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Original Article

Ajowan (*Trachyspermum copticum*) Responses to Organic Fertilizers and Bio-fertilizers under Drought Stress

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Abstract

Water stress and soil nutrients affect the growth of medicinal herbs as well as the quantity and quality of their essential oils. The effect of drought stress and different fertilizers on yield and morphological traits of Ajowan was studied in a split-plot experiment on the basis of a Randomized Complete Block Design with three replications in Qaen, Iran. The main plot was devoted to irrigation at three levels (full or weekly irrigation in the whole period of growth-C, weekly irrigation until the beginning of stem elongation and after that every other week irrigation-S1 and weekly irrigation until the beginning of flowering and after that every other week irrigation-S2). The sub-plot was devoted to fertilization at five levels (control, NPK chemical fertilizer, Nitroxin biofertilizers+Barvar 2, organic fertilizer, and cattle manure). It was found that irrigation significantly affected seed yield, branch number per plant, umbel number per plant, umbellet number per umbel, seed number per umbellet and plant height. Seed yield was reduced by 37.8% under the treatment of S1 as compared to full irrigation. The influence of fertilization treatments was significant on seed yield, umbellet number per umbel, seed number per umbellet and plant height. The treatment of chemical fertilizer resulted in the highest seed yield. In total, full irrigation accompanied with the treatment of chemical fertilizer produced the maximum seed yield. However, since chemical fertilizers are not recommended to be applied especially for medicinal herbs, it can be recommended to use biofertilizer (Nitroxin+Barvar 2) given the fact that its yield had no significant difference with that of chemical fertilizer.

Keywords: Drought stress, Organic fertilizer, Yield, Morphological traits, Ajowan

Introduction

Ajowan "*Trachyspermum copticum* (L.) Link." belongs to the family of Apiaceae. It is native to Asia and Iran. Because of containing over 3% essential oil in seeds whose main components are thymol, γ-Terpinen and ρ-Cymene [1], it is widely used in pharmaceutical, cosmetics and food industries. Ajowan is an annual plant grown in a wide range of soil textures. It has no limitation in terms of soil acidity and its essential oil is used in repelling some pests [2].

Adverse environmental conditions like drought, salinity and high temperatures impose stresses on plants with adverse implications for their growth and yield. Environmental stresses, especially water deficit stress, are the main limitations of crop production in most parts of the world, particularly in arid and semiarid regions like Iran. They change the growth of medicinal herbs as well as the quantity and quality of their essential oils [3]. In a study on the effect of irrigation regimes on quantitative and qualitative yield of *Plantago ovata* Forssk., Ramroudi *et al.* [4] reported that the highest seed yield was obtained from full irrigation so that the loss of seed yield due to irrigation withdrawal before and after flowering was 14.9 and 20.1% as compared to control, respectively. In a

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study on Isabgol, Khazaie *et al.* [5] found that the reduction of irrigation interval resulted in higher quantitative traits. Baher *et al.* [6] reported that drought stress caused the loss of plant height in *Satureja hortensis*. Colom and Vazzana [7] stated that the number of branches per plant of *Eragrostis curvula* (Schrad.) Nees was negatively affected by water deficit stress. Akbarinia *et al.* [8] investigated the influence of irrigation interval on Ajowan and observed that longer irrigation interval resulted in the loss of seed yield and plant height.

Today, fertilizers are used to maximize the production per unit area. However, in addition to increasing the production, fertilizers should enhance the quality of the crop and should minimize the accumulation of contaminants like nitrate in economical parts of the crop in addition to avoiding the pollution of environment especially ground waters. Unfortunately, application of fertilizers is unbalanced in Iran with no conformity with actual crop requirement [9]. It is believed that if the present pattern of improper, unbalance and untimely application of chemical fertilizers is continued, the next generations will be left with stone instead of arable soil [9].

Bio-fertilizers are one of the best substitutes for chemical fertilizers and can fertilize soil and ensure yield increase without destroying the environment. In contrast to the use of bio-fertilizers in agriculture, their scientific application does not have a long history. In spite of the decrease in their applications in recent years, their use in agriculture is revived recently because of the problems caused by improper use of chemical fertilizers. It is tried to use the potential of soil organisms and organic matter for maximizing the production in addition to caring for soil quality and environment safety and health [10]. Azzaz *et al.* [11] reported that the application of azotobacter increased fennel yield by 18% as compared to control. Sanches Govin *et al.* [12] stated that the application of bio-fertilizers enhanced flower yield of marigold and chamomile. According to Shaalan [13], the increase in soil fertility by bio-fertilizers (e.g., azotobacter, azospirillum and pseudomonas) improved the growth traits of *Nigella sativa* L. including plant height, the number of auxiliary branches, the number of capsules per plant and seed yield.

