EFFECT OF HUMIC ACID AND ALGAE EXTRACT ON PRODUCTIVITY OF *RUTA GRAVEOLENS* L. PLANT UNDER SINAI CONDITIONS

Rania M. Khater[1*], Wafaa, H. Abd-Allah[1], Hanan A.E. Hashem[1] and Amr M. Abd El-Gawad[2]

[1]Department of Medicinal and Aromatic Plants, Desert Research Center, Cairo, Egypt

[2]Department of Soil Fertility and Microbiology, Desert Research Centre, Cairo, Egypt

[*]E-mail: dr.raniakhater@yahoo.com

This study was conducted during the two successive seasons of 2019-2020 and 2020-2021 at Ras Sudr Station farm in South Sinai Governorate, Egypt, to study the importance of using humic acid and spraying with algae extract to reduce water loss from the soil and reduce the effect of irrigation with saline water on the growth of *Ruta graveolens* plants under North Sinai conditions. Results showed a significant increase in the studied parameters when treated with different rates of humic acid alone and different concentrations of algae extract alone. Also, the interaction treatment between humic acid and algae extract at 4 kg/feddan and 4 cm/liter, respectively, gave the highest values in all characteristics such as vegetative growth, oil production, active ingredients, and chemical composition. On the other hand, the analysis of the components of the volatile oil of *Ruta graveolens* gave the presence of three main compounds of the oil components; 2-undecan is the main compound, followed by 2-nonan, then 2-methyl-undecanal.

Keywords: humic acid, algae extract, *Ruta graveolens*

INTRODUCTION

Rue "*Ruta graveolens*" a perennial herbaceous plant belonging to the family Rutaceae, 50-100 cm in height, has a woody stem with thick, bluish-green leaves. Spain is its original home, but it is spread in the mountains and valleys. Rue leaf, which is the medically used part of the plant, contains volatile oil of greenish-yellow color, flavonoids, the most important of which is rutin, and alkaloids, the most important of which is coumarin and terpenes, and also contains vitamin B, esters and alcohols. Rutin, the main active compound in the rue plant, is used in the treatment of blood diseases, diarrhea,

antispasmodics, antiemetics, gas repellents, anthelmintics, and abortifacients. It is also used in the treatment of heart disease and high blood pressure. Now, pharmaceutical companies have turned to the production of rutin from natural sources using the rue plant and Moses stick to achieve the safety and security of their products as reported by Khater (2010) and Gewefile et al. (2009) on *Nicotiana glauca.*

One of the most important scientific explanations for the effect of algae and seaweed extracts on the efficiency and growth of different plants is that they contain natural growth regulators that delay plant entry into aging, prevent leaf fall, flowering and fruits, prevent yellowing due to their effect on protein, retain chlorophylls and prevent their decomposition, encourage cell division and encourage growth of the roots (Khater, 2016). Algae also contain a growth stimulant and natural organic materials that improve the efficiency of the soil while encouraging the increase of microorganisms in the soil, which improves the absorption of water and nutrients. Spraying with algae extracts improves the metabolism inside the leaf by increasing the photosynthesis process **(**Khater and Abd El-Azim, 2016). Furthermore, algae contain natural phenols such as tannins, which have a similar role to natural growth hormones, and also improve the formation of lignin in plants, which increases their tolerance to diseases. Likewise, they help in speeding up the absorption of nutrients because they contain alginic acid, a natural chelating substance that chelates nutrients with a soil solution. Also, they contain some types of vitamins such as B1, B2, B12, and C. Algae format of natural growth regulators and natural antibiotics within the plant because they contain free amino acids that help the balanced and good growth of the plant and increase the plant response to fertilization (Marrez et al., 2014).

There are many studies on the use of algae extract sprays that recorded the best results, as indicated by El Laban et al. (2017), who studied the effect of algae extract as an alternative to mineral fertilization on vegetative growth, essential oils, and their main components, as well as the chemical components of Dutch fennel under Sinai conditions, where algae extract, was sprayed at a rate of one liter per 200 liters of water per feddan with five levels of mineral fertilization. Mineral fertilization of 75% with spraying with algae extract led to an increase in all characteristics of vegetative growth and fruit yield and the highest value of oil yield per plant and feddan. Also, the same treatment increased the contents of N, P, and K in plant tissues. Also, Khater (2016) studied the effect of different planting dates with spraying with different concentrations of algae extract on vegetative growth, seed yield, and guaran content in *Cyamopsis tetragonoloba*. The results indicated the possibility of obtaining the highest vegetative growth parameters, seeds yield, guaran content, and chemical components in the guar plant when planted on May 1st and spraying them with algae extract at a rate of 2 cm/liter.

