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Effects of salicylic acid levels and irrigation intervals on growth and yield of coriander (*Coriandrum sativum*) in field conditions

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Abstract

Salicylic acid (SA) is known as a signaling molecule that is involved in plant resistance and tolerance to biotic and abiotic stresses. This study was carried out to evaluate the effects of salicylic acid application and irrigation intervals on growth and yield of coriander using a split-plot layout in a randomised complete block design with three replications. Two levels of irrigation including irrigation every 4th day (a1) and irrigation every 8th day (a2) were compared in main plots. Four levels of salicylic (SA) were assigned in sub-plots at 0 (distilled water), 0.01, 0.1 and 1 mM SA (as b1, b2, b3 and b4, respectively). Results showed that the reduction of irrigation interval from 8 to 4 days statistically improved plant height, seed yield and plant biomass. Application of SA significantly affected seed yield and plant biomass. The highest rate of seed yield was obtained at 0.01 mM SA and the other levels of SA were placed in a class. The interaction effect of SA × irrigation on seed yield was significant. The greatest amount of seed yield was produced by a1b2 treatment (every four days irrigation with 0.01 mM application of SA).

Key words: coriander, *Coriandrum sativum*, irrigation, salicylic acid, yield.
Abbreviations: LSD, least significant difference; SA, salicylic acid.

Introduction

Salicylic acid (SA) is a plant growth regulator known as an endogenous signaling molecule, which is involved in various physiological processes in plants, such as growth regulation, photosynthesis, stomatal conductance, nutrient uptake, plant water relations and mechanisms of plant resistance and tolerance to biotic and abiotic stresses (Popova et al. 1997; Hayat et al. 2010). Several studies have demonstrated that exogenous SA application enhances plant growth and development. Fariduddin et al. (2003) showed that mustard plants sprayed with low concentrations of SA produced larger amounts of dry matter and had higher photosynthetic rate in comparison with control plants. SA application to corn and soybean promoted leaf area and dry weight of plants (Khan et al. 2003). In another study Hussein et al. (2007) revealed that growth traits of wheat plants were improved as a result of SA spraying on the plants. In addition, Hayat et al. (2005) reported that soaking of wheat grains in low concentrations of SA significantly promoted growth of wheat seedlings.

Agronomic management factors such as irrigation play important roles in achieving the maximum potential of productivity in crop plants. Drought stress can affect the growth and development of medicinal plants and the accumulation of active substances in their organs (Haripriya et al. 2010; Azhar 2011). While moderate drought stress is known to raise the concentration of secondary metabolites in plants (Zobayed et al. 2007; Selmar 2008), it has to be taken into consideration that drought stress also reduces the growth of most plants (Selmar 2008). Furthermore, the reduction of active substance content in some medicinal plants may occur as a result of excessive irrigation, and reducing the amount of irrigation water can result in an increase of essential oil content in plant organs (Omidbaigi 2005).

Coriander (*Coriandrum sativum*) is an annual crop from the Apiaceae family. Its fruit and vegetative organs contain essential oil and is cultivated worldwide for medicinal and food purposes (Carruba et al. 2006; Msaada et al. 2009). Despite of studies regarding the response of different plants to exogenous application of SA in various conditions of water availability, there is no information available about coriander response to SA application in relation with irrigation. The study aim was to determine the growth and yield of coriander in relation to application of different levels of SA and two irrigation intervals in field conditions.

Materials and methods

In order to evaluate the effects of salicylic acid application and irrigation intervals on growth and yield of coriander (*Coriandrum sativum* L.) this trial was carried out at the experimental farm of agriculture faculty, Islamic Azad University, Sanandaj Branch (35°10'N, 46°59E; 1393 m above sea level) in spring 2011. Some of the soil physicochemical characteristics were: sand 24%, silt 33%, clay 43%, pH 7.8, organic carbon 0.68%, electrical conductivity 0.49 dS m^{-1}, and available P and K 9.3 and 340 mg L^{-1}, respectively.

The seeds of coriander cv. Lux were obtained from Zardband Pharmaceutical Company, Tehran, Iran. The experiment was laid out in a split-plot arrangement with randomised complete block design and three replications. Two intervals of irrigation including irrigation every 4^{th} day (a1) and irrigation every 8^{th} day (a2) were compared in main plots. Four levels of SA were assigned in sub-plots at 0 (distilled water), 0.01, 0.1 and 1 mM SA (as b1, b2, b3 and b4, respectively). Each sub-plot contained five sowing rows 3 m in length. Inter- and intra-row spacings were 30 and 5 cm respectively.

