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Response of Jerusalem Artichoke Growth, Yield, Quality and Disease Detection to Some Foliar Application Treatments

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Abstract: To study the effects of foliar spray with selenium (10ppm), SiO_2 (200ppm), salicylic acid (30ppm), Gabrilic acid (50ppm), benzoyl adenine (5ppm), cycocil (100ppm) and garlic extract (2000ppm) compared with control (tab water) on Jerusalem artichoke (*Helianthus tuberosus* L.) growth, tuber yield and tuber quality on the open field; a field experiment designed in randomized complete block design (RCBD) with three replicates was conducted out at the experimental farm of Environmental Studies and Research Institute, University of Sadat City during 2018 and 2019. The results revealed that, all tested treatments had a positive effect on growth, tuber yield and tuber quality compared to control in both seasons. Jerusalem artichoke plants sprayed with selenium (10ppm) gave the highest number of main and lateral stems in both seasons, stem diameter in 2018, leaf contents of phosphorus us and potassium as well as plant height in 2019. Application of sycocel at 100ppm showed the highest leaf contents of nitrogen in both seasons, leaf contents of phosphorus and potassium in 2018 and stem diameters in 2019. Benzyl adenine at the rate of 5ppm resulted in foliage fresh weights in both seasons and plant height as well as numbers of main and lateral branches in the first season. Sprayed Jerusalem artichoke with 200ppm of silicon gave the highest leaf content of total chlorophyll in both seasons. While sprayed plants with 30 ppm of salicylic acid showed the highest foliage dry weight in both seasons. As for tuber yield and quality, the results showed that Jerusalem artichoke sprayed 10 ppm of selenium gave the highest tuber weight, tuber contents of sugar and inulin in both seasons and tuber length in the second season. The application of 50 ppm of gibbrilic acid resulted in the highest tuber yield/plant in both seasons, number of tuber/plant in the first season and tuber diameter in the second season. In the same way sprayed salicylic acid at the rate of 30 ppm showed the highest tuber length and diameter in 2018. Also benzyl adenine gave the highest number of tubers/plant in the second season. Finally, garlic extract was more effective in reducing the infections of *R. solani* and *M. solani* in Jerusalem artichoke tubers than all the other treatments and the control.

Key words: Jerusalem artichoke · Selenium · Silicon · Salicylic acid · Growth regulators

INTRODUCTION

Jerusalem artichoke is a plant native to North America. It has a number of advantageous characteristics over traditionally agricultural crops, including high growth rate, good tolerance to frost, drought and poor soil, strong resistance to pests and plant diseases, with minimal to zero fertilizer requirements [1]. Conventionally, Jerusalem artichoke has been used for food or animal feed [2] and for the past two decades, alternative uses have been explored especially for the production of functional food ingredients such as inulin, oligo-fructose and fructose [3]. It is also found that some bioactive ingredients can be extracted from its leaves and stems, which creates an opportunity for applications in the pharmaceutical sector [4]. More recently, a renewed and rapidly growing interest is for the use of Jerusalem artichoke tubers, which are rich in inulin, as raw materials for bioethanol production [5]. In Egypt Jerusalem artichoke as any new crop did not have the ability to competitive the old crops in fertile lands so the crop was cultivated in new and poor lands. In these lands Jerusalem artichoke will need to manually fertilizers supported to complete their need from fertilizers. Several studies

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explained the role of selenium in higher plants such as Sun *et al.* [6] who indicated that Se increase uptake and translocation of some mineral elements and promoting K^+ uptake. Se application could enhance photosynthetic capacity of plants, especially under different biotic stress, such as cold, drought and salt stress [7]. Si is one of the most important elements for the plant life [8] where Si application improved growth and yield through improving plant water status, modification of ultrastructure of leaf organelles, activation of plant defense systems and mitigation of free radicles [9].

In addition to growth regulators such as gibbrilic acid, benzyl adenine and cycocel could as well as salicylic acid help the plant to increase their growth, yield and quality. Salicylic acid (SA) is considered as a hormone-like substance, which plays an important role in the regulation of plant growth and development, seed germination, fruit yield, glycolysis, flowering and heat production in plants. While, gibberellic acid is a vegetarianism hormone which produce by late leaves and growing caps in the roots and stems. It has many applications on vegetable crops, one of them is extend of period of storage by delaying the senescence. [10]. As for benzyl adenine Sardoei *et al.* [11] revealed that benzyl adenine (BA) is used to regulating plant growth through increased meristimatic activity due to enhance cell division and elongation. Regarding to cycocel Anosheh *et al.* [12] stated that the beneficial effects of cycocel in reducing the drought stress injury could be related to improving stomatal regulation, maintaining leaf chlorophyll content, increasing water use efficiency and stimulating root growth.

Finally, garlic extract as all essential plant material almost used as safe alternative to the chemical pesticides for reduce the environmental hazards. In this point Avato *et al.* [13] suggested that volatile compounds of garlic such as diallylmonosulfide, diallyldisulfide and diallyltrisulfide were also found to have antimicrobial properties.

The main objectives of this study were to evaluate some environmental friendly substances to improve growth, tuber yield and tuber quality and reduce fungal diseases of Jerusalem artichoke plants.

MATERIALS AND METHODS

Materials: To study the effects of foliar spray with selenium (10ppm), SiO2 (200ppm), salicylic acid (30ppm), Gabrilic acid (50ppm), benzoyl adenine (5ppm), cycocil (100ppm) and garlic extract (2000ppm) compared with control (tab water on Jerusalem artichoke (*Helianthus tuberosus* L.) cv. Fuseau growth, tuber yield and tuber quality on the open field. A field experiment designed in a strip plot design with three replicates was conducted at the experimental farm of Sadat City University, El-Menofya Governorate, Egypt during 2018 and 2019.

Methods

The Field Experiment: Whole, Jerusalem artichoke (Helianthus tuberosus L.) tubers were used within a range of 20 to 25 g and sown on April 1th and 4th in both seasons, respectively. All treatments were separated randomly in plots each plot was 6 meters long and 6 meters width each plot consisted of 5 ridges. Each ridge was 6 meters long and 120 cm width with plot area of $36m^2$. Tubers were being planted on one side of the ridge at 50 cm hill spacing with one tuber per hill.

All treatments were applied as a foliar spray with the recommended dose three times: the first one 75 days from sowing, the second one was 90 days after sowing and the third was 105 days after sowing. Soil physical and chemical properties of the experimental site and analysis of irrigation water are presented in Table 1 and 2.

Studied Characters Were

Vegetative Growth Characteristics: At flower initiation stage (at 120 days after planting), five random plants from each experimental plot were picked up to determine:

- Plant fresh Weight (g): the average weight (g) of five fresh plants chosen randomly from each plots.
- Plant dry Weight (g): the average weight (g) of five fresh plants chosen randomly from each plots after air dried for one week at room temperature.
- Stem diameter (cm): the average diameters (cm) of five plant main stems chosen randomly from each plots.

