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Effects of seed priming with ABA and SA on seed germination and seedling growth of sesame (*Sesamum indicum* L.) under saline condition

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Abstract

In order to investigate the effect of seed priming with ABA and SA on germination indices of sesame in saline conditions, an experiment with three factors and four replicates arranged in completely randomized design. The first factor was type of growth regulator as ABA and SA, the second factor was concentration of growth regulator including 10, 50 and 500 ppm and the third factor was NaCl salinity (0, 2, 4, 6 and 8 dS/m). Seeds were soaked for 6 hours in distilled water, ABA or SA solutions, after which the solution was eliminated and the seeds were dried, deposited in separate Petri dishes between two filter papers and watered. During a 10-day period, germinated seeds number were counted daily and at the final day, randomly selected seedlings were weighed (fresh and dry) and their plumule and radicle lengths were recorded. The results showed that salinity decreased germination rate (GR) and uniformity (GU), but 10 and 50 ppm ABA or SA supply induced higher GP and GU at 4 dS/m and above, more pronounced at 8 dS/m. SA with 500 ppm concentration; however, impaired seed viability. On the contrary, plumule and radicle lengths of seeds primed by 10 and 50 ppm ABA and SA tended to be lower at 0, 2, 4 and 6 dS/m and higher at 8 dS/m than non-primed control. Almost similar results were obtained for seedling dry mass, although the effects of SA were more drastic. Overall, the results suggest a considerable ameliorative effect of ABA and/or SA seed pretreatment on germinability of sesame seeds under salinity but seedling growth may be retarded which is probably an acclimation and temporary response to salinity stress.

Keywords: ABA, Germination, Priming, SA, Salinity.
Abbreviation: ABA: abscisic acid; ds/m: desi Siemen per meter; GR: germination rate; GU: germination uniformity; ppm: part per million, mg/liter; SA: salicylic acid.

Introduction

Abiotic stresses are the principle threat to plant growth and crop productivity all over the world. Salinity adversely affects almost every aspect of the physiology and biochemistry of plants and decreases yield. Salinity is the most serious threat to agriculture and major environmental factor that limits crop growth and productivity (Munns and Tester, 2008).
Sesame (*Sesamum indicum* L.), mostly grown in arid and semi-arid areas, is an annual medicinal and oilseed crop cultivated for many centuries, predominantly in the developing countries of Asia and Africa. It contains 42-54% of high quality edible oil and also contains 22-25% of protein (Desphande et al., 1996).
High and fast seed germination are usually essential for good seedling establishment and plant development to obtain best seedling numbers which results in higher yields (Murungu et al. 2003). Seed germination is negatively affected by stress conditions in most crops and is the most sensitive stage to abiotic stress (Patade et al., 2011). Seed priming is a pre-sowing treatment that partially hydrates seeds without allowing radicle emergence. Consequently, primed seeds are equipped with advanced germination and exhibit improved germination rate and uniformity (Chen and Aurora, 2013). Repressive effect of salinity on germination could be related to a decline in endogenous levels of hormones and exogenous application of plant growth regulators could alleviate damages of stress (Gharbi et al., 2017). The seedlings emerging from primed seeds showed early and uniform germination. Moreover, the overall growth of plants is enhanced due to the seed-priming treatments (Jisha et al., 2013).
Abscisic acid (ABA) and salicylic acid (SA) are two major plant growth regulators which involve in many abiotic responses, such as production of specific stress proteins (Jin et al., 2000). ABA regulates various aspects of plant growth and development, including seed maturation and dormancy, as well as adaptation to abiotic environmental stresses (Davies et al., 2005). There are evidences that ABA acts as the root-to-shoot stress signal. A study has demonstrated that ABA contributes to the increase of xylem water potential as well

as water uptake to the plant in the presence of salt (Fricke et al., 2004). In a saline environment, ABA treatment has been suggested to improve salinity tolerance by increasing growth of sorghum, rice and wheat crops (Amzallag et al., 1990; Gurmani et al., 2011). ABA mediates growth improvement via modulation of ion transport in the plant roots, stomata and storage tissue (Holbrook et al., 2002). Seed pretreatment with ABA has been reported to limit cellular Na^+ concentration and increase osmoregulation via promoting proline and sugar accumulation in salt stressed rice leaves (Gurmani et al., 2011).

