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## **Effect of cultivar, fulvic acid and the interaction between their on some physical and chemical properties and yield of broccoli (*Brassica oleracea* var. *Italica*)**

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**Abstract**--The field experiment was conducted during the fall agricultural season 2021-2022 in the Department of Horticulture and Gardens, Al-Kut municipality; the experiment was completed on 15 February, 2022, to study the effect of the cultivar, fulvic acid, and their interaction on some broccoli's physical and chemical properties. The study included two factors: cultivars, MATSURI, DOMO, JASSMINE, and the second factor has four concentrations of fulvic acid, which are: (0, 1, 2, 3) ml l<sup>-1</sup>. The experiment included twelve treatments and three replications, so the total experimental units became (36). A factorial experiment was applied with a split-block system within the Randomized Complete Block Design (R.C.B.D), and the results were statistically analyzed using the statistical program (GenStat). The results were compared using the LSD test at a probability level of 0.05. The superiority of the hybrid MATSURI in total soluble solids (TSS) in the pink discs was (23.64 %). At the same time, the JASSMINE cultivar was superior in total yield of the experimental unit and the percentage of chlorophyll in the leaves at values were (25.01 kg plant<sup>-1</sup>, Spad 84.33), respectively. The plants treated with a concentration of ( 3 ) ml l<sup>-1</sup> of fulvic acid excelled in the total yield of the experimental unit, the percentages of chlorophyll in the leaves, vitamin C in the pink discs, dry matter in the pink discs, nitrogen in the pink discs, phosphorous in the pink discs, potassium in the pink discs, sulfate in the pink discs, protein in the pink discs, and the percentage of total dissolved solids ( TSS ) in the pink discs where the values were ( 29.53 kg plant<sup>-1</sup>, 82.56 Spad, 93.82 %, 24.07

%, 14.66%) respectively. The dual interaction between the cultivar and the concentrations of fulvic acid had a significant effect. The interaction treatment between the cultivar MATSURI and the concentration of fulvic acid (3) ml l<sup>-1</sup> was superior to the percentage of vitamin C in the pink discs at (97.86 %). While the cultivar JASSMINE with the concentration of fulvic acid (3) ml l<sup>-1</sup> was superior in total yield of the experimental unit, by values reaching (32.83) kg plant<sup>-1</sup>.

**Keywords**---fulvic acid, *Brassica oleracea* var, broccoli.

## Introduction

The cruciferous family Brassicaceae includes many important vegetables, one of them is Broccoli; the scientific name is *Brassica oleraceae* var. Italica is grown for its inflorescences, which are eaten while flowering buds with their thick, juicy stalks (Hassan, 2004). The broccoli plant is characterized by high nutritional value, as it contains many nutrients, vitamins, proteins, fats, and carbohydrates, except for the high content of glucosides with anti-cancer properties (Hanson, 2000). And that eating broccoli tablets more than once a week can reduce the risk of prostate cancer by 45% (Gad and Abd-moez, 2011).

The use of humic acids (fulvic, humic, and human) is an organic material with a complex composition that results from the decomposition of plant and animal materials in the process of humic formation, and the elongation of cells in the plant, the increase in enzymatic reactions and the stimulation of vitamins inside the plant, as well as the increase in the permeability of cell membranes (Pettit, 2003). One of the most important fulvic acid components is the aromatic and aliphatic compounds consisting of carbohydrates and amino acids. It is characterized by its low partial weight, ranging from 1000 to 10,000 daltons (Al-Shater and Al-Balkhi, 2010). Due to the lack of previous studies on broccoli and fulvic acid in general.

The research aimed to:

- It knows the best cultivar of the three cultivars under the study of broccoli.
- It knows the best level of fulvic acid concentrations added to the three broccoli cultivars to achieve the highest economic return from the product.
- Determine the best interaction between the cultivars and the concentrations of fulvic acid used to which the broccoli plant responds, which achieves the highest and best yield.

