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The Effect of Spraying with Sugar Alcohols on the Vegetative Growth Traits and Yield of Two Hybrids of Broccoli (*Brassica oleracea var. Italica*)

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I. Abstract

A field experiment was conducted during the 2024-2025 growing season at the Agricultural Research Station of the College of Agriculture at the University of Basra. The aim was to study the effect of three concentrations of sugar alcohol (sorbitol) (0, 5, and 10) g/L on two hybrids of broccoli (Umbrella , Jasmine) .A completely randomized block design was used for a factorial experiment with three replicates. Average results were analyzed using the statistical program tdec-2008-31 GenStat, and the modified least significant difference test was used to compare averages at a probability level of 0.05. The most important results are summarized as follows:

The results showed that the vegetative growth indicators and the yield of the hybrids showed a significant effect, as the hybrid Umbralla recorded a significant superiority. In terms of plant height and leaf number, the results showed that the hybrid Umbralla was significantly superior in terms of main disc weight, main disc diameter, and number of secondary discs, which reached 1129 g/plant-1, 25.32 cm, and 6.20 discs/plant-1, respectively. Sorbitol had a significant effect on vegetative growth and yield, with the 10 g/L treatment being superior in terms of plant height, leaf number, and main disc weight The diameter of the main inflorescence and the number of secondary inflorescences were measured, with average values estimated at 57.54 cm, 34.48 leaves/plant-1, 1142 g/g plant-1, 25.73 cm, and 6.63 inflorescences/plant-1, respectively. The interaction between sorbitol at a concentration of 10 g L-1 and the hybrid 'Umbralla' was significantly higher in plant height, leaf number, main inflorescence weight, main inflorescence diameter, and number of secondary inflorescences.

Keywords: broccoli, sorbitol, Sugar Alcohols.

II. INTRODUCTION

Broccoli (Brassica oleracea var. Italica) belongs to the Brassicaceae family and is known for its good nutritional value, as it is low in sodium, free fat, and calories. It also contains many vitamins such as vitamins C and A, carotenes, vitamins B5 and B2, and some nutrients such as calcium, iron, and phosphorus. Broccoli is characterized by containing antioxidants that prevent the risk of cancer because it contains glucoraphanin Which enhances the body's immunity against stomach cancer and the compound Indol-3-carbinol which prevents colon cancer and enhances liver function [1]. The area

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planted with broccoli in Iraq is 1,133 hectares with a production of 12,361 tons. Therefore, the production rate per hectare is 10.9 tons ha-1 compared to the cultivated area worldwide, which amounted to 1,357,186 hectares with a production rate of 25,531,274 tons, which means that the production rate per hectare is 18.8 tons ha-1 [2].

Sugar alcohols (carbohydrates) are among the most important products of photosynthesis and are called alcohols because of their chemical composition. They move easily inside the plant. Alcohols are formed when the aldehyde group (CHO) is reduced to CH2OH. An example of sugar alcohols is sorbitol (C6H14O6), which facilitates the transport of boron and other trace elements inside the phloem tubes, which improves the growth, flowering, fruit Sorbitol is produced in the leaves during photosynthesis. It is a sugar alcohol associated with carbohydrates and can be transported in many plants, as it contributes to the metabolism of essential carbohydrates [3].

Objectives of the study:

1. To compare two broccoli hybrids in their response to the other studied factors.
2. To evaluate the effectiveness of sugar alcohols on some vegetative traits and yield in broccoli.
3- Demonstrating the effect of the interaction between the studied factors on improving the growth and yield of broccoli plants.

II. MATERIALS AND METHODS

Site for Implementation and Preparation of the Experiment:

The field experiment was conducted at the Research Station of the College of Agriculture, University of Basra, for the 2024-2025 agricultural season. The experiment was conducted to demonstrate the effect of foliar spraying of sugar alcohols (sorbitol) and their interaction on some vegetative components and yield of two broccoli hybrids. The experiment was implemented according to a completely randomized block design (RCBD) With three replicates, the average results were statistically analyzed using the statistical program tdec- 2008-31 GenStat. The modified least significant difference test (R.L.S.D.) was used to compare the averages at a probability level of 0.05 [4]. The experiment included eight factorial treatments representing the spraying of three concentrations of sugar alcohol (sorbitol) (0 g/L, 5 g/L, 10 g/L) on two broccoli hybrids (Umbrella, Jasmine) with three sprays. The first spray was applied one month after the seedlings were planted in the field soil, and the interval between sprays was 15 days.

The seedlings were planted at the age of one month after the field soil was plowed twice perpendicularly, then it was smoothed and leveled and divided into three sectors with a depth of 30 cm and the soil was smoothed using disc harrows and leveled and then a soil sample was taken for analysis before planting for the purpose of indicating the physical and chemical properties of the research soil, Table (1).

