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The effect of salicylic acid different levels on two *Coriandrum sativum* varieties under deficit irrigation condition

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ABSTRACT

This greenhouse research was conducted in the fall of 2012 in a controlled greenhouse Karaj, Iran, to evaluate the effect of various concentrations of salicylic acid foliar spray on different traits of two coriandrum sativum varieties under drought stress. Salicylic acid was applied in two stages and four concentrations (0, 4000, 8000 and 12000μM.l). Two varieties (Tehran & Hamedan) and irrigation levels (daily and once every three days) were studied. The experiment was conducted in the factorial form with 3 factors in the randomized complete design with 16 treatments and 3 replications. Each experimental unit was a planting tray with 72 places. Cultivation was done in special trays and planting trays irrigation were done equally until plants germination. Water stress treatment was applied one week after germination. Different levels of salicylic acid foliar were applied 10 days after stress beginning. There were no significant difference between all traits in two coriandrum sativum varieties. Although the concentrations of salicylic acid did not make significant effect on plant height, plant fresh weight, dry matter percent and lateral branches number, but concentration of 12000μM.l showed significant increase in the plant dry weight compared to the control and other concentrations with 58.79mg. Concentrations of 8000μM.l and especially 12000μM.l caused significant increase in chlorophyll index and decrease in plant proline. The highest essential oil percent observed in concentration of 4000μM.l with 0.147%. In short, salicylic acid improved the traits and reduced the negative effect of drought stress.

Keywords: *coriandrum sativum*, salicylic acid foliar, drought, growth traits, essential oil.

INTRODUCTION

Coriandrum sativum belongs to Umbelifera family. This plant is native to South West of Asia and North of Africa. Its height reaches up to half a meter. The plant are used to reduce anxiety and insomnia. The diuretic effect of *coriandrum sativum* in humans, makes reduce in blood pressure, kidney and bladder stones excretion and eliminate water accumulation in the tissues [8].

Drought stress occurs in the plant when plant's water intake is less than the loss. This is possible due to excessive water loss, absorption reduction or both of them [3]. Turgor reduction is one of the water deficit signs, therefore cells growth and development are especial in stem and leaves. So the first noticeable effects of water deficit can be detected in smaller leaves or plant height. Following the leaf area reduction, light absorption decreased and made reduction in total capacity of photosynthesis and growth. finally its performance decreased [2].

Considering the secondary metabolites defensive roles have been accepted for everyone but still investigation the effect of environmental stresses mechanisms on these metabolites put the complex picture in front of us. A lot of evidences suggest that some of these compounds increase several times under stress condition. But there are many reasons that showe their effect is not permanent. In many cases, secondary metabolites reduction can be seen in stress condition [9]. Lack of any resources that limit growth more than photosynthesis, increases secondary metabolites production [4]. In the other hand, effect of drough stress on all of this compounds is not the same.

Therefore the quality of secondary metabolites affected by stress and also stress effect on total biomass is generally negetive [9]. Some factors affected plant drought resistance such as occurrence time and duration of stress, frequency of drought occurrence, intrinsic properties of the soil, rainfall flucations and variations. This indicates drought resistant genotypes respond are different from year to year [12].

According to results on *Nigella sativa* [1], seed yield, plant height and yield decreased with prolongation of watering intervals.

Salicylic acid or ortho-hydroxy benzoic acid belongs to phenolic compounds group witch is derived from the name of salin [11]. Salicylic acid is a plant hormone that plays important roles in some plant physiological activities such as breath control, stomates closing, seed germination, fruit ripening, glycolysis and flowering [10]. Also this substance is one of the important signaling molecules that makes plants reaction against environmental stress and like a non-enzymatic antioxidant plays an important role in regulation physiological processes [13].

Salicylic acid plays a role in plant defense responses to abiotic stresses such as drought, cold and heat [17]. Action mechanism of salicylic acid against stress returns to its role in antioxidant enzymes regulation and compounds containing active oxygen species in plant [18, 16].

Salicylic acid application increases putrescine polyamines, spermidine and spermine in the plant which can be help membrane keeping and integrity in drought stress [14]. Mardani-Marjaneh and Goldani.investigated the effect of salicylic acid different levels (0, 100 and 200 millimolar) on reduction level of deficit irrigation stress (25,50 and 100% of field capacity) of *Calendula officinalis* in Mashhad, Iran [5]. Results indicated that 100millimolar treatment reduced the effect of 50%FC treatment so that made significant increase in leaf area, flowers number per plant, dry weight and number of seeds per plant. It seems that salicylic acid made more stress tolerant and significantly improve the measured traits with increasing antioxidants production in stress time.

