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EFFECT OF SOIL APPLICATION WITH NITROGEN LEVELS AND POTASSIUM SILICATE FOLIAR SPRAY ON GROWTH AND YIELD OF BLACK CUMIN (*Nigella sativa* L.)

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ABSTRACT

This study was carried out during the winter seasons of 2014-15 and 2015-16 at the Experimental Farm of Environmental Agricultural Sciences Faculty, Arish University, North Sinai Governorate, Egypt. The main effects and their interactions of four different nitrogen levels (0, 50, 75 and or Kg/fed) and four foliar application rates of potassium silicate spray (0, 4, 6 or 8 cm^3/L) on growth, yield component and chemical content of seeds (nitrogen, phosphorus, and potassium), and fresh leaves content of chlorophyll a and b as well as seed content of fixed oil of black cumin (*Nigella sativa*) were investigated under sandy soil conditions. A split plot design was used where nitrogen levels were randomly arranged in main plots and the potassium silicate spray rates were randomly distributed in the sub plots, Drip irrigation was used. Distance between lines was 50 cm and between plants in the same row was 30 cm (28000 plant per fed). The obtained results obviously showed that the highest value of plant height, number of branches/plant, fresh and dry weights of herb, number of capsules for each plant, number of seeds/capsule, seed yield, weight of 1000 seeds, seed content of N, P, K, leaves chlorophyll content (a and b) and seed fixed oil percentage were increased as N application level increased up to 100 kg N/fed alone or 8 ml/L potassium silicate spray alone. The interaction results indicated that the highest value of all previous traits was recorded with plants fertilized with 100 kg N/fed with 8 ml/L potassium silicate as foliar spray.

Key words: *Nigella sativa*, nitrogen, fertilization, potassium silicate, foliar spray.

INTRODUCTION

Black cumin (*Nigella sativa* L.) is an annual herbaceous plant belongs to family Ranunculaceae. It is widely cultivated throughout South Europe, Syria, Egypt, Saudi Arabia, Iran, Pakistan, India and Turkey **(Nadeem *et al.,* 2013)**. Mature seeds are consumed for edible purposes as seasoning for vegetables, legumes and different types of baked products **(Hammo, 2008)**.

Black cumin seeds and their extracts contain anti-biotic, antihistaminic, anti-hypertensive, anti-inflammatory, anti-microbial, antitumor, galactagogue and insect repellent properties **(Shirmohammadi *et al.,* 2014)**. Also, it has been widely used as liver tonics, diuretics, digestive, antidiarrheal, appetite stimulant, analgesics, and in skin disorders **(Khalid and Shedeed, 2015)**.

Nitrogen is vital in protein structure as well as being an active constituent of RNA and DNA, which are essential for protein synthesis **(Marschner, 1995)**. It is also vital for NR activity which is the enzyme presential for N metabolism and responsible for the reduction of nitrate to ammoniacal N, then amino acids **(Hopkins, 1995).**

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Nitrogen (N) is the single which most important growth limiting factor for crops and has proved to be most instrumental among all major elements in boosting the yield of numerous plants. The success of N fertilization mainly arises from the indispensability of N as a plant nutrient, where in it forms an integral part of biologically critical molecules, such as nucleic acids, structural and catalytic protein (**Shah, 2008**). Agricultural soils are often deficient in N and hence, to ensure adequate N supply to crops and to prevent from nutrient deficiencies, large amounts of inorganic N are applied (**Ali *et al.,* 2015**).

Potassium silicate is a source of highly soluble potassium and silicon. It is used in agricultural production systems primarily as a silica amendment and has the added benefit of supplying small amounts of potassium (**Abou-Baker *et al.,* 2011**).

Silicon (Si) is not considered an essential plant nutrient; however, several plant species demonstrate improved disease resistance, abiotic stress tolerance, and altered morphological traits **(Mattson and Leatherwood, 2010)**. Silicon plays an important role in growth improvement, photosynthesis increase, efficiency of transpiration and evaporation, increasing the strength of leaves, chlorophyll concentration per leaf area and product quality **(Talebi *et al.,* 2015)**.

So, the objective of this work was to study the effect of nitrogen fertilizer as soil application or potassium silicate foliar spray application each alone and their interaction treatments on *Nigella sativa* L. plant in sandy soil at EL-Arish region, North Sinai.

MATERIALS AND METHODS

This study was carried out at the Experimental Farm of Faculty of Environ. Agric. Sci., Arish University, North Sinai Governorate, Egypt, during the two successive winter seasons of 2014/2015 and 2015/2016. The main object of this work was to study the effect of soil application with different N levels and potassium silicate foliar spray rates on the vegetative growth, fixed oil yield and some chemical constituents of *Nigella sativa* L. plant.

The seeds of *Nigella sativa* L. were obtained from Medicinal and Aromatic Plant Department, Agriculture Research Center, Cairo. The seeds were sown in sandy soil on 16th November in both seasons. Drip irrigation system was used. Physical and chemical analyses of soil and chemical analysis of well water used for irrigation were carried out using Atomic Absorption Spectrophotometer according to **Page (1982)** and presented in Table 1.