Mandal *et al.* [14] revealed that the application of different rates of chemical fertilizers had considerable influence on the growth and yield of downy mildew. Nitrogen application can enhance essential oil yield of medicinal herbs by increasing seed and biomass yield per unit area [15].

The positive effects of manure on soil fertility and improvement of plant growth and development have been confirmed in many studies. It was reported that cattle manure was more effective than chemical fertilizers in increasing the seed and hay yield and mucilage percent of *Plantago ovata* Forssk. [16]. It is likely that manure increases N, P and K content of seed and hay of *P. ovata* through increasing water uptake by plants [17]. Furthermore, in a study on cumin, it was reported that the application of 20 t. ha^{-1} manure reduced the adverse effects of drought stress and increased essential oil content and qualitative traits of essential oil [18].

This experiment was conducted to evaluate the effects of organic and bio-fertilizer on Ajowan under drought stress.

Material and Methods

In order to study irrigation interval and organic and bio-fertilizers effects on yield and some traits of Ajowan an experiment was conducted in Qaen, Iran (Lat. 33°06' N., Long. 59°15' E., Alt. 1422 m.) in 2013. Climate of Qaen is semi-arid with cold and dry winters and hot and dry summers. Table 1 presents the results of soil analysis of the study farm.

The experiment was a split-plot based on a Randomized Complete Block Design with three replications. The main plot was devoted to irrigation at three levels (full or weekly irrigation in the whole period of growth-C, weekly irrigation until the beginning of stem elongation and after that every other week irrigation-S1 and weekly irrigation until the beginning of flowering and after that every other week irrigation-S2). The sub-plot was devoted to fertilization at five levels (control, NPK chemical fertilizer as normal, bio-fertilizers Nitroxin+Barvar 2, granular organic sulfur, and cattle manure). Before sowing, the soil was treated with chemical fertilizers (100 kg. ha^{-1} urea, 100 kg. ha^{-1} K_2SO_4, and 150 kg. ha^{-1} triple superphosphate), sulfur organic fertilizer and cattle manure. Also, 100 kg. ha^{-1} urea was applied at the start of stem-elongation. Bio-fertilizers nitroxin and Barvar 2 were applied as seed covering.

Table 1 Some physical and chemical properties of the soil of study farm (the depth of 0-30 cm)

EC (dS m-1)	pH	SP (%)	P (mg kg-1)	N (mg kg-1)	T.N.V (%)	Organic matter (%)	Soil texture	Clay (%)	Silt (%)	Sand (%)
1.965	7.44	25.84	2.46	420	12.96	0.314	Loam	17	36	47

The application rates of nitroxin, granular sulfur organic fertilizer, cattle manure and Barvar 2 were 100 g. ha^{-1}, 400 kg. ha^{-1}, 15 t. ha^{-1}, and 100 g. ha^{-1}, respectively. The study farm was prepared by plowing, disking and leveling and then, the 2×3 m^2 plots were created. Each replication included 15 plots. The replications were separated by an irrigation ditch and the blocks were spaced by 1.5 m. The seeds of Ajowan from a local landrace were sown on December 18, 2013. To facilitate the germination and cleaning the inhibitors, the seeds were soaked for 12 hours before sowing. The seed rate was taken as 30 kg ha^{-1}. With regard the treatment of bio-fertilizers, the seeds were inoculated immediately before sowing considering the recommendations of manufacturing company. The initial emergence occurred by the termination of winter chilling. The first weeding and thinning operation was carried out on May 8, 2014 and the second one was on May 29, 2014 as the plant height reached to 3-4 cm. The harvest date was September 16, 2014.

