Scientific J. Flowers & Ornamental Plants
www.ssfop.com/journal
ISSN: 2356-7864 **doi: 10.21608/sjfop.2024.305812.1032**

EFFECT OF PLANTING DATE AND FOLIAR APPLICATION OF HUMIC ACID ON VEGETATIVE GROWTH, YIELD, AND FIXED OIL OF BLACK CUMIN PLANTS

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Scientific J. Flowers & Ornamental Plants, 11(1):17-26 (2024).

Received:
1/2/2024
Accepted:
1/3/2024

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ABSTRACT: An experiment was established to study the influence of humic acid (HA) application at different rates (0, 1.5, 3.0 and 4.5 g/l) on vegetative characters and the production of black cumin (*Nigella sativa* L.) sown on three different dates (15th Oct., 1st and 15th Nov.). The plants cultivated on the first date (15th October) gave the best results compared to the late dates concerning plant height (61.54 and 55.34 cm), branch number/plant (4.42 and 3.62), stem diameter (5.71 and 4.42 mm), number of capsules/plant (18.10 and 16.75), seed yield/plant (8.70 and 8.92 g), total seed yield/feddan (464.03 and 475.38 kg), fixed oil percentage (19.88 and 17.28 %), fixed oil/plant (1.76 and 1.59 ml), fixed oil/feddan (93.88 and 84.52 l), chlorophyll a (0.57 and 0.57 mg/g), chlorophyll b (0.30 and 0.75 mg/g) and carotenoids (0.32 and 0.43 mg/g) during both seasons respectively. Foliar application of HA in medium rate (3 g/l) gave the best productivity of the same previous parameters compared to the lower and higher rates: plant height (58.46 and 53.33 cm), branch number/plant (3.90 and 3.65), stem diameter (5.57 and 5.00 mm), number of capsules/plant (14.94 and 14.67), seed yield/plant (8.26 and 9.13 g), total seed yield/feddan (440.62 and 486.70 kg), fixed oil percentage (26.63 and 23.30%), fixed oil/plant (2.20 and 2.11 ml) and fixed oil/feddan (117.26 and 112.67 l) during both seasons respectively. The application of humic acid in the medium concentration on black cumin sown in mid-October seems to be the best interaction for getting higher seed yield and a high percentage of fixed oil.

Keywords: Climate change, plants, *Nigella sativa*, sowing date, humic acid, fixed oil

INTRODUCTION

Black cumin (*Nigella sativa* L.) plant is an annual herbaceous plant belonging to the Ranunculaceae family. Seeds have two types of oil; the first is dark-colored fragrant and volatile, the second is clearer and more fixed and it takes the majority percent of oil percentage. From a medical point of view, the two oils have benefits. They are aromatic, antiseptic, stomachic and digestive. Also, the seeds are diuretic, digestive, carminative, emmenagogues, and effective against intestinal worms and flatulence (Gupta, 2010). The fixed oil of black cumin seeds has linoleic, oleic, and palmitic acids. The mainstream fatty acid is linoleic acid, which is a necessary fatty acid and it more than 50% of the total fatty acids in the fixed oil of black cumin (Atta, 2003). The original habitat of the plant is South Europe, North Africa, and Southern West of Asia (Atta, 2003).

Choosing an appropriate sowing date has an important role in plant growth. Due to this, capable environmental conditions give the

