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Response of *Nigella sativa* L. Plants to Humic acid and Seaweed extract treatments

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Abstract

The purpose of this experiment was to examine the effects of seaweed extract, mineral fertilizers, and organic fertilizers on the growth, yield, and oil production of black cumin (*Nigella sativa* L.) plants through of the two winter consecutive seasons of 2019/2020 and 2020/2021. A split-plot design was used to set up the experiment, and there were three duplicates, five main plots (NPK_{RD} and humic acid at 5, 10 and 15 kg/ ha.) and four sub-plots (foliar application of seaweed extract at 0, 200,300 and 400 ppm). The obtained results pointed out that the use of mineral and organic fertilizers at all levels recorded a significant enhance in plant height, branches number/ plant, shoot fresh and dry weight/ plant, capsules number/ plant, seed yield g/ plant and ton per ha., fixed oil % and it yield ml and liter per plant and ha. respectively and essential oil %, essential oil yield ml/ plant and liter/ ha. in the seed. Clearly, applying humic acid at 15 kg / ha. gave the highest values of these previous traits. Obviously, foliar spray with seaweed extract at 400 ppm led of significant augment in above mentioned parameters. The listed data indicated that the interaction effect was significant on all examined characteristics; most combined treatment significantly improved all examined parameters. In general, addition of humic acid at 15 kg/ha. plus, foliar application by seaweed extract 400 ppm was the most effective treatment.

Keywords: Black cumin, *Nigella sativa*, NPK, humic acid and seaweed extract.

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1. Introduction

The black cumin (*Nigella sativa* L.) plant, which belongs to the Ranunculaceae family, is one of the most promising fragrant and therapeutic plants. In the regions of middle and upper Egypt, it is commonly grown for its oil and seed output. For millennia, the seeds have been utilized to combat illness and enhance health, particularly in Southeast Asia and the Middle East. It is referred to as Habat-Al-Barka or Al-Habat-El-Sauda in Arabic countries. The entire seeds contain 30–35% fixed and volatile oil, which is used in the food and medicinal industries for a variety of purposes [1]. Throughout antiquity, black cumin has been regarded as a sacred medicinal seed. Egypt is the source of the best seeds, which thrive in nearly ideal conditions when hydrated until seed pods mature. Despite being mentioned in the Bible and in the teachings of the Prophet Mohammed, black cumin seed was not thoroughly studied until roughly 40 years ago. Numerous studies have been carried out since then. The ideological conviction that the herb could treat a variety of ailments greatly increased the plant's popularity. Because of its many therapeutic uses, this plant has actually earned a particular place. As a result, black cumin in particular has been thoroughly researched, supporting its wide range of traditional medicinal benefits. This could be because of the seeds' intricate chemical constituents. All of the essential fatty acids are rich in black cumin seed, which has more than 100 different chemical elements [2]. Also, the seeds have a somewhat spicy flavor and are frequently used intact in Mediterranean cheeses, curries and pastries, even though the oil is most frequently used medicinally. Although Nigella sativa seeds don't smell very strong, they are carminative, which means they tend to help with digestion and release gas in the stomach and intestines. They aid elimination and peristalsis. Black cumin essential oil has antibacterial properties and aids in worm removal from the intestines. When it comes to autoimmune disorders, which are conditions where patients suffer greatly because their own systems attack their bodies, black cumin has been found to be superior to almost every other natural remedy. However, some people may not take this seriously because it is considered a panacea [3,4]. The seeds of black cumin are highly valued for their strong, spicy, and peppery