Before harvesting, 5 plants per plot were randomly selected and the following traits were recorded: plant height, the number of branches per plant, the number of umbels per plant and the number of umbellets per umbel. Finally, 2 m^2 of each plot was harvested randomly after eliminating the margin effect. The samples were oven-dried at 75°C for 48 hours. Seed yield was determined after cleaning the seeds and harvest index was calculated as the ratio of seed yield to biomass yield. The number of seeds was measured by seed counting machine and 1000-seed weight was determined by a 0.01-precision scale. The variance of the collected data was analyzed by SAS statistical software package and the means were compared by Duncan Multiple Range Test at the 5% probability level.

Results and Discussion

Seed Yield

The effect of irrigation, fertilization and their interaction on Ajowan seed yield was significant (Table 2). The highest seed yield (35.4 $g.m^{-2}$) was obtained under full irrigation. Two other irrigation treatments were ranked in the same statistical group (Table 3). The loss of seed yield under drought stress can be related to the adverse effects of drought stress on seed yield components. Lower vegetative growth and the resulting loss of photosynthesizing area results in lower dry matter production under drought stress [19]; on the other hand, shorter seed filling period and early maturity under irrigation treatment of S1 and S2 play a role in reducing Ajowan seed yield. Pre-flowering and post-flowering drought stress reduces the yield through reducing the number of umbels per plant, the number of seeds and the current photosynthesis of the plant. As well, Koocheki *et al.* [20] reported that drought stress resulted in significant loss of seed yield of *Plantago ovata* and *P. psyillia*.

Among the studied fertilization treatments, the highest seed yield (29.6 $g.m^{-2}$) was obtained from chemical fertilization. However, there was no significant difference in seed yield among the treatments of chemical fertilizers, biofertilizers, granular sulfur organic fertilizer and manure. However these treatments showed significant differences with seed yield under control (24.1 g. m^{-2}) (Table 3). Krishmamoorthy and Madalager [21] and Krishnamoorthy and Madalager [22] reported that the addition of N and P fertilizer up to 100 and 50 kg.ha-1, respectively, increased seed yield. Nitrogen increases vegetative growth (the number of auxiliary branches) and P accelerates the growth and maturity and increases the number of umbels per plant and the number of seeds per umbel. The adequacy of these two essential nutrients is necessary for seed yield enhancement [23,24]. Akbarinia *et al.* [8] stated that the addition of 30 $t.ha^{-1}$ manure met the nutrients requirement of Ajowan and increased seed yield. Under full irrigation, the application of chemical fertilizer produced the highest seed yield followed by the application of nitroxin+Barvar 2, whereas under two other irrigation treatments (i.e. water deficit stresses) no significant differences were observed in seed yield among different fertilization levels (Table 4). Application of chemical fertilizer, under drought stress conditions, did not increase dry matter production. Thus, it can be concluded that Ajowan nutrient requirements was greatly limited by drought stresses. As a result, it is better to apply less fertilizer under moisture limitation conditions. Also, Patterson *et al.* [25] stated that most plants mainly utilize N for the production and maintenance of leaves and for maximizing carbon assimilation and do not positively respond to higher fertilization rates, especially N fertilizer, under moisture stress.

Number of Umbels per Plant

Analysis of variance indicated that the number of umbels per plant was significantly affected by irrigation treatments and the interaction between irrigation and fertilization but it was not significantly influenced by fertilization treatments (Table 2). According to means comparison, as Ajowan was more exposed to drought stress, the number of umbels per plant was significantly decreased. The number of umbels per plant under the treatment of S1 was 40% lower than that control while it was 15.6% lower under the treatment of S2 (Table 3). It seems that the increase in stress level and the resulting loss of chlorophyll was accompanied with lower support of reproductive parts. Koocheki *et al.* [26] reported that the increase in irrigation interval in fennel reduced the number of fertile umbels per main branch and the number of umbels per auxiliary branch. As irrigation water is increased, the plants are expected to produce more umbels under optimum vegetative growth. The increase in irrigation interval in psyillium enhanced the number of umbels per plant [27].

Chemical fertilizers and manure had the highest number of umbels per plant (21.4) without significant differences with granular sulfur. The lowest number of umbels per plant (15.9) was related to control with no significant differences with the treatment of nitroxin+Barvar 2 (Table 3). Higher availability of nutrients, particularly N and P to plants stimulates their growth and enhances the growth and the number of umbels per plant. Studies suggest that higher N availability results in higher number of umbels per plant [28,29]. Means comparison of the interactions revealed that the treatment of chemical fertilizers with full irrigation produced the highest number of umbels per plant followed by manure and granular organic sulfur. Under the treatment of S2, manure produced the highest number of umbels per plant and under the treatment of S1, manure and granular organic sulfur produced the highest number of umbels per plant (Table 4).

