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Studies on the Impact of Anti-Transpirants and Irrigation Intervals on *Zantedeschia aethiopica* Plants

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Abstract: This study was carried out in the nursery of the Ornamental Plant Research Department, Horticulture Research Institute, Agriculture Research Centre, Giza, Egypt in the two seasons of 2018 and 2019. Calla-lilies (*Zantedeschia aethiopica*) transplants were subjected to two irrigation frequencies. The first group was irrigated 3 times/week and the second one 4 times/week. Each group was subdivided into 7 sub-groups representing chemical treatments as follows: 8-Hydroxyquinoline sulfate (HQS) at 300 and 400 ppm, chitosan at 200 and 300 ppm, potassium chloride (KCl) at 400 and 500 ppm, in addition to a control treatment where no chemicals were used. These chemicals were applied monthly as a thorough foliar spray for 4 times during each season. Results that were consistent in the two seasons and significant in almost all cases could be briefed in the following: first factor (treatments) that chitosan at 200 ppm got the greatest leaf area while chitosan at 300 ppm achieved the highest plant height, leaf area, number of leaves, fresh and dry weight of leaves, roots and flowers; osmotic pressure, N, P, K%, contents of total chlorophyll and carotenoids and total sugars% in flowers. Second factor (irrigation frequency) showed that 4 times irrigation/week achieved the highest rank for plant height, leaf area, number of leaves, fresh and dry weights of leaves, roots and flowers; osmotic pressure, N, P, K%, contents of total chlorophyll and carotenoids, total sugars% in flowers, the fastest flowering. Regarding the effect of the interaction between chitosan at 200 ppm + 4 times irrigation/week obtained the highest degrees for fresh weight of flowers. The obtained results indicated that chitosan at 300 ppm + 4 times irrigation/week achieved the highest values for plant height, leaf area, number of leaves, fresh and dry weights of leaves, roots and flowers; osmotic pressure, N, P, K%, contents of total chlorophyll and carotenoids, total sugars% in flowers. KCl at 400 ppm+3 times irrigation/week: got the highest water consumption. Hence, it is recommended to apply chitosan at 300 ppm+4 times irrigation/week to obtain the highest values of almost all studied traits.

Key words: Hydroxyquinoline sulfate · HQS · Chitosan · Potassium chloride · KCl · Irrigation frequency

INTRODUCTION

Zantedeschia aethiopica, commonly known as calla lily and arum lily, is a species in the Family Araceae, native to southern Africa. It is a rhizomatous herbaceous perennial plant, evergreen where rainfall and temperatures are adequate, deciduous where there is a dry season. Its preferred habitat is in streams and ponds or on the banks. It grows to 0.6-1 m tall, with large clumps of broad, arrow shaped dark green leaves up to 45 cm long. The inflorescences are large and are bloomed in spring, summer and autumn, with a pure white spathe up to 25 cm and a yellow spadix up to 9 cm long. The spadix produces a faint, sweet fragrance. A number of cultivars have been selected as ornamental plants.

Zantedeschia aethiopica can be used for treatment of wastewater due to its tolerance to iron and ability to grow in wet areas. *Zantedeschia aethiopica* contains calcium oxalate and ingestion of the raw plant may cause a severe burning sensation and swelling of lips, tongue and throat; stomach pain and diarrhea may occur [1].

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Martell and Calvin [2] stated that 8-HQ is an inhibitor of enzymes and a metal-chelating agent. Chua [3] claimed that 8-HQ has a cytokinin-like activity. Oota and Tsudzuki [4] remarked that 8-HQ has plant growth-regulating properties. Parups and Peterson [5] reported that 8-HQ decreased the ethylene production. The InterNet Site 2 [6] declared that 8-Hydroxyquinoline is a chelating agent that exhibit antiseptic, disinfectant and pesticide properties.

Chitosan is a linear polysaccharide. It is made by treating the chitin shells of shrimp and other crustaceans with an alkaline substance, such as sodium hydroxide. The agricultural and horticultural uses for chitosan, primarily for plant defense helping plants to fight off fungal infections and yield increase, are based on its influence on the biochemistry and molecular biology of the plant cell. The cellular targets are the plasma membrane and nuclear chromatin. Subsequent changes occur in cell membranes, chromatin, DNA, calcium, oxidative burst, reactive oxygen species, callose pathogenesis-related [7].

Salachna and Zawadziñska [8] investigated the influence of chitosan on 'Gompey' freesia cultivated in pots. They stated that chitosan is a biostimulator. Malerba and Cerana [9] stated that chitosan is a natural, safe and cheap product of chitin deacetylation. Chitosan has been proven to stimulate plant growth and to induce abiotic and biotic stress tolerance in various horticultural commodities. Chitosan could also interact with chromatin and directly affect gene expression. El Amerany *et al.* [10] stated that chitosan had no effect on phytohormone levels in tomato plants. Suarez-Fernandez *et al.* [11] remarked that chitosan induces plant hormones (such as indoleacetic acid, abscisic acid, salicylic acid and jasmonic acid) and defense compounds including phenolics, in tomato root exudates. Ashour *et al.* [12] found that foliar application of chitosan on *Vitex trifolia* 'Purpurea' exposed to salinity stress had favorable impact on increasing vegetative traits and chemical compositions, meanwhile reducing accumulation of total phenolics and % of the toxic ions of Na^+ and Cl^- in the leaves.

MATERIALS AND METHODS

This study was carried out in the nursery of the Ornamental Plant Research Department, Horticulture Research Institute, Agriculture Research Centre, Giza, Egypt in the two seasons of 2018 and 2019. Five cm tall calla-lilies (*Zantedeschia aethiopica*) transplants were repotted individually in May 2018 in 30 cm plastic pots filled with approximately 1.300 kg of a mixture of peat moss and garden soil at 35 and 65%, respectively. Normal irrigation of pots was accompanied with adding 2.5 g of N, P and K (20:20:20)/pot. This fertilization procedure was repeated 4 times each year.

In November 2018, plants that were then about 8 cm long, were subjected to a factorial experiment composed of 2 factors, as they were divided into two main groups according to irrigation frequency. The first group was irrigated 3 times/week and the second one 4 times/week. Each group was subdivided into 7 sub-groups representing chemical treatments as follows: 8-hydroxyquinoline sulfate (HQS) at 300 and 400 ppm, chitosan at 200 and 300 ppm, potassium chloride (KCl) at 400 and 500 ppm, in addition to a control treatment where no chemicals were used. These chemicals were applied monthly as a thorough foliar spray for 4 times during each season. The second season was a repetition of the first one. At the end of each season these data were recorded: plant height (cm), leaf area (cm^2), number of leaves per plant, fresh and dry weights of leaves roots (g) and flowers; number of days to flowering, water consumption, osmotic pressure(ATM), percentages of N according to Blake [13]; P according to John [14] and K according to Dewis and Freitas [15]; contents of total chlorophyll and carotenoids according to Saric *et al.* [16] and total sugars % in flowers according to Dubois *et al*. [17].

