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The Effect of Foliar Spraying With Licorice Extract and Some Nutrients on The Growth and Yield of The Red Cabbage

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Abstract

The field experiment was carried out during the Winter/autumn cultivation season of (2021-2020) in one of the private fields in Fallujah city 60 km to the west of Baghdad at latitude 33° 19'53.6" north and longitude 43° 46'45.2" East to study the effect of foliar spraying with licorice extract and some nutrients on the growth and yield of red cabbage. A factor experiment with two factors was implemented according to the randomized complete blocks design (RCBD) with three replicates, the first factor is foliar licorice extract application in different concentrations. The second factor is the foliar spraying of nutrients. The results showed that the effect of spraying with licorice extract and some nutrients led to a significant increase in (plant height, leaf area, total chlorophyll in the leaves, Leaf content of anthocyanin, curl percentage, head weight, total yield, nitrogen percent in the leaves, Phosphorous percent in leaves, potassium percent in leaves).

Keywords: Red cabbage, Microelements, Calcium, Licorice extract.

1.Introduction

Cabbage is an important winter vegetable in Iraq. It has a scientific name *Brassica oleracea var.capitata*L. Belongs to the family, *Cruciferae*, the head that contains the curl leaves is eaten fresh or used in making pickles and salad [1]. It was found that every 100 gm of fresh leaves contains 3- 5.4% carbohydrates, 1-2% proteins, 0.2% fats, 30-50% vitamin C, 130 IU vitamin A, 0.05 mg thiamine, 238 mg potassium, 49 mg phosphorous, and 9 mg Magnesium, 1.2 mg iron and 24 calories, and it has many medical benefits in treating stomach ulcers and duodenal ulcers, reducing blood sugar, as well as preventing cancer [2]. The cabbage crop is grown in the tropics and temperate regions, and its cultivation is famous in the countries of South Korea, Germany, Japan and India. The area planted with Cabbage in Iraq in 2014 amounted to 1435 tons. ha⁻¹, with a total yield of 19,165 tons. ha⁻¹, and a production rate of 13.36 tons. ha⁻¹[3].

Foliar fertilization provides the necessary elements for the plant, especially the trace elements, and foliar fertilization is an urgent necessity when the plant is stressed to compensate for the lack of supply of elements through the roots [4,5] and that the lack of any component of it leads to a major imbalance in vegetative and root growth, and that the effect of fertilizing with these nutrients, especially microelements, leads to improved vegetative growth of the plant, and this is confirmed by [6,7]. Foliar nutrition is one of the agricultural methods that complement the process of fertilizing the land and is not a substitute for it to provide the plant with the necessary elements in the event that it is not available in the soil as a result of washing or fixation, which is reflected in the increase in vegetative growth and yield, Iraqi soil describes as alkaloid soil which contains a lot of nutrients but most of micro nutrients not available for plant uptake [8,9], foliar application suitable to provide nutrients to the plants, the ability of leaves to deliver nutrients to the plant through two pathways, The ability of the leaves to uptake the nutrients to the plant is through two pathways, one of which is mediated by bridges or visceral tubes (ectodesmata) located under the epidermal layer extending to the epidermal cells and then to the cytoplasm, the other path through the stomata, this is called Apoplasm [10]. Plant bio-stimulants are used to treat crops in a commercial setting because of their ability to increase growth rates, increase stress tolerance, increase the photosynthetic rate and increase disease tolerance [11].

The natural plant extracts, so *Glycyrrhize glabog* (Liquor ices) licorice extract, is a plant belonging to the Fabaceae family, it contributes to improving plant growth and productivity because it contains Glycyrrhizin, whose sweetness is about 50 times that of sugar cane [5]. It noted [12] the significant effect of foliar spray treatment with licorice root extract at a concentration of 2.5 g. l⁻¹ on the indicators of the study of Broccoli plant, such as leaf length 57.89 cm compared to the control treatment, which recorded 47.70 cm, and the total phosphorous ratio in flower stalks was 0.625% compared to the control treatment. The lowest value was 0.608%.



