

RESEARCH ARTICLE

EFFECTS OF FOLIAR APPLICATION OF SALICYLIC ACID AND CALCIUM CHLORIDE ON YIELD, YEILD COMPONENTS AND SOME PHYSIOLOGICAL PARAMETERS IN COTTON

Mostafa Heidari^{a*}, Mehdi Moradi^a, Mohammad Armin^b and Mohammad Reza Amerian^a

^aShahrood University of Technology, Agronomy and Plant Breeding Department, Shahrood, Iran.

^b Agronomy and Plant Breeding Department, Azad University of Sabzevar, Iran.

*Corresponding Author E-mail: m_haydari@shahroodut.ac.ir

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ABSTRACT

Salicylic acid (SA), a plant phenolic compound and calcium chloride have a great role on crop plants against biotic and abiotic stresses. This experiment was conducted to study the effects of foliar application of salicylic acid ($S_1=0$, $S_2=50$, $S_3=100$ and $S_4=150$ ppm) and calcium chloride ($C_1=0$, $C_2=1.5$ and $C_3=3$ g/L) on cotton. The results showed that, salicylic acid increased the percentage of oil and nitrogen in seeds as well as the amount of chlorophyll content in the leaves, and this increased continued until $S_4=150$ ppm. Calcium chloride had no significant effect on them. The interaction between calcium chloride and salicylic acid had significant effect on the lint and grain yield in cotton and increased them. Biological yield, weight of seed per boll, weight of cotton per boll and number of boll per plant also affected by the interantrion between of these two treatments. In these traits, although salicylic acid until S_4 increased them, but the main effect of calcium chloride was up to C_2 . It was found unlike salicylic acid, which affectd on yield, yield components, photosynthesis piments and the content of mineral elements in seeds until S_4 , calcium chloride had a major effect on yield and yield components and this effect was until the level of C_2 .

KEYWORDS

Calcium chloride, Cotton, Quantitative yield, Photosynthesis pigments, Mineral elements, Salicylic acid

1. INTRODUCTION

Cotton is widely grown in arid and semi-arid areas in the world (Wang et al., 2004). In these areas, plants are affected by environmental stresses such as heat, drought and salinity stress. Therefore, it is necessary to use compounds that can reduce the effect of these stresses on the crop plants in condition such as drought stress (Heidari et al., 2019). Plant growth regulators have been found effective in improving crop performance against abiotic stresses by activating defensive system. Salicylic acid (SA) is a plant phenol and today it is in use as internal regulator hormone, because its role in the defensive mechanism against biotic and abiotic stresses has been confirmed (Kobeasy et al., 2011). Application of salicylic acid may increase stress tolerance of plants by altering physiological phenomena in plants. Studies have demonstrated that SA supplementation also enhances the photosynthetic activity, chlorophyll content, leaf water potential, membrane stability index, activities of antioxidant enzymes like SOD, CAT, and APX, and reduces the electrolyte leakage under water stress conditions (Saheri et al., 2020).

Application of SA to water deficient plants reduces cell membrane damage in leaves by reducing cellular lipid peroxidation and H_2O_2 accumulation (Khan et al., 2014). In addition, the reduction of H_2O_2 accumulation in SA treated plants enhances the activities of antioxidant enzymes such as catalase (CAT), superoxide dismutase (SOD) and guaiacol peroxidase (GPOD) (Saruhan et al., 2012). Some researchers showed that SA increases dry weight and chlorophyll content in wheat seedlings under drought stress (Singh and Usha, 2003). The positive effects of SA application on growth and yield of medicinal plants under drought stress have also been

reported (Dianat et al., 2016; Abbaszadeh et al., 2020).

In addition to salicylic acid, nutrient elements such as calcium can also be effective on the growth and yield of crops under different environmental conditions. Calcium is involved in the regulatory mechanisms that plants activate to adjust to adverse environmental conditions of drought, heat, cold, salt, and heavy metal (Zehra et al., 2012; Zhou and Guo, 2009; Tan et al., 2011; Upadhyaya et al., 2011; Siddiqui et al., 2011). Calcium appears to play a central role in many defense mechanisms that are induced by drought, and Ca^{2+} signaling is required for the acquisition of drought tolerance (Cousson, 2009). Several studies demonstrated the effectiveness of exogenous Ca^{2+} to improve seed germination through maintaining ion homeostasis and modulating the antioxidant system under salt stress.

