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EFFECT OF MYCORRHIZAE, AZOTOBACTER AND ORGANIC MANURE ON THE GROWTH, SEED YIELD AND OIL CONTENT OF *Nigella sativa* L. PLANTS GROWN UNDER TWO LEVELS OF CHEMICAL FERTILIZERS (NPK)

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ABSTRACT

Mature black cumin (*Nigella sativa* L.) seeds were planted in clay loam soil on the 23rd of November, 2005 and 2006 and were harvested on 10th April, 2006 and 2007 seasons. The data of vegetative growth, seed yield and oil seed percentage were determined. The data indicated that the biofertilization (*Glomus macrocarpus* fungus or Nitrobein bacteria) or organic manure alone or in combination with half or full NPK fertilizer increased plant height (cm), No. of branches and leaves, root length (cm) as well as herb and root dry weight when compared with uninoculated plants (control). Also, the best significant results of herb and root dry weight were found with mycorrhizal fungus and *Azotobacter* with full NPK fertilizers treatment as compared to the other treatments under study, while, the least values in these respects were found with the control plants. Also, *G. macrocarpus* fungus + Nitrobein + organic manure with full NPK fertilizer treatment was more effective in increasing the seed yield per plant and feddan than the other treatments under study. The same effect was found with *G. macrocarpus* fungus alone or combined with Nitrobein treatment when seed total and essential oil content were concerned. Generally, the biofertilization (mycorrhizae or *Azotobacter*) or organic manure increased the vegetative growth parameters, seed yield, and oil content than the control plants of black cumin.

Key words: *Azotobacter, chemical fertilizer, mycorrhizae, Niglla sativa, NPK, oil content, organic manure, plant growth, seed yield,.*

1. INTRODUCTION

Black cumin (*Nigella sativa* L.) is belonging to family *Ranunculaceae,*. Black cumin seeds or oil seeds are used by the common people for many medicinal purposes.

Generally, many researchers have been worked on the effect of chemical fertilizers on the growth and seed or oil yield of black cumin plants such as Das *et al.* (1991) who showed that plant height, no. of branches/plant and fresh or dry weight as well as seed yield of *Nigella sativa* were increased with N fertilization at 20-60 kg/ha and P fertilization at 20-40 kg/ha. El-Deeb *et al.* (1993) working on *Nigella sativa* plants showed that application of N fertilization at any level increased plant height. Singh *et al.* (1999) found that seed yield of *Nigella sativa* plants increased as N and P rates increased. Datta *et al.* (2001) found that the highest vegetative growth and yield parameters of *Nigella sativa* plants were obtained with NPK (45-45-45) treatment. Ashraf *et al.* (2005) reported that the best growth and seed yield of *Nigella sativa* plants were recorded at 30 and 60 kg N/ha.

Meanwhile, many researches have been worked on the effect of biofertilization and organic manure with or without the addition of chemical fertilization such as Nagarajan *et al.* (1989) who reported that *Azospirillium brasilense* and *Glomus faciculatum* as a combined treatment showed a remarkable increase in shoot and root biomass of mulberry (*Morus* sp.) in comparison with the uninoculated control plants. Meanwhile, Wange and Patil (1994) applied 100 kg N/ha alone or inoculating with *Azotobacter* + *Azospirillum* mixtures significantly increased the No. of flowers/stable, blub (rhizome) yield and the No. of flower stems produced by *Polianthes tuberose* plants. Mukhopadhyay and Sem (1997) showed that a significant increases in yield components occurred in black cumin plants with N-fixing bacteria. Also, Gupta *et al.* (1999) stated that the growth and flower yields of *T. erecta* plants were the highest after treatment with

Azotobacter + phosphorus solubilizing bacteria in combination with 75 or 100% N application. Also, Salama (2002) studied the response of Balady mandarin trees to organic fertilizers and biofertilizers, and showed that Rhizobacterium produced more enhancing effect on growth cycle duration, growth intensity of different flush, leaf area and leaf dry weight than Nitrobein treatments. Saraf and Tiwari (2004) stated that 75% NPK + FYM at 10 t/ha + biofertilizers (*Azotobacter* + phosphate solubilizing bacteria) treatment recorded the highest values of the yield parameters for both the main and ratoon crops of muskdana plants. Ray *et al.* (2005) reported that the addition of *Azotobacter chroococcum* and *Azospirillum brasilense* enhanced the yield of okra plant mere than the uninoculated ones.

