

# Effect of Fulvic Acid and Seaweed on the Growth and Yield of Broccoli

Yasser H. Al-Eezzi<sup>1</sup>, Hassan H. Al-Alawy<sup>2</sup>

<sup>1,2</sup>Department of Soil Sciences and Water Resources, College of Agriculture, University of Diyala

Email: yhusen51@gmail.com

DOI: 10.47750/pnr.2022.13.501.71

## Abstract

A field experiment was conducted in the Mandali of Diyala governorate during the fall season 2021 to study the effect of fulvic acid by adding five levels (control, 150 kg ha<sup>-1</sup>, 300 kg ha<sup>-1</sup>, 2.5 g L<sup>-1</sup> and 5 g L<sup>-1</sup>) and seaweed by foliar application (control, 3 ml L<sup>-1</sup> and 6 ml L<sup>-1</sup>) in the growth and yield of broccoli and some soil characteristics. The experiment was carried out according to a randomized complete block design (RCBD) as a factorial experiment with three. The results showed that the levels of fulvic acid were superior in most of the studied traits compared to the control treatment and the interaction between fulvic acid and seaweed in all studied traits compared to the comparison treatment. The results showed the following, the superiority of the level of ground addition with fulvic acid at a concentration of, the level of spraying fulvic acid at a concentration of 2.5 g L<sup>-1</sup> (F3) exceeded the height of the plant, weight of the flower disk, total yield and total leaf area, with a value of 61.12 cm, plant-1, 765.4 g, 23.93 tons ha<sup>-1</sup> and 386.6 dm<sup>2</sup> respectively. As for spraying seaweed extract, the results showed that the concentration of 6 ml L<sup>-1</sup> (S2) exceeded flower disc weight, total yield with a value of 753.8 g, 23.55 tons ha<sup>-1</sup> respectively.

**Keywords:** fulvic acid, seaweed, broccoli.

## INTRODUCTION

Organic agriculture is an integrated system based on nature and this system depends on ecology and the interrelationships between living organisms and the environments in which they live soil (Tackie, 2011). The use of fulvic acid is beneficial because it is an organic substance with a complex structure that results from the decomposition of plant and animal materials and plays a key role in plant nutrition as well as has a positive effect on increasing enzyme activity, improving cell division and cell elongation within the plant tissues, and increase the permeability of cell membranes (Pettit, 2003). Seaweed is rich in natural components, especially plant hormones that activate and stimulate vital processes in the plant and contains many macro and micro nutrients (Jan et al., 2014). The broccoli plant is one of the most important crops within the cruciferous family, and this crop is grown in most countries of the world for its economic importance, as well as for its inflorescences that are eaten in the bud stage with their thick carriers and for its nutritional value as it contains a number of nutrients, vitamins, proteins and carbohydrates (Michaud et al., 2003) and the lack of studies related to using fulvic acid and seaweed, Mansour and El-Metwaly (2019) conducted a study on the effect of adding fulvic acid to the potato plant at two levels (0 and 10 kg ha<sup>-1</sup>), where the level of 2.5 kg ha<sup>-1</sup> significantly increased plant height (93.50 cm), number of leaves (29.08 leaves) and yield Total (36.65 tons ha<sup>-1</sup>) compared to the control which decreased to 75.16 cm, 25.16 leaves and 32.1 tons ha<sup>-1</sup> respectively, and Mahmood et al. (2021) confirmed in their study to show the effect of spraying marine algae extract (Alga Mix) on the growth and productivity of cauliflower, as the study included three levels (0, 5 and 10 ml L<sup>-1</sup>) and the results showed that the level of 10 ml L<sup>-1</sup> significantly exceeded the plant height (44.24 cm). The number of leaves (27.11 leaves) and the weight of the flower head (681.0 g) compared to the control which decreased to 38.21 cm, 18.22 leaves and 447.0 g, respectively, so the aim of this study was to:

- 1- Study of the effect of fulvic acid and seaweed on growth and yield characteristics of broccoli
- 2- Finding the optimum concentration of fulvic acid and seaweed to get the best product.

