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Coriander response to foliar application of salicylic acid and irrigation intervals

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Abstract

Salicylic acid (SA) is known as an antioxidant compound involving in plant tolerance to various biotic and abiotic stresses, thus this trial was conducted to study the effects of SA application and irrigation intervals on yield and yield components of coriander using a split-plot layout in a randomized complete block design with three replications. Two levels of irrigation including irrigation every 4th day & irrigation every 8th day were compared in main plots. Four levels of salicylic acid (SA) including: 0, 0.01, 0.1 and 1 mM of SA were assigned in sub-plots. Results showed that the reduction of irrigation interval from 8 to 4 days statistically improved umbels number per plant, seeds number per plant and seed yield. Application of lower doses of SA increased the number of umbels and seeds per plant and seed yield. Evaluation of interaction effects of irrigation and SA revealed that in optimal conditions of water availability the crop was more responsive to the lowest dose of SA, on the other hand in water deficit conditions the median dose of SA (0.1 mM) was more efficient in improving seed yield, indicating the positive and enhancing role of SA under water deficiency stress conditions.

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Introduction

Agronomic management factors including the regulation of irrigation intervals have a great effect on crop productivity. Plant growth traits and accumulation of active substances in different organs of medicinal plants are greatly affected by water deficit stress (Haripriya *et al.,* 2010; Azhar *et al.,* 2011). Drought stress is known to increase the concentration of secondary products in plants (Zobayed *et al.,* 2007; Selmar, 2008) and excessive irrigation may be resulted in the reduction of active substances content in some medicinal plants, so the increase of essential oil content in plant organs can be occurred through the increase of irrigation intervals (Omidbaigi, 2005). However it has to be taken into consideration that water deficit stress generally confuses the growth of most plants (Selmar, 2008).

Application of growth regulating substances such as salicylic acid (SA) may be useful to plants in stress conditions. SA is known as an antioxidant compound which is involved in prohibition of the activity of reactive oxygen species (Hayat *et al.,* 2010). Salicylic acid as a phenolic growth regulator is involved in different processes in plants such as stomatal conductance, plant water relations, nutrient uptake and mechanisms of plant tolerance to various stresses (Popova *et al.,* 1997; Hayat *et al.,* 2010). It is well known that SA ameliorates the impairments arised from water deficiency in plants (Hussain *et al.,* 2009). Different studies showed that plant growth and productivity have been improved by SA application. Khan *et al.* (2003) reported that SA application enhanced the leaf area and dry weight of corn and soybean plants. Arfan *et al.* (2007) showed that foliar application of SA increased the growth traits and grain yield of wheat in salt stress conditions. Shirani Bidabadi *et al.* (2012) reported that chlorophyll and proline contents of banana shoot tips were significantly increased by the application of SA under drought stress conditions. Dawood *et al.* (2012) in a study reported that all experimental treatments of SA significantly increased seed yield and yield components of sunflower. Bastam *et al.* (2013) revealed that growth rate and physiological traits of leaf chlorophyll content, relative water content and photosynthetic capacity of pistachio seedlings were improved in salt stress conditions.

Coriander (*Coriandrum sativum* L.) is an annual plant from Apiaceae family, used by people worldwide for medicinal, food and spice purposes (Carruba *et al.,* 2006; Msaada *et al.,* 2009). Despite of numerous studies and literatures regarding the reaction of different plants to exogenous application of SA in various conditions, there is limited information about coriander response to SA application in relation with irrigation, therefore this experiment was aimed to study the agronomic response of coriander to the application of different levels of SA and two irrigation intervals in field conditions.

Materials and methods

Field conditions, plant material and experimental design

This experiment was carried out at the research farm of Islamic Azad University, Sanandaj Branch (35° 10′ N, 46° 59′ E; 1393 m above sea level) in Spring 2011. Coriander seeds of cultivar *Lux*, were obtained from Zardband Pharmaceutical Company, Tehran, Iran. Physicochemical properties of farm soil were: sand 24%, silt 33%, clay 43%, pH 7.8, OC 0.68%, EC 0.49 dS m^{-1}, available P and K, 9.31 & 340 ppm respectively. The experiment was arranged in a split-plot layout with randomized complete block design in three replications. Two intervals of irrigation including irrigation every 4th day (I_1) and irrigation every 8th day (I_2) were compared in main plots. Four levels of salicylic acid (SA) including: 0 (distilled water), 0.01, 0.1 and 1 mM of SA were assigned in sub-plots (as S_1, S_2, S_3 and S_4 respectively). Each sub-plot contained 5 sowing rows, 3 m in length with 30 cm space between rows and 5 cm between plants in each row.

