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Effect of Drought Stress and Different Types of Organic Fertilizers on Yield of Cumin Components in Sistan Region

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Authors' contributions

This work was carried out in collaboration between all authors. Author MF designed the study, wrote the protocol, managed the analyses of the study and wrote the first draft of the manuscript. The laboratory work under supervision of author ZM. Author MAK performed the statistical analysis, wrote the final draft and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Cumin *(Cuminum cyminum* L.) is one of the most economical medicinal plants. Cumin is indigenous to Northern Egypt, Syria, the Mediterranean region, Iran and India; it grows easily throughout Iran. In order to study the effects of drought stress and different types of organic fertilizers on yield components of cumin this experiment was conducted in 2014 at the Agricultural Research Institute of University of Zabol, Iran in a complete randomized block in factorial design with three replications. Treatments included irrigation intervals (I1: two times irrigation, I2: three times irrigation and I3: four times irrigation that is irrigation at germination, seedling, flowering and seed filing stages) and fertilizers treatment (T1: without fertilizer application (Control), T2: 10 t/ha vermicompost, T3: 15 t/ha compost and T4: 30 t/ha animal manure. Characteristics such as seed yield, thousand –seed weight, number of seed per plant, number of seed per umbrella, number of

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umbelet per umbrella and number of umbrella per plant were evaluated. The results showed that these indices there were significant differences in all times irrigation treatments settlement number of umbelet per umbrella. Also the highest (458.29 kg/ha) and lowest (146.08 kg/ha) seed yield was produced under the traits 4 and 2 irrigations times. The application of 15 t/ha compost obtain highest number of umbrella per plant, number of umbelet per umbrella, number of seed per umbrella and number of seed per plant. The application of 30 t/ha animal manure produced highest seed yield (316.39 kg /ha) and thousand –seed weight (4.61) per plant.

Keywords: Cumin; drought stress; yield; organic fertilizers.

1. INTRODUCTION

Today, cumin is mostly grown in China, Uzbekistan, Tajikistan, Iran, Turkey, Morocco, Egypt, Syria, Mexico, Chile and India [1]. The plant was used since ancient times in the Shahr-e Sukhteh of Zabol, in Iran [2]. Seeds excavated in India have been dated to the second millennium BC. They have also been reported from several New Kingdom levels of ancient Egyptian archaeological sites [3]. In the ancient Egyptian civilization cumin was used as spice and as preservative in mummification [4]. Drought stress may limit yield of medicinal and aromatic plants by reducing the harvest index (HI). This can occur even in the absence of a strong reduction in total medicinal and aromatic plants dry matter accumulation, if a brief period of stress coincides with the critical developmental stage around flowering stage. Secondary metabolites are synthesized by plants due to plant adaptation in response to biotic and abiotic stresses e.g. water stress, cold stress, high visible light [5]. Water stress is the most influential factor affecting crop yield particularly in irrigated agriculture in arid and semi-arid regions. It is necessary to get maximum yield in agriculture by using the least available water in order to get maximum profit per unit area because existing agricultural land and irrigation water are rapidly diminishing due to rapid industrialization and urban development. Optimizing irrigation management due to water scarcity together with appropriate crops for cultivation is highly in demand; the cost of irrigation pumping and inadequate irrigation scheme capacity as well as limited water sources are among the reasons that force many countries to reduce irrigation applications. The potential for water stress tolerance and the economic value of medicinal and aromatic plants, make them suitable alternative crops in dry lands [6]. Chemical fertilizers are used in modern agriculture to correct known plant nutrient deficiencies; to provide high levels of nutrition, which aid plants in withstanding stress conditions to maintain optimum soil fertility conditions; and to improve crop quality. Adequate fertilization programs supply the amounts of plant nutrients needed to sustain maximum net returns [7]. High-input practices such as heavy use of chemical fertilizers have created a variety of economic, environmental, ecological and social problems. Furthermore, the increasing costs of chemical inputs have left farmers helpless, resulting to decreasing seed quality of certain crops and resulting in the fall of commodity prices and consequently reducing farm income [8,9]. In such situation the organic fertilizers play a major role in order to achieve sustainable agriculture. Organic fertilizer is a suitable source of macro- and micronutrient [10]. Usage of manure is more important and beneficial than chemical fertilizers [11]. Ahmadian [12] reported that an increased number of irrigation imposed a positive effect on the number of seeds and number of umbrellas per plant, and it had negative effect on seed weight in cumin, but no effect on number of seeds per umbrella and plant height per plant. The effect of fertilizer treatment and its interaction with irrigation on seed yield in cumin was significant. In water stress conditions, higher seed yield was related to 5t/ha manure+nitrogen treatment [13]. According to results Shafagh Kalvanagh and Nazari Heris [14], animal manure produced the highest, seed number per plant, 1000-seed weight and seed yield of dragon's head (*Lallemantia iberica*), 5.67 g and 5.65 g, respectively. Saboor [15] also reported that manure application increases cumin yield. James et al. [16] suggested that the change of finite nutrient availability would have the largest impact in altering community and ecosystem properties rather than changes in water availability or efficiency of water utilization. Fertilization increases the availability of limited nutrients, and then could alter system properties, which might be a potentially practical way to stimulate plant growth, enhance stress tolerance, and improve the efficiency of using finite resources in infertile and dry environments

[17,18,19]. The highest harvest index (40.66) was produced for *Lallemantia berica* under the treatment of 150 mm evaporation from class a pan and the application of Compost [14].

