The effect of spraying with silicon and moringa leaf extract on some growth and yield indicators of the cabbage plant (*Brassica oleracea* var. capitata)

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Abstract

The experiment was conducted during the winter season 2019-2020 at the Agricultural Research Station belonged to the College of Agriculture - University of Basra in the aim of determining the effect of treatment with silicon on the form of potassium silicate (K_2SiO_3) and Moringa leaf extract on improving growth indicators and the yield of the Galaxy hybrid, the experiment included 16 factorial treatments, which are four concentrations of silicon 0,1,2 and 3 $ml.L^{-1}$ and four concentrations of Morinca leaf extract 0,5,10 and 15$g.L^{-1}$, The experiment was conducted according to a split plot design system according to the Complete Block design with three replicates. The averages were compared according to the least significant difference LSD and at a probability level of 0.05. The most important results obtained can be summarized as follows:

The treatment with silicon at a concentration of 3 $ml.L^{-1}$ resulted in a significant increase in the number of wrapper leaves (31.46 $leaves.plant^{-1}$), head weight (1.17 kg), total yield (34.45 $tons.ha^{-1}$), in addition to vitamin C (64.58 mg. 100 g^{-1}), As for the concentration of 2 $ml.L^{-1}$ silicon, it significantly affected the leaf area (10143 cm2), the percentage of dry matter (13.13%), the amount of chlorophyll (41.90 $mg.g^{-1}$) and carbohydrates (55.99 mg. 100 g^{-1}). The aqueous extract of Moringa leaves at a concentration of 15 $ml.L^{-1}$ significantly affected the number of wrapper leaves (31.75 $leaves.\ plant^{-1}$),Head weight (1.16 kg), the total yield (34.01 $tons.ha^{-1}$) in addition to the amount of carbohydrates (56.98 mg. 100 g^{-1}), while the leaf area increased at concentration 10 $ml.L^{-1}$ and reached (10164 cm^2),The bi-interaction between the experiment factors had a significant effect on all the indicators under experiment (number of wrapper leaves, leaf area, head weight, total yield, dry matter percentage, amount of chlorophyll , carbohydrate and vitamin C).

Key words: cabbage, silicon, moringa leaf extract, yield .

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تأثير الرش بالسليكون ومستخلص اوراق المورينكا في بعض مؤشرات النمو والحاصل لنبات اللهانة (*Brassica oleracea*var.capitata)

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الخلاصة

أجريت التجربة خلال الموسم الشتوي 2019-2020في محطة الأبحاث الزراعية التابعة لكلية الزراعة - جامعة البصرة في بهدف معرفة تاثير المعاملة بالسليكون على صورة سليكات البوتاسيوم (K_2SiO_3) ومستخلص أوراق المورينجا في تحسين مؤشرات النمو والحاصل لهجين اللهانةGalaxy، شملت التجربة16 معاملة عاملية وهي أربعة تراكيز من السليكون 2،1،0و3 مل لتر$^{-1}$ و أربعة تراكيز من مستخلص أوراق المورينكا10،5،0 و15غم لتر$^{-1}$، وقد تم تنفيذ التجربة وفق نظامالقطع المنشقة لمرة واحدة وحسب تصميم القطاعات العشوائية وبثلاث مكررات وقورنت المتوسطات وفق اقل فرق معنوي LSD وعند مستوى احتمال0.05, ويمكن تلخيص اهم النتائج التي تم الحصول عليها بالآتي:

أدت المعاملة بالسليكون وبتركيز 3مل لتر$^{-1}$الى حصول زيادة معنوية في عدد الأوراق الملتفة (31.46ورقة.نبات$^{-1}$) وزن الرأس (1.17كغم)،الحاصل الكلي (34.45طن هكتار$^{-1}$) بالأضافة الى فيتامين ج(64.58ملغم.100غم$^{-1}$)، أماالتركيز 2مل لتر$^{-1}$ سليكون فقد اثر معنوياً في كل من المساحة الورقية (10143سم^{2})، النسبة المئوية للمادة الجافة(13.13%)، كمية الكلوروفيل(41.90ملغم.غم$^{-1}$) والكاربوهيدرات(55.99ملغم.100غم$^{-1}$). واثر معنوياً المستخلص المائي لأوراق المورنجا عند التركيز 15غم لتر$^{-1}$في عدد الأوراق الملتفة(31.75ورقة.نبات$^{-1}$)، وزن الرأس (1.16كغم)، الحاصل الكلي (34.01طن هكتار$^{-1}$) بالأضافة الى كمية الكربوهيدرات(56.98ملغم.100غم$^{-1}$)، أما المساحة الورقية فقد أزدادت عند التركيز 10غم لتر$^{-1}$ وبلغت (10164سم^{2})،وكان للتداخل الثنائي بين عاملي التجربة تأثيراً معنوياً في جميع المؤشرات قيد التجربة (عدد الأوراق الملتفة،المساحة الورقية، وزن الرأس،الحاصل الكلي،نسبة المادة الجافة، كمية الكلوروفيل،كمية الكاربوهيدرات وفيتامين C).

