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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^{-1}. 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. While the JASSMINE cultivar was superior in the wet weight of the main disc, the dry weight of the main disc, the diameter of the main disc and the weight of the side disc if the values were (851.7 gm $tablet^{-1}$,93.42 gm $tablet^{-1}$,21.33 cm,147.25 gm $tablet^{-1}$),respectively, and the MATSURI hybrid was superior in The number of side tablets reached (5.00 $plant^{-1}$ tablets). The plants treated with a concentration of (3) ml L^{-1} of fulvic acid excelled in the content and wet weight of the main disc, dry weight of the main disc, the diameter of the main disc, the number of side discs, and the weight of the side disc Where the values were (856.3 gm $Tablet^{-1}$, 100.44 gm $Tablet^{-1}$, 21.33 cm, 147.56 gm $Tablet^{-1}$, 5.56 gm $Tablet^{-1}$) respectively. The dual interaction between the cultivar and fulvic acid concentrations had a significant effect, as the interaction treatment between the cultivar JASSMINE and the concentration of fulvic acid (3) ml L^{-1} in the wet weight of the main disc, the dry weight of the main disc and the weight of the side disc were (990.7 gm $disc^{-1}$, 124.00) gm $tablet^{-1}$, 182.33 gm $tablet^{-1}$)respectively.

Keywords: fulvic acid; *Brassica oleracea* var; broccoli

I. 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,

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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.

II. 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	ing uniturmeas
PH	7.4	-
EC(1:1)	3.35	Desi Siemens. M^{-1}
Ca^{+2} Calcium	12.17	mmol l^{-1}

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Organic matter	81	mg kg $^{-1}$
mud	164	
silt	386	
the sand	450	

3.1. 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 $^{-1}$ and symbolized by V1

• Fulvic acid is sprayed at a concentration of 2 g l $^{-1}$ and symbolized by V2

• Fulvic acid is sprayed at a concentration of 3 grams per liter and symbolized by V3

3.2. 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^{-1}). 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).

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3.3. Studied characteristic

1 - Average wet weight of the main flowering disc (g plant^{-1}):

It was calculated by cutting the mature main flowering discs from 6 plants from each experimental unit and then calculating their weights and their mean.

2- Average dry weight of the main flowering tablets (plant^{-1} gm):

It was calculated by taking the main discs whose wet weight was measured from 6 plants from each experimental unit. The discs were placed in paper bags and placed inside the electric oven at a temperature of 70 °C for 72 hours. After the stability of the weight, the reading was recorded as its average.

3- Average diameter of the main pink disc (cm):

It was calculated by measuring the metric tape by measuring the distance between the two furthest points on the flower disc surface from 6 plants from each experimental unit.

4 - Number of lateral pink discs (Plant^{-1} disc):

After harvesting the main flowering disks, the side disks were left to grow and enlarge in size until they reach the appropriate maturity stage. These disks were picked and counted from 6 plants in each experimental unit.

5- Average lateral head weight (gm plant^{-1}):

It was calculated by cutting the mature lateral flower heads from 6 plants from each experimental unit and then calculating their weights and their mean.

III. RESULTS AND DISCUSSION

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

1- Weight of the main pink disc (gm disc^{-1}).

The results of Table (2) indicate that there is a significant effect between the cultivars in the average weight of the flower disc, as the hybrid JASSMINE plants excelled by giving them the highest weight of the flower disc reached (851.7) gm disc^{-1}, while the average weight of the disc in the plants of the two cultivars DOMO and MATSURI, respectively (745.5) and 695.8) gm tablet^{-1}. The results of Table (2) indicate that there is a significant effect of spraying fulvic acid on the average weight of the pink disc compared to the comparison treatment. The plants sprayed with fulvic acid (3) excelled, and the weight of the main disc was (856.3) gm disc^{-1}, followed by the plants that were sprayed with fulvic acid (1 and 2).) as each of them gave the weights (722.9 and 783.8) gm tablet^{-1}, respectively, while the plants without fulvic acid gave them the lowest weight of pink tablet, which was (694.3) gm tablet^{-1}. The results of Table (2) showed the binary

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interaction between the cultivar and fulvic acid, which significantly affected the average weight of the flower disc, as the hybrid JASSMINE plants sprayed with fulvic acid (3) gave the highest weight of the flower disc reached (990.7) gm disc^{-1}, while the hybrid MATSURI plants gave not added. Fulvic acid has the lowest weight per tablet, which is (657.3) gm, tablet^{-1} .

