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AN EVALUATION OF VARIOUS MINERAL AND BIO-FERTILIZERS APPLICATIONS ON GROWTH, PRODUCTIVITY AND SEED OIL CONTENT OF *NIGELLA SATIVA* IN CALCAREOUS SOILS

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Two field experiments were carried out in a clay loam calcareous soil to evaluate different applications of mineral and bio-fertilizers on growth, yield and oil content of *Nigella sativa*. Large difference in the growth of plants between the control and all fertilizer treatments were recorded. The seed yield, oil content, yield of oil and nutrients uptake improved significantly ($P < 0.05$) by the application of ammonium sulfate (300 kg/fed) + Azotobacter. Improvements were also noticed, but to a lesser extent, by the application of ammonium sulfate (300 kg/fed) alone or ammonium sulfate (150 kg/fed) + Azotobacter in descending order. Mineral nitrogen and Azotobacter individually or in combination increased plant N content. There was a slight improvement in the P and K content due to the application of Azotobacter.

Keywords: *Nigella sativa*, Azotobacter, Nitrogen, Micro-nutrients, carbohydrates, Black cumin oil.

Nigella sativa L. (*Ranunculaceae)* is used in traditional medicine for culinary preparations and as an ornamental in many countries and is considered for its abundant nectar secretion (D'Antuonon *et al.*, 2002). The oil of black cumin is mainly produced in Egypt and India. It is known that the region of production of black cumin is Upper Egypt where it was used as diuretic, carminative and flavoring agent. Expressed oil is used for treatment of asthma (Hashim *et al.*, 1997) and possesses antispasmodic activity (Aquel, 1993). Studies were carried out on plant morphology (Al-Jassir and Rizk, 1992), dry seed proteins (Datta *et al.*, 1987), seed oil properties (Ustun *et al.*, 1990) and on components during seed sprouting (Abd El-Hamid *et al.*, 1997). However, few studies have been carried out on the effect of balanced fertilizer application on the crop production. Sources of fertilizers namely mineral, organic and bio-fertilizers are in use. The most common source, mineral fertilizers, is also useful for treatment of nutrient deficiencies. Organic fertilizers, on the other hand, are characterized by slow release of nutrients, but have tremendous benefits in improving soil condition. Organic fertilizers increase water-holding capacity of the soil, form a good store for minerals and improve soil microbial activities. Organic fertilizer may be required in large quantities not easily available particularly in the remote deserts. Bio-fertilizers may introduce a good substitute as a source of minerals as it encourages the microbial activities that play a role in dissolving nitrogen, phosphorus and some other elements in addition to its safe use as a clean source of fertilizer. This study, therefore, aims to evaluate effects of different rates of mineral and bio-fertilizers application on the growth and yield of *Nigella sativa* with emphasis on the potentiality of the soil used.

MATERIALS AND MEHTODS

This experiment was carried out for two successive years viz 2000 and 2001 at Maryout Experimental Farm of the Desert Research Center. Soil samples were collected from the site prior to planting. Irrigation water was also tested during the process of the experiments. The main physical and chemical properties of the studied soil are illustrated in table (1).

TABLE (1). Soil physical and chemical properties.

a- Physical properties.

Depth (cm)	Sand	Silt	Clay	Texture
0-30	32.2%	30.1%	37.7%	Clay loam

b- Chemical properties.

EC		$CaCO_3$	OM	Soluble cations and anions (meq/L)						
dS/m	pH	%	%	Na^+	Ca^{++}	Mg^{++}	K^+	Cl	HCO_3	SO_4
5.9	8.1	32	0.3	25	23	9	2	30	9	20

Irrigation was carried out every 10 days with poor quality water having salinity of 4100ppm. Treatments used in this experiment included application of nitrogen in the form of ammonium sulfate at the rates of 150 and 300 kg/fed, spraying of micronutrients (Zn, Mn, Fe, Cu) at the rates of 1% and 2%, and inoculation with Azotobacter and combination of Azotobacter with each of nitrogen and micronutrients at the same rates. Applications of all treatments were carried out in three equal doses at monthly intervals from the planting date (early in October every season).