Salicylic acid is considered as a hormone like substance, which is involved in activation of the stress-induced antioxidant system when plants are exposed to many abiotic stresses such as chilling, heat, heavy metals, osmotic stress, and salinity (Janda and Ruelland, 2014) (Chen et al., 2016). Afzal et al. (2006) reported that abscisic acid and salicylic acid reduced salinity effects on germination and seedling growth of wheat.

Several methods of application (soaking the seeds prior to sowing, adding to the hydroponic solution, irrigating, or spraying with SA solution) have been shown to protect various plant species against abiotic stress factors by inducing a wide range of processes involved in stress tolerance mechanisms (Horvath et al., 2007).

This paper aims to investigate the growth regulatory effect of different doses of abscisic acid and salicylic acid on seed germination of sesame and early seedling growth under salt stress.

Results and Discussion

Germination rate (GR)

Results of the analysis of variance showed that the effects of hormone, concentration and salinity, as well as all double and triple interactions on germination rate (GR) were significant (Table 1). Increased salinity levels significantly decreased germination rate but different trends were observed when 10, 50 and 500 ppm ABA or SA were applied (Fig 1). All three ABA concentrations at control salinity (EC = 0) significantly decreased germination rate. However, along with increasing salinity, germination of the all ABA concentrations remained relatively constant or changed a little (Fig 1, Table 2). At 8 dS/m, GR decreased to 45%, for control, while three ABA concentrations led to 87.5, 100 and 95% germination rate. This finding obviously indicates that ABA could significantly maintain seed viability even in relatively severe salinities, although some differences between ABA concentrations (10 to 500 ppm) were not significantly different.

The Effects of SA on sesame GR were similar to those of ABA (Table 1, Fig 1). All three SA concentrations at the control salinity decreased GR, while at higher salinities (2 - 8 dS/m), GR was higher for 10 ppm SA than control (Table 3). Also, at 8 dS/m, GRs were 85 and 83% at 10 and 50 ppm SA and 45% for control. However, primed seeds with 500 ppm SA completely lost their viability, therefore GR was almost zero at all salinity levels. Results suggest salt tolerance induction by 10 and 50 ppm SA and ABA priming, while inhibitory effect of 500 ppm SA.

The adverse effect of salinity on germination depends on the decrease of osmotic potential and ion toxicity. Salinity increases soil osmotic pressure and thus reduces water absorption. Also, toxicity of ions such as sodium and chloride ions negatively affect cell division and elongation during germination. On the other hand, inhibitory effect of salinity on germination may be due to decreased levels of endogenous hormones (Munns and Tester, 2008).

ABA is a generic stress hormone, which is known for its multiple functions and under normal condition, may inhibit seed germination in most cases (Baskin and Baskin 1998). This effect may be through delaying the radicle expansion and weakening of endosperm, as well as the enhanced expression of transcription factors (Graeber et al., 2010). However, Afzal et al. (2006) found that ABA application increased the germination of wheat seedlings under salinity stress. Also, Zeevaart and Creelman (1990) suggested that exposure of plants to NaCl or ABA leads to the construction of proteins that increase the amount of osmotin in vacuoles and induce salt tolerance. Also, pretreatment may induce salinity tolerance to germinating seeds by increasing the amount of necessary enzymes such as alpha-amylase and maintaining ionic and hormonal balance (Farooq et al., 2010).

Positive effect of salicylic acid on germination rate of crops like wheat (Shakirova et al., 2003; Afzal et al., 2006) and barley (El-Tayeb, 2005), has been previously reported. It is likely that salicylic acid by decreases toxic and harmful effects of salinity by inducing antioxidant system which leads to better germination. Also, salicylic acid inhibits decline in the levels of growth promoting phytohormones cytokinins and auxins usually occurring under salinity conditions. Similarly, the increase in emergence rate in of primed seeds by salicylic acid may be due to enhanced oxygen uptake and the efficiency of mobilizing nutrients from the cotyledons to the embryonic axis under saline conditions (Kathiresan et al., 1984).

Shakirova et al. (2003) reported a positive effect of SA on germination of wheat seedlings under salinity conditions only in low concentrations. Similarly, Khan et al. (2009) found that concentrations above 1.0 mM of SA adversely affected seed emergence. Nonetheless, Ghoohestani et al., (2012) did not found any germination improvement in tomato seeds by 50, 100 or 150 ppm SA pretreatment under salinity.

