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EFFECT OF MAGNETIC WATER AND FOLIAR APPLICATION OF (Zolfast) AND SILICON ON SOME CHEMICAL PARAMETERS OF CAULIFLOWER PLANT (*Brassica oleracea* L. var. botrytis)

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ABSTRACT

The experiment was conducted during two growing seasons (2018-2019 and 2019-2020) in a field belonging to tomato development project Al- Zubair / Directorate for Agriculture of Basrah. The experiment included 18 factorial treatments that are the interaction between two levels of magnetically treated water (Magnetic and without), spraying with three concentrations of silicon K2SiO3 (0, 2.5, and 3.5) ml.L^{-1} and liquid sulfur (Zolfast) (0 , 1 and 1.5) ml.L^{-1} on some chemical traits of cauliflower plant. It was conducted according to Split Split Plot Design by Randomized Complete Block Design (R.C.B.D) with three replicates, the least significant difference test (L.S.D) was used to compare the averages at a probability level of 0.05.

The magnetic water was given a significant increase in the silicon, sodium, and proline in both growing seasons, while the increase in chlorophyll content and sulfur percentage were excelled in the first season, but in the second season plants gave a significant increase in the percentage of nitrogen, phosphorous and potassium.

The silicon showed an increase in both growing seasons in the chlorophyll, nitrogen, phosphorous, potassium, sulfur, silicon but decreased in the percentage of sodium and proline content. As for the factor Zolfast, the result was similar to the silicon factor, except for potassium the increase was in the second season only. The interaction between the three factors had a significant increase in most traits in the study.

Keywords: Magnetic; silicon; zolfast; cauliflower; chemical traits.

INTRODUCTION

Cauliflower (*Brassica oleracea* L. var. Botrytis) is a wintry annual crop belonging to the Brassicaceae family, cultivated with the aim of obtaining curds [1], It has similar morphology to broccoli and Cabbage and is very sensitive to hot and dry weather [2].

water technology is one of the methods that appeared in recent years because of its important role in the conditions of water scarcity in different regions of Iraq, especially the southern regions [3]. As the magnetic field formed in the magnetizing devices affects the reduction of the angle of hydrogen-oxygen binding in the water molecule from 105.5 degrees to 103 degrees, which facilitates the transfer and absorption of nutrients through the walls of cellular membranes [4]. There are many studies conducted on the use of water magnetization technique in many crops such as [5] on cucumber, [6] on the tomato plant, [7] on okra plant.

foliar fertilization or foliar feeding with nutrients can be absorbed by leaves or other parts of the plant like fruits and stems to provide the plant with the nutrients it needs, entering through the cell envelope by water, and diffusion [8,9,10], Silicon is one of the most abundant elements in soil, but adding it to plants works to resist abiotic stresses as well as stimulate anti-oxidation systems [11]. Which may lead to an increase in plant activity, especially in areas with high temperatures. It also has a positive effect on plants under conditions that are not suitable for growth, such as salt stress conditions [12], mineral toxicity, nutritional imbalance, drought, radiation, High temperatures, freezing, and ultraviolet rays are due to most of the beneficial effects of its deposition in plant tissues in the cell walls of roots, leaves, and stems, which provides a mechanical barrier against external influences [13,14,12] indicated that Silicon has a positive effect on growth and yield parameters under the conditions of salt stress. [15] also found an increase in the content of plant leaves of total chlorophyll and silicon, in addition to a reduction in the level of the amino acid proline when treating cucumber plant with four levels of sodium silicate. Sulfur can also be considered one of the fourth macronutrients after nitrogen, phosphorous, and potassium. It is an essential element for plant growth because it is present in the main metabolic compounds such as amino acids such as methionine and cysteine and proteins, so its deficiency reduces the quality and quantity of the crop [16]. As [17] found that when spraying onion plants with three levels of liquid sulfur (Zolfast), they were 0, 1.5, and 3 $ml.L^{-1}$, the levels were greater than 1.5 and 3 $ml.L^{-1}$ zolfast in the leaves of total chlorophyll and the percentage of elements of nitrogen, phosphorus, and potassium compared with the control treatment, respectively.

MATERIALS AND METHODS

The study was conducted during the winter seasons 2018-2019 and 2019-2020 in the project of developing tomato cultivation with modern techniques of the Basra Agriculture Directorate in Khor Al-Zubair - Basrah province, which is 31 km away from the province center at a longitude of 47.0 degrees and a latitude of 30.29 degrees. In a sandy Loam soil with an electrical conductivity of 7.40 and 7.10 dS.cm-1 and a pH of 7.55 and 7.23 for the two seasons respectively, As for the degree of electrical conductivity of the irrigation water (the well), it was 16.55 and 12.25 dS.cm-1, for the two seasons respectively. The experiment was conducted as Split Plot Design and based on the randomized complete block design (RCBD), Magnetization of water was considered the first factor (main plot)(Magnetic and without), and spraying with three levels of silicon in the form of potassium silicate K2SiO3, the second factor (Sub-Plot) (0, 1 and 1.5 $ml.L^{-1}$) and spraying with three levels of Liquid sulfur (Zolfast), The third factor (Sub- Sub - Plots) 0, 2.5 and 3.5 $ml.L^{-1}$, with three sprays for both factors, the first spraying after 20 days of transplanting and between one spraying and another fourteen days. The mean results were analyzed statistically, and the Least Significant Difference Test (L.S.D) was used to compare the averages at a probability level of 0.05 [18].