Nigella sativa was the task crop on which all common and recommended field practices were used from planting to harvesting. Vegetative growth parameters were measured at full maturity. Seed and oil yields were estimated. Plant macro- and micro-nutrients were determined according to Chapman and Pratt (1961). Carbohydrates were determined according to Chaplin and Kennedy (1994). Split plot design was used and data was analyzed according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Fertilization of crops aims usually to improve plant growth which is normally reflected on the yield obtained. Fertilization may also improve yield quality and thus the market value of such yield. Growth parameters differ from crop to crop but mainly include plant height, number of branches per plant, fresh weight and dry weight of plant. Yield parameters also differ with crops and the most important ones for *Nigella sativa* are seed yield, oil content and oil yield. Fertilizers may induce noticeable changes in plant contents of elements in such fertilizers. Effects of fertilizers applied on plant mineral content of N, P, K, Fe, Zn, and Mn may be helpful in the evaluation of all the treatments of the trial in hand. Some of these parameters will be highlighted below.

Plant Growth

Plant height at maturity ranged from 35 to 70 cm (Table 2). It was observed that N application had remarkable increase on plant height compared with other treatments. Nitrogen forms essential components of the protein responsible for plant growth. Higher plant height accompanied the higher rate of N (300 kg/fed). Application of combined N with Azotobacter gave almost the same positive response to Azotobacter alone implying their suitability as a substitute for each other. The preference of either may be subject to their availability, cost involved, ease of application and desire of the user. Although micro-nutrients + Azotobacter increased plant height, their effect was less than the former treatments.

Table (2) showed that number of branches per plant also increased in response to N application. Azotobacter alone also had similar effect. It seems that application of N either in the form of ammonium sulfate or as bio-fertilizers in the form of bacteria had a noticeable effect on plant growth. This may be attributed to the significant role of N in improving plant growth, on one hand, and to the deficiency status of this element in the soil, on the other hand. Soil of this experiment was characterized by low content of organic matter and available nutrients, but by high calcium carbonate (Table 2). This may explain the response of this soil to all treatments. In other words, soil content of N seemed to be very poor and thus the profound response observed on plant growth by all treatments.

Fresh weight of plants followed almost the same trend with plant height and number of branches. This may be so since all of them are integrated and responsible for plant growth and condition. Also, dry weight of plants followed the same pattern (Table 2). These results are in agreement with those reported by Das *et al.* (1991) and El-Deeb *et al.* (1993) on *Nigella* *sativa*, El-Sawy *et al.* (1998) and Ibrahim (2000) on *Ammi visnaga* and Ramar *et al.* (2000) on *Foeniculum vulgare*.

TABLE (2). Effect of treatments on plant growth parameters of *Nigella sativa* in both seasons (2000 and 2001).

Treatments	Plant height (cm)		No. of branches		Fresh weight (g/plant)		Dry weight (g/plant)	
	2000	2001	2000	2001	2000	2001	2000	2001
Control	37.8±2.1	37.8±2.3	2.0±0.2	2.3±0.3	46.6±2.7	50.7±1.7	28.0±1.6	32.0±1.0
N1	56.4±8.4	49.5±1.6	3.6±0.3	3.5±0.4	81.0±3.6	73.5±2.6	67.4±3.0	58.8±2.1
N2	69.9±2.2	64.1±3.4	4.3±0.2	4.1±0.7	87.5±2.0	84.3±2.7	74.4±1.7	70.8±2.3
Micro 1%	47.3±3.2	49.2±1.9	2.9±0.3	3.2±0.3	62.4±2.0	64.6±1.7	48.2±1.5	50.2±1.3
Micro 2%	49.1±2.8	51.0±3.3	3.5±0.3	3.6±0.3	66.2±1.7	69.4±1.7	51.8±1.3	54.8±1.3
Azoto.	59.6±1.5	63.1±4.7	3.8±0.2	4.2±0.4	74.8±4.4	82.5±2.7	59.8±3.5	67.8±2.1
N_1 + *Azoto.*	64.6±5.5	58.4±2.6	3.8±0.3	3.4±0.1	77.9±2.8	73.3±3.0	66.2±2.4	61.5±2.5
N_2 + *Azoto.*	66.4±5.5	70.1±5.0	4.5±0.1	4.0±0.2	89.0±1.1	83.9±3.3	77.5±0.9	72.1±2.9
$Micro_1$+ *Azoto.*	52.7±5.1	58.3±2.8	3.1±0.1	3.6±0.2	67.2±1.6	69.3±3.4	54.4±1.3	57.3±2.5
$Micro_2$+ *Azoto.*	60.7±1.5	65.3±1.3	3.5±0.2	3.8±0.1	73.2±2.9	74.9±3.7	60.0±2.4	62.9±3.1
LSD (5%)	6.2	4.3	0.3	0.4	3.9	3.6	1.5	1.4