Physical and chemical properties of peat moss and growing media are shown in Tables "a" and "b".

Data were statistically analyzed using analysis of variance as described by Snedecor and Cochran [18] and means were compared by Duncan range at a probability level of 5% [19].

Table a: Physical and chemical properties of peat moss:

pH = 3.4	Ash = 5%	Organic matter = 91%	Water capacity = 69%	Density = 80 mg/l
N = 1.04%	P = 0.22%	K = 1.76%	Mg = 340 ppm	Zn = 40 ppm
Fe = 410 ppm	Mn = 25 ppm	Cu = 8.5 ppm	B = 3.6 ppm	Mo = 1.3 ppm

Table b: Physical and chemical properties of growing media

Clay = 41.23%	Coarse sand = 8.67%	Fine sand = 15.18%	Silt = 34.89%	pH = 3.8	EC (ds / m) = 1.6
Anions (meq / l):	HCO_3^- = 4.53	Cl^- = 4.31	SO_4^{2-} = 3.95		
Cations (meq / l):	Ca^{2+} = 5.21	Mg^{2+} = 2.01	Na^+ = 4.76	K^+ = 2.98	

RESULTS AND DISCUSSION

Plant Height: Effect of chemical treatments and irrigation frequency and their interaction on plant height (cm) as shown in Table (1).

Effect of chemical treatments showed that the tallest plants were a result of using chitosan at 300 ppm (50.69 and 54.22 cm, respectively), in addition to chitosan at 200 ppm in the first season only (50.63 cm). The shortest plants were a result of the control treatment (33.30 and 34.14 cm).

Effect of irrigation frequency cleared that irrigation for 4 times/week gave rise to taller plants (44.86 and 47.31 cm). The shortest ones resulted when irrigation for 3 times/week was adopted (43.08 and 44.44).

Effect of the interaction between chemical treatments and irrigation frequency showed that the tallest plants resulted in both seasons as a result of watering for 4 times/week and applying chitosan at 300 ppm (52.29 and 57.18 cm in the first and second seasons, respectively), or chitosan at 200 ppm in the first season only (50.44 cm). The shortest plants were induced by the control treatment plus irrigation for 3 times/week (31.78 and 33.25 cm).

Our results are in accordance with findings of many authors. El-Shazly [20] tested the effect of 8-hydroxyquinoline (8-HQ) at rates of 0, 25, 50 and 100 mg/l on pot grown Washington navel orange. He found that plant height increased with 8-HQ applications. This increase was more pronounced at the rate of 50 mg/l.

Cabrera *et al.* [21] stated that chitosan application at 1% (w/v) improved stem length of highbush blueberry (*Vaccinium corymbosum*) cv. O'Neal. Mondal *et al.* [22] investigated the effect of foliar application of chitosan on okra. They revealed that plant height was increased with increasing concentration of chitosan upto 25 ppm. Salachna and Zawadziñska [8] showed that the chitosan-treated potted 'Gompey' freesia plants had taller plants. However, it had no influence on the length of the main inflorescence peduncle or the inflorescence spike. El-Khateeb *et al.* [23] studied the effect of chitosan at 2.5 and 5 g/l on the vegetative growth of marjoram plant. They claimed that chitosan at 2.5 g/l gave the highest values of plant height. Hussain *et al.* [24] remarked that foliar application of chitosan at 90 mg/l on tomato plants increased plant height. Irawati *et al.* [25] reported that Kemiri sunan (*Reutealis trisperma*, Euphorbiaceae) is a vegetable-oil producing plant. The vegetative growth of plants with chitosan administration had a better growth response than those without chitosan in terms of plant height. Ullah *et al.* [26] subjected tomato cv. Rio Grande to salinity stress and treated it with different concentrations of chitosan. They found that chitosan at 150 mg/l significantly mediated the effect of salinity stress and recorded maximum plant height.

Mengel and Haeder [27] investigated the composition of phloem sap in *Ricinus communis* var. *gibsonii*, grown on nutrient solution of low and high potassium content. They remarked that plants at low K (0.4 mM (15.6 ppm)) and high K (1 mM (39 ppm)) did not differ in height. However, Adiloglu *et al.* [28] determined the effects of different levels (0, 15, 30 and 60 mM) of KCl salt on seedling growth of wheat. They noticed that plant height was decreased with increasing rates of KCl applications. KC1 should be applied in a precise amount to wheat, otherwise quantity and quality of wheat plant will decrease. On the contrary, Chen *et al.* [29] cultured *Prunella vulgaris* (Lamiaceae) seedlings in media with four different KCl levels (0, 74.5, 447.0, 2980.0 ppm). They found that KCl at 447.0 ppm resulted in the highest values for shoot height. Tariq *et al.* [30] provided tomato plants with KCl at 0.1, 0.2 and 0.3 M (7450, 14900, 22350 ppm). They showed that with increasing levels of KCl, plant height was increased. The plant showed maximum growth, when provided with 0.3M Kcl.

Leaf Area: Effect of chemical treatments and irrigation frequency and their interaction on leaf area (cm^2) as provided in Table (2):

Effect of chemical treatments apparent that the greatest leaf area resulted when chitosan at either 200 ppm (185.31 and 186.52 cm^2 in the first and second seasons, respectively) or 300 ppm (187.05 and 188.62 cm^2 in the first and second seasons, respectively) were used. The lowest leaf area was induced by the control treatment (113.90 and 113.95 cm^2 in the first and second seasons, respectively).

Effect of irrigation frequency revealed that watering plants 4 times/week gave rise to greater leaf area (152.56 and 153.27 cm^2 in the first and second seasons, respectively) compared to watering 3 times/week (147.97 and 148.16 in the first and second seasons, respectively).

Effect of the interaction between chemical treatments and irrigation frequency showed that the greatest leaf area resulted in both seasons as a result of watering 4 times/week and applying chitosan at 300 ppm (190.19 and 191.77 cm^2 in the first and second seasons, respectively), or chitosan at 200 ppm in the first season only (188.55 cm^2). The lowest leaf areas were induced by the control treatment plus irrigation for 3 times/week (112.16 and 112.39 cm^2 in the first and second seasons), in addition to the control treatment plus watering for 4 times/week (115.64 cm^2) in the first season only.