The aim of the present work was to study the effect of organic and biofertilization under full or half NPK on growth, yield and chemical components of *Nigella sativa*.

2. MATERIALS AND METHODS

The experimental work was carried out at the Research Centre of the Faculty of Agriculture, Moshtohor, Benha University. The study was conducted through the two successive seasons of 2005-2006 and 2006-2007.

Seeds of black cumin (*Nigella sativa* L.) were planted on the 23rd of November, 2005 and 2006 at the rate of two plants in each site. The experiment was divided into plots (2x3 m^2), each plot contained 6 rows, 50 cm apart. The distance between the plants was 25 cm. The layout of this experiment was split-split in a complete randomized, design having 16 treatments. They were divided into two groups, each group contained 8 treatments with 6 replicates (6 rows). This experiment was statistically analyzed as a factorial experiment, the main factor was chemical fertilizers (NPK) as two levels, while the branch factor was *Mycorrhizae, Azotobacter,* organic manure or a combination of them.

The treatments included NPK fertilization according to the recommendation of the Egyptian Ministry of Agriculture (82.5 kg N, 45 kg P_2O_5 and 36 kg K_2O per feddan) or half of these amounts. The treatments were as follows:

Half NPK	Full NPK
1- Control (half NPK)	1-Control (full NPK) (recommended)
2- *Glomus macrocarpus* fungus.	2-*Glomus macrocarpus* fungus.
3-Nitrobein (N-fixiation bacteria)	3-Nitrobein (N-fixiation bacteria)
4-Organic manure (cattle)	4- Organic manure (cattle)
5- G.m. + Nitro.	5- G.m. + Nitro.
6- G.m. + O.m.	6- G.m. + O.m.
7- Nitro + O.m.	7- Nitro + O.m.
8-G.m.+ Nitro + O.m.	8- G.m. + Nitro + O.m.

The seeds of *Nigella sativa* were planted in clay loam soil. The soil was inoculated before planting with endomycorrhizal fungus (*Glomus macrocarpus*) according to the method of Menge *et al.* (1977). While, nitrogen biofertilization treatment was used with Nitrobein bacteria (*Azotobacter chroococcum*) according to the recommendation of Microbiology Unit, Agric. Research Centre, Egyptian Ministry of Agric. Meanwhile, the organic manure treatment was applied according to the recommendation of the Ministry of Agric. (10 m^3/feddan). The nitrogen fertilization was divided into 2 equal portions, the first was applied after one month from seed planting, while the second was applied after 2 months from seed planting as ammonium nitrate (33% N) form. Moreover, calcium superphosphate (15.5% P_2O_5), potassium sulphate (48% K_2O), cattle manure, mycorrhizal fungus and Nitrobein bacteria were treated prior to seed planting. However, all the treatments under study were treated with the same agriculture management practies.

Black cumin plants were harvested on 10 April in the first and second seasons (2006 and 2007). The treated plants were subjected to the following measurements:

1- Vegetative growth: plant height (cm), No. of branches and leaves per plant, root length (cm) as well as herb and root dry weight (g)/plant.
2- The seed yield per plant (g) and per feddan (kg).
3- Total and essential seed oil percentage.

Also, fertilizer dependency ratio (FDR) percentage was calculated on the basis of the ratio between plant fresh weight (g) of fertilizer plants for each mycorrhizal, Nitrobein, organic manure or their combination under full or half NPK and their corresponding control as a formula:

$$FDR = \frac{\text{Plant fresh weight of each treatment}}{\text{Control plant fresh weight (half or full NPK)}} \times 100$$

Seed oil extracted by using Soxhelet and petroleum ether (40-60°C) as a solvent according to A.O.A.C. (1985). The total oil percentage of black cumin seeds were calculated.

Data expressed as percentages were statistically analyzed according to Steel and Torrie (1960). All obtained data were subjected to analysis of variance test and least significant differences among means were calculated according to the Duncan's multiple range tests, Duncan (1955) at 1% level.