At harvest time, (185 days after planting), five random plants from each experimental plot were picked up to determine.

- Plant height (m): the average distance from soil surface to the top of the terminal bud of the main stem (m).
- Number of main branches/plant: the average branches number of five plants randomly chosen from each plot.
- Number of lateral branches/plant: the average lateral branches number of five plants randomly chosen from each plot.

Table 1: Soil physical and chemical properties of the experimental site

Physical properties											
Sand %		Silt %				Clay %					Texture
83		10				7					Sandy loamy
Chemical properties											
		Soluble salts (mg/100g)									
PH	EC dS/m	Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	HCO_3^{--}	CO_3^{--}	SO_4^-	O.M	CO_3%
8.17	1.114	3.3	0.18	1.2	1.2	7.4	1.9	0	3.4	0.35	1.7

Table 2: Analysis of irrigation water

												Fe	Zn	Mn	Cu
pH	EC dS/m	Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^{--}	HCO_3^{--}	Cl^-	SO_4^-	SAR	TDS	ppm			
7.98	1.26	4.2	2.6	6.5	0.2	0	4	7	2.5	3.5	896	0.11	0.18	<0.01	<0.01

Tuber Yield and Yield Components Traits: At harvest, five guarded plants from each plot were chosen randomly to recorded following traits:

- Number of tubers/ plant: the average count of tuber of five guarded plant.
- Average tuber length (cm): the average length of tubers of five guarded plant for each plot.
- Average tuber diameter (cm): the average diameters of tubers of five guarded plant for each plot.
- Average tuber weight (g): the average weight of tubers of five guarded plant for each plot.
- Tuber yield/plant (g): the average weight of tubers/five guarded plant for each plot.
- Chemical traits:

- Total chlorophyll content in leaf: The estimates were made according to Guthyyie, [14]
- N.P.K contents in leaf.

N, P and K Determinations: Chemical analysis of leaf N, P and K mineral contents were determined after harvest. Total nitrogen was assayed according to Chapman and Pratt [15] and Cottenie *et al.* [16] using the micro kjeldahle apparatus. Phosphorus us was determined by spectrophotometers as Cottenie *et al.* [16]. Potassium was determined photometrically, using flame photometer according to Jackson [17]. Mn and Fe were determined by flame photometer also.

- Sugars percentage: total carbohydrates and reducing sugars were colormetrically determined by the method described by Shales and Schales [18].
- Inulin content: was determined in tubers according to the method of Winton and Winton [19].

Pathogenic Test: *Rhizoctonia solani* and *Microphonina solani* were assessed as disease incidence and reduction by aye vision as follow according to Tsror (Lahkim) *et al.* [20]:

$$Disease\ incidence\ \% = \frac{Number\ of\ infected\ turbers\ in\ the\ treatment}{Total\ number\ of\ turbers\ in\ the\ same\ treatment} x100$$

$$Reducion\ \% = \frac{Disease\ severity\ in\ control\ - Disease\ severity\ in\ treatment}{Disease\ serverity\ in\ control} x100$$

Statistical Analysis: Results were expressed as mean. The data were analyzed by using one-way ANOVA followed by LSD test through SPSS 16 (version 4). The treatments means were compared using least significant difference (LSD) tested at significant levels of 5% as described by Gomez and Gomez [21].

RESULTS AND DISCUSSIONS

Effect of Some Foliar Spray Treatments on Jerusalem Artichoke Growth Characters: The results presented in Table 3 confirmed that there was a significant effect of all pre-harvest treatments on all the vegetative growth traits of Jerusalem Artichoke plants during the two seasons of this study compared to the control.

Plant Height: The results in Table 3 showed that the highest lengths of Jerusalem plants in 2018 were obtained by field spraying of the plants with 50 ppm BA (2.40 m), followed by 50 ppm CCC (A. 37 m), then 30 ppm SA(2.28 m) and 2000 ppm Si with an average of 2.10 m. As for the second season, all treatments differed in their effect on plant lengths, spraying plants with 10 ppm of Se resulted in the highest average plant height (2.38 m) followed by spraying 2000 of garlic extract (2.30 m) then

Table 3: Effect of some pre-harvest foliar spray treatments on Jerusalem Artichoke growth during 2018 and 2019 seasons

Treatments	Average plant length (m)	Stem Diameter (cm)	Number of Main branch	Number lateral branches	Canopy fresh weight (kg)	Canopy dry weight (kg)
			1st season			
Control (tap water)	1.210d	6.33c	1.00d	15.00 e	0.150 d	0.112 g
Foliar spray Se 10 ppm	1.717c	8.33a	1.67c	33.33 bc	0.367bc	0.183 e
SiO2 2000 ppm	2.103ab	6.67c	1.67c	47.33 a	0.372bc	0.223 d
Salicylic acid 30 ppm	2.280ab	7.67b	2.33ab	36.33 b	0.567a	0.367 a
GA3 50 ppm	2.000bc	7.67b	2.00bc	30.33 c	0.300c	0.154 f
BA 5 ppm	2.400a	7.67b	2.67a	23.00 d	0.370bc	0.182 e
CCC 50 ppm	2.367a	7.67b	1.67c	31.33 c	0.567a	0.353 b
Garlic extract 2000 ppm	2.050b	7.33b	2.67a	32.00 c	0.500ab	0.282 c
			2nd season			
Control (tap water)	1.653d	7.00b	1.20d	18.00 e	0.265c	0.173 f
Foliar spray Se 10 ppm	2.380a	7.67ab	1.80 c	33.33c	0.317bc	0.200 e
SiO2 2000 ppm	2.140ab	7.67ab	1.33 d	51.00 a	0.533a	0.287 c
Salicylic acid 30 ppm	1.873cd	7.33ab	2.67 b	38.67 b	0.470ab	0.383 a
GA3 50 ppm	1.893cd	7.33ab	1.80 c	28.00 d	0.543a	0.367 b
BA 5 ppm	1.940bc	7.67ab	3.00 a	21.70 e	0.307bc	0.217 d
CCC 50 ppm	2.290a	8.33a	1.80 c	29.00 d	0.470ab	0.281 c
Garlic extract 2000 ppm	2.303a	7.33ab	3.00 a	30.33 cd	0.353bc	0.183 f

Means within each column followed by the same letter are not significantly different at normal probability level 0.05 (Duncan's range test)

spraying with 50 ppm of cycocel (2.29m) and spraying 2000 ppm of silicon with an average of 2.14m. In contrast, the shortest plants appeared under the control treatment with averages of 1.21 and 1.65 m in both seasons, respectively.

Stem Diameter: The data presented in Table 3 confirmed that there was no significant effect of the treatments on Jerusalem plant stem diameter during the two seasons of this study. Nevertheless, spraying 10 ppm of selenium resulted in the highest stem diameter in the first season (8.33 cm), while spraying 50 ppm of CCC resulted in obtaining the highest stem diameter in the second season with an average of 8 33 cm, but this value did not differ significantly from the others parameters except control which gave the lowest values of the stem diameter with averages of 6.33 and 7.00 in both seasons respectively.

