

Effect of foliar application with zinc and boron sulfate on the quality of two broccoli hybrids

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Abstract

The experiment was conducted in the vegetable field/ Department of Horticulture and Landscape Engineering/ College of Agriculture and Forestry/ University of Mosul during the 2018-2019 agricultural season. To study the effect of spraying with zinc sulfate at a concentration of 300 mg. L⁻¹ and boron at a concentration of 60 mg.L⁻¹ and zinc + boron in addition to the control treatment (water spray only) in the productivity of two hybrids of broccoli Parasio and Danar. The experiment was designed according to the Split-plots-System-Split-system within the randomized complete block design (RCBD) and with three replications, and the averages were compared with Duncan's polynomial test at the probability level of 0.05. The results confirmed that the dual interaction between the Parasio hybrid and spraying with zinc + boron gave the highest percentage of dry matter in the main curd, amounting to 13.03% and the bi-interaction between the hybrid Parasio and spraying with boron gave the highest value of vitamin C content in the curd , which amounted to 75.421 mg. 100ml⁻¹ While the interaction between Parasio hybrid and spraying with water only was significantly excelled in giving the lowest nitrate content in the main curd 15.19 mg. 100g⁻¹ and the interaction between Parasio hybrid, spraying with boron, spraying with zinc + boron, hybrid Danar and spraying with zinc + boron gave the highest percentage of protein in the main curd 14.58, 15.46 and 14.12 % , respectively.

Key words: - zinc - boron - quality - curd - broccoli.

Introduction

Broccoli (*Brassica oleracea* var. Italica) is one of the vegetable crops of the (Brassicaceae) family, a herbaceous annual, similar in morphology to cauliflower, wild species found in the Mediterranean region. However, it is little spread in Iraq and ranks 31st in the world in terms of production. It is cultivated for its inflorescences that are eaten while they are in the vegetative bud stage with their thick, juicy bearer, and their heads are eaten cooked or boiled or in their natural state, or they may be used in making pickles (Thapa and Rair, 2012; Hamza and AL-Taey,2020) It is characterized by good nutritional value, as each 100 gm of fresh weight of the curd

contains 5.9 gm of sugars, 0.3 gm of fat, 3.6 gm of protein, 32 calories and 89.1 gm of water. It is considered one of the foods low in free fats, sodium and calories. It is a good source of many vitamins such as vitamin C, A and D, riboflavin, niacin, carotenoids and folic acid (Michaud et al., 2002). Broccoli has a high therapeutic nutritional value that is not available in any other plant. It is a regulator and a strong antibiotic for many common diseases (AL-Taey et al.,2019). It lowers high blood pressure, helps regulate blood sugar, and lowers cholesterol. It helps build bones, increases physical strength, and helps protect against heart diseases, urinary and reproductive tracts, and reduces cancer incidence. Recently, the demand for broccoli

consumption has increased, and global markets have witnessed this demand due to its high nutritional value and good taste. Iraq's productivity reached 31,178 tons, with a production percentage of 0.14% of global production (F.A.O, 2014). Plant producers aim to obtain hybrids and cultivars with desirable agricultural traits for important agricultural crops through breeding and improvement programs and to know the extent to which they are adapted to the environmental conditions prevailing in the area in which the plant grows. This requires providing new hybrids or cultivars (Slomy et al., 2019). One of the most important operations that lead to an increase in the crop is the cultivation of early, late and medium-ripening cultivars at different agricultural dates in order to prolong the period of the crop's presence in the markets.

The soil of Iraq is one of the basal soils that stabilize many elements, especially the micronutrients, and thus reduce the availability of nutrients to the plant (AL-Taey, 2017; AL-Bayati et al., 2019). Then, foliar spraying nutrients is the appropriate way to equip plants with micronutrients (Al-Juthery et al., 2020; Toman et al., 2020), including zinc. Zinc is a catalyst for the enzyme carbonic anhydrase and cytochromes and cannot be replaced by another element. It enters the formation of the amino acid Tryptophane, the IAA hormone responsible for cell elongation (Hassan et al., 1990; Manea et al., 2019). Boron, which plants need in small quantities, has an essential role in the formation of cell walls and works to facilitate the movement and products of photosynthesis from the leaves and its transfer to the active areas in the plant, such as the transfer of sugars, which is necessary for cell division (Travena, 2007) and that its presence increases the plant's resistance to drought. The lack of boron causes brown discoloration of the curd and causes physiological imbalance as a result of nutritional imbalance (Hassan, 2004). Nutrients provide the plant with nutrients and improve the nutritional status of the plant, as studies have shown that the increase in the