## Materials and Methods

The experiment was conducted in the nursery of the Department of Horticulture and Gardens, Directorate of Al-Kut Municipality, during the agricultural season 2022-2021 to study the effect of the cultivar, fulvic acid, the interaction between them on some physical and chemical characteristics, and yield of broccoli. Where the field was irrigated after the process of preparing the land and adding 40 kg of Dab-fertilizer to the soil before dividing it into three plots, each one containing three lines, by a line for each experimental unit, and the area of each

experimental unit is 7.5 meters, leaving a separation distance between the experimental units. Samples of field soil were taken from different regions in the shape of the letter Z before planting at the time of soil preparation, at different depths and a depth of (10, 20, 40) cm, then dried pneumatically, crushed, and passed through a sieve with holes 2 mm in diameter and kept in plastic containers to conduct the required analyzes.

Table (1)  
Some physical and chemical properties of the experimental field soil before planting

Adjective	value	measuring unit
PH	7.4	-
EC(1:1)	3.35	Desi Siemens. M <sup>-1</sup>
CalciumCa <sup>+2</sup>	12.17	mmol l <sup>-1</sup>
Organic matter	81	mg kg <sup>-1</sup>
mud	164	
silt	386	
the sand	450	

### **Study factors**

The experiment included two factors, the main factor, three cultivars of broccoli, and the secondary factor, spraying fulvic acid, four concentrations:

#### **The main factor three plant cultivars broccoli**

- Cultivar JASSMINE F1 has the symbol J.
- Cultivar Master MATSURI F1 and denotes it B
- Cultivar DOMO F1 is symbolized by D.

#### **Secondary factor four concentration of fulvic acid**

- Spray with distilled water only and has the symbol V0
- Fulvic acid is sprinkled with a concentration of 1 g l<sup>-1</sup> and symbolized by V1
- Fulvic acid is sprayed at a concentration of 2 g l<sup>-1</sup> and symbolized by V2
- Fulvic acid is sprayed at a concentration of 3 grams per liter and symbolized by V3

### **Experimental design**

The Experiment was carried out in a split-plot using (RCBD) Randomized Complete Block Design; the experiment included using two factors, the first factor for cultivars of broccoli and three hybrids of broccoli were used: JASSMINE F1, DOMO F1, and MATSURI F1. The second factor was fulvic acid, and four concentrations of fulvic acid were used with a concentration of (0, 1, 2, 3 gm l<sup>-1</sup>). Hybrids or cultivars were placed in the main plot, while the coefficients or concentration of fulvic acid were placed in the sub-plot, with three replicates, at 36 experimental units. The results were statistically analyzed using the GenStat program. The differences were compared between the arithmetic means of the results obtained from the Least Significant Differences Test (LSD) and under the 5% probability level (Al-Rawi and Khalaf, 2000).

### **Studied characteristic**

#### **1 – Leaves content of chlorophyll (Spad):**

OPTI-SCIENCES CCM estimated the chlorophyll content in broccoli leaves - 200 PLUS device supplied by the Japanese company Minolta by taking the reading for 6 leaves of plants for each experimental unit and then taking the average for them. It was measured in SPAD UNIT based on (Jemison and Williams, 2006).

#### **2- Vitamin C in pink tablets:**

The content of vitamin ( C ) in fruits is estimated by taking the weight of 20 g of the middle parts of the fruits (selected for measuring SST and percentage of dry matter), then cutting this weight into tiny pieces and adding to it (40 ml) of a mixture of metaphosphoric acid and acetic acid. It is mixed in an electric mixer for 5 minutes. The juice is filtered, 10 ml is taken from it, and crushed using Diachlorophenol - 2.6 indophenol dye as described in AOAC (1980), and the final readings are recorded in units of mg/ 100 gm of fresh weight.

#### **3 - Percentage of protein (%):**

The percentage of protein in the pink tablets was calculated based on the dry weight at the time of harvest, as the percentage of total nitrogen previously estimated in the tablets  $\times 6.25$ .

#### **4- Percentage of total dissolved solids (TSS) in pink discs:**

The percentage of total soluble solids was estimated after preparing the juice by squeezing the pink tablets by a fruit juice machine, then filtering it and putting (1:1) a drop on the bottle of the Invert Sugar Refractometer, recording the reading and whistling the device before each reading with distilled water.