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Calcium is also one of the major important and influential elements in the plant. The main problem with calcium lies in its slow or non-transfer between cells, and the best solution to reduce the deficiency of this element and its damage to the plant lies in spraying it on the vegetative group to increase its concentration in the leaves [13]. The data of [14] also indicated that foliar spraying of calcium on the plant cabbage had a positive significant effect on stem length 15.83,15.92 cm (Ca1)16.06,16.00 cm(Ca2)16.38,16.56 cm(Ca3), as well as the number of outer leaves and the thickness of the outer leaves. Micronutrients play an important role in all stages of plant development and are essential for growth primarily due to their function as essential components of various enzyme systems. The plant needs it in small quantities, but they are essential, as they play an essential role in plant physiology. If the plant does not obtain these elements in sufficient quantities whether because they are not contained in the soil or not added in sufficient quantities, foliar feeding is necessary to improve plant growth and production in quantity and quality [15].

Due to the lack of studies on this economically important crop in Iraq, the study aimed to improve the growth and quantity and quality yield of Red Cabbage by Foliar application of licorice extract, Calcium and some micronutrients.

2. Materials and Methods

The field experiment was carried out during the autumn planting season of (2020) for the period from 15/8/2020 to 10/3/2021 in a one of the private fields in the city of Fallujah, west of Baghdad (to study the effect of foliar spraying with licorice extract). The experiment was conducted according to a Randomized Complete Blocks Design (RCBD) with three replicates, the experiment included (16) treatments, the experimental unit distance with a length of (4) m, a width of (0.5) m, and the total area of (2) m². The terrace contains (10 plants) with a planting distance of (0.4) m between one plant and another and (0.4) m between one terrace and another. Samples were taken from the field soil and from different locations before the start of the experiment, at a depth of (0-0.5m) to analyzed some physical and chemical properties of the soil. As Table 1 shows some physical and chemical properties of the field soil before planting, the seeds of the red cabbage variety Broadex were sown in cork dishes in one of the private nurseries in Abu Ghraib district on 15/8/2020 AD, spraying treatments were added to the plants twice in the nursery and the seedlings were transferred to the permanent place After 45 days on October 1/10/ 2020

2.1. Study factors

1-Foliar application of licorice extract:

- A. Without spraying, symbolized by E₀.
- B. Spraying with licorice extract at a concentration of 2.5 g L⁻¹, symbolized by E₁.
- C. Spraying with licorice extract at a concentration of 5 g L⁻¹, symbolized by E₂.
- D. Spraying with licorice extract at a concentration of 7.5 g L⁻¹, symbolized by E₃.

2-Foliar application of some nutrients:

- A. Without spraying, symbolized by T₀.
- B. Calcium spray at a concentration of 2 ml L⁻¹, symbolized by T₁.
- C. Spraying with microelements at a concentration of 2 ml. L⁻¹, symbolized by T₂.
- D. Spraying with calcium at a concentration of 2 ml L⁻¹ + microelements at a concentration of 2 ml L⁻¹, symbolized by T₃.
- E. Treatments of foliar application at a rate of (4) times during the agricultural season as follow

The first spray 25/8/2020/ in the nursery.

The second spray 10/9/20/2020 in the nursery.

The third spray 1/10/2020 in the field.

Fourth spray 30/10/2020 in the field.

2.2. Studied traits

- leaves number (leaf plant⁻¹): was calculated at the end of the season.
- Leaf area dm². Plant-1: Leaf area was calculated by Digimizer program.
- Total chlorophyll in leaves (mg g⁻¹ fresh weight): It was estimated that the pigment was extracted from the leaves using acetone (80%) and then reading the optical absorption of the sample at wavelengths 663 and 645 nm by means of a spectrophotometer using the following equation [16].