This experiment included 16 treatments which were the combination between four nitrogen levels and four rates of potassium silicate foliar spray. Treatments were arranged in a split plot design with three replicates, where nitrogen fertilization levels were randomly arranged in the main plots and potassium silicate spray rates were randomly arranged in the sub plots.

Nitrogen fertilizer was applied at the levels of 0, 50, 75 or 100kg N/fed in the form of ammonium nitrate (33.5% N). The amount of chemical was divided into two equal doses, the first dose was applied at 60 days and the remainder at 75 days after sowing.

Foliar sprayed with potassium silicate (25% SiO_2+ 10% K_2O) solution was at rates of 4, 6 or 8 ml/L added in two equal doses; the first portion was after two months from sowing and the remainder at 75 days later. potassium silicate foliar spray was obtained from Abo-Ghaneima Fertilizers and Chemical Industries Company, Cairo, Egypt.

The field was properly ploughed, 3 days later it was split for lines, trenches on inside the lines were made to add compost at the rate of 15 ton/fed, ordinary supper phosphate

Table (1): Mechanical and chemical analyses of soil and chemical analysis of well water.

Properties	Soil		Well Water
	1^{st} season (2014/2015)	2^{nd} season (2015/2016)	
Mechanical analysis	**Particular size distribution (%)**		
Clay	1.80	1.60	-
Silt	3.10	3.40	-
Fine sand	76.30	76.20	-
Coarse sand	18.80	18.80	-
Soil texture	Sandy soil	Sandy soil	-
Chemical analysis	**Soluble ions ($meq.l^{-1}$) (soil past extract)**		
Ca^{++}	3.03	2.10	18.10
Mg^{++}	2.11	2.20	20.18
Na^{+}	1.18	4.49	17.70
K^{+}	0.48	0.31	0.24
Cl^{-}	1.02	2.30	38.38
Co_3^{--}	-	-	-
Hco_3^{-}	2.00	2.40	6.23
So_4^{--}	3.78	4.40	11.61
EC(dsm^{-1})	0.68	0.91	5.62
pH (1:2.5)soil suspensions	8.10	8.20	6.69
Organic carbon ($g.kg^{-1}$)	0.93	1.22	-
Organic matter ($g.kg^{-1}$)	1.16	2.10	-
Ca CO_3 ($g.kg^{-1}$)	3.95	3.95	-

(15.5% P_2O_5) and potassium sulphate (48%k2o k_2O) at the rate of 200 and 75kg. fed-1 respectively, then leveled the ground, installation of irrigation hoses and plots were prepared according to the plan of layout.

The seeds had been sown in rows spaced at 30cm after sowing; the seeds have been covered by soil and slightly pressed by hand and had been thinned to one plant in the hill after three weeks later. The experimental unit area was 15 m^2. . Every unit contained three dripper lines with 10 m length. The distance between lines was 50 cm and between plants in the same line was 30 cm (28000 plant per fed). Control plots were cultivated in the same way.

Harvesting turned into began while the capsules turn yellow and the seeds in the capsules turned to black. Harvesting was manually performed in the morning. Collecting of capsules was done in paper bags on 20th April and finished on 3th May and open in capsules was manually opened for extraction of seeds.

Data were recorded for the plant height (cm), number of branches /plant, herb fresh and dry weights, number of capsules, seed yield, and weight of 1000 seeds per plant. Ten plants were randomly selected from each plot and the observations were recorded.

Chlorophyll a, b contents in the fresh leaves of *Nigella sativa* were determined in leaf samples (mg/g fresh matter) according to **Sumanta *et al.* (2014).** Also, nitrogen and phosphorus were determined in seeds according to the standard AOAC. **Procedures (1975)**. Potassium was determined using a flame photometer

(Jackson, 1973). Protein content of the seed was calculated by multiplying percent nitrogen content in seed with the factor 6.25.

Fixed oil was determined according to **Kara *et al* (2015)**. The seed oil content was determined as a percentage from the seed weight using the following formula:

Fixed oil % = (weight of extracted oil / weight of sample) ×100

All collected data were analyzed with analysis of variance (ANOVA) procedure using the General Linear Models (GLMs) procedures using SAS **(SAS, 2004**). Differences between means were compared by using duncan multiple range test at 0.05 level **(Duncan, 1955).**

