
	Se+ SA	21.46 b	21.74 b	1.130 c	1.115 c	19.31 b	19.85 a

Se= selenium at 5 ppm, SA= salicylic acid at 200 ppm

Values having the same alphabetical letter(s) did not significantly difference at the 0.05 level of significance, according to Duncan's multiple range test

Spraying Spunta cultivar with Se, SA and Se+SA as well as water (control) gave the highest yield / plant and total yield /fad. than Lady Rosetta cultivar under the same treatment and control in both seasons may be due to the increase in average tuber weight for Spunta cultivar ranged from 159.60 to 171.10 g in the 1st season and 165.39 and 178.33 in the 2nd season for all treatments and control than Lady Rosetta cultivar (ranged from 92.01 and 102.83 in the 1st season and 94.75 and 103.58 g in the 2nd season for all treatments and control).

These results are in harmony with those reported by Germ [36]. They found that spraying potato Bard cultivar with Se at 10 mg Se (sodium selenate)/L significantly increased number of tuber/ plant and average tuber weight than Adora cultivar treated with the same rate of selenium also, Alkharpotly *et al*. [20] found the similar results in this concern.

Tuber Quality:

Effect of Cultivars: Lady Rosetta potato cultivar gave higher DM%, specific gravity (SG) and starch contents than Spunta cultivar (Table 7). DM% in the tuber were about 18.50 and 21.95 % (as average two growing seasons) for Spunta and Lady Rosetta cultivars, respectively and starch content were about 16.96 and 19.20 % as average two growing seasons for Spunta and Lady Rosetta cultivars, respectively.

Starch content as associate with dry matter content for this reason, the highest positive correlation was found between dry matter content and starch contents. Starch comprising 65.80 % for DM% is considered to be the main constituents of potato [39]. Starch content ranged from 11.81 % to 18.10 % [40]. The differences in starch content might be due to differences in DM in tubers as starch and DM contents of potato are directly related to each other.

These results are in agreement with those reported by Tessema *et al.* [14]; Abou El-Goud *et al*. [15] and Naiem *et al*. [16]. They showed that there were significant differences between potato cultivars regarding DM%, specific gravity and starch content.

Effect of Foliar Spray Treatments: Spraying potato plants with Se, SA alone or in combination increased DM%, specific gravity and starch contents in tubers compared to control (Table 7). DM%, specific gravity and starch contents in tubers increased with spraying potato pants with SA, followed by Se spraying in both growing seasons tested.

This assumption is supported by the recent results of Turakainen *et al*. [41] who suggested that Se led to retarded senescence of potato plants as demonstrated by elevated carbohydrate concentration in aged roots and shoots. Also, Se is a component of the non-protein portion of tubers (starch, sugar and water) and the starch content correlates positively with the rate of selenium addition [42].

These results are in according with those by Ali and Abdel-Halim [21] for selenium; Suleiman *et al.* [27] and El-Areiny *et al.* [28] concerning salicylic acid effect on potato.

Effect of the Interaction: The interaction between potato cultivars and foliar spray of Se or SA single or in combination had significant effect on DM%, specific gravity and starch contents in tubers (Table 8). The interaction between Lady Rosetta and spraying with SA increased DM%, specific gravity and starch contents in tubers. No significant differences were found with the interaction between Lady Rosetta and spraying with Se with respect to DM%. in both seasons and starch contents in the 1st season. In addition, spraying Lady Rosetta with SA, Se and Se+SA as well as the control gave the highest DM, specific gravity and starch content than Spunta cultivar under the same treatments and control in both growing seasons.

These results are in agreement with Alkharpotly *et al*. [20] they indicated that tubers of 'Lady Rosetta' cv., treated with 5 mg/l Se had the highest specific gravity and starch contents. However, the 'Caruso' tubers cv., treated with the same levels had the highest contents of TSS and ascorbic acid.

Early Blight Disease Incidence and Severity (%)

Effect of Cultivars: The results in Table (9) revealed that there were significant differences between two potato cultivars tested for disease incidence and severity (%) in both growing seasons. Leady Rosette showed lowest disease incidence (24.83 and 26.27%) with reduction percentages of (40.50 and 29.66 %) and disease Severity (17.91 and 18.18 %) for reduction percentages (24.76 and 29.18 %) in the 1st and 2nd seasons, respectively. While Spunta cultivar showed the highest disease incidence and severity %. These results are agreement with Soleimani and Kirk [43]. They showed that potato brown leaf spot was more severe on cv. Goldrush than cv. FL1879 as shown by a higher average disease severity.

Effect of Foliar Spray Treatments: Data in Table (9) indicate that, all foliar spray treatments resulted in significantly reduce in early blight disease i.e., incidence and severity (%) compared with unsprayed treatment during the two studied growing seasons.

Potato plants sprayed with Se at 5 ppm and SA at 200 ppm combination showed the lowest disease incidence of early blight (19.67 and 21.91%) with reduction percentages of 47.92 and 38.71%) and disease severity (15.66 and 17.03%) with reduction percentages of (32.02 and 37.24 % in the 1st and 2nd seasons, respectively.). Unsprayed plants showed highest values of disease incidence and severity percentages.

