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IMPACT OF DIFFERENT PLANTING LOCATIONS ON *NIGELLA SATIVA* L. YIELD IN EGYPT

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Climate change could negatively impact black cumin (*Nigella sativa*) cultivation, changing the crop's characteristics. Thus, the farming of new expanses was necessary. As a result, this research was carried out in Egypt to determine the effect of newly reclaimed regions on production. The study was conducted in four desert locations: El-Hammam, Matrouh Governorate; Oraby Association, Al-Eubour, Qalyubia Governorate; Tour Sinai, South Sinai Governorate; and the western desert hinterland, Minya Governorate. The results revealed that all ecosystems significantly affected growth and yield traits. The highest plant height, fresh and dry weights per plant, capsule numbers per plant, seed yield, and fixed oil per unit area were from the governorates of Minya, followed by South Sinai, Qalyubia, and Matrouh, respectively. The highest content of unsaturated fatty acids and the lowest concentration of saturated fatty acids were from the governorates of Matrouh, followed by Minya, Qalyubia, and South Sinai, in that order. Based on the quantity and quality characteristics, the study recommended cultivating black cumin in newly reclaimed lands in the western desert hinterland of Minya Governorate, then South Sinai Governorate, as new areas for this crop's production.

Keywords: black cumin, locations, seeds yield, fixed oil yield, fatty acids

INTRODUCTION

Nigella sativa, also known as black seed and black cumin, is a plant in the Ranunculaceae family that has been used for thousands of years as a spice, food preservative and medicinal for various ailments. It was used in ancient Egypt and originated in Southeast Asia, Greece, the Middle East, and Africa. In medical history, "Islamic medicine" is the medicine that emerged from the Middle East. Scientists believed that black seed could cure all illnesses except death. Modern medicine has demonstrated that the seeds are high in antioxidants and anti-inflammatory compounds. They can also improve immune system function and help treat fatigue, headache, cough, diarrhea, stomach ulcers, kidney dysfunction, and liver problems. They can help the metabolic and cardiovascular systems stay healthy. Fixed oil is the most important product extracted from seeds (Ramadan, 2020 and Khan and Rehman, 2021).

N. sativa fixed oil consumption has been linked to various beneficial health effects. They aid in the treatment of a variety of diseases due to their high concentration of antioxidants. Furthermore, this oil can help people reduce their body mass index, lower their blood sugar levels, lower their blood pressure and cholesterol levels, maintain the health of their brains, and improve the appearance and health of their skin and hair. The oil has additional potential benefits, such as its anti-cancer properties, ability to alleviate rheumatoid arthritis symptoms, and potential to improve sperm quality in men diagnosed with infertility. These are just a few of the potential advantages of using oil. Besides that, studies have shown that it has antimicrobial properties. This oil is high in unsaturated fatty acids such as linoleic acid and oleic acid, which benefit one's health. Unsaturated fatty acids are called "good" fats because they can lower blood cholesterol, reduce inflammation, stabilize heart rhythms, and do other vital things (Schleicher and Saleh, 2000; Dhull et al., 2020 and Tiji et al., 2021).

Malaysia is the biggest exporter of black cumin oil, making up 42.46% of the global market, followed by Indonesia (15.81%), China (6.70%), the Netherlands (6.59%), Germany (5.25%), Sweden (2.66%), India (1.91%), the United States (1.86%), Russia (1.81%), and Spain (1.69%). Today, global production of black cumin oil may fall in numerous countries due to the harmful effects of climate change on plant growth. Because of drought, heat waves, flooding, and increased pests, yield and quality may decrease. The influence of global climate change has been unevenly distributed due to changes in temperature, precipitation, and atmospheric carbon dioxide levels. Climate change has impacted the Middle East region (Omran and Negm, 2020 and https://www.tridge.com/intelligences/black-cumin-seed-oil/export).

Khalid and Shedeed (2014) found that black cumin was affected by salinity in a way that lowered specific growth parameters and fixed oil. According to Bayati et al. (2020), drought decreased seed output and affected fatty acid composition. The proportions of saturated and polyunsaturated fatty acids grew while those of monounsaturated fatty acids declined as the drought worsened. However, the rise in polyunsaturated fatty acids was significantly higher than the increase in saturated fatty acids. Mariod (2022) mentioned that many pests attack plants during the growing and fruiting stages. This causes the quality and quantity of the plants' yields to drop significantly.