Experimental Measurements

The readings were taken from five plants, randomly selected in advance from each experimental unit, then the average was calculated for one plant and included:

Chlorophyll (mg $100g^{-1}$), the percentage of nitrogen, phosphorous, potassium, sulfur and sodium (%), silicon ($mg.g^{-1}$), and proline ($\mu mol.g^{-1}$).

RESULTS AND DISCUSSION

Table 1 shows a significant effect of Magnetic water on the amount of chlorophyll in the first season only, where plants treated with Magnetic water significantly excelled it by 30.82 mg compared to the lowest amount of chlorophyll which was 30.02 mg without magnetization. The levels 1 and 1.5 $ml.L^{-1}$ silicon were significantly excelled in the first season, reaching 31.69 and 31.49 mg, respectively, compared to the lowest total chlorophyll amount, which was 28.08 mg, which resulted in the control treatment. In the second season, the level of 1.5 $ml.L^{-1}$ significantly excelled on the level of 39.10 mg compared to the other two levels, while the level of 1 $ml.L^{-1}$ silicon excelled on the control treatment, which was 35.17 mg. As can be seen from the table, the level of 3.5 $ml.L^{-1}$ Zolfast significantly excelled in the first season it reached 31.26 mg compared to levels 0 and 2.5 $ml.L^{-1}$, where it reached 29.77 and 30.23 mg 100 g^{-1}, respectively. In the second season, the level of 3.5 $ml.L^{-1}$ excelled on the other two levels by 38.65 mg, while the level of 2.5 $ml.L^{-1}$ excelled on the control treatment, which was 35.45 mg. It is evident from the same table that the two interaction between magnetizing factors and silicon was significant in the first season only, where plants treated with Magnetic water and 1.5 $ml.L^{-1}$ silicon were significantly excelled and gave 32.21 mg compared to the lowest amount that was 27.92 mg produced in plants treated with Magnetic water that were not treated with silicon, As for the interaction between magnetization and Zolfast, the plants treated with the level 3.5 $ml.L^{-1}$-Zolfast, which were not treated with magnetic water significantly, in the first season was 31.31 mg compared with the control treatment in plants without magnetic, where the lowest amount of chlorophyll was 28.80 mg. Whereas plants treated with magnetic water and the level of 3.5 $ml.L^{-1}$-Zolfast significantly excelled in the second season, 39.73 mg 100 g^{-1} compared to 35.38 mg 100 g^{-1} resulted in plants treated with magnetic water and not treated with zolfast (control). As for the interaction between silicon and zolfast, it was significant in the first season only, where the plants treated with the level of 1.5 $ml.L^{-1}$ silicon and 3.5 $ml.L^{-1}$ Zolfast significantly excelled and gave 32.51 mg compared with 27.04 mg produced in plants not treated with both factors. As for the triple interaction between the study factors, it was significant in the first season only, as the plants irrigated with magnetic water were superior and treated with 1.5 ml of silicon L^{-1} and 3.5 ml. L^{-1}Zolfast, which gave the highest amount of chlorophyll, was 33.68 mg, compared to the lowest amount of 25.89 mg produced in non-magnetic plants, which was not treated with both agents (control).

Table 2 shows the effect of magnetic water and spraying with zolfast and silicon and their interaction on the percentage of nitrogen in leaves for the two growing seasons. It is noticed that there is no significant effect of magnetization of water in these traits in the first season, while plants treated with magnetic water significantly excelled in the second season by 4.374% compared to the lowest average that was 4.143% without magnetic. It was also noticed that the levels 1 and 1.5 $ml.L^{-1}$ silicon were significantly excelled in the first season, reaching 2.451 and 2.486%, respectively, compared to the control treatment, which amounted to 2.084%. In the second season, the level of 1.5 $ml.L^{-1}$ significantly excelled the level by 4.468% compared to the other two levels, while the level of 1 ml. L -1 excelled on the control treatment, which reached 3.978%. It is evident from the table that the levels of 2.5 and 3.5 $ml.L^{-1}$ Zolfast were significantly excelled in the first season, reaching 2.347 and 2.487%, respectively, compared to the control treatment that gave the lowest nitrogen percentage, which was 2.187%.In the second season, the level of 3.5 $ml.L^{-1}$ zolfast significantly excelled and gave 4.682% compared to the other two levels, while the level of 2.5 ml-1-liter excelled on the control treatment, which reached 3.663%. It is evident from the same table that the two interaction between magnetizing factors and silicon was significant in both growing seasons, where plants treated with magnetic water and 1.5 ml. L^{-1} silicon significantly excelled in the first season, it reached 2.854% compared to plants treated with magnetic water that were not treated

Table 1. The effect of Magnetic water and spraying with zolfast and silicon on chlorophyll (mg 100 g^{-1}) for cauliflower plants