Since cotton is often cultivated in arid and semi-arid areas and in this area environmental stresses such as heat and drought stress can adversely effect on growth and yield of cotton. In this case, the use of compounds that can reduce the effects of environmental stresses on the plants will be useful and can improve the growth and yield of plants in this condition. Then aim of this study was to investigation the foliar application of salicylic acid and calcium chloride (As two compounds that can partially reduce the effects of environmental stresses on plants) on photosynthetic pigment, mineral nutrients stated, lint yield and yield components in cotton.

2. MATERIALS AND METHODS

A Field experiment was conducted at the central of Agricultural and

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Natural Resources Research Sabzevar, in Razavi Khorasan, Iran (latitude of 21° 50' 36" N and longitude of 57° 43' 10" E with an elevation of 977.6 m) in 2016. The field soil was sandy loam in texture, pH, 7.28; EC, 5.11 ds m⁻¹; 0.26% of organic carbon; 0.022% N, 2.6 and 110 ppm of available P and K, respectively. Experiment laid out as factorial based on randomized complete block design with three replications. Four levels of salicylic acid were S₁= 0 (control), S₂= 50, S₃=100 and S₄= 150 ppm and calcium chloride at three levels: C₁=0, C₂=1.5 and C₃=3 g/L. The variety of cotton, Varamin, was sown on 5th May 2016. Foliar application of salicylic acid and calcium chloride were applied at two stages (at 5-leaf stage and 50% flowering time). First, foliar application of salicylic acid, then 5 days after that, foliar application of calcium chloride was performed. It was applied in the afternoon and at the time of cooling. There were six rows in each plot. The width and length of each row were 0.60 and 4 m, respectively. Before sowing, the soil was fertilized with N, P and K at a rate of 250, 150 and 100 kg ha⁻¹ as urea, triple super phosphate and potassium sulfate, respectively. One third of the nitrogen was applied at sowing time, one third at the 4-6 leaf stage and one third at the 40-50% flowering stage. Seeds were placed at 3-5 cm depth.

2.1 Yield and yield components

To determination of seed cotton yield, lint and biological yield, at maturity stage total plants produced within the middle of two central rows in each plot, were removed. Yield was defined in terms of grams per square meter (m²) and quintals per hectare. Then yield components and plant height were calculated by using 5 plants per plot. The yield components included thousands of seed weight, weight of seed per boll, weight of lint per boll, number of boll per plant and number of branch per plant and obtained from 5 selected plants in each plot.

2.2 Mineral elements and oil content in seeds

The concentration of potassium and sodium in seeds were determined by Jenway PFP7 Flame photometer. Samples of seeds were dry ashed at 500 °C and then after preparing the solution, they were measured by using a

photometer. In this experiment, sodium and potassium chloride were used to prepare a standard solution (Keison Products, UK). Nitrogen content of seeds was determined according to the method (Chapman and Pratt, 1961). Samples of seeds were digested, and total nitrogen content was determined by using the Kjeldhal method. Oil content in the seed was determined as Soxhlet extractor fitted with one liter round bottom flask and a condenser. The extraction was executed with 0.5 L of n-hexane on a water bath for 5 h.

2.3 Photosynthesis pigment in leaves

To measure the amount of total chlorophyll in the leaves of cotton, ten days after the second foliar application, leaf chlorophyll content was measured by using SPAD konic minolta 502.

2.4 Statistical analyses

Data were analyzed with SAS Institute Inc. 9.2 software. Firstly, data analyzed by ANOVA to determine significant ($P=0.05$) treatment effects. Finally, the significant differences between individual means were determined by using LSD test.

3. RESULTS

3.1 Lint and seed yield

Analysis of data showed that, interaction between calcium chloride and salicylic acid treatments had significant effect on lint and seed yield in cotton (Table 1). Figure 1 shows that at S₁, salicylic acid is not used, by increasing concentration of calcium chloride from C₁ to C₃, the lint yield increased. But, with increasing concentration of salicylic acid from S₂=50 to S₄=150 ppm, the lint yield increased until C₂ treatment. By increasing concentration of calcium chloride from C₂ to C₃, the lint yield decreased. The highest lint yield in this study was obtained at S₃C₂ treatment. About grain yield, at all levels of salicylic acid (S₁-S₄), the maximum grain yield was obtained by foliar application of 3 g/L calcium chloride. As shown in figure 2, the highest grain yield is related to S₄C₃ treatments.