flavor. They yield oil, which was a valuable Egyptian cure known for its health advantages (Pharaos oil). The seeds are used to extract a water-retentive protein that can aid the skin fend off the aggression of free radicals [5]. Humic acid is an important component of brown humic substances and active components of soil organic matter humus that affect the physical quality and chemical content of soil. Also, humic substances typically consist of heterogeneous mixtures of converted biomolecules that exhibit a supramolecular structure that can be separated into smaller molecular components by sequential chemical fractionation [6]. Humic acid has been proven to increase the production of aromatic seed crops both quantitatively and qualitatively. Humic acid is used as a natural fertilizer to increase the productivity and quality of medicinal and aromatic plants that are grown in a way that does not harm the environment as compared to chemical fertilizers. It also lowers production costs and environmental pollution without affecting yield) [7,8,9,10,11,12] Many studies have revealed that humic acid is known to be a plant growth promoter by improving crop quality and nutrient supply, promoting plant growth and development, and raising yield due to its critical role in physiological and metabolic processes [13,14]. When humic acid is added to the soil, it increases the effectiveness of fertilizers by 30%, which saves a significant amount of added fertilizer, and at the same time it does not affect the amount of production, and this is an important economic factor. Humic acid also helps improve soil composition and increases the soil's ability to retain water and nutrients, which helps the plant resist drought [15]. Humic acid helps prevent the loss of nutrients due to its high capacity for cation exchange, which leads to reducing the osmotic pressure of salts on the root system of plants, and at the same time helps preserve water-soluble inorganic fertilizers and prevents them from draining. Humic acid helps provide nutrients in a form suitable for plant absorption [16].

Therefore, the current study established to assess the response of Black cumin (*Nigella sativa* L.) plants to Humic acid, mineral NPK and seaweed extract, as well as their interactions on the plant growth traits, yield and yield components (fixed oil and essential oil).

2. Materials and methods

2.1. Experimental location

At the Experimental Farm Faculty of Agriculture, Al-Azhar University, Assiut, Egypt, a field experiment was conducted throughout the 2019/2020 and 2020/2021 seasons. On November 10th, black cumin seeds were planted in 3.0 × 2.5 m plots for both seasons. The space between each row was 60 cm, and the distance between each hill was 25 cm. So, each plot contained 4 rows and 72 hills. Table (1) presented a physical and chemical properties of the utilized soil were according to listed in.

Table 1: The physical and chemical properties of the experimental soil:

Characters	Value		Characters	Value	
	2019	2020		2019	2020
Clay %	49.25	48.88	CaCo3 %	2.59	2.51
Silt %	35.52	36.60	PH (1:2.5)	7.53	7.47
Sand %	15.23	14.52	E.C m/mhos/cm	1.21	1.30
Organic matter %	2.47	2.68	Total N %	0.17	0.15
texture	Clay loam	Clay loam	Available P %	2.76	3.00
			Exchange K (mg/100 g soil)	2.38	2.27
			Exchange Ca++ (mg/100 g soil)	34.3	32.11
			Exchange Na (mg/100 g soil)	2.27	2.21

2.2. Experimental Design

A split-plot arrangement in complete randomized block design, in three replicates and five plants/ replicate, was executed in this experiment with five treatments (0 (control), NPK_{RD} (recommended dos), and humic acid at 5,10 and 15 kg/ ha.) in the main plots and four treatments (0.0, 200,300 and 400 ppm at seaweed extract) in the sub plots.

2.3. Material and Culture of Plants

The following is the application of the recommended dosage of mineral NPK: P fertilizer was added in total when the soil was being prepared for cultivation, and NK was administered in three batches at one-month intervals after 30 days from the sowing date. Humic acid was obtained from Abu Zaabal Fertilizers Company at a rate of 96% humic acid by weight. The plant root area was treated with humic acid at rates of 2, 4, and 8 kg/ha, three times a month after the sowing date. The plants were foliar sprayed with seaweed extract three times, on December 15th, 30th, and January 15th for the first, second, and third sprays, respectively, in the two seasons before the humic acid was dissolved in a predetermined amount of irrigation water. Foliar spraying was applied to the plants till they ran off. Every other aspect of farming was carried out as usual.

2.4. Sampling and Data Collection

At the end of experiment, the growth traits were listed: Plant height (cm), branches number/ plant, herb fresh and dry weight g/ plant, capsules number/ plant, yield of seed g/ plant and ton per ha. was calculated, fixed oil percentage in the seeds was extracted by Soxhlet apparatus using hexane (BP 60-80 °C) as solvent according to [17] and After determining the essential oil percentage in the seeds using the method outlined by [18], the fixed oil yield (ml)/plant was calculated by multiplying the essential oil

percentage in the seed yield (g)/plant by the fixed oil yield (ml)/plant. Additionally, fixed oil yield l/ha was observed. Both milliliters per plant and liters per hectare are essential oil yields. All obtained data were tabulated and statistically analyzed according to [19] using the L.S.D. test at 5 % to know the differences among all treatments according to [20].