Magnetic water	Zolfast ml.l-1	First season				Second season			
		Silicon ml.l-1			Magnetic x	Silicon ml.l-1			Magnetic x
		0	1	1.5	Zolfast	0	1	1.5	Zolfast
Magnetic	0	28.20	31.38	32.62	30.73	33.95	35.16	37.02	35.38
	2.5	27.61	33.55	30.33	30.50	36.70	38.07	38.74	37.84
	3.5	27.96	32.00	33.68	31.21	38.59	39.17	41.42	39.73
Without	0	25.89	29.43	31.08	28.80	31.73	35.60	39.20	35.51
	2.5	29.08	30.95	29.86	29.97	34.37	37.16	38.63	36.72
	3.5	29.76	32.83	31.33	31.31	35.67	37.46	39.58	37.57
LSD 0.05			1.84		1.07		N.S		1.74
Silicon		28.08	31.69	31.49	Magnetic	35.17	37.10	39.10	Magnetic
LSD 0.05			0.75		water		1.62		water
Magnetic x Silicon	Magnetic	27.92	32.31	32.21	30.82	36.41	37.47	39.06	37.65
	Without	28.24	31.07	30.76	30.02	33.93	36.74	39.14	36.60
LSD 0.05			1.07		0.62		N.S		N.S
					Zolfast				Zolfast
x Zolfast Silicon	0	27.04	30.40	31.85	29.77	32.84	35.38	38.11	35.45
	2.5	28.35	32.25	30.10	30.23	35.54	37.62	38.69	37.28
	3.5	28.86	32.42	32.51	31.26	37.13	38.31	40.50	38.65
LSD 0.05			1.30		0.75		N.S		0.82

Table 2. The effect of magnetic water and spraying with zolfast and silicon on nitrogen (%) for cauliflower plants

Magnetic water	Zolfast ml.l-1	First season				Second season			
		Silicon ml.l-1			Magnetic x	Silicon ml.l-1			Magnetic x
		0	1	1.5	Zolfast	0	1	1.5	Zolfast
Magnetic	0	1.747	2.123	3.150	2.340	3.570	3.873	3.967	3.803
	2.5	2.083	2.450	2.893	2.476	4.293	4.527	4.737	4.519
	3.5	2.107	2.987	2.520	2.538	4.433	4.900	5.063	4.799
without	0	1.903	2.287	1.913	2.034	3.173	3.570	3.827	3.523
	2.5	2.193	2.317	2.147	2.219	4.083	4.480	4.457	4.340
	3.5	2.477	2.543	2.290	2.437	4.317	4.620	4.760	4.566
LSD 0.05			0.40		N.S		0.18		N.S
Silicon		2.085	2.451	2.486	Magnetic	3.978	4.328	4.468	Magnetic
LSD 0.05			0.22		water		0.07		water
Magnetic x Silicon	Magnetic	1.979	2.520	2.854	2.451	4.099	4.433	4.589	4.374
	Without	2.191	2.382	2.117	2.230	3.858	4.223	4.348	4.143
LSD 0.05			0.29		N.S		0.10		0.12
					Zolfast				Zolfast
x Zolfast Silicon	0	1.825	2.205	2.532	2.187	3.372	3.722	3.897	3.663
	2.5	2.138	2.383	2.520	2.347	4.188	4.503	4.597	4.429
	3.5	2.292	2.765	2.405	2.487	4.375	4.760	4.912	4.682
LSD 0.05			0.29		0.15		N.S		0.07

with silicon. 1.979%, As for the second season, it is noted that the plants treated with magnetic water and 1.5 ml. L^{-1} silicon were excelled, where they gave 4.589% nitrogen content compared with the lowest percentage of 3.858% was obtained in the control plants not treated with magnetic water, while no significant effect was observed for the two interaction between magnetizing factor and zolfast in both growing seasons, while the two interaction between silicon and zolfast was excelled in the first season only, that gave the plants treated with level 1 $ml.L^{-1}$the highest percentage was 2.765% compared to plants not treated with both agents, and it was 1.825%. As for the triple interaction between the study factors, it was significant in both seasons, where the first season plants treated with magnetic water and 1.5 $ml.L^{-1}$ of silicon, which was not treated with Zolfast (compared), gave the highest nitrogen content of 3.150% compared to the lowest

percentage that was 1.747%. Plants treated with magnetic water and not treated with silicon and zolfast (control), In the second season, cauliflower plants irrigated with magnetic water and treated at the level of 1.5 ml.L^{-1}-silicon and 3.5 ml.L-1 Zolfast gave the highest nitrogen content of 5.063% compared to the lowest percentage that was 3.173% that resulted in non-irrigated plants with magnetic water that were not treated by both factors (control).