Egypt is now ranked 30th in the world in black cumin oil exports, with a 0.20% share that is considered extremely low and needs to be increased. The governorates of Fayoum, Beni Suef, Minya, and Assiut, all located in the Nile Valley, are primary producers. Harvests from these regions are marketed not only domestically but also globally. The policy of the Egyptian government is focused on reclaiming additional lands in the desert to increase the quantity of medicinal and aromatic plants and improve the quality of mass production.

The country has hot, dry summers and mild winters with little rain, and it is now very vulnerable to the effects of climate change. A shortage of information is currently available regarding the effect of new locations on the growth, the yield of seeds, and fixed oil that will be obtained from these different areas (Hamed, 2011; Nasef, 2015 and https://www.tridge.com/intelligences/black-cumin-seed-oil/EG/export).

The current research aims to evaluate the cultivation of *N. sativa* plants in four newly reclaimed deserts with various ecosystems to see which yields the best attributes. So, a database of information could be made for farmers, exporters, and the pharmaceutical industry, thus raising export opportunities.

MATERIALS AND METHODS

This study was conducted throughout the two seasons of 2021/2022 and 2022/2023 to evaluate the impact of varying cultivation ecosystems on *N. sativa* yield. The investigation layout was a randomized complete block design and included three replicates. The research was carried out in four locations in newly reclaimed lands, as follows:

1. El-Hammam, Matrouh Governorate
2. Oraby Association, Al-Eubour, Qalyubia Governorate
3. Tour Sinai, South Sinai Governorate
4. Western desert hinterland, Minya Governorate

The Egyptian Ministry of Agriculture and Land Reclamation provided the seeds used in this study. For the first and second seasons, seeds were sown in the locations mentioned above during the first week of October 2021 and 2022, respectively. A drip irrigation system with drippers (4 l/h) was used. The distance between hills was 30 cm, while between rows was 75 cm. The plants were thinned, and two seedlings were left on each hill (37333 plants/feddan). During the process of soil preparation, compost was added at a rate of 10 m^3/feddan in each location. Mineral fertilizers were added as the recommended dose for sandy soil (Abd El-Wahab, 1997). Good agricultural practices were followed. Mature plants were harvested. Hand harvesting was used. Seeds were extracted from their capsules and cleaned. Dry matter weight was calculated by drying the sample at 70˚C until it reached a consistent weight. According to Snedecor and Cochran (1982), the means of treatments were compared using an LSD test at 0.05. The following items were documented:

1. Geographical Information on the Various Locations

1.1. GPS data

Table (1) lists and displays the latitude and longitude data for various locations according to Google Maps' descriptions (https://www.google.com/maps).

Table (1). The GPS data of locations.

Locations	Latitude (N)	Longitude (E)
Matrouh Governorate	30.74°	29.21°
Qalyubia Governorate	30.23°	31.54°
South Sinai Governorate	28.50°	33.51°
Minya Governorate	27.62°	30.58°

1.2. Soil properties

At the start of the experiment, samples were collected from the soil surface layer (0-30 cm) to determine the mechanical and chemical soil properties at various locations. Soil samples were analyzed according to AOAC (2022). Tables (2 and 3) present the findings.

Table (2). The mechanical analysis of soil for locations.

Locations	Sand (%)	Silt (%)	Clay (%)	Soil texture
Matrouh Governorate	91.60	2.61	5.79	Sandy
Qalyubia Governorate	65.50	31.00	3.50	Sandy loam
South Sinai Governorate	53.00	41.45	5.55	Sandy loam
Minya Governorate	75.00	18.00	7.00	Sandy loam

Table (3). The chemical analysis of soil for locations.

Locations	pH	E.C. (ppm)	O.M. (%)	Soluble anions (meq/l)				Soluble cations (meq/l)			
				CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
Matrouh Governorate	8.00	300.20	0.25	-	5.60	2.60	2.17	2.88	4.42	2.06	1.01
Qalyubia Governorate	8.61	588.80	0.40	-	0.50	5.50	3.17	2.50	1.50	4.85	0.32
South Sinai Governorate	7.50	1510.40	0.29	-	2.31	17.74	23.74	8.33	12.66	20.30	2.50
Minya Governorate	7.85	1132.80	0.20	-	0.96	9.97	6.97	0.98	7.00	8.57	1.35

1.3. Irrigation water analysis

Irrigation water samples were taken from all locations and tested. As per AOAC (2022), irrigation water samples underwent investigation. The results are given in Table (4).