Table 1: Effect of chemical treatments and irrigation frequency on plant height (cm) in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	31.78 i	34.83 h	33.30 E	33.25 j	35.04 i	34.14 G
HQS 300	43.21 d-f	45.15 cd	44.18 BC	44.97 fg	47.12 de	46.04 D
HQS 400	44.25 c-e	46.25 c	45.25 B	46.20 ef	48.10 d	47.15 C
Chitosan 200	50.81 ab	50.44 ab	50.63 A	50.40 c	53.70 b	52.05 B
Chitosan 300	49.08 b	52.29 a	50.69 A	51.26 c	57.18 a	54.22 A
KCl 400	40.23 g	41.10 fg	40.66 D	41.06 h	44.05 g	42.55 F
KCl 500	42.24 e-g	43.95 c-e	43.09 C	43.96 g	45.96 ef	44.96 E
Mean	43.08 B	44.86 A		44.44 B	47.31 A	

Means with the same letter are not significantly different according to Duncan's multiple range test (DMRT)

Table 2: Effect of chemical treatments and irrigation frequency on leaf area (cm^2) in two season

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	112.16 h	115.64 h	113.90 D	112.39 l	115.50 k	113.95 F
HQS 300	140.15 e-g	145.32 de	142.74 BC	140.75 gh	146.28 de	143.51 C
HQS 400	143.04 d-f	148.11 d	145.58 B	144.11 ef	148.30 d	146.21 B
Chitosan 200	182.07 c	188.55 ab	185.31 A	183.86 c	189.18 b	186.52 A
Chitosan 300	183.91 bc	190.19 a	187.05 A	185.46 c	191.77 a	188.62 A
KCl 400	139.31 fg	138.04 fg	138.68 C	133.74 j	139.64 h	136.69 E
KCl 500	135.12 g	142.09 ef	138.61 C	136.82 i	142.19 fg	139.51 D
Mean	147.97 B	152.56 A		148.16 B	153.27 A	

Means with the same letter are not significantly different according to Duncan's multiple range test (DMRT)

Al-Hassani and Majid [31] found that chitosan at 25 mg/l had a significant effect on sweet pepper plants as it increased leaf area. Ullah *et al.* [26] subjected tomato cv. Rio Grande to salinity stress and treated it with different concentration of chitosan. They found that chitosan at 150 mg/l significantly mediated the effect of salinity stress and recorded maximum leaf area.

Mengel and Haeder [27] investigated the composition of phloem sap in *Ricinus communis* var. *gibsonii*, grown on nutrient solution of low and high potassium content. They remarked that plants at low K (0.4 mM (15.6 ppm)) and high K (1 mM (39 ppm)) did not differ in leaf area. Tariq *et al.* [30] provided tomato plants with KCl at 0.1, 0.2 and 0.3 M (7450, 14900, 22350 ppm). They showed that with increasing levels of KCl, leaf length and width increased. The plant showed maximum growth, when provided with 0.3M (22350 ppm) Kcl.

Number of Leaves: Effect of chemical treatments and irrigation frequency and their interaction on number of leaves from data averaged in Table (3):

Effect of chemical treatments exhibited that the highest number of leaves was detected when chitosan at 300 ppm was applied (23.17 and 23.67 leaves in the first and second seasons, respectively). On the other hand, the control treatment resulted in the lowest records in the same regard (8.17 and 9.50 leaves in the first and second seasons, respectively).

Effect of irrigation frequency indicated that irrigating plants 4 times/week resulted in higher number of leaves (17.52 and 18.29 leaves) compared to irrigating for 3 times/week (15.67 and 16.24) in the first and second seasons, respectively.

Effect of the interaction between chemical treatments and irrigation frequency showed that watering at 4 times/week combined with treating plants with 300 ppm chitosan induced the highest number of leaves (25.33 and 26.00 leaves), while watering for 3 times/week plus applying the control treatment resulted in the lowest number of leaves (7.33 and 8.67 leaves) in the first and second seasons, respectively.

Cabrera *et al.* [21] stated that chitosan application at 1% (w/v) improved number of leaves of highbush blueberry (*Vaccinium corymbosum*) cv. O'Neal. Mondal *et al.* [22] investigated the effect of foliar application of chitosan on okra. They revealed that leaf number/plant increased with increasing concentration of chitosan upto 25 ppm. Salachna and Zawadziñska [8]

Table 3: Effect of chemical treatments and irrigation frequency on number of leaves per plant in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	7.33 j	9.00 i	8.17 E	8.67 j	10.33 i	9.50 F
HQS 300	16.00 ef	17.00 de	16.50 C	16.33 f	18.00 de	17.17 D
HQS 400	16.67 e	18.00 d	17.33 C	17.67 e	19.00 d	18.33 C
Chitosan 200	20.33 c	23.00 b	21.67 B	21.00 c	23.33 b	22.17 B
Chitosan 300	21.00 c	25.33 a	23.17 A	21.33 c	26.00 a	23.67 A
KCl 400	14.00 h	15.00 f-h	14.50 D	14.00 h	15.33 fg	14.67 E
KCl 500	14.33 gh	15.33 fg	14.83 D	14.67 gh	16.00 f	15.33 E
Mean	15.67 B	17.52 A		16.24 B	18.29 A	

Means with the same letter are not significantly different according to Duncan's multiple range test (DMRT)

Table 4: Effect of chemical treatments and irrigation frequency on fresh weight of leaves (g) in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	119.98 m	124.18 l	122.08 G	120.17 l	123.75 k	121.96 F
HQS 300	179.56 h	184.32 f	181.94 D	179.06 hi	183.91 f	181.49 D
HQS 400	182.19 g	189.56 e	185.88 C	181.65 g	186.90 e	184.27 C
Chitosan 200	200.95 d	203.49 b	202.22 B	193.42 d	198.32 b	195.87 B
Chitosan 300	202.32 c	205.76 a	204.04 A	195.57 c	203.85 a	199.71 A
KCl 400	171.62 k	175.50 i	173.56 F	170.76 j	179.85 h	175.30 E
KCl 500	173.25 j	175.71 i	174.48 E	178.08 i	183.25 f	180.67 D
Mean	175.70 B	179.79 A		174.10 B	179.98 A	

Means with the same letter are not significantly different according to Duncan's multiple range test (DMRT)

showed that the chitosan-treated potted 'Gompey' freesia plants had more leaves. Hussain *et al.* [24] remarked that foliar application of chitosan at 90 mg/l on tomato plants increased number of leaves. Irawati *et al.* [25] reported that Kemiri sunan (*Reutealis trisperma*, Euphorbiaceae) is a vegetable-oil producing plant. The vegetative growth of plants with chitosan administration had a better growth response than those without chitosan in terms of number of leaves. Ullah *et al.* [26] subjected tomato cv. Rio Grande to salinity stress and treated it with different concentrations of chitosan. They found that chitosan at 150 mg/l significantly mediated the effect of salinity stress and recorded maximum number of leaves/plant.

Adiloglu *et al.* [28] determined the effects of different levels (0, 15, 30 and 60 mM (0, 1117.5, 2235.0 and 4470.0 ppm)) of KCl salt on seedling growth of wheat. They noticed that leaf number was decreased with increasing rates of KCl applications. Tariq *et al.* [30] provided tomato plants with KCl at 0.1, 0.2 and 0.3 M (7450, 14900, 22350 ppm). They showed that with increasing levels of KCl, number of leaves was increased. The plant showed maximum growth, when provided with 0.3M (22350 ppm) KCl.

Fresh Weight of Leaves: Effect of chemical treatments and irrigation frequency and their interaction on fresh weight of leaves as shown in Table (4):

Effect of chemical treatments exhibited that applying 300 ppm chitosan gave rise to the heaviest fresh weight (204.04 and 199.71 g), while the control treatment resulted in the lightest fresh weight (122.08 and 121.96 g in the first and second seasons, respectively).