الكلمات المفتاحية : اللهانة ،السليكون، مستخلص أوراق المورينجا، الحاصل

***مستل من رسالة الماجستير للباحث الاول**

Introduction

Cabbage (*Brassica Oleracea var.Capitata L)* . It is an important winter vegetable in Iraq and belongs to the Brassicaceae family [6].It is a herbaceous plant whose heads are eaten, which is a collection of rolled leaves, which are of high nutritional value, as each 100 g of fresh leaves contains 92.18 g of water and 25 calories 0.47 mg iron and 26 mg phosphorus and calcium 40 mg and 12 mg magnesium and 170 mg potassium and 0.181 mg of zinc, 98 international units of vitamin A, and 36.6 mg of vitamin C. In addition, it contains 1.28 g of protein, 0.10 g of fats, 5.80 g of carbohydrates, 3.20 g of sugars and 2.5 g of fiber in addition to volatile sulfur materials [32]. In addition to the high nutritional value, the leaves of Cabbage plant have great medicinal benefits, including treating stomach and duodenal ulcers and reducing blood sugar [7]. Cabbage is cultivated in most regions of Iraq. The cultivated area in 2018 amounted to 3315 dunums, with a total production of 6130 tons [5]. Cabbage cultivation suffers, like other crops, many environmental problems, which are among the determinants of production, which affect the quality and quantity of production. For the purpose of increasing production and improving its quality, there are many methods of fertilization that limit the impact of these problems, including the use of some mineral elements, including silicon, Although it is not included in the list of essential elements for plant growth, it is one of the most important beneficial elements where it strengthens cell walls, which leads to mechanical support for the aerial parts of the plant [23] As it stimulates the plant to develop some of the mechanisms that enable it to resist or endure various stress conditions, whether vital or abiotic, especially when conditions of salt tension [26].It reduces the toxic effect of toxic agents [10.2],It has a role in improving the efficiency of photosynthesis, increasing the efficiency of roots to absorb the nutrients necessary for plant growth and development, increasing the percentage of potassium to sodium [26]stimulating anti-oxidant systems [18], in addition to improving the efficiency of fertilizer use [19]. There is a need to search for alternative sources of phytonutrients, including Moringa leaf extract, which is one of the alternatives being investigated to ensure its effect on the growth and productivity of vegetable crops so that these plants can be promoted as a supplement or potential alternative to inorganic or chemical fertilizers. This research was conducted to evaluate the effect of extract of the leaves of the Moringa plant on the vegetative growth and productivity traits of Cabbage plant, where it is used as a growth hormone stimulant for many crops [11,29,30]. It has been proven that the moringa leaves contain a high percentage of the Zeatin hormone, ranging between 5-200. mcg.g^{-1}[15], this study was conducted for the purpose of knowing the effect of spraying with silicon element and extract of moringa leaves and their interaction in improving vegetative traits, yield and quality of Cabbage.

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Materials and methods

The experiment was conducted during the agricultural season 2019-2020 at the Agricultural Research Station belonged to the College of Agriculture - University of Basra in sandy clay soil with the aim of studying the effect of spraying with four concentrations of silicon in the form of potassium silicate (1,2 and 3 $g.L^{-1}$) and four concentrations of the aqueous extract of moringa leaves(5,10 and 15 $g.L^{-1}$) to include 16 experimental units, A factorial experiment was conducted by using a split plot design and according to the Complete Block Design and with three replicates, where spraying with silicon was considered the Main plot and spraying with extract of moringa leaves sub plot). The averages were compared according to the least significant difference.(LSD)was at a probability level of 0.05 [1]. The land was divided into three sectors, and each sector had four terrace .As the experiment included 12 terrace , a length of 24 m for one terrace containing four experimental units and a distance of 75 cm between one terrace and another, and 40 cm between one plant each experimental unit contains 13 plants. Galaxy hybrid seeds of the Dutch company Paracid were cultivated on 1/9/2019.The seedlings were transferred to the field on 10/13/2019. All service operations were conducted, including irrigation, fertilization, and control whenever needed. Harvesting started on 1/25 and continued until 3/3/2020. The following measurements were taken for five plants from each experimental unit, which are the number of leaves wrapper ($leaf.plant^{-1}$), leaf area (cm^2), average Cabbage head weight (g), total yield ($tons.ha^{-1}$), The percentage of dry matter of plant leaves, total chlorophyll (mg. 100 g^{-1} fresh weight), leaf content of total soluble carbohydrates (mg. 100 g^{-1} dry matter) and leaf content of vitamin C (mg. 100 g^{-1} fresh weight).

