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The Impact of Compost on Seed Yield and Essential Oil of Black Cumin under Drought Stress Conditions

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ABSTRACT

Nigella sativa L. is an annual species of the Ranunculaceae family whose essential oil is widely used in the medicinal, food and health industries. Drought stress is a major factor limiting plants growth and yield. The application of organic fertilizer is an effective method in the organic culture of medicinal plants. In order to study the impacts of drought stress and compost on the yield and essential oil content of black cumin, an experiment was conducted as split plots based on a randomized complete block design with three replications in the research farm of the University of Zabol. Treatments involved irrigation as the main factor in three levels: 1) the control (without any stress), with irrigation interval of every six days; 2) mild drought stress, with irrigation interval of every nine days; and 3) extreme drought stress, with irrigation interval of every 12 days along with municipal solid waste compost as the second factor which included: no use of compost (control) and compost of 10, 20, and 30 ton/ha. Drought stress had a meaningful impact on seed yield. Thus, seed yield declined as the stress increased. Increasing compost levels also increased seed yield, essence percentage, p-cymene, γ-terpinene, and thymoquinone contents in seed essential oil of black cumin. The highest seed yield (553.61kg/ha), percentage of p-cymene (24.6%) was observed in the compost treatment of 30 ton/ha and the least of them were (345.2kg/ha) and (15.4%) in the treatment without compost (the control) respectively. In general, using 30 ton/ha of compost seems appropriate, because of generates higher yield and essential oil.

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1. Introduction

Black cumin is one of the oldest medicinal plants with the scientific name *Nigella sativa* L. Having a substance called thymoquinone, black cumin has anticonvulsant impacts. Furthermore, the anti-tumor and anti-bacterial effects of its seeds have been proved. From black cumin essence, a substance is extracted which is called nigellone, and can be emmenagogue, vermicide, laxative, and improves milk production (Riaz *et al*., 1996). Additional properties are frequently discovered (Al-Okbi *et al*., 2013). Most of these activities have already been attributed to thymoquinone, a major component of the essential oil of the seeds (Ali and Blunden, 2003). Traditionally, black cumin seeds have been used for many centuries in the Middle East, North Africa, and South Asia to cure various diseases (Gilani *et al*., 2004). The role of essential (volatile) oil is outstanding and important in many industries, particularly medicinal and nutritional ones. The oil and its components have been introduced as anti-microbial agents (Pepeljnajk *et al*., 2003). Volatile oils are observed as different combinations, in general, they belong to a chemical group known as the terpenes or have a terpene origin. Terpenoids are compounds, derived from 5-carbon isoprene or 2-methyl-1, 3-butadiene (C5H8) (Svoboboda and Hampsan, 1999). The oil from black cumin was used in primitive clinical medicine for cough and bronchitis (Vardharajan, 1985).

In their growth environment, plants regularly are faced with several stresses, limiting to some extend

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their growth and survival chance. Drought is one of the most important factors which decrease agricultural products globally. It is one of the most important factors which cause loss of plant production in many dry and semi-dry regions of the world (Reddy *et al*., 2004). In drought conditions, the transpiration rate surpasses that of water absorption and the water level inside plant tissues and cells decreases excessively and, as a result, the growth declines and stops altogether (Sarmadnia and Koocheki, 1990). Due to water shortage, the cell volume, cellular division, cell walling, general plant size, and wet and dry weight of the plant often decrease as the general growth index. One of the first signs of water shortage is the decrease in turgor and, consequently, decreased growth as well as cell development, particularly in the stem and leaves. Cell growth is the most sensitive process, influenced by dehydration stress. As the cell growth declines, the membrane size gets limited; that is why the first tangible impact of dehydration on plants can be distinguished from smaller leaves or the plants' height (Hsiao, 1973). Depending on plant species and genotype, plants show different reactions to drought stress; therefore, irrigation management in medicinal and aromatic plants is very important. Rebey et al. (2012) in a study on the effect of drought stress (without stress, medium stress, and excessive stress) on black cumin found that plants under medium stress had higher essence than the other two treatments without stress (control) and excessive stress. By experimenting on marjoram (*Origanum majorana* L.) it was revealed that drought stress increased the amount of this plant's essence (Ardakani *et al*., 2007). Probably, the essences are influential in the mechanism of drought resistance by decreasing transpiration. Also, the essence combination and its quality usually change as a result of the drought. In another experiment, the essential oil content of *Dracocephalum moldavica* increased significantly with increasing the level of drought (Alaei, 2019). It is very important to make appropriate irrigation in order to produce new aerial members as well as desirable seed yield, because water is the main component of new production, having effects on product yield's quality and quantity (Ucan *et al*., 2007).

