Effect of calcium foliar spraying and seedling age on the chemical components of leaves and fruits of *Capsicum annuum* L., grown in unheated greenhouses

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Abstract:

The experiment was carried out during the winter agricultural season 2021-2022 AD in one of the unheated plastic houses affiliated with the Agricultural Research Station - College of Agriculture - Basrah University in Karma Ali in order to study the effect of foliar spraying with calcium and the age of the seedling and the interaction between them on the growth and yield of the sweet pepper plant,The experiment included 15 factorial treatments consisting of possible combinations of the effect of spraying with four concentrations of chelated calcium (0.5, 1.0, 1.5, 2.0) ml L^{-1} in addition to the comparison treatment of spraying with distilled water and three ages of seedlings (35, 45, 55) days as a one-time split-plot design, according to the randomized complete block design (R.C.B.D.) and with three replications, the results were analyzed Statistically, according to the applied design, and the arithmetic means were compared according to the L.S.D. test at a significant level of 0.05. The results showed that spraying with chelated calcium at a concentration of 2.0 ml L^{-1} was significantly superior in the chemical components of leaves and fruits, except for the percentage of total dissolved solids. The spraying had no significant effect on this trait. The age of 35 days showed a significant superiority in the chemical components of the leaves and fruits, except for the content of the leaves calcium, where the age of 55 days showed a significant superiority in this trait, while the age of 45 days showed significant superiority in the percentage of total dissolved solids, and the results showed that the secondary interventions had a significant effect, as the plants sprayed with chelated calcium at a concentration of 2.0 ml L^{-1} and the plants grown at the age of 35 days gave the highest percentage in the leaves' nitrogen content of 3.95 %, while the plants grown at the age of 55 days gave the highest percentage of calcium content in the leaves, amounting to 1.45%.

Keywords: sweet pepper, calcium, seedling age, vegetative growth, yield

Introduction:

Sweet pepper (*Capsicum annuum* L.) is an annual herbaceous plant native to Central and South America. It is the third crop in the Solanaceae family in terms of economic importance after tomatoes and potatoes (5), it is grown for its fruits, which are eaten fresh, cooked, or in canning, and its importance lies in its high content of nutritional components. Every 100 grams of it contains 8% dry matter, 26 calories, 1.3 grams of protein, 1.4 grams of fiber, 12 grams of calcium, 0.9 mg of Iron, 1.8 mg of Vitamin A, 0.07 mg of Vitamin B1, 0.08 mg of Vitamin B2, 0.8 mg Vitamin B3, 103 mg Vitamin C (15). The area cultivated for this crop throughout Iraq in 2019 was about 13040 tons of dunum^{-1}, with a total production capacity of 23110 tons of dunum^{-1}, at an average of 1,770 tons of dunum^{-1}, compared to some Arab countries such as Jordan 9.84 tons of dunum^{-1}, the UAE 7.32