1.4. Meteorological data

Tables (5, 6, 7, and 8) show the meteorological data for various locations during the 2021-2022 and 2022-2023 seasons (Egyptian Meteorological Authority).

Table (4). Chemical analysis of irrigation water for locations.

Locations	pH	E.C. (ppm)	Soluble anions (meq/l)				Soluble cations (meq/l)			
			CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
Matrouh Governorate	7.65	371.00	-	2.50	2.95	0.33	1.55	1.30	2.66	0.27
Qalyubia Governorate	7.20	316.00	-	1.46	1.19	2.68	3.10	1.32	0.82	0.09
South Sinai Governorate	7.93	512.00	-	1.69	4.42	1.94	2.69	3.91	0.95	0.50
Minya Governorate	7.52	885.60	-	1.97	9.00	3.38	2.00	1.00	10.42	0.93

Table (5). Means of the meteorological data of El-Hammam, Matrouh.

Months	Min temp (˚C)	Max temp (˚C)	Humidity (%)	Wind (km/day)	Sun (hours)	Solar radiation ($MJ/m^2/day$)	ETo (mm/day)
October	16.60	26.70	65.40	362.90	8.34	17.07	4.28
November	13.00	23.20	63.20	362.90	7.31	13.26	3.39
December	9.30	19.70	64.60	423.40	5.80	10.46	2.75
January	7.80	17.80	66.30	475.20	5.89	11.21	2.63
February	8.10	18.70	63.20	492.50	6.69	14.23	3.22
March	9.70	20.40	65.10	501.10	7.47	17.82	3.66
April	12.10	23.60	62.30	432.00	8.65	21.63	4.56
Average	10.94	21.44	64.30	435.71	7.16	15.10	3.50

Table (6). Means of the meteorological data of Al-Eubour, Qalyubia Governorate.

Months	Min temp (˚C)	Max temp (˚C)	Humidity (%)	Wind (km/day)	Sun (hours)	Solar radiation ($MJ/m^2/day$)	ETo (mm/day)
October	17.00	30.60	60.90	121.00	8.43	17.32	3.53
November	15.10	25.50	65.00	112.30	7.32	13.43	2.38
December	9.70	21.50	61.20	112.30	6.08	10.88	1.85
January	8.00	19.00	63.70	138.20	6.2	11.67	1.86
February	8.10	20.00	58.70	146.90	6.9	14.60	2.39
March	10.50	24.20	51.30	172.80	7.58	18.08	3.54
April	13.10	28.30	46.90	164.20	8.52	21.51	4.51

Average	11.64	24.16	58.24	138.24	7.29	15.36	2.87

Table (7). Means of the meteorological data of Tour Sinai, South Sinai Governorate.

Months	Min temp (°C)	Max temp (°C)	Humidity (%)	Wind (km/day)	Sun (hours)	Solar radiation ($MJ/m^2/day$)	ETo (mm/day)
October	20.80	29.60	54.00	466.60	8.87	18.68	6.29
November	15.90	26.10	52.70	397.40	8.79	16.00	4.83
December	12.60	21.90	53.30	432.00	7.95	13.74	4.02
January	10.30	21.20	50.50	457.90	8.57	15.16	4.13
February	11.10	22.20	48.10	466.60	9.91	19.13	4.86
March	13.90	24.40	46.90	475.20	8.84	20.43	5.76
April	18.00	27.60	46.10	457.90	9.52	23.35	6.90
Average	14.66	24.71	50.23	450.51	8.92	18.07	5.26

Table (8). Means of the meteorological data of Minya Governorate.

Months	Min temp (°C)	Max temp (°C)	Humidity (%)	Wind (km/day)	Sun (hours)	Solar radiation ($MJ/m^2/day$)	ETo (mm/day)
October	15.50	31.30	53.00	259.20	9.09	18.74	4.85
November	10.20	25.90	59.30	216.00	8.26	15.15	3.17
December	5.80	21.40	65.40	190.10	7.59	13.10	2.11
January	3.90	20.40	62.60	216.00	7.50	13.72	2.20
February	5.20	22.40	54.30	224.60	8.37	16.99	3.01
March	8.20	25.80	49.70	259.20	8.77	20.17	4.17
April	12.60	31.20	39.60	293.80	9.27	22.89	6.07
Average	8.77	25.49	54.84	236.99	8.41	17.25	3.65

2. Growth and Yield Characteristics

Plant height (cm), fresh weight per plant (g), dry weight per plant (g), number of capsules per plant, seeds weight per plant (g), and seeds yield per feddan (kg).