Total Chlorophyll (mg L^{-1}) = $20.2 D(645) + 8.02 D(663)$ Then it was converted to $\text{mg } 100 \text{ g}^{-1}$ fresh weight.

- Total anthocyanin content of leaves ($\text{mg } 100 \text{ gm}^{-1}$ fresh weight): The anthocyanin pigment in leaves was estimated by taking 5gm of fresh leaves and placing them in 100ml of a mixture (HCL standard 1.5 + 85% methyl alcohol) then filtered into a standard flask and completed the volume to 500 ml of the same mixture and read using a spectrophotometer at a wavelength of 535 nm as reported in [17].

- Percentage of heads curl: I was able to calculate the number of heads curl divided by the total number of vertices x 100 [18].

- The total yield ton ha^{-1} : The total yield of one experimental unit was calculated by calculating the yield of the experimental unit and then attributed to the hectare according to the following equation: -

$$\text{Unit area yield (ton ha}^{-1}\text{)} = \frac{\text{Experimental unit yield x 10000 [6]}}{\text{Experimental unit area}}$$

- Estimated of nutrients in leaves: nitrogen (N%) was estimated using Micro Kjeldahl device according to the method mentioned in [19], phosphorous (P%) was estimated by spectrophotometer at a wavelength of 662 nanometers [20], and potassium was estimated (K%) with a flame photometer) according to the method proposed by [21].

- Average total head weight (ton ha^{-1}): The average of total head weight was calculated by dividing the group of head weights in the experimental unit by their number.

Table 1. Chemical and physical properties of soil before planting.

Property	Unit	value
Soil Separators	Sand	362
	Silt	g kg^{-1} 332
	Clay	306
Soil texture	-	Clay Loam
bulk density	Mg m^{-3}	1.46
PH	-	7.78
EC	dS m^{-1}	2.86
OM		1.74
CaSO ₄	g kg^{-1}	53.64
CaCO ₃		168.87
ready nitrogen		34.65
ready phosphorous	mg kg^{-1}	12.39
ready potassium		73.35

3. Results and Discussion

Table (2) showed that treatment of the foliar application of licorice extract E₂ at the concentration 5 g L⁻¹ was significantly achieved the highest number of leaves per plant, leaf area, reaching (76.19 Leaf plant⁻¹, 323.9 dm² plant⁻¹) compared to the control treatment. also, the treatment of spraying with microelements T₂ best values was (75.83 leaf plant⁻¹, 354.3 dm² plant⁻¹) compared to the control, whereas, T₃ treatment was the lowest in leaf area (226.4 dm² plant⁻¹). As for the interaction of the study factors, the treatment E₂T₂ had a significant effect on the characteristics of the number of leaves of the plant and the leaf area, to record the best values of yielded (91.83 leaf plant⁻¹, 460.7dm²plant⁻¹), while The lowest values were recorded by the control treatment E₀T₀ (17.50 leaf plant⁻¹, 176.9 dm² plant⁻¹).

Table 3 shows the significant effect of foliar spray treatment with licorice extract E₂ on the total leaf content of chlorophyll and leaf content of total anthocyanin, the results of which were (37,583, 346.58 mg 100 g⁻¹ fresh weight) compared with the treatment of E₀ sprayed with water only, which amounted to (36,083, 340.25 mg 100 g⁻¹ fresh weight), while the T₂ microelements spray treatment gave a significant increase in the same two characteristics mentioned above, where this increase amounted to (37.750, 345.75 mg 100 g⁻¹ fresh weight) while the control treatment was recorded (35,583, 339.67 mg 100 g⁻¹ fresh weight), which expressed the lowest values recorded during the study season. The same table indicated the superiority of the foliar spray treatment with micro-elements and licorice extract at a concentration of 5 g L⁻¹ and indicated by the symbol E₂T₂ in both characteristics, which amounted to (39.000mg 100 g⁻¹ fresh weight), while the control treatment recorded the lowest content of chlorophyll in leaves amounted to (34,667 100 g⁻¹ fresh weight).