## Materials and methods

The study was carried out in one of the private fields in the Mandali, located 90 km east of Baquba, the center of Diyala governorate/ Iraq. The design of the complete random Block design was used and the program SAS (2001) was adopted in the

statistical analysis. The experiment included five levels of fulvic acid and three levels of seaweed with three replications. The number of experimental units is forty five experimental units. The distance between one plant and another is 0.4 m, and the distance between one line and another is 0.8 m. The Block consists of three lines. The area of the experimental unit was 3.84 m. Soil samples were taken from the field before planting at a depth of 0-30 cm and some characteristics were measured that shown in table. 1 and poultry manure was added to the soil a month before planting, drip irrigation system was used and agricultural service were conducted as stated in.

**Table 1.** Some physical and chemical properties of field soil before cultivation.

Traits	Values	Units
pH	7.4	
EC	1.85	dSm <sup>-1</sup>
Organic matter	10.1	g Kg <sup>-1</sup>
Availability nitrogen	25	mg kg <sup>-1</sup> soil
Availability phosphorous	25.4	mg kg <sup>-1</sup> soil
Availability potassium	147.4	mg kg <sup>-1</sup> soil
Soil Texture	Clay loam	
Sand	208	g Kg <sup>-1</sup>
Silt	400	g Kg <sup>-1</sup>
Clay	392	g Kg <sup>-1</sup>

The broccoli seeds were planted at 15-8-2021 in one of the private nurseries in the Khan Bani Saad. The seedlings were transferred to the field designated for cultivation. at 22-9-2021, fulvic acid and seaweed were sprayed in three times, and the duration between one spray and another was 15 days. While the ground levels of fulvic acid were added at beginning cultivation Studied traits

Total leaf area of leaves (dm<sup>2</sup> plant<sup>-1</sup>)

It was extracted by dry weight method (Dvornic, 1965) as follows:

1- 5 fully-grown leaves were taken at the fifth to eighth node from the top and in different directions from the plant.

2- A circular drill with a diameter of (2 cm) was made and cuts were made from each of the five sheets of paper assigned to the size mentioned above, so we have a known paper space.

3- The five papers and the discs of known size were placed in an electric oven at a temperature of 70 degrees Celsius until the weight was stable and the dry weight was measured.

4- The area of the paper was extracted according to the equation

Paper area = “whole leaf weight (g) x disk area (dm<sup>2</sup>)” / “cut disk weight (g)”

5- The total paper area of the papers was calculated from the following equation:

Total leaf area of leaves = average area of one leaf x average number of leaves of the plant.

Total yield (tons ha<sup>-1</sup>)

It is the sum of the pink discs and was calculated according to the following equation:

Total yield (ton ha<sup>-1</sup>) = weight of flowering disc (kg) x number of plants per ha / 1000.

Specific weight of flower disc (g cm<sup>-3</sup>)

It is the value obtained from the result of dividing the average weight of the pink disc in grams divided by its volume in cubic centimeters.

Disc specific weight (g cm<sup>-3</sup>) = Disc weight (g) / Disc volume (cm<sup>3</sup>)

## Results

### Growth characteristics

The results of table 2 showed that there were significant effects of fulvic acid levels on plant height, stem diameter, number of leaves and total leaf area of the plant. The F3 level surpassed the plant height by 61.12 cm and the total leaf area of the plant reached 386.6 dm<sup>2</sup> plant<sup>-1</sup>, the F4 level with the largest stem diameter amounted to 4.043 cm, and the F2 level in the