Table 3 It was found that the plants treated with magnetic water had no significant effect on the percentage of phosphorus in the first season, while it significantly exceeded in the second season by 0.540% compared to the lowest average of 0.343% without magnetization. Also noticed that the levels 1 and 1.5 ml.L^{-1} silicon were significantly excelled in the first season, reaching 0.488 and 0.506%, respectively, compared to the control treatment, which was 0.452%. In the second season, the level of 1.5 ml.L^{-1} showed a significantly excelled and gave 0.464% compared to the other two levels, while the level of 1 ml.L^{-1} significantly excelled on the control treatment, which reached 0.411%. It is evident from the table that the levels of 2.5 and 3.5 ml.L^{-1}Zolfast were significantly excelled in the first season, reaching 0.493 and 0.496%, respectively, compared to the control treatment, which was 0.458%. As for the second season, the level of 3.5 ml.L^{-1} excelled on the other two levels, reaching 0.474%, and the level of 2.5 ml.L^{-1} excelled on the control treatment, which gave the lowest percentage, which was 0.404%. The same table shows the excelled of plants treated with magnetic water and 1.5 ml.L-1silicon significantly in the second season only, where it gave the highest percentage of 0.556% compared to plants that were not treated with compressed water or with silicon, which was 0.298%, Plants treated with non-magnetic water and 2.5 ml.L^{-1} Zolfast significantly excelled in the first season, by 0.512, compared with 0.457% in plants treated with non-magnetic water that were not treated with Zolfast. As for the second season, it is noted that the plants were treated with magnetic water and the level was 3.5 ml.L^{-1}, which reached 0.569 % compared to 0.298 % that resulted in plants that were not treated with magnetic water or zolfast. It was also noted that the interaction of the level of 1 ml.L^{-1} silicon and 2.5 ml.L^{-1} zolfast was observed in the first season only, where it gave the highest percentage of phosphorous amounted to 0.517% compared to 0.411% in the control treatment for both factors. As for the triple interaction between the study factors, it was not significant in both growing seasons.

Table 3. The effect of magnetic water and spraying with zolfast and silicon on phosphorous (%) for cauliflower plants

Magnetic water	Zolfast ml.l-1	First season				Second season			
		Silicon ml.l-1			Magnetic x	Silicon ml.l-1			Magnetic x
		0	1	1.5	Zolfast	0	1	1.5	Zolfast
Magnetic	0	0.405	0.476	0.495	0.459	0.492	0.511	0.527	0.510
	2.5	0.451	0.480	0.491	0.474	0.529	0.540	0.554	0.541
	3.5	0.461	0.487	0.501	0.483	0.540	0.579	0.588	0.569
without	0	0.416	0.478	0.476	0.457	0.250	0.313	0.330	0.298
	2.5	0.482	0.512	0.542	0.512	0.313	0.361	0.380	0.351
	3.5	0.499	0.497	0.530	0.508	0.346	0.387	0.410	0.380
LSD 0.05			N.S		0.03		N.S		0.01
Silicon		0.452	0.488	0.506	Magnetic	0.411	0.448	0.464	Magnetic
LSD 0.05			0.02		water		0.01		water
Magnetic x Silicon	Magnetic	0.439	0.481	0.495	0.472	0.520	0.543	0.556	0.540
	Without	0.466	0.496	0.516	0.492	0.303	0.354	0.372	0.343
LSD 0.05			N.S		N.S		0.01		0.01
					Zolfast				**Zolfast**
x Zolfast Silicon	0	0.411	0.480	0.485	0.458	0.371	0.412	0.428	0.404
	2.5	0.466	0.496	0.517	0.493	0.421	0.450	0.468	0.446
	3.5	0.480	0.492	0.515	0.496	0.443	0.483	0.497	0.474
LSD 0.05			0.03		0.01		N.S		0.01

Table 4 notes that there was no significant effect of water magnetization on the percentage of potassium in the first season, while plants treated with magnetic water significantly excelled in the second season by 1.684% compared to the lowest average of 1.504% without magnetic. It was also observed that the level of 1.5 ml.L^{-1} silicon was significantly higher in the first season, which reached 1.573%, while the control treatment gave the lowest percentage, which was 1.506%, while in the second season, the level of 1.5 ml.L^{-1} silicon gave the highest percentage of potassium, which reached 1.741% compared to the other two levels. The table showed that there was no significant effect of treatment with Zolfast in the first season. Whereas, plants treated with the level 3.5 ml.L^{-1} Zolfast significantly excelled in the second season by 1.818%, compared to the other two levels, which excelled the level 2.5 on the control treatment, which was 1.363%. It can be seen from the same table that the interaction between magnetizing factors and silicon was significant in the first season only, where plants treated with magnetic water and 1.5 ml.L^{-1} silicon gave the highest percentage of potassium, which was 1.594%. While the plants treated with magnetic water and the level 0 ml.L^{-1} gave the lowest percentage of 1.432%. It was also noticed that there was no significant effect of the interaction between magnetization and Zolfast and between silicon and Zolfast in these traits and in both growing seasons. As for the triple interaction between study factors, it was not significant either in both growing seasons.