3. Fixed Oil Properties

3.1. Fixed oil percentage

The fixed oil in seeds was determined using the soxhlet method. The clean seeds were crushed in a Willey mill, then extracted in a soxhlet apparatus by n-hexane. The hexane extract was dried over anhydrous sodium sulphate, then filtered, and the oil was obtained by distillation under vacuum. The fixed oil percentage was calculated as weight/weight (AOAC, 1970).

3.2. Fixed oil yield per plant

Fixed oil yield per plant (g) was considered as following equation: fixed oil percentage × seeds dry weight per plant / 100.

3.3. Fixed oil yield per feddan

Fixed oil yield per feddan (kg) was calculated as fixed oil yield per plant × number of plants per feddan.

3.4. Fatty acids composition

For the first season samples, methyl esters of fatty acids were prepared using benzene: methanol: concentrated sulfuric acid (10: 86: 4), and methylation was carried out for one hour at 80-90ºC. The acidified solution was extracted three times with ether. The ether extract was washed with distilled water (many times) till a neutral condition was noticed with the phenolphthalein indicator. The ether extract was dried over anhydrous sodium sulphate, filtered, and finally evaporated under a vacuum, according to Stahl (1967). Identification of fatty acids was carried out by Gas Liquid Chromatography, 6890 Gas Chromatography Method. The analysis was carried out at the National Research Center, Egypt, under the following conditions. Oven (initial temperature: 70ºC and initial time: 1 min). Ramps (rate: 40ºC/min., final temperature: 120ºC, and final time: 1 min.; rate: 4ºC/min., final temperature: 220ºC, and final time: 20 min.). Injection temperature (250ºC). Flame ionization detector (F.I.D.). Flow rates (N_2 as carrier gas 30 ml/min., H_2 30 ml/min., and air 300 ml/min.).

RESULTS AND DISCUSSION

1. Growth and Yield Attributes

The effect of different locations on black cumin's growth and yield parameters were offered in Tables (9 and 10) and illustrated in Fig. (1). According to the given data, all the growth characteristics (plant height, fresh weight per plant, and dry weight per plant) and yield characteristics (number of capsules per plant, weight of seeds per plant, and yield of seeds per feddan) were significantly affected and varied.

In terms of growth, Minya Governorate had the highest records of plant height and fresh and dry weights per plant (59.17 cm, 52.47 g, and 19.70 g, respectively), followed by South Sinai Governorate (50.00 cm, 41.00 g, and 12.81 g, respectively), Qalyubia Governorate (36.87 cm, 30.93 g, and 9.65 g, respectively), and Matrouh Governorate (31.31 cm, 24.62 g, and 7.85 g, respectively). Also, the yield attributes had the same trend. The maximum values of the number of capsules per plant, the weight of seeds per plant, and the yield of seeds per feddan were produced in Minya Governorate (44.00 capsules, 21.69 g, and 809.75 kg, respectively), followed by South Sinai Governorate (38.00 capsules, 16.77 g, and 626.07 kg, respectively), Qalyubia

Governorate (31.67 capsules, 11.66 g, and 435.30 kg, respectively), and Matrouh Governorate (25.00 capsules, 9.10 g, and 339.73 kg, respectively).

Table (9). Effect of different locations on plant height (cm), fresh weight per plant (g), and dry weight per plant (g) of *Nigella sativa* (mean values of the two successive seasons).

Locations	Plant height	Fresh weight per plant	Dry weight per plant
Matrouh Governorate	31.31 [a]	24.62 [a]	7.85 [a]
Qalyubia Governorate	36.87 [b]	30.93 [b]	9.65 [b]
South Sinai Governorate	50.00 [c]	41.00 [c]	12.81 [c]
Minya Governorate	59.17 [d]	52.47 [d]	19.70 [d]
LSD at 0.05	5.05	6.00	1.64

Means with the same letter are not significantly different at 5% level of probability

Table (10). Effect of different locations on number of capsules per plant, weight of seeds per plant (g), and yield of seeds per feddan (kg) of *Nigella sativa* (mean values of the two successive seasons).

