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The Effect of Water Shortage and Foliar Application of Salicylic Acid on Quantitative and Qualitative Performance of Cumin Herb

Farzaneh Jami, Ahmad Mehraban* and Hamid Reza Ganjali

Department of Agricultures, College of Basic Science, Zahedan Branch, Islamic Azad University, Zahedan, Iran; farzanehjami@yahoo.com

Abstract

The outcome of different levels of drought stress and salicylic acid on quantitative as well as qualitative performance of cumin herb and split-plot test with entirely randomized block design has been conducted for four-times, in the city of Khash in 2013-14. The treatments includes foremost factor of stress in three different levels of controls vis; umbelet stage, grain filling and the sub factor of salicylic acid in four-levels namely 1.5, 0.7, 0.1 and 0 mm. In this experiment, the characteristics measured and investigated are height of plant, number of seeds per umbel, number of umbels per plant, grain yield and weight, grain yield per plot and wet and dry forage yield as well. Results, evidently displayed the dryness and foliar application of salicylic acid's influence on the most of the characteristics. On one hand, dryness caused a negative impact on these attributes and on the other hand, foliar application of salicylic acid has visibly improved these features.

Keywords: Cumin, Drought Stress, Irrigation, Qualitative Performance, Salicylic Acid

1. Introduction

Irrigation facilities, chemicals and environmental factors play fundamental role in increasing performance and improving the quality of cumin. Its deficiency has deep impact on the production, more than that of any other inputs. Despite the comprehensive studies conducted, on the effect of water stress on agricultural products, the medicinal plants behavior, under such conditions hasn't been studied well enough Ebrahimpour et al.[1] so, in order to understand the existence and survival of medicinal plants, in arid and semi-arid areas which occupies very large part of our country, an extensive research is required on plants with medicinal value for various different treatments. "A review on biotechnology, genetic diversity in cumin" highlights that in the near future these biotechnological tools, especially molecular markers, will indeed become absolutely noteworthy, Madhuri et al.[2] moreover, mutations induced with gamma rays are thoroughly beneficial in creating desirable variability in spices. Water shortage is the key factor that confines the agricultural production Aminpour et al[3].

Environmental factors demonstrate changes in the growth of medicinal plants and effective materials viz; alkaloids, glycosides, steroids and volatile oil, Vagujfalvi[4]. Furthermore cumin plants are medicinal plants - which are now being exported broadly too. Planting of this medicinal herb is concentrated in the provinces of Khorasan, Eastern Azerbaijan, Central Azerbaijan and Golestan in Iran. The Province of Khorasan with 90 percent of cumin production stands at the first position Nabizadeh et al.[5] Cumin seeds contains high amount of carotene, iron and secondary pharmaceutical compounds which are used in traditional and modern medicine, as an antioxidant and carminative these medicinal contents are effective for treating diarrhea, indigestion, headache, common cold, fever and mouth and throat ulcers Nakhzari et al.[6] Chloroform and ethanol extracts of black cumin seeds (Nigella sativa) were analyzed

**Author for correspondence*

for antibacterial activities, outcome suggests, black cumin seeds may have strong antibacterial activity against multiple antibiotic resistant bacteria Alam et al.[7] Forouzan Faret al.[8] in a review on antimicrobial effects have stated (Black Cumin) that seeds have antimicrobial effects against different pathogens. Natalia et al.[9] investigating antibacterial activity of black cumin oil and formulated naneomulsion gel, the results of in vitro antibacterial activity assesses by using the disc method indicates, black cumin oil contains superior inhibiting zone as compare to naneomulsion gels. Sangeeta et al.[10] the aqueous extracts of *Cuminum cyminum* seeds showed predominantly anti inflammatory activity while the ethanolic extracts shows predominant analgesic activity. Bansal et al.[11] cumin is found as a major ingredient in both chili powder and curries, its added as an important ingredient in food around the globe, furthermore it includes medicinal properties too.