2. MATERIALS AND METHODS

The field experiment was conducted in 2013 and 2014 growing seasons at the Agricultural Research Institute of University of Zabol, Iran. The experiment is conducted based on a complete randomized block in factorial design with three replicates. The soil texture was sandy-loam, having 1.1% organic matter. Soil chemical analysis was as follows: pH= 7.7, EC (ds/m) = 2.4; cations (meq/L): Ca^{2+}= 2.43, Mg^{2+}= 2.5, Na^{+}= 6.46, K^{+} = 2.74; anions (meq/L): $CO3^{2-}$ = zero, HCO^{3-} = 3.6, Cl^{-} = 2.4, $SO4^{2-}$ = 5.6 [20]. The experimental plot size was 2 m×2 m. Seeds were planted onto December 14th 2014 in 40 cm row distance, 1.5 cm sowing depth. (I1: two times irrigation, I2: three times irrigation and I3: four times irrigation, that are irrigation at germination, seedling, flowering and seed filing stages) and fertilizers treatment (T1: without fertilizer application (Control), T2: 10 t/ha vermicompost, T3: 15 t/ha compost and T4: 30 t/ha animal manure. Number of seed per umbrella, number of umbelet per umbrella, number of umbrella per plant, number of seed per plant, 1000-seed weight (g) and seed yield (kg/ha) were determined. The studied traits were measured on the 10 randomly selected plants. Weeds were controlled by hand weeding during crop growth and development. At maturity, plants of 2 m^2 in the middle part of each plot were harvested and parameters calculated. All data were averaged and statistically analyzed using analysis of variance (ANOVA) by MSTATC and SAS analytical software. The Duncan's multiple range test level was used to compare means.

3. RESULTS AND DISCUSSION

3.1 Number of Umbrella per Plant

Drought stress had significant effect on number ofumbels per plant. Also the effect of fertilizer treatment and its interaction with irrigation on number of umbrella per plant was not significant and that was not significantly different between two and three times irrigation (Table 1). Interaction of irrigation and fertilizer treatments on number of umbrella per plant was not significant (Table 1). The lowest umbel per plant (8.01) was obtained from I3: four times irrigation (Table 2). The highest number of umbrella per plant (7.82) resulted from 15 t/ha compost application treatment. According to results Motamedi-Mirhosseini et al. [21] Drought stress decreased the number of umbels per plant about 66.33% in comparison with control treatment. The reduction of cumin umbel number per plant in water stress condition also has reported by Ahmadian et al. [22]. In that experiment, the highest number of umbels per plant resulted from 3 applications of irrigation with an application of manure. Organic compost is a rich and a slow release fertilizer which using leads to a clean product of plants, continuous supply of nutrients, which improve some physical properties of soil, increase water retention than that for chemical fertilizers and improves the soil texture. The structural improvement can encourage the plant to have a good root development by improving the aeration in the soil, which leads to a higher plant vegetative growth.

3.2 Number of Umbelet per Umbrella

(Table 1) shows the effects of irrigation times and fertilizers organic on cumin growth. Irrigation times, fertilizers organic and Interaction F×I had no significant effects on the number of umbelet per umbrella (Table 1). Also results showed that the highest number of umbelet per umbrella (3.72) was obtained from four times irrigation (I3) but in different levels of drought stress were not significant differences (Table 2). The highest number of umbelet per umbrella was related to compost treatment with mean (3.9) umbelet per umbrella (Table 2). In conclusion, results showed that manure could be used effectively to modify the impact of water shortage and to stimulate an increase in cumin seed and essential oil yields probably through improving the water holding capacity of the soil [13].

3.3 Number of Seed per Umbrella

Analysis of variance showed that the number of seed per umbrella was significantly affected by irrigation times at 1% probability level and fertilizers at 5% probability level (Table 1). According to results of analysis of variance, all traits in different levels of drought stress were significantso the number of seeds per umbrella decreased under drought stress (Table 2). In between irrigation levels,Highest (12.97) and lowest (10.92) levels ofnumber of seed per umbrella were obtained in 4 irrigations (I3) and 2 irrigations (I1) treatments, respectively. Infertilizers application, higher number of seed per umbrella (13.07) was related to compost treatment and animal manure, vermicompost and Control treatments had lower number of seed per umbrella respectively. Motamedi-Mirhosseini et al. [21] studied the effects of irrigation regimes on the yield of cumin and reported that drought stress decreased the number of seed per umbels.