Adding humic acid to the soil increases the effectiveness of fertilizers in the soil by 30% when adding the same amount of fertilizer, which leads to a saving in the amount of added fertilizer without affecting the amount of production. It also works to improve the soil composition and protect it from losing water and nutrients, thus helping the plant resist drought (Zhou et al., 2019). Humic acid helps the soil to retain nutrients and prevents their loss due to the high ability of humic acid to cation exchange, which leads to lowering the osmotic pressure of salts on the roots of the plant. It also keeps inorganic water-soluble fertilizers in the root areas and prevents their drainage. It increases and improves the transformation of nutrients into a suitable form for plant uptake (Rosa et al., 2018).

From a physiological point, humic acid can activate plant enzymes that work to increase cell division, so the growth rate in the roots increases by increasing the permeability of plant cells, which leads to an increase in the rate of plant absorption of water and nutrients, and thus increase growth, production rate, the amount of dry matter, improve the quality of the crop and improve its quality and value. Therefore, many studies were found that conducted on the importance of adding humic acid to the soil and its effect on plant growth. Khater and Abd El-Azim (2016) studied in a field experiment on *Plantago psyllium*, the effect of different chemical fertilization rates using different levels of humic acid (0, 2 and 4 kg/feddan) on growth, seed yield, active ingredients, and chemical components. Results showed a significant effect on plant height, the number of branches per plant, fresh and dry weights, seed yield per plant and feddan, as well as gum percentage and content per plant and per feddan as a result of adding chemical fertilizers at 75% of the recommended dose with the addition of humic acid at a rate of 4 kg / feddan. Also, Khater and Salama (2021) on coriander plants, studied the effect of different types of fertilizers and spraying with boron on growth, the yield of fruits, and volatile oil per plant and per feddan. Results indicated significant differences that led to an increase in growth characteristics and yield productivity with the treatment of humic acid and biofertilizer, which recorded the best values in the two studied seasons, as well as the highest percentages of essential oil components such as linalool, geraniol and limonene.

The study aims to investigate the effect of using humic acid and spraying with algae extract to reduce water loss from the soil and reduce the harmful effects of irrigation water salinity on the growth of *R. graveolens* plants under North Sinai conditions.

MATERIALS AND METHODS

This study was conducted during the two successive seasons of 2019/2020 and 2020/2021 at Ras Sudr station farm in South Sinai governorate, Egypt. *R. graveolens* seeds were obtained from the Department

of Medicinal and Aromatic Plants, Ministry of Agriculture, Dokki. The seeds were sown in a nursery on July 20th and 25th for both two seasons; respectively. After two months, seedlings were transplanted into the soil. The distances between rows were 70 cm and 30 cm between plant hills (20,000 plants/feddan). All agricultural practices of cultivation were performed as recommended. The soil texture was characterized as sandy loam, highly calcareous, and saline. The soil analysis was carried out according to Chapman and Pratt (1971) the mechanical analyses of the experimental soil revealed pH 7.96, EC 7.35 dS/m^2, $CaCO_3$ 27.40%, sand 80.08%, silt 10.59%, and clay 9.33%. The chemical analyses of the experimental soil for soluble anions (meq/100 g) HCO_3^{-1}, SO_4^{-2}, and Cl^{-1} were 3.50, 23.50, and 46.50, respectively, but soluble cations (meq/100 g) Ca^{+2}, Mg, Na, and K were 15.80, 3.80, 41.20 and 12.70, respectively.

The experiment was irrigated with saline water pumped from a well (4500 ppm). The drip irrigation method was carried out using a dripper flow rate (4 liter/hour) every day for an hour.

The experiment treatments

Humic acid was added in a solid form at the rates of 0 (without), 2, and 4 kg/feddan, while algae extract spraying rates were 0 (control), 2, and 4 cm/liter. The source of algae extract was from the Algae Biotechnology Unit, National Research Center, Egypt.