One of the negative impacts of drought stress is a disorder in plants' mineral nutrition that can be caused as below: change in the roots ion absorption, decrease in the ions transmission from soil to the root, decrease in the ability to transmit minerals inside the plant, shortage or accumulation of the ions that might cause disorder in metabolism or induce harmony responses (Chaudhry *et al*., 1999).

Cultivation of medicinal plants with organic and biological fertilizers increases their medicinal quality, thus many medicinal plant producing companies prefer combinations of plants, produced via organic or biodynamical cultivation (Pan *et al*., 2013). In the process of medicinal plant production, the real value is given to product quality as well as product sustainability, while the quantity of the product is set in the second degree of importance. Therefore, plant nutrition management in stress conditions is one of the most important issues of farming and gardening products (Mohammadkhani and Heidari, 2007).

One of the cultivation methods, which has gained a specific place, is organic cultivation. Its goal is to increase soil's organic substances and, consequently, to keep soil fertility in the long term. The process of utilizing the remnants of organic substances depends on their quantitative and qualitative features, climatic conditions, plants' type, soil inhabitants and soil factors, and the method of management. Organic substances of the soil contain inherent rich sources of N, P, K, and S in organic and micronutrient form. Nonetheless, compared to their mineral form, the availability and mobility of these elements in organic compounds are usually much lower (Astaraei, 2006).

The soils of arid and semi-arid regions of Iran, forming more than 80% of farmlands, are deprived of organic substances, restricting product growth and yield. Therefore, it is necessary to add organic substances to agricultural soils so that their fertility can be improved (Malakuti and Homaei, 1994). Organic substances improve the soil physical features (structure and aggregation) as well as its chemical features (decreasing the soil acidity, increasing cation exchange capacity, and improving nutritional elements), which is important for plant growth (Snyman *et al*.,1998; Al-Fraihat *et al*., 2011). One solution to increase the amount of organic substances of the country's farm soils is to use organic fertilizers such as compost. In past decades, the use of compost in the soil has had specific importance in order to generally keep and increase the stability and sustainability of the aggregates along with the fertility of farm and garden soils (Lalande *et al*., 2000).

In the cultivation of aromatic medicinal plants, in addition to the essence percentage and yield, the type and amount of the chemicals, composing the essence itself, are important. The present research has been conducted in order to study the impacts of drought stress and the use of different rates of compost on black cumin yield as well as the essence percentage and its compounds in Zabol climatic conditions.

2. Materials and methods

2.1. Plant material, study area and treatments

The experiment was carried out in a research farm of the Faculty of Agriculture, University of Zabol, located in the Sistan Dam region, 15 km west of Zabol. The city of Zabol is located in a latitude of 61 degrees and 29 minutes and longitude of 30 degrees and 13 minutes, 498.2 meters above mean sea level (Kiyani and Firoozi Jahantigh, 2011). The experiment was conducted as a split plot in form of a randomized complete block design with three replications. Drought stress as the main factor was applied in three levels, including 1) the control (without stress), with irrigation interval of every six days; 2) mild drought stress, with irrigation interval of every nine days; and 3) extreme drought stress, with irrigation interval of every 12 days, along with municipal solid waste compost as the second factor which included: no use of compost (control) and compost of 10, 20, and 30 ton per hectare. In order to determine the physical and chemical characteristics of the soil at the planting site, at the beginning of the experiment, the soil was sampled from a depth of 0 to 30 cm and transferred to the laboratory.