N_1: Ammonium sulfate (150kg/fed). N_2: Ammonium sulfate (300kg/fed).
$Micro_1$: (Zn, Mn, Fe, Cu) at 1%. $Micro_2$: (Zn, Mn, Fe, Cu) at 2%. *Azoto.*: *Azotobacter*

It could be concluded that in such a poor soil the application of fertilizer is necessary to guarantee reasonable plant growth. Higher rate of ammonium sulfate (300 kg/fed) seemed to be the best, however, the uses of Azotobacter either alone or in combination with mineral N could be a satisfactory substitute. Application of micro-nutrients improved plant growth to a lesser extent (Table 2).

Seed and Oil Yield

Seed yield was improved significantly by all fertilizer sources (Table 3). The highest seed yield was obtained by the application of the higher rate of 300 kg/fed of ammonium sulfate. This was in agreement with Singh and Singh (1999) and Datta *et al.* (2001). Application of higher rate of N alone or in combination with Azotobacter had almost the same result and ranked as the second choice among all treatments. Micro-nutrients application either alone or in combination with Azotobacter though slightly improved seed yield was not very effective in this regard. This proved that abundance of micro-nutrients in the absence of N had little effect in increasing seed yield. In other words, the availability of balanced fertilizer is much more important than increasing the rate of some nutrients on the expense of others. It is, therefore, recommended to use N (300kg/fed) + Azotobacter for the improvement of seed yield. In the absence of Azotobacter, N (300kg/fed) alone could be a satisfactory substitute. Use of Azotobacter enhanced seed yield probably due to the effect on the enzymatic systems responsible for the storage of foods (Ibrahim, 2000). For this reason, application of Azotobacter may be justified inspite of the little improvement in seed yield compared with the application of nitrogen alone.

TABLE (3). Effect of treatments on seed and oil yield and oil content of *Nigella sativa* in both seasons (2000 and 2001).

Treatments	Seed yield (kg/fed)		Oil content (%)		Oil yield (l/fed)	
	2000	2001	2000	2001	2000	2001
Control	243±40	291±11	0.15±0.03	0.20±0.01	25±3	31±1
N1	403±44	378±32	0.51±0.06	0.47±0.04	54±6	49±4
N2	511±32	490±22	0.71±0.04	0.69±0.02	75±5	71±3
Micro 1%	273±11	315±21	0.27±0.01	0.33±0.02	28±1	34±2
Micro 2%	301±16	378±32	0.30±0.02	0.41±0.06	32±2	40±2
Azoto	431±38	487±16	0.57±0.05	0.65±0.02	60±5	69±2
N1 + *Azoto*	525±28	494±11	0.69±0.05	0.66±0.01	75±4	69±1
N2 + *Azoto*	599±21	571±16	0.85±0.03	0.80±0.02	89±3	84±2
Micro1+ *Azoto*	357±11	389±21	0.42±0.01	0.46±0.03	44±1	49±3
Micro2+ *Azoto*	399±21	473±11	0.49±0.03	0.59±0.01	51±3	62±1
LSD (5%)	41	24	0.03	0.04	5	3

N_1: Ammonium sulfate (150kg/fed). N_2: Ammonium sulfate (300kg/fed).
$Micro_1$: (Zn, Mn, Fe, Cu) at 1%. $Micro_2$: (Zn, Mn, Fe, Cu) at 2%. *Azoto.*: *Azotobacter*

Oil content of seed also increased along with the seed yield. This may not be surprising as good plant growth and high seed yield, normally, reflect on the quantity and oil content of seeds (Table 2). It could be concluded that the highest seed yield, oil content and yield of oil were significantly improved by the application of ammonium sulfate (300kg/fed) +Azotobacter. Such improvements were noticed but to a lesser extent by the application of ammonium sulfate (300kg/fed) alone or ammonium sulfate (150kg/fed) + Azotobacter.