#### **5- The total yield of the experimental unit of pink tablets (kg plant<sup>-1</sup>):**

It was calculated after harvest by calculating the total yield of the experimental unit according to the equation:

**The total yield of experimental unit = yield of experimental unit/area of the experimental unit**

## **Results and Discussion**

### **Effect of cultivar, fulvic acid concentrations and their interactions on some characteristics of flowering broccoli discs.**

#### **1- Percentage of chlorophyll in leaves (Spad)**

The results of Table (2) indicate significant differences between the studied cultivars in the content of chlorophyll in leaves. The cultivar JASSMINE scored a value of 84.33 Spad from the percentage of chlorophyll in the leaves, as well as the cultivar MATSURI gave a value of 75.83 Spad from the percentage of chlorophyll in the leaves. The cultivar DOMO gave the lowest value, and it reached 70.75 Spad from the percentage of chlorophyll in the leaves.

Also, the results of the statistical analysis of the same table indicated that the concentrations of fulvic acid used over than comparison treatment (0) in the same trait, as the plants that used the concentration of fulvic acid (3) recorded the highest relative chlorophyll content in the leaves, which amounted to Spad 82.56, while the comparison treatment recorded (0). The lowest value was Spad 72.11. The two concentration treatments of fulvic acid (1 and 2) differed in their

chlorophyll content in the leaves and gave (75.11 and 78.11) Spad, respectively. The interactions between the cultivars and the concentration of fulvic acid were not significant in the chlorophyll content in the leaves.

Table (2)  
Effect of cultivar, the concentration of fulvic acid and their interactions on the percentage of chlorophyll in the leaves (Spad) for broccoli

Cultivar	Fulvic acid gm l <sup>-1</sup>				Average cultivar
	0	1	2	3	
MATSURI	72.33	74.67	76.00	80.33	75.83
DOMO	66.00	69.00	72.00	76.00	70.75
JASSMINE	78.00	81.67	86.33	91.33	84.33
<b>Average fulvic acid</b>	72.11	75.11	78.11	82.56	
LSD <sub>≤ 0.05</sub>	Cultivar		Fulvic	Cultivar* Fulvic	
	1.83		1.38	2.48	

### **2- Vitamin C in pink tablets (mg 100 g):**

Table (3) shows there are significant differences between the studied cultivars in the content of vitamin C in the pink tablets, as cultivar MATSURI achieved the highest value, amounting to (93.67) mg 100 g, which significantly outperformed cultivar JASSMINE, which gave the content of Vitamin C in pink tablets amounted to (92.12) mg 100 g, and cultivar DOMO recorded the lowest value of vitamin C content in the pink tablets was (86.69) mg 100 g.

The results of the statistical analysis of the same table indicated the superiority of the treatments of the types of fulvic acid concentrations ( 3 ) used over the comparison treatment in the same trait, as the plants used by the concentration of fulvic acid ( 3 ) recorded the highest vitamin C content in the pink tablets amounted to ( 93.82 mg 100 g). In contrast, the comparison treatment recorded the lowest value of 86.68 mg 100 g, while the concentration treatments ( 1 and 2 ) differed among themselves in their vitamin C content in the pink tablets and gave ( 89.29 and 93.54 ) mg 100 g, respectively.

The coefficients of dual interaction between cultivars and the fulvic acid concentration significantly affected the value of the vitamin C content in the pink tablets. The plants of MATSURI cultivar that were sprayed with the concentration of fulvic acid (3) had the highest value of vitamin C content in the pink tablets, which amounted to (93.53) mg 100 g, while this value decreased in the plants of the cultivar DOMO untreated in any concentration of fulvic acid and reached (82.36). mg 100 g vitamin C in pink tablets (Table 3).