The soil characteristics of the planting site are presented in Table1. Each secondary plot included five cultivation rows, each 3 m long. The distance between the rows was 30 cm and the distance between the two shrubs in each row, 8.3 cm. The distance between the main plots along with the replications was considered 1.5 m, while the distance between the secondary plots was 0.5 m. During late September, the land was plowed and disked. Afterward, the plots were prepared and determined. Based on the cultivation map, the compost in a certain amount was applied inside the plots and got mixed with the soil (Table 2). The seeds were planted in mid-December in rows and were then irrigated. The post-planting maintenance, such as thinning, weeding, irrigating, and tilling, was performed regularly.

Table 1. Physical and chemical features of the soil (0-30 cm) before the experiment.

Soil texture	Sand	Clay	Silt	Organic matter	Organic carbon	Zn	K	P	N	pH	E.C. ds/m
		%					ppm				
Clay loam	45	34.6	20.4	0.81	0.47	2.8	125	9.2	6.3	8	1.46

Table 2. Some features of the applied compost (Source of Mashhad Municipality catalog).

Moisture (%)	EC (dS/m)	pH	Potassium (%)	Phosphorus (%)	Nitrogen (%)	organic matter (%)
30	7.2	7.3	1.42	0.5	1.3	22.7

To prevent seeds from falling, they were harvested when the shrubs got yellow and at least 80% of the capsules had ripened. Excessive stress, mild stress, and control treatments were harvested on the 4^{th}, 13^{th}, and 20^{th} of May, respectively. For this purpose, the three middle rows of each plot got selected and, keeping the distance of 30 cm from both sides as the margin, the shrubs were clipped with a pair of gardening scissors and the capsules were separated and by means of a thresher machine the seeds got winnowed and divided, then to be weighed. The essence from the seeds was extracted via distillation method with water steam for three hours by means of a Clevenger apparatus (Model: 8500-10).

2.2. Separation and identification of essence compounds by means of GC/MASS devices

The device's characteristics are as follows:

(GB Device device model: Hewlett Packard (HP) 6890, the temperature of the injection location: 250 degrees centigrade, thermal programming: 60-220 degrees centigrade, column type: HP-5MS, carrier gas: helium, gas flow speed: 1ml/min, column length: 30 m, internal diameter: 250 micron *MS Device*) device

model: HO-5973, ionization energy: 70eV The compounds were identified in a computer-based library based on peaks' exit pattern, their inhibitor index, and their adjustment to the existing standard mass spectra, all taking place in Mehr Azma Company Lab, Tehran.

2.3. Statistical analysis

Statistical analyses and diagrams' drawings were conducted by MSTATC and Excel, respectively. The comparisons of the averages were done via Least Significance Difference (LSD) at the %5 probability level.

3. Results

3.1. Seed yield

Variance analysis results in Table 3 showed that the effect of drought stress and compost on black cumin seed yield were significant ($p < 0.01$). Data mean comparison (Fig. 1) showed that the highest seed yield (523.49 kg/hectare) resulted from no-stress treatment (once every 6 days) and the lowest (412.59 kg/hectare) belonged to excessive stress treatment (once every 12 days) which, as a result of the stress, seed yield decreased by 27% compared to the control and a significant difference was observed between the no-stress level, the second level (mild stress), and the third one (excessive stress).

In comparison, a significant difference ($p < 0.01$) was observed in the effect of compost on seed yield among treatment levels, with the maximum rate of seed yield (553.61 kg per hectare) belonging to compost treatment of 30/ha and minimum one (345.2 kg per hectare) to the control treatment (without compost) (Table 4), in which the seed yield with compost function of 30 ton per hectare increased by 33.3%, compared to non-compost treatment. The interaction of stress and compost factors in seed yield was not significant (Table 3).