Plant Chemical Composition

Results in Table (4) showed that plant nitrogen content increased significantly ($P < 0.05$) with the application of N both rates. This is obvious as the application of N in a mineral form directly to the soil increases its availability. Also, treatment with Azotobacter increased the plant content of N probably due to the well-known role of Azotobacter as a nitrogen dissolving bacteria in the soil. Also, the highest content of plant N was reached when N was used in combination with Azotobacter. Plant content of N recorded 2.6 to 2.9% with N at higher rate (300kg/fed) + Azotobacter. This was followed by the application of N at lower rate (150kg) + Azotobacter, which recorded N plant content of 2.5 and 2.6%. Nitrogen alone at higher rate recorded a plant content of 2.3 to 2.5%.

Phosphorus content of plants ranged from 0.2 to 0.5% in the two experiments. Changes in P content could not be linked with the effect of any treatment (Table 4). However, a slight increase in P content of plant was observed with all treatments that contain Azotobacter. This may be due to the possible effect of inoculated bacteria on the enzymatic systems (Ibrahim, 2000).

Potassium content of plants ranged from 2.1 to 2.7% in the two experiments. Changes in the plant content of K were inconsistent and could not be connected with treatments. The concentration of K in black cumin fell within the range widely accepted between 1% and 5% of dry weight of most plants.

It must be remembered that K, unlike several other plant nutrients, does not combine with other elements to form plant components such as protoplasm, fats and cellulose. Instead, it exists in mobile ionic form and its function appears to be primarily catalytic in nature (Tisdale *et al.*, 1985).

However, there was a slight increase in K content that accompanied the application of Azotobacter. This may be due to possible effect of bacteria on the biological activities in the soil in general and to its effect on enzymatic system in particular.

All the applications of mineral N alone or in combination with Azotobacter increased the plant N content. Application of Azotobacter had the same effect. There was slight improvement on the content of P and K accompanied the application of Azotobacter, though other treatments did not show any significant effect on the plant content of P and K.

TABLE (4). Effect of treatments on macronutrients contents of *Nigella sativa* in both seasons (2000 and 2001).

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Sodium (%)	
	2000	2001	2000	2001	2000	2001	2000	2001
Control	1.40±0.07	1.50±0.08	0.20±0.01	0.20±0.01	2.10±0.11	2.20±0.11	0.60±0.03	[illegible]
N1	2.00±0.10	2.10±0.11	0.30±0.02	0.30±0.02	2.70±0.14	2.90±0.15	0.71±0.04	0.74±0.04
N2	2.30±0.12	2.50±0.13	0.40±0.02	0.40±0.02	2.80±0.14	3.00±0.15	0.73±0.04	[illegible]
Micro 1%	1.60±0.08	1.70±0.09	0.20±0.01	0.30±0.02	2.40±0.12	2.50±0.13	0.65±0.03	[illegible]
Micro 2%	1.50±0.08	1.50±0.08	0.30±0.02	0.30±0.02	2.50±0.13	2.50±0.13	0.68±0.03	[illegible]
Azoto.	2.10±0.11	2.10±0.11	0.40±0.02	0.50±0.03	2.70±0.14	2.50±0.13	0.70±0.04	[illegible]
N1 + *Azoto.*	2.50±0.13	2.60±0.13	0.50±0.03	0.40±0.02	2.90±0.15	2.60±0.13	0.72±0.04	[illegible]
N2 + *Azoto.*	2.60±0.13	2.90±0.15	0.50±0.03	0.50±0.03	2.90±0.15	2.70±0.14	0.74±0.04	[illegible]
Micro1 + *Azoto*	2.20±0.11	2.20±0.11	0.40±0.02	0.40±0.02	2.50±0.13	2.30±0.12	0.69±0.03	[illegible]
Micro2 + *Azoto*	[illegible]	2.20±0.11	0.40±0.02	0.40±0.02	2.70±0.14	2.60±0.13	0.71±0.04	0.72±0.04
LSD (5%)	0.12	0.13	0.02	0.02	0.16	0.15	0.04	0.04