Asaduzzaman et al.[12] nigella sativa has proven effective against cancer in blood system. Moraghebi[13] high percentage of aldehyde, in essential oil shows its appropriate quality and results indicate, its treatments have different effects on essential oil composition. Mehran et al.[14] cumin seed primed with different Gibberellic Acid (GA3) concentrations had better germination and different temperature regimes affect seed germination. Gangadevi et al.[15] the isolation of endophytic fungi, from medical plants, for any bio-active compound may facilitate in a product discovery process.

Dryness is one of the major off-putting factors of plants that are grown around the world and also the most common environmental stress as well. Obviously, the effect of water stress on growth and performance depends on the type of plant's genes Bannayan[16]. Drought stress can cause changes such as on nutrient intake by plants, it also affects the ability of plants to absorb the water and minerals from the roots Tavoosi[17]. Irrigation diet has a significant effect on grain and components yield. Applying the five-time irrigation treatment process increased the performance, as compared to four-time irrigation treatment course. Now again, when irrigation treatment process, was increased for the sixth time- it showed no significant effect on the performance of cumin seeds. Salicylic acid or orthohydroxy benzoic acid belongs to the group of phenolic compounds Popover et al[18]. Stated about, a plant hormone-Germination of seeds, fruit ripening, glycolysis (acid) and heat production Chen et al[19]. Salicylic acid is also known as a messenger molecule in plant it responds to several biotic and abiotic stresses. Therefore, the effect of salicylic acid on the quantity and quality of cumin medicinal plant, under the drought stress has been investigated during the entire study process.

2. Methodology and Materials

Evaluation of various different levels of drought stress on quality and quantity yield of cumin (medicinal) plant also includes plant height, number of seeds per umbel, number of umbels per plant, Table 1. The split-plot test randomized block design has been conducted for four-times. The treatments includes, foremost factor of stress in three-different levels of controls vis; umbelet stage, grain filling and sub factor of salicylic acid in four-levels namely 1.5, 0.7, 0.1 and 0 mm. Piece Assesment1: With an approximate area of 25 m × 16 m = 2 400 . In each block there are twelve-plots with dimensions of 4m × 1m with four-planting lines having a length of 4m, with row spacing of 5cm and the distance between the rows is 15 to 20 cm. The distance between the plots, during growth is 1m, then stress was applied, rendering to water stopover in umbelet and grain filling stages. All plots were sprayed with salicylic acid, so that irrigation could be stopped for ten-days in the umbelet stage. Irrigation was started again, but once every three days and continued till the flowering stag. In the next stage of the grain formation, particularly during the grain filling irrigation was terminated for next seven-days, until the cumin harvesting. Owing to the sensitivity of cumin to weeds, during the growing season, weeds can be controlled manually by hands. For statistical analysis of data, Statistical Analysis System (SAS) software's aid was taken. For comparing the averages, Duncan's multiple range tests were used at 5%.For drawing chart, MS EXCEL software aid was taken.

2.1 Soil Characteristic

Characteristics	Depth cm	EC DSM^{-1}	PH	O.C %	N %	CLAY %	Texture
Sample	30	8/41	7/75	0/32	0/02	8	Sandy loam

3. Experiment's Outcomes and Discussion

3.1 Plant Height

Data variance analysis shows that plants heights were significantly affected by drought stress. (Table 1). The maximum height belongs to, the control treatment, with an average height of 176.25 cm and the minimum height belongs to an umbel formation stage, with an average height of 167.06 cm (Table 2).