highest production. On the other hand, the planting date plays a significant role in seed productivity through affecting the diseases and pests, harvest time, and the quality of the product. In very premature sowing, the low degree of land and the frost led to a soft increase in the growth of plants in spring. Furthermore, very belated sowing causes a decrease in the plant yield and the scope of agreement at the flowering period since rising degrees leads to an effect on the vegetative characters of sown plants. Choosing the best date for farming is one of the most significant operators of agricultural production to gain maximum benefits from input sources through the accretion time (Safaei *et al.*, 2017). Appraisal of planting time effect on crop, yield characters and development of black cumin was estimated by Saddam *et al*. (2012). Three farming times (1st October, 1st November and 1st December) were tested, which significantly affected the seed yield. The early planting time significantly maximized the yield production, branches number/plants, capsules number/plants and plant height. On fennel plants, the percent of boost production and biological harvest on 1st Oct. obtained as 34.4 and 32.2%, in the first and second seasons compared to 1st Dec. (Saddam *et al.*, 2012). A trial was done by Kiran *et al.* (2019) to show the influence of sowing time on growth, yield, and quality of *Nigella sativa*. The plants were sown on four dates (1st Oct., 15th Oct., 30th Oct. and 15th Nov.). They declared that sowing on 1st Oct. resulted in the maximum biological yield and seed yield/plant. Sultana *et al.* (2018) did a field experiment to clear the influence of sowing date on black cumin. the plants were sown on four dates (mid-September, end of September, mid-Oct., and early Nov.). They found that black cumin plant gave the highest production when it was sown in mid-Oct. compared to other planting times.

The organic farming technique is a way to replace the conventional agriculture system which causes the sustainability of the environmental sources and verdure preservation. The globe is significantly concerned with the productivity of medicinal and aromatic plants because of increasing the necessity of outputs of these important crops, particularly those that are sown in the organic farming technique (Safaei *et al.*, 2014). The application of organic agriculture system improves land natural parameters like structure and aggregation. Also, it improves soil alchemical characteristics such as soil pH and cation exchange capacity in addition to enhancing the simplification of a lot of elements, this is necessary for plant development and oil harvest (Snyman *et al.*, 1998). Using traditional chemicals causes the depletion of soil resources and deterioration of its properties, therefore the use of an organic technique system with districted application of conventional technique shows the best yield (Anwar *et al.*, 2005). HA is discovered in the soil composition of the organic part naturally. The compound can resolve in water. HA maximizes plant accretion, harvest, and elements absorption (Aiyafar *et al.*, 2015). Humic acid

Humic acid is regarded as one of the most important ingredients of humate. It is used as an optimizer of plant development for improving plant yield and stress resistance (Piccolo *et al.*, 1992; Albayrak and Camas, 2005). A field experiment was conducted on fennel plants by Zulfiqar *et al.* (2019) to study the influence of humic acid on fennel plants. Plants were treated with HA at three rates (0,1, 2 and 3 g/l). The results cleared that the rate of 3 g/l produced the best plant height, number of branches per plant, fresh weight, and dry weight. Ariafar and Forouzandeh (2017) performed a field experiment to examine the influence of humic acid addition on the growth and production of *Nigella sativa* plants under a restricted irrigation system, humic acid was added as a soil drench at 3 rates (0, 1, 2 and 3 kg/ha). They suggested that using humic acid has a significant effect on the vegetative growth of black cumin and seed yield. The best data regarding plant height (19.84 cm) and the number of leaves per plant (12.2) were gained from the addition of humic acid at 3 kg/ha. According to the Ministry of Agriculture of Egypt, 89% of medical crops are planted in strategic soils.

On the other hand, just 9% of the land is sown with these crops where the land and ecology are appropriate for farming them (Hassanein, 2009).

So, this experiment seeks to assess the productivity of *Nigella sativa*, which is one of the most economically profitable medicinal and aromatic crops, in new reclaimed land depending on the organic technique and to study the impact of climate change as grown under different planting times. This study aimed to estimate the effect of changed planting date and/or various rates of HA (humic acid), moreover, the interaction of planting time and HA on plant parameters, harvest, and oil result for black cumin (*Nigella sativa* L.) plants which was planted under new reclaimed land.

MATERIALS AND METHODS

This current trial was done in the plantation of the Faculty of Agriculture, Sohag University, Sohag, Egypt through two successive seasons of 2017/2018 and 2018/2019.