Table 5 The percentage of sulfur in the leaves of the plant showed significant superiority in the plants treated with magnetic water in the first season only, by 0.177% compared to the lowest percentage that was 0.142% without magnetism. It is also noticed that the level of 1 ml.L^{-1} silicon was significantly excelled and gave 0.176% in the first season compared to the other two levels. Whereas, the second season plants treated with levels 1 and 1.5 ml.L^{-1} silicon significantly excelled by 0.222 and 0.285%, respectively, compared to the control treatment was 0.140%. It is evident from the table that the level of 3.5 ml.L-1 Zolfast was significantly higher in the first season by 0.181% compared to the other two levels, in the second season, the levels of 2.5 and 3.5 ml.L^{-1} showed a significantly excelled and gave 0.212 and 0.262%, respectively, compared to the control treatment that was 0.172%. It is evident from the same table that the two interaction between magnetizing factors and silicon was significant in the first season only, where plants treated with magnetic water and 1 ml.L^{-1} of silicon excelled 0.195% compared to 0.120% that resulted in control plants that were not treated with magnetic water. While the plants treated with magnetic water and 3.5 ml.L-^{1}Zolfast

Table 4. The effect of magnetic water and spraying with zolfast and silicon on potassium (%) for cauliflower plants

Magnetic water	Zolfast ml.l-1	First season				Second season			
		Silicon ml.l-1			Magnetic x	Silicon ml.l-1			Magnetic x
		0	1	1.5	Zolfast	0	1	1.5	Zolfast
Magnetic	0	1.353	1.447	1.601	1.467	1.337	1.427	1.575	1.446
	2.5	1.482	1.601	1.603	1.562	1.563	1.620	1.847	1.677
	3.5	1.460	1.480	1.578	1.506	1.813	1.926	2.051	1.930
without	0	1.499	1.667	1.649	1.605	1.178	1.268	1.393	1.280
	2.5	1.656	1.470	1.504	1.543	1.359	1.529	1.688	1.525
	3.5	1.586	1.550	1.502	1.546	1.507	1.722	1.892	1.707
LSD 0.05			N.S		N.S		N.S		N.S
Silicon		1.506	1.536	1.573	Magnetic	1.459	1.582	1.741	Magnetic
LSD 0.05			0.06		water		0.06		water
Magnetic x Silicon	Magnetic	1.432	1.509	1.594	1.512	1.571	1.658	1.824	1.684
	Without	1.480	1.562	1.552	1.565	1.348	1.507	1.658	1.504
LSD 0.05			0.13		N.S		N.S		0.02
					Zolfast				**Zolfast**
x Zolfast Silicon	0	1.426	1.557	1.625	1.536	1.257	1.348	1.484	1.363
	2.5	1.569	1.535	1.553	1.553	1.461	1.575	1.767	1.601
	3.5	1.523	1.515	1.540	1.526	1.660	1.824	1.971	1.818
LSD 0.05			N.S		N.S		N.S		0.05

in the first season only gave the highest percentage of sulfur, which reached 0.200%, compared to plants that were not treated with magnetic water or Zolfast, which was 0.120%. Plants treated with the level 1 ml.L^{-1} silicon and 3.5 ml.L^{-1}Zolfast significantly excelled in the first season only by 0.203% compared to plants that were not treated with both factors (control), which gave 0.092%. As for the triple interaction, the plants treated with magnetic water, which was not treated with silicon, and treated with the level 3.5 ml.L^{-1}zolfast in the first season only. It gave the highest percentage of sulfur was 0.234% compared to the lowest percentage of sulfur of 0.091%, which was produced in plants without magnetic, which were not treated with both factors (control).

Table 6 shows the excelled of plants treated with magnetic water in both growing seasons in obtaining the lowest percentage of sodium which amounted to 1.162 and 1.341%, respectively, compared to the highest percentage that was 1.250 and 1.512%, respectively, that resulted in plants that were not irrigated with magnetic water. It is also noticed that the level of 1 ml.L-1 silicon was significantly excelled in the first season in obtaining the lowest percentage of sodium which reached 1.180% compared to the control treatment that gave the highest percentage of sodium which amounted to 1.238%. As for the second season, it is noticed that the plants treated with levels 1 and 1.5 ml.L^{-1} were significantly excelled, reaching 1.378 and 1.382%, respectively, compared to the control treatment, which was 1.518%. It is evident from the table that the level of 2.5 ml.L^{-1} Zolfast was significantly higher in the first season, reaching 1.199% compared to the other two levels, and the level of 3.5 ml.L^{-1} zolfast was excelled to the control treatment, which gave the highest percentage of sodium which was 1.218%.In the second season. the plants treated with levels 2.5 and 3.5 ml.L^{-1} zolfast significantly excelled, where the lowest percentage of sodium was obtained, respectively, reaching 1.419 and 1.370%, while the control treatment gave the highest percentage, which was 1.489%. As it can be seen from the same table that the two interaction between the magnetizing factors and silicon was significant in both seasons, as the plants treated with magnetic water and the level 1 ml.L^{-1} gave silicon the lowest sodium content of 1.110, 1.270%, respectively, compared to the plants that were not treated with magnetization and 0 ml. L^{-1} silicon gave the highest percentage was 1.217 and 1.570%, respectively. As for the interaction between magnetization and zolfast, the plants treated with magnetic water and 2.5 ml.L^{-1} Zolfast significantly excelled plants in the first season by 1.157% compared to the highest sodium content that was 1.279% in plants without magnetic and that were not treated with Zolfast. Whereas the plants treated with magnetic water and 3.5 ml.L^{-1} Zolfast significantly excelled in the second season, it was 1.249% compared to the plants without magnetic, and the treatment with the level 0 ml.L^{-1}Zolfast gave the highest percentage of sodium, which was 1.538%. It is also evident from the same table that cauliflower plants treated with the level 1 ml.L^{-1}silicon and 2.5 ml.L^{-1} Zolfast were significantly excelled in the first season, which reached 1.155% compared to the plants that were not treated with both factors, which gave 1.292%, while in the second season, the treated plants at the level 1 ml.L^{-1} silicon and 3.5 ml.L^{-1} zolfast, excelled and gave 1.313% compared to the plants that were not treated with both factors, where it was 1.631%. As for the triple interaction between the study factors, it was not significant in the first season, while the plants treated with magnetic water and the level of 1 ml.L^{-1}silicon and 3.5 ml^{-1}Zolfast significantly excelled and gave 1.176% compared to the plants irrigated with magnetic water that were not treated with both factors (control) where it gave the highest sodium content of 1.635%.