Effect of irrigation frequency revealed that watering plants for 4 times/week resulted in heavier fresh weight (179.79 and 179.98 g) than the outcome of watering for 3 times/week (175.70 and 174.10 g in the first and second seasons, respectively).

Effect of the interaction between chemical treatments and irrigation frequency showed that applying chitosan at 300 ppm combined with irrigation for 4 times/week

induced the heaviest fresh weight (205.76 and 203.85 g). On the other hand, the control treatment plus watering at 3 times/week resulted in the lightest fresh weight (119.98 and 120.17 g in the first and second seasons, respectively).

In this respect, Mengel and Arneke [32] studied the effect of potassium on the water potential, osmotic potential and pressure potential in leaves of *Phaseolus vulgaris*. They stated that potassium had a beneficial effect on plant growth, especially on fresh matter production. Adiloglu *et al.* [28] determined the effects of different levels (0, 15, 30 and 60 mM (0, 1117.5, 2235.0 and 4470.0 ppm)) of KCl salt on seedling growth of wheat. They noticed that weight of plant fresh matter was decreased with increasing rates of KCl applications. Tariq *et al.* [30] provided tomato plants with KCl at 0.1, 0.2 and 0.3 M (7450, 14900, 22350 ppm). They showed that with increasing levels of KCl, plant fresh weight was increased. The plant showed maximum growth, when was provided with 0.3M (22350 ppm) KCl.

Dry Weight of Leaves: Effect of chemical treatments and irrigation frequency and their interaction on dry weight of leaves from data recorded in Table (5):

Effect of chemical treatments clarified that using 300 ppm chitosan resulted the heaviest dry weight (22.01 and 21.89 g), while the control treatment produced the lightest dry weight (11.24 and 11.60 g in the first and second seasons, respectively).

Effect of irrigation frequency stated that irrigating plants 4 times/week resulted in heavier dry weight (18.83 and 18.93 g) than the outcome of watering for 3 times/week (17.55 and 17.30 g in the first and second seasons, respectively).

Effect of the interaction between chemical treatments and irrigation frequency showed that applying chitosan at 300 ppm plus irrigation for 4 times/week produced the heaviest dry weight (23.31 and 22.82 g) besides chitosan at 200 ppm plus irrigation for 4 times/week (22.22 g). On the other hand, the control treatment plus watering at 3 times/week resulted in the lightest dry weight (10.29 and 10.50 g) in the first and second seasons, respectively.

These results are in accordance with those of other workers. El-Shazly [20] tested the effect of 8-hydroxyquinoline (8-HQ) at rates of 0, 25, 50 and 100 mg/l on pot grown Washington navel orange. He found that plant dry weight increased with 8-HQ applications. This increase was more pronounced at the rate of 50 mg/l.

Cabrera *et al.* [21] stated that chitosan application at 1% (w/v) improved shoot dry weight of highbush blueberry (*Vaccinium corymbosum*) cv. O'Neal. Mondal *et al.* [22] investigated the effect of foliar application of chitosan on okra. They revealed that total dry mass/plant increased with increasing concentration of chitosan up to 25 ppm. El-Khateeb *et al.* [23] studied the effect of chitosan at 2.5 and 5 g/l on the vegetative growth of marjoram plant. They claimed that chitosan at 2.5 g/l gave the highest values of fresh and dry weights of the herb. El Amerany *et al.* [10] observed an increase of shoot biomass was observed in tomato plants sprayed with chitosan.

Mengel and Haeder [27] investigated the composition of phloem sap in *Ricinus communis* var. *gibsonii*, grown on nutrient solution of low and high potassium content. They remarked that plants at low K (0.4 mM (15.6 ppm)) and high K (1 mM (39 ppm)) did not differ in growth. Adiloglu *et al.* [28] determined the effects of different levels (0, 15, 30 and 60 mM (0, 1117.5, 2235.0 and 4470.0 ppm)) of KCl salt on seedling growth of wheat. They noticed that dry matter weight of plant decreased with increasing rates of KCl applications. Teixeira *et al.* [33] investigated the effect of KCl on pineapple growth. They stated that biomass accumulation of pineapple plants was impaired by chlorine added with potassium chloride. The detrimental effects of KCl were associated with excess of chlorine. Chen *et al.* [29] cultured *Prunella vulgaris* (Lamiaceae) seedlings in media with four different KCl levels (0, 74.5, 447.0, 2980.0 ppm). They found that KCl at 447.0 ppm resulted in the highest values for dry weight. Tariq *et al.* [30] provided tomato plants with KCl at 0.1, 0.2 and 0.3 M (7450, 14900, 22350 ppm). They showed that with increasing levels of KCl, plant dry weight increased. The plant showed maximum growth, when provided with 0.3M (22350 ppm) KCl. Xu *et al.* [34] used Apple dwarf rootstock seedlings (M9T337) to study the impacts of different K levels on plant growth. They showed that both deficiency and excess of K inhibited the growth and root development. When K supply concentration was 0 mM (0 ppm) and 12 mM (468 ppm), the biomass of each organ and net photosynthetic rate were decreased significantly. Deficiency and excess of K could reduce N absorption and C assimilation accumulation. On the other hand, seedlings treated with 6 mM (234 ppm) K^+ had higher N and C metabolizing enzyme activities and higher nitrate transporter gene expression levels.

Fresh Weight of Roots: Effect of chemical treatments and irrigation frequency and their interaction on fresh weight of roots as shown in Table (6):

Table 5: Effect of chemical treatments and irrigation frequency on dry weight of leaves (g) in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	10.29 h	12.19 g	11.24 F	10.50 h	12.70 g	11.60 F
HQS 300	18.37 e	19.49 d	18.93 D	17.20 ef	18.64 d	17.92 D
HQS 400	19.36 d	20.30 c	19.83 C	18.00 de	19.69 c	18.85 C
Chitosan 200	20.31 c	21.98 b	21.15 B	20.34 bc	22.22 a	21.28 B
Chitosan 300	20.71 c	23.31 a	22.01 A	20.96 b	22.82 a	21.89 A
KCl 400	16.87 f	17.10 f	16.99 E	16.53 f	17.79 e	17.16 E
KCl 500	16.93 f	17.43 f	17.18 E	17.58 e	18.64 d	18.11 D
Mean	17.55 B	18.83 A		17.30 B	18.93 A	

Means with the same letter are not significantly different according to Duncan's multiple range test (DMRT)

Table 6: Effect of chemical treatments and irrigation frequency on fresh weight of roots (g) in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	202.86 l	211.18 k	207.02 G	203.66 l	212.23 k	207.95 F
HQS 300	240.82 g	244.31 e	242.57 D	242.97 gh	247.18 d	245.07 C
HQS 400	242.25 f	244.46 e	243.35 C	245.05 ef	246.91 de	245.98 C
Chitosan 200	251.57 d	254.92 b	253.24 B	255.20 c	258.83 b	257.02 B
Chitosan 300	253.27 c	256.70 a	254.99 A	255.68 c	261.40 a	258.54 A
KCl 400	236.14 j	239.48 h	237.81 F	236.35 j	241.52 hi	238.93 E
KCl 500	238.46 i	239.59 h	239.03 E	240.24 i	243.78 fg	242.01 D
Mean	237.91 B	241.52 A		239.88 B	244.55 A	

