Original Article

Effect of Fulvic Acid and Seaweed on the Nutrient uptake and Some Soil Chemical Properties

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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-1, 300 kg ha-1, 2.5 g L-1 and 5 g L-1) and seaweed by foliar application (control, 3 ml L-1 and 6 ml L-1) 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 intraction between fulvic acid and seaweed in all studied traits compared to the comparison treatment. The superiority of the level of ground addition with fulvic acid at a concentration of 300 kg ha -1 (F2) increased of availability of pH, EC, nitrogen , phosphorous and potassium 7.08 , 2.01 dS m-1 33.96 mg kg-1 soil and 40.17 mg kg-1 soil and 273.5 mg kg-1 soil respectively, (F3) exceeded concentration of phosphorous and potassium in the flower disk with a value 0.42% and 2.915% , respectively, and the level (F4) exceeded in the concentration of nitrogen and sulfur in the flower disc with a value of 4.807%, 0.374 respectively, as for spraying seaweed extract, (S2) exceeded in most of the studied characteristics such as the available of pH , nitrogen concentration , phosphorous concentration, potassium , sulfur concentrations in flower disc with a value of 7.13, 33.55 mg kg-1 soil and 34.56 mg kg-1 soil ,2.924%, 0.353 % respectively while the control treatment gave the lowest values for all studied traits.

Keywords: fulvic acid, seaweed, broccoli.

INTRODUCTION

Organic agriculture aims to enhance biodiversity, biological cycles and soil biological activity to achieve an optimal socially, environmentally and economically sustainable system in order to reduce the use of chemical fertilizers (Riyaz et al, 2021)). Fulvic acids have a higher overall acidity, greater numbers of carboxyl groups, and higher absorption and cation exchange capabilities compared to humic acid, and may play a role as natural chelators in the mobilization and transport of micronutrients (, 2020 Ismail and Fayed). It was found AL-Bandawy and Hameed, 2015 that organic fertilization leads to a decrease in the pH value of the soil. Seaweed is rich in natural ingredients, especially hormones. Plants that activate and stimulate the vital processes in the plant and contain many macro and micro nutrients (Jan et al., 2014). Scientific experiments have shown that foliar feeding is highly efficient and effective compared to the ground fertilization process, due to the speed of nutrients reaching the tissues of the leaf, as well as the importance of nutrition from the soil through the roots (Kuepper, 2003). Broccoli is one of the most important crops within the cruciferous family, and this crop is grown in most countries of the world, as it is a rich source of sulforaphane that contains high levels of glucosides that have anti-cancer properties (Hanson, 2000) , the results of the study conducted by Sun et al. (2019) were confirmed to show the effect of adding fulvic acid as a ground application on the crops of yellow corn and barley, as the experiment included two levels (0 and 0.075 ton ha-1), where the level of 0.075 ton ha-1 exceeded after harvesting corn in the concentration of ready nitrogen (1264.82 mg kg̅¹ soil), ready-made phosphorous (402.62 mg kg̅¹ soil), ready-made potassium (0.09 gm kg̅¹ soil) and pH (9.14) compared to the control, which decreased to 528.23 mg kg̅¹ soil, 216.59 mg kg̅¹ soil, 0.08 gm kg̅¹ soil and 9.13 barley, respectively, after harvesting, the level of 0.075 ton ha-1 exceeded the concentration of ready nitrogen (470.00 mg kg̅¹ soil), ready phosphorous (145.68 mg kg-1 soil) and ready potassium (0.11 g kg-1 soil) compared to the control, which decreased to 411.63 mg kg ¹ soil and 124.90 mg kg-1 soil and 0.10 g kg-1 soil sequentially, Youssif and Tawfeeq (2021) concluded in a study conducted to show the effect of foliar spraying of seaweed extract (Seasol) on the growth and yield of cauliflower, and the study included three concentrations (0, 3 and 6 ml L̅ ¹) , where the concentration exceeded 3 ml L̅ ¹ in N concentration (3.988). %) and K concentration (2.932%) in the flower head compared to the control treatment, which decreased to 1.307% and 2.426%, respectively, while spraying with a concentration of 6 ml liter led to a superiority in the concentration of P (0.395%) in the flower head compared to the control treatment, which decreased

to 0.217% in sequence. The aim of this study was to:

1- Finding the optimal concentration of fulvic acid and seaweed to get the best concentration & nutrients in soil .

2- Study of the effect of fulvic acid and seaweed on uptake & nutrients by broccoli .

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. The design of the complete random sectors 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. Same physical and chemical properties of field soil before cultivation.