3. Results

3.1. Growth parameters

The obtained results in Table (2) indicated that the utilize of NPK at recommended dos and any level of humic acid, during both seasons, resulted a significant augment in vegetative growth characters (plant height, branches number/ plant, herb fresh and dry weight/ plant) of black cumin, as in comparison with control group. It could be noticed that utilizing humic acid at 15 kg/ ha. registered the maximum mean values of plant height reached (33.2 and 31.9 %), branches number/ plant (54.2 and 50.6 %), herb fresh weight/ plant (44.8 and 40.2 %) and herb dry weight/ plant (38.5 and 46.2 %) over the control plants, during the two growing seasons, respectively. Obtained results agreed with those of revealed by [21,22,23] on coriander, [24,25] on sweet marjoram. As for seaweed extract treatments, data in Table (3) pointed out that treating black cumin plants with all concentration (led to a significant augment in plant growth traits (fresh and dry weights of herb / plant, branches number/ plant as well as plant height), in both seasons, as compared to no treated ones. Obviously, the treatment (400 ppm) gave positive effect on vegetative growth characters (plant height reached 9.7 and 11.6 %, branches number/ plant 17.4 and 15.6 %, herb fresh weight/ plant 7.5 and 7.1 % and herb dry weight/ plant 21.3 and 23.1 %, over the check treatment, during the two consecutive seasons, respectively. According to the studies collected, which also showed that bio-stimulants increased growth parameters output by [26,27] on rosemary (*Rosmarinus officinalis* L.) plants. Data in Table (2) showed that the combined effect between the two factors on vegetative growth characters of black cumin had statistically significant, during the two experimental seasons. It is obvious that vegetative growth characters (plant height and herb fresh and dry weight/ plant as well as branches number/ plant,) was significantly increased by applying black cumin with most combined treatments, in both seasons, as compared to untreated plants. From the revealed data, it could be noticed that the use of humic acid at 15 kg/ ha. +foliar application with seaweed extract at a concentration of 400 ppm resulted a significant augment in vegetative growth characters, in comparison with those obtained by other combination treatments, in the two seasons.

3.2. Yield and yield components

The revealed data in Table (3) illustrated that fertilizing black cumin plants with NPK_{RD} and humic acid at all levels, led to a significant increase in yield and yield components (capsules number/ plant, seed yield g/ plant and ton per ha.), in both seasons, comparing to the check treatment. Therefore, the use of humic acid at 15 kg/ ha. proved to be more effective in augmenting yield and yield components than those given by other treatments and control, during both seasons. Numerically, this above-mentioned superior treatment increased such by 29.6 and by 35.0 % for capsules number, by 44.0 and by 43.1 % for seed yield g/ plant and seed yield ton/ ha. in both seasons over unfertilized plants, respectively. The positive effect of humic acid on the yield has been confirmed, [28] on fennel (*Foeniculum vulgare* Miller) plants, [29] on olive seedlings (*Olea europaea*), [30] on dutch fennel (*Foeniculum vulgare*) plants, [31] on garlic (*Allium sativum*) and [32] on *Ruta graveolens*.

With respect to seaweed extract treatments, the listed data in Table (3) revealed that yield and yield components of black cumin plants was significantly augmented, in the two seasons due to treated with the different concentrations of seaweed extract, as compared to no sprayed ones. Obviously, supplying black cumin plants with the High concentration of seaweed extract (400 ppm) has been shown to registered the heaviest value in yield and yield components reached 8.9 and 15.6 % for capsules number, 16.8 and 18.1 % for seed yield g/ plant seed yield ton/ hectare over check group, during the two experimental seasons, respectively. According to the studies collected, which also showed that bio-stimulants increased growth parameters output by [26,27] on *Rosmarinus officinalis* plants. In regard to the interaction between both studied factors, it was statistically significant influence on yield and yield components, during the two seasons. Obviously, all combined treatments, in both seasons, resulted a significant augment in yield and yield parameters. Furthermore, the heights value of yield and yield parameters were detected due to treating black cumin plants with humic acid 15 kg/ ha. + sprayed the plants by 400 ppm of seaweed extract comparison with those given by other combinations, during both seasons.