Means with the same letter are not significantly different according to Duncan's multiple range test (DMRT)

Table 7 Effect of chemical treatments and irrigation frequency on dry weight of roots (g) in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	39.12 k	43.67 j	41.40 G	40.49 k	43.99 j	42.24 G
HQS 300	80.37 f	83.00 e	81.68 D	80.53 g	84.30 f	82.41 D
HQS 400	82.92 e	83.45 e	83.19 C	83.48 f	86.38 e	84.93 C
Chitosan 200	94.30 d	102.06 b	98.18 B	97.82 d	105.24 b	101.53 B
Chitosan 300	98.06 c	104.28 a	101.17 A	100.23 c	107.97 a	104.10 A
KCl 400	75.88 i	78.83 g	77.36 F	77.30 i	78.90 h	78.10 F
KCl 500	77.59 h	79.55 fg	78.57 E	77.74 hi	81.11 g	79.43 E
Mean	78.32 B	82.12 A		79.66 B	83.98 A	

Means with the same letter are not significantly different according to Duncan's multiple range test (DMRT)

Table 8: Effect of chemical treatments and irrigation frequency on fresh weight of flowers (g) in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	14.44 i	16.13 h	15.28 E	15.37 j	17.52 i	16.45 D
HQS 300	22.05 de	23.01 cd	22.53 B	21.07 fg	24.52 d	22.79 B
HQS 400	22.18 de	23.24 c	22.71 B	22.67 e	24.65 d	23.66 B
Chitosan 200	23.97 bc	25.69 a	24.83 A	26.04 c	27.60 ab	26.82 A
Chitosan 300	24.38 b	26.46 a	25.42 A	26.41 bc	28.19 a	27.30 A
KCl 400	18.13 g	20.27 f	19.20 D	18.92 h	21.84 ef	20.38 C
KCl 500	19.03 g	21.32 e	20.17 C	20.20 g	22.49 e	21.34 C
Mean	20.59 B	22.30 A		21.52 B	23.83 A	

Means with the same letter are not significantly different according to Duncan's multiple range test (DMRT)

Effect of chemical treatments apparent that applying chitosan at 300 ppm resulted in heavier fresh roots (254.99 and 258.54 g) than the outcome of the control treatment (207.02 and 207.95 g in the first and second seasons, respectively).

Effect of irrigation frequency exhibited that watering plants for 4 times/week gave rise to heavier fresh roots (241.52 and 244.55 g) compared to watering for 3 times/week (237.91 and 239.88 g) in the first and second seasons, respectively.

Effect of the interaction between chemical treatments and irrigation frequency indicated that using 300 ppm chitosan + watering for 4 times/week induced the heaviest fresh roots (256.70 and 261.40 g), while the control treatment combined with watering for 3 times/week induced the lightest fresh roots (202.86 and 203.66 g in the first and second seasons, respectively).

Dry Weight of Roots: Effect of chemical treatments and irrigation frequency and their interaction on dry weight of roots first season from data averaged in Table (7):

Effect of chemical treatments showed that using chitosan at 300 ppm produced heavier dry roots (101.17 and 104.10 g) than those produced by the control treatment (41.40 and 42.24 g) in the first and second seasons, respectively.

Effect of irrigation frequency clarified that irrigating plants for 4 times/week gave rise to heavier dry roots (82.12 and 83.98 g) compared to watering for 3 times/week (78.32 and 79.66 g in the first and second seasons, respectively).

Effect of the interaction between chemical treatments and irrigation frequency exhibited that applying 300 ppm chitosan + watering for 4 times/week produced the heaviest dry roots (104.28 and 107.97 g), while the control treatment combined with watering 3 times/week induced the lightest dry roots (39.12 and 40.49 g) in the first and second seasons, respectively.

In this concern, Cabrera *et al.* [21] stated that chitosan application at 1% (w/v) improved root dry weight of highbush blueberry (*Vaccinium corymbosum*) cv. O'Neal. Al-Hassani and Majid [31] found that chitosan at 25 mg/l had a significant effect on sweet pepper plants as it increased dry weight of roots.

Chen *et al.* [29] cultured *Prunella vulgaris* (Lamiaceae) seedlings in media with four different KCl levels (0, 74.5, 447.0, 2980.0 ppm). They found that KCl at 447.0 ppm resulted in the highest values for root weight.

Fresh Weight of Flowers: Effect of chemical treatments and irrigation frequency and their interaction on fresh weight of flowers as can be seen, tabulated data in Table (8):

Effect of chemical treatments concluded that applying 200 ppm chitosan gave rise to the heaviest fresh flowers (24.83 and 26.82 g), in addition to 300 ppm chitosan (25.42 and 26.82 g) in the first and second seasons, respectively. The lightest fresh flowers were induced by the control treatment (15.28 and 16.45 g in the first and second seasons, respectively).

Effect of irrigation frequency indicated that the heaviest fresh flowers (22.30 and 23.83 g) and the lightest ones (20.59 and 21.52 g) in the first and second seasons, respectively were observed when irrigation was applied at 4 and 3 times/week, respectively.

Effect of the interaction between chemical treatments and irrigation frequency clarified that the heaviest fresh flowers resulted from watering plants for 4 times/week combined with chitosan at either 200 ppm (25.69 and 27.60 g) or at 300 ppm (26.46 and 28.19 g in the first and second seasons, respectively). The lightest fresh flowers were noticed in the control plants that were watered 3 times/week (14.44 and 15.37 g in the first and second seasons, respectively).

Dry Weight of Flowers: Effect of chemical treatments and irrigation frequency and their interaction on dry weight of flowers, (Table, 9):

Effect of chemical treatments exhibited that using 300 ppm chitosan gave rise to the heaviest dry flowers (5.87 and 6.51 g), while the lightest dry flowers were induced by the control treatment (2.21 and 2.25 g in the first and second seasons, respectively).

Effect of irrigation frequency showed that the heaviest fresh flowers (4.10 and 4.75 g) and the lightest ones (3.24 and 3.71 g in the first and second seasons, respectively) were observed when irrigation was applied at 4 and 3 times/week, respectively.

Effect of the interaction between chemical treatments and irrigation frequency clarified that applying 300 ppm chitosan + watering for 4 times/week produced the heaviest dry flowers (6.61 and 7.15 g), while the control treatment combined with watering 3 times/week induced the lightest dry flowers (1.71 and 1.60 g) in the first and second seasons, respectively.

In this regard, Chen *et al.* [29] cultured *Prunella vulgaris* (Lamiaceae) seedlings in media with four different KCl levels (0, 74.5, 447.0, 2980.0 ppm). They found that KCl at 447.0 ppm resulted in the highest values for spike weight.