Results and discussion

Table (1)showed that the study factors silicon and moringa leaves extract and their interaction significantly affected the number of wrapped $leaves.plant^{-1}$, where the plants treated with silicon excelled on the control treatment, where the concentration 3 $ml.L^{-1}$ gave the highest number of wrapped leaves, which reached 31.46 leaves compared to the lowest number of wrapped leaves had 28.83 leaves at a concentration of 0 $ml.L^{-1}$. Plants treated with moringa leaves extract excelled on control treatment, where the concentration 15 $g.L^{-1}$ gave the largest number of wrapped leaves, reaching 31.75 leaves, compared to the lowest number, which was 29.29 leaves, for a concentration of 0 $ml.L^{-1}$. As for the bi-interaction, the plants treated with silicon at a concentration of 1 $ml.L^{-1}$and the Moringa extract at a concentration of 15 $g.L^{-1}$ gave the largest number of wrapped leaves with 33.67 leaves compared to the lowest number of 25.67 leaves produced in the control plants for both factors. The results of the same table indicate the excelled of the plants treated with silicon on the control treatment in the leaf area, where the concentration of 2 $ml.L^{-1}$gave the highest leaf area of 10143 cm^2 compared to the lowest area of 8970 cm^2 for the concentration of 0 $ml.L^{-1}$. The plants treated with Moringa leaves extract at a concentration of 10 $g.L^{-1}$excelled and gave the highest area was 10164 cm^2 compared to the lowest leaf area which was 8907 cm^2 at concentration 0 $ml.L^{-1}$, As for the bi-interaction, the plants treated with silicon at a concentration of 2 $ml.L^{-1}$ and Monica at a concentration of 15 g. L^{-1} gave the highest leaf area of 11158 cm^2 compared to the lowest area, which was 7524 cm^2, which resulted in the control plants for both factors. Silicon has a role in increasing the absorption of water and nutrients and thus accelerating growth and development [17], which helped increase the number of leaves in the plant. This agrees with [16] on the lettuce plant. or it may be an increase in the leaf area due to the role of silicon in many physiological processes, the most important of which is improving the effectiveness of photosynthesis and increasing the effectiveness of the roots to absorb the nutrients necessary for plant growth and development [10,26]. This agrees with [3]. As for the significant effect of Moringa leaf

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extract on the vegetative traits, it is a good source of plant hormones, which are a good catalyst for plant growth and productivity, and this is in agrees with [9] on the bean plant and [12] on the tomato plant.

Table (1) Effect of silicon and moringa leaf extract and their interactions on the number of wrapper leaves and the leaf area for Cabbage plant(Galaxy cultivar).

leaf area cm^2					number of wrapper leaves.$plant^{-1}$					
The effect of Silicon	Moringa leaf extract($g.L^{-1}$)				The effect of Silicon	Moringa leaf extract($g.L^{-1}$)				silicon ($ml.L^{-1}$)
	15	10	5	0		15	10	5	0	
8970	9406	9849	9102	7524	28.83	29.67	30.33	29.67	25.67	0
9713	9763	10878	9753	8457	31.29	33.67	30.67	31.50	29.33	1
10143	11158	10213	9954	9246	31.33	32.00	32.33	30.67	30.33	2
9980	9154	9716	10651	10400	31.46	31.67	30.67	31.67	31.83	3
	9870	10164	9865	8907		31.75	31.00	30.88	29.29	The effect of Moringa
Interaction		Moringa		silicon	Interaction		Moringa		silicon	LSD 0.05
1211.4		663.5		492.5	2.29		1.178		1.29	