Number of Main Branches: Spraying 5 ppm of BA or 2000 ppm of garlic extract resulted in the highest number of main branches, with averages of 2.67 and 3.00 for both treatments, followed by spraying of 30 ppm of salicylic acid (2.33 and 2.67) in both seasons, respectively. On the other hand, the lowest numbers of the main branches were under the control treatment with averages of 1.00 and 1.20 in the first and second season, respectively (Table 3).

Number of Lateral Branches: It was clear from the results in Table 3 that sprayed Jerusalem plants with 2000 ppm of silicon gave the highest number of lateral branches (47.33 and 51.00), followed by spraying with 30 ppm of salicylic acid (36.33 and 38.67) then spraying with 10 ppm of selenium with averages of 33.33 and 33.33 in both seasons, respectively. On the other hand, the lowest numbers of lateral branches were obtained under the control treatment, with averages of 15.00 and 18.00 in the first and second season, respectively.

Canopy Fresh Weight: The results presented in Table 3 confirmed that the highest fresh weight of the Jerusalem canopy was obtained from spraying 5 ppm of BA (0.57 and 0.54 kg) and spraying 30 ppm of salicylic acid with averages of 0.57 and 0.53 kg in both seasons, respectively. On the contrast of this, the Jerusalem plants under the control gave the lowest canopy fresh weight with averages of 0.15 and 0.27 kg in both seasons, respectively.

Canopy Dry Weight: The results showed in Table 3 that there was a significant difference in the effect of the treatments on the dry weight of the Jerusalem plant during the two seasons of the study. In the first season, spraying the Jerusalem plants with 50 ppm of salicylic acid resulted in the highest canopy dry weight (0.367 kg) followed by spraying 50 ppm of Cycocel with an average of 0.353 kg. The superiority of salicylic acid continued in the second season where, it give the highest canopy dry weight (0.383 kg), followed by a spray of 50 ppm of gibberellic acid with an average of 0.367 kg. On the other hand, Jerusalem plants, under the control treatment, gave the lowest weight of canopy, with averages of 0.112 and 0.173 kg in the first and second seasons, respectively.

In this study spraying Jerusalem plant with 10 ppm of selenium significantly increased plant height, stem diameter and branches number. This finding is in agreed with those by Turakainen *et al.* [22] showed that at the high addition levels (0.075 and 0.9 mg kg^{-1} quartz sand), Se had some positive effects on the growth of potato cv. sprouts. Malik *et al.* [23] who stated that, shoot growth was enhanced by 24 and 27% in mungbean plants were grown hydroponically in the presence of selenium at 0.5 and 0.75 ppm, respectively. Also, Boghdady *et al.* [24] showed that foliar application with 10 ppm selenium significant improvement effects on vegetative growth of faba bean.

As for Si the results indicated that silicon had a positive effect on leaf content of total chlorophyll, plant height and number of branches/plant. In the same way Salim, [25] reported that Silicon play an important role in enhancing the growth and yield of maize. Also, Abd El –Gawad *et al.* [26] indicated that spraying potassium silicate at 2000 ppm on potato plants increase leaf area. Moussa and Shama, [27] revealed that, spraying potato plants with potassium silicate solution significantly gave positive results on characteristics of plant height (cm), foliage fresh weight (g) compared to non-spraying, while number of branches/plant was not affected by spraying.

In this study, salicylic acid increase leaf content of chlorophyll and potassium as well as plant height, number of branches, foliage fresh and dry weight. In the same line Youssef, [28] revealed that applied of 150 ppm of SA in potato plants increased the No. main stems, plant height (cm). Increasing concentrations of SA reduced plant height (cm), shoot fresh weight (g/plant) and No main stems/plant. Also, Metwaly and El-Shatoury [29] exhibited that, in potato plants vegetative growth parameters (Plant height, leaves number, leaves area, number of main stem and foliage fresh weight per plant) El-Tohamy *et al.* [30] reported that foliar application of SA improved growth, productivity, quality as well as some physiological parameters of Jerusalem artichoke plants exposed to drought stress.

Our findings indicated that gibbrilic acid showed a positive effect in increasing leaf content of chlorophyll, nitrogen, phosphorus and potassium as well as foliage dry weight. Similar results were obtained by Abd El-Aal *et al.* [31] reported that GA3 increase plant growth such as numbers of shoots and/or leaves as well as fresh and dry weight of potato. EL-Abagy *et al*. [32] reported that fresh and dry weights of the 4th leaf of globe artichoke cv. 'Herious' was significantly correlated with the applied concentration of the GA3 compare to untreated (control) plants. Also, Ruttanaprasert *et al.* [33] who revealed that GA at all concentrations increased shoot dry weight of Jerusalem artichoke.

Benzyl adenine significantly increases plant height, branches number and foliage fresh weight. Similar results were obtained before by, Sardoei *et al.* [11] who indicated that the effect of benzyl adenine BA ($p<0.05$) on No. of vines, length of side branch, petiole length and plant fresh and dry weight were positive and significant. Similarity, Nassour and Boissa [34] showed the positive effect of the benzyl aminoporine on the development of the vegetative variety (length of plant, number of leaves, area of paper. Also, Brengi [35] revealed that spraying okra plants with Benzyl amino purine (BAP), significantly, increased plant height, number of leaves, number of branches and leaf area plant-1 compared to the untreated control.

Our results revealed that cycocel significantly increase leaf contents of nitrogen, phosphorus and potassium as well as stem diameter, number of branches and foliage dry weight. These results are in the same line with those by Devi [36] who reported that cycocel, one of the growth retardants, has been widely applied for chemical manipulation of growth and development of various crops and it causes retardation of vegetative part. Kumar *et al.* [37] stated that sprayed potato with cycocel at 3000 ppm increased the number of branches.

Effect of Some Foliar Spray Treatments on Tuber Yield of Jerusalem Artichoke: The present results in Table 4 showed that there was a significant effect of all foliar spray treatments on all the tuber characteristics and tubers yield per plant in both seasons of this study.

Tuber Length: The data presented in Table 4 and confirmed that spraying Jerusalem Artichoke plants with one of the three treatments 30 ppm salicylic acid or 50 ppm gibberlic acid or 50 ppm benzyladenine acid gave the longest of Jerusalem tubers in the first season with averages of 12.89, 12.89 and 13.06 cm for the three treatments, respectively. Whereas, spraying Jerusalem plants with 10 ppm of selenium, 2000 ppm of silicon and 50 ppm of cycocel resulted in the longest Jerusalem tubers in the second season with averages of 13.08, 12.94 and 13.30 cm for the three treatments, respectively. On the contrary, Jerusalem plants under control treatment, gave the shortest tubers (10.64 and 10.17 cm) in both seasons, respectively.