The seeds of black cumin were brought from the local market and were planted at 3 various times: 15th Oct., 1st Nov. and 15th Nov. for the two agricultural seasons. A dripping irrigation system was employed, where the space between pipes was 50 cm and between drippers was 35 cm. The watering time was every day for one hour during the first 7 days after seed sowing, then was decreased for 20 min/2 days until 15th March when the watering period was extended to 40 min/2 days. Water was prevented for one week prior to crop harvest. Soil chemical and physical characteristics of the planted region were analyzed at the Department of Soils and Water, Faculty of Agriculture, Sohag University following Black *et al*. (1965) and Jackson (1973) as cleared in Table (1). The metrological data of the experimental location were gained from the Station of Meteorological in Sohag Province as shown in Table (2). The present trial was performed in a split-plot scheme by using 3 replicates. Every plot had eighteen black cumin plants that came through planting various seeds next to the drippers. Two weeks after the first appearance of plants, the plants were thinned out to two seedlings per every dripper. The main plots comprised three different times of planting: 15th Oct., 1st Nov. and 15th Nov. On the other hand, the sub-plots had the foliar application with humic acid (HA) in three rates: control (tap water) in addition to 3 concentrations of HA; 1.5, 3, and 4.5 g/l. The application of HA began 45 days after seed sowing and was repeated six times every 15 days during the growing season. Humic Acid was bought from the Agro Care Egyptian Company. Its properties were: 70% Humate potassium, 5% fulvic acid and 10% potassium dioxide. Black cumin was treated with the the recommended dose of a 20-20-20 NPK foliar fertilizer which was obtained from Shoura Chemicals Egyptian Company. It was applied at a rate of 3 g/l water, as a foliar spray to all sown plants 50 days after planting and was repeated 4 times every 15 days. At the harvest time, in May of both seasons, black cumin plants were collected in the morning, where capsules became clearly less soft and greenish yellow color.

All development parameters, flowering, productivity, oil percentage, and the properties of oil were estimated. A sample of ten plants was taken randomly and was collected carefully from the middle of each plot. The results were taken for plant length, number of branches/plant, diameter of the main stem, capsules number/plants, seed yield/plant, seed yield/feddan, percentage of fixed oil and yield of fixed oil as well as the concentration of chlorophyll a, chlorophyll b and carotenoids. A sample of 3 g ground seeds was used to extract fixed using n-hexane (50 ml) by a Soxhlet extractor at 70 °C for 6 hours. By the end of the operation, the hexane-oil extract was passed through a layer of anhydrous magnesium sulfate placed over filter paper in a funnel. The solvent was evaporated under vacuum by a rotary evaporator at 40 °C. The weight of resulted oil was recorded and was stored at 4 °C.

Table 1. Properties of the soil used at the beginning of the experiment (average of both seasons).

Particle size distribution (%)								Soluble ions (mg/kg, soil)									
								Anions			Cations						
Sand	Silt	clay	Texture grade	pH (1:2.5) soil suspension	EC. dS /m (1:5) soil extract	Total $CaCO_3$ (%)	Organic matter (%)	Cl^-	$CO_3^=$	HCO_3^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+	K^+	NH_4-N	NO_3-N
79.67	4.77	15.56	Sandy loam	7.83	4.31	6.72	0.75	1242	-	3050	240	460	440	3100	105	210	490

Table 2. The mean of metrological values every month for the research farm through first and second seasons.