Table (2) The effect of cultivar and fulvic acid concentrations and their interactions on the weight of the main flower disk (gm disc^{-1}) of broccoli

Cultivar	Fulvic acid gm l^{-1}				verageA Cultivar
	0	1	2	3	
MATSURI	657.3	669.3	705.7	751.0	695.8
DOMO	688.0	702.0	764.7	827.3	745.5
JASSMINE	737.7	797.3	881.0	990.7	851.7
verage fulvic acidA	694.3	722.9	783.8	856.3	
LSD≤ 0.05	Cultivar		Fulvic	Fulvic *Cultivar	
	47.05		25.15	52.93	

2- Dry weight of the main disc (gm disc^{-1}):

The results of Table (3) indicate that there is a significant effect between hybrids in the dry matter, as the plants of the cultivar JASSMINE excelled by giving it the highest dry weight of the main disc reached (93.42) gm disc^{-1}, while the dry weight of the main disc was in the plants of the two cultivars DOMO and MATSURI, respectively (80.75 and 72) .33) gram tablet^{-1}. The results of Table (3) indicate a significant effect that was sprayed with fulvic acid at concentration (3) on the dry weight of the main disc compared to the comparison treatment. The plants sprayed with fulvic acid concentration (3) excelled and reached (100.44) gm tablet^{-1}, followed by the plants sprayed With fulvic acid concentration (1 and 2), they each gave (73.67 and 86.22) gm tablet^{-1}, respectively, while plants without fulvic acid gave them the lowest dry weight of main tablet, which was (68.33) gm tablet^{-1}. The results of Table 3) showed the binary interaction between cultivars and fulvic acid, which significantly affected the dry weight of the main disc, as the hybrid JASSMINE plants sprayed with fulvic acid (3) gave the highest dry weight of the main disc (124.00) gm, while the hybrid plants gave MATSURI No fulvic acid was added to it. The lowest rim weight of the main tablet was (63.67) g. Tablet^{-1}.

Table (3) Effect of variety and concentrations of fulvic acid and their interactions on dry weight of the main tablet (gm tablet^{-1}) of broccoli

Cultivar	Fulvic acid gm l^{-1}	verageA Cultivar

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	0	1	2	3	
MATSURI	63.67	67.33	74.67	83.67	72.33
DOMO	69.33	72.00	88.00	93.67	80.75
JASSMINE	72.00	81.67	96.00	124.00	93.42
verage fulvic acidA	68.33	73.67	86.22	100.44	
LSD≤ 0.05	Cultivar		Fulvic	Fulvic *Cultivar	
	1.42		2.21	3.46	

3- Diameter of the main pink disc (cm).

From the results of Table (4), it is noticeable that there are significant differences between the studied cultivars in the diameter of the main flowering disc, as the hybrid JASSMINE plants achieved the highest value in the flower disc diameter of 22.50 cm, which significantly outperformed the hybrid DOMO plants that gave the stem diameter reached 18.42 cm and the hybrid MATSURI plants The lowest value of the stem diameter was 18.17 cm. In terms of the effect of the concentration of fulvic acid on this trait, it was noted that fulvic acid at concentration (3) had a significant effect on the characteristic of the diameter of the main pink disc. The concentrations of fulvic acid (1 and 2) from each other were recorded as the main pink disc and amounted to (19.22 and 20.00) cm, respectively, while the comparison treatment gave the lowest diameter of 18.22 cm. As for the interaction between cultivars and fulvic acid, the results of Table (4) indicated that there were no significant differences in the characteristic of the diameter of the main pink disc.

Table (4) Effect of the variety and concentrations of fulvic acid and their interactions on the diameter of the main flower disk (cm) of broccoli plant.

Cultivar	Fulvic acid gm l^{-1}				verageA Cultivar
	0	1	2	3	
MATSURI	17.00	17.67	18.33	19.67	18.17
DOMO	17.00	18.00	18.67	20.00	18.42
JASSMINE	20.67	22.00	23.00	24.33	22.50
verage fulvic acidA	18.22	19.22	20.00	21.33	
LSD≤ 0.05	Cultivar		Fulvic	Fulvic *Cultivar	
	0.88		0.41	0.95	

4- Number of lateral pink discs (Plant^{-1} disc)

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It was noted in Table (5) that there were significant differences between them, as the MATSURI cultivar was distinguished by its production of the highest rate of side tablets amounting to (5.00) plant disc^{-1}, while the remaining two cultivars JASSMINE and DOMO did not differ from each other and gave the following values, respectively (3.58 and 3.58, respectively).) tablet plant^{-1}. Also, the effect of fulvic acid had a significant effect in giving broccoli plants the highest rate of side tablets, and this was noticed when sprayed with fulvic acid concentration (3), as it outperformed the rest of the concentration by giving it the highest average of the side tablets reached (5.56) plant tablet^{-1}, and it gave the comparison treatment (without Addition of fulvic acid) the lowest rate of the side tablets was (2.67) plant^{-1} tablet. The same table shows that in the interaction between cultivars and fulvic acid, there were no significant differences in the rate of side tablets.