Number of Umbellets per Umbel

Irrigation and fertilization treatments affected the number of umbellets per umbel at the 5% level, but their interaction was not significant (Table 2). There was no statistically significant difference in the number of umbellets per umbel under full irrigation and the treatment of S2 so that they were both ranked in the same statistical group by producing 8.7 and 8.3 umbellets per umbel, respectively. The treatment of S1 had the lowest number of umbellets per umbel (i.e., 6.2) (Table 3). The availability of water and nutrients causes optimum vegetative and reproductive growth, thereby affecting the reproductive parts. Kafi and Keshmiri [30] reported that the number of cumin umbels per plant was lost by deficit irrigation and was increased as irrigation frequency was increased resulting in higher yield. The application of chemical fertilizers as well as organic fertilizer and manure improved the vegetative growth and yield components of Ajowan through gradual release of nutrients which resulted in higher number of umbellets per umbel. Chemical fertilization had the highest number of umbellets per umbel (8.5) but with no significant difference with that under the application of manure, granular organic sulfur and nitroxin + Barvar 2 (Table 3). Organic fertilizers provide much better conditions for the activity of beneficial microbes than control and improve the growth and flowering by optimum uptake of macro and micronutrients by roots [31].

Number of Seeds per Umbellet

The number of seeds per umbellet, in fact, determines sink capacity so that more number of seeds, the greater sink for the reception of photosynthates which, in turn, increases the yield. It was revealed that irrigation and fertilization affected the number of seeds per umbellet at the 5% level, but their interaction was not significant for this trait (Table 2). Full irrigation resulted in the highest seed number per umbellet, but the irrigation treatment of S2 and S1 resulted in the significant loss of seed number per umbellet although these two latter treatments did not show significant differences in terms of seed number per umbellet (Table 3). In most crops, the occurrence of water stress during flowering reduces the number of fertile flowers resulting in the loss of seed number and yield [32]. Najafi [27] reported an increase in seed number per spike of psyllium with the decrease in irrigation interval. It was found that chemical fertilizer produced the highest number of seeds per umbellet (9.5) with no significant differences to the application of manure and nitroxin + Barvar 2; in addition, control had the lowest number of seeds per umbellet with no significant difference with the application of granular organic sulfur (Table 3). It seems that probably the application of organic fertilizer and manure improves soil physical properties resulting in better nutritional condition for the plants and more water availability, and consequently the number of umbels per plant and the number of seeds are increased.

Plant Height

Like all vegetative and reproductive parts, plant height is deeply influenced by nutrients and water. The availability of water and nutrients, especially N, increases plant height through affecting the division and enlargement of the cells. Plant height was found to be significantly affected by irrigation and fertilization treatments, but their interaction was not significant for this trait (Table 2). The treatments of S1 and S2 resulted in plant heights of 21.7 and 23.8 cm which were 25.4 and 17.9% lower than that under full irrigation (29.1 cm), respectively (Table 3). At stem-elongation stage, plants have the highest acceleration of photosynthesizing area increase, and the deficiency of photosynthesis inputs results in lower growth and plant height [16]. The treatments of nitroxin + Barvar 2 and granular organic sulfur had higher plant height (27.1 and 26 cm, respectively) than control, but they did not exhibit significant differences with chemical fertilizers and manure (Table 3). With respect to the effect of N and phosphate biofertilizers on plant height, it should be noted that this effect is probably related to the increased uptake of N and P and their impact on increasing assimilate production and the growth of Ajowan [33]. Since nutrient deficiency is an important factor in determining plant height, it seems that control treatment had lower growth because of the deficiency of nutrients, whereas the nutrients sufficed for vegetative growth in all fertilization treatments. Biofertilizers increased the growth and subsequently, plant height by improving root growth and the absorption of water. Nitrogen is a factor that increases internode length which results in higher growth and plant height. Therefore, if plants are supplied with N before the termination of their stem elongation, it will be reflected in plant height.

Number of Branches per Plant

It was shown that only irrigation treatments affected the number of branches per plant at the 1% level and the effect of fertilization treatments and its interaction with irrigation was not significant for this trait (Table 2). All irrigation treatments were ranked in distinct statistical groups.