yield of many agricultural crop plants forms a direct relationship with the boost of nutrients to the optimal plant-ready unit (Taiz and Zeiger, 2010). Studies have confirmed that the plant takes its nutrients through the leaves and that the penetration of nutrient solutions into the tissues of the leaf is either through the stomata or through their surface or both together and that the stomata work to absorb more efficiently than the surfaces of the leaves; This is due to the low thickness of the cuticle layer (Barraclough and Haynes, 1996). The process of absorption of nutrients by the cells of a leaf is similar to the operation of absorption of nutrients by roots. The primary step in the process is to move across biofilms (cell membranes). The foliar spray process is helpful, especially in conditions where nutrient absorption is difficult due to soil fixation of many elements necessary for plant growth, reducing availability (Al-Nuaimi, 2000). The behavior of micro-nutrients such as zinc is less critical than the macronutrients such as NP, NP and K because zinc is one of the critical and essential nutrients for plant growth. It is involved in many vital processes, including stimulating oxidation processes in plant cells, and it is necessary to form the amino acid Tryptophan, which consists of auxin (IAA). Tryptophan Tusi, 1984 Boron is one of the essential micro-nutrients in plant growth and production, and it has a significant role in transporting the food made in the leaves to storage areas. The speed of the transfer of sugars after combining with boron is higher than the polarized ones. It also has an essential role in cell division. Elongation and the lack of availability negatively affect the plant, so it is believed that its deficiency is related to the death of the developing tops as well as its impact on the vital activities of the cell through its union with the hydroxyl compounds that are included in the composition of the walls, that it is often found in the soil on Boric acid form (H_3BO_3) It may be dissolved in the soil solution or adsorbed in the form of borates on the surfaces of clay colloids (Al-Sahhaf, 1989). Also, it is found in the form of borates in different formats: BO_3^-

3, HBO3-2, H2BO-3, B4O7-2, and B (OH)4, and it is determined by plant growth (Acquaah (2002).

Study objectives:

- 1- Evaluate two broccoli hybrids under the conditions of Nineveh province to know the best ones for growth and curds production.
- 2- Increasing the yield by improving the nutritional status of the plant by spraying with zinc and boron sulfate.
- 3- Finding the best combination between the interactions of the studied factors to improve the quality of broccoli.

Materials and methods

The experiment was conducted in the vegetable field, Department of Horticulture and Landscape Engineering, College of Agriculture and Forestry, University of Mosul - during the agricultural season 2018-2019, samples were taken from the soil of the field and from different areas before starting the experiment from the surface of the soil at a depth of 30 cm to determine some chemical and physical properties of the soil of the field (Table 1) The maximum and minimum temperatures, average wind speed and rainfall average were recorded during the planting season as shown in Table (2).

Table (1) some physical and chemical properties of field soil before planting.

Traits	values	units
ECe	2.5	dS.m ⁻¹
pH	7.42	——
nitrogen	0.126	%
phosphorous	9.54	mmol.L ⁻¹
potassium	125.173	mmol.L ⁻¹
Clay	14	%
silt	16	%
sand	70	%
Texture	Sandy loam	

* The chemical and physical properties of soil were analyzed in Kirkuk Agriculture Directorate, Laboratories of the Water and Soil Management Division.

Table (2) Average maximum and minimum temperatures, average wind speed and rain during the study period from October - end of March 2018-2019

Months	climatic elements			
	average maximum temperature(°C)	Average minimum temperature (°C)	average wind speed m/s	Rainfall rate (mm)
October	32.1	21.8	21.1	5.2
November	20.8	13.0	129.8	4.6
December	15.8	9.3	94.0	3.7
January 2019	14.7	5.8	46.2	5.2
February	16.0	7.1	37.9	11.3
March	18.2	8.6	117.6	5.4

* Al-Anwaa Air Station / Kirkuk Governorate.

