

DOI: 10.1515/cerce-2016-0034

Available online: www.uaiasi.ro/CERCET\_AGROMOLD/

Print ISSN 0379-5837; Electronic ISSN 2067-1865

Cercetări Agronomice în Moldova

Vol. XLIX , No. 4 (168) / 2016: 35-42

## EFFECT OF FOLIAR APPLICATION WITH SALICYLIC ACID ON SOME MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERISTICS OF SESAME (*SESAMUM INDICUM* L.) UNDER DROUGHT STRESS

A. KHATIBY<sup>1</sup>, F. VAZIN<sup>1</sup>, M. HASSANZADEH<sup>1</sup>, A. AHMADI SHADMEHRI<sup>2\*</sup>

\*E-mail: ahmadi492004@yahoo.com

Received Sept. 11, 2016. Revised: Dec. 14, 2016. Accepted: Dec. 19, 2016. Published online: Feb. 13, 2017

**ABSTRACT.** Drought is an important factor that could restrict plants growth and productivity through several biological and physiological processes. Salicylic acid (SA) has a key role in many physiological processes of plants and stimulate specific responses against various stresses biotic and abiotic, in some of plants. In order to evaluate the effect of foliar application by salicylic acid (SA) under drought stress on some morphological characteristics sesame, a split-plot experiment with a completely random design with three replications was performed. There were three levels of irrigation: control (normal irrigations), water stress at flowering stage and water stress at seed production stage, as main plot and sub plot consisting of four levels of the foliar application of salicylic acid: 0 (control), 1, 1.5 and 2.25 mM. Results indicated that the effects of water stress on traits, such as plant height, height of first capsule from soil surface, number of branches, number of capsules per plant

showed significant difference at a level of 1%, while on the number of seeds per capsule, seed weight, leaf area index, biological yield, grain yield sesame, without significant difference indicated. Foliar application with salicylic acid was not so significant ( $P < 0.05$ ) at different concentrations on measured traits, as well as interactive effects between drought stress and different amounts of salicylic acid, without significant difference observed.

**Keywords:** salicylic acid; water stress ; irrigation; sesame (*Sesamum indicum* L.).

### INTRODUCTION

Environmental stresses, such as drought, salinity low, and high temperatures, cause adverse effects on the growth of plants and production of agricultural systems worldwide. Among these stresses, drought stress

<sup>1</sup> Islamic Azad University, Gonabad Branch, Gonabad, Iran

<sup>2</sup> Young Researchers and Elite Club, Gonabad Branch, Islamic Azad University, Gonabad, Iran

leads to a series of morphological, physiological, biochemical and molecular changes (Harfi, 2016). That is the primary cause of crop loss, reducing average yield for most crop plants (Anjum, 2011). Sesame (*Sesamum indicum* L.) is a member of the *Pedaliaceae* family (Gouveia *et al.*, 2016) and one of the oldest oil seed crops (Pham *et al.*, 2010). Generally, sesame is cultivated in tropical and subtropical area (Olowe, 2007), sesame oil (47-52%) being considered as a rich source of natural antioxidants, such as sesamin and sesamol (Tabatabaei *et al.*, 2011), vitamin E (alpha tocopherol). Therefore, sesame seed has an important role in human health (Bagheri *et al.*, 2013) and also is constituted of abundant fatty acids, such as oleic acid (43%), linoleic acid (35%), palmitic acid (11%) and stearic acid (7%). In addition, sesame oil is one of the most important oilseed crops in the world That is important in the food industry because of its distinct flavor (Athari *et al.*, 2014). Sesame is known as a drought tolerant crop (Poor-Esmaeil *et al.*, 2014), but moisture is required for plant growth and high efficiency (Bagheri *et al.*, 2013). This plant is sensitive to drought stress, therefore can lead to yield loss. The biochemical changes in plants, in response to abiotic stresses, for example drought, is oxidative damage that may lead to an imbalance between antioxidant defenses and reactive oxygen species (ROS) levels (Noreen *et al.*, 2009), induction of

oxidative stress, protein degradation, lipidperoxidation, pigment bleaching and other cellular components (Yazdanpanah *et al.*, 2011). Plant cells, to overcome the negative effects of environmental stresses, have special defense mechanisms that require the cooperation of other enzymatic antioxidants (such as superoxide dismutase, catalase, peroxidase etc.) and non-enzymatic antioxidant components (carotenoids, tocopherols, ascorbate, glutathione, etc.) (Kumar Pate *et al.*, 2011).