Locations	Number of capsules per plant	Weight of seeds per plant	Yield of seeds per feddan
Matrouh Governorate	20.00 [a]	9.10 [a]	339.73 [a]
Qalyubia Governorate	31.67 [b]	11.66 [b]	435.30 [b]
South Sinai Governorate	38.00 [c]	16.77 [c]	626.07 [c]
Minya Governorate	44.00 [d]	21.69 [d]	809.75 [d]
LSD at 0.05	3.81	1.59	59.10

Means with the same letter are not significantly different at 5% level of probability

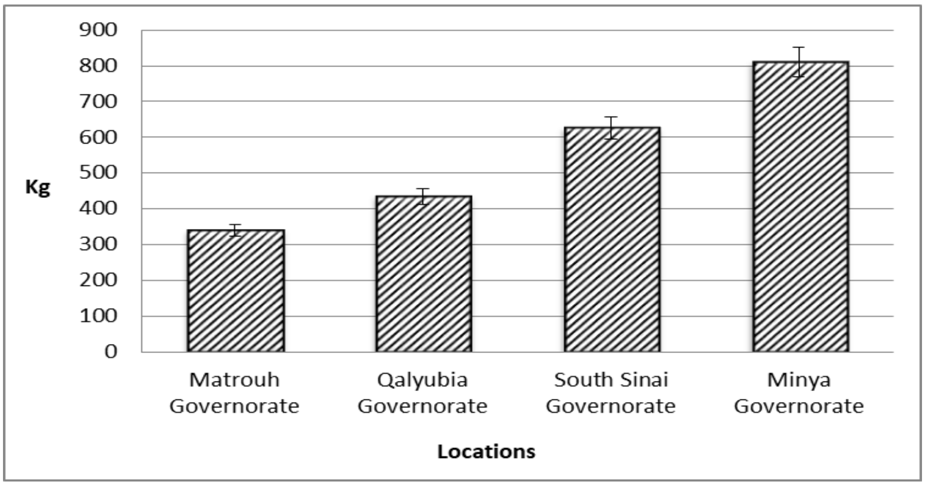

Fig. (1). Influence of planting locations on yield of seeds.

These differences could result from the dissimilar environments across the investigated sites. The results showed that locations with the highest average maximum temperatures, sun hours, and solar radiation during the season, such as Minya Governorate and South Sinai Governorate, had the highest growth and yield attributes. These were the circumstances: Minya Governorate (maximum air temperature 25.49ºC, sun hours 8.41 hours, and solar radiation 17.25 MJ/m^2/day); South Sinai Governorate (maximum air temperature 24.71ºC, sun hours 8.92 hours, and solar radiation 18.07 MJ/m^2/day); Qalyubia Governorate (maximum air temperature 24.16ºC, sun hours 7.29 hours, and solar radiation 15.36 MJ/m^2/day); and Matrouh Governorate (21.44ºC, sun hours 7.16 hours, and solar radiation 15.10 MJ/m^2/day) (Tables 5-8). These climatic conditions positively contributed to the rate of photosynthesis and vegetation growth. Ozguven and Sekeroglu (2007) and Tuncturk et al. (2012) reported that factors such as the number of branches and capsules directly affect the seed yield of black cumin.

These findings are consistent with those of Kara et al. (2015), who discovered that the different ecological conditions of growing locations significantly impacted seed output and yield components. Fufa (2018) found a highly significant interaction between genotype and environment. According to Salaheldin et al. (2020), the crop region significantly impacted production traits under various environmental conditions.

2. Quality Attributes

Tables (11 and 12) show how the fixed oil percentage, fixed oil yield per plant, fixed oil yield per feddan, and fixed oil composition were affected by where the plants were grown. Fig. (2 and 3) exhibit these effects. The tables and figures show that these parameters changed significantly.

Minya Governorate had the highest average of fixed oil percentage, fixed oil yield per plant, and fixed oil yield per feddan (26.19%, 5.68 g, and 212.05 kg, respectively), followed by South Sinai Governorate (25.11%, 4.21 g, and 157.17 kg, respectively), Qalyubia Governorate (19.88%, 2.32 g, and 86.61 kg, respectively), and Matrouh Governorate (18.35%, 1.67 g, and 62.35 kg, respectively). These findings may be explained by the fact that the Minya Governorate and South Sinai Governorates had the highest vegetative growth due to the favorable environmental conditions discussed previously, which competed with other sites to produce rich secondary metabolites. Based on the literature, the results of Minya and South Sinai Governorates followed the GCC Standardization Organization's Instructions (2017), indicating that the fixed oil percentage in seeds for whole and ground *N. sativa* should be at least 25%.

Our findings on fixed oil yield were consistent with those of Palabıyık and Aytaç (2018) and Can et al. (2021), who discovered statistically significant differences in the oil of *N. sativa* populations based on region.

Salaheldin et al. (2020) found that cultivation sites significantly impacted fixed oil production.