Table 3. Variance analysis of quantitative and qualitative characteristics of black cumin, under the influence of drought stress and compost.

		Mean of squares				
S.O.V	df	Seed yield	Essential oil percentage	P-Cymene	γ –Terpinene	Thymoquinone
Rep	2	25.331^{ns}	33.87*	0.039^{ns}	342.25*	11.51*
Stress	2	694.76**	1.74^{ns}	0.112^{ns}	25.74^{ns}	1.84^{ns}
Error1	4	21.321	10.24	0.190	32.73	0.53
Compost	3	199.87**	64.24*	0.543*	59.26*	225.41*
S*C	6	14.898^{ns}	14.03^{ns}	0.029^{ns}	75.04^{ns}	0.77^{ns}
Error2	18	11.627	4.3	0.128	1.33	6.5
C.V (%)		6.90	15.26	12.94	14.34	8.57

* and **: Significant at the 0.05 and 0.01 probability levels, respectively.
ns: Not- significant

Table 4. Effects of compost on seed yields, and some qualitative traits of Black cumin.

Compost levels (ton/ha)	Seed yield (kg/ha)	Essence percentage	P-Cymene (%)	γ –Terpinene (%)	Thymoquinone (%)
Control	345.20^{c}	1.48^{bc}	15.40^{c}	5.60^{b}	17.40^{c}
10	413.60^{b}	1.69^{b}	21.12^{b}	6.68^{ab}	20.98^{b}
20	468.89^{b}	1.20^{c}	22.96^{ab}	6.89^{a}	27.79^{a}
30	553.61^{a}	2.80^{a}	24.60^{a}	7.20^{a}	30.10^{a}

Common letters in each column represent non-significant differences at a 5% probability level.

3.2. Essential oil percentage

The results of Analysis of Variance (ANOVA) indicated that the effect of drought stress on essence percentage was not significant (Table 3). The effect of compost on this trait was significant ($p \geq 0.05$) (Table 3). The maximum essence percentage (2.8%) belonged to the application of 30 ton/ha compost and the minimum (1.2%) to control treatment (without compost) (Table 4).

The interaction of stress and compost levels on seed essence percentage did not become significant (Fig.1).

3.3. Results from experiments of identification of essence combinations with GC/MASS method

When cultivating aromatic medicinal plants, in addition to the essence percentage and yield, the type and amount of the chemicals that form the essence is important too. By analyzing black cumin seed essence, the results from these experiments showed that there are 23 main compounds in the black cumin essence, in which thymoquinone, p-cymene, and γ –Terpinene make the highest essence percentage (above 50%) (Table 5) and their amount went under statistical analysis. Considering the results of ANOVA, it was clarified that compost treatment had a significant effect on p-cymene of black cumin essence ($p < 0.05$) (Table 3). Results from data average comparison showed that the maximum p-cymene percentage (24.6%) belonged to compost treatment of 30 ton/ha and the minimum (15.4%) to no-compost (control) treatment. In general, by increasing the rate of compost applied, the amount of p-cymene increased (Table 4).

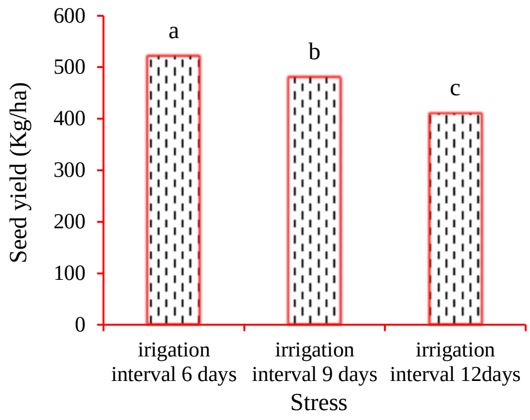

Figure1. Effect of drought stress on seed yield of black cumin.