. Table (1) Some physical and chemical characteristics of the soil in which plants are grown

Value	Unit of measurement	.Adjective
7.6	------	Ph
6.55	Ds .m$^{1=}$	EC
Sandy Mxture	Silty loam	Tissue
65.24	Mg L^{1-}	.Sandy
16.41	Mg L^{1-}	Green

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18.45	Mg L^{1-}	Clay
2.90	Mg L^{1-}	N
3.45	Mg L^{1-}	P
4.81	Mg L^{1-}	K

2-1 Experimental Measurements:

Five plants were randomly selected from each experimental unit, and the average was calculated for each treatment and then for each replicate. The vegetative and yield measurements included the following:

2.1.1 Plant Height (cm):

Plant height (at the end of the experiment) was measured at the flower disc maturity stage using a tape measure from the point of contact of the stem to the soil (crown area) to the highest leaf height of the plants selected for the experimental units. The height was then calculated based on the individual plants.

2.1.2 Total number of leaves per plant (leaf per plant^{-1}):

Depending on the number of leaves per plant selected from the experimental units at the flower disc maturity stage.

2.1.3 Main disc weight (gm per plant^{-1}):

Main flowering disc weight was calculated by taking the weight of the mature main flower discs of five plants from each experimental unit and then averaging them.

2.1.4 Main flowering disc diameter (cm):

Measure the diameter of the mature main flower discs by measuring the disc circumference using a tape measure for the widest area of the disc surface for five discs. Then calculate the diameter using the following equation: Diameter (cm) = Circumference / 3.14.

2.1.5 Number of secondary flowering discs (plant disc $^{-1}$):

Calculate the number of secondary flower discs on the main stem of the plants in the experimental unit and take the average.

III. RESULTS

1- Plant Height (cm):

It is noted from Table (2) that the sorbitol spraying treatment showed a significant effect among treatments. The 10g/L treatment recorded the highest average of 57.54 cm, while the control treatment recorded the lowest average of 51.34 cm.

It is also noted that the hybrid had a significant effect, as the Umbralla hybrid outperformed the Jassamin hybrid, which produced the highest value of 55.51 cm, over the Jassamin hybrid, which produced the lowest value of 53.28 cm.

As for the interaction between the study factors, significant differences were found between them. The treatment with 10 g/L spray on the Umbralla hybrid recorded the highest value, reaching 59.58 cm, while the treatment without spraying on the Jassamin hybrid recorded the lowest value, reaching 50.83 cm.

Table (2) Effect of spraying with sorbitol on two broccoli hybrids and the interaction between them in plant height (cm)

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Hybrid	Sorbitol spray concentrations			Hybrid rate
	0	5g	10 g	
Umbrella	51.84	55.10	59.58	55.51
Jassamine	50.83	53.51	55.51	53.28
Spray rate with Sorbitol	51.34	54.31	57.54	
LSD 0.05				
	1.963	2.404	3.400	

2 - Total number of leaves per plant (leaf per plant^{-1}):

It is noted from Table (3) that the sorbitol spraying treatment showed a significant effect among treatments. The 10 g/L treatment recorded the highest average of 34.48 leaves per plant^{-1}, while the control treatment recorded the lowest average of 26.82 leaves per plant^{-1}.

It is also noted that the hybrid had a significant effect, as the Umbralla hybrid outperformed the Jassamin hybrid, which produced the highest value of 33.59 leaves per plant^{-1}, over the Jassamin hybrid, which produced the lowest value of 27.04 leaves per plant^{-1}.

As for the interaction between the study factors, significant differences were found between them. The treatment of spraying 10 g/L on the Umbralla hybrid recorded the highest value, reaching 38.82 leaves per plant^{-1}, while the treatment without spraying on the Jassamin hybrid recorded the lowest value, reaching 24.48 leaves per plant^{-1}.

Table (3) Effect of spraying with sorbitol on two broccoli hybrids and the interaction between them in the number of leaves (leaf per plant^{-1})

Hybrid	Sorbitol spray concentrations			Hybrid rate
	0	5g	10 g	
Umbrella	29.15	32.82	38.82	33.59
Jassamine	24.48	26.48	30.15	27.04
Spray rate with Sorbitol	26.82	29.65	34.48	
LSD 0.05				
	1.892	2.317	3.277	

3- Main flowering disc weight (g/plant^{-1}):

It is noted from Table (4) that the sorbitol spraying treatment showed a significant effect among treatments, as the 10 g/L treatment recorded the highest average of 1142 g/plant^{-1}, while the control treatment recorded the lowest average of 801 g/plant^{-1}.

It is also noted that the hybrid had a significant effect, as the Umbralla hybrid outperformed the Jassamin hybrid, which produced the highest value of 1129 g/plant^{-1}, over the Jassamin hybrid, which produced the lowest value of 836 g/plant^{-1}.

As for the interaction between the study factors, significant differences were found between them. The treatment of spraying 10 g/L on the Umbralla hybrid recorded the highest value, reaching 1330 g/plant^{-}

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[1], while the treatment without spraying on the Jassamin hybrid recorded the lowest value, reaching 717 g/plant^{-1}.