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

At physiological maturity (96 days after sowing), plant height and number of branches per plant were determined based on five randomly selected plants from each sub-plot. At harvest maturity (103 days after sowing) seed yield and plant biomass (biological yield) were determined by harvesting the central three rows of each sub-plot.

All collected data were subjected to analysis of variance operations and means of treatments were compared with the least significant difference (LSD) test at $P \leq 0.05$. The statistical calculations were performed with MSTAT-C software version 2.10.

Results

When coriander plants were subjected to different irrigation regimes in field conditions, plant height was significantly affected by irrigation interval. Extending of the irrigation interval from 4 to 8 days statistically decreased plant height (Table 1), whereas SA application and interaction effect of irrigation interval × SA on plant height were not significant. The number of branches per plant was not affected by irrigation interval, SA application and their interaction (Tables 1 and 2).

The effects of irrigation and SA application on seed yield and plant biomass were significant. Seed yield and plant biomass produced by 4 days interval of irrigation were greater than that with 8 days interval of irrigation, and application of 0.01 mM SA resulted in the highest rates of seed and biological yields compared with other levels of SA application (Table 1). Means comparison of interaction effect between two experimental factors showed that the greatest seed and biological yields per area unit (1740.1 and 3496.6 kg ha^{-1} respectively) were recorded at 4 days interval of irrigation with 0.01 mM application of SA (Table 2).

Discussion

Significant reduction in growth and yield of coriander at 8-day interval of irrigation when compared to that at 4-day interval well demonstrated the susceptibility of this plant to soil water deficiency, which was in agreement with the results of Gabler (2002) on drought stress effect on yield and agronomic traits of coriander. In spite of non-significant effects of SA application on plant height and its branching trait, application of the lowest level of SA (0.01 mM) led to significant elevation by about 81% of seed yield, compared with control plants (Table 1). However, with increasing SA concentration from 0.01 to 0.1 mM, and up to 1 mM SA the seed yield significantly decreased.

The biological yield differed among SA treatments similarly to seed yield, with a highest biomass production at SA 0.01 mM. However, the differences in biomass yield between SA 0.01 to 1 mM treatments were not statistically significant. These results suggested positive response of the

Table 1. Main effects of irrigation interval and salicylic acid on plant height, number of branches per plant, seed yield and plant biomass. Data are means from three replications. Means followed by same letters in a group of a column are not significantly different at $P \leq 0.05$ according to LSD test

Treatment	Value	Plant height (cm)	Number of branches	Seed yield (kg ha^{-1})	Plant biomass (kg ha^{-1})
Irrigation interval	4 days	44.4 a	5.9 a	1171.6 a	2601.0 a
	8 days	41.4 b	5.9 a	966.5 b	1948.7 b
Salicylic acid (mM)	0	41.2 a	5.7 a	797.4 b	1659.6 b
	0.01	43.2 a	6.0 a	1440.5 a	2839.7 a
	0.1	44.9 a	6.0 a	1047.2 b	2355.5 ab
	1	42.2 a	5.7 a	991.2 b	2244.6 ab

Table 2. Interaction effect of irrigation interval × salicylic acid on plant height, number of branches per plant, seed yield and plant biomass. Data are means from three replications. Means in each column followed by same letters are not significantly different at $P \leq 0.05$ according to LSD test

Irrigation interval	Salicylic acid (mM)	Plant height (cm)	Number of branches	Seed yield (kg ha^{-1})	Plant biomass (kg ha^{-1})
4 days	0	43.0 ab	5.9 a	841.4 bc	1769.9 c
	0.01	44.9 ab	6.1 a	1740.1 a	3496.6 a
	0.1	47.3 a	5.8 a	873.4 bc	2244.6 bc
	1	42.2 ab	5.8 a	1231.6 b	2893.0 ab
8 days	0	39.3 b	5.6 a	753.4 c	1549.4 c
	0.01	41.5 ab	5.9 a	1140.9 bc	2182.8 bc
	0.1	42.6 ab	6.1 a	1221.0 b	2466.3 abc
	1	42.2 ab	5.7 a	750.7 c	1596.1 c

plant to 0.01 mM concentration of SA. Similarly, Elwan and el-Hamahmy (2009) reported that SA application at low concentration positively improved the growth and quality traits of pepper (*Capsicum annuum*) in greenhouse conditions. In another experiment by Gharib (2007) the effect of different levels of SA (0, 0.01, 0.1 and 1 mM) on sweet basil (*Ocimum basilicum*) and marjoram (*Majorana hortensis*) plants was studied.