Table (2)showed that the study factors silicon and the extract of moringa leaves and their interactions had a significant effect on the weight of the Cabbage head, where the plants treated with silicon excelled on control treatment. The 3 $ml.L^{-1}$concentration gave the largest head weight of 1.17 kg compared to the smallest weight of 1.05 kg for the 0 $ml.L^{-1}$concentration. The plants treated with Moringa leaf extract excelled on the control treatment. The concentration 15 $g.L^{-1}$ gave the largest head weight of 1.16 kg compared to the smallest weight of 1.10 kg for the concentration of 0 $ml.L^{-1}$.As for the bi-interaction, the plants treated with silicon at a concentration of 1 $ml.L^{-1}$and the extract of moringa at a concentration of 15 $g.L^{-1}$ gave the largest head weight of 1.21 kg compared to the smallest weight of 0.97 kg produced in the control plants for both factors. The results in the same table indicate the excelled of plants treated with silicon at a concentration of 3 $ml.L^{-1}$ and gave the highest yield amounted to 34.45 tons. ha^{-1} compared to the lowest total yield amounted to 30.69 tons. ha^{-1} for a concentration of 0 $ml.L^{-1}$. Plants treated with Moringa leaf extract at a concentration of 15 $g.L^{-1}$ excelled and gave the highest total yield of 34.01 tons. ha^{-1} compared to the lowest yield of 32.21 $tons.ha^{-1}$ for a concentration of 0 $ml.L^{-1}$. As for the bi-interaction, the plants treated with silicon at a concentration of 1 $ml.L^{-1}$and the extract of moringa at a concentration of 15 $mg.L^{-1}$ gave the highest total yield of 35.48 tons. ha^{-1} compared to the lowest yield of 28.51 $tons.ha^{-1}$ results in the control plants for both factors. The increase in the number of leaves and the leaf area (Table 1), with the increase in silicon concentrations, which helped to utilize the largest possible amount of light needed for photosynthesis [21]. In addition to the fact that silicon has a positive role in the overall physiological activities of the plant, where it contributes to increasing the effectiveness of the root system and increasing the efficiency of the plant to absorb mineral elements important for its growth, increase plant hormones that encourage growth, maintain ionic and hormonal balance, and reduce the speed of transpiration [26], The reason for the increase may be due to the role of potassium and

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silicon together, which form the compound potassium silicate. Together, these effects contribute to an increase in head weight and thus increase the total yield. The presence of Zeatin in the extract of moringa leaves, which is a hormone related to cytokinin, is responsible for improving the growth and productivity of crops treated with it [27, 28], which helped increase the yield.

Table (2) Effect of silicon and moringa leaf extract and their interactions on the head weight and total yield for Cabbage plant(Galaxy cultivar).

Total yield (ton.ha^{-1})					the head weight(Kg)					
The effect of Silicon	Moringa leaf extract(g.L^{-1})				The effect of Silicon	Moringa leaf extract(g.L^{-1})				silicon (ml.L^{-1})
	15	10	5	0		15	10	5	0	
30.69	31.94	31.02	31.29	28.51	1.05	1.09	1.06	1.07	0.97	0
34.11	35.48	34.00	33.97	33.01	1.16	1.21	1.16	1.16	1.13	1
34.02	34.55	34.18	35.06	32.29	1.16	1.18	1.17	1.20	1.10	2
34.45	34.08	33.99	34.70	35.03	1.17	1.16	1.16	1.18	1.19	3
	34.01	33.30	33.75	32.21		1.16	1.14	1.15	1.10	The effect of Moringa
Interaction		Moringa	silicon		Interaction		Moringa	silicon		LSD 0.05
1.369		0.627	0.994		0.047		0.021	0.034		

Table (3)showed that the silicon factor had a significant effect on the percentage of dry weight of the Cabbage leaves. where the plants treated with silicon excelled on the control treatment, where the concentration of 2 ml.L^{-1} gave the highest percentage of dry matter, which reached 13.13% compared to the lowest percentage of dry matter, which amounted to 11.40%, for the concentration of 0 ml.L^{-1}, while the extract of moringa leaves had no significant effect in these traits, As for the bi-interaction, the plants treated with silicon at a concentration of 2 ml.L^{-1} and the extract of moringa at a concentration of 15 g.L^{-1} gave the highest percentage of dry matter at 14.89% compared to the lowest percentage of 10.88% that was obtained in the control plants for both factors. The reason for this may be due to the fact that silicon increases the efficiency of transporting nutrients, which helped to increase the efficiency of the photosynthesis process and improve its activity, which led to an increase in the percentage of dry matter. [25], [25] The results of the same table indicate the excelled of plants treated with silicon on the control treatment in the amount of chlorophyll, where the concentration of 2 ml.L^{-1} gave the largest amount of chlorophyll which amounted to 41.90 mg compared with the lowest amount which was 37.32 mg for a concentration of 1 ml.L^{-1}, while the extract of the Moringa leaves was not A significant influence in this traits. As for the bi-interaction, the plants treated with silicon at a concentration of 3 ml.L^{-1} and the extract of moringa at a concentration of 5 g.L^{-1} gave the largest amount of chlorophyll with a concentration of 44.29 mg compared to the lowest amount that was 34.96 mg produced in the control treatment for silicon and 15 g. Silicon had a role in increasing the size of chloroplasts and increasing the number of grana units [31], which helped increase the amount of chlorophyll in the leaves.

