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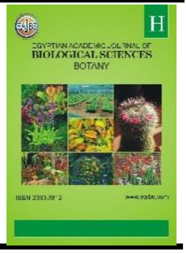

The Efficiency of The Foliar Application Using Silica and Silver Nanoparticles on *Duranta erecta* under Salinity Conditions

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ABSTRACT

Evergreen shrub *Duranta erecta* "Golden Edge" is utilized for ledges, summer color, and expanding specimens in landscaped gardens. It is projected that the landscaping and gardening of these places will suffer due to a lack of non-saline irrigation water and fewer ornamental species that can grow in these conditions. Thus, pot experiments were conducted in the seasons of 2021 and 2022 to investigate the impact of diluted seawater (DSW), which was assigned as the main plot, and nano-silica (SiO_2NPs) and nano-silver (AgNO3NPs), which were situated as the subplot. The data gathered indicated that the "Golden Edge" *D. erecta* survival rate was 100% up to 30% DSW. Whitest at 40 and 50%, there was little chance of survival. DSW levels had adverse effects on vegetative growth traits (plant height, branches per plant, stem diameter, fresh and dry weights of aerial parts, roots per plant, and leaf greenness degree), chemical composition (N, P, K, Si and total carbohydrates and water content%), and relative to the control (tap water). With rising DSW% during the two seasons, the values of these attributes significantly and gradually dropped. On the other hand, DSW increased proline content, Na, and Cl% when compared to the control. Nevertheless, SiO_2NPs and $AgNO_3$NPs applications at 150 and 300 mg/l of each considerably enhanced vegetative and chemical features except for Na and Cl%, which decreased in comparison to the control. In some cases, the rate of 300 mg/l $AgNO_3$NPs and 300 mg/l SiO_2NPs had no appreciable variations in their effects on the maximum significant values of vegetative characteristics, N, P, K, total carbohydrates %, and proline content. While the control had the highest Na and Cl% results. The highest plant water content and Si content were given at the same time by 150 and 300 mg/l SiO_2NPs. The interaction between 300 mg/l $AgNO_3$NPs and irrigation with tap water (control) produced the greatest values of the abovementioned traits, apart from Na and Cl% and proline content, whose highest values were recorded for the plants irrigated by 30% DSW combined with non-sprayed and 300 mg/l AgNPs, respectively. Also, the plants that received tap water irrigation and were successively sprayed with 150 and 300 mg of SiO_2NPs during the two seasons had the highest water content.

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INTRODUCTION

The world's ecosystem greatly benefited from ornamental plants in a number of ways, including the reduction of CO_2 and heat emissions and the removal of air pollutants (whether dust or chemicals). In tourist cities, attractive plants are the most economically significant used for a variety of tasks including opening gardens, golf grounds, interior designs, etc. In the family Verbenaceae, the genus *Duranta* contains roughly 30 species of tiny trees and shrubs that are native to tropical South America, Central America, and the United States. *D. erecta* L., also known as Golden dewdrop, Pigeon berry, Sky flower, and other names, is an upright to spreading, evergreen bushy shrub or small tree (3-4.5 m height). Axillary, pendent panicles (10–15 cm long) of tiny blue, lilac-blue, purple, or white blossoms are produced by this plant, primarily in the summer. *D. erecta* plant can be grown outside in soil that is somewhat fertile, moist but well-drained, and receives full sun. This plant makes an intriguing specimen, colourful summer hedges, and summer color. The difference between *D. erecta* "Golden Edge" and "*Variegata*" is that "Golden Edge" leaves have showy gold patterns, whilst "*Variegata*" leaves are margined and unevenly splashed with cream and white (Michael, 2011).

The value of the world's output of cut flowers and ornamental plants is estimated to be around 50 billion euros, which reflects a significant annual global demand. However, there is currently a decline in this production, which can be attributed in part to issues with abiotic stresses such as salinity (Cassaniti *et al*., 2013; Garca-Caparrós *et al*., 2016).

The important trend is the usage of saline irrigation water due to the storage and needs for a lot of irrigation water. Saltwater diminishes plant size and growth when used to hydrate ornamental plants, which results in smaller leaves, shorter stems, and occasionally fewer green leaves, which lowers aesthetic value. The previous criteria, which are still important but should be primarily based on aesthetic value, are frequently evaluated based on growth decrease for salt tolerance of landscape plants. Two factors must be considered to boost the sustainability of a landscape that uses salt water: choosing plants that can withstand the salt and treating the plants to make them more tolerant of the salinity (Cassaniti *et al*., 2013).

A common abiotic factor that restricts plant productivity and geographic distribution is soil salinity. The effects of salinity are particularly severe in nations where irrigation underpins all or most of the agricultural production (such as Egypt and Pakistan) and where agriculture accounts for a sizable portion of the national income (McWilliam, 1986 and Mashali, 1999). The growth and yield of plants in arid and semi-arid climates are negatively impacted by high soluble salt concentrations in the soil (Evelin *et al*., 2009 and Hammer *et al*., 2011). All-important biological functions, including growth, photosynthesis, protein, and fat metabolism, are impacted by excessive salts in soil (Evelin *et al*., 2009). Extreme salinity can increase the soil's uptake of Na+ and Cl- and decrease the transfer of other vital nutrients including N, P, K, and Ca (Shrivastava and Kumar, 2015; Safdar *et al*., 2019). Physiological drought, or the inability to absorb water, is caused by the ionic and secondary stresses that follow, such as dietary imbalances, which alter the overall osmotic equilibrium (Riaz *et al*., 2019).