Table 4: Effect of some pre-harvest foliar spray treatments on Jerusalem artichoke tuber yield and tuber quality during 2018 and 2019 seasons

Treatments	Tuber length (cm)	Tuber diameter (cm)	Average tuber weight (g)	Number of tuber/plant	Tuber yield/ plant (kg)
			1st Season		
Control (tap water)	10.64d	6.94e	33.577 d	10.40 f	0.349 f
Foliar spray Se 10 ppm	11.79b	7.83c	59.734 a	18.80 d	1.123 c
SiO2 2000 ppm	11.31c	7.56d	57.887 ab	21.80 c	1.262 b
Salicylic acid 30 ppm	12.89a	8.94a	56.547 b	22.60 b	1.278 b
GA3 50 ppm	12.89a	7.89c	55.331 b	27.20 a	1.505 a
BA 5 ppm	12.17b	8.00c	58.070 ab	11.40 f	0.662 f
CCC 50 ppm	13.06a	8.56b	49.937 c	15.80 e	0.789 e
Garlic extract 2000 ppm	11.86b	7.56d	57.313 ab	16.00 e	0.917 d
			2nd Season		
Control (tap water)	10.17e	7.11d	31.610 g	11.60 e	0.462 f
Foliar spray Se 10 ppm	13.08a	8.05ab	63.166 a	14.60 d	1.087 c
SiO2 2000 ppm	12.94a	7.78c	55.578 cd	17.20 c	1.223 b
Salicylic acid 30 ppm	12.56b	7.89bc	53.381 de	22.00 b	1.238 b
GA3 50 ppm	11.83c	8.17a	51.076 e	23.20 b	1.461 a
BA 5 ppm	11.44d	8.00ab	58.243 bc	28.60 a	0.676 e
CCC 50 ppm	13.30a	7.89bc	43.633 f	17.40 c	0.759 e
Garlic extract 2000 ppm	12.03c	7.72c	59.774 b	14.80 d	0.885 d

Means within each column followed by the same letter are not significantly different at normal probability level 0.05 (Duncan's range test)

Tuber Diameter: The results in Table 4 and revealed that, the highest tuber diameters were obtained in the first season under 50 ppm salicylic acid (8.94 cm) followed by 50 ppm of cycocel (8.56cm) while, the spraying of 50 ppm gibberellic acid resulted in significant increase on tuber diameter compared to control in the second season where it scored the highest tuber diameter (8.17 cm) followed by 10 ppm selenium (8.05cm) then 5 ppm benzyladenine acid with an average of 8.00 cm. on the other side Jerusalem plants under the control treatment showed the lowest tuber diameters with averages of 6.94 and 7.11 in both seasons, respectively.

Average Tuber Weight: The presented data in Table 4 confirmed that, sprayed Jerusalem plants with 10 ppm selenium resulted in the highest increase in average tuber weight (59.73 and 63.17 g) followed by 5 ppm benzyladenine acid (58.07 and 58.24 g) then 2000 ppm garlic extract (57.31 and 59.77g) in both seasons, respectively. In the same line, the result indicated that Jerusalem plants sprayed 2000 ppm silicon had high tuber weight with an average of 57.89 g in the first season only. On the other hand, Jerusalem plants under the control treatment gave the lowest tuber weight with averages of 33.58 and 31.61 g in the 1st and 2nd seasons, respectively.

Number of Tubers/Plant: The data shown in Table 4 indicated that, the highest number of tubers/plant were obtained when spraying Jerusalem plants with 50 ppm of gibberellic acid (27.20) followed by 30 ppm of salicylic acid (22.60) then 2000 ppm of silicon (21.80) in the first season and from spraying plants with 5 ppm benzyladenine acid (28.60) followed by 50 ppm gibberellic acid (23.20) then 30 ppm salicylic acid (22.00) in the second season. On the contrast of this, Jerusalem plants under control treatment showed the lowest number of tubers /plant with averages of 10.40 and 11.60 in both seasons, respectively.

Tuber Yield/Plant: The results in Table 4 confirmed that, the highest tuber yield/plant were obtained from Jerusalem plants sprayed with 50 ppm gibberellic acid (1.51 and 1.46 kg) followed by 30 ppm SA (1.28 and 1.24 kg) then sprayed 2000 ppm Si with averages of 1.26 and 1.22 kg in both seasons, respectively. On the other hand the lowest tuber yield/plant were obtained from Jerusalem plants under the control treatment with averages of 0, 35 and 0.46 kg in the first and second seasons, respectively.

Our results indicated that silicon significantly increased tuber yield, yield components. Similar results were obtained before by, Soratto *et al*. [38] who, found that silicon foliar application increased potato tuber yield. Moussa and Shama, [27] showed that spraying potato plants with potassium silicate solution significantly improved total tubers yield/feddan (ton) compared to non -spraying treatment. Increasing number of spraying to three times with potassium silicate solution significantly stimulated total tubers yield/feddan (ton) and average tuber weight (g). In the same line benzyl adenine significantly increased tuber diameter, tuber weight, tuber yield/plant, tuber content of total sugar and inulin. In the same way of our results, Liu and Xie [39] declared that benzyl aminoporine increased the size and weight of tubers and a linear relationship was observed between the size and weight of potato. Moreover, Roosta *et al.* [40] reported that diameter and tuber yield of potato plants were increased by spraying of benzyl aminoporine. Lahijani *et al.* [41] indicated that tuber yield per plant, mean tuber weight and tuber number were stimulated by foliar spraying of plants with benzyl aminoporine compared with the untreated ones. García *et al.* [42] indicated that the Appling of benzilaminopurine increased the number of tubers, which were larger and heavier than those of the control treatment. In this study gibbrilic acid increased tubers length, diameters, numbers and tuber yield/plant and this may to the effect gibberellic acid (GA3) on many mechanisms of plant growth including stem elongation, flowering and fruit development [43]. GA3 increased also, plant height, number of leaves and these increase help the artichoke plants yield [44]. Alexopoulos *et al.* [45] observed that sprayed GA3 30 days after planting caused a significant increase the number of tubers per plant. Plants that had been treated with GA3 early in the growth cycle consistently produced more elongated tubers yields than control. In addition, Alexopoulos *et al.* [46] reported that foliar application of GA3 increased the number of tubers formed per plant, but reduced mean tuber size. Chindi and Tsegaw, [47] showed that GA3 application affected potato tuber yield and quality. About 10% increment in average tuber weight was observed by haulm application of 750 or 1000 ppm where as 5% increment was obtained by dipping treatments of 40 or 50 ppm GA3 solutions. Haulm applications of 750 and 1000 ppm GA3 increased tuber yield per hill by about 26% and 45%, respectively as compared to untreated tubers. Selenium play an important role in carbohydrates accumulates in potato tubers and many other tuber crops. Also, Se significant increase in potato yield with addition of selenium up to a rate of 0.3 mg selen/kg substrate [48]. In this study, selenium had a positive effect in tuber diameter and weight. Yassen *et al.* [49] found that Se increased vegetative growth and tuber yield, protein content and starch percentage in potato. Bideshki *et al.* [50] indicated that selenium spraying increased potato tuber yield (24%), nitrate reductase activity (47%), tuber selenium (5.4 fold) and tuber starch (42%).