Agronomic management

Sowing operation was done by hand on 11 April 2011. All experimental plots were initially well watered to assure seed germination and establishment of the plants. From the stage of flowering to maturity the irrigation treatments were applied in related main plots. Foliar spraying with distilled water (control) and salicylic acid levels was performed twice (63 and 70 days after sowing) in the amount of 2 L per plot.

Data collection

At maturity stage, number of umbels and seeds per plant were determined based on five randomly selected plants from each sub-plot, then by harvesting the plants of central three rows of each sub-plot, the traits of 1000-seed weight, seed yield and harvest index were determined. The harvest index (HI) was calculated as:

HI (%) = (seed yield/biological yield)×100

Data analysis

The analysis of variance operation was performed for all collected data and means of treatments were compared with least significant difference (LSD) test at $P \leq 0.05$. The statistical calculations were performed by MSTAT-C software version 2.10.

Results and discussion

Yield components

The number of umbels and seeds per plant were significantly affected by irrigation interval. The effects of SA application and interaction effects of two factors (irrigation interval×SA) on umbel and seed number per plant were also statistically significant, whereas 1000-seed weight of coriander was not affected by irrigation, SA and their interaction (Table 1). Means comparison showed that shortening of the irrigation interval from 8 to 4 days statistically increased the number of umbels and seeds per plant (Table 2). These results in regard to harmful effects of water deficiency on yield components are in agreement with the results of Hashem *et al.* (1998) who declared that drought stress significantly reduced the numbers of pods/plant and seeds/pod in *Brassica napus* L. compared to well watered treatment.

Table 1. Analysis of variance of coriander characteristics affected by irrigation interval and salicylic acid application.

Source of variation	df	Mean squares				
		No. of umbels/plant	No. of seeds/plant	1000-seed weight	Seed yield	HI
Replication	2	0.062^{ns}	49.762^{ns}	3.014^{ns}	100438.721*	0.002^{ns}
Irrigation interval (I)	1	21.282*	6660.003*	0.179^{ns}	252448.761**	0.038**
E_a	2	0.927	184.532	0.183	1128.186	0.001
Salicylic acid (SA)	3	10.388*	22061.923**	1.211^{ns}	436682.823**	0.023**
I×SA	3	25.184**	12200.141**	0.421^{ns}	275250.002*	0.007**
E_b	12	2.439	92.876	0.953	66968.270	0.001
CV (%)		12.55	4.00	14.28	24.21	5.31

ns, * and **: Non significant and significant at 5 and 1% levels of probability, respectively.

Foliar application of SA increased the number of umbels per plant so that a significant increase was recorded in S_3 treatment (0.1 mM SA) compared with control. Foliar spraying of the plant by all doses of SA significantly increased the number of seeds per plant compared with control treatment (0 mM SA) in addition to the highest number of seeds per plant (325 seeds/plant) was obtained by applying the minimum rate (0.01 mM) of salicylic acid (Table 2). In an experiment conducted by Khan *et al.* (2010) the effect of different concentrations of SA on mungbean plants was studied and they similarly showed that the application of a higher dose of SA had no beneficial effect on yield components of mungbean.

Seed yield and harvest index

Ghanging the irrigation interval resulted in significant alterations in seed yield and harvest index of coriander. Shortening the irrigation interval from 8 to 4 days resulted in a significant increase in seed yield, but the harvest index was statistically decreased (Table 2). Koocheki *et al.* (2007) similarly reported that seed yield of *Plantago psyllium* was negatively affected by increasing intervals of irrigation. Increasing of harvest index with extending interval of irrigation in our results may be attributed to leaf abscission under water deficiency conditions which can be led to weight loss in plant shoot and decreasing of biological yield.

Table 2. Main effects of irrigation interval and salicylic acid on coriander characteristics.

Treatments	No. of umbels/plant	No. of seeds/plant	1000-seed weight (g)	Seed yield (kg/ha)	HI (%)
Irrigation interval					
4 days	13.4 a	257.8 a	6.9 a	1171.6 a	44.6 b
8 days	11.5 b	224.5 b	6.7 a	966.5 b	52.6 a
SA levels					
0 mM	10.8 b	180.7 c	6.9 a	797.4 b	48.1 b
0.01 mM	12.3 ab	325.3 a	7.0 a	1440.5 a	57.5 a
0.1 mM	14.0 a	226.9 b	6.2 a	1047.2 b	43.5 c
1 mM	12.7 ab	231.5 b	7.2 a	991.2 b	45.4 bc

Different letters in a group of each column indicate significant differences at $P \leq 0.05$ according to LSD test.