tons of dunum^{-1}, Kuwait 17.14 tons of dunam^{-1}, and a diameter of 7.01 tons of dunam^{-1} (8). The process of foliar fertilization is one of the main factors to avoid a lack of nutrients, including calcium, which is one of the major slow-moving elements. It has many physiological functions and is important for plant growth and development, as it is the main component of the middle plate, as it is present in the form of calcium Pectate and enters into the formation of phosphatidic acid, which contributes to the synthesis of cell membranes (7). Calcium is also one of the necessary elements for the processes of growth and cell division, and it plays a key role in the permeability of the plasma membranes because of its role in transmitting signals within the plant It also increases the plant's ability to represent CO2 gas and absorb and benefit from many nutrients, thus, it increases the cells' tolerance to environmental, thermal, and water stress, and their resistance to fungal and insect infections. It also plays an important role in activating enzymes (19). (11) showed that the addition of calcium to tomato plants at a concentration of (0, 500, 1000, 3000, 5000) mg kg^{-1}, the results showed that the concentration of 3000 mg kg^{-1} was significantly higher in the chlorophyll content of the leaves, the calcium content of the fruits, and the proportion of dry matter. in the fruits, while both concentrations 3000 and 5000 mg kg^{-1} showed significant superiority in the calcium content of the fruits compared to the other concentrations and the comparison treatment. (17) noted that when spraying sweet pepper plants with calcium chloride (CaCl2) at a concentration of (0, 5, 10) mmol^{-1} , the results showed that the concentration of 10 mmol^{-1} was significantly higher in the content of leaves of chlorophyll, the content of fruits of vitamin C, and the content of fruits of calcium compared to other transactions, (12) found that when spraying potato plants with calcium at a concentration of (0, 0.6, 0.8)%, the results showed that the concentration was significantly higher than 0.8% in the leaf content of chlorophyll, nitrogen, and calcium, the percentage of dry matter in tubers, and the tuber content of calcium compared with the rest other transactions. (10) mentioned when studying sweet pepper plants treated with the addition of two sources of calcium(calcium sulfate 25% calcium, calcium thiosulfate 6% calcium) 200 kg ha^{-1}.The source of calcium sulfate had a significant superiority in the nitrogen content of the leaves, while the sources of calcium had no significant effect on the percentage of total dissolved solids in the fruits. (13) noticed that spraying hot pepper plants with calcium at a concentration of (0, 1.5) ml L^{-1} caused the concentration of 1.5 ml L^{-1} to significantly increase the content of the leaves of the nitrogen component, the percentage of carbohydrates, and the content of the fruits of vitamin C compared to the control treatment, while it did not Calcium had a significant effect on the percentage of total soluble solids in fruits For early production of most vegetable crops Such as tomatoes, lettuce and eggplant, it follows the method of propagation by seedling, which has several advantages, the most important of which is the optimal exploitation of the land and economy in the amount of seeds, providing the necessary care for it during its growth in the nursery and providing the possibility of selecting healthy seedlings (4), through several studies, (2) when studying the effect of the age of the seedlings on the eggplant plant, where the ages reached (5, 6, 7) weeks, the results showed that the age of 6 weeks was significantly superior in the content of vitamin C in the fruits, while the age of the seedlings did not show a significant effect on the content of the fruits of calcium compared with the rest of the

ages. (14) observed when studying the effect of the age of the seedling on the African eggplant plant (*Solanum macrocarpon* L.), where the ages reached (4, 6) weeks. (16) when studying the effect of the age of the seedling on cucumber plants, where the ages reached (12, 17, 22), found no effect of the age of the seedling on the leaves content of the total chlorophyll and the percentage of carbohydrates compared with the rest of the other ages. (3) indicated when studying the effect of the age of seedlings on cucumber plants, where the ages reached (15, 20, 25) days, there was a significant superiority of the age of 15 days in the fruit content of vitamin C, while both ages 15 and 20 days showed significant superiority in the percentage of solids the total solubility Tss compared with the rest of the other ages, while the age of the seedling did not have a significant effect on the leaves content of total chlorophyll and the percentage of carbohydrates.

Materials and Methods:

The experiment was conducted in one of the greenhouses affiliated with the Agricultural Research Station at the College of Agriculture - University of Basra, Karma Ali site, during the winter season 2021-2022 AD to study the effect of foliar spraying with calcium and the age of the seedling on the growth and yield of sweet pepper plant grown in the greenhouses, and table (1) represents the traits Physical and chemical soil of the plastic house and irrigation water.

Table 1: Physical and chemical properties of greenhouse soil and irrigation water before planting

Soil		
Trait	Unite	Value
Sand	gm kg^{-1}	584.3
Silt	gm kg^{-1}	312.2
Clay	gm kg^{-1}	103.5
Soil texture	-	Silty Clay
Total nitrogen	mg kg^{-1}	22.63
available Phosphorus	mg kg^{-1}	7.19
Available Potassium	mg kg^{-1}	19.87
Degree of electrical conductivity	**$dS.m^{-1}$**	4.12
pH	-	7.28
Irrigation Water		
Degree of electrical conductivity	**$dS.m^{-1}$**	2.5
pH	-	7.3