Table (3)  
Effect of cultivar, the concentration of fulvic acid and their interactions on vitamin C content in broccoli tablets (mg100g)

Cultivar	Fulvic acid gm l <sup>-1</sup>				Average cultivar
	0	1	2	3	
MATSURI	89.51	92.11	95.21	97.86	93.67
DOMO	82.36	85.46	88.88	90.06	86.69
JASSMINE	88.16	90.29	96.52	93.53	92.12
<b>Average fulvic acid</b>	86.68	89.29	93.54	93.82	
LSD <sub>≤ 0.05</sub>	Cultivar		Fulvic	Cultivar* Fulvic	
	0.25		0.21	0.36	

### 3- Percentage of protein in pink discs (%):

The results of Table (4) indicate significant differences between the cultivars under study in their protein content in the pink discs. MATSURI cultivar recorded a value of (23.56 %) of the protein in the pink discs, and JASSMINE cultivar gave a value of (21.75) % of the protein in the pink discs. Then the DOMO cultivar gave the lowest value and reached (20.75) %.

The results showed that the concentration (3) of fulvic acid was superior to the comparison treatment, where the treatment of spraying fulvic acid at a concentration (2) recorded the highest values and amounted to (25 %), while the comparison treatment (0) gave the lowest value of protein in its pink tablets (19.69) %. The results of Table (4) indicate no significant differences between the interaction between the cultivar and fulvic acid in the percentage of protein in the pink discs.

Table (4)  
Effect of cultivar, the concentration of fulvic acid and their interactions on the percentage of protein in the pink discs (%) of broccoli

Cultivar	Fulvic acid gm l <sup>-1</sup>				Average cultivar
	0	1	2	3	
MATSURI	20.56	22.81	24.19	26.69	23.56
DOMO	19.69	20.31	21.06	21.94	20.75
JASSMINE	20.25	22.19	25	23.56	21.75
<b>Average fulvic acid</b>	20.17	21.77	23.42	24.06	
LSD <sub>≤ 0.05</sub>	Cultivar		Fulvic	Cultivar* Fulvic	
	2.03		1.63	2.87	

**4 - The total dissolved solid substance (TSS) percentage in the pink discs (%).**

The results of table (5) indicate there was a significant effect between the cultivars on the percentage of total dissolved solids (TSS) in the flowering tablets, as the MATSURI cultivar plants outperformed them by giving them the percentage of total dissolved solids (TSS) in the flowering tablets amounted to (14.68 %). While the percentage of total dissolved solids (TSS) in the flowering discs of plants of the two cultivars DOMO and JASSMINE and STRAIGHT (14.29 and 14.64) %.

The results of Table (5) indicate a significant effect of the concentration of fulvic acid (3) on the average percentage of total dissolved solids (TSS) in the pink discs compared to the comparison treatment. It was followed by plants that concentrated fulvic acid (1 and 2), as they each gave (14.57 and 14.63) %, respectively. In contrast, plants without adding fulvic acid concentration gave the lowest total dissolved solids ( TSS ) percentage in the pink tablets, which amounted to ( 14.29 )%. The results of Table (5) showed no significant differences between the interactions of the variety with fulvic acid.

Table (5)  
Effect of cultivar, the concentration of fulvic acid and their interactions on the percentage of total dissolved solids (TSS) in pink discs (%) in broccoli

Cultivar	Fulvic acid gm l <sup>-1</sup>				Average cultivar
	0	1	2	3	
MATSURI	14.50	14.64	14.74	14.83	14.68
DOMO	14.02	14.46	14.24	14.45	14.29
JASSMINE	14.34	14.60	14.91	14.71	14.64
<b>Average fulvic acid</b>	14.29	14.57	14.63	14.66	
LSD <sub>≤ 0.05</sub>	Cultivar		Fulvic	Cultivar* Fulvic	
	0.19		0.16	0.28	

**5 - Total yield of the experimental unit (kg plant<sup>-1</sup>):**

The results of the table (6) indicate that there was a significant effect between the cultivars on the total yield of the experimental unit, as the JASSMINE cultivar outperformed it by giving it the highest yield per plant, which amounted to (25.01) kg plant<sup>-1</sup>, while the yield of one plant in DOMO and MATSURI cultivars was (22.12 and 20.24) kg plant<sup>-1</sup>, respectively.