Algae extract was sprayed three times every 21 days, the first spray after 30 days from transplanting. Humic acid was added twice, the first after 30 days and the second after 60 days from transplanting, and the untreated plants were sprayed with tap water until the runoff. The plants were harvested in the first week of May during the first and second seasons.

Data recorded

1. Vegetative growth included:
   (a) Plant height (cm)
   (b) Number of branches/plant
   (c) Dry weights per plant (g) and feddan (kg)
   (d) Seeds weights per plant (g) and feddan (kg)
2. Oil production included:
   (a) Oil percentage (%)
   (b) Oil content per plant (ml), and feddan (L)
   (c) Oil chemical constituents by GLC according to Adams (2007).
3. Active ingredients were determined in dried herbs including:
   (a) Ruin percentage (%) according to Zhuang et al. (1992).
   (b) Coumarin percentage (%) according to Harbone (1998).
4. Chemical composition included:
   (a) Nitrogen percentage (%) according to Naguib (1969).
   (b) Phosphorus percentage (%) according to Hucker and Catroux (1980).

(c) Potassium percentage (%) according to Brown and Lilleland (1964).

The experiment was designed as a split-plot design with three replications. Every replicate included 9 treatments which were the combinations of three levels of both humic acid and algae extract. The main plots were devoted to the humic acid, while the subplots were occupied with the algae extract. According to Snedecor and Cochran (1989), statistical analysis was carried out using the computer program of Statistic version[9] Analytical Software (1985).

RESULTS AND DESICCATION

1. Effect of Adding Humic Acid and Spraying Algae Extract on Vegetative Growth

Results in table (1) indicate the effect of adding humic acid on some vegetative growth characteristics of the *R. graveolens* plant. It is clear from the table that the addition of humic acid at the rates of 2 and 4 kg/feddan significantly increased most of the vegetative growth characteristics in both seasons as compared with control, with the superiority of 4 kg/feddan of humic acid which gave the highest values in the two seasons in plant height of 49.843 and 49.901 cm, number of branches of 12.667 and 13.667, dry weight per plant of 87.480 and 89.456 (g), dry weight per feddan (kg) of 1.7498 and 1.7894, seeds weight per plant of 20.393 and 20.640 (g) and seed weight per feddan of 407.86 and 412.80 (kg) compared with untreated plants during the first and second seasons, respectively. This superiority indicates the effect of adding humic acid to increase the efficiency of vital processes, increasing the absorption of nutrients and reducing water evaporation from the soil, which is important, especially in sandy lands which increases the formation of chlorophyll and increases the efficiency of the leaves to carry out the process of photosynthesis, which is positively reflected in all the characteristics of vegetative growth. These results agrees with El-Shazly and Ghieth (2019) on olive seedlings, Abd El-Aleem et al. (2017) on dutch fennel plants and Abou El-Khair et al. (2010) on garlic.

On the other hand, the results in table (1) indicate that spraying with algae extract at 2 and 4 cm/liter caused significant increases in all parameters in both seasons as compared with control. The treatment of 4 cm/liter was significantly superior in obtaining the highest values of vegetative growth traits; plant height, number of branches, dry weight per plant, dry weight per feddan, seed weight per plant, and seed weight per feddan (46.942, 11.833, 84.505, 1.6902, 19.285 and 385.70, respectively) during the first season. In

Table (1). Effect of adding humic acid and spraying algae extract on vegetative growth of *Ruta graveolens* plant during 2019/2020 and 2020/2021seasons.