Recently, agricultural researchers have focused a great deal of attention on nano-compound materials to increase plant tolerance to salinity stress (Pourkhaloee *et al*., 2011). Nanomaterials show different properties as a result of their small size. In comparison to bulk materials, they can modify their physicochemical characteristics. They also have a larger surface area, which increases their solubility and surface reactivity (Cheng *et al*., 2014).

One of the helpful nanomaterials found to have an advantage in modern agriculture is nano-silicon (Si NPs) (Torney *et al*., 2007). Although not considered an essential nutrient, silicon participates in several metabolic pathways that increase plants' ability to withstand biotic and abiotic conditions such as salt and drought stresses (Bao-Shan *et al*., 2004 and Coskun *et al*., 2016). The key mechanisms of Si-mediated reduction of abiotic stresses in higher plants include activation of plant antioxidant systems, complexation, co-precipitation of toxic metal ions with Si, immobilization of toxic metal ions in growth media, uptake mechanisms, and compartmentation of metal ions within plants (Liang *et al*., 2007). The unique physiological properties of Si nanoparticles enable them to penetrate plants and affect plant metabolic processes (Rastogi *et al*., 2019).

In addition to promoting seed germination and plant growth, silver nanoparticles (AgNPs) have also been linked to increased photosynthetic quantum efficiency and the control of microbial infections that cause plant illnesses. Uncertainty surrounds the contribution of nanoparticles to the enhancement of plant resistance to environmental conditions like salinity and drought stresses (Almutairi, 2016b).

Consequently, the research aims to explore how diluted seawater affects the growth and chemical composition of *Duranta erecta* "Golden Edge" plants and to improve their resistance to salinity through foliar application of nano-silicon and nano-silver.

MATERIALS AND METHODS

During the growing seasons of 2021 and 2022, two pot experiments were carried out at the greenhouse of the Faculty of Agriculture (Saba-Basha), Alexandria University, Egypt, to investigate the influence of nano silica and nanosilver on the growth and chemical makeup of *Duranta erecta* "Golden Edge" plants under salt stress.

1. Type of Soil:

For each season, 7.5 kg of dried soil was placed in 90 plastic pots with a 30 cm diameter. The experiment's soil had a clayey sand texture and was only moderately fruitful. The same soil was used for the two seasons, and Table 1 lists some of the physical and chemical characteristics of the soil.

Table 1. Some chemical and physical properties of the soil of the experiment analyzed before cultivation (average of the two seasons).

Mechanical Analysis														
Sand			Silt				Clay			Textural class				
31.12			16.00				52.88			Clayey sand				
Chemical analysis														
pH (1:2)	EC	O.M.	Soluble cations (meq/l)				Soluble anions (meq/l)				Available nutrients (meq/l)			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3	HCO_3^-	Cl^-	SO_4^{2-}	N	P	K	
8.1	2.29	2.04	3.63	3.09	4.92	0.26	0.00	1.70	5.96	3.52	98.23	18.00	1000	

2. Tap Water and Seawater Analysis:

Table (2) displays the analysis of either tap water (TW) or seawater (SW), and Table (3) displays the pH and EC of diluted seawater.

Table (2). Analysis of tap water and seawater.

Kind water	Parameter										
	pH	EC (ds/m)	EC (ppm)	Soluble cations (meq/l)				Soluble anions (meq/l)			
				Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	CO_3^{2-}	Cl^-	SO_4^{2-}
Tap water	7.20	0.59	377	2.0	1.5	2.3	0.1	3.0	0.0	2.0	0.9
Seawater	8.34	55.5	35520	100.0	200.0	245.8	9.2	4.0	0.0	456.0	35.0

Table (3). pH and EC of diluted seawater (DSW).

Parameter	10%	20%	30%	40%	50%
pH	7.24	7.24	7.41	7.57	7.83
EC (ds/m)	12.12	14.72	19.42	29.10	29.40
EC (ppm)	7756	9420	12430	18624	18816

3. Cultivation of Plants:

Six-month-old, uniform Duranta plants measuring 30±2 cm in height were purchased from a nearby commercial nursery. On April 1st of the 2021 and 2022 growing seasons, the plants were transferred into 30 cm plastic pots (one plant per pot). After being transplanted, the plants were watered with tap water for a month. On May 1st, the plants received continuous irrigation of diluted seawater at rates of 0, 10, 20, 30, 40, and 50%, up to the field's capacity. To prevent salt buildup, the plants were irrigated with tap water after every third watering with seawater.

4. Nano Silica and Nano Silver Applications:

Nano silica (SiO_2NPs) and nanosilver ($AgNO_3$NPs) were sprayed on the leaves (foliar application) at the rate of (0, 150, and 300 mg/l), respectively. In the two seasons of 2021 and 2022, foliar spraying was initiated on May 1st and continued until September 1st with one-month breaks. The plants received morning spraying till runoff.

5. Experimental Layout:

A split plot design with three replicates was used to conduct the studies. The other five nano-silica and nano-silver fertilizers (control, nano-silica (150 and 300 mg/l), and (150 and 300 mg/l) nano-silver) were arranged in sub-plots, with the six sea water levels (control (tap water), 10, 20, 30, 40, and 50) being placed in main plots. There were 30 treatments, comprising 3 plants, in each replicate (one plant of each replicate). These are some examples of the treatments: 10% SW, 20% SW, 30% SW, 40% SW, and 50% SW are the main plots (SW levels), followed by control (TW). Fertilizer sub-plots (silica and nano-silver), Control (TW), nano-silica at 150 mg/l, nano-silica at 300 mg/l, nano-silver at 150 mg/l, and nano-silver at 300 mg/l.