3. RESULTS AND DISCUSSION

3.1. Growth characters

3.1.1. Plant height and No. of branches

The data in Table (1) showed that black cumin plants treated with *Glomus macrocarpus* fungus combined with organic manure (cattle) and mineral fertilizers with full NPK gave the highest values of plant height (cm). The same trend of the highest significant value was observed in No. of branches per plant treated with the interaction treatment (*G. macrocarpus* + Nitrobein + O.m. with full dose NPK fertilizers) as compared to the other treatments. In contrast, the least values of both plant height and No. of branches were obtained from the control whether full or half dose of NPK fertilizers alone in the two studied seasons.

Also, *Mycorrhizal* fungus alone or combined with Nitrobein bacteria treatment under any level of mineral fertilizer (half or full) improved plant height (cm) and No. of branches when compared with corresponding plants fertilized with the same level of NPK mineral fertilizer alone.

3.1.2. Number of leaves per plant and root length (cm)

The data in Table (2) showed that *G. macrocarpus* fungus + Nitrobein with full dose NPK treatment was more effective in increasing No. of leaves per plant and root length (cm) when compared with the other treatments. While, the least values were obtained with the control whether with full or half dose of NPK.

Meanwhile, when concerning the specific effect of treatments alone, the data revealed that *Mycorrhizae* or *Azotobacter* or organic manure induced a significant increase on No. of leaves and root length of *Nigella sativa* plants than the control plants. In the same time, the biofertilization treatments or organic manure with half NPK fertilizers treatment were reached the same level effect in this respect to the same values of No. of leaves and root length which obsereved with the same biofertilization or organic manure with full dose NPK fertilizers.

3.1.3. Root and herb dry weight of black cumin

The results in Table (3) indicated that the interaction treatment of *G. macrocarpus* fungus + Nitrobein + full dose NPK fertilizers gave the best significant values of herb and root dry weights of *Nigella sativa* plants. While, the least significant herb and root dry weights were obtained with the control (half NPK treatment).

G. macrocarpus fungus + Nitrobein bacteria treatment was more effective in inducing significant increase in herb and root dry weights more than the other treatments in both seasons.

The specific effect of mycorrhizae or Azotobacter or organic manure gave the best significant herb and root dry weights than the control treatment with NPK fertilizers.

Generaly, the obtained results assured the findings of Gendiah (1987) on sour oranges and Cleopatra mandarin seedlings with mycorrohizal fungi, Rao and Dass (1989) on *Zizphus mauritiana* cv. Seb and Gola and on root cuttings of pomegranate with *Azospirillum* and *Azotobacter*, Nagarajan *et al.* (1989) on mulberry with *Glomus fasiculatum* fungus and *Azospirillum bacterium*, Mousa *et al.* (2001) and Nataraja *et al.* (2003) on *Nigella sativa* plants.

3.1.4. Fertilizer dependency ratio (FDR)%

The results tabulated in Table (4) showed that *G. macrocorpus* + Nitrobein bacteria with full dose NPK treatment gave the highest significant value of fertilizer dependency ratio percentage of *Nigella sativa* plants as compared to the other treatments in both seasons. *G. macrocorpus* fungus + Nitrobein + organic manure + half dose NPK treatment came in the second rank as a significant increase of FDR% value of black cumin plants. On the contrast, *G. macrocarpus* fungus + organic manure + half dose NPK treatment gave the least significant value of FDR% as compared to the other treatments except the control plants as a ratio to the other treatments.

Generally, it might be said that Azotobacter treatment was more effective in increasing the FDR% values of black cumin plants than mycorrhizal fungus or organic manure. This result might be due to the effect of Nitrobein bacteria on inducing an increase in fresh vegetative growth as compared to other treatments. These results are in agreement with the findings of Gendiah (1987) who found that mycorrhizal dependency percentage values of mycorrhizae treated Cleopatra mandarin and sour oranges were increased in a significant level as compared to untreated seedlings.

Table (1): Effect of biofertilization (*Mycorrhizae* or Nitrobein), organic manure or their combinations on plant height and No. of branches of *Nigella sativa* plants grown under two levels of NPK fertilizers.