RESULTS AND DISCUSSION

Effect of nitrogen fertilizer rates
Growth, yield and its component

The effect of N levels on plant characters and yield components of *Nigella sativa* L in both seasons are presented in Table 2. The results showed that nitrogen fertilizer had significant influences on all studies traits in the two growing seasons. plant height (cm) number of branches/plant, herb fresh and dry weights, No. of capsules/plant, number of seed/capsule , number of seeds/capsules and 1000 seed weights, were increased markedly and significantly with increasing N level up to 100 kg/fed compared with control in both seasons. However there were no significant effects between treatments of 75 and 100 kg N/fed regarding plant height (cm) number of capsules/plant, number of seed/capsule and seed yield/plant in the first season and number of branches, number of capsules/plan, number of seeds/plant and 1000 seed weight in the second season. These results may be due to higher doses of nitrogen application which itself increases plant growth by promoting processes such as cell division, cell enlargement, and metabolic processes (**Marschner, 1995**). These results are similar with those stated by **Rana *et al.* (2012), Tuncturk *et al.* (2012)**, **Seyyedan *et al*. (2014) and Yimam *et al*. (2015)** who indicated that plant height, number of branches, herb fresh ,dry weight and number of capsules/plant of black cumin plants increased with increasing nitrogen levels Also, **El-Deeb *et al.* (1993)** on *Nigella sativa* plants showed that nitrogen fertilization at 60 and 80 kg N/fed-1 significantly increased seed yield/ plant. Moreover, **Shah and Samiullah (2007), Rana *et al.* (2012) and Kaheni *et al.* (2013)** found significant effect of N fertilizer levels on 1000 seed weight of black cumin. On the other side **Muhammad *et al.* (2017)** found that the application of N at level of 30 kg/ha had the highest plant height (cm), No. of capsules/ plant, No. of seeds capsules and1000 seed weigh, compared to the application 60 kg/ha in *Nigella sativa* plants.

Chemical constituents and oil yield:

Results presented in Table 3 show the effect of different N levels on N, P, K, protein percentage in seed, chlorophyll a &b in leaf and seed fixed oil. These resultsindicated that N fertilization significantly increased N, P, K, protein percentage in seeds, chlorophyll a &b and fixed oil.

Results indicated that the highest values for each of N, P, K , protein percentage in seeds, chlorophyll a &b were obtained by application100 kg N/fed followed by 75 kg N/fed without significant differences in both seasons, while the minimum values for these traits were obtained from control treatment in both seasons.

This may suggest that nitrogen plays an important role in the physiological processes leading to the synthesis of leaf pigments. These results are in agreement with those reported by **Rana *et al*. (2012)** on black cumin who found that application of 60 kg N ha^{-1} and 120 kg P ha^{-1} recorded maximum value for N, P and K percentage.

Table (2): Effect of nitrogen levels on vegetative growth and yield component of *Nigella sativa L.* plants during 2014/2015 and 2015/2016 seasons.

Parameter / N levels (kgfed^{-1})	Plant height (cm)	No. Branches/plant	Herb fresh weight (g)	Herb dry weight (g)	No. capsules/ plant	No. seeds/ capsule	Seed yield /Plant (g)	1000 seed weight (g)
				First season				
Control	30.61^{c}	6.33^{c}	4.82^{d}	2.04^{d}	13.91^{c}	86.33^{c}	2.27^{c}	1.89^{c}
50	32.05^{b}	6.83^{b}	9.35^{c}	3.66^{c}	17.00^{b}	96.19^{b}	3.38^{b}	2.07^{b}
75	37.39^{a}	8.58^{a}	14.57^{b}	6.11^{b}	27.50^{a}	95.55^{b}	5.65^{a}	2.15^{b}
100	39.98^{a}	9.75^{a}	20.37^{a}	7.16^{a}	27.58^{a}	102.63^{a}	6.71^{a}	2.37^{a}
				Second season				
Control	31.75^{c}	6.58^{c}	6.82^{d}	2.19^{d}	13.91^{c}	76.67^{c}	2.00^{c}	1.88^{b}
50	35.50^{b}	7.50^{bc}	12.06^{c}	4.28^{c}	23.41^{b}	83.78^{b}	4.00^{b}	2.04^{ab}
75	36.34^{b}	8.08^{ab}	20.18^{b}	5.72^{b}	26.00^{ab}	84.00^{ab}	4.54^{b}	2.08^{ab}
100	39.15^{a}	8.66^{a}	24.70^{a}	7.00^{a}	28.00^{a}	93.00^{a}	5.86^{a}	2.25^{a}

Means having the same letter within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability.

Table 3. Effect of nitrogen levels on chemical constituents and oil yield of *Nigella sativa* L. seeds during 2015/2016 and 2016/2017 seasons:

Parameter / N levels (kgfed^{-1})	N (%)	P (%)	K (%)	Seed Protein (%)	Chl. a (mg/g fw)	Chl. b (mg/g fw)	Fixed oil(%)
				First season			
Control	2.26^{b}	0.28^{b}	0.96^{b}	14.17^{b}	6.24^{b}	1.43^{b}	36.07^{c}
50	2.47^{b}	0.29^{ab}	1.00^{ab}	15.43^{b}	6.56^{b}	1.92^{ab}	36.28^{c}
75	3.02^{a}	0.29^{ab}	1.01^{a}	18.89^{a}	6.97^{ab}	2.05^{a}	38.13^{b}
100	3.28^{a}	0.32^{a}	1.04^{a}	20.54^{a}	7.19^{a}	2.06^{a}	40.17^{a}
				Second season			
Control	2.32^{c}	0.29^{b}	0.93^{b}	14.51^{c}	6.45^{d}	1.72^{c}	36.26^{d}
50	2.50^{bc}	0.30^{ab}	0.95^{b}	15.62^{bc}	6.87^{c}	2.05^{bc}	36.99^{c}
75	3.02^{ab}	0.30^{ab}	1.03^{a}	18.92^{ab}	7.35^{b}	2.32^{ab}	37.90^{b}
100	3.20^{a}	0.31^{a}	1.04^{a}	20.11^{a}	7.81^{a}	2.65^{a}	39.25^{a}

Means having the same letter within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability.