Table 7 shows the significance of the plants treated with magnetic water in silicon content for the two growing seasons by 0.085 and 0.131 mg for the two seasons respectively, compared to the lowest percentage that was 0.072 and 0.099 mg, respectively, for the non-magnetic plants. It was also noted that the level of 1.5 ml.L^{-1}silicon was significantly higher in both seasons, by 0.122 and 0.146 mg, respectively, compared with the other two levels. The level of 1 ml.L^{-1}silicon was excelled on the control treatment, which was 0.038 and 0.081 mg, respectively. The level of 3.5 ml.L^{-1}Zolfast significantly excelled in both seasons, reaching 0.094 and 0.145 mg, respectively, compared to the other two levels, and

the level of 2.5 ml.L^{-1} Zolfast excelled on the control treatment that gave the lowest percentage, which is 0.062 and 0.079 mg, respectively. It is evident from the table that the plants treated with magnetic water and 1.5 ml.L-1silicon gave the highest percentage of silicon, which were 0.139 and 0.172 mg, respectively, compared to the lowest percentage that was 0.038 and 0.072 mg, respectively, that were produced in comparison plants that were not treated with magnetic water. As can be seen from the same table, only the second season plants, treated with magnetic water and 3.5 ml.L^{-1}Zolfast, gave the highest percentage of 0.168 mg compared with 0.070 mg that was produced in control plants that were not treated with magnetic water. Cauliflower plants treated with level 1.5 ml.L^{-1} silicon and 3.5 ml.L^{-1}Zolfast significantly excelled in both seasons, by 0.145

Table 5. The effect of magnetic water and spraying with zolfast and silicon on sulfur (%) for cauliflower plants

Magnetic water	Zolfast ml.l-1	First season				Second season			
		Silicon ml.l-1			Magnetic x	Silicon ml.l-1			Magnetic x
		0	1	1.5	Zolfast	0	1	1.5	Zolfast
Magnetic	0	0.091	0.180	0.155	0.142	0.087	0.163	0.216	0.155
	2.5	0.183	0.203	0.184	0.190	0.161	0.194	0.250	0.202
	3.5	0.234	0.203	0.162	0.200	0.180	0.234	0.268	0.227
without	0	0.092	0.122	0.147	0.120	0.108	0.221	0.236	0.188
	2.5	0.140	0.145	0.149	0.145	0.144	0.251	0.274	0.223
	3.5	0.128	0.203	0.155	0.162	0.158	0.268	0.463	0.297
LSD 0.05			0.02		0.01		N.S		N.S
Silicon		0.145	0.176	0.159	Magnetic water	0.140	0.222	0.285	Magnetic water
LSD 0.05			0.01				0.06		
Magnetic x Silicon	Magnetic	0.169	0.195	0.167	0.177	0.143	0.197	0.245	0.195
	Without	0.120	0.157	0.151	0.142	0.137	0.247	0.324	0.236
LSD 0.05			0.01		0.01		N.S		N.S
					Zolfast				**Zolfast**
x Zolfast Silicon	0	0.092	0.151	0.151	0.131	0.098	0.192	0.226	0.172
	2.5	0.161	0.174	0.167	0.167	0.152	0.223	0.262	0.212
	3.5	0.181	0.203	0.159	0.181	0.169	0.251	0.366	0.262
LSD 0.05			0.01		0.01		N.S		0.05

Table 6. The effect of magnetic water and spraying with zolfast and silicon on sodium (%) for cauliflower plants