Treatment	Plant height (cm)						No. of branches/plant					
	2005-2006			2006-2007			2005-2006			2006-2007		
	H.F.*	F.F.**	Mean	H.F.*	F.F.**	Mean	H.F.*	F.F.**	Mean	H.F.*	F.F.**	Mean
Control	44.4 j	45.6 hij	45.0 d	47.8 d	41.2 f	44.5 f	3.8 def	4.6 cde	4.2 c	4.0 d	4.6 cd	4.3 d
Glomus macrocarpus (G.M.)	49.0 efg	53.6 d	51.3 b	58.8 a	54.8 c	56.8 a	6.0 ab	6.8 a	6.4 a	5.0 cd	5.6 bcd	5.3 bcd
Nitrobein (Nitro.)	47.6 fgh	48.4 efg	48.0 c	44.6 e	55.8 bc	50.2 cd	4.6 bc	4.4de	4.5 bc	6.0 bc	5.0 cd	5.5 bc
Organic manure (O.M.)	50.0 e	56.2 c	53.1 b	43.6 e	59.4 a	51.5 bcd	5.6 bc	3.8 def	4.7 bc	6.8 ab	5.0 cd	5.9 b
G.M. + Nitro.	53.6 d	60.0 b	56.8 a	45.4 e	56.2 bc	50.8 bcd	4.8 cd	4.4 de	4.6 bc	4.2 cd	6.0 bc	5.1 bcd
G.M. + O.M.	50.2 e	63.0 a	56.6 a	48.0 d	57.8 ab	52.9 b	4.6 cde	3.2 f	3.9 c	5.0 cd	4.0 d	4.5 cd
Nitro. + O.M.	47.0 ghi	58.6 b	52.8 b	44.8 e	55.0 c	49.9 d	3.6 ef	3.8 def	3.7 c	5.0 cd	4.0 d	4.5 cd
G.M. + Nitro. + O.M.	45.0 ij	49.6 ef	47.3 c	43.4 e	58.8 a	51.1 bcd	4.8 cd	6.0 ab	5.4 ab	7.0 ab	8.0 a	7.5 a
Specific effect												
NPK (control)	44.4 c	45.6 b	45.0 b	47.8 a	41.2 b	44.5 b	3.8 b	4.6 a	4.2 b	4.0 b	4.6 b	4.3 b
Mycorrhizae	49.5 b	56.6 a	53.1 a	48.9 a	56.9 a	52.9 a	6.1 a	5.1 a	5.6 a	5.3 a	5.9 a	5.6 a
Azotobacter	58.3 a	54.2 a	51.3 a	44.6 b	56.5 a	50.6 a	4.5 b	4.7 a	4.6 ab	5.6 a	5.8 a	5.7 a
Organic manure	48.1 b	56.9 a	52.5 a	45.0 b	57.8 a	51.4 a	4.7 b	4.2 a	4.5 b	6.0 a	5.3 ab	5.7 a

* H.F.: Half dose NPK fertilizers. ** F.F.: Full dose NPK fertilizers.

Means followed by the same letter, within each column, are not significantly different for each other at 1% level.

Table (2): Effect of biofertilization (*Mycorrhizae* or Nitrobein), organic manure or their combinations on No. of leaves and root length (cm) of *Nigella sativa* plants grown under two levels of NPK fertilizers.