There is a significant effect of fulvic acid at a concentration (3) on the average total yield of the experimental unit compared to the comparison treatment. Fulvic at a concentration ( 1 and 2 ), each of it gave ( 19.09 and 24.48 ) kg plant<sup>-1</sup>, respectively, while the plants without adding fulvic acid concentration gave the lowest total yield of the experimental unit, which amounted to ( 16.75 ) kg plant<sup>-1</sup>.

The results of table (6) showed the dual interaction between the cultivars and the concentration of fulvic acid, which significantly affected the total yield of the experimental unit. The plants of the cultivar JASSMINE that were sprayed with fulvic acid concentration ( 3 ) gave the highest total yield of the experimental unit, amounting to ( 32.83 ) kg of plant <sup>-1</sup>, while Plants of the cultivar DOMO not treated with fulvic acid gave the lowest total yield of the experimental unit was ( 16.15 ) kg of plant <sup>-1</sup>.

Table (6)  
Effect of cultivar, the concentration of fulvic acid and their interactions on total yield of the experimental unit (kg plant <sup>-1</sup>) of broccoli

Cultivar	Fulvic acid gm l <sup>-1</sup>				Average cultivar
	0	1	2	3	
MATSURI	16.30	18.20	21.63	24.85	20.24
DOMO	16.15	17.50	23.95	30.91	22.24
JASSMINE	17.79	21.57	27.86	32.83	25.01
<b>Average fulvic acid</b>	16.75	19.09	24.48	29.53	
LSD <sub>≤ 0.05</sub>	Cultivar		Fulvic	Cultivar* Fulvic	
	2.31		1.42	2.78	

The above noted the superiority of the broccoli cultivar JASSMINE over the studied cultivars in terms of the characteristics of chlorophyll content in the leaves (Table 2) and the total yield of the experimental unit (Table 6). As for the superiority of the MATSURI cultivar than the three cultivars in the characteristics of content and vitamin C (Table 3) and protein (Table 4), and TSS content (Table 5). The difference in cultivars may be due to some genetic and environmental traits that control each cultivar. For example, the experimental unit is the genetic factor that controls chlorophyll content in leaves, vitamin C, protein, TSS content, and the total yield, noting that some studies refer to the matter due to the different genetic and environmental traits (Branca et al., 2005). This result agrees with what was reached by Sharabi et al. (2014) on the broccoli plant.

The reason for the superiority of fulvic acid treatments at a concentration ( 3 ) in the studied traits is also attributed to the humic acids (fulvic, humic) in increasing vegetative growth, which is followed by an increase in the results of carbon metabolism and the collection of process products, which include carbohydrates and proteins in the stored plant parts, which is reflected positively during the content of chlorophyll, vitamin C, protein and TSS content in the pink discs and the total yield of the experimental unit ( Neeraja and Reddy, 2005 ). As for the role of humic acids in the studied traits, it is attributed to humic acids (fulvic, humic), as they contain most of the necessary elements needed in the formation and increase of the products of metabolic processes, which cause an increase in the activity of the root group and vegetative growth represented in increased cell division and elongation (Al-Azzawi, 2020). On the broccoli (Juneid, 2016; Marza et al., 2013) on the cauliflower (Mahmoud and Al-Zaidi, 2012) Cabbage.

About the effect of an interaction between humic acids, including (fulvic and humic) and cultivars that led to superiority in increasing vitamin C and the total yield of the experimental unit, it is what these fertilizers contain major and minor elements necessary for plant growth, which caused an increase in the varying proportions of vitamin C in the flowering tablets as a result of different concentrations fulvic acid is one of the nutrients, especially the nitrogen element, which is one of the most important nutrients necessary for plants after carbon, hydrogen, and oxygen. Any difference in the percentage of nitrogen leads to a difference in the percentage of dry matter in the pink tablets. Humic acids increase the rates of nitrogen liberated in the soil, which grows from the accumulation of nitrogen in the plant as nitrogen forms amino acids (Pang and Letey, 2000).

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