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In the experiment, seeds of sweet pepper (Drago F1) produced by Elite Seeds of Spanish origin were used. The seeds were planted in plates made of Styropore. Each plate contained 209 wells filled with peat moss. The seeds were sown on 10/1/2021 with one seed for each well. The dishes were placed inside a canopy covered with green

saran cloth to reduce the sun's rays. The soil of the plastic house with an area of (357) m^2 and dimensions of 42 x 8.5 meters was plowed well and perpendicularly twice, then smoothed and leveled, and then the land was divided into lines of (5) lengths (36) m, width (50) cm, height (15) cm, and the distance between one line and another (1.416) m. Then decomposed animal manure (cow waste) was added to the lines before planting and during the preparation of the house soil at a rate of 25 kg. Plastic $House^{-1}$ and fertilizer were added. Triple Calcium Super Phosphate P2O5 (45%) at a rate of 7.5 kg. Plastic $House^{-1}$ (18). The lines were covered with house soil and a drip irrigation system was installed, and then the lines were covered with mulching black plastic cover, then the single line was divided into 9 experimental units and the length of the experimental unit was 4 m so that the total number of experimental units reached 45 experimental units, every 15 experimental units is considered one sector and distributed to it Three ages of seedlings randomly, which are (35, 45, 55) days from the date of planting. Four concentrations of spraying with chelated calcium were distributed to each age, which is (0.5, 1.0, 1.5, 2.0) ml L^{-1} in addition to the comparison treatment, spraying with distilled water. In addition to the comparison treatment, spraying with distilled water, it was carried out as a one-time split factor experiment. Split plot design, according to the randomized complete block design (R.C.B.D.) and with three replications. Genstat and the least significant difference test (L.S.D.) were used to compare the arithmetic means at the 0.05 level of significance (6).

The cultivation process was carried out according to the treatments, at a distance of 40 cm between one plant and another on both sides of the line by the interchange method, and the number of plants in the experimental unit was 20 plants, the area of the experimental unit was 5.66 m^{-2}, and the plant density was 3.53 plants square meters. Seedlings of the first age of 35 days were planted on 4/11/2021, the second age of 45 days on 14/11/2021, and the third age of 55 days on 24/11/2021. After that, the plants were grafted two days after the transplanting date for each age. The concentrations of chelated calcium were sprayed with five sprays, the first in the vegetative growth stage, 86 days after planting the seeds on 12/25/2021, and the other two were separated by three weeks between one spray and the other. The plants were irrigated as needed, and the weeding process was carried out manually. To protect the plants from breakage as a result of the agricultural service operations, wooden stakes were placed on both sides of the line and tied with plastic threads. The plastic house was covered using a transparent polyethylene cover on 16/11/2021. After that, the process of harvesting the crop took place from 2/1/2022 until the end of the experiment on 1/5/2022, bringing the total number of harvests to 7. Five heterogeneous plants were selected randomly from each experimental unit, and the chemical indicators of the leaves were studied, which included the content of the leaves of total chlorophyll, the percentage of carbohydrates, and the content of the leaves of the element nitrogen and calcium. And a study of the chemical indicators of the fruits, included the percentage of dry matter of the fruits, the content of the fruits of vitamin C, the percentage of total soluble solids, and the content of the fruit's calcium.

Results and discussion:

It is clear from Table 2 that the foliar application of calcium and the age of the seedling and the interaction between them had a significant effect on all the