Table 9: Effect of chemical treatments and irrigation frequency on dry weight of flowers (g) in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	1.71 i	2.71 gh	2.21 F	1.60 k	2.91 j	2.25 E
HQS 300	3.11 fg	3.44 ef	3.28 CD	3.10 ij	4.47 ef	3.79 CD
HQS 400	3.42 ef	3.66 e	3.54 C	3.93 fg	4.74 de	4.34 C
Chitosan 200	4.28 d	5.82 b	5.05 B	5.32 cd	6.45 b	5.88 B
Chitosan 300	5.12 c	6.61 a	5.87 A	5.87 bc	7.15 a	6.51 A
KCl 400	2.28 h	3.19 e-g	2.73 E	2.89 j	3.70 g-i	3.29 D
KCl 500	2.75 gh	3.30 ef	3.02 DE	3.23 h-j	3.85 f-h	3.54 D
Mean	3.24 B	4.10 A		3.71 B	4.75 A	

Means with the same letter are not significantly different according to Duncan's multiple range test (DMRT)

Table 10: Effect of chemical treatments and irrigation frequency on number of days to flowering in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	180.00 a	172.67 ab	176.33 A	179.33 a	174.67 b	177.00 A
HQS 300	164.67 ab	159.33 ab	162.00 AB	166.00 e	160.67 g	163.33 D
HQS 400	160.67 ab	61.67 c	111.17 C	163.33 f	158.33 h	160.83 E
Chitosan 200	146.33 ab	143.33 b	144.83 B	148.67 i	145.33 j	147.00 F
Chitosan 300	146.00 ab	139.33 b	142.67 B	146.67 j	140.67 k	143.67 G
KCl 400	169.33 ab	166.67 ab	168.00 AB	171.00 c	167.67 d	169.33 B
KCl 500	169.67 ab	162.33 ab	166.00 AB	170.67 c	165.00 e	167.83 C
Mean	162.38 A	143.62 B		163.67 A	158.90 B	

Means with the same letter are not significantly different according to Duncan's multiple range test (DMRT)

Table 11: Effect of chemical treatments and irrigation frequency on water consumption (cm^3) in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	49.90 k	54.43 j	52.16 G	50.66 gh	38.63 h	44.65 D
HQS 300	59.82 i	65.61 g	62.72 E	61.01 e-g	65.54 c-f	63.27 C
HQS 400	62.99 h	68.34 f	65.66 D	63.66 d-f	68.35 b-e	66.01 BC
Chitosan 200	74.25 e	77.02 c	75.63 B	74.90 a-d	77.92 a-c	76.41 A
Chitosan 300	75.50 d	79.22 b	77.36 A	76.12 a-d	79.72 ab	77.92 A
KCl 400	82.69 a	63.53 h	73.11 C	83.33 a	64.23 d-f	73.78 AB
KCl 500	54.84 j	67.17 f	61.00 F	54.94 fg	68.54 b-e	61.74 C
Mean	65.71 B	67.90 A		66.37 A	66.13 A	

Means with the same letter are not significantly different according to Duncan's multiple range test (DMRT)

Number of Days to Flowering: Effect of chemical treatments and irrigation frequency and their interaction on number of days to flowering as shown in Table (10):

Effect of chemical treatments apparent that plants of the control treatment took the greatest number of days to flowering (176.33 and 177.00 days in the first and second seasons, respectively). The shortest time to flowering was achieved by plants treated with 400 ppm HQS and 300 ppm chitosan (111.17 and 143.67 days in the first and second seasons, respectively).

Effect of irrigation frequency showed that plants watered for 3 times/week needed longer time to flower (162.38 and 163.67 days in the first and second seasons, respectively) compared to those watered for 4 times/week (143.62 and 158.90 days in the first and second seasons, respectively).

Effect of the interaction between chemical treatments and irrigation frequency clarified that plants of the control treatment that were irrigated for 3 times/week took the longest time to flower (180.00 and 179.33 days in the first and second seasons, respectively). The least number of days to flowering was recorded plants watered for 4 times/week and treated with 400 ppm HQS (61.67 days) or with 300 ppm chitosan (140.67 days), in the first and second seasons, respectively.

In this connection, Salachna and Zawadziñska [8] showed that the chitosan-treated potted 'Gompey' freesia plants flowered earlier.

Water Consumption: Effect of chemical treatments and irrigation frequency and their interaction on water consumption as can be seen, tabulated data in Table (11):

Effect of chemical treatments exhibited that the highest consumption was achieved by applying 300 ppm chitosan (77.36 and 77.92 cm^3 in the first and second seasons, respectively), in addition to 200 ppm chitosan and 400 ppm KCl (76.41 and 73.78 cm^3) in the second season only. The lowest record in the same regard was detected in the control treatment (52.16 and 44.65 cm^3 in the first and second seasons, respectively).

Effect of irrigation frequency indicated that the effect of irrigation frequency on water consumption was significant in the first season only where the highest and lowest consumptions (67.90 and 65.71 cm^3, respectively) were induced by watering for 4 and 3 times/week, respectively.

Effect of the interaction between chemical treatments and irrigation frequency clarified that applying 400 ppm KCl resulted in the highest water consumption (82.69 and 83.33 cm^3 in the first and second seasons, respectively). Plants of the control treatment that were watered for 3 times/week had the lowest consumption (49.90 cm^3 in the first season), besides those watered for 4 times/week plus the same treatment (38.63 cm^3).

In this concern, El-Deeb *et al.* [35] reported that a solution containing 8-HQC at 300 ppm plus GA_3 + BA + citric acid + sugar increased water uptake in unrooted cuttings of *Dracaena marginata*.

Osmotic Pressure: Effect of chemical treatments and irrigation frequency and their interaction on osmotic pressure from data averaged in Table (12):

Effect of chemical treatments concluded that chitosan at 300 ppm induced the highest osmotic pressure (6.18 and 6.20 ATM), while the control treatment resulted in the lowest osmotic pressure (4.53 and 4.54 ATM), in the first and second seasons, respectively.

Effect of irrigation frequency showed that watering plants for 4 times/week resulted in higher osmotic pressure (5.47 and 5.50 ATM) compared to watering for 3 times/week (5.23 and 5.25 ATM), in the first and second seasons, respectively.

Effect of the interaction between chemical treatments and irrigation frequency clarified that chitosan at 300 ppm combined with watering for 4 times/week produced the highest osmotic pressure (6.48 and 6.51 ATM), in the first and second seasons, respectively. The lowest values in the same request were induced by the control treatment plus watering for 3 times/week (4.50 and 4.52 ATM) or plus watering 4 times/week (4.55 and 4.56 ATM), in the first and second seasons, respectively.

However, Mengel and Haeder [27] investigated the composition of phloem sap in *Ricinus communis* var. *gibsonii*, grown on nutrient solution of low (15.6 ppm) and high (39 ppm) potassium content. They remarked that the osmotic pressure of the phloem sap was increased substantially in the higher K treatment. Mengel and Arneke [32] studied the effect of potassium on the water potential, osmotic potential and pressure potential in leaves of *Phaseolus vulgaris* . They stated that the water status of leaves (water content, pressure potential, osmotic potential) responded more sensitively to potassium supply than dry matter production. It is concluded that K^+ is indispensible for attaining an optimum potential (turgor) in young leaves which in turn has an impact on plant growth.