Table (11). Effect of different locations on fixed oil percentage, fixed oil yield per plant (g), and fixed oil yield per feddan (kg) of *Nigella sativa* (mean values of the two successive seasons).

Locations	Fixed oil percentage	Fixed oil yield per plant	Fixed oil yield per feddan
Matrouh Governorate	18.35 [a]	1.67 [a]	62.35 [a]
Qalyubia Governorate	19.88 [b]	2.32 [b]	86.61 [b]
South Sinai Governorate	25.11 [c]	4.21 [c]	157.17 [c]
Minya Governorate	26.19 [d]	5.68 [d]	212.05 [d]
LSD at 0.05	1.53	0.54	20.57

Means with the same letter are not significantly different at 5% level of probability

Table (12). Effect of different locations on fixed oil constituents of *Nigella sativa.*

Fatty acids	Locations			
	Matrouh Governorate	Qalyubia Governorate	South Sinai Governorate	Minya Governorate
Lauric acid (C12:0)	0.05	-	0.64	0.12
Myristic acid (C14:0)	0.18	0.22	0.37	0.18
Palmitic acid (C16:0)	11.43	7.71	12.72	9.59
Palmetoleic acid (C16:1)	-	2.53	-	-
Stearic acid (C18:0)	0.28	2.53	0.66	3.65
Oleic acid (C18:1)	47.00	49.34	27.09	40.43
Linoleic acid (C18:2)	24.89	17.43	45.10	23.06
Linolenic acid (C18:3)	8.76	4.71	2.27	16.02
Arachidic acid (C20:0)	3.55	8.69	3.32	3.46
Eicosenoic acid (C20: 1)	2.29	3.39	1.27	2.69
Total identified fatty acids	98.43	96.55	93.44	99.20
Total saturated fatty acids	15.49	19.15	17.71	17.00
Total unsaturated fatty acids	82.94	77.40	75.73	82.20

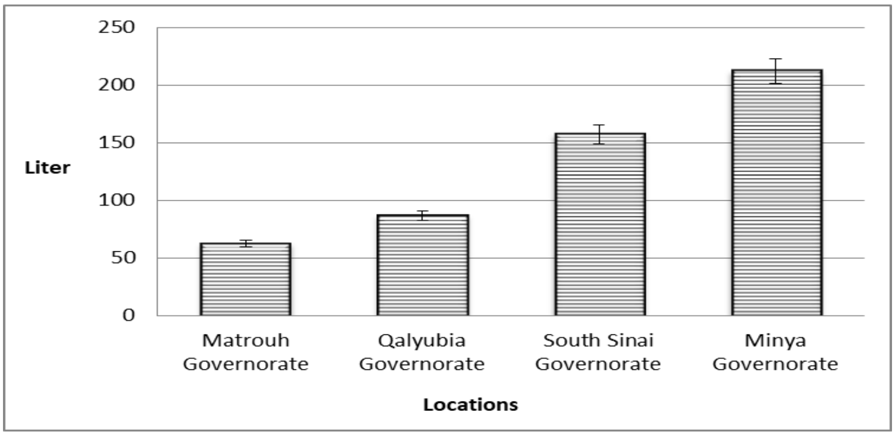

Fig. (2). Influence of planting locations on oil yield.