chemical indicators of the leaves, where the plants sprayed with calcium at a concentration of .02 ml L^{-1} were significantly superior in the leaves content of total chlorophyll a + b compared to the control treatment and a concentration of 0.5 ml L^{-1}, with an increase rate of 27.72, 18.63%, respectively, and did not differ significantly with concentrations 1.0 and 1.5 ml L^{-1} And the percentage of carbohydrates with an increase of 36.77, 21.58, 25.88, 26.72%, the content of the leaves of the nitrogen element, with an increase of 133.97, 209.32, 48.37, 27.17%, and the content of the leaves of the calcium element with an increase of 57.69, 33.69, 18.26, 12.84% compared to the comparison treatment And the rest of the other concentrations, respectively, the reason may be attributed to the fact that the treatment with calcium leads to improving and increasing the indicators of vegetative growth and thus increasing the absorption of water and nutrients from the soil and increasing the activity of many enzymes, including energy transfer enzymes Adenosine tri phosphatase, which plays an important role in many processes such as photosynthesis, respiration, carbohydrate metabolism, food processing and its transfer to All parts of the plant and then increase the percentage of the elements (7), this is consistent with the findings of (11) (17) (12) (10) and (13). As for the age of the seedlings, the results showed that the age of 35 days had a significant superiority in the content of the leaves of the nitrogen element compared to the age of 45 days, with an increased rate of 15.59%, and it did not differ significantly with the age of 55 days, while the age of 55 days showed significant superiority in the content of the leaves of the element calcium compared to with the age of 35 and 45 days, an increase of 106.15 and 28.84%, respectively. While the age of the seedlings did not appear to have a significant effect on the content of the leaves of total chlorophyll and the percentage of carbohydrates. As for the interaction between the two factors, it showed a significant effect, as the plants sprayed with calcium at a concentration of 2.0 ml L^{-1} excelled, and the plants planted at the age of 35 days gave the highest percentage of nitrogen, reaching 3.95%, while the plants sprayed with calcium at a concentration of 2.0 ml L^{-1} excelled. The lowest percentage of nitrogen was in the plants sprayed with calcium at a concentration of 0.5 ml L^{-1} and grown at the age of 45 days, reaching 1.13%. While the interference showed that the plants sprayed with calcium at a concentration of 2.0 ml L^{-1} and grown at the age of 55 days were superior, as they gave the highest percentage of calcium reaching 1.45%, while the lowest percentage of calcium was in the plants of the control treatment, which were grown at the age of 45 days, reaching 0.48%, and the reason may be attributed to The speed of the seedlings resuming growth after transplantation and the increase in the speed of root renewal, which led to the absorption of nutrients from the soil, and this is consistent with the findings of (2) (14) (16) and (3). It is clear from Table 3 that the foliar application of calcium and the age of the seedling and the interaction between them had a significant effect on all the chemical indicators of the fruits, as the plants sprayed with calcium at a concentration of . The fruits of vitamin C, with an increased rate of 44.08, 28.35, 13.86, 7.61%, and the content of the fruits of calcium, with an increase of 52.26, 45.67, 33.48, 23.67%, compared with the comparison treatment and other concentrations, respectively, while calcium spraying had no significant effect on the percentage of vitamin C. Total dissolved solids, the reason may be attributed to the fact that calcium plays a role in the

formation of the middle lamellae of the cell walls well, which prevents the leakage of organic and mineral materials from the cells and thus causes an increase in the accumulation of carbohydrates and control of the water balance (1). also, calcium leads to an increase in the vitamin C content of fruits (9), and this agrees with the findings of (11) (17) (12) (10) and (13). As for the age of the seedling, the results showed that the age of 35 days was significantly superior in the dry matter percentage of the fruits, with an increase of 14.08, 26.84%, and the fruit content of vitamin C, with an increase of 12.04, 16.31%, compared with the ages of 45 and 55 days, respectively, while the age showed 45 days of age had a significant superiority in the percentage of total dissolved solids compared to the age of 55 days, with an increased rate of 9.88%, and it did not differ significantly with the age of 35 days, while the age of the seedling did not appear to have a significant effect on the calcium content of the fruits. The reason for this may be attributed to improving and increasing vegetative growth indicators and thus increasing the absorption of water and nutrients from the soil and increasing the activity of many enzymes, including energy transfer enzymes Adenosine tri phosphatase, which plays an important role in many processes such as photosynthesis, respiration, and metabolism, and the reason for this may be attributed to improving and increasing growth indicators vegetative, thus

increasing the absorption of water and nutrients from the soil and increasing the activity of many enzymes, including energy transfer enzymes Adenosine tri phosphatase, which plays an important role in many processes such as photosynthesis, respiration, carbohydrate metabolism, food processing and its transfer to all parts of the plant (7), and this agrees with The findings of (2) and (14) and (16) and (3) . As for the interaction between the two factors, the results showed that there were no significant differences between the treatments in all the traits under study.