6. Data Recorded:

On 1st Nov. of each season, the following measurements were recorded

6.1 Vegetative growth parameters include plant height (cm), main stem diameter (cm) at 5 cm from the soil surface, number of branches per plant, shoot fresh weight (g) per plant, shoot dry weight (g) per plant, root fresh weight (g) per plant, root dry weight (g) per plant, leaf area (cm2), and the degree of the greenness of the leaves (measured in SPAD units using a chlorophyll metre (SPAD-502, Minolta Co.

6.2 According to the method described by Tandon (1995) chemical parameters, the levees were dried to a constant weight at 75°C for 72 hours. The levels samples were ground to create a homogeneous powder after drying. Nevertheless, according to Lowther (1980), 0.5 g of the leaf powder was wet-digested with an H_2SO_4-H_2O_2 solution before the following analyses were done in the digested solution.

N % was determined in digested plant material calorimetrically by Nessler`s method (Chapman and Pratt, 1978). Nessler solution (35 IK/100 ml d. w. + 20g $HgCl_2$ / 500 ml d. w.) +120 g NaOH / 250 ml d. w. Readings were achieved using a wavelength of 420 nm and N was determined as a percentage as follows:

% N = NH4 % x 0.776485

P% was determined by the Vanadomolyate yellow method as given by Jackson (1973) and the intensity of color developed was read using a spectrophotometer at 405 nm.

K and Na % were determined according to the method described by Jackson (1973) using Beckman Flame photometer.

Cl % was measured according to Taleisnik and Grunberg (1994).

- **Proline content:** using a technique recommended by Bates *et al*. (1973) proline content in leaf tissue was determined during the second season. In 10 ml of 3% (w/v) sulpho salicylic acid, 300 mg of dry leaf samples were homogenized, and they were centrifuged at 4000 g for 10 min at 4°C. The acid ninhydrin reagent and glacial acetic acid were added to two ml of the supernatant that had been collected in a test tube. After being heated in a water bath for 30 minutes at 98°C, the mixture was left to cool at room temperature. Toluene was used to extract the mixture, and an instrument reading the absorbance at 520 nm was used. Using the following formula, the proline content of leaf tissue was determined:

$$\textbf{Proline (mg g}^{-1}\textbf{)} = \frac{\textbf{34.11 x OD520 xV}}{\textbf{2xf}}$$

Where, V= Total volume of extract, f = Grams of fresh leaf, 2= Volume of extract taken

- **Determination of Silicon:** The silicon concentration in plant parts was analyzed using the molybdenum blue method (Estefan *et al.,* 2013) to observe silicon accumulation in plants. The distribution of silicon in different parts of plants was calculated using the Equation:

Si distribution = (Si concentration in plant part/Total Si concentration) × 100

- **Determination of Total Carbohydrates:** Total carbohydrates were determined, quantitatively, in the leaves by Anthron method according to Mahadevan and Sridhar (1986) as follows:

Dry materials were ground in a Mahadavaine buffer for extraction (sodium citrate buffer, pH 6.8). The extracts were homogenised for three minutes and then centrifuged for 15 minutes at 4000 rpm. The total carbs were then calculated using the supernatant.

Statistical Analysis:

All recorded data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the split-plot design as published by (Gomez and Gomez, 1984). The Least Significant Difference (LSD) method was used to test the differences between treatment means at a 5% level of probability. All the statistical analyses were performed application of (CoStat, 2005) for Windows.

RESULTS AND DISCUSSION

1-The Impact of Diluted Seawater Levels, Nano-Silica, Nano-Silver Concentrations, And Their Interaction on Survival% And Vegetative Growth Trait of *Duranta erecta* "Golden Edge"

At the end of the experimental period of the two seasons *D. erecta* "Golden Edge" plants tolerated salinity up to 30% diluted seawater (DSW). The survival % was 100% until such level. On the other side, irrigated plants by 40 and 50% DSW survival was nil (0.0%) at harvesting time on 1st Nov. in both seasons.

As SW contains a greater concentration of ionic components, utilizing SW for irrigation is often restricted (Xias-Hua *et al*., 2009). Saline water irrigation causes plants to experience abiotic stress and toxic effects that cause photosynthesis to gradually drop (Manai *et al*., 2014) as well as a reduction in chlorophyll and NPK concentrations (Aydin *et al*., 2012). Moreover, oxidative stress in plants is brought on by salinity stress, which also results in an osmatic effect, insufficient water utilization, nutritional deficiencies, and ionic imbalances (Rehman *et al*., 2019). In saline water, *Farsetia argyptia* showed 38% survival under EC 5.5 ds/m (Suleiman *et al.,* 2020). Moreover, a rise in Na^+ levels prevent the absorption of K^+ ions, a crucial nutrient for growth and development, which lowers productivity and may even cause death (Sun *et al.,* 2015).