3.3. Fixed oil productivity

Data recorded in Table (4) revealed that using fertilizer treatments significantly enhanced the fixed oil productivity of black cumin plants compared to the control. Clearly, fixed oil (%), fixed oil / plant (ml) and fixed oil / ha. (l) was significantly augmented with mineral NPK_{RD}, followed with humic acid at 15 kg/ ha. in the two seasons. Thus, the application of mineral NPK at the recommended dose registered the highest fixed oil %, fixed oil ml/ plant and fixed oil l/ ha. reached 17.2 and 17.1 % for fixed oil %, 62.9 and 60.0 % for Fixed oil ml/ plant and Fixed oil l/ ha. over control, during the two seasons, respectively.

As for the influence of seaweed extract treatments, the given data in Tables (4) indicated that treating black cumin plants with the concentration of 400 ppm was the best as it gave led to a great significant augment in essential oil productivity in the seeds of black cumin comparing to no treated plants, during the two tested seasons. reached 9.5 and 10.0% for essential oil %, 27.5 and 30.1 % for essential oil /plant (ml) and essential oil / ha. (l) over untreated plants, during both seasons, respectively.

Table 2: Effect of mineral, humic acid and seaweed extract treatments, as well as, their interactions on vegetative growth characters of black cumin plants during 2019/2020 and 2020/2021 seasons

Fertilization (A)	Seaweed extract (B) (B)									
	First Season					Second Season				
	Control	SW 1	SW 2	SW 3	Means (A)	Control	SW 1	SW 2	SW 3	Means (A)
	Plant height (cm)									
Control	54.7	57.3	59.0	63.0	58.5	56.0	58.3	61.0	68.3	60.9
NPK $_{RD}$	74.3	76.3	77.3	79.0	76.8	76.7	77.7	79.0	81.7	78.8
H1	60.0	62.3	66.3	69.0	64.4	62.0	65.0	69.0	74.7	67.7
H2	65.3	67.0	68.3	70.0	67.7	68.3	69.3	72.0	74.0	70.9
H3	75.3	77.3	78.7	80.3	77.9	78.7	79.0	81.0	82.3	80.3
Means (B)	65.9	68.1	69.9	72.3		68.3	69.9	72.4	76.2	
L.S.D for 0.05	A= 2.3 B= 1.9 AB= 4.3					A= 1.7 B= 1.5 AB= 3.4				
branches number/plants										
Control	6.6	7.1	7.5	7.8	7.2	7.6	7.9	8.3	8.6	8.1
NPK $_{RD}$	9.5	9.9	11.0	11.8	10.5	10.4	11.0	12.1	12.7	11.5
H1	8.0	8.3	8.6	8.8	8.4	8.8	9.2	9.5	9.8	9.3
H2	9.2	9.5	9.7	9.9	9.6	10.0	10.3	10.6	11.2	10.5
H3	9.9	10.6	11.6	12.3	11.1	10.9	11.5	12.9	13.4	12.2
Means (B)	8.6	9.1	9.7	10.1		9.6	10.0	10.7	11.1	
L.S.D for 0.05	A= 0.3 B= 0.1 AB= 0.2					A= 0.3 B= 0.2 AB= 0.5				
Herb fresh weight g/ plant										
Control	76.5	78.2	80.7	82.3	79.4	79.3	80.8	82.2	84.8	81.8
NPK $_{RD}$	105.2	107.3	109.8	111.5	108.4	106.2	107.5	110.7	112.7	109.3
H1	79.2	80.7	82.3	84.0	81.5	81.3	82.7	84.7	86.3	83.8
H2	82.0	84.3	87.0	90.7	86.0	86.0	88.3	90.3	94.0	89.7
H3	110.8	112.0	117.9	119.2	115.0	110.9	112.0	117.1	118.8	114.7
Means (B)	90.7	92.5	95.6	97.5		92.7	94.3	97.0	99.3	
L.S.D for 0.05	A= 4.4 B= 0.6 AB= 1.3					A= 2.6 B= 0.7 AB= 1.5				
Herb dry weight g/ plant										
Control	17.2	18.5	19.0	20.0	18.7	17.6	18.8	20.0	21.7	19.5
NPK $_{RD}$	22.5	24.0	25.0	28.3	25.0	24.0	25.7	26.7	31.2	26.9
H1	18.3	19.3	20.4	21.5	19.9	19.3	21.0	22.2	23.5	21.5
H2	22.3	23.6	25.2	26.0	24.2	24.1	25.3	28.2	27.0	26.2
H3	23.0	24.7	26.0	29.8	25.9	25.3	26.7	29.3	32.8	28.5
Means (B)	20.7	22.0	23.1	25.1		22.1	23.5	25.3	27.2	
L.S.D for 0.05	A= 0.4 B= 0.3 AB= 0.7					A= 1.0 B= 0.4 AB= 0.9				