Months	First season (2017/2018)				Second season (2018/2019)			
	Air temperature (°C)			Average relative humidity (%)	Air temperature (°C)			Average relative humidity (%)
	Max	Min	Average		Max	Min	Average	
October	30.00	16.38	23.18	45.91	32.44	18.64	25.54	45.01
November	24.72	10.69	17.70	52.84	26.24	12.48	19.36	51.28
December	22.8	8.71	15.75	56.35	20.54	7.89	14.21	60.32
January	19.61	6.25	12.93	55.46	19.01	6.14	11.94	55.20
February	25.73	11.09	18.41	43.84	21.44	7.97	14.40	53.31
March	30.32	13.98	22.15	37.23	24.46	10.00	17.22	45.63
April	32.11	16.41	24.25	37.70	29.53	14.14	21.57	38.77
May	37.46	21.51	29.48	29.62	37.34	22.33	29.78	30.18

The content of Chlorophyll a, b and carotenoids was estimated as the acetone incubation way shown by Krishnan *et al*. (1996). A 100 mg sample of shredded leaves was put in a graduated tube containing 25 ml of 80% acetone. The tubes were tightly closed and stored under dark conditions at 4±2 °C for 48 h with occasion shaking. The resulting liquid was filtered through glass wool to get rid of the leaf pieces and was transferred to another tube. Then the liquid extract was increased to a volume of 25 ml with 80% acetone.

The chlorophyll content was spectrophotometrically measured, in a UV visible spectrophotometer machine (Optizen Pop, Mecasys - Korea) by using 3 ml closed quartz-glass curettes with a path length of 1 cm. The absorbance was recorded at 663, 645 and 470 nm wavelength and then the chlorophylls and carotenoids content were calculated as mg/g fresh weight following the equations cited in Dere *et al*. (1998):

Chlorophyll a = 11.75 A_{663} - 2.350 A_{645}

Chlorophyll b = 18.61 A_{645} - 3.960 A_{663}

Carotenoids = 1000 A_{470} - 2.270 Chlorophyll a - 81.4 Chlorophyll b/227

Results were subjected to statistical analysis by the "F" Test (Snedecor and Cochran, 1989), and L.S.D. test for the comparison between treatments and averages done according to Steel and Torrie (1982).

RESULTS AND DISCUSSION

Results introduced in Tables (3, 4, 5 and 6) cleared that planting time has a significant effect on the plant height, number of branches/plant, diameter of the stem, number of capsules/plant, seed yield/plant, seed yield/feddan, fixed oil percentage, fixed oil yield, chlorophyll a, b, and carotenoids

Table 3. Influence of the three planting dates and foliar application of humic acid on plant height, number of branches/plant and stem diameter of black cumin through 2017/2018 and 2018/2019 seasons.

Sowing dates	Humic acid (g/l)	Plant length (cm)		Number of branches/plant		Diameter of stem (mm)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
15th October	Control	58.00	50.02	4.11	2.61	5.18	3.66
	1.5	62.87	56.05	4.54	3.40	5.94	4.45
	3.0	63.02	59.00	4.59	4.70	6.04	4.84
	4.5	61.28	56.30	4.42	3.78	5.69	4.73
Mean		61.54	55.34	4.42	3.62	5.71	4.42
1st November	Control	54.04	52.05	3.78	2.78	5.60	4.99
	1.5	60.64	53.81	4.43	3.07	5.89	5.15
	3.0	62.02	54.33	4.47	3.10	5.95	5.18
	4.5	56.81	52.51	4.43	2.81	5.86	5.08
Mean		58.38	53.18	4.28	2.94	5.83	5.10
15th November	Control	47.82	43.73	2.38	3.01	4.15	4.62
	1.5	49.30	44.65	2.60	3.13	4.40	4.77
	3.0	50.33	46.65	2.65	3.16	4.73	4.98
	4.5	50.70	46.76	2.84	3.29	4.84	4.87
Mean		49.54	45.45	2.62	3.15	4.53	4.81
Means of humic acid treatments	Control	53.29	48.60	3.42	2.80	4.98	4.42
	1.5	57.60	51.50	3.86	3.20	5.41	4.79
	3.0	58.46	53.33	3.90	3.65	5.57	5.00
	4.5	56.26	51.86	3.90	3.29	5.46	4.89
LSD 0.05	Sowing	3.76	3.86	0.29	0.34	0.11	0.48
	Humic acid	2.90	2.13	0.19	0.21	0.16	0.34
	Interaction	5.69	4.96	0.41	0.50	0.26	0.69

Table 4. Influence of the three planting dates and foliar application of humic acid on capsules number/plant, yield/plant (g) and sum yield/fed (Kg) of black cumin through 2017/2018 and 2018/2019 seasons.