Treatments	Characters	Plant height (cm)		No. of branches/plant		Dry weight/ plant (g)		Dry weight/feddan (kg)		Seeds weight/ plant (g)		Seeds weight/feddan (kg)	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Effect of humic acid													
Control		35.16	35.21	7.78	8.78	71.13	73.17	1.42	1.46	14.25	14.38	285.08	287.53
2 kg/feddan		45.11	44.99	11.33	12.33	82.90	84.25	1.66	1.69	18.84	18.99	376.82	379.73
4 kg/feddan		49.84	49.90	12.67	13.67	87.48	89.46	1.75	1.79	20.39	20.64	407.86	412.80
L.S.D. at 0.05		0.49	0.61	0.10	0.21	1.32	0.55	0.03	0.01	0.04	0.19	0.77	3.79
Effect of algae extract													
Control		38.89	38.95	9.11	10.06	75.21	77.07	1.50	1.54	15.97	16.22	319.47	324.29
2 cm/liter		44.29	44.32	10.83	11.83	81.80	83.26	1.64	1.67	18.23	18.38	364.58	367.52
4 cm/ liter		46.94	46.84	11.83	12.89	84.51	86.56	1.69	1.73	19.29	19.41	385.70	388.24
L.S.D. at 0.05		0.30	0.39	0.09	0.15	0.96	0.37	0.02	0.01	0.07	0.11	1.38	2.12
Effect of interaction between humic acid and algae extract													
Control	Control	31.52	31.59	6.33	7.33	64.49	67.41	1.29	1.35	12.82	13.00	256.46	260.07
	2 cm/liter	36.13	36.18	8.00	9.00	73.00	74.19	1.46	1.48	14.26	14.37	285.25	287.48
	4 cm/liter	37.83	37.87	9.00	10.00	75.89	77.92	1.52	1.56	15.68	15.75	313.51	315.02
2 kg/feddan	Control	41.04	41.11	10.00	10.83	78.64	80.19	1.57	1.60	16.91	17.10	338.23	341.89
	2 cm/ liter	45.85	45.88	11.50	12.50	83.86	84.99	1.68	1.70	19.33	19.54	386.63	390.74
	4 cm/ liter	48.44	47.99	12.50	13.67	86.20	87.59	1.72	1.75	20.28	20.33	405.59	406.55
4 kg/feddan	Control	44.10	44.14	11.00	12.00	82.49	83.60	1.65	1.67	18.19	18.55	363.72	370.91
	2 cm/ liter	50.88	50.91	13.00	14.00	88.53	90.60	1.77	1.81	21.09	21.22	421.87	424.35
	4 cm/ liter	54.55	54.65	14.00	15.00	91.42	94.17	1.83	1.88	21.90	22.16	438.00	443.15
L.S.D. at 0.05		0.65	0.82	0.17	0.30	1.89	0.76	0.04	0.02	0.10	0.24	2.09	4.82

the second season, the values were 46,836, 12.889, 86.559, 1.7314, 19.412, and 388.24, respectively. This effect may be due to the role of algal extracts in increasing the efficiency of nutrient absorption, which was positively reflected in the content of chlorophyll in the leaves and an increase in the efficiency of the photosynthesis process, in addition to that this extract contains macro and micronutrients and plant hormones, especially cytokines, which had an effective impact in increasing cell division and thus increasing the characteristics of vegetative growth, especially at high concentrations of algae extract, because of its effective role in increasing the content of chlorophyll in leaves because it contains betaine, which plays an important role in preventing the decomposition of chlorophyll.

Results of table (1) also indicate that the interaction between humic acid and spraying with algae extract was significant. The interaction treatment of 4 kg/feddan of humic acid + 4 cm/liter of algae extract was superior by registering the highest mean of plant height (cm) of 54.553 and 54.650 cm, number of branches of 14.00 and 15.00, dry weight per plant (g) of 91.423 and 94.171, dry weight per feddan (kg) of 1.829 and 1.884, seed weight per plant (g) of 21.900 and 22.157 and seed weight per feddan (kg) of 438.000 and 443.150 during the first and second seasons, respectively. The interaction effect of the two factors of the study led to an increase in the characteristics of vegetative growth, as the addition of the algae extracts with humic acid that does not contain amino acids, which are natural compounds that help in the well-balanced growth of the plant and strengthen it and works to increase chlorophyll and reduce stress, which is attributed to the presence of active oxygen, gibberellin and vitamins in the extract and these substances help to activate the cytokinins,, which causes the prevention of chlorophyll oxidation. The above-revealed results established with those obtained by Khater and Salama (2021) on coriander plants, El Laban et al. (2017) on dutch fennel, and Abd El-Aleem et al. (2021) on curly parsley.