H1 = Humic acid at 5 kg/ ha. H2 = Humic acid at 10 kg/ ha. and H3 = Humic acid at 15 kg/ ha.
SW = Salicylic acid (SW 1 = 200, SW2=300 and SW3=400 ppm)

Table 3: Effect of mineral, humic acid and seaweed extract treatments, as well as, their interactions on yield and yield components of black cumin plants during 2019/2020 and 2020/2021 seasons

Fertilization (A)	Seaweed extract (B) (B)									
	First Season					Second Season				
	Control	SW 1	SW 2	SW 3	Means (A)	Control	SW 1	SW 2	SW 3	Means (A)
	Capsules number/plant									
Control	60.0	61.7	62.3	64.3	62.1	62.0	63.3	65.3	67.3	64.5
NPK $_{RD}$	74.7	77.7	79.7	81.7	78.4	75.7	83.7	88.0	91.0	84.6
H1	64.3	66.0	67.7	69.0	66.8	65.3	70.0	72.7	75.0	70.8
H2	68.0	70.0	72.0	74.0	71.0	70.3	73.0	76.0	80.3	74.9
H3	76.0	79.7	82.0	84.3	80.5	78.3	86.7	90.3	93.0	87.1
Means (B)	68.6	71.0	72.7	74.7		70.3	75.3	78.5	81.3	
L.S.D for 0.05	A= 4.5 B= 1.1 AB= 2.5					A= 5.5 B= 1.5 AB= 3.4				
Seed yield g/ plant										
Control	16.4	17.6	19.7	21.2	18.8	17.4	19.6	20.7	22.0	19.9
NPK $_{RD}$	24.5	25.4	26.7	27.7	26.1	25.3	26.6	27.9	28.8	27.2
H1	22.2	22.8	23.8	24.8	23.4	21.9	23.1	24.2	25.3	23.6
H2	21.6	23.1	24.7	25.8	23.8	22.5	23.6	25.3	26.3	24.4
H3	25.2	26.4	27.7	28.8	27.1	26.0	27.4	29.5	31.0	28.5
Means (B)	22.0	23.1	24.5	25.7		22.6	24.1	25.5	26.7	
L.S.D for 0.05	A= 1.2 B= 0.4 AB= 0.9					A= 1.0 B= 0.3 AB= 0.7				
Seed yield ton/ ha.										
Control	1.578	1.693	1.894	2.035	1.800	1.670	1.878	1.984	2.109	1.910
NPK $_{RD}$	2.352	2.436	2.560	2.663	2.503	2.432	2.556	2.677	2.763	2.607
H1	2.134	2.192	2.289	2.379	2.249	2.106	2.221	2.321	2.425	2.268
H2	2.070	2.213	2.374	2.480	2.284	2.160	2.266	2.430	2.522	2.344
H3	2.422	2.534	2.662	2.768	2.597	2.496	2.630	2.832	2.976	2.734
Means (B)	2.111	2.214	2.356	2.465		2.173	2.310	2.449	2.559	
L.S.D for 0.05	A= 0.117 B= 0.037 AB= 0.083					A= 0.109 B= 0.030 AB= 0.067				