N_1: Ammonium sulfate (150kg/fed). N_2: Ammonium sulfate (300kg/fed)
$Micro_1$: (Zn, Mn, Fe, Cu) at 1%. $Micro_2$: (Zn, Mn, Fe, Cu) at 2%. *Azoto*: *Azotobacter*

Sodium content in the plants ranged from 0.60 to 0.78% (Table 4). Changes in Na concentration were neither consistent nor remarkable and fall within a very narrow range. Lack of comprehensive information on component of this crop in the literature made it difficult to give precise judgment on the level of Na in these experiments. However, the concentration of Na here may be considered moderate in comparison with all other nutrients. Tisdale *et al.* (1985) reported that concentration of Na varies widely from 0.1 to as high as 10% in leaf tissue dry matter of plants. Surprisingly, Na concentration in plants in these experiments did not reflect the effect of the high salinity of irrigation water used. This suggests a sign of selectivity in absorbing nutrients, which needs further elaboration.

Table (5) shows the plant content of Fe, Zn and Mn. Iron concentration ranged from 186 to 420ppm with irregular changes. This falls within the sufficiency range between 50 and 250ppm in plant dry matter reported by Mengel and Kirkby (1982). A noticeable increase of iron content was observed with Azotobacter treatment and Azotobacter + N fertilizer. Zinc concentration varied from 102 to 198ppm in black cumin plant which was considered high compared with the average of 25 to 150ppm for most plants.

Manganese concentration ranged from 9 to 20ppm. Normally, plants contain from 15 to 25ppm. It seems that the plants of the control and those receiving N showed Mn deficiency, while plants receiving other treatments absorbed sufficient levels. This may suggest a role of bio-fertilizer in the improvement of the availability of such elements in the soil and as a result of the uptake of plants. The uses of bio-fertilizer, therefore, may be recommended in such poor soil that lacks sufficient micro-nutrients.

TABLE (5). Effect of treatments on micronutrients contents of *Nigella sativa* in both seasons (2000 and 2001).

Treatments	Iron (ppm)		Zinc (ppm)		Manganese (ppm)	
	2000	2001	2000	2001	2000	2001
Control	186±9	195±10	102±5	107±5	9.0±0.5	10.0±0.5
N1	215±11	210±11	145±7	130±7	12.0±0.6	11.0±0.6
N2	225±11	220±11	155±8	147±7	12.5±0.6	11.9±0.6
Micro 1%	320±16	350±18	180±9	172±9	16.6±0.8	17.0±0.9
Micro 2%	390±20	409±20	195±10	186±9	18.5±0.9	18.9±0.9
Azoto	240±12	265±13	160±8	170±9	15.5±0.8	14.2±0.7
N1 + *Azoto*	260±13	250±13	148±7	139±7	12.8±0.6	12.1±0.6
N2 + *Azoto*	289±14	271±14	159±8	150±8	13.3±0.7	13.0±0.7
Micro1+ *Azoto*	360±18	375±19	184±9	180±9	18.5±0.9	19.1±1.0
Micro2+ *Azoto*	398±20	420±21	198±10	190±10	19.2±1.0	19.8±1.0
LSD (5%)	17	18	10	9	0.9	0.9

N_1: Ammonium sulfate (150kg/fed). N_2: Ammonium sulfate (300kg/fed).
$Micro_1$: (Zn, Mn, Fe, Cu) at 1%. $Micro_2$: (Zn, Mn, Fe, Cu) at 2%. *Azoto.*: *Azotobacter*

Plant Uptake of Macro-nutrients

Table (6) shows the calculated plant uptake of N, P, K and Na. These figures are useful in estimating the fertilizer requirement of this plant for each element in this particular soil. The increase in plant uptake of an element shows higher demand for that element as well as fertilizers. Plant uptake could, therefore, be used as an indicator for plant fertilizer requirement.

TABLE (6). Effect of treatments on macronutrients uptake of *Nigella sativa* in both seasons (2000 and 2001).