Table 5. Analysis of the identified compounds of black cumin essence under the influence of drought stress and compost.

Essence Combinations	RI	S1C1	S1C2	S1C3	S1C4	S2C1	S2C2	S2C3	S2C4	S3C1	S3C2	S3C3	S3C4
Tricyclen	895	2.75	1.59	1.65	2	0.9	1.8	1.6	1.8	1.15	1.45	1.15	1.3
ß-pinene	924	2.5	3.54	4.45	3.7	3.5	5.3	1.7	5.3	1.35	1.6	2.4	1.1
α-pinene	940	2	2.32	3.05	2.3	1.8	1.3	1.7	1.3	1.55	2.45	2.55	1.9
Comphene	951	1.15	1.31	1.1	0.75	0.7	0.8	0.55	0.8	1.05	1.4	1.5	1.25
Sabinene	978	1	1.32	1	1.1	1.5	0.7	1.2	0.7	0.45	0.95	1	1.1
β-pinene	992	1.2	2.52	1.55	1.4	2.1	1.2	1.25	1.2	1.05	2.15	1.3	1.5
α –phellendrene	1076	2.05	1.93	1.15	1.65	0.9	1.3	1.1	1.3	1.15	1.05	1.4	1.4
α –Terpinene	1089	1.05	0.9	1	1.6	2	1.1	1.6	1.1	2.01	1.62	0.83	1.59
p-cymene	1120	22.7	21.46	21.35	25.85	21.4	19.2	22.6	15.6	23.5	20.9	18.5	20.35
Limonene	1137	1.05	2.01	1.1	1.5	0.8	1.9	1.9	1.7	1.95	2.5	1.1	0.75
β –Ocymene	1151	2.5	2.31	1.8	2.5	2.3	2.15	2.3	1.1	2.8	1.45	2.1	2.85
γ –Terpinene	1159	5.1	4.02	5.9	7.05	6.6	4.65	4.15	5.2	5.95	6.45	6.95	4.55
Linalool	1169	1.7	1.42	1.4	1.7	1.4	1.55	1.8	0.7	1.35	1.45	1.3	1.8
Borneol	1177	0.8	0.66	0.7	0.45	0.9	0.6	0.8	1.3	0.8	1	1.1	1.25
Trans-Dihydrocarovone	1189	0.8	0.9	0.9	1.1	1.6	0.99	1.2	1.1	1.05	0.98	0.76	0.85
Terpinolene	1199	1.7	1.42	1.1	1.3	2	1.2	1.85	0.9	2.55	3.6	2.45	1.15
Spathulenol	1205	1.2	1.28	1.5	1.15	1.3	0.85	1.25	0.6	1.2	1.8	1.45	1.95
Tymoquinon	1210	23.6	27.76	26.8	30.9	17.4	19.25	28.6	30.1	19.3	17.6	19.55	20.4
Thymol	1236	1.9	2.1	2	2.6	2.5	1.6	1.4	1.7	1.5	1.6	1.3	2
Carvacrol	1270	2	2.2	3	3.4	2.8	2.4	1.3	1	1.4	1.5	1.5	2.4
1-methoxymethyl-Decalin	1291	0.9	1	0.8	1.3	1.1	0.92	0.8	1.3	0.7	0.9	0.8	1
β –Caryophyllen	1309	1	1.2	0.8	1.4	0.9	1.1	1.5	0.7	0.85	1.2	2	2.4
Alpha-bisabolol oxid	1322	1.4	1.1	1	1.5	1.3	0.8	0.7	0.9	1.1	1.7	0.9	0.76

Drought stress treatments as well as the interaction between drought stress and compost levels did not have a significant effect on p-cymene percentage (Table 3). The amount of γ –Terpinene was affected by compost treatment ($p < 0.05$) (Table 3). The maximum amount of γ –Terpinene (7.2%) belonged to compost treatment of 30 ton per hectare and the minimum (5.6%) to no-compost (control) treatment (Table 4). Drought stress treatments as well as the interaction between drought stress and compost levels did not have a significant effect on γ –Terpinene percentage (Table 3).