Treatment	No. of leaves/plant						Root length (cm)					
	2005-2006			2006-2007			2005-2006			2006-2007		
	H.F.*	F.F.**	Mean	H.F.*	F.F.**	Mean	H.F.*	F.F.**	Mean	H.F.*	F.F.**	Mean
Control	14.0 ef	14.8 e	14.4 c	14.2 hi	15.5 gh	14.9 d	11.3 cde	9.4 ef	10.4 b	10.0 ef	7.2 g	8.6 c
Glomus macrocarpus (G.M.)	15.0 e	18.4 d	16.7 bc	16.0 fgh	18.0 def	17.0 cd	10.0 def	13.8 ab	11.9 a	10.2 ef	11.4 cde	10.8 b
Nitrobein (Nitro.)	14.4 ef	14.4 ef	14.4 c	13.0 i	20.0 bcd	16.5 d	9.6 ef	12.6 bc	11.1 ab	10.0 ef	11.2 de	10.6 b
Organic manure (O.M.)	14.4 ef	21.6 b	18.0 ab	17.2 efg	20.2 bcd	18.7 bc	11.0 cde	12.0 bcd	11.5 ab	9.8 ef	12.0 bcd	10.9 b
G.M. + Nitro.	12.6 fg	24.6 a	18.6 ab	19.0 cde	23.8 a	21.4 a	11.0 cde	13.4 ab	12.2 a	10.8 de	13.8 a	12.3 ab
G.M. + O.M.	11.6 g	19.4 cd	15.5 c	18.8 cde	18.8 cde	18.8 bc	8.4 f	15.4 a	11.9 a	11.0 de	13.3 ab	12.2 ab
Nitro. + O.M.	13.2 efg	23.0 ab	18.1 ab	18.3 de	20.8 bc	19.6 ab	9.0 ef	12.8 bc	10.9 ab	9.0f	12.2 abcd	10.6 b
G.M. + Nitro. + O.M.	17.6 d	21.2 bc	19.4 a	18.0 def	22.0 ab	20.0 ab	12.0 bcd	11.0 cde	11.5 ab	12.0 bcd	13.0 abc	12.5 a
Specific effect												
NPK (control)	14.0 a	14.8 b	14.4 b	14.2 b	15.5 b	14.9 b	11.3 a	9.4 b	10.4 b	10.0 a	7.2 b	8.6 b
Mycorrhizae	14.2 a	20.9 a	17.6 a	18.0 a	19.8 a	18.9 a	10.4 a	13.4 a	11.9 a	11.0 a	12.4 a	11.7 a
Azotobacter	14.5 a	20.8 a	17.7 a	17.1 a	20.8 a	19.0 a	10.4 a	12.5 a	11.5 ab	10.5 a	12.1 a	11.3 a
Organic manure	14.2 a	21.3 a	17.8 a	18.1 a	21.4 a	19.8 a	10.1 a	12.8 a	11.5 ab	10.5 a	13.1 a	11.8 a

* H.F.: Half dose NPK fertilizers. ** F.F.: Full dose NPK fertilizers.

Means followed by the same letter, within each column, are not significantly different for each other at 1% level.

Table (3): Effect of biofertilization (*Mycorrhizae* or Nitrobein), organic manure or their combinations on dry weight of herb and root dry weight (g) of *Nigella sativa* plants grown under two levels of NPK fertilizers.

Treatment	Dry weight of herb (g)						Root dry weight (g)					
	2005-2006			2006-2007			2005-2006			2006-2007		
	H.F.*	F.F.**	Mean	H.F.*	F.F.**	Mean	H.F.*	F.F.**	Mean	H.F.*	F.F.**	Mean
Control	2.43 g	3.54 f	3.00 e	1.61 g	2.34 f	1.98 c	0.13 e	0.21 de	0.17 c	0.14 g	0.33 de	0.24 b
Glomus macrocarpus (G.M.)	2.74 g	5.09 cd	3.92 cd	3.30 e	4.41 d	3.86 b	0.14 e	0.41 b	0.28 ab	0.20 fg	0.39 cd	0.30 ab
Nitrobein (Nitro.)	2.88 g	5.89 b	4.39 bc	3.31 e	6.10 b	4.71 a	0.19 de	0.44 ab	0.32 ab	0.21 fg	0.44 bc	0.33 a
Organic manure (O.M.)	4.45 de	6.43 a	5.44 a	2.54 f	6.17 b	4.36 ab	0.23 cde	0.40 b	0.32 ab	0.14 g	0.50 ab	0.32 ab
G.M. + Nitro.	3.60 f	7.21 a	5.41 a	2.52 f	6.91 a	4.72 a	0.19 de	0.52 a	0.36 a	0.16 g	0.53 a	0.35 a
G.M. + O.M.	2.25 g	4.97 d	3.61 de	4.50 cd	5.01 cd	4.76 a	0.21 de	0.26 cde	0.24 bc	0.36 cd	0.37 cd	0.37 a
Nitro. + O.M.	2.88 g	5.92 b	4.40 bc	3.24 e	5.17 c	4.21 ab	0.16 de	0.39 b	0.28 ab	0.22 fg	0.51 ab	0.37 a
G.M. + Nitro. + O.M.	4.11 ef	5.24 cd	4.68 b	3.16 e	4.61 cd	3.89 b	0.28 cd	0.34 bc	0.31 ab	0.26 ef	0.34 de	0.30 ab
Specific effect												
NPK (control)	2.43 b	3.54 b	3.00 b	1.61 b	2.34 b	1.98 b	0.13 b	0.21 c	0.17 b	0.14 b	0.33 b	0.24 b
Mycorrhizae	3.18 a	5.63 a	4.41 a	3.37 a	5.24 a	4.31 a	0.21 a	0.38 ab	0.30 a	0.25 a	0.41 a	0.33 a
Azotobacter	3.37 a	6.07 a	4.72 a	3.06 a	5.70 a	4.38 a	0.21 a	0.42 a	0.32 a	0.21 a	0.46 a	0.34 a
Organic manure	3.42 a	5.64 a	4.53 a	3.36 a	5.24 a	4.30 a	0.22 a	0.35 b	0.29 a	0.25 a	0.43 a	0.34 a

* H.F.: Haif dose NPK fertilizers. ** F.F.: Full dose NPK fertilizers.