Magnetic water	Zolfast ml.l-1	First season				Second season			
		Silicon ml.l-1			Magnetic x	Silicon ml.l-1			Magnetic x
		0	1	1.5	Zolfast	0	1	1.5	Zolfast
Magnetic	0	1.232	1.110	1.130	1.157	1.635	1.343	1.343	1.441
	2.5	1.207	1.080	1.183	1.157	1.452	1.289	1.259	1.334
	3.5	1.163	1.140	1.217	1.173	1.313	1.176	1.258	1.249
without	0	1.352	1.266	1.218	1.279	1.627	1.521	1.467	1.538
	2.5	1.241	1.230	1.253	1.242	1.507	1.490	1.519	1.505
	3.5	1.230	1.257	1.205	1.231	1.577	1.450	1.447	1.491
LSD 0.05			N.S		0.043		0.084		0.049
Silicon		1.238	1.180	1.201	Magnetic water	1.518	1.378	1.382	Magnetic water
LSD 0.05			0.031				0.034		
Magnetic x Silicon	Magnetic	1.201	1.110	1.177	1.162	1.467	1.280	1.287	1.341
	Without	1.275	1.251	1.225	1.250	1.570	1.487	1.477	1.512
LSD 0.05			0.043		0.025		0.049		0.028
					Zolfast				**Zolfast**
x Zolfast Silicon	0	1.297	1.188	1.174	1.218	1.631	1.432	1.405	1.489
	2.5	1.224	1.155	1.218	1.199	1.479	1.390	1.389	1.419
	3.5	1.197	1.198	1.211	1.202	1.445	1.313	1.352	1.370
LSD 0.05			0.053		0.031		0.060		0.034

Table 7. The effect of magnetic water and spraying with zolfast and silicon on silicon (mg g-1) for cauliflower plants

Magnetic water	Zolfast ml.l-1	First season				Second season			
		Silicon ml.l-1			Magnetic x	Silicon ml.l-1			Magnetic x
		0	1	1.5	Zolfast	0	1	1.5	Zolfast
Magnetic	0	0.033	0.060	0.114	0.069	0.045	0.093	0.126	0.088
	2.5	0.036	0.078	0.144	0.086	0.099	0.135	0.176	0.137
	3.5	0.045	0.096	0.158	0.100	0.126	0.164	0.215	0.168
without	0	0.033	0.057	0.081	0.057	0.036	0.078	0.096	0.070
	2.5	0.036	0.072	0.105	0.071	0.081	0.114	0.126	0.107
	3.5	0.045	0.087	0.132	0.088	0.099	0.129	0.135	0.121
LSD 0.05			N.S		N.S		N.s		0.012
Silicon		0.038	0.075	0.122	Magnetic	0.081	0.119	0.146	Magnetic
LSD 0.05			0.008		water		0.006		water
Magnetic x Silicon	Magnetic	0.038	0.078	0.139	0.085	0.090	0.131	0.172	0.131
	Without	0.038	0.072	0.106	0.072	0.072	0.107	0.119	0.099
LSD 0.05			0.010		0.007		0.013		0.016
					Zolfast				**Zolfast**
x Zolfast Silicon	0	0.033	0.058	0.097	0.063	0.040	0.085	0.111	0.079
	2.5	0.036	0.075	0.124	0.078	0.090	0.124	0.151	0.122
	3.5	0.045	0.091	0.145	0.094	0.112	0.147	0.175	0.145
LSD 0.05			0.010		0.005		0.009		0.005

and 0.175 mg, respectively, compared with 0.033 and 0.040 mg, respectively, that resulted in plants not treated with both factors. As for the triple interaction between study factors, it was not significant in both growing seasons.

Table 8 shows the effect of magnetization of water and spraying with zolfast and silicon and their interaction on total proline in leaves for the two growing seasons, where the plants treated with magnetic water in the growing seasons gave the lowest content of proline of 15.16 and 16.06 µmol for the two seasons, respectively. Compared with the highest content of 18.20 and 16.93 µmol, respectively, it was produced in plants irrigated with untreated magnetic water. It was also noted that the level of 1.5 ml. L^{-1}-silicon was significantly higher in the two growing seasons, as it gave the lowest proline content of 15.18 and 15.91 µmol for the two seasons, respectively, Compared with the other two levels, the 1 ml.L^{-1} silicon level excelled on the control treatment that gave the highest amount of proline was 18.54 and 17.08 µmol, respectively. It was found that the level of 3.5 ml. L^{-1} Zolfast was significantly higher in the two growing seasons. The lowest amount of proline was 15.55 and 16.04 µmol, respectively, and the level of 2.5 ml.L^{-1}-zolfast was excelled on the control treatment that gave the highest amount of proline was 18.13 and 16.96 µmol, respectively. It can be seen from the same table that the two interactionbetween magnetizing factors and silicon was significant in the two growing seasons, where plants treated with magnetic water and 1.5 ml.L^{-1}-silicon gave the lowest amount of proline of 13.46 and 15.69 µmol, for the two seasons respectively, compared to plants that were not treated with magnetic water or silicon, which gave the highest amount of proline, which was 19.33 and 17.69 µmol, respectively .As for the interaction between magnetization and zolfast, the plants treated with magnetic water and 3.5 ml.L^{-1} Zolfast significantly excelled in the two growing seasons, reaching 13.88 and 15.77 µmol, respectively, compared to the highest amount of proline was 19.29 and 17.50 µmol, respectively.