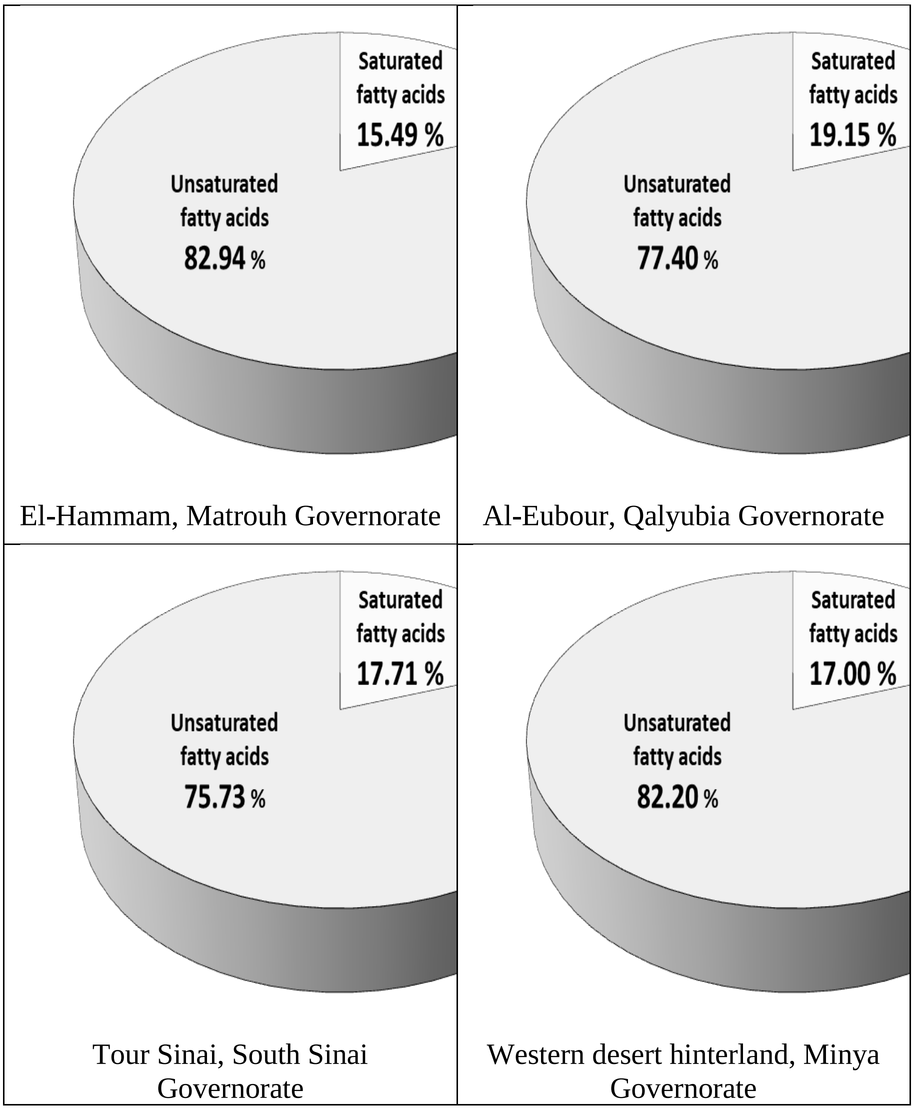

Fig. (3). The fatty acids composition for various locations.

The fatty acid profile revealed that the obtained oil was rich in unsaturated fatty acids and had a low content of saturated fatty acids. The fixed oil's chemical composition was equivalent to the oil produced in other Mediterranean countries (Tulukcu, 2011 and Gharby et al., 2015). The unsaturated fatty acids included (palmetoleic acid, oleic acid, linoleic acid, linolenic acid, and eicosenoic acid) while the saturated fatty acids involved (lauric acid, myristic acid, palmitic acid, stearic acid, and arachidic acid). However, the proportions of fatty acids varied according to location.

The oil from Matrouh Governorate had the highest total unsaturated fatty acids of 82.94% (47.00% oleic acid, 24.89% linoleic acid, 8.76% linolenic acid, and 2.29% eicosenoic acid), followed by Minya Governorate with 82.20% (40.43% oleic acid, 23.06% linoleic acid, 16.02% linolenic acid and 2.69% eicosenoic acid), Qalyubia Governorate with 77.40% (2.53% palmetoleic acid, 49.34% oleic acid, 17.43% linoleic acid, 4.71% linolenic acid and 3.39% eicosenoic acid), South Sinai Governorate recorded 75.73% (27.09% oleic acid, 45.10% linoleic acid, 2.27% linolenic acid and 1.27% eicosenoic acid).

In terms of saturated fatty acids, Qalyubia Governorate had the highest amount of 19.15% (0.22% myristic acid, 7.71% palmitic acid, 2.53% stearic acid and 8.69% arachidic acid), followed by South Sinai Governorate of 17.71% (0.64% lauric acid, 0.37% myristic acid, 12.72% palmitic acid, 0.66% stearic acid and 3.32% arachidic acid), Minya Governorate had 17.00% (0.12% lauric acid, 0.18% myristic acid, 9.59% palmitic acid 3.65% stearic acid and 3.46% arachidic acid), and at last, Matrouh Governorate with 15.49% (0.05% lauric acid, 0.18% myristic acid, 11.43% palmitic acid, 0.28% stearic acid and 3.55% arachidic acid).

According to previous findings, oil from the Matrouh and Minya Governorates had more total unsaturated fatty acids than oil from other studied locations because their minimum nighttime temperatures were the lowest. The average minimum temperature in Minya Governorate was 8.77ºC, while it was 10.94ºC in Matrouh Governorate (Tables 5 and 8).