H1 = Humic acid at 5 kg/ ha. H2 = Humic acid at 10 kg/ ha. and H3 = Humic acid at 15 kg/ ha.
SW = Salicylic acid (SW 1 = 200, SW2=300 and SW3=400 ppm)

Table 4: Effect of mineral, humic acid and seaweed extract treatments, as well as, their interactions on fixed oil productivity of black cumin plants during 2019/2020 and 2020/2021 seasons

Fertilization (A)	Seaweed extract (B)									
	First Season					Second Season				
	Control	SW 1	SW 2	SW 3	Means (A)	Control	SW 1	SW 2	SW 3	Means (A)
	Fixed oil %									
Control	22.04	22.52	23.70	24.25	23.13	22.91	23.46	24.33	24.85	23.89
NPK RD	25.73	26.42	27.48	28.75	27.10	26.15	27.60	28.30	29.83	27.97
H1	22.70	23.18	24.37	23.37	23.41	23.57	24.12	25.00	24.24	24.23
H2	22.85	23.80	25.04	25.90	24.40	23.66	24.58	25.70	26.40	25.09
H3	24.32	25.32	26.25	26.58	25.62	24.98	25.88	26.90	28.02	26.45
Means (B)	23.53	24.25	25.37	25.77		24.25	25.13	26.05	26.67	
L.S.D for 0.05	A= 1.11 B= 0.40 AB= 0.90					A= 1.48 B= 0.33 AB= 0.74				
Fixed oil ml/ plant										
Control	3.62	3.96	4.67	5.12	4.34	3.98	4.58	5.02	5.43	4.75
NPK RD	6.30	6.69	7.32	7.97	7.07	6.61	7.34	7.88	8.57	7.60
H1	5.02	5.26	5.77	5.73	5.44	5.15	5.56	6.02	6.11	5.71
H2	4.92	5.46	6.15	6.65	5.80	5.31	5.77	6.48	6.90	6.11
H3	6.13	6.67	7.27	7.66	6.93	6.48	7.08	7.93	8.67	7.54
Means (B)	5.20	5.61	6.24	6.63		5.51	6.07	6.67	7.14	
L.S.D for 0.05	A= 0.24 B= 0.12 AB= 0.27					A= 0.50 B= 0.13 AB= 0.29				
Fixed oil l/ ha.										
Control	347.2	380.5	448.3	491.8	417.0	381.8	439.7	481.9	521.6	456.2
NPK RD	604.5	642.6	702.4	764.8	678.6	634.9	704.6	756.5	822.7	729.7
H1	481.9	505.0	553.9	549.8	522.6	494.7	534.1	577.9	586.6	548.3
H2	472.3	523.8	590.7	638.7	556.4	509.4	554.2	622.1	662.1	587.0
H3	588.2	640.6	697.9	735.0	665.4	622.4	679.7	761.6	832.3	724.0
Means (B)	498.8	538.5	598.7	636.0		528.6	582.5	640.0	685.1	
L.S.D for 0.05	A= 23.1 B= 11.8 AB= 26.4					A= 48.2 B= 11.4 AB= 25.4				

H1 = Humic acid at 5 kg/ ha. H2 = Humic acid at 10 kg/ ha. and H3 = Humic acid at 15 kg/ ha.
SW = Salicylic acid (SW 1 = 200, SW2=300 and SW3=400 ppm)

Concerning the interaction between mineral NPK_{RD} and seaweed extract treatments, data showed that the Fixed oil productivity of black cumin plants was enhanced as a result of this interaction in comparison with any treatment alone. The maximum value was obtained by the treatment NPK_{RD} and High concentration of seaweed extract in both season for fixed oil %, while the treatment of NPK_{RD} and Medium concentration of seaweed extract (300 ppm) resulted the maximum value for fixed oil ml/ plant and fixed oil l/ ha. in the second one.