Traits	Values	Units
pH	7.4	
EC	1.85	dSm^{-1}
Organic matter	10.1	$g\ Kg^{-1}$
Availability nitrogen	25	$mg\ kg^{-1}$soil
Availability phosphorous	25.4	$mg\ kg^{-1}$soil
Availability potassium	147.4	$mg\ kg^{-1}$soil
Soil Texture	Clay loam	
Sand	208	$g\ Kg^{-1}$
Silt	400	$g\ Kg^{-1}$
Clay	392	$g\ Kg^{-1}$

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 , at22-9-2021, fulvic acid and seaweed were sprayed in three sprays, and the duration between one spray and another was 15 days.While the grourd levels of fulvic acid were added at begining cultivation Studied traits

Soil characteristics

PH

The pH was measured in the soil suspension leachate: water 1:1 using a pH-meter according to the method described in Page et al. (1982).

EC

The electrical conductivity was measured in a 1:1 soil suspension filtrate: water using a Conductivity Bridge according to the method described in Page et al. (1982).

Ready Nitrogen Concentration (mg/kg¹ soil)

The prepared nitrogen was estimated with a solution of 2M-KCl, and the ammonium ion was determined using magnesium oxide (MgO) by distillation using a microcalcium device and nitrate ion reduction using Devarde alloy) according to the method of Bremner and Keeney (1965) described in Black (1965).

Ready phosphorous concentration (mg/kg-1 soil)

The prepared phosphorous was estimated using sodium bicarbonate with a reaction degree of pH = 8.5, then the color of the extract was developed using ammonium molybdate and ascorbic acid using a spectrophotometer at a wavelength of 882 nm according to the method of Olsen and Sommers (1982) mentioned in Page et al. (1982).

Ready Potassium Concentrate (mg/kg¬ soil)

The prepared potassium was determined using ammonium acetate and estimated using a flame photometer according to the method presented in Page et al. (1982).

The biochemical characteristics of flower dick

Nitrogen Concentration (%)

Wet digestion was carried out according to the method proposed by Cresser and Parsons (1979) and the total nitrogen ratio was estimated according to the Kjeldahl method using the Micro Kjeldahl apparatus.

Phosphorous concentration (%)

The percentage of total phosphorous element was estimated by digestion and using ammonium molybdate, then measuring it with a spectrophotometer at a wavelength of 882 nm (Olsen and Sommers, 1982).

Potassium concentration (%)

Potassium was determined in samples of the digested tablets using a flame photo meter, according to the method proposed by Haynes (1980).

Sulfur concentration (%)

Sulfur was estimated by a Spectrophotometer (at a wavelength of 420 nm and the sulfur concentration was extracted from the standard curve (Hammed et al., 2002).

Results

Chemical properties of the soil after planting

The results presented in table 2 showed that there were significant differences for fulvic acid in the pH and EC of the soil and the concentrations of nitrogen, phosphorous and potassium available in the soil compared to the control , where the F2 level recorded the lowest pH value of 7.08 and the EC of the soil amounted to 2.01 dSm-1 while the control recorded the highest value of 7.27 and 2.50 dSm-1 respectively, while the same level exceeded the concentrations of nitrogen, phosphorous and potassium in available form in soil with the highest values of 33.96 mg kg-1 soil, 40.17 mg kg-1 soil, and 273.5 mg kg-1 soil compared to the control which decreased to 22.66 mg kg-1 soil , 23.27 mg kg-1 soil and 94.96 mg kg-1 soil respectively .The data in the same table showed significant effects when spraying seaweed on soil pH , nitrogen, phosphorous and potassium available concentrations in the soil compared to the control , the pH decreased to 7.13 when spraying the S2 level, while the control gave the highest value of 7.21, but the EC was no significant differences between treatments and the S2 level was superior in the concentrations of available nitrogen and phosphorous in the soil with the highest values amounting to 33.55 mg kg-1 soil and 34.56 mg kg-1 soil compared to treatment the control decreased to 25.86 mg kg-1 soil and 25.80 mg kg-1 soil respectively , while the level S1 exceeded the concentration of available potassium with the highest value of 194.5 mg kg-1 soil compared to the control which decreased to 147.0 mg kg-1 soil .The effect of the interaction between fulvic acid levels and seaweed spray had a significant effect on soil chemical properties , the F2S2 interference treatment gave the lowest value for pH and EC 7.04 and 2.06 dSm-1 compared to the control which amounted to 7.33 and 2.54 dSm-1 respectively , while the same interaction treatment was superior to the concentrations of nitrogen, phosphorous and potassium available in the soil with the highest values 38.73 mg kg-1 soil, 41.26 mg kg-1 soil and 305.7 mg kg-1 soil respectively compared to the control which decreased to 17.66 mg kg-1 soil, 20.35 mg kg-1 soil and 80.93 mg kg-1 soil respectively .