Means followed by the same letter, within each column, are not significantly different for each other at 1% level.

Table (4): Effect of biofertilization (*Mycorrhizae* or Nitrobein), organic manure or their combinations on fertilizer dependency ratio (FDR) % of *Nigella sativa* plants grown under two levels of NPK fertilizers.

Treatment	Fertilizer dependcy ration % (FDR)					
	2005-2006			2006-2007		
	H.F.*	F.F.**	Mean	H.F.*	F.F.**	Mean
Control	0.00 j	0.00 j	0.00f	0.00 j	0.00 j	0.00 e
***Glomus macrocarpus* (G.M.)**	39.27 hi	77.46 g	58.37 e	95.60 f	72.98 g	84.29 c
Nitrobein (Nitro.)	54.62 h	115.45 bc	85.04 c	89.36 f	111.36 e	100.36 b
Organic manure (O.M.)	118.86 b	89.93 ef	104.40 b	45.11 h	89.77 f	67.44 d
G.M. + Nitro.	106.63 cd	182.46 a	144.55 a	123.36 cd	186.81 a	155.09 a
G.M. + O.M.	47.98 hi	90.73 ef	69.36 d	17.59 i	138.25 b	77.92 c
Nitro. + O.M.	100.39 de	86.84 fg	93.62 c	129.36 bc	179.29 a	154.33 a
G.M.+ Nitro.+ O.M.	125.88 b	104.81cd	115.35 b	119.29 de	127.27 cd	123.28 b
Specific effect						
NPK (control)	0.00 c	0.00 c	0.00 c	0.00 d	0.00 c	0.00 c
Mycorrhizae	79.94 b	113.87 a	96.91 b	88.96 b	131.33 b	110.15 b
Azotobacter	96.88 a	122.39 a	109.64 a	115.34 a	151.18 a	133.26 a
Organic manure	98.28 a	93.08 b	95.68 b	77.84 c	133.65 b	105.75 b

* H.F.: Half dose NPK fertilizers. ** F.F.: Full dose NPK fertilizers.
Means followed by the same letter, within each column, are not significantly different fro each other at 1% level.

3.2. Seed yield/feddan

The results in Table (5) showed that *G. macrocapus* fungus with a half dose NPK fertilizers or *G. macrocarpus* fungus + Nitrobein bacteria + organic manure with full NPK gave a higher significant seed yield per plant or feddan as compared to the other treatments in both seasons. On the contrast, the control plants fertilized with half NPK gave the least yield per plant or feddan of black cumin plants.

These results agree with the findings of Das *et al.* (1991) and Singh *et al.* (1999) on the effects of chemical fertilizers N and P on *Nigella sativa* plant yield, Srivastava *et al.* (2002) on organic manure fertilizers and mycorrhizal fungi with citrus trees. Also, Saraf and Tiwari (2004) stated that 75% NPK + FYM at 10 t/ha + biofertilizers (*Azotobacter* + phosphate solubilizing bacteria) treatment recorded the highest values for No. of fruits/plant, fruit length, fruit diameter, fruit weight, seed number per fruit, seed weight/fruit and seed yield for both the main and ratoom crops of muskdana plants.

3.3. Total seed oil percentage

The results in Table (6) showed that *G. macrocarpus* fungus with half NPK treatment or mycorrhizal fungus + Nitrobein with half NPK gave the highest significant values of seed oil percentage as compared to the other treatments. While, the least value of seed total oil percentage was observed with the control plants fertilized with half NPK.

Moreover, the biofertilization with endomycorrhizae or Nitrobein (Azotobacter) as well as organic fertilization with cattle manure for *Nigella sativa* plants induced highly significant values of seed oil percentage more than uninoculated plants fertilized only with chemical NPK. Also, mycorrhizal fungus treated plants and fertilized with half NPK produced higher seed oil percentage comparing with the analogous ones (mycorrhizal plants) with full NPK treatments.