In arid areas, water shortage reduces both - the turgor and growth and development of cells, especially; in the stem and leaves. The primary and tangible impact of water shortage can be clearly distinguished from the leaves which are, smaller in size or shorter in height. Decrease in a leaf area or leaf size- reduces light absorption capacity too. It also reduces the overall capacity of the plants photosynthesis process Hassani[20]. Evidently, significant decrease in plants height, leaf length, leaf area and leaf weight was witnessed, during the mild and moderate treatment of water stress Senaranta et al.[21]

The results of experiment revealed that, plants height were affected by foliar application of salicylic acid and this is significant at the level of 5% (Table 1). The averages

Table 1. Variance analysis of cumin features affected by stress levels and foliar application

Sources of changes	Degree of freedom	(HeightCm)	Number of umbels per plant	Number of seeds per umbel	Grain weight(gr)	Grain yield (Kg per hectare)	Wet forage yield (Kg per hectare)	Dry forage YieldKg per hectare)
Repetition	3	25.40	17.46	288.91	0.009	8.52	73.98	29.74
Strays (A)	2	352.27**	255.77**	10298.31*	0.98**	154.75*	997.74**	256.09**
A error	6	13.90	47.71	862.39	0.048	40.41	80.41	28.78
foliar application (B)	3	193.07*	152.90*	9790.80*	0.19*	135.07*	119.33*	221.96**
A*B	6	67.07ns	98.74ns	2228.36ns	0.11nss	172.47**	161.79**	12.02ns
B error	27	42.98	45.76	2178.99	0.05	30.76	26.98	8.11
Coefficient of Variation (%)	-	*3.83*	*9.44*	*9.71*	*8.99*	*13.97*	*12.78*	*13.82*

ns: non-significant:
**:Significant at probability level of five percent*
***: Significant at the probability of one percent*

Table 2. Comparison of average of cumin features affected by stress levels and foliar application

Experimental treatments	Height (cm)	Number of umbels per plant	Number of seeds per umbel	Grain Weightgr))	Grain YieldKilograms per hectare)	Wet forage yield (Kilograms per hectare)	Dry forage yield (Kilograms per hectare)
Stress							
Without stress (control)	176.25a	76.12a	503.56a	2.80a	43.06a	47.51a	24.99a
Stage of umbelet formation	167.06b	68.43b	453.38b	2.31c	36.93b	32.01b	17.16b
Grain filling stage	170b	70.37ab	484.94a	2.59b	39.06ab	42.36a	19.65b
Foliar application							
Without fertilizer (control)	166b	67.33b	449.17c	2.42b	36.50b	37.74b	15.35c
0.1 MM	170.58ab	70.25ab	467.25bc	2.51b	37.41b	38.86b	20.29b
0.7 MM	172.16a	73.66a	491.33ab	2.61ab	41.08ab	44.90a	25.86a
1.5 MM	175.66a	75.33a	514.75a	2.71a	43.75a	41.01ab	20.90b

In each column, averages containing common letters have no significant difference in the level of five percent according to Duncan's multiple range test.

comparison shows that the maximum height was obtained in 1.5 mm treatment (Table 2).

Salicylic acid is effective in the buds blossoming, the permeability of the membrane, mitochondrial respiration, stomata closure, material handling, photosynthesis, growth and the absorption of ions Senaranta et al[21]. In another experiment, application of salicylic acid and inoculation azospirillum furthermore, increased basil growing in drought stress was observed too Omidbaigi[22].

3.2 Number of Umbels per Plant

Analysis of variance indicates that the number of umbels per plant was severely affected due to drought stress (Table 1). The maximum number of umbels were obtained in, without-stress treatment (Table 2). Probably, the highest number of embossing without-stress treatment is due to suitable moisture at the field capacity. According to the outcome of variance analysis, the effect of salicylic acid foliar application on the number of umbels per plant was significant at the 5% level (Table 1). The comparison of averages indicates, the maximum number of umbels per plant was obtained in 1.5 mm treatment (Table 2). Result clearly shows, overall treatments increased in the number of umbels per plant, has noteworthy and highest correlation with seed yield Rahimi et al.[23]