Table (5) Effect of cultivar and fulvic acid concentrations and their interactions on the number of lateral flowering discs (disc^{-1}) of broccoli:

Cultivar	Fulvic acid gm l^{-1}				verageA Cultivar
	0	1	2	3	
MATSURI	3.33	4.33	6.00	6.33	5.00
DOMO	2.33	2.67	4.33	5.67	3.75
JASSMINE	2.33	3.00	4.33	4.67	3.58
verage fulvic acidA	2.67	3.33	4.89	5.56	
LSD≤ 0.05	Cultivar		Fulvic	Fulvic *Cultivar	
	1.07		0.73	1.37	

5- Weight of the side flower tablets (g. plant^{-1}):

The results of Table (6) indicated that there were significant differences between the studied cultivars in the characteristics of the weight of the lateral flowering discs, where the cultivar JASSMINE was distinguished in giving it the highest weight of 147.25 g plant^{-1}, outperforming the two cultivars (DOMO and MATSURI), which did not differ from each other significantly and were given The values (119.75 and 83.83) gm plant^{-1}, respectively. In terms of the effect of fulvic acid on the average of the same trait, it was found that spraying broccoli plants with fulvic acid concentration (3) affected them, as this acid gave the highest average amount of 147.56 g plant^{-1}, outperforming all concentration treatments (1 and 2), which amounted to (102.56 and 125.33)gm plant^{-1}, respectively, as well as the treatment of plants without added fulvic acid, which gave the lowest average for the weight of the side tablets was (92.33)gm plant^{-1}, as shown in Table (5). As for the interaction between the studied variety and fulvic acid, it is noted that the plants of the cultivar JASSMINE that were sprayed with fulvic acid concentration (3) outperformed all the interactions by giving them the highest average weight of the side tablets reached (182.33) g plant^{-1}, while the plants of the variety MATSURI that were not sprayed with acid The value of the fulvic was recorded as (90.33) gm plant^{-1} , giving the lowest average for the weight of the side tablets.

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Table (6) Effect of cultivar and fulvic acid concentrations and their interactions on the weight of lateral flowering discs (g plant^{-1}) of broccoli.

Cultivar	Fulvic acid gm l^{-1}				verageA Cultivar
	0	1	2	3	
MATSURI	73.67	79.00	85.67	97.00	83.83
DOMO	90.33	95.00	130.33	163.33	119.75
JASSMINE	113.00	133.67	160.00	182.33	147.25
verage fulvic acidA	97.33	102.56	125.33	147.56	
LSD≤ 0.05	Cultivar		Fulvic	Fulvic *Cultivar	
	10.49		5.45	11.66	

We note in the tables (2,3,4,6) the superiority of the variety JASSMINE in the wet weight of the main disc, the diameter of the main floral disc, the dry weight of the main disc and the weight of the lateral disc, as the weight of the main floral discs reached (851.7 g plant^{-1}) and the diameter of the main floral disc (22.50 cm). The dry weight of the main disc was (93.42 gm plant^{-1}) and the wet weight of the side tablets (147.25 gm plant^{-1}) From the table we note the superiority of the MATSURI cultivar in significance among the cultivars in the number of side tablets (5.00 plant^{-1} tablets), The reason for the different varieties in the characteristics of the yield may be due to the genetic traits that control each variety. For example, the genetic factor that controls the weight of the pink disc (wet and dry), the diameter of the main disc and the weight of the lateral disc, we note that it is superior in the variety JASSMINE over the rest of the other varieties and therefore the varieties differ in this trait Or the reason may be due to the appropriate climatic conditions, noting that there are some studies that indicate the possibility of forming lateral discs with the presence of the middle disc, which is due to the genetic nature of the variety (Branca et al., 2005) and this result agrees with what was reached (Sharabi et al., 2014) on broccoli plant. The reason for the superiority of fulvic acid treatments with concentration (3) in the yield characteristics is due to the increase in the added amount of humic acid (fulvic, humic) because it contains nitrogen in a high percentage. In the results of the carbon metabolism and the gathering of the products of the process, which include carbohydrates and proteins in the stored plant parts, and then our positive impact is reflected on the increase in yield by increasing the weight of the wet main disk The main pink disc diameter, the pink disc dry weight, the number of lateral discs, and the lateral disc weight (Neeraja and Reddy, 2005). The reason for the increase in the total yield is due to the role of adding humic acids (humic, fulvic) to the soil and plants in the bio-building process and to its role in activating the photosynthesis process and the manufacture of carbohydrates for leaves, and then its final impact on the characteristics of the yield (Al-Zuhairi, 2016). As for the effect of an interaction between the cultivar and fulvic acid in increasing the quantitative characteristics of the yield in the wet weight of the main disc (Table 2), the dry weight of the main disc (Table 3) and the weight of the side disc (Table 6), the reason may be attributed to the fact that humic acids improve the physical and chemical properties of the plant and soil and help in increasing Absorption of some nutrients

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necessary for the plant and then an increase in production. As for the role of humic acids in increasing the weight of the wet disc and the diameter of the main disc, the weight of the rim of the main disc, the number of side discs and the weight of the disc The side effect may be attributed to humic acids (fulvic, humic), as they contain most of the necessary elements needed in the formation and increase of metabolic processes, which cause an increase in the activity of the root group and vegetative growth, represented by an increase in cell division and elongation (Al-Azzawi, 2020) on broccoli and (Juneid). (2016 and Marza et al., 2013) on cauliflower, (Mahmoud and al-Zaydi, 2012 and Rhahman, 2011) on al-Lahana.

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