Conclusion:

We conclude from this study that in the cultivation of a hybrid sweet pepper plant (Drago F1) in greenhouses, the 35-day-old seedling plants sprayed with chelated calcium at a concentration of 2.0 ml L^{-1} by five sprays, the first after 86 days of planting seeds and the second every three weeks showed a significant effect. Most of the characteristics under study.

Table 2: The effect of calcium foliar spraying and the age of the seedling and the interaction between them on the chemical indicators of the leaves

Treatments			Total chlorophyll a + b (mg $100g^{-1}$ fresh weight)	Carbohydrates (mg g^{-1} dry weight)	The nitrogen content of the leaves %	The calcium content of the leaves %
The average effect of calcium ml L^{-1}	0		10.17	4.16	1.56	0.78
	0.5		10.95	4.68	1.18	0.92
	1.0		11.76	4.52	2.46	1.04
	1.5		12.64	4.49	2.87	1.09
	2.0		12.99	5.69	3.65	1.23
LSD 0.05			1.33	0.65	0.55	0.13
The average effect of seedling age (day)	35		11.85	4.98	2.52	0.65
	45		11.73	4.79	2.18	1.04
	55		11.53	4.36	2.33	1.34
LSD 0.05			NS	NS	0.28	0.08
The effect of the interaction between calcium and seedling age	0	35	10.31	4.11	1.91	0.60
		45	10.17	4.77	1.49	0.48
		55	10.02	3.60	1.29	1.28
	0.5	35	10.90	4.56	1.22	0.60
		45	11.07	4.81	1.13	0.88
		55	10.87	4.67	1.20	1.28
	1.0	35	11.08	4.79	1.91	0.64
		45	12.22	4.77	2.88	1.12
		55	11.99	4.01	2.60	1.36
	1.5	35	13.13	4.59	3.62	0.64
		45	12.50	4.44	2.11	1.28
		55	12.30	4.43	2.88	1.36
	2.0	35	13.81	6.84	3.95	0.80
		45	12.68	5.16	3.33	1.44
		55	12.48	5.07	3.69	1.45
LSD 0.05			NS	NS	0.71	0.18

Table 3: Effect of calcium foliar spray and seedling age and their interaction on chemical indicators of fruits

Treatments			Percentage of drymatter in fruits %	Vitamin C (mg 100g $^{-1}$ fresh weight)	Total Dissolved Solids %	Calcium content of fruits %
The average effect of calcium ml L^{-1}		0	4.63	54.44	5.00	0.199
		0.5	4.81	61.11	5.27	0.208
		1.0	4.78	68.89	5.22	0.227
		1.5	4.99	72.89	5.44	0.245
		2.0	5.98	78.44	5.94	0.303
LSD 0.05			**0.79**	**2.75**	**NS**	**0.047**
The average effect of seedling age (day)		35	5.67	73.20	5.50	0.244
		45	4.97	65.33	5.56	0.221
		55	4.47	62.93	5.06	0.244
LSD 0.05			**0.52**	**4.19**	**0.41**	**NS**
The effect of the interaction between calcium and seedling age	0	35	5.65	56.00	5.16	0.199
		45	4.43	49.33	5.00	0.199
		55	3.80	58.00	4.83	0.199
	0.5	35	5.54	68.00	5.00	0.199
		45	4.26	61.33	5.33	0.199
		55	4.62	54.00	5.50	0.227
	1.0	35	5.03	76.00	5.50	0.227
		45	4.87	66.67	5.50	0.227
		55	4.45	64.00	4.66	0.227
	1.5	35	5.42	80.00	5.66	0.228
		45	5.15	72.00	5.83	0.227
		55	4.39	66.67	4.83	0.282
	2.0	35	6.70	86.00	6.16	0.369
		45	6.16	77.33	6.16	0.256
		55	5.07	72.00	5.50	0.284
LSD 0.05			**NS**	**NS**	**NS**	**NS**

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