The obtained results on black cumin plants are in agreement with the findings of Akath Singh and Singh (2004) who found that the treatment of three-fourth dose N + full dose P + 20 g *Azotobacter*/tree of olive trees gave the highest increase in oil content of fruits. Also, Khalid *et al.* (2005) reported that celery plants treated with S and S-oxidizing bacteria (*Thiobacillus thiooxidans*) increased total fixed and essential oil contents than the control plants.

Generally, the combination of organic and biofertilizers under half dose of NPK resulted in beneficial effects on increasing seed yield. This might allow the reduction of chemical fertilization saving money and biohazard environment pollution.

Table (5): Effect of biofertilization (*Mycorrhizae* or Nitrobein), organic manure or their combinations on the yield of plant (g) and yield/feddan (kg) of seed *Nigella sativa* plants grown under two levels of NPK fertilizers.

Treatments	The seed yield of plant (g)						The seed yield/feddan (kg)					
	2005-2006			2006-2007			2005-2006			2006-2007		
	H.F.*	F.F.**	Mean	H.F.*	F.F.**	Mean	H.F.*	F.F.**	Mean	H.F.*	F.F.**	Mean
Control	2.916 g	3.625 f	3.271 f	3.010 h	3.920 g	3.465 e	168.0 j	208.8 i	188.4 e	173.4 i	225.8 h	199.6 e
Glomus macrocarpus (G.M.)	5.875 ab	5.416 bc	5.646 ab	6.800 a	5.810 cd	6.305 a	338.4 bc	312.0 de	325.2 a	391.7 a	334.7 de	363.2 a
Nitrobein (Nitro.)	4.583 de	4.083 ef	4.333 e	5.020 e	4.200 fg	4.660 cd	264.0 g	235.2 h	249.6 d	289.2 f	247.7 g	268.5 c
Organic manure (O.M.)	3.750 f	4.500 e	4.125 e	4.200 g	4.200 g	4.200 d	216.0 hi	259.2 g	237.6 d	241.9 gh	241.9 gh	241.9 d
G.M. + Nitro.	5.000 cde	5.583 b	5.292 bc	5.600 d	5.700 cd	5.650 b	288.0 f	321.6 cd	304.8 b	322.6 e	328.3 e	325.5 b
G.M. + O.M.	3.833 f	5.958 ab	4.896 cd	4.800 ef	6.100 bcd	5.450 b	220.0 hi	343.2 b	282.0 c	276.5 f	351.4 cd	313.9 b
Nitro. + O.M.	5.041 cd	3.916 f	4.479 de	5.600 d	4.010 g	4.805 c	290.4 ef	225.6 hi	258.0 d	322.6 e	231.0 gh	276.8 c
G.M. + Nitro. + O.M.	5.333 c	6.333 a	5.833 a	6.200 bc	6.500 ab	6.350 a	307.2 def	364.8 a	336.0 a	357.1 bc	374.4 ab	365.8 a
Specific effect												
NPK (control)	2.916 c	3.625 c	3.271 c	3.010 b	3.920 c	3.465 c	168.0 c	208.8 c	188.4 c	173.4 c	225.8 c	199.6 c
Mycorrhizae	5.010 a	5.823 a	5.417 a	5.850 a	6.028 a	5.939 a	288.6 a	335.4 a	312.0 a	337.0 a	347.2 a	342.1 a
Azotobacter	4.989 ab	4.979 b	4.984 ab	5.605 a	5.103 b	5.354 b	287.4 a	286.8 b	287.1 b	322.9 a	295.4 b	309.2 b
Organic manure	4.489 b	5.177 ab	4.833 b	5.200 a	5.203 b	5.202 b	258.6 b	298.2 b	278.4 b	299.5 b	299.7 b	299.6 b

* H.F.: Half dose NPK fertilizers. ** F.F.: Full dose NPK fertilizers.

Means followed by the same letter, within each column, are not significantly different for each other at 1% level.

Table (6): Effect of biofertilization (*Mycorrhizae* and Nitrobein) and organic manure on seed oil (%) of *Nigella sativa* plants grown under two levels of NPK fertilizers.