Table (4) Effect of spraying with sorbitol on two broccoli hybrids and the interaction between them in the weight of the main disc (g/plant^{-1})

Hybrid	Sorbitol spray concentrations			Hybrid rate
	0	5g	10 g	
Umbrella	886.	1171.	1330.	1129.
Jassamine	717.	838.	954.	836
Spray rate with Sorbitol	801.	1005.	1142.	
LSD 0.05				
	82.6	101.2	143.1	

4- Main flowering disc diameter (cm):

It is noted from Table (5) that the sorbitol spraying treatment showed a significant effect among treatments. The 10g/L treatment recorded the highest average of 25.73 cm, while the control treatment recorded the lowest average of 19.95 cm.

It is also noted that the hybrid had a significant effect, as the Umbralla hybrid outperformed the Jassamin hybrid, which produced the highest value of 25.32 cm, over the Jassamin hybrid, which produced the lowest value of 20.65 cm.

As for the interaction between the study factors, significant differences were found between them. The treatment with 10 g/L spray on the Umbralla hybrid recorded the highest value, reaching 27.76 cm, while the treatment without spraying on the Jassamin hybrid recorded the lowest value, reaching 17.18 cm.

Table (5) Effect of spraying with sorbitol on two broccoli hybrids and the interaction between them in the main disc diameter (cm)

Hybrid	Sorbitol spray concentrations			Hybrid rate
	0	5g	10 g	
Umbrella	22.72	25.49	27.76	25.32
Jassamine	17.18	21.07	23.70	20.65
Spray rate with Sorbitol	19.95	23.28	25.73	
LSD 0.05				
1.208		1.480		2.093

5-Number of secondary flowering discs (disc plant^{-1}):

It is noted from Table (6) that the sorbitol spraying treatment showed a significant effect among treatments. The 10 g/L mg treatment recorded the highest average of 6.63 discs plant^{-1}, while the control treatment recorded the lowest average of 4.74 discs plant^{-1}.

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It is also noted that the hybrid had a significant effect, as the Umbralla hybrid outperformed the Jassamin hybrid, which produced the highest value of 6.20 discs plant^{-1}, compared to the Jassamin hybrid, which produced the lowest value of 5.08 discs plant^{-1}.

As for the interaction between the study factors, significant differences were found between them. The treatment with 10 g/L spray on the Umbralla hybrid recorded the highest value, reaching 7.58 discs per plant^{-1}, while the treatment without spraying on the Jassamin hybrid recorded the lowest value, reaching 4.34 discs per plant^{-1}.

Table (6) Effect of spraying with sorbitol on two broccoli hybrids and the interaction between them in the number of lateral discs (disc per plant^{-1})

Hybrid	Sorbitol spray concentrations			Hybrid rate
	0	5g	10 g	
Umbrella	5.14	5.88	7.58	6.20
Jassamine	4.34	5.21	5.68	5.08
Spray rate with Sorbitol	4.74	5.54	6.63	
LSD 0.05				
	0.494	0.605	0.856	

From the above, the results of the vegetative growth and yield indicators in the tables indicate that hybrids have a significant effect on the vegetative growth and yield indicators. This is due to the presence of differences in genetic compositions. Also, the interaction of genetic factors with the surrounding environment will affect the performance of hybrids, as quantitative traits are controlled by a large number of genes and their effect is of the secondary type, which makes them greatly affected by the environment. This creates a second effect, which is the interaction between the environment and genetics, in addition to the presence of dormant genes whose effect can appear in a specific environment called the gene environment. The compatibility of environmental conditions with the requirements of hybrid growth is due to the efficiency of the photosynthesis process and the accumulation of manufactured nutrients, which positively affect the increase in the strength of vegetative growth and yield [5]. This is consistent with the findings of [6], who concluded that hybrid variations influence the vegetative growth characteristics of broccoli.

As for sorbitol, this increase may be attributed to the role of sorbitol, which can accumulate in plant tissues due to its small size, which helps it penetrate the leaves through the stomata, thus improving the plant's absorption of water and nutrients for use in increasing vegetative growth [7]. It is known that sorbitol returns to carbohydrates, so it will lead to an increase in the primary metabolic products of carbohydrates, which have an influential role in the vital processes of the plant, respiration, energy release, and ATP production, which participate in plant growth by increasing cell division and elongation. These results are consistent with what [8] , reached When spraying pepper plants with sugar alcohols (sorbitol and mannitol) in combination with boric acid, a significant increase was observed in most vegetative traits.

Conclusions

1- The results showed that the hybrid Umbrella significantly outperformed most indicators.

2- The results showed that spraying broccoli plants with sugar alcohols at a concentration of 10 g/L significantly outperformed most indicators.

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3- The two-way interactions between the hybrids and sugar alcohols showed a significant superiority in most indicators.

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