Also, **Khalid (2013)** on Anise, coriander and sweet fennel plants demonstrated that nitrogen fertilization at the level of 200kg.N.ha^{-1} had a higher N, P, K, content in these plants. Moreover, **Al-Hatem (2018)** found that the chlorophyll content in *Coriandrum sativum* reached the maximum values as a results of 100 kg.N.ha^{-1}application. On the other hand **Shah and Samiullah (2007)** reported that the application of nitrogen levels at (0, 40, 60, 80, 100 kg N ha^{-1} on black cumin plants significantly decreased the chlorophyll content in tissue.

The fixed oil percentage in seed was higher with application of 100 kg N/fed followed by 75 and 50 kg N/fed. While the lower value of fixed oil percentage in seed were recorded in control treatment in both seasons. These results coincided with those obtained by **Aytac *et al.* (2017)** who revealed that the highest oil yield (kg ha^{-1}) in black cumin was obtained from the applications of 60 kg N ha^{-1}. Also, **Khalid and Shedeed (2015)** on *Nigella sativa* showed that the highest fixed oil was recorded from $N_3P_3K_3$ with foliar nutrition. Moreover, **Khalid (2013)** reported that the application of N at a level of 200kg ha^{-1} recorded the highest fixed oil percentage for anise, coriander and sweet fennel plants. In contrary, **Ashraf *et al.* (2005) and Muhammad *et al.* (2017)** observed higher oil content in *Nigella sativa* plants treated with 30 kgNha^{-1} compared with 60 and 90 kgNha^{-1} rate.

Effect of potassium silicate foliar spray Growth, yield and its component

Results presented in Table 4 show the effect of different potassium silicate foliar spray on growth, yield and its component. Results indicate that plant height (cm), number of branches/plant, herb fresh and dry weights/plant, number of capsules/ plant, number of seeds/capsule, seed yield/ plant and 1000 seed weight were progressively increased with increasing application rate of potassium silicate foliar spray reach maximal values by the highest rates (8 cm^3/L) with significant differences compared with control in the two seasons. This improvement may be due to the role of silicon in enhancing plant growth via promoting desirable plant physiological processes **(Korndorfer and Lepsch, 2001)**. These results are in a harmony with those found by **Hussein and Muhammed (2017)** who indicated that the higher concentrations of potassium silicate increased plant height on *Solanum melongena* L. plant. Also, **Abdelkader *et al.* (2016)** on roselle showed an increase in plant height and number of branches due to silicon fertilization rates.

Table (4): Effect of potassium silicate foliar spray treatments on vegetative growth and yield production of *Nigella sativa* L. plants during 2014/2015 and 2015/2016 seasons.

Parameters / K Silicate rates (mi/L))	Plant height (cm)	No. Branches/ plant	Herb fresh weight (g)	Herb dry weight (g)	No. capsules/ plant	No. seeds/ capsule	Seed yield /Plant (g)	weight of 1000 seeds (g)
				First season				
Control	30.75^b	6.75^c	4.72^d	2.63^c	15.58	89.33^c	2.48^d	1.78^b
4	32.68^b	7.16^{bc}	8.92^c	3.30^b	18.83	90.63^c	3.75^c	2.20^a
6	37.86^a	8.50^{ab}	12.93^b	6.38^a	24.58^b	97.77^b	5.17^b	2.15^a
8	38.75^a	9.08^a	16.55^a	6.67^a	27.00^a	102.97^a	6.51^a	2.34^a
				Second season				
Control	32.30^c	6.58^b	7.75^d	2.45^c	14.83^c	76.67^d	2.19^d	1.88^b
4	35.69^b	7.91^{ab}	10.38^c	4.83^b	23.33^b	85.11^c	3.87^c	1.95^b
6	36.61^a	7.91^a	13.96^b	5.26^{ab}	26.08^a	93.00^b	5.04^b	2.08^b
8	38.15^a	8.41^a	19.67^a	6.66^a	27.08^a	96.11^a	6.06^a	2.33^a

Means having the same letter within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability.

Chemical constituents and oil yield

Results presented in Table 5 indicate that there were significant increases on all studies parameters, except N content and seeds protein (%). chlorophyll a &b in leaf and fixed oil in both seasons. Application of 8cm^3/L of potassium silicate foliar spray significantly recorded the highest value in all traits compared with control in both seasons without significant differences than 6cm3L-1 for P and Chlorophyll a at first seasons, K content and fixed oil percentage in both seasons and chlorophyll b in the second season. These results are in agreement with those reported by **Hussein and Muhammed (2017)** on *Solanum melongena* who showed that higher concentrations of potassium silicate increased N, P and K percentage and chlorophyll content. Also, **Talebi *et al.* (2015)** on *Solanum tuberosum* showed that chlorophyll a and b were increased compared to control application due to potassium silicate solution and spray. The highest value of fixed oil percentage in seed was obtained in plant treated with 8cm^3/L potassium silicate foliar spray in both seasons, while, the minimum oil percentage in seed was obtained from control treatment in both seasons. These results are in the same line with **Abd El-Razik *et al.* (2015)** who found the highest essential oil content (%) were in chervil (*Anthriscus cerefolium*) plants treated with potassium silicate at 100 ppm rate.