According to these reasons (such as reducing of annual rainfall and the termination of underground water resources), foliar application by salicylic acid (SA) is an effective method during the period of plant growth, when it can reduce the harmful effects of drought stress and increase crop yield (Kazemi, 2014).

Salicylic acid (SA) belongs to a group of phenolic compounds, which is widely in plants and is now known as a hormone-like substance (Joseph *et al.*, 2010; Levent Tuna *et al.*, 2007). SA acts as a potential non-enzymatic antioxidant as well as a plant growth regulator (Salarizdah *et al.*, 2012), which play an important role in regulation of plant physiological stages, including photosynthesis (El-Khallal *et al.*, 2009), growth, nitrate metabolism, heat production (Joseph *et al.*, 2010), flowering (Gharib *et al.*, 2007), the effect on the germination of seeds (Hanan, 2007), maturity and response to stress. Salicylic acid significantly affects on the structure

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of the membrane and photosynthesis system (Yazdanpanah *et al.*, 2011).

The main purpose of the production of sesame seed oil not only earning high product quality is better, but also revealing sesame plants treated with different concentrations of SA could tolerant drought stress. Achieving this goal requires the use of specific biochemical methods in an area with high quality and the use of appropriate water management practices. This research was to evaluate the effect of salicylic acid on sesame seed and the traits under drought stress. To achieve this understanding important physiological characteristics of particular importance, after drought stress at different levels of irrigation and spraying with salicylic acid yield sesame seed, such as plant height, height of the first capsule from soil surface, number of branches, number of capsules per plant, number of seeds per capsule and seed weight, biological yield, grain yield have been measured and evaluated.

The aim of the present work was to examine the effects of foliar salicylic acid application (SA) and different irrigation regimes on sesame seed yield, morphological attributes and oil content and to explore the possible SA, induced drought tolerances in this plant.

### MATERIALS AND METHODS

In order to evaluate the effect of treatment with salicylic acid under drought stress on some morphological characteristics sesame, the experiment

was laid out in a split-plot design, based on randomized complete blocks with three replications. The factors are as follows: A) the main plots, drought, including three levels: I 1: control (normal irrigation), I 2: drought stress at seed production stage and I 3: drought stress at flowering stage; B) sub-plots, treatment with salicylic acid by spraying the leaves in different concentrations, including four levels: 0 mM (control), 1 mM, 1.5 mM and 2.25 mM.

The experiment was conducted during the 2012-2013 field season. Prior to sowing seed, the field was fertilized with ammonium phosphate and urea at the rate of 250 and 100 kg/ha, respectively. Additional urea was applied before flowering stages, at a rate of 75 kg/ha.

The soil texture was sandy clay with pH = 7.8. Each experimental unit was a plot of 2×3 m. Sesame seeds was planted at a depth of 2-2.5 cm, using a hand open groove in two rows on the ridges.

Plots were immediately irrigated after planting and then were watered every 8 days. Weeds were controlled by applying herbicides. Deltamethrin was used to eliminate aphids and *Amygdalinus* pests. Plants were harvested after four months.

### Sampling and measurements

#### *Morpho-physiological measurements*

In the laboratory, after recording the morphologic characteristics, including plant height, number of branches, length of pods per plant and 1000-seed weight, determined based on five randomly selected plants from each sub-plot, the plant was placed in an oven at 70°C for 72 hours. After this period, the dried samples were weighted.

Ultimate harvest was conducted at the time of plant maturity. The analysis is based on the determination of the following 17 parameters: leaf area index,

number of capsules per plant, number of seeds per capsule, number of branches, the first capsule from soil surface, grain yield (dry weight, fresh weight), 1000-seed weight, plant height, number of seeds per pod, fresh weight and dry weight per plant, number of leaves, leaf area, that was determined by harvesting the central four rows of each sub-plot.

#### **Statistical analysis**

All collected data were fed to the computer and analyzed using SAS software. Data were described using Duncan's multiple range method and was judged with the least significant difference (LSD) test at  $P \leq 0.05$ , in order to compare the means of each feature.

## **RESULTS**

#### **Analysis of variance**

The results of variance analysis under effect of drought stress and foliar application by salicylic acid (SA) on some sesame related traits are presented in *Table 1*.