Several researchers have explained the increase in oil-unsaturated fatty acids under low-temperature stress by citing some important physiological reasons. When plants are subjected to low-temperature stress, biomembranes are the first to be damaged. The fluidity and stability of plant membranes are closely related to cold resistance. Unsaturated fatty acids are widely believed to be beneficial for membrane stability. Because unsaturated fatty acids contain one or more double bonds, molecules cannot pack tightly, increasing membrane fluidity. The membrane's increased fluidity allows it to retain its liquid form under low-temperature stress, increasing plant stability and cold resistance. Increasing the content of unsaturated fatty acids in membrane lipids can improve cold resistance in a low-temperature environment. The activity of fatty acid desaturase is related to the unsaturation of membrane lipids. Increased fatty acid desaturase activity increases membrane lipid unsaturation and fluidity and improves plant membrane system stability at low temperatures (Horiguchi et al., 2000; Routaboul et al., 2000; Falcone et al., 2004; Upchurch, 2008; Wang et al., 2019 and Tian et al., 2022).

So, the patterns of output from the different locations could be evaluated and summed up as follows:

- Western desert hinterland, Minya Governorate (yield of seeds per feddan was 809.75 kg, fixed oil percentage in seeds was 26.19%, yield of fixed oil per feddan was 212.05 kg, total unsaturated fatty acids in fixed oil was 82.20%, and total saturated fatty acids in fixed oil was 17.00%).

- Tour Sinai, South Sinai Governorate (yield of seeds per feddan was 626.07 kg, fixed oil percentage in seeds was 25.11%, yield of fixed oil per feddan was 157.17 kg, total unsaturated fatty acids in fixed oil was 75.73%, and total saturated fatty acids in fixed oil was 17.71%).
- Oraby Association, Al-Eubour, Qalyubia Governorate (yield of seeds per feddan was 435.30 kg, fixed oil percentage in seeds was 19.88 %, yield of fixed oil per feddan was 86.61 kg, total unsaturated fatty acids in fixed oil was 77.40%, and total saturated fatty acids in fixed oil was 19.15%).
- El-Hammam, Matrouh Governorate (yield of seeds per feddan was 339.73 kg, fixed oil percentage in seeds was 18.35 %, yield of fixed oil per feddan was 62.35 kg, total unsaturated fatty acids in fixed oil was 82.94%, and total saturated fatty acids in fixed oil was 15.49%).

CONCLUSION

According to the current study results on black cumin, the tested locations significantly impacted seed yield, fixed oil, and the fatty acid composition found in the oil. The several sites each had their own unique values for these factors. The new promising lands for investment in this crop were the Western Desert of the Minya Governorate, followed by Tour Sinai in the South Sinai Governorate. These were the best locations for cultivating and producing a good yield.

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تأثير مواقع الزراعة المختلفة على محصول حبة البركة في مصر

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يمكن أن يؤثر تغير المناخ سلبًا على زراعة حبة البركة وتغيير خصائص المحصول. وبالتالي كانت زراعة مساحات جديدة ضرورية. نتيجة لذلك تم إجراء هذا البحث في مصر لتحديد تأثير المناطق المستصلحة الجديدة على الإنتاج. أجريت الدراسة في أربعة مواقع صحراوية هي: الحمام بمحافظة مطروح، جمعية عرابي بالعبور بمحافظة القليوبية، طور سيناء بمحافظة جنوب سيناء، والظهير الصحراوي الغربي بمحافظة المنيا. أظهرت النتائج أن جميع النظم البيئية أثرت بشكل كبير على النمو وصفات المحصول. كان أعلى ارتفاع للنبات، والوزن الطازج والجاف لكل نبات، وعدد الكبسولات لكل نبات، ومحصول البذور، والزيت الثابت من وحدة المساحة من محافظات المنيا، تليها جنوب سيناء، والقليوبية، ومطروح، على التوالي. وكانت أعلى نسبة من الأحماض الدهنية غير المشبعة وأقل تركيز للأحماض الدهنية المشبعة من محافظات مطروح تليها المنيا والقليوبية وجنوب سيناء بهذا الترتيب. بناءً على الخصائص الكمية والنوعية أوصت الدراسة بزراعة حبة البركة في الأراضي المستصلحة الجديدة في الظهير الصحراوي الغربي بمحافظة المنيا ثم محافظة جنوب سيناء كمناطق جديدة لإنتاج هذا المحصول.