2. Effect of Adding Humic Acid and Spraying Algae Extract on Oil Production.

The results in table (2) indicate the effect of adding humic acid and spraying with algae extract on the oil production of *R. graveolens*. The results showed that the addition of humic acid at 2 or 4 kg/feddan significantly increased oil production [oil percentage, oil content per plant (ml), and oil content per feddan], as the treatment of 4 kg/feddan gave the highest increase in oil percentage, oil content per plant (ml) and oil content per feddan (l) were 0.158%, 0.144 ml, and 2.88 liter in the first season, respectively, while they were recorded 0.162%, 0.151 ml and 3.014 liter in the second season, respectively. Also, results in the same table indicated the effect of spraying with algae extract, which gave the superiority to spraying *R. graveolens* plants

at a rate of 4 cm/liter on oil production, as it gave a significant increase in all oil characteristics, which was 0.147% and 0.152% oil percentage, 0.131 and 0.138 ml oil content per plant and 2.619 and 2.766 liter oil content per feddan, during the first and second seasons, respectively.

Table (2). Effect of adding humic acid and spraying algae extract on oil production of *Ruta graveolens* plant during 2019-2020 and 2020-2021 seasons.

Characters / Treatments		Oil %		Oil content (ml/ plant)		Oil content (liter/ feddan)	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Effect of humic acid							
Control		0.093	0.101	0.073	0.080	1.466	1.609
2 kg/feddan		0.135	0.135	0.117	0.119	2.333	2.385
4 kg/feddan		0.158	0.162	0.144	0.151	2.880	3.014
L.S.D. at 0.05		0.037	0.025	0.010	0.011	0.020	0.014
Effect of algae extract							
Control		0.106	0.114	0.088	0.095	1.755	1.896
2 cm/liter		0.133	0.132	0.115	0.117	2.305	2.347
4 cm/liter		0.147	0.152	0.131	0.138	2.619	2.766
L.S.D. at 0.05		0.010	0.010	0.044	0.010	0.015	0.143
Effect of interaction between humic acid and algae extract							
Control	**Control**	0.076	0.091	0.059	0.069	1.184	1.384
	2 cm/liter	0.095	0.101	0.075	0.080	1.496	1.608
	4 cm/liter	0.107	0.112	0.086	0.092	1.719	1.836
2 kg/feddan	**Control**	0.116	0.120	0.095	0.101	1.903	2.010
	2 cm/liter	0.127	0.128	0.109	0.114	2.179	2.278
	4 cm/liter	0.138	0.133	0.120	0.115	2.394	2.294
4 kg/feddan	**Control**	0.152	0.159	0.135	0.143	2.702	2.867
	2 cm/liter	0.165	0.169	0.151	0.158	3.024	3.154
	4 cm/liter	0.182	0.185	0.172	0.180	3.436	3.595
L.S.D. at 0.05		0.020	0.017	0.015	0.010	0.029	0.245

Table (2) shows the superiority of the interaction treatment by adding 4 kg/feddan of humic acid with spraying algae extract at a rate of 4 cm/liter over the rest of the treatments, showing a significant increase in the oil productivity of *R. graveolens* plants, where the increase in oil percentage was recorded 0.182 and 0.185% during the first and second seasons, respectively compared to the control. As for the oil content per plant (ml), the interaction of 4 kg/feddan of humic acid with 4 cm/liter of algae extract showed the highest increase in oil content per plant (ml), as the increase was 0.172 and 0.180 ml during the first and second seasons, respectively, also had the same effect in oil content per feddan (liter), where it recorded the highest oil yield/ feddan during the first and second seasons by 3.436 and 3.595 liter compared to the control and other treatments. These results were established with those reported by Abd El-Aleem et al. (2021) on curly parsley and Ghasemi (2015) on garlic.

It is clear from table (3) that, 10 active compounds in the oil of *R. graveolens*, were α-pinene, camphene, β-pinene, 2-nonan, 1,5, linalool, 2-methyl-undecanal, 2-undecan, 2-dodecan, α-copaene, and pentadecanol. However, 2-undecan, 2-nonan and 2-methyl-undecanal were identified as the main compounds in the essential oil of *R. graveolens*. Likewise, 2-undecan was the main compound that represents the highest percentage component of the volatile oil of *R. graveolens*, as its percentage ranged between 58.269% and 45.246%, and the treatment of humic acid at the rate of 4 kg/feddan combined with algae extract at 4 cm/liter recorded the highest value (58.269%), while the lowest value was obtained from the control. Whereas 2-nonan was the second active compound in *R. graveolens* oil components.