3.3 Number of Seeds per Umbel

Analysis of variance indicates, the number of seeds per umbel was severely affected by drought stress (Table 1) and the same can be inferred from the table viz-comparison of averages. Maximum number of seeds per umbel is obtained in control treatment (Table 2). The effect of salicylic acid foliar application on number of seeds per umbel was substantial (Table 1). The comparison of averages shows, the 1.5 mm treatment had a positive impact on the number of seeds per umbel (Table 2). In other experiment conducted, the effect of concentration of salicylic acid triggered, some major differences in traits viz; number of seeds in umbel as well as in the plant. The application of salicylic acid and different concentrations had zero-effect on umbel per plant Sfinifarahani et al.[24]

3.4 1000 Seed Weight

Analysis of variance indicates that thousand seed weight was significantly affected by drought stress (Table 1). “Investigating effect of water deficit stress”, is one of the key components of performance of cumin seed, by applying humidity treatments of FC, 2/3 and 1/3 Kazemi[25]. The observation was, the FC treatment has the highest average in the characteristics of seed yield and weight, number of umbel per plant and weight of various kinds. Other treatments have no significant differences, in any of the features. According to the results, grain weight was significantly affected by foliar application of salicylic acid (Table 1). The comparison of averages shows, the maximum grain weight was obtained in 1.5 mm treatment. The 0.7 and 0.1 mm treatments are placed in the next group, respectively (Table 2). To evaluate the effect of salicylic acid on coriander yield and its component, an assessment was conducted. The outcome shows, the grain weight has no fundamental response, to the applied treatment Rahimi et al.[23]

3.5 Grain Yield

Grain yield shows the efficiency of photosynthesis, produces material distribution of plant to seeds. Analysis of variance indicates, the grain yield was significantly affected by drought stress (Table 1). As can be inferred from the table of comparison of averages, the maximum grain yields were obtained in without-stress treatment (Table 2). Stress resulted from the water shortage was viz; decrease in number of spikes per square meter, number of grains per spikelet, biological yield, one-thousand seeds weight, photosynthesis of seeds, weight of dry leaf and stem, seed filling rates, germination rate, seedling weight, leaf surface, dry matter production, stem length, wet root stem and seed weight, plant height, yield components, shortening the growth period, dry root weight, shoot and root weight ratio, phenol, water leaf potential, leaf specific weight and praline in agricultural plants. Appropriate and effective management can prevent the harmful effects of drought Senaranta et al.[21] This analysis of variance revealed the significant effect of salicylic acid foliar application on grain yield (Table 1). The comparison of averages shows, the highest grain yield is related to 1.5 mm treatment and the lowest one is related to control treatment (Table 2). In the year 2010–2011 a test entitled “The study of salicylic acid on yield and yield components of cumin” was conducted by Bakhtiyari and Pak Nejadin Karaj University, Iran, the results were, the foliar application of salicylic acid is more effective than acid, hence, salicylic treatment via irrigation method is appropriate. The highest grain yield is related to foliar application of salicylic acid, with the concentration of 0.7 mm and the lowest one is related to the treatment

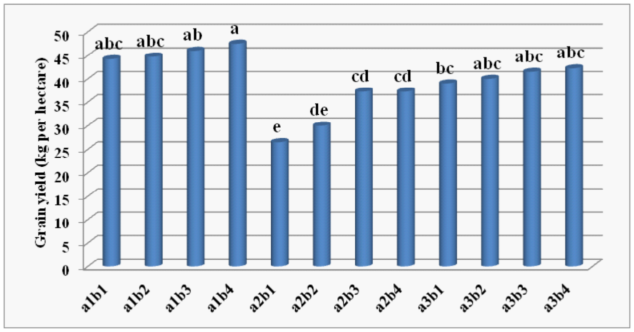

Chart 1. The interaction between stress levels and foliar application on grain yield (kg per hectare).