Effect of Some Foliar Spray Treatments on Jerusalem Artichoke Chemical Characters

Leaf Content of Total Chlorophyll: The results showed in Table 5 that there was a significant difference in the effect of pre-harvest treatments on leaf content of total chlorophyll in both seasons. Sprayed Jerusalem plants with 2000 ppm silicon gave the highest leaf chlorophyll content (12.57 mg / 100 g f.w.), followed by spraying 50 ppm of GA acid (11.68 mg / 100 g f.w.) then sprayed 30 ppm of Salicylic acid, with an average of 10.38 mg / 100 g f.w., in the first season. For the second season, spraying of 30 ppm of salicylic acid resulted in the highest leaf content of total chlorophyll (13.70 mg / 100 g f.w.), followed by spraying 2000 ppm of silicon (13.65 mg / 100 g f.w.) then sprayed 50 ppm gibbrilic acid with an average of 12.33 mg /100g f.w. On the other hand, the lowest Jerusalem leaves contents of total chlorophyll were under the control treatment with averages of 6.08 and 8.92 mg / 100 g f.w. in both seasons respectively, but these values did not differ significantly with spraying both 50 ppm of CCC and 2000 ppm of garlic extract in both seasons.

Leaf Content of Nitrogen: The presented data in Table 5 indicated that, Jerusalem plants sprayed with 50 ppm Cycocel gave the highest leaf contents of nitrogen (2.80 and 2.26 mg/100g fw) in both seasons, respectively followed by 2000 ppm garlic extract (2.47 mg/100g fw) in the first season and also, followed by 5 ppm benzyladenine acid (2.24 mg/100g fw) then 50 ppm gibberellic acid (2.08 mg/100g fw) in the second season. On the other side Jerusalem plants under the control treatment had the lowest leaf contents of nitrogen with averages of 1.30 and 1.49 mg/100g fw in the first and second seasons, respectively.

Leaf Content of Phosphorus: The presented data in Table 5 confirmed that, Jerusalem plants sprayed with 50 ppm Cycocel had the highest leaf content of phosphorus (0.48 mg/100g fw) followed by sprayed 2000 ppm garlic extract (0.43 mg/100g fw) then 50 ppm gibberellic acid (0.42 mg/100g fw) in the 1st season. While, sprayed the four treatments 10 ppm selenium, 5 ppm benzyladenine acid, 50 ppm Cycocel and 2000 ppm garlic extract gave the highest leaf contents of phosphorus in the 2nd season with averages of 0.46, 0.48, 0.44 and 0.40 mg/100g fw for the four treatments, respectively. In the contrast of this Jerusalem plants under the control treatment showed the lowest leaf contents of phosphorus with averages of 0.33 and 0.32 mg/100g fw in both seasons, respectively.

Leaf Content of Potassium: The presented data in Table 5 confirmed that, Jerusalem plants sprayed with one of the four treatments 10 ppm selenium, 2000 ppm silicon, 50 ppm Cycocel and 2000 ppm garlic extract showed the

Table 5: Effect of some pre-harvest foliar spray treatments on Jerusalem Artichoke chemical characters during 2018 and 2019 seasons

Treatments	Chlorophyll (mg/100g fw.)	Leaf content of N (mg/100g fw)	Leaf content of P (mg/100g)	Leaf content of K (mg/100g)	Tuber content of Total sugar (mg/100g)	Tuber content of Inulin (g/100g)
				1st season		
Control (tap water)	6.08f	1.30f	0.32d	2.96b	4.02 e	6.44 f
Foliar spray Se 10 ppm	9.05d	1.59de	0.41bc	3.17ab	7.24 a	18.96 a
SiO2 2000 ppm	12.57a	1.98c	0.37cd	3.09ab	7.01 ab	18.38 b
Salicylic acid 30 ppm	10.38c	1.47ef	0.33d	2.99b	6.85 bc	17.95 cd
GA3 50 ppm	11.68b	1.76cd	0.42bc	2.99b	6.71 c	17.57 d
BA 5 ppm	9.61d	1.63de	0.38b-d	3.32a	7.03 ab	18.43 b
CCC 50 ppm	6.35ef	2.80a	0.48a	3.32a	5.98 d	9.58 e
Garlic extract 2000 ppm	6.82e	2.47b	0.43ab	3.18ab	6.95 bc	18.19 bc
				2nd season		
Control (tap water)	8.92f	1.49d	0.32c	3.96d	3.53 f	6.07 h
Foliar spray Se 10 ppm	10.80d	1.67cd	0.46ab	3.36ab	7.15 a	20.05 a
SiO2 2000 ppm	13.65a	1.77c	0.39bc	3.24bc	6.28 bc	17.64 d
Salicylic acid 30 ppm	13.70a	1.66cd	0.38bc	3.14cd	6.04 c	16.95 e
GA3 50 ppm	12.33b	2.08ab	0.39bc	3.56a	5.78 d	16.21 f
BA 5 ppm	11.57c	2.24a	0.48a	3.28bc	6.59 b	18.49 c
CCC 50 ppm	9.83e	2.26a	0.44ab	3.30bc	4.87 e	8.37 g
Garlic extract 2000 ppm	9.00f	1.89bc	0.40a-c	3.40ab	6.75 b	18.98 b

Means within each column followed by the same letter are not significantly different at normal probability level 0.05 (Duncan's range test)

highest leaf contents of potassium in the first season with averages of 3.17, 3.09, 3.32 and 3.18 mg/100g fw for the four treatments, respectively. While, sprayed the three treatments 10 ppm selenium, 50 ppm gibberellic acid and 2000 ppm garlic extract gave the highest leaf contents of potassium in the 2nd season with averages of 3.36, 3.56 and 3.40 mg/100g fw for the three treatments, respectively. In the contrast of this Jerusalem plants under the control treatment showed the lowest leaf contents of potassium with averages of 2.96 and 1.88 mg/100g fw in both seasons, respectively.

Tuber Content of Total Sugar: The data in Table 5 showed that, the highest sugar contents in Jerusalem tuber were obtained when the plants sprayed with 10 ppm selenium (7.24 and 7.15 mg/100g fw), 2000 ppm silicon (7.01 and 6.28 mg/100g fw), 5 ppm benzyladenine acid (7.03 and 6.59 mg/100g fw) and 2000 ppm garlic extract (6.95 and 6.75 mg/100g fw) in both seasons, respectively. In the contrast of this Jerusalem plants under the control treatment showed the lowest tuber contents of total sugar with averages of 4.02 and 3.53 mg/100g fw in both seasons, respectively.