The highest number of branches per plant (8) was related to full irrigation treatment and the treatment of S1 produced the lowest number of branches per plant (5.3) which was 33.7% lower than the maximum one (Table 3). The increase in drought stress suppresses the vegetative growth and the plants adopt the strategy of entering the reproductive phase with minimum vegetative growth to quickly terminate their growth cycles resulting in the descending trend of auxiliary branch production.

Koocheki *et al.* [26] in fennel and Amiridehahmadi *et al.* [34] in dill, coriander and fennel reported that the increase in irrigation interval resulted in the reducing of auxiliary branches. On the other hand, since Ajowan has an indeterminate growth, it is able to produce branches throughout its growth period. Therefore, even post-flowering drought stress reduced the number of branches.

Harvest Index

It was revealed that the effect of irrigation and fertilizer and their interaction on HI was not significant (Table 2) suggesting that seed and biomass yield, i.e. the vegetative and reproductive structures, were equally influenced by irrigation treatments. In spite of the fact that irrigation treatments were applied after the commencement of reproductive growth and harvest index would be expected to decrease, their insignificant effect on this trait can be explained by the fact that Ajowan is an indeterminate plant and as mentioned before, it continues its vegetative growth even after the beginning of reproductive growth. Therefore, the occurrence of stress even at this stage can adversely affect the production of vegetative biomass. However, harvest index was higher under full irrigation (Table 3). Wright *et al.* [35] and Vafabakhsh *et al.* [36] reported that drought stress severely decreased harvest index.

Table 2 Results of analysis of variance of irrigation and fertilization treatments for the studied traits of Ajowan

Sources of variation	df	Means of squares							
		Seed yield	Umbels per plant	Umbellets per umbel	Seeds per umbellet	Plant height	Branches per plant	Harvest index	Essential oil
Block	2	51.60	8.99	0.47	2.13	17.05	0.091	36.72	0.23
Irrigation	2	705.37**	342.58**	26.70*	57.05*	217.75*	29.49**	74.80ns	0.24ns
Error a	4	38.22	4.78	2.34	3.52	20.30	0.188	48.13	0.11
Fertilizer	4	46.65*	53.62ns	3.75*	5.03*	33.91*	2.504ns	44.45ns	0.05ns
I × F	8	60.26**	3.48**	1.28 ns	2.20ns	8.92ns	1.388ns	40.25ns	0.46*
Error b	24	13.66	6.49	1.72	1.72	8.61	1.239	33.87	0.14
C.V.		13.25	13.19	16.90	15.88	11.80	17.07	15.87	19.02

* and ** show significance at 5 and 1% level, respectively and ns shows insignificance.

Table 3 Results of means comparison of the effects of irrigation and fertilization treatments on studied traits of Ajowan

Treatment	Seed yield ($g.m^{-2}$)	Umbels per plant	Umbellets per umbel	Seeds per umbellet	Plant height (cm)	Branches per plant	Harvest index (%)	Essential oil (%)
Irrigation								
C	35.4 a	23.7 a	8.7 a	10.3 a	29.1 a	8.0 a	39.2 a	1.950 a
S1	22.0 b	14.2 c	6.2 b	6.4 b	21.7 b	5.3 c	35.8 a	2.114 a
S2	26.3 b	20.0 b	8.3 a	8.2 b	23.8 b	6.3 b	35.0 a	1.865 a
Fertilization								
NF	24.1 b	15.9 b	6.7 b	7.4 b	21.9 b	5.7 b	37.5 a	1.885 a
F	29.6 a	21.4 a	8.5 a	9.2 a	24.7 ab	7.1 a	36.2 a	1.959 a
NB	29.4 a	17.6 b	7.8 ab	8.6 ab	27.1 a	6.5 ab	39.2 a	1.926 a
OS	28.8 a	20.3 a	8.0 ab	7.6 b	26.0 a	6.7 ab	37.3 a	2.055 a
M	27.5 ab	21.4 a	7.8 ab	8.6 ab	24.5 ab	6.7 ab	33.2 a	2.056 a