Germination uniformity (GU)

Germination uniformity (GU) is time taken from 10% to 90 % of final germination percentage (D10 to D90), lower values representing less uniformity (Soltani et al. 2001). Results of analysis variance showed that hormone, salinity and hormone × salinity interaction significantly affected GU (Table 1). Increased salinity decreased GU at control priming (distilled water), but 10, 50 and 500 ppm ABA, caused different responses. All three ABA concentrations at control salinity (EC = 0 dS/m), although, GU of seed primed with 10 (and rather 50) ppm ABA remained relatively constant when salinity increased (Fig 2, Table 2). At 8 dS/m, the highest GU belonged to with 10, 50 and 500 ppm ABA priming. Also, 10 and 50 ppm SA treatments led to higher GU, especially at 6 and 8 dS/m compared to control (Fig 2, Table 3). Priming

Table 1. Summarized ANOVA of effect of hormone, concentrations and salinity on some germination indices of sesame seeds.

Source of Variation	df	Germination rate	Germination uniformity	Plumule length	Radicle length	Seedling dry weight
Hormone (H)	1	1899.1**	244.8*	9.8**	61.7**	3.1**
Concentration (C)	2	62.1 ^{ns}	15.5 ^{ns}	4.2 **	9.6**	2.1**
Salinity (S)	4	686.1**	132.2 **	4.3 **	9.7**	2.7**
H × S	8	999.7**	254.1**	4.2**	7.5**	1.8**
H × C	1	781.2**	0.87^{ns}	0.71**	0.15 ^{ns}	2.8 ^{ns}
C × S	8	810.8**	50.1^{ns}	0.42**	2.3**	2.7**
H ×C× S	4	370.5**	49.1^{ns}	0.49**	0.97**	3.5**
Error	90	42.3	122.1	0.05	0.09	1.4
CV%		7.8	9.8	14.2	15.5	4.7

ns, * and **: non-significant, significant at 0.05 and 0.01, respectively. Values inside tables are mean squares except for dfs

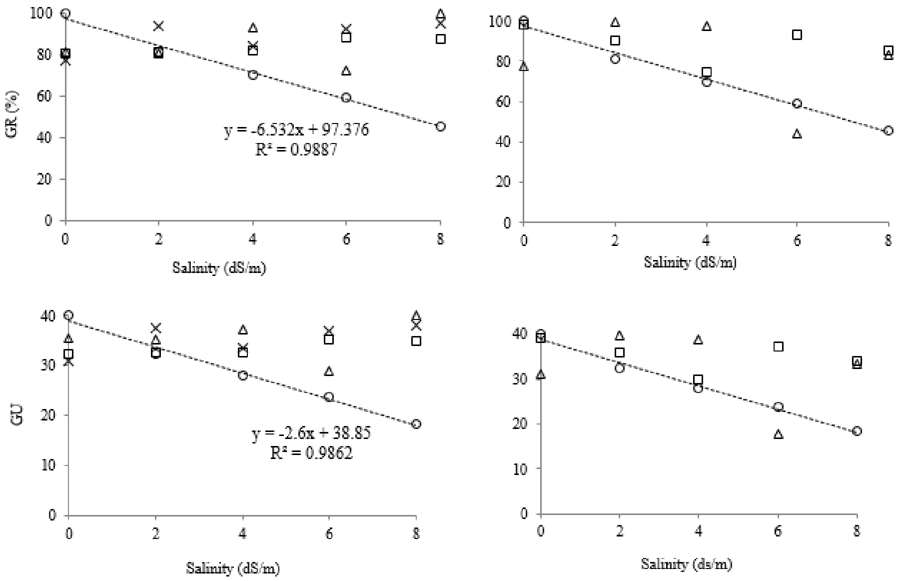

Fig 1. Changes in germination rate (GR) (up) and germination uniformity (GU)(down) of sesame seeds along with salinity and at different concentrations of abscisic acid (ABA) (left) and salicylic acid (SA) (right). O: control (distilled water); □: 10 ppm; Δ: 50 and ×: 500 ppm. Equations inside plots indicate linear trend (dashed line) fitted for changes of GR and/or GU at control pretreatment.

Table 2. Mean comparison of traits measured at germination of sesame seed primed with different concentrations of ABA and NaCl salinities.