In relation to the main effect of DSW, the data in Table (4) demonstrated that the measured vegetative growth traits (plant height (cm), branch numbers/plant, stem diameter (cm), leaf area (cm^2), fresh and dry weights of aerial parts and roots (g/plant), and leaf green color degree (SPAD units) gradually decreased with increasing SW level in irrigation water in comparison to corresponding control in the two seasons. That signifies that the qualities with the greatest significant values were from the control, while the traits with the lowest significant values were DSW at 30% in the two seasons. According to Zaman *et al.* (2018), excessive salinity reduces plant growth, photosynthesis, biomass, and water usage efficiency and resulting in physiological drought and ion toxicity in plants, which lowers agricultural productivity and yields. Moreover, Valdez-Aguilar *et al*. (2011) noted that excessive concentrations of soluble salts, particularly Na+ and Cl-, in irrigation water may cause ornamental species to have reduced growth and necrosis or browning of leaves. Salinity is regarded as one of the primary abiotic stressors that inhibits plant development and productivity. The vegetative characteristics of Acacia nilotica and A. ampliceps were reportedly adversely impacted by EC 10, 20, and 30 Dsm^{-1}, according to Abbasi *et al*. (2016). Vegetative growth characters linearly decreased with increasing salinity levels (El-Sayed *et al.*, 2017) on *Duranta plumeri,* (Abdel-Aziz *et al.*, 2020 and Delacerda *et al.*, 2020) on *D. erecta* and Alam et al. (2022) on *Atriplex leucodada.*

Table 4: Vegetative growth traits of *Duranta erecta* "Golden Edge" as affected by DSW in 2021 and 2022 seasons.

DSW levels	Plant height (cm)		No. of branches/ plant		Stem diameter (cm)		Leaf area (cm^2)		Leaf green color degree (SPAD units)		Fresh weights of aerial parts		Dry weights of aerial parts (g/ plant)		Fresh weights of roots (g/ plant)		Dry weights of roots (g/ plant)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	67.36	70.96	8.20	9.60	1.25	1.39	30.63	33.68	40.29	43.75	69.46	80.21	20.36	27.65	36.75	36.50	12.49	12.58
10	61.40	65.42	7.53	8.47	1.13	1.28	28.08	31.24	36.51	40.79	62.26	71.27	18.99	25.68	32.68	31.51	11.65	11.22
20	50.89	55.61	6.47	7.33	0.91	1.03	24.90	26.43	28.92	32.80	49.84	55.54	16.16	20.67	29.26	27.61	10.83	10.15
30	45.31	48.85	5.27	5.13	0.66	0.74	20.44	22.30	20.78	22.91	35.18	41.22	12.28	16.03	25.22	23.26	9.49	8.97
LSD $_{(0.05)}$	**1.84**	**0.93**	**0.36**	**0.27**	**0.04**	**0.02**	**1.31**	**1.16**	**0.58**	**1.17**	**0.83**	**1.10**	**0.15**	**0.53**	**1.54**	**0.96**	**0.47**	**0.38**

Table 5: Vegetative growth traits of *Duranta erecta* "Golden Edge" as affected by SiO_2NPs and $AgNo_3$NPs in 2021 and 2022 seasons.

NPs (mg/l)	Plant height (cm)		No. of branches/ plant		Stem diameter (cm)		Leaf area (cm^2)		Leaf green color degree (SPAD)		Fresh weights of aerial parts		Dry weights of aerial parts (g/ plant)		Fresh weights of roots (g/ plant)		Dry weights of roots (g/ plant)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	48.46	51.26	5.67	5.83	0.88	1.03	23.93	25.76	28.55	31.76	46.03	48.67	14.77	18.01	22.73	21.34	8.23	7.72
150 SiNPs	52.64	57.03	6.84	7.42	0.97	1.07	25.07	27.44	30.19	33.41	50.40	59.48	15.52	21.61	27.64	26.28	10.01	9.40
300 SiNPs	59.59	64.20	7.34	8.00	1.02	1.11	27.02	29.52	32.74	36.54	57.01	66.25	17.67	23.83	31.29	30.15	11.26	10.91
150 AgNPs	57.36	60.40	6.84	7.92	0.99	1.11	25.72	28.22	31.64	35.27	54.78	63.17	17.31	22.78	34.40	33.15	12.41	11.99
300 AgNPs	63.15	68.16	7.67	9.00	1.10	1.23	28.32	31.13	35.01	38.32	62.70	72.74	19.47	26.32	38.82	37.68	13.67	13.64
LSD$_{(0.05)}$	**1.83**	**1.52**	**0.47**	**0.49**	**0.04**	**0.02**	**1.11**	**1.11**	**0.91**	**0.83**	**0.87**	**1.28**	**0.33**	**0.47**	**1.20**	**1.02**	**0.54**	**0.34**