3.4 Number of Seed per Plant

The results of analysis of variance showed that the effect of irrigation times was significant ($p<0.01$) on number of seed per plant (Table 1).The highest number of seed per plant (103.75) was produced under the treatment 4 irrigations (I3) andalso the application of 15 t/ha compost treatment was obtained 101.75 number of seed per plant (Table 2). Drought stress in agricultural lands is one of the factors of environments, which limits the growth and yield of cumin and other crops in many arid and semiarid regions of the world [23,24]. It seems that in drought stress condition number of seedsper plant was the greatest factor that is affected by drought stress [21].

3.5 Thousand–Seed Weight

Results showed that thousand –seed weight was significantly affected by irrigation times at 1% probability level and fertilizers at 5% probability level (Table 1). Drought stress decreased1000-seed weight in cumin plant. The highest 1000-seed weight (4.68 gr) was produced under the treatment 4 irrigations (I3) and also the application of 30 t/ha animal manure was obtained highest thousand –seed weight (4.61 gr) (Table 2). Shafagh Kalvanagh and Nazari Heris [14] reported that in animal manure treatment application produced the highest 1000-seed weight with mean 5.67 in dragon,s head (*Lallemantia iberica*) plant.

3.6 Seed Yield

According to results of analysis of variance, Seed yield was significantly affected by irrigation times at 1% probability level and fertilizers at 5% probability level. Also interaction between irrigation times and fertilizers types were not significant differences (Table 1). The highest (458.29 kg/ha) and lowest (146.08 kg/ha) seed yield was produced under the treatments 4 and2 irrigations times respectively. Also the application 30 t/ha animal manure treatment was obtained 316.39 kg/ha seed yield (Table 2). Manure application improves the soil structure and soil moisture content, provides plant with essential elements, increases growth, number of umbrella per plant and biological yield and finally led to increase seed yield [22]. Saboor [15] on cumin and Seghatoleslami [13] on cumin also reported that manure application increases cumin yield. This data agreement whit results Moradi [25] on fennel plant (*Foeniculum vulgare* L).

Table 1. Square means of yield components affected by fertilizers organic and drought stress

Sources of variation	df	Number of umbrella per plant	Number of umbelet per umbrella	Number of seed per umbrella	Number of seed per plant	Thousand –seed weight	Seed yield
		-	-	-	-	(gr)	(kg/ha)
Replication	2	0.41ns	0.16 ns	1.01 ns	13.64 ns	0.17 ns	29770.34*
Irrigation	2	8.63*	0.10 ns	12.70**	3220.59**	1.27**	316927.42**
Fertilizers	3	5.02 ns	0.35 ns	5.64*	1520.25 ns	0.50*	26838.34*
Interaction F×I	6	5.26 ns	0.14 ns	3.62 ns	1353.82 ns	0.18 ns	11212.20 ns
Error	22	1.97	0.12	0.94	384.63	0.11	5933.43
CV %	-	19.9	9.6	8.1	23.1	7.9	27.8

*** , * statistical significant on 0.01 and 0.05 ns : not significant*

Table 2. Mean of yield components affected by fertilizers organic and drought stress

Sources of variation	Number of umbrella per plant	Number of umbelet per umbrella	Number of seed per umbrella	Number of seed per plan	Thousand –seed weight	Seed yield
	-	-	-	-	(gr)	(kg/ha)
I1	6.77 B	3.60 A	10.92 C	74.20 B	4.18 B	146.08 C
I2	6.39 B	3.54 A	11.83 B	76.71 B	4.08 B	223.92 B
I3	8.01 A	3.72 A	12.97 A	103.75 A	4.68 A	458.29 A

Table 2 continued……

Control	6.81 AB	3.50 B	11.30 B	76.97 B	4.04 B	200.33 B
Vermicompost	7.47 AB	3.62 AB	11.55 B	88.14 AB	4.36 AB	272.00 AB
Compost	7.82 A	3.90 A	13.07 A	101.75 A	4.24 B	315.67 A
Animal manure	6.13 B	3.46 B	11.71 B	72.67 B	4.61 A	316.39 A

There were no statistical differences among the means shown by the same letters at 5 % probability level

4. CONCLUSION

This study concluded that highest (458.29 kg/ha) and lowest (146.08 kg/ha) seed yield was produced under the treatments 4 and2 irrigations times respectively. Also the application 30 t/ha animal manure treatment was obtained 316.39 kg/ha seed yield. Manure application improves the soil structure and soil moisture content, provides plant with essential elements, increases growth, number of umbrella per plant and biological yield and finally led to increase seed yield.

CONSENT

Not applicable.

ETHICAL APPROVAL

All authors hereby declare that "Principles of laboratory animal care" (NIH publication, revised 1996) were followed; all experiments have been examined and approved by the appropriate ethics committee. All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee of the *agricultural research institute, university of Zabol. IR, Iran*, and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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