Effect of drought stress on plant height, height of first capsule from soil surface, number of branches, number of capsules per plant showed significant difference at a level of 1%, while on the number of seeds per capsule, seed weight, leaf area index, biological yield, grain yield sesame without significant difference indicated. Foliar application by salicylic acid (SA) was not so significant ( $P < 0.05$ ) at different levels of salicylic dozes on measured traits, as well as interactive effects

between drought stress and different amounts of salicylic acid without significant difference observed.

#### **Traits means comparisons**

The results of mean comparison indicated that effect of drought stress had significant effects at a level of 1% on some related traits. Drought stress at flowering stage was greater than drought stress at seed production stage and control (normal irrigation) for all traits, except biological function.

The effect of salicylic acid dozes did not show significant on measured traits. Between different SA dozes, least concentration of salicylic acid (1 mM) were greater for most of measured traits including plant height, number of branches, the number of capsules per plant, number of seeds per capsule, 1000-seed weight in both environments drought stress and non-drought stress, in compared with control treatment, while the maximum height first capsule from soil surface and biological function were related the control treatment.

The variance analysis results showed that the interaction between irrigation treatment (drought stress) and foliar application with salicylic acid was no significant difference between the studied traits. The highest level was related to the drought stress at flowering stage and foliar of least concentration of salicylic acid (1 mM).

Table 1 - Analysis of variance (mean squares) of some morphological characteristics, physiological and sesame seed yield under drought stress and foliar application

SC	DF	Mean of square									
		PH (cm)	NCP	NSC	HFCSS (cm)	TSW (g)	LAI	NB	BY	SY (kg/ha)	
Replicat	2	20.08 ns	1082.52 ns	0.44 ns	20.43 ns	0.36 ns	25.16 ns	0.52 ns	2768.54 ns	27910.09 ns	
Stress (A)	2	653.25 ***	3794.19 **	38.11 ns	19.27 **	7.52 ns	163.25 ns	16.02 **	80.65 ns	27149.61 ns	
Main factor error	4	787.33 ns	5727.69 ns	72.94 ns	67.70 ns	2.77 ns	47.80 ns	15.44 ns	271.54 ns	4911.7 ns	
Salicylic acid (B)	3	33.18 ns	1633.58 ns	45.07 ns	5.62 ns	3.88 ns	50.03 ns	3.48 ns	23.04 ns	0.012 ns	
A × B	6	8.65 ns	32.08 ns	17.51 ns	0.26 ns	1.08 ns	62.10 ns	0.17 ns	138.60 ns	1539.61 ns	
Total error	18	14.69	538.86	43.25	0.07	3.26	68.06	1.69	366.58	50531.2	

\*, \*\* significantly at the 5% and 1% levels of probability, respectively, and ns (non significant)

DF = degrees of freedom; SC = sources of changes, PH = plant height; HFCSS = height of first capsule from soil surface; NCP = number of capsules per plant; NSC = number of seeds per capsule; TSW = thousand seed weight (g); LAI = leaf area index; NB = number of branches; BY = biological yield; SY = seed yield (kg/ha)

## DISCUSSION

Application of SA improved plant growth and grain yield and also it reduce adverse effects of drought stress. Although in this study it did not mitigate the adverse effects of drought stress on plant growth. Our results are contradictory to some studies in which it has been observed that application of SA improves the plant growth and reduces the stress induced growth inhibition due to drought stress in different plants (Waseem, 2006). Earlier studies suggested positive responses of some plants to application of SA in both normal and water deficit environments (Athari, 2014).

These results suggested that different amounts of salicylic acid did not show significant difference on measured traits, but growth responses to SA was more obvious in low concentration applied. For example, in the present study, least concentration of salicylic acid (1 mM), applied in both, the normal and drought stress for sesame, has the highest average of agronomic traits, able to tolerance of plant against the oxidative damage created by stress factors. In fact, SA in low concentrations acts as a stress mediator.

The data obtained from this study and previous studies demonstrate higher concentrations of salicylic acid (SA) did not show fruitful results. In fact, concentrations of SA and the duration of treatment depends on factors, such as the type of

plant, plant species, plant growth stage, stress factor and structure of the tissue or organ exposed to stress.

## CONCLUSION

From the above results we can be conclude that applied higher concentrations of SA could not cause an increase in growth under drought stress conditions, but lower concentration applied SA can help to reduce the damaging effects of drought stress and may improved growth sesame under stress condition. Thus, further studies are needed to elucidate the current mechanisms of salicylic acid through various methods involved in plants in respond to the application of salicylic acid.

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