3.4. Essential oil productivity

Table (5) pointed out that essential oil %, essential oil ml/plant and essential oil l/ ha. were significantly increased, in both seasons, due to the application of NPK_{RD} and humic acid at all tested rates over those of unfertilized plants. In both seasons, these features gradually increased in tandem with the humic acid level's progressive rise. Essential oil (%), essential oil / plant (ml) and essential oil / ha. (l) were increased by 21.1 and 20.0 % for essential oil %, by 80.0 and 64.3 % for essential oil ml/plant and essential oil l/ ha. in the two seasons due to the use of humic acid at 15 kg/ ha. in comparison with control plants. The role of organic manure in increasing oil yield parameters detected in this study was, also insured by [33,34] on basil, [35,36] on caraway (*Carum carvi* L.), [37] on anise and [38] on (*Mentha piperita* L.) [39]. These results also are consistent with those reported by [40]. Concerning seaweed extract treatments, significant differences were obtained, for essential oil %, essential oil ml/plant and essential oil l/ ha.in both seasons, due to both seaweed extract treatments, in comparison with control. In addition, high concentration (400 ppm) augmented such aspect by 15.8 and by 14.3 % for essential oil %, by 32.6 and by 32.7 % for essential oil / plant (ml) and essential oil / ha. (l) over control plants, during the two consecutive seasons, respectively as shown in Table (5).

Table 5: Effect of mineral, humic acid and seaweed extract treatments, as well as, their interactions on essential oil productivity of black cumin plants during 2019/2020 and 2020/2021 seasons

Fertilization (A)	Seaweed extract (B) (B)									
	First Season					Second Season				
	Control	SW 1	SW 2	SW 3	Means (A)	Control	SW 1	SW 2	SW 3	Means (A)
	Essential oil %									
Control	0.17	0.18	0.19	0.20	0.19	0.19	0.20	0.21	0.22	0.20
NPK RD	0.20	0.21	0.22	0.24	0.22	0.22	0.23	0.24	0.25	0.24
H1	0.18	0.19	0.20	0.21	0.19	0.20	0.21	0.22	0.23	0.21
H2	0.19	0.20	0.21	0.22	0.21	0.21	0.22	0.23	0.24	0.22
H3	0.21	0.22	0.23	0.24	0.23	0.23	0.24	0.25	0.26	0.24
Means (B)	0.19	0.20	0.21	0.22		0.21	0.22	0.23	0.24	
L.S.D for 0.05	A= 0.01 B= 0.003 AB= 0.007					A= 0.02 B= 0.002 AB= 0.005				
Essential oil ml/ plant										
Control	0.030	0.033	0.037	0.040	0.035	0.033	0.040	0.043	0.050	0.042
NPK RD	0.050	0.053	0.060	0.067	0.058	0.057	0.060	0.070	0.073	0.065
H1	0.040	0.043	0.047	0.050	0.045	0.043	0.050	0.050	0.060	0.051
H2	0.040	0.047	0.053	0.060	0.050	0.050	0.050	0.060	0.060	0.055
H3	0.053	0.060	0.067	0.070	0.063	0.060	0.067	0.070	0.080	0.069
Means (B)	0.043	0.047	0.053	0.057		0.049	0.053	0.059	0.065	
L.S.D for 0.05	A= 0.004 B= 0.003 AB= 0.007					A= 0.003 B= 0.002 AB= 0.005				
Essential oil l/ ha.										
Control	2.704	3.067	3.626	4.099	3.374	3.133	3.717	4.122	4.590	3.891
NPK RD	4.736	5.146	5.668	6.334	5.471	5.448	5.984	6.540	7.024	6.249
H1	3.835	4.147	4.553	4.967	4.376	4.170	4.620	5.059	5.528	4.844
H2	3.952	4.455	5.028	5.501	4.734	4.490	4.937	5.541	6.001	5.242
H3	5.116	5.607	6.159	6.766	5.912	5.672	6.243	7.001	7.653	6.642
Means (B)	4.069	4.484	5.007	5.533		4.582	5.100	5.652	6.159	
L.S.D for 0.05	A= 0.446 B= 0.103 AB= 0.231					A= 0.283 B= 0.095 AB= 0.213				