Results of this experiment indicated that exogenous application of SA, especially at 0.1 mM, improved growth traits of both species. Amin et al. (2008) studied the response of wheat plants to foliar application of salicylic acid and ascorbic acid in concentrations of 1, 2 and 4 mM. They showed that the growth and yield parameters of wheat were enhanced by 1 and 2 mM salicylic acid, whereas a reverse and inhibitory effect was shown at a high concentration (4 mM) of salicylic acid. Khan et al. (2010) found that the application of a higher dose of SA had either provd inhibitory or no additional benefit in mungbean plants.

Growth and yield of coriander was promoted by shortening of the irrigation interval and application of the lowest dose of SA in this experiment. It was shown that growth and yield of this crop can be improved by suitable soil water content and SA application in low concentrations. Moreover, considering interaction effect of the two factors on seed yield and plant biomass, the application of salicylic acid in suboptimal conditions of water availability may improve the growth and productivity of the plant as compared with control plants.

References

Amin A.A., Rashad E.S.M., Gharib F.A.E. 2008. Changes in morphological, physiological and reproductive characters of wheat plants as affected by foliar application with salicylic acid and ascorbic acid. *Aust. J. Basic Appl. Sci.* 2: 252–261.

Azhar N., Hussain B., Ashraf M.Y., Abbasi K.Y. 2011. Water stress mediated changes in growth, physiology and secondary metabolites of Desi Ajwain (*Trachyspermum ammi* L.). *Pak. J. Bot.* 43: 15–19.

Carruba A., la Torre R., Saiano F., Alonzo G. 2006. Effects of sowing time on coriander performance in a semiarid Mediterranean environment. *Crop Sci.* 46: 437–447.

Elwan M.W.M., El-Hamahmy M.A.M. 2009. Improved productivity and quality associated with salicylic acid application in greenhouse pepper. *Sci. Hortic.* 122: 521–526.

Fariduddin Q., Hayat S., Ahmad A. 2003. Salicylic acid influences net photosynthetic rate, carboxylation efficiency, nitrate reductase activity and seed yield in *Brassica juncea*. *Photosynthetica* 41: 281–284.

Gabler J. 2002. Drought stress and nitrogen effects on *Coriandrum sativum* L. *J. Herbs Spices Med. Plants* 44: 12–28.

Gharib F.A.E. 2007. Effect of salicylic acid on the growth, metabolic activities and oil content of basil and marjoram. *Int. J. Agri. Biol.* 9: 294–301.

Haripriya M., Vijaya T., Mouli K.C. 2010. Effect of water stress on growth, metabolic activities of *Withania somnifera* – an important phytoceutical plant: Ameliorative effects of VAM. *J. Glob. Pharma Tech.* 2: 112–116.

Hayat S., Fariduddin Q., Ali B., Ahmad A. 2005. Effect of salicylic acid on growth and enzyme activities of wheat seedlings. *Acta Agron. Hung.* 53: 433–437.

Hayat Q., Hayat S., Irfan M., Ahmad A. 2010. Effect of exogenous salicylic acid under changing environment: A review. *Environ. Exp. Bot.* 68: 14–25.

Hussein M.M., Balbaa L. K., Gaballah M.S. 2007. Salicylic acid and salinity effects on growth of maize plants. *Res. J. Agric. Biol. Sci.* 3: 321–328.

Khan W., Prithviraj B., Smith D.L. 2003. Photosynthetic responses of corn and soybean to foliar application of salicylates. *J. Plant Physiol.* 160: 485–492.

Khan N.A., Syeed S., Masood A., Nazar R., Iqbal N. 2010. Application of salicylic acid increases contents of nutrients and antioxidative metabolism in mungbean and alleviates adverse effects of salinity stress. *Int. J. Plant Biol.* 1: 1–8.

Msaada K., Ben Taarit M., Hosni K., Hammami M., Marzouk B. 2009. Regional and maturational effects on essential oils yields and composition of coriander (*Coriandrum sativum* L.) fruits. Sci. Hortic. 122: 116–124.

Omidbaigi R. 2005. *Production and Processing of Medicinal Plants.* Vol. 1. Behnashr Press, Mashhad, Iran.

Popova L., Pancheva T., Uzunova A. 1997. Salicylic acid: properties, biosynthesis and physiological role. *Bulg. J. Plant Physiol.* 23: 85–93.

Selmar D. 2008. Potential of salt and drought stress to increase pharmaceutical significant secondary compounds in plants.

Landbauforschung 58: 139–144.
Zobayed S.M.A., Afreen F., Kozai T. 2007. Phytochemical and physiological changes in the leaves of St. John's wort plants under a water stress condition. *Environ. Exp. Bot.* 59: 109–116.

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