Treatments	N (kg/fed)		P (kg/fed)		K (kg/fed)		Na (kg/fed)	
	2000	2001	2000	2001	2000	2001	2000	2001
Control	9.5±0.5	12.2±0.6	1.9±0.1	2.4±0.1	17.5±0.9	18.4±0.9	6.2±0.3	6.6±0.3
N1	35.2±1.8	31.9±1.6	4.7±0.2	4.8±0.2	42.6±2.1	42.5±2.1	11.4±0.6	10.5±0.5
N2	39.3±2.0	38.5±1.9	6.7±0.3	6.1±0.3	47.8±2.4	46.5±2.3	12.5±0.6	11.4±0.6
Micro 1%	12.1±0.6	14.1±0.7	2.9±0.1	3.6±0.2	28.3±1.4	32.6±1.6	7.4±0.4	8.4±0.4
Micro 2%	16.9±0.8	21.0±1.1	3.7±0.2	3.9±0.2	32.7±1.6	34.7±1.7	9.1±0.5	9.5±0.5
Azoto.	32.0±1.6	33.1±1.7	6.2±0.3	7.7±0.4	40.2±2.0	40.4±2.0	10.4±0.5	11.7±0.6
N1 + *Azoto.*	37.9±1.9	36.8±1.8	7.0±0.4	6.3±0.3	43.3±2.2	37.1±1.9	11.0±0.5	9.9±0.5
N2 + *Azoto.*	46.7±2.3	47.1±2.4	8.7±0.4	7.8±0.4	51.8±2.6	43.6±2.2	13.4±0.7	12.7±0.6
Micro1+ *Azoto*	29.4±1.5	31.0±1.6	4.6±0.2	5.6±0.3	32.9±1.6	32.6±1.6	9.0±0.4	9.8±0.5
Micro2+ *Azoto*	31.9±1.6	34.1±1.7	5.6±0.3	6.6±0.3	38.9±1.9	39.3±2.0	10.0±0.5	1.0±0.0
LSD (5%)	1.7	1.8	0.3	0.3	2.3	2.0	0.6	0.6

N_1: Ammonium sulfate (150kg/fed). N_2: Ammonium sulfate (300kg/fed).
$Micro_1$: (Zn, Mn, Fe, Cu) at 1%. $Micro_2$: (Zn, Mn, Fe, Cu) at 2%. *Azoto.*: *Azotobacter*

Soluble Sugars and Carbohydrates Contents

Carbohydrates do not only serve as a source of energy, but they also furnish the basic carbon skeleton for all other organic substances found in plants (Malik and Srivastava, 1982). The ratio of soluble sugar and total carbohydrates may be taken as an indication of oil formation in plants (Chaplin and Kennedy, 1994). In these experiments, total carbohydrates ranged from 9.2% to 15.7% in the first experiment (2000) and from 10.6% to 17.8% in the second experiment (2001). Changes in total carbohydrates were irregularly affected by treatments though a noticeable increase accompanied the second dose of nitrogen and the second dose of N + Azotobacter. Soluble sugar ranged from 1.8% to 2.9% in the first experiment and from 1.9% to 3.0% in the second experiment (Table 7). Ratio between soluble sugar and total carbohydrates showed negligible changes that could not be confidentially taken as a guide or an indicator for oil formation.

TABLE (7). Effect of treatments on soluble sugar (SS), total carbohydrate (TC) and SS/TC ratio in *Nigella sativa* in both seasons (2000 and 2000).

Treatments	Soluble sugar (%)		Total carbohydrate (%)		SS/TC	
	2000	2001	2000	2001	2000	2001
Control	1.80 ± 0.09	1.90 ± 0.10	9.20±0.46	10.60±0.53	0.20±0.01	0.18±0.01
N1	2.40±0.12	2.50±0.13	12.90±0.65	13.30±0.67	0.19±0.01	0.19±0.01
N2	2.60±0.13	2.80±0.14	14.90±0.75	16.80±0.84	0.17±0.01	0.17±0.01
Micro 1%	2.00±0.10	2.10±0.11	10.20±0.51	12.60±0.63	0.20±0.01	0.17±0.01
Micro 2%	2.10±0.11	2.20±0.11	11.40±0.57	13.50±0.68	0.18±0.01	0.16±0.01
Azoto.	2.30±0.12	2.50±0.13	12.10±0.61	12.90±0.65	0.19±0.01	0.19±0.01
N1 + *Azoto.*	2.60±0.13	2.70±0.14	13.80±0.69	14.90±0.75	0.19±0.01	0.18±0.01
N2 + *Azoto.*	2.90±0.15	3.00±0.15	15.70±0.79	17.80±0.89	0.18±0.01	0.17±0.01
Micro1+ *Azoto.*	2.00±0.10	2.10±0.11	11.90±0.60	12.30±0.62	0.17±0.01	0.17±0.01
Micro2+ *Azoto.*	2.40±0.12	2.50±0.13	12.90±0.65	14.00±0.70	0.19±0.01	0.18±0.01
LSD (5%)	0.14	0.15	0.75	0.83	0.01	0.01