Selenium application could enhance photosynthetic capacity of plants, especially under different biotic stress such as cold, drought, salt stress and activation of plant defense systems agnist pathogen [44]. Salicylic acid is an important signal molecule that plays a critical role in plant defense against pathogen invasion [25]. In addition, application of salicylic acid has induced disease resistance on tomato plants against Alternaria leaf spot in glasshouse trials [29] for controlling early blight of potato plants under field conditions.

These results are harmony with those obtained by Soleimani and Kirk [43]. They showed that spraying potato plants with salicylic acid significantly inhibition of early blight than unsprayed plants. Also, Ahmed *et al.* [45] found that spraying Jerusalem Artichoke with selenium at 10ppm and salicylic acid at 30ppm was more effective in reducing the infections of *Rhizoctonia solani* and *Microphonina solani* in Jerusalem artichoke tubers than control treatment. In this regard, El-Shennawy and Abd El-All [46] showed that spraying tomato plants with salicylic acid 30 mg/l had the greatest inhibitory effect on early blight disease appearance in the two growing seasons (76% reduction in disease incidence in average two growing seasons) and in disease severity (62.0% reduction average two growing seasons) compared with unsprayed plants.

Effect of the Interaction: The interaction between cultivars and foliar spray with Se and SA singly or interacted had significant effect on early blight disease incidence and severity on potato plants grown in winter seasons (Table 10). Spraying Leady Rosetta plants with 5 ppm selenium and 200 ppm salicylic acid three times recorded the lowest values of disease incidence of early blight (17.67 and 19.35%) with reduction

Table 9: Effect of foliar spray with selenium and salicylic acid on early blight disease of potato cultivars during 2019/2020 and 2020/2021 growing seasons

	Disease Incidence (%) DI		Reduction (%) in (DI)		Disease Severity % (DS)		Reduction (%) in DS	
Treatments	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season	2019/2020 season	2020/2021 season
				Effect f cultivars				
Spunta	30.80 a	31.34 a	29.70	21.81	20.75 a	25.29 a	18.06	22.63
Lady Rosetta	24.83 b	26.27 b	40.50	29.66	17.91 b	18.18 b	24.76	29.18
				Effect of foliar spray treatments				
Control	37.67 a	35.63 a	--	--	23.00 a	26.87 a	--	---
Se	24.61 c	26.86 c	35.00	24.90	18.16 c	19.62 c	21.22	27.75
SA	29.33 b	30.82 b	22.38	13.61	20.50 b	23.42 b	10.99	12.74
Se+ SA	19.67 d	21.91 d	47.92	38.71	15.66 d	17.03 d	32.02	37.24

Se= selenium at 5 ppm, SA= salicylic acid at 200 ppm

Values having the same alphabetical letter(s) did not significantly difference at the 0.05 level of significance, according to Duncan's multiple range test

Table 10: Effect of interaction between potato cultivars and foliar spray with selenium and salicylic acid on early blight disease during 2019/2020 and 2020/2021 growing seasons

Treatments		Disease Incidence (%) DI	Reduction (%) in (DI)	Disease Severity % (DS)	Reduction (%) in DS
Cultivars	Spray treatments		2019/2020 season		
Spunta	Control	39.67 a	--	24.00 a	---
	Se	29.22 d	26.07	20.00 c	16.67
	SA	32.67 c	17.65	22.00 b	8.33
	Se+ SA	21.67 f	45.37	17.00 d	29.17
Lady Rosetta	Control	35.67 b	--	22.00 b	
	Se	20.00 f	43.93	16.33 d	25.77
	SA	26.00 e	27.11	19.00 c	13.64
	Se+ SA	17.67 g	50.46	14.33 e	34.86
			2020/2021 season		
Spunta	Control	37.47 a	--	30.46 a	--
	Se	30.27 c	19.22	23.79 c	21.90
	SA	33.15 b	11.53	26.35 b	13.49
	Se+ SA	24.47 d	34.69	20.56 d	32.50
Lady Rosetta	Control	33.79 b		23.28 c	
	Se	23.46 d	30.57	15.46 e	33.59
	SA	28.49 c	15.69	20.49 d	11.98
	Se+ SA	19.35 e	42.73	13.51 f	41.97

Se= selenium at 5 ppm, SA= salicylic acid at 200 ppm

Values having the same alphabetical letter(s) did not significantly difference at the 0.05 level of significance, according to Duncan's multiple range test.

% (50.46 and 42.73%) and disease severity (14.33 and 13.51%) with reduction percentages of (34.86 and 41.97 % in the 1st and 2 nd seasons, respectively). On the other hand, unsprayed Spunta cultivar showed the highest values of disease incidence (39.67 and 37.47 %) and (24.00 and 30.46 %) for Severity percentages in the 1st and 2nd seasons, respectively. These results are harmony with those obtained by Soleimani and Kirk [43] they reported that spraying potato FL1879 cv. with AS significantly reduced disease Index of early blight than that spraying potato Goldrush cultivar with the same treatment.

CONCLUSION

From the obtained results, it could be concluded that, spraying Spunta cultivars with Se+SA increased plant height, number of leaves per plant, number of branches/ plant, dry weight of branches, leaves and dry weight of shoots, yield / plant, average tuber weight and total yield, followed by spraying with the same cultivar with Se. While spraying Lady Rosetta cultivar with the same treatments increased tuber quality (DM%, specific gravity and starch contents) and reduced incidence and severity percentages of early blight disease.

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