The treatment of 4 kg/feddan of humic acid with spraying algae extract at a rate of 4 cm/liter gave the highest value of 20.675% followed by 4 kg/feddan of humic acid with control, which gave 19.631%, while control treatment gave 18.878%. On the other hand, the lowest value (10.197%) was recorded by using 2 kg/feddan of humic acid alone. Also, 1,5, linalool recorded the highest value of 3.071% when plants were treated with 4 kg/feddan of humic acid with spraying algae extract at a rate of 4 cm/liter, followed by 2 kg/feddan of humic acid with spraying algae extract at a rate of 4 cm/liter, which recorded 2.057%, followed by spraying with 4 cm/liter algae extract alone, which gave 1.362%. While the lowest value was 0.428% linalool when treated with 4 kg/feddan of humic acid without spraying algae extract. Alternatively, 2-methyl-undecanal represents the third major component of the essential oil of *R. graveolens*, its absence was observed when plants were treated with 4 kg/feddan of humic acid with spraying algae extract at 4 cm/liter, while the treatment of 2 kg/feddan of humic acid alone recorded the greatest value of 20.475%, while the treatment of 4 kg/feddan of

humic acid with spraying algae extract at 2 cm/liter recorded the lowest value of 4.751% for the compound 2-methyl-undecanal.

Table (3). Effect of adding humic acid and spraying algae extract on the main components (%) of the volatile oil of *Ruta graveolens* plant during the second season.

Treatments / Components	Control			2 kg/feddan			4 kg/feddan		
	Control	2 cm/liter	4 cm/liter	Control	2 cm/liter	4 cm/liter	Control	2 cm/liter	4 cm/liter
α-Pinene	1.679	5.684	6.642	0.781	3.363	-	1.771	6.809	2.001
Camphene	9.622	8.833	7.527	9.764	8.359	8.442	8.300	5.624	10.119
β-Pinene	5.628	0.731	7.931	-	0.405	1.803	0.508	3.854	-
2-Nonan	18.878	14.415	15.37	10.197	14.299	13.496	19.631	15.38	20.675
1,5, Linalool	0.583	-	1.362	0.542	0.441	2.057	0.428	0.548	3.071
2-Methyl-undecanal	15.119	10.551	4.899	20.475	15.536	15.236	10.200	4.751	-
2-Undecan	45.246	50.068	50.531	51.23	51.542	52.585	54.139	57.236	58.269
2-Dodecan	2.324	-	-	-	0.796	0.820	0.476	0.613	0.833
α-Copaene	0.922	0.718	0.369	0.845	0.620	0.441	0.456	0.935	0.026
Pentadecanol	-	9.000	5.370	6.166	4.641	5.121	4.092	4.251	5.006

On the other hand, α-pinene was absent due to the treatment of humic acid at 2 kg/feddan combined with spraying algae extract at the rate of 4 cm/liter, while the highest value (6.809%) was obtained due to adding humic acid at 4 kg/feddan combined with spraying algae extract at the rate of 2 cm/liter. Whereas camphene recorded the highest value of 10.119% with adding humic acid at 4 kg/feddan combined with spraying algae extract at the of 4 cm/liter, while the treatment of humic acid at 2 kg/feddan combined with control recorded the lowest values of α-pinene, while β-pinene was absent in both treatments of 4 kg/feddan humic acid with spraying algae extracts at the rate of 4 cm/liter and humic acid alone at 2 kg/feddan. Conversely, the control treatment recorded the highest value of 2-dodecan as it gave 2.324%, while it was absent from each of the treatments of 2 and 4 cm/liter of algae extract alone and humic acid alone at 2 kg/feddan.

Moreover, α-copaene recorded the lowest value when plants were treated with 4 kg/feddan of humic acid combined with spraying, algae extract at 4 cm/liter rate, while the highest value was recorded from the control treatment. The compound pentadecanol gave the highest value (9.00%) with spraying algae extract at 2 cm/liter alone, while the treatment of humic acid of 4 kg/feddan without spraying algae extract recorded the minimum value of 4.092%. The above revealed results are in harmony with those obtained by

Khater and Salama (2021) on coriander plants, El Laban et al. (2017) on dutch fennel and Abd El-Aleem et al. (2021) on curly parsley.