In terms of the impacts of nano-silica and nano-silver, data in Table (5) showed that the various concentrations of SiO_2 and $AgNO_3$ NPs significantly enhanced the vegetative growth traits of the *Duranta erecta* "Golden Edge" plant in comparison to the control treatment during the two seasons. Except for root fresh and dry weights, where Ag NO3NPs at 150 mg/l was in second place, the application of Ag NO3NPs at 300 mg/l produced the highest significant values of vegetative growth characteristics. SiO2NPs at 300 mg/l, AgNO3NPs at 150 mg/l, and SiO2NPs at 150 mg/l followed. In contrast, the control plants' least significant values for these traits throughout the duration of both seasons were noted. Moreover, in the majority of cases, the variations in the SiO2NPs and AgNO3NPs concentrations utilized reached a substantial level. These results may be recognized that $AgNO_3$NPs improved plant growth, photosynthetic efficiency, and act as antimicrobial agents among plant diseases (Almutairi *et al.,* 2016b). Also, under abiotic stress, Si treatments can enhance stem diameter, plant height, leaf area, roots length and lateral root number (Safoora *et al.,* 2018) on strawberries. In addition, SiO_2NPs have been used to improve plant growth and photosynthetic quantum under environmental stresses (Almutairi *et al.*, 2016a). Si reduces transpiration due to accumulation in the tissues of cuticles (Keller *et al.*, 2015). The results are in accordance with those of El- Shawa *et al.* (2022) found that the highest increase in plant height, leaf width, stem diameter and leaves the number of philodendron plants duo to 60mg/l AgNPs in compression to control, FeNPs and ZnNPs. And Ismail *et al.* (2022) revealed that SiNPs application at the rate of 3 mM caused a significant increase in plant height, fresh and dry weights and total yield of *Pisum sativum* plant when compared to the control. The findings of the vegetative traits in Tables (6 and 7) indicated that the treatments utilized had varied effects on the vegetative development features of *Duranta* in the two seasons.

Table 6: Interaction between DSW and NPs of SiO_2 and $AgNo_3$ on vegetative growth trait of *Duranta erecta* "Golden Edge" in 2021 and 2022 seasons**.**

Treatments		Plant height (cm)		No. of branches/ plant		Stem diameter (cm)		Leaf area (cm^2)		Leaf green color degree (SPAD)	
DSW levels	**NPs (mg/l)**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**
Control	Control	58.70	60.57	7.33	7.33	1.13	1.30	27.70	30.21	36.41	40.79
	150 SiNPs	64.57	66.57	7.67	9.33	1.20	1.33	29.34	32.03	38.24	41.26
	300 SiNPs	70.67	73.30	8.67	10.00	1.27	1.40	31.82	35.00	42.05	45.38
	150 AgNPs	69.87	72.17	7.67	10.00	1.27	1.40	31.04	34.53	41.04	44.06
	300 AgNPs	72.97	80.17	9.67	11.33	1.40	1.50	33.24	36.64	43.69	47.24
10	Control	52.87	57.57	6.33	6.33	1.00	1.17	26.13	28.16	32.82	36.42
	150 SiNPs	57.37	65.93	7.67	8.00	1.10	1.23	27.39	29.82	32.20	38.75
	300 SiNPs	64.47	67.73	7.67	8.67	1.20	1.30	29.49	32.48	37.79	42.70
	150 AgNPs	61.57	64.20	7.33	9.00	1.10	1.30	26.17	31.73	36.61	41.16
	300 AgNPs	70.70	71.67	8.67	10.33	1.27	1.40	31.20	34.00	40.11	44.92
20	Control	44.47	48.17	5.33	5.33	0.87	0.97	22.75	24.51	26.25	29.40
	150 SiNPs	47.10	53.83	6.67	7.000	0.90	1.00	23.91	25.86	27.56	31.54
	300 SiNPs	53.77	59.30	7.00	8.00	0.90	1.00	25.78	27.99	30.07	34.16
	150 AgNPs	50.57	54.17	6.67	7.67	0.87	1.00	25.43	24.47	28.65	32.94
	300 AgNPs	58.53	62.60	6.67	8.67	1.03	1.17	26.62	29.33	32.09	35.94
30	Control	37.80	38.73	3.67	4.33	0.53	0.67	17.13	20.17	18.72	20.43
	150 SiNPs	41.50	41.77	5.33	5.33	0.67	0.70	19.65	22.03	19.74	22.09
	300 SiNPs	49.43	54.47	6.00	5.33	0.70	0.74	20.98	22.60	21.04	23.91
	150 AgNPs	47.43	51.07	5.67	5.00	0.70	0.73	20.24	22.16	20.26	22.93
	300 AgNPs	50.40	58.20	5.67	6.67	0.70	0.84	22.21	24.53	24.13	25.17
LSD $_{(0.05)}$		**3.65**	**3.03**	**0.95**	**0.98**	**0.09**	**0.04**	**2.22**	**2.23**	**1.83**	**1.67**

Table 7: Interaction between DSW and NPs of SiO_2 and $AgNO_3$ on fresh and dry weights of aerial parts and roots of *Duranta erecta* "Golden Edge" in 2021 and 2022 seasons

Treatments		Fresh weights of aerial parts		Dry weights of aerial parts (g/ plant)		Fresh weights of roots (g/ plant)		Dry weights of roots (g/ plant)	
DSW levels	**NPs (mg/l)**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**
Control	Control	58.72	62.57	17.29	21.57	28.99	26.48	9.99	9.13
	150 SiNPs	64.53	76.49	18.26	26.38	32.62	31.95	11.21	11.01
	300 SiNPs	72.94	87.40	21.11	30.13	38.67	36.90	13.22	12.72
	150 AgNPs	69.93	81.16	21.49	27.98	40.79	41.55	13.96	14.33
	300 AgNPs	81.16	93.41	23.64	32.20	42.69	45.60	14.06	15.72
10	Control	52.84	56.02	16.50	20.73	22.74	21.49	8.16	7.67
	150 SiNPs	58.07	68.64	17.62	28.85	28.86	26.93	10.33	9.61
	300 SiNPs	65.76	75.84	19.92	26.89	31.12	33.04	11.71	11.80
	150 AgNPs	63.27	73.29	19.27	26.17	38.41	36.51	13.71	13.04
	300 AgNPs	71.36	82.38	21.62	29.77	40.23	39.18	14.36	13.99
20	Control	42.25	44.66	14.08	17.17	20.70	10.87	7.65	7.35
	150 SiNPs	46.46	55.08	14.98	20.39	25.65	24.63	9.50	8.74
	300 SiNPs	52.48	58.15	16.93	21.53	27.72	26.76	10.62	9.91
	150 AgNPs	50.68	57.33	16.33	21.23	33.87	30.99	12.54	11.47
	300 AgNPs	67.31	62.49	18.49	23.04	38.34	35.80	14.19	13.26
30	Control	30.31	31.43	11.22	12.57	18.49	17.50	7.11	6.72
	150 SiNPs	32.52	37.50	11.21	14.83	23.44	21.62	9.01	8.23
	300 SiNPs	36.87	43.60	12.71	16.77	25.61	23.91	9.85	9.19
	150 AgNPs	35.23	40.90	12.14	15.73	25.51	23.13	9.42	9.12
	300 AgNPs	40.97	52.69	14.12	20.26	34.03	30.13	12.06	11.58
LSD $_{(0.05)}$		**1.73**	**2.56**	**0.66**	**0.95**	**2.41**	**2.03**	**0.72**	**0.68**