number of leaves reached 33.62 leaf plant<sup>-1</sup> compared to the control which decreased to 58.73 cm and 299.8 dm<sup>2</sup> plant<sup>-1</sup>, 3.887 cm and 32.38 leaf plant<sup>-1</sup>. The same table showed that there were no significant differences between spraying treatments with seaweed extract in the characteristics of the vegetative growth. The interaction between the levels of fulvic acid and spraying seaweed had a significant effect on the characteristics of the vegetative system, as the interaction F2S0 treatment excelled in the plant height reached 61.53 cm, and the F3S2 treatment excelled in the diameter of the stem reached 4.063 cm, and the F2S1 treatment was superior in the number of leaves It was 33.76 leaf plant<sup>-1</sup> and leaf area 426.1 dm<sup>2</sup> plant<sup>-1</sup> compared to the control, which decreased to 56.80 cm, 3.786 cm, 32.10 leaf plant<sup>-1</sup> and 234.8 dm<sup>2</sup> plant<sup>-1</sup>, respectively.

**Table 2.** Effect of fulvic acid and seaweed on vegetative growth characteristics

Treatments	Plant height (cm)	Stem diameter (cm)	Number of leaves per plant	Total leaf area (dm <sup>2</sup> )
<b>Fulvic acid</b>				
F <sub>0</sub>	58.73 C	3.887 B	32.38 B	299.8 B
F <sub>1</sub>	59.37 BC	3.995 AB	33.18 AB	351.9 AB
F <sub>2</sub>	60.76 AB	4.003 AB	33.62 A	385.8 A
F <sub>3</sub>	61.12 A	4.015 A	33.31 AB	386.6 A
F <sub>4</sub>	60.11 ABC	4.043 A	33.40 A	380.6 A
<b>Seaweed</b>				
S <sub>0</sub>	59.86 A	3.959 A	32.82 A	353.5 A
S <sub>1</sub>	59.89 A	3.974 A	33.44 A	378.5 A
S <sub>2</sub>	60.31 A	4.033 A	33.28 A	350.9 A
<b>Interaction F * S</b>				
F <sub>0</sub> S <sub>0</sub>	56.80 c	3.786 c	31.10 b	234.8 c
F <sub>1</sub> S <sub>0</sub>	59.60 ab	4.020 ab	32.80 a	405.1 ab
F <sub>2</sub> S <sub>0</sub>	61.63 a	3.983 abc	33.63 a	376.9 ab
F <sub>3</sub> S <sub>0</sub>	61.53 a	4.020 ab	33.73 a	404.3 ab
F <sub>4</sub> S <sub>0</sub>	59.73 a	3.986 abc	32.86 a	346.4 ab
F <sub>0</sub> S <sub>1</sub>	58.66 bc	3.826 bc	32.86 a	344.6 ab
F <sub>1</sub> S <sub>1</sub>	59.10 abc	3.966 abc	33.73 a	348.8 ab
F <sub>2</sub> S <sub>1</sub>	61.06 ab	4.016 ab	33.76 a	426.1 a
F <sub>3</sub> S <sub>1</sub>	60.96 ab	3.963 abc	33.20 a	398.7 ab
F <sub>4</sub> S <sub>1</sub>	59.66 ab	4.100 a	33.63 a	374.2 ab
F <sub>0</sub> S <sub>2</sub>	60.73 ab	4.050 ab	33.20 a	320.1 abc
F <sub>1</sub> S <sub>2</sub>	59.43 ab	4.000 abc	33.03 a	301.8 ac
F <sub>2</sub> S <sub>2</sub>	59.60 ab	4.010 ab	33.46 a	354.5 ab
F <sub>3</sub> S <sub>2</sub>	60.86 ab	4.063 a	33.00 a	356.8 ab
F <sub>4</sub> S <sub>2</sub>	60.93 ab	4.043 ab	33.70 a	421.2 a

\* note :- The symbols in the table indicate the following: F = levels of fulvic acid where F<sub>0</sub>= control (spraying with distilled water only), F<sub>1</sub> = ground addition 150 kg ha<sup>-1</sup>, F<sub>2</sub> = ground addition 300 kg ha<sup>-1</sup>, F<sub>3</sub> = foliar spray 2.5 g L<sup>-1</sup>, F<sub>4</sub> = foliar spray 5 g L<sup>-1</sup> and S = levels of foliar spray with seaweed, where S<sub>0</sub> = control (spray with distilled water only), S<sub>1</sub> = first level (3 ml L<sup>-1</sup>) and S<sub>2</sub> = second level (6 ml L<sup>-1</sup>).