Sowing dates	Humic acid (g/l)	Capsules number/plant (cm)		Seed yield/plant (g)		Seed yield/fed (kg)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
15th October	Control	13.73	10.96	7.76	7.72	413.94	411.47
	1.5	21.33	15.67	8.76	9.35	467.38	498.59
	3.0	18.59	18.83	9.65	9.97	514.67	531.67
	4.5	18.74	21.55	8.63	8.62	460.13	459.80
Mean		18.10	16.75	8.70	8.92	464.03	475.38
1st November	Control	12.59	12.79	7.20	7.91	383.96	421.92
	1.5	14.75	8.88	7.75	8.95	413.36	477.50
	3.0	14.83	13.68	7.99	9.33	426.15	497.35
	4.5	12.61	12.14	7.60	8.41	405.33	448.61
Mean		13.70	11.87	7.64	8.65	407.20	461.35
15th November	Control	6.67	9.45	6.75	6.82	360.02	363.90
	1.5	8.11	8.21	6.77	7.66	361.06	408.51
	3.0	11.40	11.50	7.14	8.08	381.05	431.07
	4.5	7.92	9.49	6.87	7.46	366.66	397.90
Mean		8.53	9.66	6.88	7.51	367.20	400.35
Means of humic acid treatments	Control	11.00	11.07	7.24	7.48	385.97	399.10
	1.5	14.73	10.92	7.76	8.65	413.93	461.53
	3.0	14.94	14.67	8.26	9.13	440.62	486.70
	4.5	13.09	14.39	7.70	8.16	410.71	435.44
LSD 0.05	Sowing	2.27	3.13	0.47	1.23	25.11	N.S.
	Humic acid	0.90	0.92	0.30	0.27	16.04	14.25
	Interaction	2.61	5.14	0.64	1.28	34.45	N.S.

Table 5. Influence of the three planting dates and foliar application of humic acid on fixed oil percentage, fixed oil yield/ plant and fixed oil yield/fed of black cumin through the 2017/2018 and 2018/2019 seasons.

Sowing dates	Humic acid (g/l)	Fixed oil (%)		fixed oil yield/plant (ml)		fixed oil yield/fed (l)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
15th October	Control	15.47	11.68	1.20	0.90	64.10	47.77
	1.5	19.67	19.76	1.73	1.87	92.41	99.60
	3.0	27.07	22.76	2.61	2.27	139.40	121.33
	4.5	17.30	14.92	1.49	1.30	79.61	69.36
Mean		19.88	17.28	1.76	1.59	93.88	84.52
1st November	Control	16.56	13.48	1.19	1.08	63.71	57.43
	1.5	24.54	18.77	1.90	1.69	101.42	90.02
	3.0	26.83	19.40	2.14	1.82	113.89	97.33
	4.5	20.93	14.99	1.59	1.27	84.86	67.65
Mean		22.22	16.66	1.71	1.47	90.97	78.11
15th November	Control	14.01	13.97	0.94	0.96	50.26	51.41
	1.5	20.18	20.12	1.37	1.54	72.88	82.12
	3.0	25.98	27.75	1.85	2.24	98.48	119.35
	4.5	15.27	17.16	1.05	1.28	56.05	68.42
Mean		18.86	19.75	1.30	1.51	69.42	80.33
Means of humic acid treatments	Control	15.35	13.04	1.11	0.98	59.36	52.20
	1.5	21.46	19.55	1.67	1.70	88.90	90.58
	3.0	26.63	23.30	2.20	2.11	117.26	112.67
	4.5	17.83	15.69	1.38	1.28	73.51	68.48
LSD 0.05	Sowing	2.13	1.95	0.12	0.11	6.76	5.14
	Humic acid	3.39	2.81	0.28	0.25	14.83	13.43
	Interaction	5.50	4.98	0.44	0.40	23.19	22.08

Table 6. Influence of the three planting dates and foliar application of humic acid on chlorophyll a, chlorophyll b and carotenoids of black cumin through 2017/2018 and 2018/2019 seasons.