Based on the results of ANOVA, it was shown that compost treatment had a significant effect on the amount of black cumin essence thymoquinone (p <

0.05) (Table 3). The maximum percentage of thymoquinone (30.1%) belonged to 30 ton/ha treatment and the minimum (17.4%) to no-compost (control) one (Table 4). Drought stress treatments as well as the interaction between drought stress and compost levels did not have a significant effect on thymoquinone percentage (Table 3).

4. Discussion

Rezaei Chianeh and Pirzad (2014) reported that in the Orumiyeh climate as the irrigation interval increased, the seed yield in black cumin declined. Such that by increasing the irrigation interval from six days to 12 and 18 days, the seed yield decreased by 11% and 43%, respectively. Also, our results are in agreement with those reported on other plants such as oregano (*Origanum vulgare* L.) (Gerami *et al*., 2016) and lemon balm (*Melissa officinalis* L.) (RADÁCSI *et al*., 2016).

The reductions in seed yield in higher irrigation intervals may be due to the decrease in the cell enlargement and more leaf senescence resulting from reduced turgor pressure (Shao *et al*., 2008; Farooq *et al*., 2009) or it may be due to a decrease in photosynthesis and alter canopy structure during the higher irrigation intervals (Shao *et al*., 2008). Additionally, in drought conditions materials and nutrition absorption declines too; therefore, the leaves' growth and development are limited (Mandal, 1986). Other reasons for lower yield during higher drought stress can be related to more attribution of photosynthesis substances to the roots, compared to the plant's aerial section (Sreevalli *et al*., 2001). Furthermore, by causing a disorder in metabolic reactions and producing reactive oxygen species, environmental stresses such as drought stress harm the DNA, proteins, and nucleic acids, damages the peroxidation of the membrane's lipids and, subsequently decreases the selected penetrability of the cellular membrane, eventually leading to cellular death (Hayata *et al*., 2010). Increasing grain yield can be attributed to more vegetative growth, Canopy development and as a result, better use of solar radiation and Higher photosynthesis in good condition of irrigation (Noorooz Poor *et al*., 2005). Al-Fraihet et al. (2011) proved that organic fertilizers improved physical, chemical, and biological characteristics of the soils, causing (C.E.C) to increase and water maintenance, consequently, leading to better growth. Moreover, organic fertilizers can increase suitable micro-organisms (Drinkwater *et al*., 1995).

Frouzandeh et al. (2014) reported that the maximum seed yield in medicinal plants of cumin was obtained by using 15 ton/ha of Municipal Solid Waste (MSW) compost. As a result of drought stress, there was no decrease in the seed essence percentage of black cumin. Whereas, Bethaieb et al. (2009) concluded that drought stress can increase essential oil. Furthermore, Alinian and Razmjoo (2014) reported that drought stress can decrease essential oil (Hosseini *et al*. 2018) in a study on 16 landraces of black cumin growing in natural conditions in different regions of Iran, reported essential oil percentage in the range of 0.68 to 1.23.

Plant nutrition is one of the most important factors affecting the quantity and quality of secondary metabolites in plants. Organic fertilizers had a stimulating effect on major parameters of vegetative growth and accelerating essence accumulation (Hosseini *et al*., 2006). Moreover, the useful effect of organic fertilizer levels on essence percentage might be due to its impact on accelerating metabolism reactions as well as the stimulating the reactions of enzyme systems for essence biosynthesis (Khalid and Hossein, 2012). Many researchers (Badran and Safwat, 2004; Tanu *et al*., 2004; Hendawy and Khalid, 2011) also reported that using organic fertilizers increases the essence percentage in medicinal plants.