Tuber Content of Inulin: The data in Table 5 indicated that, the highest inulin contents in Jerusalem tuber were obtained when the plants sprayed with 10 ppm selenium (18.96 and 20.05 g/100g fw), 2000 ppm silicon (18.38 and 17.64 g/100g fw), 5 ppm benzyladenine acid (18.43 and 18.49 g/100g fw) and 2000 ppm garlic extract (18.19 and 18.98 g/100g fw) in both seasons, respectively. In the contrast of this Jerusalem plants under the control treatment showed the lowest tuber contents of inulin with averages of 6.44 and 6.07 g/100g fw in both seasons, respectively.

In this study spraying Jerusalem plant with 10 ppm of selenium significantly increased leaf content of phosphorus. This finding is in agreed with those by Boldrin *et al.*, (2013) observed that the soil application of Se showed higher content of P on rice.

As for silicon the results indicated that silicon had a positive effect on leaf content of total chlorophyll. In the same way Gong and Chen, (2012) found that, silicon can increase the photosynthesis, in wheat. Abd El–Gawad *et al.* [26] indicated that spraying potassium silicate at 2000 ppm on potato plants increase leaf area and chlorophyll fluorescence readings.

In this study, salicylic acid increase leaf content of chlorophyll and potassium as well as plant height, number of branches, foliage fresh and dry weight. In the same line Youssef, [28] revealed that pigment contents (chl a, chl b and carotenoid) were increased with the lowest concentration (100 ppm) of SA. Also, Metwaly and El-Shatoury [29] exhibited that, in potato plants leaves chemical composition (N, P, K, chlorophyll a, chlorophyll b and carotenoids increased with the increase of SA level up 100 ppm. El-Tohamy *et al.* [30] reported that foliar application of SA improved growth, productivity, quality

Table 6: Effect of some foliar spray treatments on *Rhizoctonia solani* and *Microphonina solani* Disease incidence % and reduction % measured on Jerusalem Artichoke tubers after harvest during 2018 and 2019 seasons

	Rhizoctonia solani		*Microphonina solani*	
Treatments	Disease incidence %	Reduction %	Disease incidence %	Reduction %
		1st season		
Control (tap water)	13.35 A		9.81 A	
Foliar spray Se 10 ppm	7.10 B	46.81 E	7.20 B	26.61 E
SiO2 2000 ppm	6.88 B	48.46 E	5.88 C	40.06 C
Salicylic acid 30 ppm	6.03 C	54.82 D	6.03 C	38.52 C
GA3 50 ppm	5.99 C	55.15 CD	6.65 BC	32.20 D
BA 5 ppm	5.73 C	57.10 C	4.44 D	54.77 B
CCC 50 ppm	5.33 CD	60.04 B	4.54 D	53.76 B
Garlic extract 2000 ppm	4.74 D	64.52 A	3.21 E	67.33 A
	2nd season			
Control (tap water)	12.58 A		8.11 A	
Foliar spray Se 10 ppm	7.40 B	41.20 F	6.87 B	15.35 E
SiO2 2000 ppm	7.17 BC	43.02 E	6.73 B	16.99 E
Salicylic acid 30 ppm	6.28 CD	50.07 D	6.28 BC	22.55 D
GA3 50 ppm	6.13 D	51.26 CD	5.30 C	34.64 C
BA 5 ppm	5.96 D	52.60 C	5.63 C	30.64 C
CCC 50 ppm	5.56 D	55.83 B	4.28 D	47.29 B
Garlic extract 2000 ppm	4.93 E	60.81 A	2.83 E	65.15 A

Means within each column followed by the same letter are not significantly different at normal probability level 0.05 (Duncan's range test)

as well as some physiological parameters of Jerusalem artichoke total chlorophyll content and relative water content in plants compared to control plants when subjected to drought stress.

Our results revealed that cycocel significantly increase leaf contents of nitrogen, phosphorus and potassium. These results are in according with those by Devi [36] who reported that cycocel, one of the growth retardants, has been widely applied for chemical manipulation of growth and development of various crops and it causes retardation of vegetative part while photosynthetic activities are accelerated at appreciable rate.

Our results indicated that silicon significantly increased tuber contents of total sugars and inulin. Similar results were obtained before by, Soratto *et al*. [38] who, found that silicon foliar application increased potato tuber dry matter content. Moussa and Shama, [27] showed that spraying potato plants with potassium silicate solution had significant positive effects on both tubers' quality characteristics (dry matter, total sugars and starch percentages).

In the same line benzyl adenine significantly increased tuber tuber content of total sugar and inulin. In the same way of our results, Ramawat and Merillon, [51] reported that benzyl aminoporine stimulates starch biosynthesis by activating enzymes of potato tubers.

Selenium play an important role in carbohydrates accumulates in potato tubers and many other tuber crops. Also, Se significant increase in potato yield with addition of selenium up to a rate of 0.3 mg selen/kg substrate [48]. In this study, selenium had a positive effect in tuber content sugar and inulin contents. The increase of total sugar in tubers under selenium application may due that about 30% of total Se in potato tubers is a major protein building factor. Whereas some 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 [52].

Effect of Some Foliar Spray Treatments on *Rhizoctonia solani* and *Microphonina solani* Disease Incidence % and Reduction % Measured on Jerusalem Artichoke Tubers after Harvest During 2018 and 2019 Seasons: The results in Table 6 revealed that all pre-harvest treatments resulted in significantly reduce in both *Rhizoctonia solani* and *Microphonina solani* disease incidence during the two studied seasons compared with the control treatment. Jerusalem artichoke plants sprayed 2000 ppm of garlic extract showed the lowest disease incidence of *Rhizoctonia solani* (4.74 and 4.93%) and *Microphonina solani* (3.21 and 2.83%) with reduction percentages of 64.52 and 60.81% for *Rhizoctonia solani* and 67.33 and 65.15% for *Microphonina solani* in both seasons, respectively. Also, sprayed 50 ppm of sycoccil resulted in a great reduce in the disease incidence of *Rhizoctonia solani* (60.04 and 55.93%) and *Microphonina solani* (4.54 and 4.28%) with reduction ratios of 60.04 and 55.83% for *Rhizoctonia solani* and 55.76 and 47.29 for *Microphonina solani* in both seasons respectively but these values did not differ significantly with those obtained by sprayed 5 ppm of benzyladenine acid in some cases.

In this study garlic extract was more effective in reducing the infections of *R. solani* and *M. solani* in Jerusalem artichoke tubers than all the other treatments and the control. Garlic extract contains volatile compounds such as diallylmonosulfide, diallyldisulfide and diallyltrisulfide that found to have antimicrobial properties [13]. El-Shayeb [53] indicated that, 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 defense against bests and diseases. Sikandar *et al.* [54] found that garlic extract, stimulation of the antioxidant enzymes such as superoxide dismutase (SOD) and peroxidase (POD). These inducing defense responses prior to *Phytopthora capsici* inoculation and the treated plants therefore successfully resisted infection through activated antioxidant systems and probably carotenoid and other protectory metabolites. Stress-induced H_2O_2 content was extremely low in the treated plants, indicating successful resistance against pathogenic infection.