Nitrogen: Effect of chemical treatments and irrigation frequency and their interaction on nitrogen as can be seen, tabulated data in Table (13):

Effect of chemical treatments indicated that applying 300 ppm chitosan resulted in the highest nitrogen% (2.51 and 2.52%), while the control treatment induced the lowest percentage (1.22 and 1.44%), in the first and second seasons, respectively.

Effect of irrigation frequency exhibited that irrigation at 4 times/week gave rise to higher nitrogen% (2.00 and 2.02%) compared to irrigation at 3 times/week (1.81 and 1.89%), in the first and second seasons, respectively.

Effect of the interaction between chemical treatments and irrigation frequency concluded that chitosan at 300 ppm combined with irrigation at 4 times/week resulted in the highest nitrogen% (2.58 and 2.59%), while plants of the control treatment that were watered 3 times/week had the lowest nitrogen% (1.00 and 1.42%), in the first and second seasons, respectively.

Similarly, Hussain *et al.* [24] remarked that foliar application of chitosan at 90 mg/l on tomato plants increased percentage of nitrogen in the leaves.

Phosphorus: Effect of chemical treatments and irrigation frequency and their interaction on phosphorus as shown in Table (14):

Effect of chemical treatments apparent that using 300 ppm chitosan resulted in the highest phosphorus% (0.22 and 0.23%), while the control treatment produced the lowest percentage (0.12 and 0.13%), in the first and second seasons, respectively.

Effect of irrigation frequency clarified that watering plants for4 times/week resulted in higher phosphorus% (0.19 and 0.19%) compared to irrigation for 3 times/week (0.16 and 0.17%), in the first and second seasons, respectively.

Table 12: Effect of chemical treatments and irrigation frequency on osmotic pressure (ATM) in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	4.50 j	4.55 j	4.53 G	4.52 i	4.56 i	4.54 G
HQS 300	5.28 f	5.49 d	5.38 D	5.30 e	5.51 d	5.41 D
HQS 400	5.37 e	5.54 d	5.46 C	5.38 e	5.57 d	5.48 C
Chitosan 200	5.84 c	6.18 b	6.01 B	5.86 c	6.23 b	6.04 B
Chitosan 300	5.88 c	6.48 a	6.18 A	5.90 c	6.51 a	6.20 A
KCl 400	4.84 i	4.97 h	4.91 F	4.85 h	4.99 g	4.92 F
KCl 500	4.89 hi	5.11 g	5.00 E	4.91 gh	5.13 f	5.02 E
Mean	5.23 B	5.47 A		5.25 B	5.50 A	

Means with the same letter are not significantly different according to Duncan? s multiple range test (DMRT)

Table 13: Effect of chemical treatments and irrigation frequency on Nitrogen % in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	1.00	1.44	1.22	1.42	1.45	1.44
HQS 300	1.80	1.89	1.85	1.81	1.91	1.86
HQS 400	1.84	1.94	1.89	1.84	1.95	1.90
Chitosan 200	2.11	2.52	2.32	2.16	2.53	2.35
Chitosan 300	2.43	2.58	2.51	2.45	2.59	2.52
KCl 400	1.74	1.81	1.78	1.76	1.83	1.80
KCl 500	1.77	1.85	1.81	1.79	1.86	1.83
Mean	1.81	2.00		1.89	2.02	

Table 14: Effect of chemical treatments and irrigation frequency on Phosphorus % in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	0.11	0.13	0.12	0.11	0.14	0.13
HQS 300	0.15	0.18	0.17	0.16	0.19	0.18
HQS 400	0.17	0.20	0.19	0.18	0.20	0.19
Chitosan 200	0.20	0.22	0.21	0.21	0.23	0.22
Chitosan 300	0.21	0.23	0.22	0.22	0.24	0.23
KCl 400	0.15	0.17	0.16	0.16	0.18	0.17
KCl 500	0.16	0.18	0.17	0.17	0.18	0.18
Mean	0.16	0.19		0.17	0.19	

Effect of the interaction between chemical treatments and irrigation frequency showed that chitosan at 300 ppm plus irrigation at 4 times/week resulted in the highest phosphorus% (0.23 and 0.24%), while plants of the control treatment that were irrigated for 3 times/week had the lowest phosphorus% (0.11%), in the first and second seasons, respectively.

Similarly, Hussain *et al.* [24] remarked that foliar application of chitosan at 90 mg/l on tomato plants increased percentage of phosphorus in the leaves.

Potassium: Effect of chemical treatments and irrigation frequency and their interaction on potassium from data averaged in Table (15):

Effect of chemical treatments showed that applying chitosan at 300 ppm induced the highest potassium% (1.45 and 1.46%), while the control treatment resulted in the lowest percentage (1.21 and 1.23%), in the first and second seasons, respectively.

Effect of irrigation frequency exhibited that irrigating plants for 4 times/week resulted in higher potassium% (1.35 and 1.36%) compared to irrigation for 3 times/week (1.30 and 1.31%), in the first and second seasons, respectively.

Effect of the interaction between chemical treatments and irrigation frequency showed that chitosan at 300 ppm combined when irrigation at 4 times/week resulted in the highest potassium% (1.47 and 1.49%), while plants of the control treatment which were watered 3 times/week had the lowest potassium% (1.19 and 1.21%), in the first and second seasons, respectively.

Table 15: Effect of chemical treatments and irrigation frequency on Potassium % in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	1.19	1.23	1.21	1.21	1.24	1.23
HQS 300	1.28	1.32	1.30	1.29	1.33	1.31
HQS 400	1.30	1.33	1.32	1.31	1.34	1.33
Chitosan 200	1.36	1.44	1.40	1.37	1.45	1.41
Chitosan 300	1.42	1.47	1.45	1.43	1.49	1.46
KCl 400	1.27	1.30	1.29	1.28	1.32	1.30
KCl 500	1.28	1.33	1.31	1.28	1.34	1.31
Mean	1.30	1.35		1.31	1.36	

Table 16: Effect of chemical treatments and irrigation frequency on total chlorophyll content (mg/g fwt) in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	1.06	1.08	1.07	1.05	1.11	1.08
HQS 300	1.20	1.25	1.23	1.22	1.27	1.25
HQS 400	1.22	1.27	1.25	1.22	1.29	1.26
Chitosan 200	1.32	1.45	1.39	1.36	1.50	1.43
Chitosan 300	1.35	1.55	1.45	1.37	1.58	1.48
KCl 400	1.14	1.18	1.16	1.16	1.21	1.19
KCl 500	1.15	1.22	1.19	1.17	1.24	1.21
Mean	1.21	1.29		1.22	1.31	

Table 17: Effect of chemical treatments and irrigation frequency on carotenoids content (mg/g fwt) in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	0.57	0.58	0.58	0.59	0.59	0.59
HQS 300	0.80	0.85	0.83	0.82	0.87	0.85
HQS 400	0.83	0.90	0.87	0.84	0.91	0.88
Chitosan 200	0.94	1.00	0.97	0.95	1.04	1.00
Chitosan 300	0.97	1.05	1.01	0.97	1.06	1.02
KCl 400	0.75	0.82	0.79	0.77	0.83	0.80
KCl 500	0.79	0.84	0.82	0.80	0.85	0.83
Mean	0.81	0.86		0.82	0.88	

Total Chlorophyll Content: Effect of chemical treatments and irrigation frequency and their interaction on total chlorophyll content as can be seen, tabulated data in Table (16):

Effect of chemical treatments showed that chitosan at 300 ppm resulted in the highest chlorophyll content (1.45 and 1.48 mg/g fwt), while the control treatment resulted in the lowest content (1.07 and 1.08 mg/g fwt), in the first and second seasons, respectively.