Hormone	Concentration (ppm)	Salinity (dS/m)	Germination rate (%)	Germination uniformity	Plumule length (cm)	Radicle length (cm)	Seedling dry weight (mg)
		0	100.0 a	40.0 a	3.9 a	6.9 a	2.2 a
		2	81.3 j-m	32.3 j-n	3.5 b	6.0 b	2.0 b
Control	0	4	70.0 nop	28.0 op	3.2 b	4.3 c	2.0 b
		6	59.4 q	23.8 q	1.0 onp	2.0 igh	1.8 c
			45.6 r	18.3 r	0.5 q	1.5 hg	1.5 cd
		0	80.8 j-m	32.3 j-n	2.5 c	3.5 d	2.5 a
		2	81.3 i-m	32.5 j-m	1.9 efg	2.9 ef	1.5 cd
ABA	10	4	82.0 i-m	32.8 j-m	1.8 efg	1.4 i-h	-
		6	88.3 b-k	32.3 j-n	1.7 hjig	1.4 i-l	1.5 cd
		8	87.5 c-k	35.0 c-k	1.3 k-o	2.0 gh	2.0 b
		0	81.5 i-m	35.5 a-k	2.4 cd	3.0 e	1.8 c
		2	80.8 i-m	35.3 b-k	1.2 k-o	2.6 ef	2.0 b
ABA	50	4	93.3 b-h	37.3 a-g	1.4 j-n	1.1 k-n	1.8 c
		6	72.5 m-p	29.0 m-p	1.0 m-p	0.8 l-o	2.5 a
		8	100.0 a	40.0 a	1.4 i-l	2.8 ef	1.8 c
		0	77.5 l-o	31.0 k-o	1.3 k-o	0.6 no	2.5 a
ABA	500	2	93.8 a-g	37.5 a-g	1.1 l-o	1.1 k-n	2.2 a
		4	83.8 f-l	33.5 f-m	1.5 h-k	1.9 igh	2.0 b
		6	92.5 a-f	37.0 a-i	1.0 nop	0.8 l-o	2.0 b
		8	95.0 b-f	38.0 a-i	1.0 op	0.8 l-o	1.8 c

In each column, values with one similar letter are not statistically different (p≤ 0.05, Duncan Multiple Range Test).

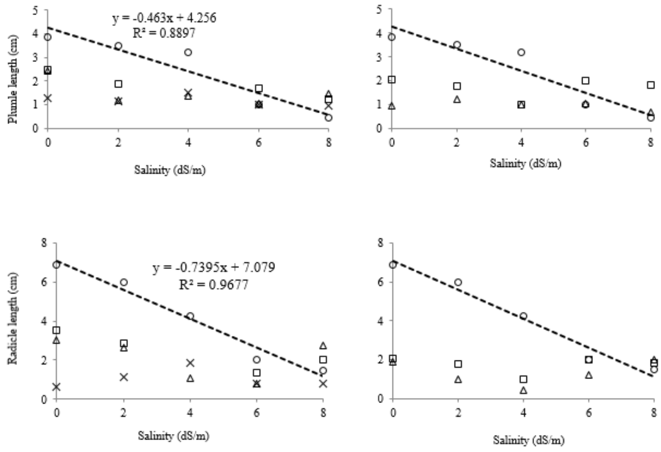

Fig 2. Changes in plumule (up) and radicle (down) length of sesame seedlings along with salinity and at different concentrations of abscisic acid (ABA)(left) and salicylic acid (SA) (right) seed pretreatment. O: control (distilled water); □: 10 ppm; Δ: 50 and ×: 500 ppm. Equations inside plots indicate linear trend for changes of plumule and/or radicle length at control pretreatment ($p \leq 0.05$).

Table 3. Mean comparison of traits measured at germination of sesame seed primed with different concentrations of SA* and NaCl salinities

Hormone	Concentration)ppm(	Salinity dS/m)(	germination rate (%)	germination uniformity	plumule length (cm)	radicle length (cm)	seedling dry weight (mg)
		0	100.0 a	40.0 a	3.9 a	6.9 a	2.2 a
		2	81.3 j-n	32.3 j-n	3.5 b	6.0 b	2.0 b
Control	0	4	70.0 nop	28.0 nop	3.2 b	4.3 c	2.0 b
		6	59.4 q	23.8 q	1.0 nop	2.0 igh	1.8 c
		8	45.6 r	18.3 r	0.5 q	1.5 hg	1.5 cd
		0	98.3 a-d	39.3a-d	2.1 ef	1.9 h	2.2 a
SA	10	2	90.0 a-j	36.0 a-i	1.8 f-h	1.0 k-o	2.2 a
		4	74.5 l-n	29.8 l-o	1.0 onp	0.4 o	2.2 a
		6	93.3 a-g	37.3 a-h	2.0 efg	1.3 j-m	1.8 c
		8	85.0 f-l	34.0 e-l	1.8 hfg	2.0 igh	1.8 c
		0	77.5 k-n	31.0 k-o	1.0 op	1.1 k-n	2.5 a
		2	99.5 ab	39.8 ab	1.3 k-o	1.3j-m	2.1 b
SA	50	4	97.0 a-d	38.8 a-e	1.1 nop	1.3 j-m	2.0 b
		6	44.5 r	17.8 r	1.1 m-p	1.0 k-o	2.5a
		8	83.3 g-l	33.3 g-m	0.7 qp	1.1 k-n	2.0 b