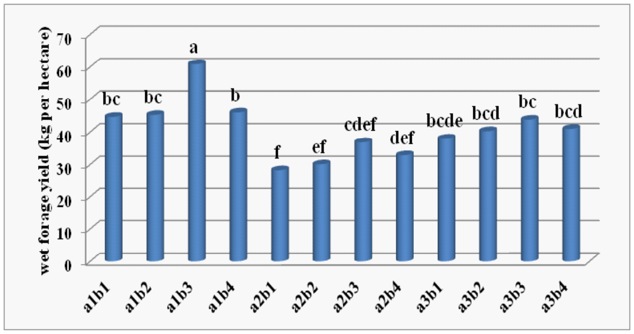

Chart 2. The interaction between stress levels and foliar application on wet forage yield (kg per hectare).

of irrigation with a concentration of 0 mm Sfinifarahani et al.[24] The highest yield is associated with the control treatment and 1.5 mm salicylic acid too (a1b4) (Chart 1). Stress resulted from water shortages have abridged grain yield. Foliar application of salicylic acid at higher levels, improves the yield.

3.6 Wet Forage Yield

Variance analysis indicates, the wet forage yield significantly affected stress (Table 1). According to the table comparison of averages, the maximum wet forage yield is obtained in the control treatment (Table 2). Leaf shape, short size of plants, color and organs of plants surface cover, show the compatibility of cumin in drought stress conditions, and Sadaria Kafi[26]. Patel et al.[27] observed significant factor i.e., increasing in the amount of irrigation based on 0.3 to 0.6 resulted in a positive impact, on the growth and yield of cumin. The results of analysis of variance reveal the significant effect of salicylic acid foliar application on wet forage yield (Table 1). The comparison of averages shows that the highest wet forage yield is related to 0.7 mm treatment (Table 2). Priming with salicylic acid has shown a significant effect on the average time of plant emergence, the percentage and emergence of seeds of caraway at 1%. It displayed no major effect on the ratio of wet weight to dry weight (FW/DW) McDonald[28]. The outcome of the interaction, between stress levels, foliar application and wet forage yield are significant. The highest wet forage yield is related to the control treatment and 0.7 mm salicylic acid (a1b3) (chart 2). Adequate water for irrigation surely shows positive effect on wet forage performance, right from the early growth stage. Foliar application with salicylic acid resulted in significant impact on wet forage yield.

3.7 Dry Forage Yield

Dry weight is the key factor in assessing the crop yield. It reveals, adoring the radiation of the sun and other environmental factors, during the growing season Sarmadnia et al.[29] Analysis of variance indicates, the dry forage yield insignificantly affected by drought stress (Table 1). As can be inferred, from the table-comparison of averages, the maximum dry forage yield is obtained in without-stress treatment (Table 2). It reduces germination, shoot growth and production of dry matter. High water stress reduces the light absorption and photosynthesis, especially in the stem and leaf and entirely disrupts the entire physiological processes, also the growth and eventually results in death of the plant Omidbagi[22]. The results of analysis of variance revealed the significant effect of salicylic acid foliar application on dry forage yield (Table 1). The comparison of averages shows, the highest dry forage yield is related to 0.7 mm treatment (Table 2). 1 and 1.5 mm treatments are also included, respectively. Fariduddin et al.[30] have reported that the spraying of salicylic acid by the concentration of 10 mm on leaves of Indian mustard resulted as, increased concentration of dry matter.

3.8 Correlation of Cumin Features

The result shows that there is a significant correlation between plant height and yield of wet forage and there is a direct relationship between plant height and yield of wet forage. With the increase in plant height, wet forage yield will be added. Water shortage, reduces both the turgor and the growth of cells, especially in the stem and leaves. The first tangible effect of water shortage can be distinguished from the smaller size or shorter length of leaves. Decrease in leaf area reduces light absorption ability and also reduces the total capacity of plant's photosynthesis process, its growth and, ultimately the overall

Table 3. Correlation of properties of cumin affected by stress levels and foliar application