Effect of interaction between nitrogen rates and potassium silicate foliar spray on *Nigella sativa* L. plant

Growth, yield and its component

Results presented in Table 6 illustrate a significant effect for interaction between nitrogen rates and potassium silicate foliar spray on all studied traits. Application of 100 kg/fed N with 8cm^3/L of potassium silicate foliar spray had the highest values of all studied traits; viz, number of branches/plant, herb fresh and dry weights, No. of capsules plant^{-1}, number of seeds/capsule, number of seeds capsules^{-1} and 1000 seed weight. Without significant differences than application of 75 Kg N with potassium silicate as foliar spray. These results are in agreement with **Emara *et al.* (2018) and Siam *et al* (2018)** who found that the application of NPK 125% + K-silicate organic achieved the best plant height in cotton and rice plants, respectively. Also **Daneshm and Alamdari (2014)** indicated that The highest number of seeds per panicle, seed weight and seed yield were observed by 2 L/ha application of potassium silicate and 100 kg/ha nitrogen rate in RICE plants. Moreover, **Mohsen *et al.* (2016)** indicated that the highest values of plant height, number of branches and fresh & dry weights per plant were achieved in plants treated with 8 m^3/fed vermicompost combined with 15 kg/fed. potassium silicate in Marjoram plants.

Table (5): Effect of potassium silicate foliar spray treatments on chemical constituents and oil yield of *Nigella sativa* L. plants during 2014/2015 and 2015/2016 seasons.

Parameters / K Silicate rates (mi/L)	N %	P %	K %	Seeds Protein %	Chl. A	Chl. B	Fixed Oil %
				First Season			
Control	2.54 a	0.28 b	0.85 b	15.87 a	5.90 c	1.58 b	35.89 c
4	2.74 a	0.28 b	1.05 a	17.17 a	6.54 b	1.67 b	37.66 b
6	2.78 a	0.30 ab	1.04 a	17.41 a	6.82 b	2.00 b	38.61 a
8	2.97 a	0.32 a	1.08 a	18.58 a	7.69 a	2.22 a	39.13 a
				Second Season			
Control	2.69 a	0.28 b	0.84 c	16.84 a	6.62 c	2.01 b	36.38 c
4	2.71 a	0.29 b	0.98 b	16.97 a	6.95 bc	2.13 ab	37.48 b
6	2.80 a	0.29 b	1.05 ab	17.53 a	7.12 b	2.23 a	38.01 ab
8	2.85 a	0.34 a	1.10 a	17.83 a	7.78 a	2.38 a	38.12 a

Means having the same letter within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability.

Table (6): Effect of interaction between nitrogen fertilizer levels and potassium silicate (P.S) foliar spray rates on *Nigella sativa* L. plant.