N_1: Ammonium sulfate (150kg/fed). N_2: Ammonium sulfate (300kg/fed).
$Micro_1$: (Zn, Mn, Fe, Cu) at 1%. $Micro_2$: (Zn, Mn, Fe, Cu) at 2%. *Azoto.*: *Azotobacter*

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TABLE (7). Effect of treatments on soluble sugar (SS), total carbohydrate (TC) and SS/TC ratio in *Nigella sativa* in both seasons (2000 and 2000).

Treatments	Soluble sugar (%)		Total carbohydrate (%)		SS/TC	
	2000	2001	2000	2001	2000	2001
Control	1.80 ± 0.09	1.90 ± 0.10	9.20±0.46	10.60±0.53	0.20±0.01	0.18±0.01
N1	2.40±0.12	2.50±0.13	12.90±0.65	13.30±0.67	0.19±0.01	0.19±0.01
N2	2.60±0.13	2.80±0.14	14.90±0.75	16.80±0.84	0.17±0.01	0.17±0.01
Micro 1%	2.00±0.10	2.10±0.11	10.20±0.51	12.60±0.63	0.20±0.01	0.17±0.01
Micro 2%	2.10±0.11	2.20±0.11	11.40±0.57	13.50±0.68	0.18±0.01	0.16±0.01
Sizm.	2.30±0.12	2.50±0.13	12.10±0.61	12.90±0.65	0.19±0.01	0.19±0.01
N1 + Sizm	2.60±0.13	2.70±0.14	13.80±0.69	14.90±0.75	0.19±0.01	0.18±0.01
N2 + Sizm	2.90±0.15	3.00±0.15	15.70±0.79	17.80±0.89	0.18±0.01	0.17±0.01
Micro1+Sizm	2.00±0.10	2.10±0.11	11.90±0.60	12.30±0.62	0.17±0.01	0.17±0.01
Micro2+Sizm	2.40±0.12	2.50±0.13	12.90±0.65	14.00±0.70	0.19±0.01	0.18±0.01
LSD (5%)	0.14	0.15	0.75	0.83	0.01	0.01

N_1: Ammonium sulfate (150kg/fed). N_2: Ammonium sulfate (300kg/fed).
$Micro_1$: (Zn, Mn, Fe, Cu) at 1%. $Micro_2$: (Zn, Mn, Fe, Cu) at 2%.

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تقييم التسميد المعدني والحيوي في الأراضي الجيرية وتأثيرها على نمو وإنتاج حبة البركة

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أجريت تجربتان حقليتان في أراضي جيرية بمنطقة مريوط في عـامي ٢٠٠٠، ٢٠٠١ لتقييم معدلات مختلفة من الأسمدة المعدنية والحيوية وتأثيرها على النمـو ومحصـول الحبـوب والزيت ومكونات النبات في محصول حبة البركة.

أظهرت النتائج أن هناك فروقا كبيرة بين جميع المعاملات والقطـع التجريبيـة غيـر المسمدة مما يوضح أهمية التسميد في هذه الأراضي بصفة عامة للحصول على نمو أفضل وإنتاج أوفر. وكان أفضل نمو خضري وأعلى محصول من البذور والزيت وامتصـاص النبـات مـن العناصر نتيجة إضافة سلفات الأمونيوم بمعدل ٣٠٠ كجم/فدان + التلقيح بالأزوتوباكتر. يلي ذلـك التسميد النتروجيني بنفس المعدل فقط ثم التسميد النتروجيني بمعدل ١٥٠ كجم/فـدان + التلقـيح بالأزوتوباكتر.

وكان لإضافة النتروجين والأزوتوباكتر سواء منفردا أو معا تأثير واضح فـي زيـادة محتوى النباتات من النتروجين. كما لوحظ تحسن في محتوى النباتات من الفوسفور نتيجة التلقيح بالأزوتوباكتر.