Table 2. Effect of fulvic acid and seaweed extract on the chemical properties of soil

Treatments	pH	EC (dSm^{-1})	N ($mg\ kg^{-1}$ soil)	P ($mg\ kg^{-1}$ soil)	K ($mg\ kg^{-1}$ soil)
Fulvic acid					
F_0	7.27A	2.50A	22.66C	23.27 D	94.96 D
F_1	7.12C	2.18C	32.73A	35.18 B	223.5 B
F_2	7.08D	2.01D	33.96A	40.17 A	273.5 A
F_3	7.21B	2.42AB	26.94 B	30.39 CD	116.1 D
F_4	7.18B	2.32 B	29.33 B	32.10 BC	165.7 C
Seaweed					
S_0	7.21 A	2.30 A	25.86 B	25.80 B	147.0 B
S_1	7.17 B	2.26 A	27.96 B	34.31 A	194.5 A
S_2	7.13 C	2.29 A	33.55 A	34.56 A	182.6 A
Interaction F * S					
F_0 S_0	7.33 a	2.54 a	17.66 g	20.35 d	80.93 g
F_1 S_0	7.15 e-i	2.21 cde	29.66 c-f	32.34 bcd	192.2 bcd
F_2 S_0	7.11 hi	2.06 ef	30.66 cde	37.67 ab	208.2 bc

F_3 S_0	7.25 b	2.40 abc	23.83 f	28.39 cd	97.93 efg
F_4 S_0	7.21 b-e	2.31 bcd	27.50 def	30.25 cd	156.1 c-g
F_0 S_1	7.24 bc	2.47 ab	24.33 f	28.97 cd	115.5 d-g
F_1 S_1	7.12 ghi	2.13 def	30.83 cde	38.25 ab	239.9 ab
F_2 S_1	7.10 i	1.99 f	32.50 bcd	41.58 a	306.6 a
F_3 S_1	7.20 b -f	2.44 ab	25.83 ef	30.55 cd	146.0 c-g
F_4 S_1	7.18 c-g	2.28 bcd	26.33 ef	32.19 bcd	164.8 b-f
F_0 S_2	7.24 bcd	2.54 a	26.00 ef	30.51 cd	88.42 fg
F_1 S_2	7.09 ij	2.21 cde	37.70 ab	34.94 abc	238.4 ab
F_2 S_2	7.04 j	2.06 ef	38.73 a	41.26 a	305.7 a
F_3 S_2	7.17 d-h	2.40 abc	31.16 ecd	32.23 bcd	104.4 efg
F_4 S_2	7.14 f-i	2.31 bcd	34.16 abc	33.88 bc	176.2 bcd

* 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-1, F2 = ground addition 300 kg ha-¹, F3 = foliar spray 2.5 g L-1 , F4 = foliar spray 5 g L-1 and S = levels of foliar spray with seaweed, where S0 = control (spray with distilled water only), S1 = first level (3 ml L-1) and S2 = second level (6 ml L-1).

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.

Nutrients uptake

The results presented in Table 3 indicate a significant effect of fulvic acid on the concentration of nitrogen, phosphorous, potassium and sulfur in the flowering disc of broccoli plant , the F4 level was superior to the highest concentration of nitrogen, which amounted to 4.807, and the highest concentration of sulfur which amounted to 0.374%, in the flower disc compared to the control which decreased to 4.154% and 0.280%, respectively, the F3 level was superior to the highest concentration of phosphorous which amounted to 0.42% and the highest concentration of potassium, which amounted to 2.915%, compared to the control which decreased to 0.34% and 2.618% respectively. The results of the same table show that there are significant differences between the treatments of spraying seaweed in the concentration of nitrogen, potassium and sulfur but the coucentration at phosphory was no significant differences between the treatments , the level S1 had the highest nitrogen concentration in the flower disc which amounted to 4.775 %, while it decreased in the control to 4.305% , level S2 was superior to the highest potassium concentration of 2.924% and the highest sulfur concentration of 0.353% compared to the control which decreased to 2.666% and 0.317% respectively. The effect of the interaction between fulvic acid levels and seaweed spray had a significant effect on the biochemical characteristics of the flower disc, the treatment F4S2 had the highest nitrogen concentration, which amounted to 5.246% , treatment F3S0 the highest phosphorous concentration 0.45%, F3S2 treatment the highest potassium concentration 3.186% , treatment F4S1 the highest sulfur concentration 0.398 percent in the flower disc, compared to the control which decreased to 3.303% , 0.30% , 2.403% and 0.251% respectively.