Attributes	1	2	3	4	5	6	7
1. The plant height	1						
2. number of umbels per plant	0.15ns	1					
3. The number of seeds per umbel	0.12ns	0.12ns	1				
4. Thousand seed weight	–0.015ns	0.07ns	0.14ns	1			
5. Grain yield	0.23ns	0.24ns	0.36**	0.08ns	1		
6. Wet forage yield	0.39**	0.24ns	0.16ns	0.29*	0.43**	1	
7. Dry forage yield	0.03ns	0.02ns	0.41**	0.12ns	0.26ns	0.01ns	1

performance. Hence, there is a clear correlation between the number of seeds per umbel and grain yield. Naturally, by increasing the number of seeds per umbel, grain yield will be added. Possibly, the higher number of umbels in, without-stress treatment is due to the appropriate moisture at the field capacity. Number of umbels per plant has resulted in the highest correlation with seed yield.

Stress caused by water shortage, reduces the seeds per umbel, number of umbels per plant and thousand grain weights. A significant relationship exists between the number of seeds per umbel and dry forage yield. With an increase in dry forage yield, thereby, it reduces germination, shoot growth and dry matter production. High water stress reduces the light absorption and photosynthesis, especially in the stem and leaf and disrupts the complete physiological processes, growth and eventually causes the death of a plant. There is a significant correlation between thousand grain weight and yield of wet forage. With the increase in wet forage yield, the thousand grain weight will be added. There is a significant correlation between grain yield and wet forage yield. Hence, it can be concluded that, increasing the amount of irrigation has a positive impact on overall all growth and performance of cumin.

4. Discussion

Cumin (*Cuminum cyminum*) is investigated via split-plot test, with complete randomized block design, that has been conducted for four-times, in the city of Khash in the year 2013-2014. The treatments includes foremost factor of stress in three-different levels of controls vis; umbelet stage, grain filling and the sub factor of salicylic acid in four-levels. In this experiment, the characteristics measured includes, plant height, number of seeds per umbel, number of umbels per plant, grain yield, grain weight, grain yield per plot, wet forage yield and dry forage yield. In this study, results showed that different levels of stress and foliar application of salicylic acid have a significant impact on the above features. The interaction between stress and salicylic acid foliar application was significant, only on grain yield and wet forage yield. The highest yield of grain, wet forage and dry forage is related to the control treatment. Whereas, 1.5 mm salicylic acid, has the highest yield of grain viz; wet forage and dry forage.

5. Conclusion

The objective of this study was to investigate the repercussions of water shortage and foliar application of salicylic acid on quantitative and qualitative performance of cumin herb and the outcome is as follows.

- Drought affects major traits, such as plant height, number of umbel per plant, number of seeds per umbel, thousand grain weights, seed yield, wet forage yield and dry forage yield. It definitely has a negative impact on these attributes.
- In this experiment, the highest thousand grain weight, seed yield, wet forage yield and dry forage yield are associated with control treatment.
- The foliar application of salicylic acid affects the majority of qualities, such as plant height, number of umbel per plant, number of seeds per umbel, thousand grains weight, seed yield, wet forage yield and dry forage yield. It surely, resulted as a positive impact on these attributes.
- In this experiment, the highest thousand grain weight and seed yield are related to 1.5 mm salicylic acid treatment, the highest wet forage yield and dry forage yield is related to 0.7 mm salicylic acid treatment.

6. Suggestions

According to the test results it can be suggested:

- Appropriate selection of time is the key factor - for irrigation and salicylic acid, irrigation and foliar application, time should be fixed in such a way, that the plant can make an optimum and maximum possible utilization of environmental factors and equally along with this, stress must also be minimized, up tosuch a level, in order to have least negative impact, on the performance.
- Applying appropriate and well-organized management system, which will prevent the harmful effects of drought. The favorable effects of this stress should be used- taking into account, the water and climatic conditions of the country. According to the test results, to achieve the finest performance, irrigation without stress and salicylic acid foliar application at 1.5 mm is necessary to be conducted, on regular basis.

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