3. Effect of Adding Humic Acid and Spraying Algae Extract on the Active Ingredients

Data in table (4) indicate that the highest significant increase in rutin and coumarin in *R. graveolens* plants were obtained with the treatment of humic acid at 4 kg/feddan, which recorded 1.867% and 0.014%, respectively during the first season, while it recorded 2.013% and 0.017%, respectively, during the second season compared to the control plants. Similarly, table (4) shows the superiority of rutin percentage in *R. graveolens* plants significantly with the treatment of algae extract at 4 cm/liter, as it reached 1.678% and 1.914%, respectively, and the highest coumarin percentages were obtained for the control treatment (0.027% and 0.031%) during the two seasons, while the lowest values of rutin (1.135% and 1.212%, respectively) were obtained in the control treatment. Whereas algae extract at 4 cm/liter gave the lowest coumarin percentages of 0.018 and 0.020%, during the first and second seasons, respectively.

Table (4) also shows that the highest significant increase in rutin and coumarin percentages in *R. graveolens* plants was obtained due to the treatment of humic acid at 4 kg/feddan combined with algae extract at 4 cm/liter, reaching (2.330% and 2.561%) and (0.038% and 0.043%) during the two seasons, respectively compared to control and other treatments. The above revealed results agree with those obtained by Khater and Salama (2021) on coriander plants, El Laban et al. (2017) on dutch fennel, Abd El-Aleem et al. (2021) on curly parsley, and Aminifard et al. (2012) on *Capsicum annuum*.

4. Effect of Adding Humic Acid and Spraying Algae Extract on the Chemical Composition

Results in table (5) point out that the addition of humic acid had a significant effect on the chemical composition of *R. graveolens*, as all treatments outperformed the control treatment, especially at 4 kg/feddan, which gave the highest percentages of nitrogen, phosphorous, potassium and carbohydrates, which recorded 2.252, 0.266, 1.615 and 25.634% during the first season, respectively. While they recorded 2.263, 0.283, 1.615 and 26.640% during the second season, respectively, however, the values for control plants without addition recorded 1.676, 0.122, 0.796 and 19.761% during the first season, respectively. While they recorded 1.714, 0.140, 0.782 and 20.296% during the second season; respectively.

Furthermore, the data in table (5) show that spraying with algae extracts caused significant increases in all chemical constituents, especially at a concentration of 4 cm/liter as the highest percentages of nitrogen, phosphorous, and potassium were recorded, which reached 2.137, 0.241 and

1.442 during the first season, respectively. While it scored 2.144, 0.253, 1.449 and 25.509% during the second season, respectively. This increase is consistent with the role of algae extracts in increasing the efficiency of nutrient absorption, in addition to that algae extracts contain nutrients and amino acids, and contain betaine, which is a source of nitrogen to build protein.

Table (4). Effect of adding humic acid and spraying algae extract on the active substances of *Ruta graveolens* plant during the 2019-2020 and 2020-2021 seasons.

Characters / Treatments		Rutin %		Coumarin %	
		1st Season	2nd Season	1st Season	2nd Season
Effect of humic acid					
Control		1.027	1.106	0.030	0.033
2 kg/feddan		1.395	1.597	0.023	0.026
4 kg/feddan		1.867	2.013	0.014	0.017
L.S.D. at 0.05		0.061	0.074	0.012	0.013
Effect of algae extract					
Control		1.135	1.212	0.027	0.031
2 cm/liter		1.475	1.590	0.023	0.026
4 cm/liter		1.678	1.914	0.018	0.020
L.S.D. at 0.05		0.052	0.056	0.011	0.018
Effect of interaction between humic acid and algae extract					
Control	**Control**	0.9035	0.9968	0.0117	0.0141
	2 cm/liter	1.029	1.106	0.014	0.018
	4 cm/liter	1.147	1.217	0.016	0.020
2 kg/feddan	**Control**	1.224	1.271	0.019	0.021
	2 cm/liter	1.404	1.554	0.023	0.025
	4 cm/liter	1.556	1.965	0.024	0.027
4 kg/feddan	**Control**	1.279	1.367	0.027	0.030
	2 cm/liter	1.992	2.110	0.030	0.033
	4 cm/liter	2.330	2.561	0.038	0.043
L.S.D. at 0.05		0.095	0.108	0.020	0.028

Table (5). Effect of adding humic acid and spraying algae extract on the chemical composition of *Ruta graveolens* plant during the 2019-2020 and 2020-2021 seasons.