Table 2. Effect of spraying with licorice extract and some nutrients on plant leaf number and leaf area.

Factor levels (E)	leaves number (plant leaf ⁻¹)				Factor levels (E)	Total leaf area				Factor levels (E)
	Factor levels (T)					Factor levels (T)				
	T ₀	T ₁	T ₂	T ₃		T ₀	T ₁	T ₂	T ₃	
E ₀	17.50	79.33	62.33	60.00	54.79	176.9	353.5	298.3	207.2	259.0
E ₁	57.78	74.00	69.00	64.33	66.28	216.7	301.3	274.5	216.3	252.2
E ₂	67.67	66.44	91.83	78.83	76.19	260.0	282.6	460.7	292.2	323.9
E ₃	66.33	69.67	80.17	66.83	70.75	258.9	338.4	383.9	194.0	293.8
Factor levels (T)	52.32	72.36	75.83	67.50		228.1	319.0	354.3	226.4	
LSD E			1.84					35.21		
LSD T			1.84		0.05			35.21		0.05
LSD ET			3.67					70.42		

Table 3. Effect of foliar spraying with licorice extract and some nutrients on the leaves content of total chlorophyll and total anthocyanins (mg 100 g⁻¹ fresh weight).

Factor levels (E)	Total chlorophyll in leaves (mg 100g ⁻¹ fresh wt)				Factor levels (E)	Total anthocyanins in leaves (mg 100g ⁻¹ fresh wt)				Factor levels (E)
	Factor levels (T)					Factor levels (T)				
	T ₀	T ₁	T ₂	T ₃		T ₀	T ₁	T ₂	T ₃	
E ₀	34.667	38.000	36.667	35.000	36.083	336.00	343.00	343.33	338.67	340.25
E ₁	35.667	36.333	37.000	36.000	36.250	338.33	339.33	344.00	343.00	341.17
E ₂	36.000	38.000	39.000	37.333	37.583	343.33	347.00	349.00	347.00	346.58
E ₃	36.000	37.000	38.333	35.000	36.583	341.00	346.33	346.67	339.33	343.33
Factor levels (T)	35.583	37.333	37.750	35.833		339.67	343.92	345.75	342.00	
LSD E			0.4305					4.340		
LSD T			0.4305		0.05			4.340		0.05
LSD ET			0.8611					N.S		

Table No. 4 indicated that there was a significant effect on the percentage of the curl when treated with foliar spraying with licorice extract at concentrations (2.5 and 7.5) g L⁻¹, which amounted to (96.7%), while the foliar spray treatment with microelements + calcium (T3) recorded the best values in the percentage of a curl of (96.7%), as for the interaction between the two study factors E0T3 of (spray with calcium + spray with microelements) and E3T2 (Spraying with licorice extract at a concentration of 7.5 and spraying with calcium) recorded the highest results in the percentage of curl yield of (100.0%) compared to the control treatment (23.3%), through the same table mentioned above, significant differences appear between the treatments of foliar spraying with licorice extract in the percentage of potassium in the leaves, where treatment E2 reached to (0.18686%) compared to treatment E1, which gave the lowest percentage of (0.17775%) while the foliar spraying with nutrients T1 treatment with calcium spray outperformed all other treatments by giving it the highest percentages of (0.18630%) compared to the T3 treatment, which recorded the lowest value table 4, the interaction between treatments of E2T2 and E2T3 achieved the highest values in the highest percentages of heads which amounted to (0.18000%) compared to the control treatment (0.03433%).

Table 4. Effect of spraying with licorice extract and some nutrients on the percentage of heads curl-up and the total potassium percentage (%).