Regarding the interaction between DSW levels and SiO_2NPs and AgNPs concentrations. In contrast, most of the time there were noticeable changes between the therapies. Data showed that the plants that were irrigated with tap water (the control) and sprayed with 300 mg/l $AgNO_3$NPs produced the highest significant values of plant height, branches numbers/plant, stem diameter, area/leaf, fresh and dry weights of aerial parts and roots/plant, and leaf green color degree. On the converse, the lowest significant values of such attributes were given for the plants irrigated by 30% DSW and non-sprayed (control) during the two seasons. Many reports suggested that SiO_2NPs mitigated the adverse effects of salinity stress such Tantawy *et al.* (2015) on sweet pepper, Almutairi *et al.* (2016a) on tomato, Avestain *et al.* (2019) on strawberry, as well as Ashour (2017) observed that SiNPs enhanced vegetative growth traits of *Jatropha integerrima* under saline water irrigation (1000-4000 ppm). Similar results were obtained by El-Dengawy *et al.* (2021) on "Gahrawy " and "Sukkary" mango rootstocks with an application of 100g/l SiO_2NPs under irrigation by seawater at 1750 ppm. Also, El- Shawa *et al.* (2022) found that AgNPs at 60 mg/l had a positive effect on the vegetative growth traits of philodendron plants.

2- Chemical composition of *Duranta erecta* "Golden Edge" as affected by DSW, SiO_2NPs ,$AgNO_3$NPs and their interaction:

Results in Table (8) showed that, in comparison to tap water (control) in both seasons, the percentages of total carbohydrates, N, P, K, and Si in the leaves and plant water content steadily decreased as SW% in irrigation water increased. On the other hand, with rising SW% in irrigation water over both seasons, Na%, Cl%, and proline content considerably increased above the control. This indicates that the plants watered with tap water had the greatest significant values of total carbohydrates, N, P, and K as well as water content percent. Meanwhile, the plants that were watered with 30% DSW produced the highest significant Na%, Cl%, and proline content.

These findings may be due to that the irrigation by saline water caused abiotic stress and toxic influences on plants leading to gradually decayed in photosynthesis (Manai *et al.*, 2014), and lowered chlorophyll and NPK contents in the plants (Aydin *et al.*, 2012), but enhanced amino acids level, especially proline (Jouyban, 2012). Also, as a result of salinity stress, Na % and Cl% ions accumulate in plant tissues exposed to soil with high NaCl concentration. Ashour and El-Attar (2017) stated that NaCl and $CaCl_2$ at 1000-8000 ppm led to an increase in Na%, Cl% and proline content in the leaves of *leucophyllum frutescens*. Similarly, El- Sayed *et al.* (2017) found that DSW at 2000-6000 ppm reduced carbohydrates content, N, P, K and Mg uptake, but increased Na^+ and Cl^- in *Duranta plumieri.* In addition, De lacerda *et al.*, 2020) concluded that *D. erecta* sensitivity was associated with high Na^+ and proline concentrations in leaves. Also, the results are supported by Alam *et al.* (2022) on *Atriplex leucoclada*, they found that under salt and water stress Na^+ and Cl^- uptake and proline content enhanced.

Table 8: Chemical compositions of *Duranta erecta* "Golden Edge" as affected by DSW in 2021 and 2022 seasons.

DSW levels	Carbohydrates (%)		Water content (%)		N (%)		P (%)		K (%)		Si (mg/l)		Na (%)		Cl (%)		Proline (mg/g D.W.)
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	2nd
Control	30.63	34.30	70.84	65.79	2.24	2.40	0.36	0.41	1.78	1.90	0.48	0.62	0.40	0.39	1.26	1.28	2.13
10	28.38	32.43	69.42	64.09	2.14	2.29	0.33	0.36	1.67	1.83	0.41	0.61	0.43	0.43	1.37	1.42	2.34
20	22.78	27.13	67.42	62.90	1.89	2.02	0.26	0.30	1.41	1.47	0.35	0.55	0.47	0.48	1.48	1.55	2.58
30	16.04	22.63	64.77	61.30	1.75	1.80	0.20	0.21	1.25	1.35	0.27	0.46	0.52	0.53	1.66	1.71	2.81
LSD $_{(0.05)}$	**0.42**	**0.40**	**0.35**	**0.43**	**0.01**	**0.01**	**0.01**	**0.01**	**0.03**	**0.02**	**0.014**	**0.017**	**0.005**	**0.004**	**0.02**	**0.04**	**0.05**