N rate Kg/fed^{-1}	K Silicate mlL^{-1} (Parameter)	Plant height (cm)	No. Branches /plant	Herb fresh weight (g)	Herb dry weight (g)	No. capsules/ plant	No. seeds/ capsule	Seed yield / Plant (g)	1000 seed weight (g)
					First Season				
Control	Control	28.01^{e}	6.01 e	6.12i	1.16 f	11.00h	79.44 ^{f}	1.31i	1.50^{g}
	4	30.66 ^{cd}	6 .00 ^{e}	7.70 ^{h}	1.56 ^{ef}	13.00 h	81.89 f	1.70 ^{hi}	1.60 ^{fg}
	6	32.33 ^{cd}	6.33 ^{de}	9.12 ^{h}	2.03^{def}	14.66gh	92.77 d	2.67 $^{e\text{-}h}$	1.96 $^{c\text{-}f}$
	8	34.66 ^{c}	7.33 ^{cde}	15.36 ^{f}	3.42$^{c\text{-}f}$	17.00fg	91.22 ^{de}	3.10 ^{fgh}	2.00 $^{c\text{-}f}$
50	Control	28.33^{de}	6.33 de	11.25 h	1.76ef	12.66h	87.77 ^{e}	1.89gh	1.70^{efg}
	4	32.00 ^{cd}	6.33 ^{de}	16.29 ^{g}	3.53^{cde}	14.66gh	89.66 de	3.06 ^{fgh}	2.33^{abc}
	6	32.56 ^{cd}	6.66^{cde}	19.45 ^{de}	4.22^{cd}	17.66fg	99.89 c	3.53 ^{efg}	2.00 $^{c\text{-}f}$
	8	35.33 ^{bc}	8.00$^{a\text{-}e}$	23.44 ^{c}	5.15^{c}	23.00de	100.55 ^{c}	5.23 ^{cde}	2.26$^{a\text{-}d}$
75	Control	29.53^{cde}	7.00 cde	13.39 g	3.29c-f	18.33f	92.11 ^{de}	3.31efg	1.96 $^{c\text{-}f}$
	4	34.36 ^{cd}	7.66 $^{b\text{-}e}$	18.24 ^{ef}	3.61^{cde}	22.66de	90.22 de	5.03 ^{def}	2.46 ^{ab}
	6	43.66 ^{a}	10.00 ^{abc}	22.45 ^{cd}	9.89 ^{a}	28.33 c	99.33 c	6.61 ^{cb}	2.35^{abc}
	8	41.33 ^{a}	9.66 $^{a\text{-}d}$	28.19 ^{ab}	7.67 ^{b}	31.66 b	107.44 ^{b}	8.54 ^{b}	2.51 ^{a}
100	Control	40.33^{ab}	8 .00 a-e	22.13de	4.30 cd	20.33e	98.00 ^{c}	3.71efg	1.86$^{d\text{-}g}$
	4	33.70 ^{cd}	8.66 $^{a\text{-}e}$	25.46 ^{bc}	4.51 ^{c}	25.00 d	100.78c	5.19 ^{d}	2.06$^{b\text{-}e}$
	6	42.23 ^{a}	11.00 ^{ab}	25.71 ^{bc}	9.40^{ab}	36.33 a	99.11 c	8.32 ^{bcd}	2.31^{abc}
	8	44.33 ^{a}	11.33 ^{a}	31.20 ^{a}	10.44^{a}	37.66a	112.66 ^{a}	10.82 ^{a}	2.55 ^{a}
					Second Season				
Control	Control	30.16e	5.99 c	6.23 i	1.17 f	11.33 f	76.67 f	1.36 ^{e}	1.56 ^{c}
	4	30.40 e	6.00 c	8.42 i	1.65 f	13.66 ef	85.11 e	2.24 ^{cd}	1.93 ^{bc}
	6	32.46 de	7.33 abc	10.08 h	2.64 ef	14.33 ef	96.11 c	2.75 ^{c}	2.00 ^{bc}
	8	34.00cde	7.33 abc	16.56 g	3.32 e	16.33 ef	93.00 d	2.98 ^{c}	1.96 ^{bc}
50	Control	32.01de	6.33 bc	8.97 i	1.46 f	13.66ef	83.78 e	2.13 ^{d}	1.86 ^{bc}
	4	34.83cde	8.00 abc	16.84 g	5.39cd	24.33d	91.67 de	4.37 ^{bc}	1.96 ^{bc}
	6	35.16b-e	7.66 abc	21.94ef	3.66 e	26.33 cd	96.67 c	5.24 ^{bc}	2.06 ^{bc}
	8	40.00 ab	8.00 abc	23.49cd	6.60bc	29.33a-d	97.89 bc	6.12 ^{b}	2.13 ^{bc}
75	Control	32.34de	6.33 bc	16.80gh	3.97de	15.33ef	84.00 e	2.65 ^{cd}	2.06 ^{bc}
	4	37.20a-d	9.00 a	24.09 de	5.63 c	27.33bcd	96.66 c	5.36 ^{b}	2.03 ^{bc}
	6	38.16abc	8.00 abc	28.78 c	6.89bc	31.66abc	99.33 bc	6.60 ^{b}	2.10 ^{bc}
	8	37.66abc	9.00a	32.06b	6.40bc	29.66a-d	103.33ab	6.83 ^{b}	2.23 ^{b}
100	Control	34.70cd	8.00 abc	21.99 fg	3.20 e	19.00 e	93.33 d	3.60 ^{bc}	2.03 ^{bc}
	4	40.33ab	8.66 ab	22.16cde	6.63bc	28.00a-d	100.67 b	5.36 ^{b}	1.90 ^{bc}
	6	40.66a	8.66 ab	31.03 b	7.86 b	32.00 ab	100.33 b	7.71 ^{ab}	2.40 ^{ab}
	8	40.93a	9.33a	33.60a	10.33a	33.00a	105.78 a	9.63^{a}	2.76 ^{a}

Means having the same letter within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability.

Effect of interaction between nitrogen levels and potassium silicate foliar spray rates on *Nigella sativa* L. plant

Growth, yield and its component

Results in Table 7 show the effect of interaction between nitrogen and potassium silicate rates on chemical constituents and fixed oil yield of black cumin seed. Results show significant effects for the interaction on all studied traits, except, N content and nitrogen content in the second season. The highest values for each of N, P, and K percentages in seed, and chlorophyll a &b in leaf were obtained with 100 kg/fed N with 8 cm^3/L of potassium silicate foliar spray in both seasons without significant differences than application of 75 Kg N fed^{-1} + 8 or 6 cm^3L^{-1} of K silicate in first season on 75 Kg N fed^{-1} + 6cm^3L^{-1} of K silicate in the second season in most studied cases. In the same line **Abou Basha *et al.* (2013)** indicated that the treatment of 100 kg N/fed + 5% potassium silicate significantly increased fresh, dry weight, chlorophyll a, b, N, P and K content in wheat plants. Also, in Marjoram plant **Mohsen *et al.* (2016)** observed that the highest values of N, P, K and Ca content were recorded with 8 m^3/fed. of vermicompost and $CaSiO_3$ at 15 kg/fed.