Sowing dates	Humic acid (g/l)	Chlorophyll a (mg/g)		Chlorophyll b (mg/g)		Carotenoids (mg/g)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
15th October	Control	0.49	0.46	0.25	0.64	0.35	0.51
	1.5	0.60	0.58	0.28	0.87	0.32	0.40
	3.0	0.63	0.61	0.33	0.75	0.30	0.36
	4.5	0.57	0.61	0.32	0.73	0.32	0.45
Mean		0.57	0.57	0.30	0.75	0.32	0.43
1st November	Control	0.51	0.53	0.25	0.74	0.34	0.32
	1.5	0.54	0.74	0.26	1.05	0.33	0.31
	3.0	0.65	0.64	0.34	0.85	0.30	0.29
	4.5	0.50	0.59	0.26	0.85	0.33	0.29
Mean		0.55	0.63	0.28	0.87	0.33	0.30
15th November	Control	0.43	0.81	0.23	0.33	0.36	0.35
	1.5	0.47	1.02	0.24	0.42	0.32	0.28
	3.0	0.53	0.91	0.25	0.53	0.30	0.28
	4.5	0.48	0.88	0.22	0.54	0.30	0.30
Mean		0.48	0.91	0.24	0.45	0.32	0.30
Means of humic acid treatments	Control	0.48	0.60	0.24	0.57	0.35	0.39
	1.5	0.54	0.78	0.26	0.78	0.32	0.33
	3.0	0.60	0.72	0.31	0.70	0.30	0.31
	4.5	0.51	0.69	0.27	0.70	0.32	0.35
LSD 0.05	Sowing dates	0.10	0.05	0.04	0.17	0.01	0.12
	Humic acid	0.09	0.07	0.02	0.12	0.02	0.10
	Interaction	0.18	N.S.	0.05	0.25	0.04	N.S.

content in leaves in the two planted seasons. Of the three tested sowing dates, the premature date (15th Oct.) gave the best results concerning all parameters of vegetative characteristics, yield, fixed oil yield and chlorophylls a & b, and carotenoids content. Those plants grown on 1st Nov. significantly have better characteristics than those sown on 15th Nov. at most of the recorded parameters. For instance, those plants sown on 15th Oct. gave 49.54 and 45.45 cm for plant height, in the two seasons respectively, and had. best branches (4.42 and 3.62) in the two seasons respectively. Also, 15th Oct. date gave a significant result regarding plant stem diameter (5.71 and 4.42 mm) for both seasons. Number of capsules, as an important yield characteristic, also showed significant differences and it was enhanced by early sowing time (18.10 and 16.75 for two sown years, respectively). The early planting date on 15th Oct. significantly resulted in best crop yield/plant (8.70 and 8.92 g), and sum crop yield/feddan (464.03 and 475.38 kg), in the two seasons, respectively. Fixed oil yield/plant recorded 1.76 and 1.59 ml. on 15th Oct. compared to 22.22 and 16.66 ml for 1st Nov. and 18.86 and 19.75 ml for 15th Nov. for the two seasons, respectively. But yield that was collected from the 15th of Nov. date was estimated that it has overcome in the fixed oil percentage followed by 15th Oct. sown plants.