In each column, values with one similar letter are not statistically different ($p \leq 0.05$, Duncan Multiple Range Test).
*: Seeds lost their viability at 500 ppm SA pretreatment, therefore no data was recorded

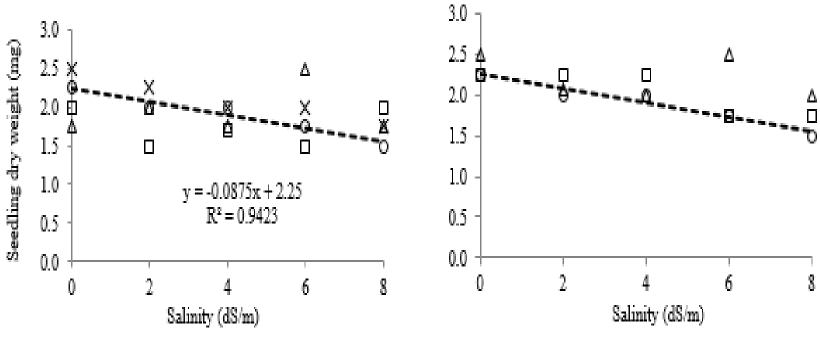

Fig 3. Changes in sesame seedlings dry weight along with salinity and at different concentrations of abscisic acid (ABA)(left) and salicylic acid (SA) (right) seed pretreatment. O: control (distilled water); □: 10 ppm; Δ: 50 and ×: 500 ppm. Equation inside plot indicates a linear trend for changes of seedling dry weight at control pretreatment ($p \leq 0.05$)

with 500 ppm SA, however, eliminated seed viability since no seed germinated.

Results suggest that sesame seed pretreatments with ABA, either at low (10 ppm) or high (500 ppm) concentration, improves GU under relatively severe salinities. Similar results are expected for 10 and 50 ppm SA.

In saline soils, due to low water potential, seeds imbibe water very slowly which may lead to slow and uneven germination and poor establishment. Abscisic acid, by effecting ions uptake, stimulating synthesis of antioxidant enzymes and synthesis of compatible osmolytes, induces salt tolerance in plants (Kang et al., 2005). Jiriaie et al. (2013) reported that pretreatment of seeds with 0.1 mM salicylic acid could partly compensate for damages caused by drought and low seed weight and enhances the germination rate and uniformity. If water absorption is impaired or proceeds slowly, activities inside the seed will be too slow and increases duration of radicle emergence and consequently lower germination rate and uniformity. Ansari et al. (2013) examined four concentrations of SA (25, 50, 75 and 100 ppm) on germination of rye seeds under drought stress and concluded that 25 ppm SA increased germination uniformity.

Plumule length

Results showed that plumule length was significantly affected by hormone, concentration, salinity and all double and triple interactions (Table 1). Plumule length linearly was declined by increasing salinity with a sharp and significant slope (0.46 cm per 1 dS/m). Importantly, priming with 10 and 50 ppm ABA and SA resulted in significantly lower plumule length compared to non-primed control at 0, 2 and 4 dS/m salinity (Fig 3, Table 2) but at 8 dS/m, this effect was reversed so that, plumule length was the lowest for control priming. Also, priming with 10 ppm ABA or SA significantly increased plumule length at 8 dS/m compared to control (Table 2). Our results suggest that ABA and SA decrease plumule length and probably seedling growth on normal condition and moderate salinities, but under severe salinity (8 dS/m) may mitigate adverse effects of NaCl on cell division and enlargement in plumule.