The averages that share the same letters are not significantly different from each other according to Duncan's polynomial test at the 0.05 probability level.

#### Yield and yield components

The results of table 3 showed that there were significant effects of fulvic acid levels on flower disc weight, biological yield, total yield and specific weight of flower disc, the superiority of the F<sub>3</sub> level in the weight of the disc was 765.8 g and the total yield amounted to 23.93 ton ha<sup>-1</sup>, and the F<sub>2</sub> level in the biological yield reached 66.76 ton ha<sup>-1</sup> and the superiority of the F<sub>4</sub> level in the specific weight of the flower disc amounted to 1.032 g cm<sup>-3</sup> compared to the control which decreased to 666.9 g, 20.83 ton ha<sup>-1</sup>, 61.05 ton ha<sup>-1</sup>, and 1.004 g cm<sup>-3</sup>, respectively. The results of the same table showed that there were significant differences between the levels of spraying seaweed extract in the flower disc weight, biological yield and total yield, as level S<sub>2</sub> was superior to the highest average in the flower disc weight, biological yield and total yield 753.7 g, 69.35 ton ha<sup>-1</sup> and 23.55 ton ha<sup>-1</sup> respectively, compared to the control which decreased to 694.1 g, 60.81 ton ha<sup>-1</sup> and 21.68 ton ha<sup>-1</sup>, respectively. The interaction between the levels of fulvic acid and the spraying of seaweed had a significant effect on the yield characteristics, as the interaction F<sub>3</sub>S<sub>2</sub> treatment excelled in the weight of the flower disc 814.4 g and the total yield 25.45 ton ha<sup>-1</sup>, and the F<sub>2</sub>S<sub>2</sub> treatment was superior in the biological yield 74.46 ton ha<sup>-1</sup> and the interference F<sub>1</sub>S<sub>0</sub> treatment was

superior in the specific weight of the flower disc 1.046 g cm<sup>-3</sup> compared to the control which decreased to 587.2 g and 18.34 ton ha<sup>-1</sup>, 54.23 ton ha<sup>-1</sup> and 0.973 g cm<sup>-3</sup> respectively .

**Table 3.** Effect of fulvic acid and seaweed on yield and yield components

Treatments	Flower disc weight (g)	Biological yield (ton ha <sup>-1</sup> )	Total yield (ton ha <sup>-1</sup> )	Specific weight of flower disc (gcm <sup>-3</sup> )
<b>Fulvic acid</b>				
F <sub>0</sub>	666.9 C	61.05 B	20.83 C	1.004 B
F <sub>1</sub>	705.1 BC	63.44 AB	22.03 BC	1.024 AB
F <sub>2</sub>	743.6 AB	66.76 A	23.23 AB	1.010 AB
F <sub>3</sub>	765.8 A	66.47 A	23.93 A	1.011 AB
F <sub>4</sub>	727.5 AB	65.31 A	22.73 AB	1.032 A
<b>Seaweed</b>				
S <sub>0</sub>	694.1 B	60.81 B	21.68 B	1.013 A
S <sub>1</sub>	717.6 B	63.65 B	22.42 B	1.017 A
S <sub>2</sub>	753.7 A	69.35 A	23.55 A	1.018 A
<b>Interaction F * S</b>				
F <sub>0</sub> S <sub>0</sub>	587.2 d	54.23 d	18.34 d	0.973 b
F <sub>1</sub> S <sub>0</sub>	697.2 c	61.10 cd	21.78 c	1.046 a
F <sub>2</sub> S <sub>0</sub>	692.1 c	62.03 c	21.62 c	1.001 ab
F <sub>3</sub> S <sub>0</sub>	768.8 abc	64.22 bc	24.02 abc	1.013 ab
F <sub>4</sub> S <sub>0</sub>	725.4 bc	62.49 bc	22.67 bc	1.036 a
F <sub>0</sub> S <sub>1</sub>	694.9 c	61.21 cd	21.71 c	1.012 ab
F <sub>1</sub> S <sub>1</sub>	699.4 c	62.40 bc	21.85 c	1.021 a
F <sub>2</sub> S <sub>1</sub>	742.2 abc	63.79 bc	23.19 abc	1.017 ab
F <sub>3</sub> S <sub>1</sub>	714.3 bc	64.88 bc	22.32 bc	1.006 ab
F <sub>4</sub> S <sub>1</sub>	737.1 abc	65.99 bc	23.03 abc	1.032 a
F <sub>0</sub> S <sub>2</sub>	718.6 bc	67.70 abc	22.45 bc	1.028 a
F <sub>1</sub> S <sub>2</sub>	718.9 bc	66.83 abc	22.46 bc	1.006 ab
F <sub>2</sub> S <sub>2</sub>	796.6 ab	74.46 a	24.89 ab	1.013 ab
F <sub>3</sub> S <sub>2</sub>	814.4 a	70.32 ab	25.45 a	1.014 ab
F <sub>4</sub> S <sub>2</sub>	720.0 bc	67.44 abc	22.49 bc	1.030 a