Concerning the effect of Si and $AgNO_3$NPs, data in Table (9) showed that the used concentrations of SiNPs and AgNPs significantly raised plant water content and total carbohydrates, N, P and K%, Si and proline content, but reduced Na and Cl% in comparison to the control in both seasons. The maximum significant values of water and proline content, total carbohydrates, N, P and K% resulted from the sprayed plants, with 300 mg/l AgNPs. While higher Si content was recorded for 300 mg/l SiO_2NPs. On the opposite, higher significant values of Na and Cl % resulted from the control plants in the two seasons. These results agree with those of Ashour (2017) who reported that SiO_2NPs foliar application (1 and 2 mM) had positive effects on chemical constituents, at the same time reducing the accumulation of Na^+ and Cl^- % in *Jatropha integerrima*. Also, Salachna *et al.* (2019) found that 100 ppm AgNPs gave the highest values of chl. a and b, K, Ca and Si in the leaves of lilium cv. Monalisa. Ayman *et al.* (2020) showed that SiNPs by soil or by spraying significantly improved the uptake of N, P and K content and reduced the uptake of Na^+ content in wheat seedlings.

Table 9: Chemical compositions of *Duranta erecta* "Golden Edge" as affected by SiO_2NPs and $AgNo_3$NPs in 2021 and 2022 seasons.

NPs (mg/l)	Carbohydrates (%)		Water content (%)		N (%)		P (%)		K (%)		Si (mg/l)		Na (%)		Cl (%)		Proline (mg/g D.W.)
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st
Control	22.49	26.50	66.96	62.72	1.91	2.00	0.19	0.21	1.43	1.52	0.29	0.40	0.55	0.56	1.60	1.63	1.71
150 SiNPs	23.53	28.65	68.70	63.68	1.97	2.08	0.26	0.29	1.48	1.59	0.42	0.55	0.49	0.51	1.53	1.56	2.37
300 SiNPs	25.43	30.56	68.40	64.03	2.05	2.17	0.32	0.36	1.57	1.69	0.53	0.69	0.41	0.40	1.35	1.42	2.68
150 AgNPs	24.02	28.11	68.05	63.68	2.00	2.12	0.29	0.34	1.53	1.64	0.31	0.57	0.46	0.45	1.43	1.49	2.68
300 AgNPs	26.83	31.78	68.44	63.49	2.11	2.28	0.36	0.41	1.65	1.76	0.34	0.60	0.37	0.37	1.31	1.36	2.89
LSD (0.05)	**0.49**	**0.66**	**0.40**	**0.56**	**0.01**	**0.02**	**0.01**	**0.01**	**0.01**	**0.03**	**0.246**	**0.014**	**0.007**	**0.003**	**0.02**	**0.03**	**0.03**

As for the combined effects of DSW levels and used concentrations of NPs of Si and Ag, data tabulated in Table (10 and 11) cleared that the different used combinations of the applied factors had various exhibit impacts on the chemical composition of *D. erecta* "Golden Edge". It is noticed from the results that the highest water content was found in plants sprayed with 150 mg SiNPs and irrigated with tap water in the first season and those irrigated by tap water without spraying with nano Si and Ag (control) in the second season. Si higher content resulted from the treatment of tap water combined with 300 mg/l SiO_2NPs. In the interim, the treated plants with 300 mg/l AgNPs and irrigated by tap water had the highest significant total carbohydrates, N, P and K% in comparison to the other ones in the two seasons. While the highest values of proline resulted from plants irrigated by 30% DSW and sprayed with 300 mg/l AgNPs. Na^+ and Cl^- highest % were found in the plants irrigated by 30% DSW without treatment with NPs which contain the lowest significant total carbohydrates, N, P, K%, Si and proline content during both seasons.

Si application may reduce the water loss through the cuticle because Si deposition underlying epidermal cells of leaf and stem plants impacts water loss (Liang *et al.,* 2015). Moreover, Abdul Qades and Moftah (2015) and Tantawy *et al.* (2015) on faba bean and sweet pepper, respectively revealed the benefits of Si or SiNPs for plants grown under salinity stress relates to increase nutrient elements (N, P, K, Ca and Mg) and decrease toxic ions (Na). Si can reduce proline content under salinity stress in tomatoes (Haghighi and Preaasrakli, 2013), on the other side, Si can increase proline content in plants like talh trees (Al-Hugail *et al.,* 2017). Also, Rastogi *et al.* (2019) reported that SiNPs have distinctive physiological traits that allow them to enter plants and affect plant metabolic activities. Additionally, Sadak (2019) mentioned that AgNPs increased some biochemical aspects alike photosynthetic pigments and IAA contents thus enriching carbohydrate and protein % in seeds of fenugreek plants under salinity stress. SiO_2NPs at 600 mg/l led to the enhancement of N, P, K and Si contents in wheat plants and Na was reduced with Si increasing in plant tissues (Ayman *et al.,* 2020). As well as Si NPs increased K^+ content in roots and shoots of *Pisum sativum* and decreased Na^+ content under salinity stress (Ismail *et al.,* 2022).

Table 10: Interaction between DSW and NPs of SiO_2 and $AgNO_3$ on chemical compositions of *Duranta erecta* "Golden Edge" in 2021 and 2022 seasons.