In the plant under stress, external application of salicylic acid make increase in proline production [7]. On the other hand, make deterrence in the ethylene synthesis [15]. This substance plays a key role in defensive resistance and is able to increase the production capacity of plant antioxidant [6].

According to the nutritional and medicinal value of *coriandrum sativum*, Evaluation the effect of drought stress with salicylic acid foliar application was performed to find the best treatment for increasing yield and essential oil of the plant, And select the best variety between Tehran and Hamedan varieties for cultivation.

MATERIALS AND METHODS

The experiment was conducted in a private greenhouse, Karaj, Iran in 2012. The greenhouse was glass with central heating system. Its average temperature, relative humidity and light intensity was 20℃, 75% and 10000lux, respectively.

The experiment was conducted in the factorial form with 3 factors in the randomized complete design with 16 treatments and 3 replications. Factor A was salicylic acid concentration included four levels: 0µM.l (a_1), 4000µM.l (a_2), 8000µM.l (a_3) and 12000µM.l (a_4). Factor B included two *coriandrum* varieties: Hamedan (b_1) and Tehran varieties (b_2). Two watering intervals, daily watering (c_1) and once every three days watering (c_2) were factor C.

Coriandrum seeds prepared from Hamedan Research Center of Agriculture and Natural Resources. Seed planting started with planting plans in trays with 72 places in late October (28 October 2012). After a week, seeds germinated completely. Seedlings watered twice a day. Irrigation treatments started when their height reached up to 15cm (15 days after planting). Some of the trays were irrigated per day and some of them once every three days. The first foliar was done 10 days after beginning of irrigation treatment. The second foliar was repeated after a week.

Some traits were measured such as plant height, plant fresh weight, plant dry weight, number of lateral branches per plant, chlorophyll index, root length, amount of leaf proline and plant essential oil percent. Data analysis and comparison of means were performed by the Duncan's multiple range test at the level of 5%, And evaluation of the correlation between traits was done with SAS software.

RESULTS

Analysis of variance indicated (Table 1) that drought stress significantly affected plant fresh weight, root length, leaf proline, chlorophyll index and plant essential oil percent ($\alpha \leq 0.01$) and also plant dry matter percent ($\alpha \leq 0.05$). The

effect of variety were different for plant essential oil percent (α≤0.01) and for plant fresh weight, root length and leaf proline (α≤0.05). Salicylic acid significantly affected root length (α≤0.05) and plant dry weight, leaf proline, chlorophyll index and plant essential oil percent (α≤0.01). The interaction effect of drought and variety were not different for none of the traits. The interaction effect of drought and salicylic acid were different for plant fresh weight and leaf proline (α≤0.01) and for plant height, plant dry matter percent and lateral branches number per plant (α≤0.05). Variety and salicylic acid concentration significantly affected plant dry matter percent (α≤0.01) and plant fresh weight (α≤0.05). The interaction effect of three factors: drought, variety and salicylic acid was different only for chlorophyll index (α≤0.05).

Table 1. Analysis of variance of the effect of the treatments on the measured traits

SOV	df	Mean Squares (MS)								
		Plant height	Plant fresh weight	Plant dry weight	dry matter percent	Root length	lateral branches number	leaf proline	chlorophyll index	Plant essential oil percent
Deficit watering stress (A)	1	1.88ns	132090.08**	108.00ns	223.38*	12.38**	0.046ns	54.18**	310.08**	54.40**
Coriandrum varieties (B)	1	2.66ns	18486.75*	133.33ns	0.06ns	3.04*	0.016ns	3.52*	0.00ns	14.41**
Salicylic acid concentrations (C)	3	3.39ns	7063.47ns	417.00**	72.01ns	1.55*	0.052ns	5.07**	77.80**	1.45**
A×B	1	0.38ns	4294.08ns	75.00ns	0.22ns	0.58ns	0.000ns	0.02ns	3.00ns	0.31ns
A×C	3	7.29*	39538.25**	29.88ns	184.55*	0.35ns	0.156*	5.18**	0.80ns	0.39ns
B×C	3	0.03ns	12131.36*	19.22ns	256.79**	0.19ns	0.065ns	1.07ns	1.27ns	0.32ns
ABC	3	1.11ns	3976.58ns	41.55ns	59.12ns	0.11ns	0.047ns	o.24ns	4.83*	0.43ns
Error	32	2.02	4542.31	62.77	43.33	0.55	0.062	0.87	2.08	0.20
CV(%)	-	9.87	13.04	11.08	15.84	19.92	8.73	6.79	3.47	3.19

*ns, non significant; *, significant at P≤0.05; **, significant at P≤0.01.*

Drought comparison results showed (Table 2) that daily watering had the highest plant fresh weight (569.17mg) and chlorophyll index (44.08). The highest plant dry matter percent (20.533), root length (4.24cm), leaf proline (14.83µg.gfw**)** plant essential oil percent (0.153) belonged to once every three days watering.