\* note :- The symbols in the table indicate the following: F = levels of fulvic acid where F0 = control (spraying with distilled water only), F1 = ground addition 150 kg ha<sup>-1</sup>, F2 = ground addition 300 kg ha<sup>-1</sup>, F3 = foliar spray 2.5 g L<sup>-1</sup> , F4 = foliar spray 5 g L<sup>-1</sup> and S = levels of foliar spray with seaweed, where S0 = control (spray with distilled water only), S1 = first level (3 ml L<sup>-1</sup>) and S2 = second level (6 ml L<sup>-1</sup>).

The averages that share the same letters are not significantly different from each other according to Duncan's polynomial test at the 0.05 probability level.

## Discussion

### Growth characteristics

It is noted from the results presented in table 2, the clear significant effect of fulvic acid levels on increasing the vegetative growth characteristics (plant height, stem diameter, number of leaves and total leaf area) and may be attributed to the role it plays in improving cell division and cell elongation, as the acid directly affects various vital processes of the plant, such as respiration, carbon metabolism, protein synthesis and various enzymatic reactions, as the effect of acid is similar to the effect of plant hormones (Kulikova et al. 2003) and this is consistent with what was found by El-Helaly.(2018) on carrot plants when spraying fulvic acid caused an increase in vegetative growth characteristics.

The results of the same table showed that there were significant differences when the levels of fulvic acid and seaweed sprayed overlap in plant height, stem diameter, number of leaves and leaf area before the plant which led to stimulating the processes of vegetative growth and encouraging division and elongation of cells in addition to their role in balancing the vital processes within the plant tissue as a result of increasing the availability of nutrients (Wagahatula, 2009) , The results were in agreement with the findings of Hasan and Hussein (2020) on the plant cucumber .

## Yield and yield components

The significant increase in the indicators of broccoli yield in flower disc weight, biological yield, total plant yield and specific weight of flower disc (table 3) when fulvic acid was added, may be attributed to the stimulating effects of fulvic acid and its effectiveness in increasing the plant's ability to absorb macronutrients N, P and K and other nutrients. (Priga et al. 2014), which leads to an increase in its concentration in the leaves and its entry into the metabolic processes inside the plant, which leads to an increase in processed nutrients and their transfer to the flowering discs of the broccoli plant, thus increasing its weight. These results are in line with what was reached by Mahmood et al. (2021) on the plant cabbage, which found an increase in the yield characteristics when fulvic acid was added.