Treatments		Carbohydrates (%)		Water content (%)		N (%)		P (%)		K (%)	
DSW levels	NPs (mg/l)	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	Control	28.79	33.25	70.54	66.22	2.14	2.28	0.24	0.27	1.67	1.78
	150 SiNPs	30.03	33.76	71.68	65.53	2.19	2.34	0.33	0.37	1.72	1.85
	300 SiNPs	31.21	35.02	71.18	66.20	2.29	2.46	0.40	0.46	1.82	1.96
	150 AgNPs	29.47	33.33	69.94	65.47	2.23	2.38	0.38	0.44	1.78	1.88
	300 AgNPs	33.64	34.14	70.87	65.52	2.37	2.54	0.44	0.53	1.92	2.04
10	Control	25.91	29.81	68.76	62.92	2.03	2.15	0.22	0.24	1.56	1.69
	150 SiNPs	27.13	31.79	69.98	64.53	2.10	2.23	0.30	0.33	1.61	1.76
	300 SiNPs	29.52	33.75	69.71	65.26	2.18	2.35	0.37	0.40	1.73	1.91
	150 AgNPs	28.08	32.02	68.98	63.86	2.13	2.31	0.33	0.37	1.66	1.84
	300 AgNPs	31.26	39.76	69.66	63.86	2.24	2.42	0.41	0.47	1.81	1.97
20	Control	20.73	24.49	66.36	61.52	1.82	1.92	0.18	0.20	1.33	1.36
	150 SiNPs	21.61	26.45	67.61	62.96	1.87	1.98	0.24	0.27	1.36	1.42
	300 SiNPs	23.97	28.01	67.64	63.14	1.92	2.03	0.30	0.33	1.44	1.53
	150 AgNPs	22.45	24.89	67.75	63.85	1.87	1.98	0.26	0.31	1.41	1.47
	300 AgNPs	25.16	31.80	67.72	63.03	1.97	2.19	0.34	0.38	1.53	1.59
30	Control	14.54	19.46	62.19	60.20	1.63	1.65	0.13	0.14	1.16	1.25
	150 SiNPs	15.33	22.59	65.54	61.68	1.70	1.77	0.18	0.19	1.24	1.34
	300 SiNPs	16.99	25.44	65. 06	61.53	1.82	1.82	0.22	0.24	1.27	1.37
	150 AgNPs	16.08	22.21	65.53	61.55	1.75	1.79	0.19	0.23	1.25	1.35
	300 AgNPs	17.26	23.43	65.51	61.55	1.87	1.95	0.26	0.27	1.34	1.42
LSD (0.05)		**0.99**	**1.23**	**0.81**	**1.12**	**0.03**	**0.03**	**0.03**	**0.02**	**0.03**	**0.03**

Table 11: Interaction between DSW and NPs of SiO_2 and $AgNO_3$ on chemical compositions of *Duranta erecta* "Golden Edge" in 2021 and 2022 seasons**.**

Treatments		Na (%)		Cl (%)		Si (mg/l)		Proline (mg/g DW)
DSW levels	NPs (mg/l)	1st	2nd	1st	2nd	1st	2nd	2nd
Control	Control	0.47	0.48	1.39	1.40	0.380	0.467	1.31
	150 SiNPs	0.43	0.43	1.32	1.35	0.523	0.570	2.06
	300 SiNPs	0.38	0.35	1.21	1.21	0.677	0.773	2.29
	150 AgNPs	0.42	0.39	1.25	1.28	0.390	0.633	2.40
	300 AgNPs	0.31	0.32	1.14	1.17	0.417	0.673	2.57
10	Control	0.52	0.53	1.51	1.54	0.300	0.427	1.51
	150 SiNPs	0.46	0.48	1.45	1.48	0.483	0.673	2.21
	300 SiNPs	0.38	0.38	1.29	1.35	0.620	0.717	2.64
	150 AgNPs	0.42	0.43	1.35	1.41	0.320	0.593	2.51
	300 AgNPs	0.38	0.34	1.24	1.30	0.343	0.620	2.82
20	Control	0.57	0.58	1.65	1.69	0.260	0.373	1.84
	150 SiNPs	0.51	0.53	1.59	1.63	0.373	0.610	2.48
	300 SiNPs	0.42	0.42	1.36	1.47	0.513	0.657	2.75
	150 AgNPs	0.45	0.47	1.45	1.55	0.280	0.550	2.86
	300 AgNPs	0.38	0.38	1.34	1.41	0.320	0.577	2.98
30	Control	0.63	0.64	1.85	1.88	0.213	0.347	2.16
	150 SiNPs	0.57	0.58	1.74	1.79	0.310	0.353	2.72
	300 SiNPs	0.46	0.47	1.54	1.64	0.320	0.603	3.03
	150 AgNPs	0.55	0.52	1.65	1.70	0.240	0.497	2.96
	300 AgNPs	0.41	0.42	1.50	1.54	0.273	0.520	3.17
LSD (0.05)		**0.014**	**0.007**	**0.04**	**0.07**	**0.049**	**0.035**	**0.06**

Conclusion

Duranta erecta "Golden Edge" has a moderate tolerance to salinity which led to an adverse effect on its growth and development. To enhance *D. erecta* tolerance up to 30% DSW (ECs 19.42 dSm^{-1}) can spray at the rate of 300 mg/l of each SiO_2NPs or AgNPs 5 times with one-month intervals, during the two seasons.

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