Factor levels (E)	Curl percentage (%)				Factor levels (E)	Potassium percentage(%)				Factor levels (E)
	Factor levels (T)					Factor levels (T)				
	T ₀	T ₁	T ₂	T ₃		T ₀	T ₁	T ₂	T ₃	
E ₀	23.3	86.7	90.0	100.0	75.0	0.17000	0.18667	0.18000	0.17467	0.17783
E ₁	93.3	100.0	96.7	96.7	96.7	0.17000	0.18000	0.18000	0.18000	0.17775
E ₂	86.7	96.7	96.7	96.7	94.2	0.17533	0.19000	0.19210	0.19000	0.18686
E ₃	96.7	96.7	100.0	93.3	96.7	0.17867	0.17400	0.19210	0.17617	0.18023
Factor levels (T)	75.0	95.0	95.8	96.7		0.18021	0.18630	0.18267	0.17350	
LSD E			133.276					0.004048		
LSD T			133.276		0.05			0.004048		0.05
LSD ET			266.552					0.008096		

It appears from the values of the arithmetic averages presented in Table (5) that the foliar spray treatment with licorice extract E2 had a significant effect on the average total head weight amounted to (820.58 g plant⁻¹) and the same treatment gave the highest total yield estimated at (51.3 ton ha⁻¹) while the control treatment recorded the lowest values, the arithmetic averages that appear in the same table above showed a significant effect in both traits, the average of total head weight and the total yield for the treatment of spraying with microelements T2 amounted to (1097.25 g plant⁻¹, 54.9 ton. ha⁻¹) compared to the control treatment (592.45 g plant⁻¹, 29.6 Mg ha⁻¹).

The results of the same table also indicated that there was a significant difference in the two characteristics mentioned above in the treatment of the interaction between the two factors of the study, represented by the E2T2 treatment, where this treatment outperformed all treatments, as it gave the highest values amounting to (1420.07 g plant⁻¹, 71.0 ton ha⁻¹) while The control treatment recorded the lowest values mentioned in the table (211.47 g plant⁻¹, 10.6 ton ha⁻¹).

Table 5. Effect of spraying with licorice extract and some nutrients on average of head weight (g plant⁻¹) and total yield (ton ha⁻¹).

Factor levels (E)	Average of total head weight (g plant ⁻¹)				Factor levels (E)	Total yield (ton ha ⁻¹)				
	Factor levels (T)					Factor levels (T)				
	T ₀	T ₁	T ₂	T ₃		T ₀	T ₁	T ₂	T ₃	
E ₀	211.47	983.87	929.53	662.20	696.77	10.6	49.2	46.5	33.1	34.8
E ₁	664.00	885.20	959.87	773.27	820.58	33.2	44.3	48.0	38.7	41.0
E ₂	736.67	985.93	1420.07	962.20	1026.22	36.8	49.3	71.0	48.1	51.3
E ₃	757.67	934.60	1079.54	586.20	839.50	37.9	46.7	54.0	29.3	42.0
Factor levels (T)	592.45	947.40	1097.25	745.97		29.6	47.4	54.9	37.3	
LSD E			133.27					6.66		
LSD T			133.27		0.05			6.66		0.05
LSD ET			266.55					13.33		

The results of Table (6) showed that there were significant differences in the estimation of the total phosphorous percentage, as the foliar spray treatment with licorice extract E₂ gave the highest percentage of phosphorous content of leaves, estimated at (0.03833 %), compared to the comparison treatment, which gave the lowest percentages amounted to (0.03542%). As for foliar spraying with nutrients, the treatment of spraying with microelements T₂ gave the highest percentage (0.03833%) compared to the control treatment, which was the lowest (0.03533%). While the same table shows that there are significant differences during the interaction of the two factors of the study, as the treatment E₂T₂ gave the highest percentage (0.04033%) and the treatment of spraying with water only gave the lowest percentage (0.03433%). The same table also recorded the spraying treatment with licorice extract at the concentration (5g L⁻¹), symbolized by (E₂), the highest percentages in the nitrogen content in the leaves compared to the control treatment, which gave the lowest percentages (0.2428%) and gave the treatment of the microelements indicated by the symbol T₂ had the highest nitrogen content of leaves (0.2427%), and the lowest levels were given by spraying with distilled water only.