Generally, it could be recommended to use gibbrilic acid and selenium as pre harvest foliar spraying in Jerusalem Artichoke plant to increase tuber yield and yield content of total sugar and inulin.

REFERENCES

1. Slimestad, R., R. Seljaasen, K. Meijer and S.L. Skar, 2010. Norwegian-grown Jerusalem artichoke (*Helianthus tuberosus* L.): morphology and content of sugars and fructo-oligosaccharides in stems and tubers, J. Sci. Food Agric., 90: 956-964.
2. Ma, X.Y., L.H. Zhang, H.B. Shao, G. Xu, F. Zhang, F.T. Ni and M. Brestic, 2011. Jerusalem artichoke (*Helianthus tuberosus*), a medicinal salt-resistant plant has high adaptability and multiple-use values, J. Med. Plants Res., 5: 1272-1279.
3. Panchev, I., N. Delchev, D. Kovacheva and A. Slavov, 2011. Physicochemical characteristics of inulins obtained from Jerusalem artichoke (*Helianthus tuberosus* L.), Eur. Food Res. Technol., 233: 889 -896 .
4. Yuan, X.Y., M.Z. Gao, H.B. Xiao, C.Y. Tan and Y.G. Du, 2012. Free radical scavenging activities and bioactive substances of Jerusalem artichoke (*Helianthus tuberosus* L.) leaves, J. Food Chem., 133: 10-14.
5. Cepl, J., P. Kasal, H. Souckova, A. Svobodova and P. Bucher, 2012. Non-food production of Jerusalem artichoke (*Helianthus tuberosus*) and possibilities of its energetic utilization, Actual Task s Agric. Eng. Zagreb, 40: 517-526.
6. Sun, H.Y., X.Y. Wang, H.X. Dai, G.P. Zhang and F.B. Wu, 2013. Effect of exogenous glutathione and selenium on cadmium-induced changes in cadmium and mineral concentrations and antioxidative metabolism in maize seedlings. Asian Journal of Chemistry, 25: 2970-2975.
7. Feng, R., C. Wei and S. Tu, 2013. The roles of selenium in protecting plants against abiotic stresses. Environmental and Experimental Botany, 87: 58-68.
8. Karimi, J. and S. Mohsenzadeh, 2016. Effects of silicon oxide nanoparticles on growth and physiology of wheat seedlings. Russian Journal of Plant Physiology, 63(1): 119-123.
9. Parveen, N. and M. Ashraf, 2010. Role of silicon in mitigating the adverse effects of salt stress on growth and photosynthetic attributes of two maize (*Zea mays* L.) cultivars grown hydroponically. Pakistan Journal of Botany, 42(3): 1675-1684.
10. Abd El-Hameid, A.M., Afaf T.M. Kasim and S.S.M. El-Zohiri, 2008. Effect of vernalization and gibberellic acid on earliness, total yield and quality of globe artichoke. Annals Agric. Sci., Moshtohor, 46(4): 511-523.
11. Sardoei, A.S., M. Zarinkolah and H. Mohammadi, 2018. Foliar applications of gibberellic acid and benzyladenine increase vines of 'White Butterfly' Syngonium podophyllum. IJFAS., 7(2): 31-36.
12. Anosheh, H.P., Y. Emam, M. Ashraf, M.R. Foolad, 2012. Exogenous application of salicylic acid and chlormequat chloride alleviates negative effects of drought stress in wheat. Adv. Stud. Biol., 4(11): 501-520.

13. Avato, P., E. Tursil, C. Vitali, V. Miccolis and V. Candido, 2000. Allylsulfide constituents of garlic volatile oil as antimicrobial agents. Phytomedicine, 7(3): 239-243.
14. Guthyyie, J.D., 1928. Actable Colorimetric Standard For Chlorophyll.
15. Chapman, H.D. and P.F. Pratt, 1961. Methods of analysis for soils, plants and waters.University of California, Riverside, CA.
16. Cottenie, A., M. Verloo, G. Velghe and R. Camerlynch, 1982. Chemical Analysis of Plants and Soil. Laboratory of Analytical and Chemistry. State of Univ. Gent, Belgium.
17. Jackson, M.L., 1965. Soil chemical analysis. Constable Co, London.
18. Shales, O. and S.S. Schales, 1945. A simple method for the determination of glucose in blood. Arch. Biochem. B. 285. (c.f. El-Abassi, F.S., 1972).
19. Winton, A.L. and K.B. Winton, 1958. The analysis of foods. John Wileyand Sons, Inc. London, pp: 857.
20. Tsror (Lahkim) L., R. Barak and B. Sneh, 2001. Biological control of black scurf on potato under organic management. Crop. Prot., 20: 145-150.
21. Gomez, K.A. and A.A. Gomez, 1984. Statistical procedures for Agriculture Research 2nd Ed., Willey and Sons. Inc. New York. USA.
22. Turakainen, M., H. Hartikainen, T. Sarjala and M.M. Seppänen, 2008. Impact of selenium enrichment on seed potato tubers. Agricultural and Food Science, 17: 278-288.
23. Malik, J.A., S. Kumar, P. Thakur, S. Sharma, N. Kaur, R.P. Kaur, D. Athania, K. Bhandhari, N. Kaushal, K. Singh, A. Srivastava and H. Nayyar, 2011. Promotion of growth in mungbean (*Phaseolus aureus* Roxb.) by selenium is associated with stimulation of carbohydrate metabolism. Biol. Trace. Elem. Res., 143: 530-539.
24. Boghdady, M.S., E.M. Desoky, S.N. Azoz and Dalia M.A. Nassar, 2017. Effect of selenium on growth, physiological aspects and productivity of faba bean (*Vicia faba* L.). Egypt. J. Agron., 39(1): 83-97.
25. Salim, B.B., H.G. Abd El-Gawad and A. Abou El-Yazied, 2014. Effect of foliar spray of different potassium sources on growth, yield and mineral composition of potato (*Solanum tuberosum* L.). Middle East Journal of Applied Sciences, 4(4): 1197-1204.
26. Abd El-Gawad, H.G., Nashwa A.I. Abu El-Azm and M.S. Hikal, 2017. Effect of potassium silicate on tuber yield and biochemical constituents of potato plants grown under drought stress conditions. Middle East J. Agri. Res., 06(03): 718-731.
27. Moussa, S.A.M. and M.A. Shama, 2019. Mitigation the adverse effects of irrigation water salinity on potato crop using potassium silicate foliar application. Middle East Journal of Applied Sciences, 09(03): 804-819.
28. Youssef, N.S., 2011. Carryover effects of salicylic acid on the per-formance of pre-planting seed tuber, growth and yield characteristics of some potato cultivars. Assiut J. Agric. Sci., 36(5): 31-51.
29. Metwaly, E.E. and R.S. El-Shatoury, 2017. Impact of Foliar Application with Salicylic Acid on Growth and Yield of Potato (*Solanum tuberosum* L.) under Different Irrigation Water Quantity. J. Plant Production, Mansoura Univ., 8(10): 969-977.
30. El-Tohamy, W.A., H.M. El-Abagy, M.A.A. Badr and N. Gruda, 2018. Effect of exogenous salicylic acid on the response of snap bean (phaseolus vulgaris l.) And jerusalem artichoke (*Helianthus tuberosus* L.) To drought stress. Acta Sci. Pol. Hortorum Cultus, 17(4): 81-91.
31. Faten, S. Abd El-Aal, A.M. Shaheen and F.A. Rizk, 2008. The Effect of Foliar Application of GA3 and Soil Dressing of NPK at Different Levels on the Plant Productivity of Potatoes (*Solanum tuberosum* L.). Res. J. Agri. Biol. Sci., 4: 384-91.
32. EL-Abagy, H.M.H., R. El-Sh M., A.M.R. Abdel-Mawgoud and N.H. EL- Gridy, 2010. Physiological and biochemical effects of some bioregulators on growth, productivity and quality of artichoke (*Cynara scolymus* L.) plant. Res. J. Agric. Biol. Sci., 6: 683-690.
33. Ruttanaprasert, R., S. Jogloy, R.S. Kanwar and M.L. Gleason, 2018. Gibberellic acid effect on tuber dormancy of jerusalem artichoke. Pak. J. Bot., 50(2): 741-748.
34. Nassour, M. and H. Boissa, 2018. Effect of Gibberellic acid (GA3) and benzylaminopurine (BAP) on growth and flowering of Stock (*Matthiola incana*). Tishreen Univ. J. Res. and Scientific Studies - Biological Sci. Series., 04(1): 143-157.
35. Brengi, S.H.M.A., 2018. Growth, yield and chemical composition of okra as affected by three types and levels of synthetic cytokinins under high temperature conditions. Alex. J. Agric. Sci., 63(6): 365-372.