Frouzandeh et al. (2014) concluded that the maximum essence percentage of cumin was observed by using 15 ton/ha of MSW compost. Applying organic fertilizers increases the essence percentage of medicinal plants (Atiyeh *et al*., 2000). It has been reported that the use of compost is more effective than chemical fertilizers in increasing the amount of the plant essence and as the applied compost ascends, the essence percentage improves (Mona *et al*., 2008). Earlier experiments have shown the application of organic manures had progressive effects on seed yield, seed essential oil content and yield in *Coriandrum sativum* L. (Darzi, 2012) and *Melisa officinalis* L. (Santos *et al*., 2009).

Darzi et al. (2009) reported that the use of compost was more effective than chemical fertilizer on increasing the amount of fennel essence; as the amount of the applied compost increased, the essence percentage improved. Since the essences were terpenoid compounds and their forming units (isotroponides) like Isopentanyl pyrophosphate (IPP) and Di-methylallyl pyrophosphate (DMAPP) urgently require NADPH and ATP. Given the fact that the presence of elements like Nitrogen and Phosphorous is necessary for the formation of late compounds (Loomis and Corteau, 1972) it can be concluded that by improving the amount of nitrogen and phosphorous, the experimented fertilizer treatments improved the essence, compared to the control. Moreover, nitrogen plays an important role in the development and division of new cells, which contain the essence as well as influential substances in medicinal plants. It seems that black cumin essence compounds are sensitive to environmental changes, especially the stress from nutrition shortage. The generation of secondary compounds is regulated by environmental and non-environmental factors and usually, when the plant is under stress, it changes excessively (Kumar and Patra, 2012).

Considering the results obtained from this experiment, it can be concluded that higher compost levels increase black cumin's thymoquinone, γ –Terpinene, and p-cymene. Thymoquinone is the most important effective substance, in this plant's essence, belonging to the phenols group. Furthermore, given the obvious and proven role of compost in increasing the growth and yield with different methods such as expanding the root system and assisting better absorption of the nutrient element, it can be concluded that in the best growth and yield state, the amount of thymoquinone in this plant's essence was in its highest rate. It can be concluded that some elements such as nitrogen, phosphorous, potassium, and magnesium play an important role in plant growth and biosynthesis of the essence (Sell, 2003).

In a plant species, possibly 5000-20000 primary and secondary outstanding compounds are produced. In spite of numerous kinds of secondary metabolites, the number of biosynthesis paths, relevant to these compounds, is limited and certain. The pre-substances, required for glycolysis and the relevant path is originated from the shikimates. In other words, primary metabolites are considered a prerequisite for the synthesis of secondary metabolites, e.g. from carbohydrates: the glycosides, gums, and mucilages; from aromatic amino acids: the phenols and tannins; and from aliphatic and aromatic amino-acids, the alkaloids are produced (Najafi, 2011).

As it can be seen, the highest amount of bio-active molecules, existing in black cumin essence, are thymoquinones derived from the phenols group. Thymoquinone is a major component of the essential oil of the black cumin seeds (Ali and Blunden, 2003). The changes in the composition of essential oil due to nutritional stress were most prominently reflected in the main oil constituent, thymoquinone, which varied with applied compost doses. Furthermore, the most important terpenes, existing in the essence, i.e., p-cymene and γ –Terpinene were in high percentage in this experiment. In an experiment, it was shown that the fertilizers sometimes increased and sometimes decreased the secondary metabolite (Mohsenzadeh and Zamanpour Shahmansouri, 2019).

5. Conclusion

Increasing irrigation interval has a negative effect on seed yield, but increasing irrigation interval did not have a significant effect on essential oil percentage. Using compost had a positive influence on some features such as the yield, the amount of essence, and its compounds. In general, it seems that black cumin cultivation with an irrigation interval of six days and application of 30 tons of compost per hectare is appropriate for receiving more essence and yield in this region.

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