Treatment	Total seed oil (%)					
	2005-2006			2006-2007		
	H.F.*	F.F.**	Mean	H.F.*	F.F.**	Mean
Control	24.98 g	25.67 g	25.33 e	25.18 j	27.18 ij	26.18 e
Glomus macrocarpus (G.M.)	38.21 a	30.85 cde	34.53 ab	37.71 ab	32.35 fg	35.03ab
Nitrobein (Nitro.)	31.40 bcd	30.34 cde	30.87 c	32.15 fg	31.50 fg	31.83 cd
Organic manure (O.M.)	27.31 fg	29.19 def	28.25 d	28.80 hi	30.82 gh	29.81 d
G.M. + Nitro.	39.46 a	33.37 b	36.42 a	38.65 a	35.16 cd	36.91 a
G.M. + O.M.	32.94 bc	32.12 bc	32.53 bc	33.56 def	34.60 cde	34.08 abc
Nitro. + O.M.	28.42 ef	33.94 b	31.18 c	30.18 gh	35.62 cde	32.90bc
G.M. + Nitro. + O.M.	31.94 bc	33.78 b	32.86 bc	32.87 efg	36.28 bc	34.58 abc
Specific effect						
NPK (control)	24.98 c	25.67 b	25.33 b	25.18 c	27.18 b	26.18 b
Mycorrhizae	35.64 a	32.53 a	34.09 a	35.68 a	34.60 a	35.14 a
Azotobacter	32.81 ab	32.86 a	32.84 a	32.18 b	34.64 a	33.41 a
Organic manure	30.15 b	32.26 a	31.21 a	31.34 b	34.33 a	32.84 a

* H.F.: Half dose NPK fertilizers. ** F.F.: Full dose NPK fertilizers.
Means followed by the same letter, within each column, are not significantly different for each other at 1% level.

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تأثير الميكورهيزا والأزوتوباكتر والتسميد العضوى على نمو ومحصول البذرة ومحتوى الزيت فى نباتات حبة البركة النامية تحت مستويين من التسميد الكيميائى (النيتروجين، والفوسفور، والبوتاسيوم)

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ملخص

زرعت بذور حبة البركة الناضجة فى تربة طينية فى ٢٣ نوفمبر خلال عامى ٢٠٠٥، ٢٠٠٦م وتم جمع النباتات فى ١٠ أبريل عامى ٢٠٠٦، ٢٠٠٧م وتم أخذ البيانات على النمو الخضرى وكذلك محصول البذرة من الزيت الكلى. أشارت النتائج المتحصل عليها إلى أن التسميد الحيوى بفطر جلومس كروكاربس أو بكتريا النيتروبين أو التسميد العضوى (روث الماشية) سواء كانت منفردة أو فى مخلوط تحت مستوى التسميد الكيماوى (بالنيتروجين والفوسفور والبوتاسيوم) بمستوى نصف الكمية أو الكمية الكاملة التى أوصت بها وزارة الزراعة المصرية أدت إلى حدوث زيادة فى ارتفاع النبات وعدد الأفرع والأوراق وطول الجذر بالإضافة إلى الوزن الجاف للنمو الخضرى والجذرى مقارنة بنباتات الكنترول (المسمدة بالتسميد الكيماوى فقط سواء بنصف الكمية أو بالكمية الكاملة). وجد بالإضافة إلى ذلك أن أفضل النتائج معنويا فى الوزن الخضرى والجذرى الجاف حدثت مع المعاملة بالتسميد الحيوى بفطر الميكورهيزا والأزوتوباكتر مع التسميد الكيماوى (NPK) بالكمية الكاملة بالمقارنة بجميع المعاملات الأخرى تحت الدراسة. بينما وجد أن أقل النتائج كانت مع معاملة الكنترول سواء المسمدة بنصف الكمية أو بالكمية الكاملة (NPK). وجد أيضا أن المعاملة التى تحتوى خليط من فطر الميكورهيزا والنيتروبين والسماد العضوى مع التسميد الكيماوى (NPK) بالكمية الكاملة كانت أكثر زيادة معنوية فى محصول البذرة للنبات والفدان مقارنة بجميع المعاملات الأخرى تحت الدراسة – كذلك وجد نفس تأثير الزيادة مع المعاملة بفطر الميكورهيزا سواء وحدها أو مخلوطة مع النيتروبين وذلك فى محتوى البذرة من الزيت الكلى.

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