Table 3. Effect of fulvic acid and seaweed extract on the biochemical characteristics of flower dick

Treatments	N(%)	P(%)	K(%)	S (%)
Fulvic acid				
F_0	4.154 B	0.34 B	2.618 B	0.280 C
F_1	4.795 A	0.39 A	2.801 AB	0.331 B
F_2	4.735 A	0.41 A	2.826 AB	0.332 B
F_3	4.571 AB	0.42 A	2.915 A	0.358 AB
F_4	4.807 A	0.39 A	2.897 A	0.374 A
Seaweed				
S_0	4.305 B	0.38A	2.666 B	0.317 B
S_1	4.775 A	0.39 A	2.845 A	0.335 AB
S_2	4.758 A	0.39 A	2.924 A	0.353 A
Interaction F * S				
F_0 S_0	3.303 c	0.30 b	2.403 d	0.251 e
F_1 S_0	4.516 ab	0.37 ab	2.610 cd	0.312 cd
F_2 S_0	4.563 ab	0.40 ab	2.890 abc	0.320 cd
F_3 S_0	4.613 ab	0.45 a	2.743 a-d	0.363 abc
F_4 S_0	4.530 ab	0.41 ab	2.683 bcd	0.341 abc
F_0 S_1	4.836 ab	0.36 ab	2.740 a-d	0.280 de
F_1 S_1	4.880 ab	0.42 a	2.890 abc	0.328 bcd

F_2 S_1	4.903 ab	0.44 a	2.883 abc	0.324 cd
F_3 S_1	4.610 ab	0.37 ab	2.816 a-d	0.345 abc
F_4 S_1	4.646 ab	0.36 ab	2.896 abc	0.398 a
F_0 S_2	4.323 a	0.35 ab	2.713 bcd	0.310 cd
F_1 S_2	4.990 ab	0.39 ab	2.903 abc	0.352 abc
F_2 S_2	4.740 ab	0.38 ab	2.706 bcd	0.353 abc
F_3 S_2	4.490 ab	0.43 a	3.186 a	0.366 abc
F_4 S_2	5.246 a	0.41 ab	3.113ab	0.385 ab

* 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-1, F2 = ground addition 300 kg ha-¹, F3 = foliar spray 2.5 g L-1 , F4 = foliar spray 5 g L-1 and S = levels of foliar spray with seaweed, where S0 = control (spray with distilled water only), S1 = first level (3 ml L-1) and S2 = second level (6 ml L-1).

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

Chemical properties of the soil

It is noted from the results presented in tables 2 on the effect of fulvic acid by adding ground or spraying on the pH and EC of the soil and the concentrations of available nitrogen, phosphorous and potassium in the soil , however the ground addition of fulvic acid showed a clear superiority over the spray levels as well as the control , the decrease in the pH of the soil when adding fulvic acid to the soil is due to the possession of fulvic acid to a number of hydrogen atoms that are released into the soil when the fulvic acid is decomposed as an organic substance and this leads to a decrease in the pH value of the soil when adding fulvic acid when adding fulvic acid to what this acid possesses which is an organic fertilizer of macro and micro nutrients, which led to an increase in the readiness of nutrients in the soil. This in turn led to the dominance of these nutrients in the exchange complex and the displacement of salt ions such as sodium and chloride which led to a decrease in soil EC by adding fulvic acid , the decrease in soil pH by the addition of fulvic acid led to an increase in the availability of nutrients (Yang et al., 2013) .

The results of the same table showed that there were significant differences when spraying seaweed extract in the characteristics of pH, available nitrogen, phosphorous and potassium concentrations in the soil. Carbon and the transfer of some of its products to the roots, which positively affected the increase in the activity of the root system and the increase in acidic secretions, which led to a decrease in the pH value and thus an increase in the availability of nutrients in the soil (Abd El-Motty et al., 2010).

Nutrients uptake

The significant effect achieved in the increase in nitrogen, phosphorous, potassium and sulfur concentrations of the flower disc (table 3) when fulvic acid was added , it is attributed to the effect of fulvic acid in stimulating the absorption of nutrients from plant surfaces to plant tissues in the case of foliar spray (Chen et al. 2004) , or it may be attributed to the positive role of fulvic acid in influencing cell membranes, which leads to enhancing the transport of nutrients improving protein synthesis enhancing carbon metabolism, modifying enzyme activities dissolving macro and micro elements reducing active levels of metal toxins and increasing the number of microbes (Malan, 2015) , this is consistent with the findings of Yildirim and Unay (2011) who indicated that foliar spraying of fulvic acid enhanced the nutritional status of tomato plants and AL-Jumally and Abul whab (2012) on potato .

As for the treatments of seaweed spraying the results in table 3 showed the significant effect on the concentration of nitrogen, potassium and sulfur in the flowering discs of broccoli , this may be due to the fact that the extract contains natural plant hormones and nutrients which may be responsible for the better absorption of nutrients by the broccoli plant in addition the extract contains a chelating substance that helps absorb nutrients (Salat, 2004) , this is consistent with what was found Garari et al. (2019) on the potato plant which found an improvement in the biochemical characteristics by increasing the concentrations of seaweed extract.

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