The significant increase in the weight of the flower disc and the total yield of the plant (table 3) when spraying seaweed extract may be due to the fact that this extract contains a high percentage of macro and micro nutrients and what these elements are of great importance in the vital construction of the plant and its role in activating the metabolism process carbon and the manufacture of carbohydrates in the leaves and then their transfer and storage in the flower disks, which contributes to an increase in the weight of the flower disc and thus increases the yield of one plant and the total production (Nardi and etal, 2002). The results were in agreement with the findings of Abdulrhman (2014) on the radish plant with an increase in the characteristics of the yield when they use seaweed.

## REFERENCES

1. Abdulrhman, Harith B.2014. Effect of spraying Algaa600 on the growth and yield of two varieties the Radish ) Raphanus sativus L.(. Diyala Agricultural Sciences Journal ,6(1) :172-178,2014 .
2. Dvornic, V. (1965). Lacrali Pratic de Ampelo Gratic E. Didactica Sipedagogica Ducureseti. R. S. Romania.
3. El-Helaly, M. . 2018. Effect of Foliar Application of Humic and Fulvic Acids on Yield and its Components of Some Carrot ( *Daucus c arota L.* ) Cultivars. Journal of Horticultural Science & Ornamental Plants, 10(3), 159–166.
4. Hasan, E. F., & Hussein, A. A. 2020. Effect of soil coverage with organic mulching and spraying with seaweed extract on some vegetative and productive traits of cucumber grown in greenhouses. Diyala Agricultural Sciences Journal, 12(special Issue), 206-220.
5. Jan, K., Rather, A. M., Boswal, M. V., & Ganie, A. H. (2014). Effect of biofertilizer and organic fertilizer on morpho-physiological parameters associated with grain yield with emphasis for further improvement in wheat yield production (Bread wheat= *Triticum aestivum L.*). International Journal of Agriculture and Crop Sciences, 7(4), 178.
6. SAS.2001.Statistical Analysis System,Release7,SAS.Institute.Inc.car.USA.
7. Tackie, N. 2011. Economic of organic farming and related issues. Cooperative extention programe/ GWC. Agriculture experiment station, Tuskegee University.
8. Kulikova, N. A., Dashitsyrenova, A. D., Perminova, I. V. and Lebedeva G.F.2003. Auxin-like activity of different fractions of coal humic acids, Bulgarian J. Ecolog. Sci. 2(3-4),
9. Mahmood, A. K., Omar, S. J., & Halshoy, H. S. 2021. The Impact of ( Alga Mix ) Seaweed and Garlic Extraction on Growth and Yield of Cauliflower. 13(3), 9–15.
10. Mansour, F. Y. O., & El-Metwaly, H. M. B. 2019. Influence of addition methods of fulvic acid and foliar spray with potassium sources on productivity and quality of potato crop. Fayoum Journal of Agricultural Research and Development, 33(1), 130-147.
11. Michaud, D S, Pietinen, P, Taylor, P RM, Virtanen, J, and Albanes, 2003. fruits and vegetables, carotenoids and vitamin A, E, C in relation to the risk of bladder cancer in the ATBC cohort study. British Journal of Cancer, 87(9), 960-965.
12. Nardi, S., D. Pizzeghello, A. Muscolo and A. Vianello.(2002). Physiological effects of humic substances on higher plants. Soil Biol. Biochem, 34(11):1527-1536.
13. Pettit, Robert E. 2003. Emeritus Associate Professor Texas A & M university, Organic Matter, Humus, Humates Humic Acid, Fulvic Acid and Humin: Their Importance in Soil Fertility and Plant Health. 55-56.
14. Priga, B. N. V., Mahavishnan, K., Gurumurthy, D. S., Bindumadhavh, A., Ambika, P.U., Navin, K. SH. 2014. Fulvic acid for enhanced nutrient uptake and growth: insights from biochemical and genomic studies. Journal of Crop Improvement, 28,740–757.
15. Wajahatullah, k N; D Rayorath; M. H. Alan and C. J. Norrie.(2009). Seaweed Extracts as Biostimulants of Plant Growth and Development. Journal plant Growth Regulator. 28:386–399.