H1 = Humic acid at 5 kg/ ha. H2 = Humic acid at 10 kg/ ha. and H3 = Humic acid at 15 kg/ ha.
SW = Salicylic acid (SW 1 = 200, SW2=300 and SW3=400 ppm)

The primitive impact of biostimulants treatments on oil yield aspects revealed in this research was, also mentioned on coriander (Coria*ndrum sativum* L.) [40,41,42,43] on *Anethum graveolens*. The interaction between organic and mineral fertilization treatments was significant for essential oil productivity in both seasons, (Table 5). The highest values for the three traits were obtained when black cumin plants were supplied with humic acid at 15 kg/ ha. in combination with high concentration of seaweed extract (400 ppm).

4. Discussion

4.1. Humic acid effects

The superior plant growth by adding humic acid is attributed to its vital role in providing the plant with the macro- and micro-nutrients necessary to enhance the plant's metabolism and development. It can directly enhance growth of plant by accelerating photosynthesis and increasing nutrient and water absorption and plant productivity [44]. Furthermore, organic compounds are expected to raise chlorophyll levels in green plants, assisting in chlorosis resistance and photosynthesis, when added to soil, humic acid can offer defense against certain harmful compounds that hinder growth [45]. It's possible that humic acid's beneficial effects on growth are also caused by the optimal availability and delivery of nutrients from both organic and inorganic sources, which improved nutrient uptake and accelerated plant growth [46], humic acid plays a part in the synthesis of compounds that can influence plant growth, such as growth regulators or analogues of plant hormones [47]. Humic acid has a positive influence on the formation of essential oils because it directly affects the solubilization and transport of nutrient elements, which improve vegetative growth characteristics and are crucial for

the synthesis of plant constituents like essential oil. a better herb yield and, by extension, a higher essential oil output might result from these ingredients being sufficiently available by [48].

4.2. Seaweed extract effects

Seaweed extract is a fantastic source of trace elements like iron zinc, manganese and copper, as well as several primary nutrients like phosphorus and potassium and secondary nutrients like magnesium and calcium, as well as advantageous elements like nickel and salt. A variety of ailments that are either incurable or infrequently cured by modern medical systems are treated with herbal extracts. The health and healing of almost 80% of the world's population is dependent on medicinal plants [49]. Seaweed extract improves and controls the physiological functions of the crops. Through a variety of mechanisms, it affects plant physiology to enhance nutrient uptake, yields, quality, and resistance to abiotic challenges in crops as noticed by [30,50,51,52]. In actuality, natural growth regulators found in algae extracts actually postpone the plant's entry into the aging stage. They also stop harvesting, flowering, and leaf fall. Because of the way they affect protein, they also stop yellowing. They stop the breakdown of chlorophyll and conserve it. They promote root growth and induce cell division. It is among the most significant scientific reasons for how algae extracts affect the productivity and development of numerous commercial plants [53]. Moreover, seaweed contain natural phenols like tannins that function similarly to natural growth hormones. They also help plants produce more lignin, which makes them more disease-tolerant. In a similar vein, they facilitate faster nutrient absorption because they include alginic acid, a naturally occurring chelating agent that chelates nutrients with a soil solution. They additionally include many vitamin types, such as C, B1, B2, and B12. Because seaweed contain free amino acids which promote balanced, productive development and enhance the plant's response to fertilization, they function as both natural antibiotics and growth regulators within the plant [54]. Seaweed extracts can be used directly as organic fertilizers by adding them to the soil or foliar treatment to enhance and improve productivity, quality and its metabolites. [55]. the increments in growth aspects, seed yield and oil production due to using biostimulants which have been studied by [56].

5. Conclusions

The results of this study show that when fertilizer was applied at a high level (15 kg/hectare), the maximum values of the characteristics under study (growth traits, yield, oil production and its components) were listed. When compared to untreated plants, foliar spraying with seaweed extract at 400 ppm also boosted the quantities of main components. The usage of humiv acid levels and biostimulant (seaweed extract concentrations) applications also had an impact on fixed and volatile oil production in comparison to control, plants sprayed with seaweed extraction at 400 ppm and the higher level humic acid (15 kg/ hectare) often produced larger value of plant productivity.

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