Means followed by the same letter within each column are not significantly different according to Duncan multiple test (P=0.05), (NF- no fertilization, F- chemical fertilizer, NB- nitroxin+Barvar2, OS- granular organic sulfur, M-manure, C-full or weekly irrigation in the whole period of growth, S1-weekly irrigation until the beginning of stem elongation and after that every other week irrigation, S2- weekly irrigation until the beginning of flowering and after that every other week irrigation)

Table 4 Results of means comparison of the interaction between irrigation and fertilizer for the studied traits of Ajowan

Irrigation	Fertilizer	Seed yield ($g.m^{-2}$)	Umbels per plant	Umbellets per umbel	Seeds per umbellet	Plant height (cm)	Branches per plant	Harvest index (%)	Essential oil (%)
C	NF	27.8 de	19.2 defg	7.5 abcd	8.4 cde	25.5 bc	6.5 cdef	35.6 ab	1.216 c
	F	44.0 a	27.2 a	9.8 a	12.5 a	28.7 ab	9.4 a	43.6 a	2.027 ab
	NB	39.9 ab	21.9 bcde	8.8 ab	11.0 ab	30.9 a	8.6 ab	43.7 a	1.841 abc
	OS	35.5 bc	24.6 abc	9.4 ab	9.1 bcd	28.9 ab	7.6 abcd	41.2 ab	2.197 ab
	M	29.8 cd	25.4 ab	8.2 abc	10.4 abc	31.4 a	8.1 abc	31.9 b	2.466 a
S1	NF	20.7 e	11.0 i	5.1 d	5.8 e	17.8 d	4.8 f	40.9 ab	2.439 a
	F	20.9 e	16.7 fgh	7.0 bcd	6.7 de	20.5 cd	5.4 ef	32.0 b	2.111 ab
	NB	20.5 e	12.3 hi	7.1 bcd	5.9 e	25.1 bc	5.1 ef	37.0 ab	2.264 ab
	OS	22.9 de	15.3 ghi	6.0 cd	6.2 e	24.2 bc	5.2 ef	34.8 ab	2.082 ab
	M	24.8 de	15.7 ghi	6.0 cd	7.3 de	20.9 cd	5.8 def	34.4 ab	1.673 bc
S2	NF	23.7 de	17.5 efg	7.7 abcd	8.0 cde	22.5 cd	5.7 def	36.1 ab	1.999 ab
	F	23.3 de	20.2 cdefg	8.8 ab	8.4 cde	24.9 cde	6.5 cdef	33.1 ab	1.738 abc
	NB	28.4 d	18.5 defg	7.4 abcd	8.8 bcd	25.4 bc	5.7 def	36.8 ab	1.673 bc
	OS	28.1 d	21.0 bcdef	8.5 abc	7.6 de	24.9 bc	7.2 bcde	35.9 ab	1.884 abc
	M	28.0 d	23.0 abcd	9.2 ab	8.1 cde	21.3 cd	6.1 cdef	33.2 ab	2.028 ab

Means followed by the same letter within each column are not significantly different according to Duncan multiple test (P=0.05), (NF- no fertilization, F- chemical fertilizer, NB- nitroxin+Barvar2, OS- granular organic sulfur, M-manure, C- full or weekly irrigation in the whole period of growth, S1-weekly irrigation until the beginning of stem elongation and after that every other week irrigation, S2- weekly irrigation until the beginning of flowering and after that every other week irrigation)

Essential oil Percent

The effect of irrigation and fertilizer on essential oil percent was not significant, but their interaction was significant (Table 2). Fertilizer application at non stress condition increased significantly essential oil percent. But at severe drought stress (S1) condition, fertilizer application declined essential oil percent and at mild drought stress conditions, fertilizer application had not any significant effect (Table 4).

Macronutrients such as nitrogen, phosphorous, and potassium affect the growth and essential oil synthesis in medicinal plants. These constituents influence the levels of enzymes that are very important in the terpenoides biosynthesis [37].

However, the final result in this regard is different. In an experiment on *Lippia origanoides* Kunth, Teles *et al.* [38] indicated that organic fertilizer had not any significant effect on essential oil percent.

At this experiment, a favorable environment in terms of soil water content, improved plant growth and thus essential oil production.

Conclusion

According to the results, it can be concluded that, full irrigation treatment with chemical fertilizers will produce the highest seed yield. But the yield of this treatment was not significantly different with NB one. Thus it is recommended to use biofertilizers (nitroxin+Barvar 2) due to lower environmental problems.

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