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Table (3) Effect of silicon and moringa leaf extract and their interactions on the percentage of dry matter in the leaves and chlorophyll for Cabbage plant(Galaxy cultivar)

Chlorophyll(mg.g fresh weight)					the percentage of dry matter					
The effect of Silicon	Moringa leaf extract($g.L^{-1}$)				The effect of Silicon	Moringa leaf extract($g.L^{-1}$)				silicon ($ml.L^{-1}$)
	15	10	5	0		15	10	5	0	
37.39	34.96	39.55	38.73	36.31	11.40	11.16	11.44	12.10	10.88	0
37.32	37.41	35.32	36.88	39.69	12.75	12.02	13.78	13.24	11.96	1
41.90	42.20	42.22	41.59	41.60	13.13	14.89	13.27	11.78	12.58	2
38.91	38.67	36.15	44.29	36.55	12.89	14.05	12.08	12.70	12.72	3
	38.31	38.31	40.37	38.54		13.03	12.65	12.45	12.04	The effect of Moringa
Interaction		Moringa		silicon	Interaction		Moringa		silicon	LSD 0.05
4.471		N.S		2.826	1.555		N.S		1.055	

Table (4) that the two study factors and their interaction had a significant effect on the amount of carbohydrates, where the plants treated with silicon excelled the control treatment, where the concentration of 2 $ml.L^{-1}$ gave the highest amount of carbohydrates with 55.99 mg compared to the lowest amount that was 50.88 mg for a concentration of 0 $ml.L^{-1}$. The results showed an increase in the amount of carbohydrates for plants treated with Moringa leaf extract on the control treatment. The concentration of 15 $g.L^{-1}$ gave the highest amount of carbohydrates with 56.98 mg compared to the lowest amount of 53.38 mg for the concentration of 0 $ml.L^{-1}$. As for the bi-interaction between the two factors, the plants treated with silicon at a concentration of 3 $ml.L^{-1}$ and the extract of moringa at a concentration of 15 g. L^{-1} gave the highest amount of carbohydrates with a concentration of 57.78 mg compared to the lowest amount that was 45.17 mg in plants treated with silicon at a concentration of 0 $ml.L^{-1}$ and the extract of moringa leaves at a concentration of 5 $g.L^{-1}$. The results in the same table indicate the excelled of plants treated with silicon over the control treatment in the amount of vitamin C. Where the concentration 3 $ml.L^{-1}$ gave the highest amount of vitamin C with 64.58 mg compared with the lowest amount that was 57.50 mg, which was produced at a concentration of 0 $ml.L^{-1}$.Plants treated with Moringa leaf extract at a concentration of 10 $g.L^{-1}$ excelled and gave 63.50 mg, compared to the lowest amount that was 58.67 mg in the control treatment. While the bi- interaction did not have a significant effect on this trait, the increase in carbohydrates may be due to the fact that the extract of moringa leaves is a source rich in essential nutrients for plants, which helped in improving growth [33]. In addition to its positive effect on growth indicators (number of leaves and leaf area), which was reflected positively in the qualitative traits[4].Moreover, Moringa leaf extract can be used as a biostimulator because it is rich in cytokinins and auxins [20] which helps in improving growth and productivity

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Table (4) Effect of silicon and moringa leaf extract and their interactions on the carbohydrates content in leave and vitamin C.for Cabbage plant(Galaxy cultivar)

The amount of vitamin C. (mg. 100 g fresh weight)					The amount of carbohydrates (mg. 100 g dry weight)					silicon ($ml.L^{-1}$)
The effect of Silicon	Moringa leaf extract($g.L^{-1}$)				The effect of Silicon	Moringa leaf extract($g.L^{-1}$)				
	15	10	5	0		15	10	5	0	
57.50	60.00	59.67	57.67	52.67	50.88	56.10	56.06	45.17	46.18	0
60.58	60.00	62.33	62.33	57.67	55.52	58.70	53.40	54.44	55.54	1
64.00	62.33	64.33	66.33	63.00	55.99	55.33	56.26	54.63	57.74	2
64.58	68.00	67.67	61.33	61.33	54.95	57.78	52.32	55.66	54.05	3
	62.58	63.50	61.92	58.67		56.98	54.51	52.47	53.38	The effect of Moringa
Interaction		Moringa	silicon		Interaction		Moringa	silicon		LSD 0.05
N.S		3.11	3.11		4.24		2.24	2.17		

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