The interaction between the two factors of the study and their effect on the total nitrogen content in the leaves in the same table shows the significant effect of the E₂T₂ treatment, which amounted to (0.2653%) compared to the control treatment.

Table 6. Effect of spraying with licorice extract and some nutrients on the percentage of phosphorous and nitrogen (%).

Factor levels (E)	Phosphorous percentage(%)				Factor levels (E)	Nitrogen percentage(%)				
	Factor levels (T)					Factor levels (T)				
	T ₀	T ₁	T ₂	T ₃		T ₀	T ₁	T ₂	T ₃	
E ₀	0.03433	0.03667	0.03567	0.3500	0.03542	0.2167	0.2295	0.2293	0.2200	0.2239
E ₁	0.03567	0.03567	0.03700	0.03533	0.03592	0.2190	0.2300	0.2295	0.2235	0.2255
E ₂	0.03600	0.04000	0.04033	0.03700	0.03833	0.2238	0.2416	0.2653	0.2404	0.2428
E ₃	0.03533	0.03733	0.04033	0.03667	0.03742	0.2233	0.2269	0.2467	0.2377	0.2337
Factor levels (T)	0.03533	0.03742	0.03833	0.03600		0.2207	0.2320	0.2427	0.2304	
LSD E			0.001013					0.00630		
LSD T			0.001013		0.05			0.00630		0.05
LSD ET			0.002026					0.01259		

The results obtained can be explained. An increase in the vegetative growth indicators of red cabbage represented by plant height, leaf area and leaf content of anthocyanins when treated with E2 licorice extract is attributed to the role of the extract in stimulating the vegetative growth of the plant by encouraging dormant buds as a result of its role similar to gibberellin due to its participation With gibberellin with the intermediate compound Mevalonic Acid in the biosynthesis process for both and the fact that the extract contains many terpenoid compounds thus, the behavior of gibberellin in its effect in increasing vegetative growth, increasing elongation and cell division as a result of its effect on enzymes for converting complex compounds into simple compounds that the plant exploits in building new protein materials necessary for its growth and then it gave large vegetative growths that caused an increase in the vegetative characteristics of the plant and perhaps the plant cells were able to absorb part of the extract sugars and benefit from them in their vital activities [22], these results agreed with the findings of [12] when spraying broccoli plant with licorice extract at a concentration of 2.5 g L⁻¹, which had a significant effect on the indicators of studying vegetative growth such as leaf length. The high level of nitrogen and magnesium in licorice extract may explain the reason for the increase in chlorophyll content, as nitrogen constitutes 70% of the components of chlorophyll because it is included in the formation of chlorophyll and thus increases photosynthesis and energy production, and magnesium is the main component of the chlorophyll molecule [23].

The reason for the significant increase in the indicators of the study when spraying with microelements may be attributed to the fact that microelements have an effective role in many vital activities in the plant, including activating the formation of proteins and various enzymes and stimulating the formation of chlorophyll, as well as helping to transport carbohydrates and sugars and regulating the osmotic effort of plant cells, The reason for the superiority of the T2 micro-elements treatment over the rest of the other treatments is since it contains zinc, which is involved in the manufacture of the amino acid tryptophan(C₁₁H₁₂N₂O₂), which is an essential material for the manufacture of the hormone indole acetic acid (IAA), It is also attributed to the fact that it contains naphthalene, which is classified as a growth regulator, and acetic acid NAA, which play an important role in improving growth through increasing division and cell expansion [24-26].

As for calcium, its positive effect on the studied indicators is attributed to the roles that this element plays in the plant, as it acts as a link between the components of the cell wall, and here its presence is the basis for continued growth and ensuring the strength of the plant structure [27] and calcium has a key role in the permeability and stability of cell membranes [28]. It also has a role in cell division and elongation [29].

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