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Original article

The Effect of elicitors on some physiological vharacteristics, essential oil percentage and yield in hyssop (*Hyssopus officinalis* L.) under different irrigation regimes

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Extended abstract

Introduction

Drought stress is the most important environmental factor limiting the growth and development of plants worldwide, so drought effect is much more than other environmental stresses. The results of various studies show that drought stress will significantly reduce dry matter production of plant and some other agronomic traits such as yield and yield components. Elicitors are compounds of biological or non-biological origin that cause biosynthesis and accumulation of secondary metabolites through induction of the Defense system. One of the newest of these compounds that can reduce the effects of drought stress is chitosan, it is a non-toxic polymer, it is degradable in nature and environmentally friendly. Salicylic acid is a natural hormone-like compound that regulates endogenous plant growth as a messenger molecule, it regulates numerous physiological processes in plants such as growth, photosynthesis, and some metabolic processes. Use of salicylic acid under drought stress enhances some physiological processes that can increase plant resistance to drought stress. The aim of this study was to evaluate the effect of using elicitors under drought stress on some physiological characteristics and yield of hyssop essential oil.

Materials and methods

The study was conducted at the research farm of the Faculty of Agriculture and Natural Resources, Gonbad Kavous University, with 55° 12′ longitude and 37° 16′ north latitudes and 45 m altitude from sea in winter and spring in the crop year 2018-2017. Gonbad-Kavus climate is classified as warm and semi-arid by Mediterranean climate and has an average annual rainfall of 450 mm. The experiment was conducted as a factorial experiment in a randomized complete block design with three replications. The factors studied in this irrigation were three levels including 7-day irrigation (I1), 14-day irrigation (I2) and 21-day irrigation (I3) as main factors and four levels of spraying including no use of elicitors (control treatment). Spraying solution with pure water), spraying solution of salicylic acid (300 mg/L), chitosan spraying solution (5 g/L) and combination of salicylic acid and chitosan were considered as sub-agents. After application of spraying treatments, to evaluate the effect of elicitors on relative leaf water content, saturation water deficiency, antioxidant enzyme activity, yield and essential oil yield samples were transferred to the laboratory.

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Results and discussion

The results showed that the lowest relative humidity (48.39%) and the highest saturated water deficit (51.60%) were related to severe stress conditions (21 days' irrigation) without using elicitors that Salicylic acid increased 30.54% relative water content of plant leaves and 28.64% reduced saturated water deficit compared to non-consumed treatments. Concerning antioxidant enzymes, the results showed that the highest amount of catalase activity was related to treatment with salicylic acid and chitosan under 14-day irrigation, which resulted in a 20% increase in this enzyme. Also, the combination of two substances increased the activity of ascorbate peroxidase in control and mild (14 days) stress. Yield and essential oil percentage were not affected by interaction, but it was observed that the simple effect of spray increased this rate in this plant. Due to dry climatic conditions in the country and lack of rainfall with poor irrigation, better performance of this medicinal plant can be achieved and water loss can be prevented.

Conclusion

Environmental stresses are the most important factors in decreasing crop yield worldwide. Spray of salicylic acid and chitosan reduced the adverse effects of drought stress on plant and improved antioxidant activity, yield and essential oil content of hyssop.

Keywords**:** Antioxidant enzyme, Catalase, Drought stress, Essential oil percentage, Medicinal plant

Table 1. Physical and chemical characteristics of the soil in experimental site (0-30 cm depth)

EC	pH	Soil texture	Silt	Sand	Clay	Available phosphorus	Total nitrogen	Organic carbon	Self-neutralizing material
ds/m			----------%----------			ppm	----------%----------		
0.96	7.6	Silt-Loam	56	13	31	13	0.08	0.78	10.8

Table 2. Analysis of variance of physiological and biochemical traits of hyssop

S.O.V	df	essential oil yield	Essential oil percentage	WSD	RWC
Replication	2	28.00	0.01	52.60	52.60
Irrigation (I)	2	127.40*	0.03**	265.5**	265.5**
Main error	4	15.03	0.0004	14.08	14.08
Foliar solution (F)	3	72.29**	0.02**	137.67**	137.67**
F × I	6	1.42^{ns}	0.001^{ns}	54.68**	54.68**
Sub Error	12	1.66	0.0007	7.27	7.27
C.V%	-	*6.38*	*4.41*	*7.09*	*4.35*

Table 2. Continued

S.O.V	df	APX	POX	CAT
Replication	2	79.57	0.81	7.38
Irrigation (I)	2	7871.6**	2896.7**	1572.4**
Main error	4	53.2	11.01	4.59
Foliar solution (F)	3	1194.1**	303.6**	168.4**
F × I	6	144.3**	26.58**	26.05**
Sub Error	12	5.9	3.01	2.65
C.V%	-	6.5	7.26	7.37

**, * and ^{ns} indicate significance at the level of probability of one percent, five percent and non-significance, respectively.

Table 3. Comparison of mean simple effects of different levels of irrigation on studied traits (Similar letters indicate no significant difference)

Irrigation	essential oil yield	Essential oil percentage
	kg/ha	%
Control	23.21[a]	0.55[b]
Mild drought	20.70[a]	0.63[a]
Severe drought	16.75[a]	0.64[a]

In each columns, similar letters indicate no significant difference

Table 4. Comparison of mean simple effects of foliar application on studied traits (Similar letters indicate no significant difference)

Foliar solution	essential oil yield	Essential oil percentage
	kg/ha	%
Control	16.63[c]	0.55[b]
Salicylic acid	19.33[b]	0.59[b]
Chitosan	22.08[a]	0.66[a]
Salicylic acid+chitosan	22.85[a]	0.64[a]

In each columns, similar letters indicate no significant difference

Table 5. Means comparison of Interactive effects of irrigation and foliar spraying on evaluated traits of hyssop

Irrigation	Foliar solution	APX	CAT	peroxidase	WSD	RWC
		----------µmol/mlg pr----------			----------%----------	
control	**H1**	3.59[c]	6.71[c]	3.05[b]	34.49[a]	65.50[b]
	H2	7.23[b]	10.55[a]	4.82[b]	25.78[b]	74.22[a]
	H3	9.17[b]	8.64[b]	6.13[b]	33.27[a]	66.72[b]
	H4	15.99[a]	11.62[a]	9.68[a]	38.19[a]	61.80[b]
LSD		*3.24*	*1.71*	*3.48*	*6.07*	*6.07*
Mild drought	**H1**	37.43[d]	21.59[c]	23.76[c]	42.04[a]	57.95[b]
	H2	51.77[c]	33.85[b]	29.71[bc]	37.23[b]	62.76[a]
	H3	64.27[b]	31.44[b]	35.61[ab]	39.84[a]	60.15[b]
	H4	81.57[a]	39.38[a]	43.58[a]	36.41[b]	63.58[a]
LSD		*7.22*	*4.98*	*8.49*	*2.51*	*2.51*
Severe drought	**H1**	31.35[c]	20.49[b]	26.48[b]	51.60[a]	48.39[b]
	H2	40.79[bc]	24.83[ab]	28.18[b]	36.82[b]	63.17[a]
	H3	49.05[ab]	27.10[a]	35.36[a]	43.44[ab]	56.55[ab]
	H4	56.31[a]	29.07[a]	39.92[a]	37.00[b]	62.99[a]
LSD		*10.27*	*6.27*	*6.56*	*12.44*	*12.44*

In each columns, similar letters indicate no significant difference