The increase in the amount of chlorophyll when treated with magnetic water may be due to an increase in the mobility of ions and an improvement in the absorption of ions under the magnetic field that leads to the stimulation of chlorophyll formation [19],Moreover, the increase may be due to the role of water magnetization in increasing the pigments of carbon representation due to the increase of cytokinin, which plays an important role in the development of chloroplasts and the induction of a number of genes responsible for the development of chloroplasts [20],The low percentage of sodium in the magnetization treatment may be due to the role of

Table 8. The effect of magnetic water and spraying with zolfast and silicon on proline (mmol g^{-1} DW) for cauliflower plants

Magnetic water	Zolfast ml.l-1	First season				Second season			
		Silicon ml.l-1			Magnetic x	Silicon ml.l-1			Magnetic x
		0	1	1.5	Zolfast	0	1	1.5	Zolfast
Magnetic	0	18.00	17.24	15.69	16.97	16.69	16.38	16.24	16.44
	2.5	17.68	13.47	12.75	14.63	16.41	15.90	15.56	15.96
	3.5	17.56	12.16	11.93	13.88	16.30	15.75	15.27	15.77
without	0	21.24	19.04	17.58	19.29	18.32	17.25	16.86	17.48
	2.5	18.64	18.45	17.23	18.11	17.73	17.20	16.10	17.01
	3.5	18.12	17.62	15.89	17.21	17.01	16.52	15.42	16.32
LSD 0.05			0.87		0.40		N.S		0.27
Silicon		18.54	16.33	15.18	Magnetic	17.08	16.50	15.91	Magnetic
LSD 0.05			0.52		water		0.35		water
Magnetic x Silicon	Magnetic	17.75	14.29	13.46	15.16	16.47	16.01	15.69	16.06
	without	19.33	18.37	16.90	18.20	17.69	16.99	16.13	16.93
LSD 0.05			0.61		0.14		0.42		0.28
					Zolfast				Zolfast
x Zolfast Silicon	0	19.62	18.14	16.64	18.13	17.51	16.82	16.55	16.96
	2.5	18.16	15.96	14.99	16.37	17.07	16.55	15.83	16.48
	3.5	17.84	14.89	13.91	15.55	16.65	16.13	15.35	16.04
LSD 0.05			0.67		0.34		N.S		0.20

magnetic water in improving the physical properties of the soil by improving its structure and eliminating the negative effects of salts and pushing them away from the root zone [21]. It is noted from the results of a decrease in the content of the amino acid proline in the state of magnetization due to the reduction of the harmful effect of salinity on the plant, and there is an inverse relationship between the level of proline accumulation and a decrease in the total chlorophyll content [22], This is because salinity has a role in inhibiting the fusion of the amino acid molecules Glutamat as a common precursor to the synthesis of both proline and chlorophyll [23] or due to the lack of activity of the oxidizing enzymes [24]. This is in agrees with [25-28].

The increase in the total chlorophyll percentage in the treatment of silicon may be due to its role in increasing the size of the chloroplasts and increasing the number of grana units [29], or the silicon may have a role in encouraging the plant to increase its ability to absorb the elements that are involved in building chlorophyll, including iron and magnesium [30]. The increase in the levels of nutrients in the leaves when treated with silicon may be due to its important role in increasing the availability of these elements to the plant in addition to reducing the harmful effect of salinity and then increasing the plant's absorption of these elements [13,31], By encouraging (silicon) the growth of roots under conditions of salt stress [32] and that silicon enhances the plant's phosphorous use by increasing its content in the plant. The increase in potassium can be due to the role of silicon in increasing potassium absorption through an increase in the activity of potassium ion carrying across the plasma membrane due to the increase in the electrical voltage gradient as a result. To increase H-AT Pase enzyme activity [33]. While the decrease in the content of the amino acid proline in the leaves when treated with silicon may be due to the role of this element in reducing the damage to salinity and thus the plant does not need to produce large quantities of it [34], and these results agree with [35-37] on the tomato plant; [38] on eggplant [39,40].

The increase in the total chlorophyll content of the leaves in the leaves due to the action of the zolfast factor is due to the positive effect of the sulfur content, which is considered one of the components of the Porphyins groups [41]. The importance of sulfur in the formation of the chlorophyll pigment, although it is not involved in its composition [42,43]. An increase in the phosphorous content of leaves may be due to the positive effect of sulfur in increasing the growth of the root system and increasing its ability to absorb elements, including phosphorous [41] or that the increase in photosynthesis in plants requires an increase in the nutrients absorbed by

the roots, including phosphorous. In addition to other elements [44], and its accumulation in the plant tissues. As for the increase in the concentration of the amino acid proline in the control plants, in the case of treatment with zolfast, it is due to the increased salinity of irrigation water, where proline is a defence method that plants use to get rid of the irregularity in the construction of proteins and ammonia accumulated inside the plant cells by consuming them in building protein [45], Where proline plays an important role in the enzymatic equilibrium under conditions of salt stress of plants [46]. These results are in agrees with [47] on peas. [48] on the onion plant [49] on the tomato.

CONCLUSION

Through the results obtained from the current study, it was noted that the study factors, which are magnetization of irrigation water and spraying with silicon and liquid sulfur compound (Zolfast), have a role in increasing the leaf content of chlorophyll and nutrients and a significant decrease in sodium and the amino acid proline.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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