Characters / Treatments		Nitrogen %		Phosphorous %		Potassium %	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Effect of humic acid							
Control		1.676	1.714	0.122	0.140	0.796	0.782
2 kg/feddan		2.020	2.030	0.218	0.225	1.342	1.343
4 kg/feddan		2.252	2.263	0.266	0.283	1.615	1.615
L.S.D. at 0.05		0.035	0.071	0.011	0.017	0.029	0.031
Effect of algae extract							
Control		1.788	1.798	0.158	0.179	1.016	0.993
2 cm/liter		2.023	2.064	0.208	0.217	1.295	1.298
4 cm/liter		2.137	2.144	0.241	0.253	1.442	1.449
L.S.D. at 0.05		0.039	0.062	0.009	0.018	0.026	0.027
Effect of interaction between humic acid and algae extract							
Control	**Control**	1.587	1.603	0.096	0.116	0.666	0.636
	2 cm/liter	1.691	1.756	0.121	0.142	0.785	0.770
	4 cm/liter	1.749	1.783	0.150	0.164	0.937	0.941
2 kg/feddan.	**Control**	1.842	1.850	0.169	0.184	1.143	1.104
	2 cm/liter	1.935	1.941	0.208	0.229	1.240	1.240
	4 cm/liter	2.052	2.062	0.231	0.236	1.361	1.376
4 kg/feddan.	**Control**	2.167	2.179	0.254	0.261	1.521	1.550
	2 cm/liter	2.327	2.348	0.271	0.279	1.738	1.749
	4 cm/liter	2.494	2.499	0.319	0.333	1.868	1.856
L.S.D. at 0.05		0.065	0.112	0.016	0.031	0.047	0.049

Analogous consequences were detailed by Khater (2016) on *Cyamopsis tetragonoloba*, El Laban et al. (2017) on dutch fennel, and Abd El-Aleem et al. (2017) on dutch fennel plants. Likewise, The data in table (5) indicate that the interaction effect between humic acid and algae extract was significant, as the interaction treatment of 4 kg/feddan of humic acid with spraying algae extract at the rate of 4 cm/liter gave the highest increase in the percentages of nitrogen (2.494 and 2.499), phosphorous (0.319 and 0.333),

potassium (1.868 and 1.856) during the first and second seasons, respectively. While the lowest values were recorded for the control treatment. Similar consequences were detailed by Abd El-Gawad et al. (2015) on faba bean and Aminifard et al. (2012) on *Capsicum annuum*.

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تأثير حمض الهيوميك ومستخلص الطحالب على إنتاجية نبات السذب تحت ظروف سيناء

رانية مرتضى خاطر[١]*، وفاء حامد عبد العليم[١]، حنان علي هاشم[١] وعمرو محمود عبد الجواد[٢]

[١]قسم النباتات الطبية والعطرية، مركز بحوث الصحراء، القاهرة، مصر

[٢]قسم خصوبة التربة وميكروبيولوجي الأراضي، مركز بحوث الصحراء، القاهرة ، مصر

أجريت هذه الدراسة خلال الموسمين المتعاقبين ٢٠١٩/٢٠٢٠ و٢٠٢٠/٢٠٢١ بمزرعة محطة رأس سدر بمحافظة جنوب سيناء بمصر، لدراسة أهمية استخدام حمض الهيوميك والرش بمستخلص الطحالب لتقليل الفاقد المائي من التربة وتقليل تأثير ملوحة مياه الري على نمو نباتات السذب تحت ظروف شمال سيناء. أظهرت النتائج زيادة معنوية عند المعاملة بمعدلات مختلفة من حمض الهيوميك والرش بتركيزات مختلفة من مستخلص الطحالب، كما أعطت معاملة التفاعل بين حمض الهيوميك ومستخلص الطحالب (٤ كجم/فدان + ٤ سم / لتر) أعلى القيم في جميع صفات النمو الخضري وإنتاج الزيت والمكونات الفعالة والتركيب الكيميائي. من ناحية أخرى، أظهر تحليل مكونات الزيت الطيار لنبات السذب وجود ثلاث مركبات رئيسية من مكونات الزيت وهي: 2-Undecan وهو المركب الرئيسي، يليه المركب 2-Nonan، ثم المركب 2-Methyl-undecanal.