Adverse effects of salinity on shoot length of sesame and maize have been previously reported. (Bahrami and Razmjoo, 2012; Ghoulam et al., 2001) and increased plumule and radicle length may be used as a suitable criterion for selection of salt tolerance at seedling stage (Bahrami and Razmjoo, 2012). Abscisic acid delays deleterious effects of NaCl and improve resistance to ionic stress in sorghum (Amzallag et al., 1990). Also, Gurmani et al. (2009) found that shoot and root dry weight of wheat seedling decreased by salt treatment, but 10^{-5} M ABA treatment showed significant ameliorative effect.

On the other hand, results of some studies have shown that seed pretreatment with SA increased plumule length in wheat (Shakirova et al., 2003) and peppers (Khan et al., 2009), but this effect may be largely dependent to concentration. Ahmad et al. (2012) reported that increasing SA concentration enhances ABA synthesis which can inhibit seed germination. Sharafizad et al. (2013) reported that pretreatment of wheat seeds with high concentrations (1.2 and 2.7 mM) of salicylic acid, compared to a low concentration (0.7 mM), reduced hypocotyl length. Accordingly, Zadehbagheri (2014) reported that pretreatment with high SA concentration (3 mM) damaged seed germination and seedling growth of corn while lower concentrations improved them in stress conditions.

Overall, our findings suggest that lower concentrations of SA show ameliorating stress effect and are often more effective than higher concentrations.

Radicle length

Results of analysis of variance for the radicle length resembles to those for plumule length (Table 1). When no ABA or SA was applied, increasing salinity from 0 to 8 dS/m, decreased radicle length from approximately 7 to 2 mm. Slope coefficient for fitted linear trend was 0.739 ($P = 0.01$) which was almost 160 % higher than that of plumule length (0.463, Fig 2). This finding suggests that salinity induce more adverse effect on radicle than plumule growth at germination stage. Again, pretreatment with 10, 50 and ABA and SA and 500 ppm ABA significantly decreased radicle length at 0, 2 and 4 dS/m. However, at 8 dS/m, radicle length for 50 ppm ABA was significantly higher than control. Neither 10 nor 50 ppm SA increased radicle length at 8 dS/m.

Decrease in root length by salinity in sesame (Bahrami and Razmjoo 2012) has been previously reported which may be due to osmotic or toxic effect of NaCl on cell division and enlargement (Geholt et al., 2005). Saab et al. (1990) found that ABA accumulation plays direct roles in both the maintenance of primary root and the inhibition of shoot elongation at low water potentials. However, salinity effect on root length may be different with shoots as roots are direct target of toxic ions such as Na^+ and Cl^-. Indeed, abscisic acid (ABA) integrates root growth and development in response to both drought and high saline environments (Davies et al. 2005). Also, exogenous application of ABA onto seeds has been shown to increase salinity tolerance in rice (Gurmani et al., 2011), while many of the root architectural responses to NaCl can also be stimulated by ABA (Desmet et al., 2003).

Some studies have shown that SA improved root growth in maize (Khodary, 2004), wheat (Shakirova et al. 2003) and barley (Hanan, 2007) under salinity. On the contrary, Deef (2007) reported that priming of wheat and barley seeds had no significant effect on root dry weight under salinity but significantly reduced root length. Also, foliar application of 10^{-5} M SA significantly increased root length of maize plants grown at 4 dS/m soil salinity compared to control (no SA), but still much lower than non-saline control. Also, SA did not alter root length under no salt control (Fahad and Bano, 2012). Different type of application, development stage and specific sensitivity may be involved in diverse responses to SA.

Seedling dry mass

Similar to previous sections, seedling dry mass gradually decreased along with salinity (0 - 8 dS/m) (Fig 3, Table 2). Comparing results of seedling dry mass with those of plumule and radicle length (Fig 2 and 3), it seems that inhibitory effects of salinity on root and shoot expansion was much more drastic than dry matter accumulation. For example, at 8 dS/m shoot and root lengths were 4.6 and 8.5

fold lower than non-saline control (0.5 vs 3.9 cm and 1.5 vs 6.9 cm, respectively) but seedling dry mass was only 1.5 fold lower. On the other hand, pretreatment with 10 and 50 ppm ABA induced slight decrease in seedling dry mass at 0, 2, 4 and 6 dS/m but a significant increase at 8 dS/m. Also, priming with 500 ppm ABA often caused greater seedling weight compared to non-primed, though differences were only significant at 2 and 6 dS/m. Priming with 10 and 50 ppm SA, however, did not significantly alter seedling dry mass at 0, 2 and 4 dS/m but at 6 and 8 dS/m, 50 ppm SA induced significantly higher seedling dry mass compared to control (Table 3). Taking together, results suggest that ABA and SA may improve dry mass accumulation under high salinity of sesame seedlings.