The present trial cleared that changing the planting date in combination with the foliar spray application of HA has an effect on black cumin growth, yield and fixed oil content. The collected data exhibited a significant influence for planting time on plant development parameters which were greatly enhanced by the early planting date on 15th Oct.

Due to the variation in planting dates, all growth parameters of black cumin were impacted positively or negatively. The influence of planting date is related to climatic conditions like temperature and relative moisture which are shown in Table (2). It is clear that the environmental conditions that best suit the growth of black cumin are those recorded on 15th Oct. This could explain the enhanced growth and productivity of black cumin plants cultivated in mid-October. Inferior results of the vegetative and yield characteristics of black cumin plants cultivated during the two late seasons provide a clear indication of the sensitivity of this important medicinal crop to the accelerating change in climate conditions. Various experiments have been conducted in several parts of the world and they ensured that the early sowing dates had a significant chance for gaining better vegetative growth in terms of quantities and qualities, which were attributed to the more appropriate environmental conditions and, therefore, led to better seed weight/plant (El-Khayat and Gouda, 2005: Sudeep *et al.* 2005). Giridhar *et al.* (2017) investigated the effect of planting dates on the growth of black cumin. The experiment was performed on different dates, 1st fortnights of Oct., 2nd fortnight of Oct., 1st fortnight of Nov., 2nd fortnight of Nov. and 1st fortnight of December. They indicated that the delay in sowing caused a reduction in all recorded parameters (plant height, seed yield/plant, fixed oil percentage and chlorophyll).

The foliar spray application of HA showed a positive influence on plant height, number of branches/plant, stem diameter, umbels number /plant, seed yield /plant, seed yield/feddan, fixed oil percentage, fixed oil yield, chlorophyll a, chlorophyll b and carotenoids content in the leaves for the both growing seasons. Furthermore, the application of HA at 3 g/l produced better plant heights (58.46 and 53.33 cm) for the two seasons, respectively) compared to the control, 1.5 and 4.5 g/l. The same dose had the same effect on number of branches /plants, diameter of stem and umbels number/plant. The same concentration of HA gave also the highest yield of fixed oil/plant and fixed oil yield/feddan for the two seasons compared with the 0, 1.5 and 4.5 g/l. Meanwhile, when the highest concentration of HA was applied, it led to a significant prevalence in some parameters like seed yield/plant (29.19 and 32.80 g through the two seasons) and the sum

yield/feddan (440.62 and 486.70 kg through two seasons).

HA is one of the natural compounds with H^+ sites linked with carboxyl acid of phenolic and benzoic (cation exchange positions). It is a natural macromolecule compound resulting from alchemical and bacterial episodes in the soil. Composed as a result of moisturization, is proportional great weight of molecular of spot acid starting 104 to 106 Dalton, also its molecular weight is formed of carbon at a rate 50%. HA has its frontal significant influence on leaves raise (Ariafar and Forouzandeh, 2017). According to a study conducted by Russo and Berlya (1990), HA is the largest compound of organic naturals in soil, and it increases plant growth by increasing photosynthesis, respiration, root lengthening, and nutrient absorption. This supports the findings of the current study and provides an explanation for the improvement in growth and productivity recorded in black cumin plants treated with HA. A field experiment was conducted on black cumin plants by Mazrou (2019) to assess the impact of HA on vegetative parameters and seed yield of black cumin. Plants were foliar sprayed with humic acid at 100, 200 and 400 mg/l. They found that the application of 200 mg/l resulted in the best vegetative growth parameters (plant height, branch number/plant, fresh weight, dry weight, seed yield and chlorophyll content in leaves). In another trial on coriander, humate potassium containing 65% HA was tested as a foliar spray at 0, 1, 2 and 3 g/l. The results showed that the application of HA at 3 g/l led to the best results regarding plant height, numbers of branches/plant, fresh weight/plant, dry weight/plant, umbels number/plants, and yield/plant compared to the untreated plants (control) (Abou-Sreea *et al.*, 2017).