Table 2. Effect of drought stress levels on measured traits

Deficit watering stress (A)	Plant height (cm)	Plant fresh weight (mg)	Plant dry weight (mg)	dry matter percent	Root length (cm)	lateral branches number	leaf proline (µg.gfw)	chlorophyll index	Plant essential oil percent
Daily watering (a_1)	14.20a	569.17a	70.00a	16.20b	3.23b	2.88a	12.70b	44.08a	0.13b
Once every three days watering (a_2)	14.60a	464.25b	73.00a	20.52a	4.24a	2.82a	14.83a	39.00b	0.15a

Means in a column followed by the same letter are not significantly different at P≤0.01

Between studied varieties, Hamedan variety had the highest plant fresh weight (536.33mg) and root length (3.99cm). The highest leaf proline (14.04µg.gfw) and plant essential oil percent (0.148) observed in Tehran variety (Table 3).

Table 3. Effect of *coriandrum* varieties on measured traits

Coriandrum varieties (B)	Plant height (cm)	Plant fresh weight (mg)	Plant dry weight (mg)	dry matter percent	Root length (cm)	lateral branches number	leaf proline (µg.gfw)	chlorophyll index	Plant essential oil percent
Hamedan variety (b_1)	14.17a	536.33a	69.83a	18.48a	3.99a	2.87a	13.50b	41.54a	0.13b
Tehran variety (b_2)	14.64a	497.08b	73.17a	18.25a	3.49b	2.83a	14.04a	41.54a	0.14a

Means in a column followed by the same letter are not significantly different at P≤0.01

Comparison results of salicylic acid concentration indicated (Table 4) that the highest plant dry weight (79.58mg), root length (4.22cm) and chlorophyll index (44.33) belonged to 12000µm.l of salicylic acid application. The highest leaf proline (14.33µ g.gfw) observed in both of 0 and 4000µm.l of salicylic acid application treatment. The highest plant essential oil percent observed in 4000µm.l of salicylic acid application.

Table 4. Effect of salicylic acid concentrations on measured traits

Salicylic acid concentrations (C)	Plant height (cm)	Plant fresh weight (mg)	Plant dry weight (mg)	dry matter percent	Root length (cm)	lateral branches number per plant	leaf proline (µg.gfw)	chlorophyll index	Plant essential oil percent
0µm.l (c_1)	13.80a	510.42a	65.75b	17.45a	3.38b	2.91a	14.33a	38.42d	0.141bc
4000µm.l (c_2)	14.16a	522.58a	69.08b	15.32a	3.77ab	2.83a	14.33a	40.75c	0.147a
8000µm.l (c_3)	14.67a	487.83a	71.58b	20.24a	3.57ab	2.90a	13.25b	42.67b	0.139c
12000µm.l (c_4)	15.00a	546.00a	79.58a	20.45a	4.22a	2.76a	13.17b	44.33a	0.144ab

Means in a column followed by the same letter are not significantly different at P≤0.01

DISCUSSION

Results showed that once every three days watering decreased the plant growth and increased proline and essential oil amount. Also increasing salicylic acid concentration, especially 8000 and 12000µm.l had good effect on plant dry weight. In this project, daily and once every three days watering significantly increased plant growth, fresh weight and chlorophyll index. Thus, deficit irrigation significantly reduced cells growth and plant growth. In the once every three days watering treatment, the plant was struggled to water absorption that has been looked for water absorption with root growth. Proline amount increased in the plant under deficit irrigation stress. This mechanism was increased the plant tolerance in stress condition. Previous researches on the relationship of salicylic acid external application with proline increasing were mentioned [7].

According to Salehi-Arjomand results [9], essential oil and mucilage production was increased in drought stress. In the present study, similar results observed and essential oil production increased.

Salicylic acid spray in high concentrations, especially 8000 and 12000µM.l are able to reduce the effect of deficit watering stress and increase plant dry weight, root length, chlorophyll index and plant essential oil percent. Therefore, the present study confirmed salicylic acid positive effect in decreasing stress damage. External application of salicylic acid could increased the amount of internal salicylic acid and act as a defensive response against stress. This acid role as signaling against environmental stresses was reported by Arfan and his colleagues [13] that these effects specifically observed in the current study.

Due to the reduction effect of watering stress in salicylic acid high concentrations, proline amount reduced.

According to Mardani-Marjaneh and Goldani report, salicylic acid foliar up to concentration of 200 mM had positive effect on *Calendula officinalis* in drought stress. The researchers was applied drought stress on the basis of field capacity [5]. So in the experimental condition, we could emphasized efficiency of salicylic acid external spray in reducing the effect of deficit watering stress on *Coriandrum* varieties.

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