Inhibitory role of ABA in cell division and expansion especially under stress conditions have been known extensively (e.g. Taiz and Zeiger, 2006; Zevaart and Creelman, 1988). Spraying etiolated soybean seedlings with ABA, as well as water deficit treatment, significantly decreased hypocotyl and root dry weight probably by altering cell wall characteristics (Creelman et al., 1990). However, Bakht et al., (2011) found that maize seed pretreatment with NaCl increased yield, as well as shoot ABA content in saline soil suggesting an ameliorative effect for ABA. On the other hand, exogenous SA application on seedling and whole plant growth under normal and stress conditions may improve crop performance (Gunes et al., 2007; Singh and Usha, 2003). Shakirova et al. (2003) reported that treatment of wheat plants with 0.05 mM salicylic acid (SA) under salinity stress increased the level of cell division within the apical meristem of seedling roots. Further, seed priming with 20 and 40 mg/l SA increased shoot and root dry weight of maize seedlings under suboptimal temperatures (Ahmad et al., 2012).

Materials and Methods

Plant materials

This study was conducted in 2012 in laboratory condition at Vali-e-Asr University of, Rafsanjan, to study the effect of pretreatment by two growth regulators abscisic acid and salicylic acid on sesame seed germination under saline conditions.

Seed materials

Seeds of Sesame (Sesamum indicum L. cv. Dashtestan.) were obtained from Agricultural Research Center of Jiroft. Before the start of experiment, seeds were surface sterilized in 1% sodium hypochlorite solution.

Experimental design

This experiment arranged in randomized complete design as factorial with three factors and three replicates. The first factor was seed pretreatment with distilled water (control), abscisic acid (ABA) or salicylic acid (SA). The second factor was growth regulator concentration at three levels of 10, 50 and 500 ppm and the third factor was five levels of salinity including 0, 2, 4, 6 and 8 dS/m.

The seeds were kept for 6 hours in distilled water, ABA and SA solutions, after which the solution was eliminated and the seeds were dried lightly by depositing them on filter paper that absorbed most of the solution left on the seeds and then finally they were deposited in separate Petri dishes between two filter papers.

Seedling Vigor Evaluation

The germinating seeds were counted at regular intervals. The germination percentage was calculated as follows:

Germination Percentage $= \frac{n}{N} \times 100$

Where n is the number of germinated seeds, and N is the total number of seeds. Also, the coefficient of uniformity of germination (CUG) was calculated according to Bewley and Black (1985) methods: CUG=Σn / Σ [(t`-t) 2×n]

Where n is the number of germinated seeds per day and Σ [(t `-t) 2 × n] is equivalent to the mean germination time.

Radicle and hypocotyl lengths of the germinated seeds, which were more than 2 mm in length were measured and recorded after 10 days. Dry weights were measured after drying root and shoot at 80°C for 48 hours in an air oven. Data for all parameters were expressed as mean values.

Data analysis

Analysis of variance was performed using standard techniques and differences between means were compared through Duncan's multiple range test ($p<0.05$) using the SAS[1] software.

Conclusion

Sesame seed priming with 10 and 50 ppm ABA and SA maintained high germination rate and uniformity at 6 and 8 dS/m, yet 500 ppm SA impaired seed viability. On the contrary, plumule and radicle lengths, as well as, seedling dry weights significantly decreased by 10 and 50 ppm ABA and SA, except for 8 dS/m, in which seed pretreatment caused higher values compared to non-primed control. We assume that this inhibitory effect is an acclimation and temporary response, helping young seedlings to protect from toxic and osmotic effect of high amounts of salts. Therefore, growth may be recovered to normal rates after seedling establishment. On the other hand, seedling survival under salinity may be more important factor than early growth rate, since the former determines final crop density, and consequently final yield. Also, maintaining high dry mass during germination stage under osmotic or ionic stress may be a valuable criterion for stress tolerance, but in the situation of this experiment, seedlings growth was restricted to Petri dish containers filled with water. Thus, dry matter of seedlings was originated only from seeds reserves. Overall, our results suggest that seed priming may be worthy agronomic approach for better sesame stand establishment under saline soils.

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