The field is prepared after removing the growing plants and weeds and then carrying out the process of tillage, softening and levelling. Added is the compound chemical fertilizer Jordanian DAP NPK in 333 tons. ha⁻¹ before planting seedlings and for all treatments, mixing the fertilizer well and homogeneously, then dividing the land into three replicates to include each replicate 24 experimental units; each experimental unit has a length of 3 m and a width of 1 m. The area of the experimental unit is 3 m², leaving a distance of 1 m between one terrace and another and leaving a distance of 0.75 m between each experimental unit and another to prevent the mixing of spray materials between the treatments, with the cultivation of an experimental unit at the beginning and end of each sector as guard plants. A drip irrigation system was installed, and the soil and all the experimental units were covered with black

plastic. The experiment included a study of two factors, the first factor: the hybrid planting of two hybrids of broccoli Parasio and Danar, and the second factor spraying with zinc and boron sulfate: spraying with water only (Control), zinc sulfate (ZnSo₄) at a concentration of 300 mg.L⁻¹ and boron at a concentration of 60 mg. L⁻¹.Boric acid (H₃BO₃) 17% boron and the synthesis of zinc sulfate + boron (300 mg. L⁻¹ + 60 mg. L⁻¹). The spraying was conducted a month after the transplant date, 15 days between one spray and another, and the number of sprays per treatment was 4. The dry matter in the main curd, the curd vitamin C content (mg/100ml-1 fresh weight) and the nitrate content (mg.100g-1) dry matter in the main curd and the protein percentage in the main curd were calculated.

Qualitative traits:**1: Percentage of dry matter in the main curd:**

The rate of dry matter in the main curd was calculated by taking a fresh weight of 200 g and placed in perforated paper bags. The samples were air-dried inside the room and then placed in an electric oven at a temperature of 68 °C until the weight was stable. The dry matter rate was extracted according to the following equation:

The percentage of dry matter in curd = $\frac{\text{Sample dry weight (g)}}{\text{Sample fresh weight}} \times 100$

2: curd content of Vitamin C (mg/100ml⁻¹ fresh weight)

It was calculated by taking 50 gm of curd for each experimental unit and placing it in an electric mixer with 50 ml of oxalic acid at a concentration of 6% for five minutes until the solution became homogeneous and then extracting the juice through a gauze cloth, 10

mL of the filtrate was pipette taken into a standard flask of 50 mL capacity and the volume was supplemented to the mark with 3% oxalic acid.

3: The curd content of Nitrate (mg.100gm⁻¹) dry matter in the main curd:

0.1 g of the dried and crushed sample of curd was weighed and placed in a test tube, 10 ml of distilled water was added to it, then it was shaken by hand and placed in the incubator at a temperature of 45 °C for an hour, then placed on the vibrator for 15 minutes. Then it was placed in a centrifuge (5000 rpm) for 15 minutes, then 0.2 ml of this suspension was taken and placed in a beaker and 0.8 ml of salicylic and sulfuric acid (H₂SO₄-SA) was added to it, and after 20 minutes 19 ml (NaOH 2 N) was added to the beaker and then The samples were read on a spectrophotometer at a wavelength of 410 nm and then the equation mentioned in the standard curve for nitrate was applied to extract the curd content of nitrate.