The highest value of oil percentage in seed was obtained by application of 100 kg/fed with 8 cm^3/L of potassium silicate foliar spray in both seasons in both seasons. While the lowest oil percentage in seed was obtained from control treatment in both seasons. These results are in the same line with **Mohammed *et al.* (2018)** who found that the highest values of essential oil yield were recorded by using vermicompost at a rate 3 or 4-ton fed^{-1} combined with spraying 3.75 mM of silicon solution on leaves of Marjoram plant. Also, **Mohsen *et al.* (2016)** indicated that the application of vermicompost at the rate of 8 m^3/fed., combined with 15 kg/fed increased significantly essential oil determinations in Marjoram plant.

In conclusion, inoculation of *Nigella sativa* plants with N fertilizer at the level of 100 kg/fed or potassium silicate foliar spray at a rate of 8 m^3/fed alone or together gave the highest plant height (cm), number of branches/ plant, herb fresh and dry weight, number of capsules/plant, number of seeds/ capsule, seed yield/plant and 1000 seed weight, N, P, K content, protein percentage, chlorophyll a & b in leaf and fixed oil percentage under sandy soil condition of El-Arish region.

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Table (7): Effect of interaction between nitrogen levels and potassium silicate foliar spray rates on chemical constituents and oil yield of *Nigella sativa* plants during 2014/2015 and 2015/2016 season.

N rate Kg/fed^{-1}	K Silicate mlL^{-1} (Parameters)	N %	P %	K %	Seeds protein %	Chl. a	Chl. b	Fixed oil %
					First season			
		1.54 d	0. 25 c	0.83 d	9.66 d	5.59 f	5.71 f	34.36 fg
	4	2.19 ^{cd}	0. 27 ^{bc}	1.98 $^{a-d}$	13.68 ^{cd}	5.93 ^{ef}	1.51 ^{bc}	35.87 ^{d}
Control	6	2.34 ^{bcd}	0.27 ^{bc}	1.01 ^{abc}	14.66^{bcd}	6.23 ^{def}	1.50 ^{bc}	36.30 ^{cd}
	8	2.33 ^{bcd}	0.29 ^{abc}	1.02 ^{ab}	14.56^{bcd}	7.20 ^{bc}	1.78 ^{abc}	36.80 ^{cd}
	Control	2.25 ^{bcd}	0. 27 ^{bc}	0.86 ^{cd}	14.06^{bcd}	5.84 ^{ef}	1.44 ^{bc}	34.90 ^{e}
50	4	2.38 ^{bcd}	0. 27 ^{bc}	1.04 ^{a}	14.91^{bcd}	6.39 $^{c-f}$	1.97 ^{abc}	35.87 ^{d}
	6	2.95 ^{abc}	0. 30 ^{abc}	1.02 ^{ab}	18.45^{abc}	6.72 $^{b-e}$	1.94 ^{abc}	36.53 ^{cd}
	8	2.79 ^{abc}	0. 32 ^{abc}	1.08 ^{a}	17.44^{abc}	7.29 ^{abc}	2.11 ^{ab}	37.81 ^{bc}
75	Control	2.97 ^{abc}	0. 29^{abc}	0.85 ^{d}	18.58^{abc}	5.93 ^{ef}	1.75 ^{abc}	35.54 ^{de}
	4	3.04 ^{abc}	0. 29^{abc}	1.06 ^{a}	19.00^{abc}	6.93 ^{bcd}	2.14 ^{ab}	37.59 ^{bc}
	6	2.99 ^{abc}	0.30 ^{abc}	1.09 ^{a}	18.68^{abc}	6.92 ^{bcd}	2.26 ^{ab}	38.52 ^{b}
	8	3.08 ^{abc}	0. 33 ^{ab}	1.12 ^{a}	19.29^{abc}	7.42 ^{ab}	2.31 ^{ab}	40.89 ^{ab}
100	Control	3.11 ^{abc}	0. 31^{abc}	0.87 ^{bcd}	19.43^{abc}	6.26 ^{def}	1.79 ^{abc}	38.78 ^{b}
	4	3.19 ^{abc}	0. 32^{abc}	1.01 ^{abc}	19.93^{abc}	6.91 ^{bcd}	2.28 ^{ab}	39.10 ^{b}
	6	3.39 ^{ab}	0.32 ^{abc}	1.08 ^{a}	21.18 ^{ab}	8.09 ^{a}	2.38 ^{ab}	41.01 ^{a}
	8	3.61 ^{a}	0. 35 ^{a}	1.13 ^{a}	22.60 ^{a}	8.16 ^{a}	2.69 ^{a}	41.81 ^{a}
					Second season			
	Control	2.02^{a}	0.26 ^{f}	0.82 ^{d}	12.66 ^{a}	5.71 ^{f}	1.56 ^{c}	34.52 ^{h}
Control	4	2.23^{a}	0.27 ^{ef}	0.97 ^{bcd}	13.97 ^{a}	6.15 ^{ef}	1.73 ^{c}	35.43 ^{fg}
	6	2.51^{a}	0.27 ^{ef}	0.98 ^{bcd}	15.71 ^{a}	7.03 ^{cd}	1.75 ^{c}	36.03 ^{ef}
	8	2.18^{a}	0.32 ^{bcd}	1.02 ^{bcd}	13.62 ^{a}	6.90 ^{cde}	1.87 ^{c}	36.92 ^{d}
50	Control	2.47^{a}	0.27 ^{ef}	0.84 ^{d}	15.45 ^{a}	6.59 ^{de}	1.99 ^{abc}	35.84 ^{g}
	4	2.66^{a}	0.28 ^{ef}	0.94 ^{bcd}	16.66 ^{a}	6.87 ^{cde}	1.97 ^{abc}	36.67 ^{de}
	6	2.73^{a}	0.32 ^{bc}	1.01 ^{bcd}	17.10 ^{a}	7.29 ^{bcd}	2.01 ^{abc}	37.09 ^{d}
	8	2.34^{a}	0. 33 ^{b}	1.08 ^{abc}	14.67 ^{a}	6.72 ^{de}	2.31 ^{abc}	37.44 ^{c}
75	Control	2.84^{a}	0.28 ^{ef}	0.86 ^{cd}	17.79 ^{a}	7.03 ^{cd}	2.14 ^{abc}	36.22 ^{ef}
	4	2.94^{a}	0.29 ^{def}	1.02 ^{bcd}	18.40 ^{a}	7.15 ^{cd}	2.24 ^{abc}	38.98 ^{c}
	6	3.13^{a}	0.32 ^{bc}	1.05 ^{abc}	19.61 ^{a}	7.12 ^{cd}	2.44 ^{abc}	38.08 ^{bc}
	8	3.29^{a}	0. 34 ^{ab}	1.12 ^{ab}	20.57 ^{a}	8.09 ^{ab}	2.30 ^{abc}	39.86 ^{b}
100	Control	3.02^{a}	0.29 ^{def}	0.85 ^{cd}	18.92 ^{a}	7.15 ^{cd}	2.41 ^{abc}	38.96 ^{c}
	4	3.22^{a}	0.30 ^{cde}	1.00 ^{bcd}	20.13 ^{a}	7.64 ^{bc}	2.55 ^{abc}	39.95 ^{b}
	6	3.30^{a}	0.33 ^{b}	1.10 ^{ab}	20.65 ^{a}	7.75 ^{bc}	2.89 ^{ab}	40. 20 ^{ab}
	8	3.31^{a}	0. 37^{a}	1.17 ^{a}	20.74 ^{a}	8.70 ^{a}	2.94 ^{a}	40.64 ^{a}