In the current study, the combined treatment of spray application of HA and planting date significantly affected the studied parameters for black cumin in the two seasons. The best results were recorded in the plants cultivated on 15th Oct. and treated with HA at 3 g/l. The same combined treatment also led to the highest fixed oil content in black cumin seeds.

Ultimately, this study ensured that early planting of black cumin (15th Oct.) combined with the application of HA at the medium rate (3 g/l) is better to be recommended for planting black cumin in newly reclaimed soil in Sohag Province and alike conditions.

CONCLUSION

A significant difference in impact was recorded among the different sowing dates and the concentrations of humic acid used as well as within their combined treatments. Sowing black cumin seeds in mid-October led to improvement in all growth, yield and fixed oil measurements. In general, early sowing of black cumin seeds in mid-October with together with the application of a medium concentration of humic acid (3.0 g/l) can be recommended for the cultivation of black cumin.

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تأثير مواعيد الزراعة والرش الورقي بحامض الهيوميك على النمو الخضري والمحصول والزيت الثابت لنبات حبة البركة

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أجريت تجربة حقلية لتقييم تأثير تراكيز من حامض الهيوميك (٠، ١,٥، ٣,٠ و ٤,٥ جم/لتر) على نمو وإنتاجية نبات حبة البركة خلال موسمين متتاليين ٢٠١٨/٢٠١٧ و٢٠١٩/٢٠١٨. سجل التاريخ المبكر (١٥ أكتوبر) أفضل النتائج فيما يتعلق بارتفاع النبات (٦١,٥٤ و٥٥,٣٤ سم)، عدد الفرع/نبات (٤,٤٢ و٣,٦٢)، قطر الساق (٥,٧١ و٤,٤٢ ملم)، عدد الكبسولات/نبات (١٨,١٠ و ١٦,٧٥)، وزن البذور/نبات (٨,٧٠ و٨,٩٢ جم)، إجمالي إنتاج محصول البذور/فدان (٤٦٤,٠٣ و٤٧٥,٣٨ كجم)، نسبة الزيت الثابت (١٩,٨٨ و١٧,٢٨٪)، كمية الزيت الثابت/نبات (١,٧٦ و١,٥٩ مل)، كمية الزيت الثابت / فدان (٩٣,٨٨ و ٨٤,٥٢ لتر)، كلوروفيل أ (٠,٥٧ و ٠,٥٧ ملجم / جم)، كلوروفيل ب (٠,٣٠ و ٠,٧٥ ملجم / جم) والكاروتين (٠,٣٢ و ٠,٤٣ ملجم / جم) خلال الموسمين على التوالي. أعطى الرش الورقي بحامض الهيوميك بتركيز متوسط (٣ جم/لتر) أعلى إنتاجية لنفس الصفات السابقة: ارتفاع النبات (٥٨,٤٦ و٥٣,٣٣ سم)، عدد الفرع/نبات (٣,٩٠ و٣,٦٥)، قطر الساق (٥,٥٧ و٥,٠٠ ملم)، عدد الكبسولات/نبات (١٤,٩٤ و١٤,٦٧)، إنتاجية الكابسولات/نبات (٨,٢٦ و٩,١٣ جم)، إجمالي إنتاجية محصول البذور/فدان (٤٤٠,٦٢ و٤٨٦,٧٠ كجم)، نسبة الزيت الثابت (٢٦,٦٣ و٢٣,٣٠٪)، كمية الزيت الثابت/نبات (٢,٢٠ و ٢,١١ مل) وكمية الزيت الثابت/فدان (٩٣,٨٨ و ٨٤,٥٢ لتر) خلال الموسمين على التوالي. المعاملة بحامض الهيوميك لاتركيز المتوسط لنباتات حبة البركة المنزرعة فى منتصف أكتوبر كانت هى أفضل توليفة أعطت أفضل محصول بذور وأعلى نسبة زيت ثابت.