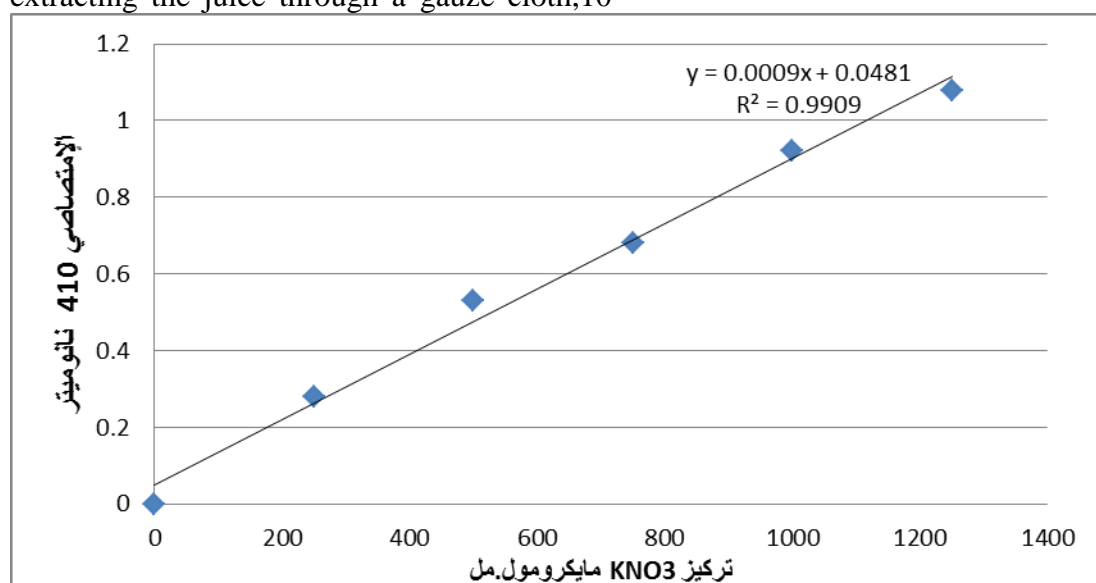


Figure (1) standard curve for nitrate

4: Percentage of protein in the main curd:

The percentage of proteins in the plant curd was calculated on the basis of dry weight (A.O.A.C, 1970) according to the following equation:

Protein % = percentage of nitrogen x 6.25.

The results of the experiment were statistically analyzed according to the SAS program (2001) and Duncan's multiple range

test was conducted as reported (Al-Rawi and Khalaf Allah, 2000).

Results and discussion

Table (3) shows that the percentage of dry matter in the central curd values has no significant differences between the two

hybrids in the rate of dry weight in the main curd. It is noted that the spraying treatments with zinc and boron sulfate significantly excelled on the percentage of dry matter in the main curd compared to spraying with water only, which gave the lowest value for this trait amounting to 9.59%.

Table (3): Effect of zinc and boron application and their interaction on the dry weight rate in the main curd.

hybrid	Average effect of spray treatments(mg.L ⁻¹)				average effect of hybrid
	water only (control))	Zinc (300)	Boron(60)	Zinc (300) + boron 60	
Parasio	10.06 d e	12.30 a- c	12.68 a b	13.03 a	12.02 a
Danar	9.11 e	11.58 c h	11.08 c d	12.23 a – c	11.00 a
Average effect of spray treatments	9.59 b	11.94 a	11.88 a	12.63 a	

* The averages that share the same alphabetic letters for each factor and each overlap do not differ significantly among themselves according to Duncan's polynomial test at the 0.05 probability level.

The bi- interaction between hybrids and foliar fertilizers showed that Parasio hybrid with zinc + boron achieved the most percentage of dry matter in the main curd, amounting to 13.03%, and it differed significantly from most treatments, and the lowest value in this trait was 9.11% in the treatment of hybrid Danar and spraying with water only.

From the results in Table (4) in the content of the main curd of vitamin C (mg.100 ml⁻¹ fresh weight), No significant difference was

observed between Parasio and Danar hybrids in this trait. It is noted that spraying with boron significantly excelled and gave the highest vitamin C content in the central pink discs, which amounted to 74.01 0 mg. 100 ml⁻¹, and it differed considerably with all treatments. The treatments of spraying with zinc and spraying with zinc + boron significantly excelled on the treatment of spraying with water only, which gave the lowest value for this trait 59.48 mg. 100 ml⁻¹.

Table (4): Effect of zinc and boron application and their interaction on the content of the main curd of vitamin C (mg. 100 ml⁻¹ fresh weight) .

hybrid	Average effect of spray treatments(mg.L-1)				average effect of hybrid
	water only (control)	Zinc (300)	Boron(60)	Zinc (300) + boron 60	
Parasio	60.45 d	73.34 a b	75.42 a	70.33 a c	69.89 a
Danar	58.51 d	66.99 c	72.61 a c	68.94 b c	66.76 a
Average effect of spray treatments	59.48 c	70.16 b	74.01 a	69.64 b	

* The averages that share the same alphabetic letters for each factor and each overlap do not differ significantly among themselves according to Duncan's polynomial test at the 0.05 probability level.

the bi-interaction between the hybrids and the spraying treatments showed that the Parasio hybrid and the boron spray gave the highest value in the vitamin C content in the main curd, which amounted to 75.421 mg. 100 ml⁻¹ and it differed significantly with some treatments, and the lowest vitamin C content in the main curd was 58.51 mg. 100 ml⁻¹ in the treatment of hybrid Danar and sprayed with water only.