Means having the same letter within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability.

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الملخص العربي

تأثير الإضافة الأرضية لمستويات النيتروجين للنيتروجين والرش بسيليكات البوتاسيوم على نمو ومحصول حبة البركة

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أجريت هذه التجربة بالمزرعة التجريبية لكلية العلوم الزراعية البيئية، جامعة العريش، شمال سيناء، مصر خلال موسمي ٢٠١٥/٢٠١٤ و٢٠١٦/٢٠١٥، تهدف هذه التجربة الي دراسة تأثير الاضافات الارضية لمستويات مختلفة من النيتروجين (صفر، ٥٠، ٧٥ و١٠٠ كجم/فدان) والرش الورقي بمركب سيليكات البوتاسيوم بمعدلات (صفر، ٤، ٦، ٨ سم^{3}/لتر) على النمو الخضري والمحصول البذري ومحصول الزيت الثابت وبعض المكونات الكيميائية بالبذرة لنبات حبة البركة، تم استخدام تصميم القطاعات كاملة العشوائية في ثلاث مكررات في هذه التجربة، أوضحت النتائج أن معاملات النيتروجين وسيليكات البوتاسيوم نتج عنها تأثيرًا معنويًا على معظم الصفات التي تم دراستها (النمو الخضري والمحصول ومكوناته الكيميائية) وكانت أعلى قيمة لطول النبات، قطر الساق، عدد الافرع، الوزن الطازج والجاف للعشب، عدد الكبسولات للنبات، عدد البذور في الكبسولة، وزن ١٠٠٠ بذره والمكونات الكيمائية والزيت الثابت تم الحصول عليها باستخدام التسميد النيتروجيني منفردا بمعدل (١٠٠ كجم/فدان) أو الرش الورقي بسليكات البوتاسيوم منفردا بمعدل (٨ سم^{3}/ لتر) وكانت أعلى القيم لجميع الصفات السابقة مع استخدام الإضافة للنيتروجين بمعدل ١٠٠كجم للفدان مع الرش بسيليكات البوتاسيوم بمعدل ٨ سم^{3} للتر.

الكلمات الإسترشادية: حبة البركة، النيتروجين، التسميد، سليكات البوتاسيوم، الرش الورقي.

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