36. Devi, D., 2002. Eco-Physiological studies on germination, growth, metabolism and yield of Sunflower {*Helianthus annus* L.) Ph.D. Thesis. Gauhati University. Assam.
37. Kumar, J., M. Lal and K. Pal, 2012. Effect of cycocel on growth, yield and quality of tomato (*Lycopersicon esculentus* Mill.). Hort Flora Research Spectrum, 1(2): 162-164.
38. Soratto, R.P., A.M. Fernandes, C.A. Crusciol and G.D. De Souza? Schlick, 2012. Yield, tuber quality and disease incidence on potato crop as affected by silicon leaf application. Pesq. agropec. bras., Brasília, 47(7): 1000-1006.
39. Liu, J. and C. Xie, 2001. Correlation of Cell Division and Cell Expansion to Potato Microtuber Growth *In vitro*. Plant Cell Tissue Organ Cul., 67(2): 159-164.
40. Roosta, H., S. Vazirinasab and M. Raghami, 2015. Effect of 6-benzylaminopurine and Cycocel on Minituber Production in Two Potato Cultivars In Vitro. Iran. J. Hotr. Sci., 46(1): 141-156.
41. Lahijani, M.J.A., M. Kafi, A. Nezami, J. Nabati and J. Erwin, 2018. Effect of 6-benzylaminopurine and abscisic acid on gas exchange, biochemical traits and minituber production of two potato cultivars (*Solanum tuberosum* L.). J. Agr. Sci. Tech., 20: 129 -139.
42. García, J.A., F.S. Campos, J.B.A. Bolaños and R.O. Rodríguez, 2019. Effect of two cytokinins and a growth inhibitor on the in vitro tuberization of two genotypes of *Solanum tuberosum* L. cvs. Atlantic and Alpha. Uniciencia., 33(2): 1-12.
43. Neil, A.C. and J.B. Reece, 2002. Phytohormones (plant hormones) and other growth regulators: Gibberellin. In: Biology. 6th ed. SanFransisco, Bengamin Cummings.
44. El-Bassiouny, R.E. and M.A. Hassan, 2003. Effect of gibberellic acid and a mixture of micronutrients (Nutramine) on earliness, head yield and pre and postharvest quality of globe artichoke (*Cynara scolimus*). J. Agric. Sci. Mansoura Univ., 28(8): 1949-1967.
45. Alexopoulos, A.A., K.A. Akoumianakis and H.C. Passam, 2006. Effect of plant growth regulators on the tuberisation and physiological age of potato (*Solanum tuberosum* L.) tubers grown from true potato seed. Can. J. Plant Sci., 86: 1217-1225.
46. Alexopoulos, A.A., G. Aivalakis, K.A. Akoumianaki and H.C. Passam, 2007. Effect of foliar applications of gibberellic acid or daminozide on plant growth, tuberization and carbohydrate accumulation in tubers grown from true potato seed. J. Hort. Sci. and Biotec., 82: 535-40.
47. Chindi, A. and T. Tsegaw, 2019. Effect of gibberellic acid on growth, yield and quality of potato (S*olanum tuberosum* L.) In central highlands of ethiopia. J. Hortic. Sci., 1(2): 1-10.
48. Turakainen, M., H. Hartikainen and M. Sepänen, 2004. Effect of selenium treatments on potato (*Solanum tuberosum* L.) growth and concentration of soluble sugars and starch. Journal of Agricultural and Food Chemistry, 52: 5378-5382.
49. Yassen, A.A., M.A. Safia and M.Z. Sahar, 2011. Impact of nitrogen fertilizer and foliar spray of selenium on growth, yield and chemical constituents of potato plants. Australian Journal of Basic and Applied Sciences, 5(11): 1296-1303.
50. Bideshki, A., M.J. Arvin, A. Aien, M.R. Hasandokht and A. Khalighi, 2019. Interactive effects of Foliar 24-Epibrassinolide and selenium applications on yield, reduce nitrate accumulation and selenium enrichment in potato tuber in field. Cogent Food and Agriculture, 5: 2-13.
51. Ramawat, K.G. and J. M.Merillon, 2013. Bulbous Plants Biotechnology. CRC Press, USA, pp: 450.
52. Cuderman, P., I. Kreft, M. Germ, M. Kovaèeviè and V. Stibilj, 2008. Selenium species in selenium-enriched potatoes and drought-exposed potatoes. Journal of Agricultural and Food Chemistry, 56: 9114-9120.
53. El-Shayeb, N.S.A., 2009. Physiological studies (bio-fertilization & plant extracts) on Oenothera biennis (*Evening primrose*). Ph.D. Thesis, Fac. Agric., Moshtohor, Benha Univ., pp: 86-204.
54. Sikandar, H., H. Ahmad, M. Ali, H. Kashif, M.A. Khan and Z. Cheng, 2018. Aqueous Garlic Extract as a Plant Biostimulant Enhances Physiology, Improves Crop Quality and Metabolite Abundance and Primes the Defense Responses of Receiver Plants. Appl. Sci., 8: 2-25.