Effect of irrigation frequency clarified that watering plants for 4 times/week resulted in higher chlorophyll content (1.29 and 1.31 mg/g fwt) compared to irrigation for 3 times/week (1.21 and 1.22 mg/g fwt), in the first and second seasons, respectively.

Effect of the interaction between chemical treatments and irrigation frequency showed that chitosan at 300 ppm plus watering at 4 times/week resulted in the highest chlorophyll content (1.55 and 1.58 mg/g fwt), while plants of the control treatment that were irrigated for 3 times/week had the least chlorophyll content (1.06 and 1.05 mg/g fwt), in the first and second seasons, respectively.

Table 18: Effect of chemical treatments and irrigation frequency on total sugars % in the flowers in two seasons

	1st season			2nd season		
	Irrigation frequency			Irrigation frequency		
Treatments (ppm)	3 times/week	4 times/week	Mean	3 times/week	4 times/week	Mean
Control	1.44	1.46	1.45	1.45	1.47	1.46
HQS 300	1.81	1.90	1.86	1.83	1.91	1.87
HQS 400	1.83	1.93	1.88	1.84	1.94	1.89
Chitosan 200	1.98	2.30	2.14	2.00	2.31	2.16
Chitosan 300	2.11	2.34	2.23	2.13	2.36	2.25
KCl 400	1.69	1.75	1.72	1.70	1.76	1.73
KCl 500	1.72	1.79	1.76	1.73	1.80	1.77
Mean	1.80	1.92		1.81	1.94	

In parallel, El-Deeb *et al.* [35] reported that a solution containing 8-HQC at 300 ppm (plus GA_3 + BA + citric acid + sugar) increased chlorophyll a, b contents in unrooted cuttings of *Dracaena marginata*.

Salachna and Zawadziñska [8] showed that the chitosan-treated potted 'Gompey' freesia plants had a higher chlorophyll content. El-Khateeb *et al.* [23] studied the effect of chitosan at 2.5 and 5 g/l on the vegetative growth of marjoram plant. They claimed that chitosan at 2.5 g/l gave the highest values of chlorophyll-a content, while chitosan at 5 g/l increased chlorophyll-b content. Hussain *et al.* [24] remarked that foliar application of chitosan at 90 mg/l on tomato plants increased contents of chlorophyll. Ullah *et al.* [26] subjected tomato cv. Rio Grande to salinity stress and treated it with different concentrations of chitosan. They found that chitosan at 150 mg/l significantly mediated the effect of salinity stress and recorded maximum chlorophyll content.

Chen *et al.* [29] cultured *Prunella vulgaris* (Lamiaceae) seedlings in media with four different KCl levels (0, 74.5, 447.0, 2980.0 ppm). They found that KCl at 447.0 ppm resulted in the highest values for net photosynthetic rate and the highest chlorophyll content.

Carotenoids Content: Effect of chemical treatments and irrigation frequency and their interaction on carotenoids content as shown in Table (17):

Effect of chemical treatments apparent that using chitosan at 300 ppm induced the highest carotenoids content (1.01 and 1.02 mg/g fwt), while the control treatment resulted in the least one (0.58 and 0.59 mg/g fwt, in the first and second seasons, respectively).

Effect of irrigation frequency indicated that watering plants for 4 times/week resulted in higher carotenoids content (0.86 and 0.88 mg/g fwt) compared to irrigation for 3 times/week (0.81 and 0.82 mg/g fwt), in the first and second seasons, respectively.

Effect of the interaction between chemical treatments and irrigation frequency exhibited that applying chitosan at 300 ppm plus watering at 4 times/week induced the highest carotenoids content (1.05 and 1.06 mg/g fwt), while plants of the control treatment which were watered 3 times/week had the least carotenoids content (0.57 and 0.59 mg/g fwt), in the first and second seasons, respectively, in addition to plants of the control treatment which were watered for 4 times/week in the second season (0.59 mg/g fwt).

However, El-Khateeb *et al.* [23] studied the effect of chitosan at 2.5 and 5 g/l on the vegetative growth of marjoram plant. They claimed that chitosan at 2.5 g/l gave the highest values of carotenoids content.

El-Deeb *et al.* [35] reported that a solution containing 8-HQC at 300 ppm (plus GA_3 + BA + citric acid + sugar) increased carotenoids content in the unrooted cuttings of *Dracaena marginata*.

Total Sugars in Flowers: Effect of chemical treatments and irrigation frequency and their interaction on total sugars in flowers from data averaged in Table (18):

Effect of chemical treatments showed that using chitosan at 300 ppm resulted in the highest total sugars% in the flowers (2.23 and 2.25%), while the control treatment induced the least one (1.45 and 1.46%, in the first and second seasons, respectively).

Effect of irrigation frequency exhibited that watering plants for 4 times/week produced higher total sugars% in flowers (1.92 and 1.94%) compared to irrigation for 3 times/week (1.80 and 1.81%), in the first and second seasons, respectively.

Effect of the interaction between chemical treatments and irrigation frequency indicated that using chitosan at 300 ppm plus watering at 4 times/week resulted in the highest total sugars% in the flowers (2.34 and 2.36%), while plants of the control treatment that were irrigated for

3 times/week had the least total sugars% in the flowers (1.44 and 1.45%, in the first and second seasons, respectively).

In a parallel line, El-Deeb *et al.* [35] reported that a solution containing 8-HQC at 300 ppm (plus GA_3 + BA + citric acid + sugar) increased total carbohydrates content in unrooted cuttings of *Dracaena marginata*.

Mondal *et al.* [22] investigated the effect of foliar application of chitosan on okra. They revealed that photosynthesis increased with increasing concentration of chitosan up to 25 ppm. El-Khateeb *et al.* [23] studied the effect of chitosan at 2.5 and 5 g/l on the vegetative growth of marjoram plant. They claimed that chitosan at 5 g/l increased content of carbohydrates. El-Amerany *et al.* [10] observed an increase of shoot biomass in tomato plants sprayed with chitosan. Chitosan had no effect on sugar and phytohormone levels.

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