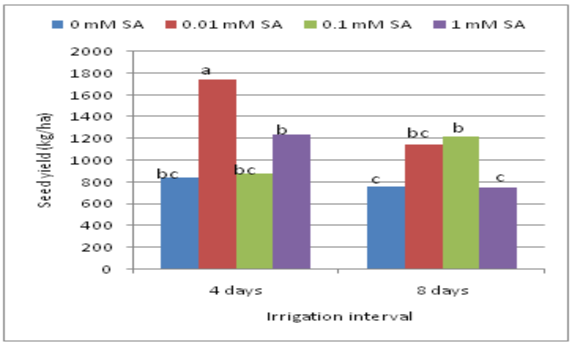

Fig. 1. Interaction effect of irrigation interval and salicylic acid on seed yield. Mean values with the same letter are not significantly different at $P \leq 0.05$ according to LSD test.

Salicylic acid application significantly affected seed yield per unit area and harvest index. The greatest amount of seed yield and the highest rate of harvest index were recorded by application of the minimum level of SA (0.01 mM) (Table 2) indicating the positive response of coriander to the lowest dose of SA. This result conforms with the findings of Elwan and el-Hamahmy (2009) who reported that SA application at low concentration positively improved the growth attributes and fruit yield of pepper (*Capsicum annuum* L.). In another experiment Amin *et al.* (2008) studied the response of wheat plants to foliar application of salicylic acid and ascorbic acid in different concentrations. They showed that the growth and yield parameters of wheat were enhanced by applying lower doses of salicylic acid, whereas a reverse and inhibitory effect was shown by using the high concentration of salicylic acid.

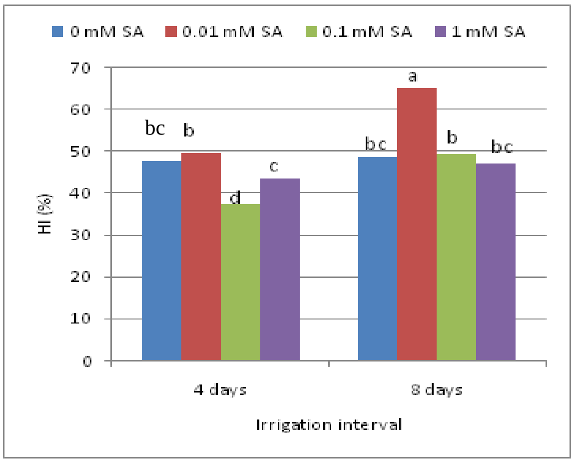

Fig. 2. Interaction effect of irrigation interval and salicylic acid on harvest index (HI). Mean values with the same letter are not significantly different at $P \leq 0.05$ according to LSD test.

The interaction effect of irrigation interval×SA on seed yield showed that with 4 days interval of irrigation, the greatest amount of seed yield was recorded at the level of 0.01 mM SA, whereas with extended interval of irrigation (8 days), the greatest amount of seed yield was produced at 0.1 mM treatment of SA (Fig. 1), suggesting that in optimal conditions of water availability the crop may be more responsive to low doses of SA and in water deficit conditions the crop may have the potential of exploiting the median dose of SA (0.1 mM) in improving the yield because of positive and ameliorative role of SA in stress conditions (Fig. 1).

Means comparison of interaction effect between irrigation interval and SA revealed that the highest rate of harvest index was recorded by I_2S_2 treatment (8 days interval with 0.01 mM SA) (Fig. 2), indicating that the enhancing role of low dose of SA in increasing the rate of harvest index may be more pronounced under water deficit conditions compared with optimal conditions of water availability.

Conclusion

Based on the results of this study the reduction of irrigation interval improved umbels and seeds number per plant and seed yield. Application of lower doses of SA increased the number of umbels and seeds per plant and seed yield. Evaluation of interaction effects of irrigation and SA revealed that in optimal conditions of water availability the crop showed more positive response to the lowest dose of SA, on the other hand in water deficit conditions the median dose of SA (0.1 mM) was more efficient in improving seed yield, indicating the positive and enhancing role of SA in suboptimal conditions of water availability.

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