From the data in Table (5), the curd content of nitrate (mg.100gm⁻¹) as a dry

matter, no significant difference was observed between the two hybrids Parasio and Danar in this trait. It is noted that spraying with water only gave the lowest nitrate content in the main curd , 17.16 mg. 100gm⁻¹ and with significant difference with all other spraying treatments,

The highest nitrate content in the main curd was 28.43 and 25.88 mg. 100 g⁻¹ for spraying treatments with boron and zinc + boron, respectively.

Table (5): Effect of zinc and boron application and their interaction on curd content of nitrate (mg. 100gm⁻¹) dry matter in the main curd.

hybrid	Average effect of spray treatments(mg.L ⁻¹)				average effect of hybrid
	water only (control))	Zinc (300)	Boron(60)	Zinc (300) + boron 60	
Parasio	15.19 d	20.57 c	27.51 a	26.10 a b	22.34 a
Danar	19.13 c	22.85 b c	29.36 a	25.66 a b	24.25 a
Average effect of spray treatments	17.16 c	21.71 b	28.43 a	25.88 a	

* The averages that share the same alphabetic letters for each factor and each interaction do not differ significantly among themselves according to Duncan's polynomial test at the 0.05 probability level.

the interaction between hybrids and spraying treatments, it was found that the Parasio hybrid and spraying with water only were significantly excelled in giving the lowest nitrate content in the main curd 15.19 mg. 100gm⁻¹, While treatments of the two hybrids Parasio and Danar with boron spray gave the highest nitrate content in the main curd 27.51 and 29.36 mg. 100gm⁻¹. The results in Table (6) show the percentage of protein in the main curd. It is noted that there is no significant difference between the Parasio hybrid and the Danar hybrid in this trait and in the treatments of spraying with zinc sulfate and boron. The

highest values were 14.79 compared to the treatment of spraying with water only, which gave the lowest values, which amounted to 11.88%. In the interaction between hybrids and spraying, it is noted that the Parasio hybrid, spraying with boron, spraying with zinc + boron, hybrid Danar and spraying with zinc + boron gave the highest percentage of protein in the main curd 14.58, 15.46 and 14.12%, respectively, and it differed significantly only with the treatment of the hybrid Parasio and spraying with water only amounted to 10.70% .

Table (6): Effect of zinc and boron application and their interaction on the percentage of protein in the main curd.

hybrid	Average effect of spray treatments(mg.L ⁻¹)				average effect of hybrid
	water only (control))	Zinc (300)	Boron(60)	Zinc (300) + boron 60	
Parasio	10.70 b	13.31 a b	14.58 a	15.46 a	13.60 a
Danar	13.07 a b	12.88 a b	13.31 a b	14.12 a	13.35 a
Average effect of spray treatments	11.88 b	13.95 b	13.26 a b	14.79 a	

* The averages that share the same alphabetic letters for each factor and each overlap do not differ significantly among themselves according to Duncan's polynomial test at the 0.05 probability level.

From the results in Tables (3, 4, 5 and 6) in the effect of hybrids, there are no significant differences between crosses in the traits of the specific yield. Regarding the impact of spraying treatments, we notice from the results of tables (3,4 and 6) the features of the percentage of dry matter in curd, the content of vitamin C and the rate of protein, the treatment of spraying with zinc and boron and spraying with zinc + boron excelled on the treatment of spraying with water only. While spraying with water only gave the lowest content of nitrates in the main curd, this is due to the effectiveness of these elements and the extent of their impact on plant growth and the extent to which the plant needs to spray with these elements. The spraying with zinc and boron and mixing them (zinc + boron) significantly excelled due to the effectiveness of these elements and spraying them on the leaves, as boron facilitates the movement and transfer of photosynthetic products from the leaves to the active areas and that the foliar feeding prepares the plant with the elements

necessary for growth (Abu Dahi and Younis, 1988). The zinc element works on the transfer of active substances in the plant, such as the transfer of sugars. It is necessary for cell division (Travena, 2007). It also enters into the formation of the amino acid tryptophan responsible for the elongation of cells (Hassan et al., 1990), the reason for the significantly excelled of the bi-treatments of some of the treatments to the cumulative effect of the single factors.

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