Source of Variation (S.O.V)	df	Seed yield	Lint yield	Biological yield	Weight of seed per boll	Weight of cotton per boll	Number of boll per plant	Branch per plant	Lint per boll	Plant height	Thousand of seed weight	Total chlorophyll	Oil	Nutrient elements in seed		
														Nitrogen	Potassium	Sodium
Block	2	1544.1 ^{ns}	252.4 ^{ns}	340507 ^{ns}	8.36 ^{ns}	3.51 ^{ns}	14.34 ^{**}	1.07 ^{ns}	1.43 ^{ns}	13.94 ^{ns}	25.44 ^{ns}	1.55 ^{ns}	0.006 ^{ns}	0.43 [*]	162.14 ^{ns}	347.8 ^{ns}
Salicylic acid (S)	3	28537 ^{**}	62006.6 ^{**}	1962070 ^{**}	2.63 ^{ns}	6.43 ^{ns}	13.72 ^{**}	3.3 [*]	13.7 ^{**}	219.8 ^{**}	185.01 ^{**}	12.59 ^{**}	0.45 ^{**}	0.46 [*]	89.06 ^{ns}	197.3 ^{ns}
Calcium chloride (C)	2	27496 [*]	90376.1 ^{**}	81036.1 ^{ns}	147.1 ^{**}	213.1 ^{**}	8.85 ^{**}	1.29 ^{ns}	8.8 [*]	70.9 ^{ns}	15.7 ^{ns}	2.26 ^{ns}	0.001 ^{ns}	0.60 [*]	12.16 ^{ns}	185.1 ^{ns}
S×C	6	14174 [*]	15565.2 ^{**}	3086574 ^{**}	43.5 [*]	238 ^{**}	3.24 [*]	0.19 ^{ns}	1.2 ^{ns}	17.1 ^{ns}	18.8 ^{ns}	0.799 ^{ns}	0.04 ^{ns}	0.05 ^{ns}	144.2 ^{ns}	415.7 ^{ns}
Error	22	5575	3397.0	321876.3	12.6	13.2	1.25	1.34	1.25	26.1	35.2	2.51	0.047	0.14	121.4	742.9
CV (%)		10.3	15.8	18.7	19.7	13.4	10.4	14.4	10.4	6.64	5.2	3.24	9.25	17.9	25.2	50.6

* $P<0.05$ and ** $P<0.01$: Numbers represent F values at 5% level, ns, not significant.

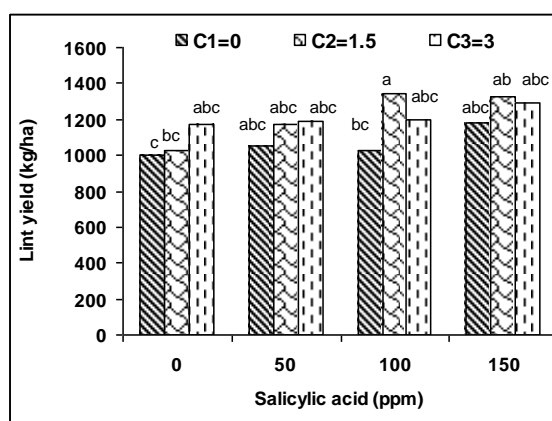


Figure 1: Interaction between salicylic acid and calcium chloride on lint yield

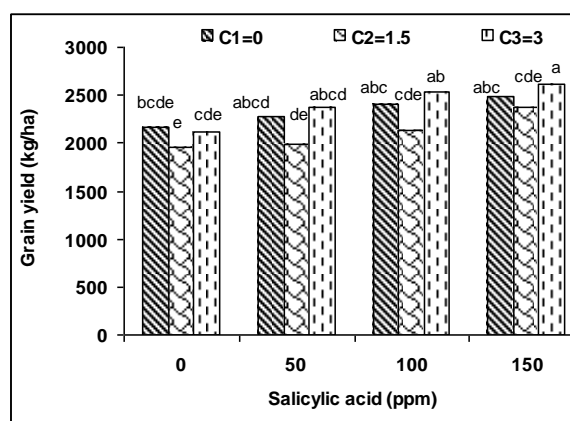


Figure 2: Interaction between salicylic acid and calcium chloride on grain yield

3.2 Biological yield, weight of seed per boll, weight of cotton per boll and number of boll per plant

Statistical analysis of data indicated that, interaction between calcium chloride and salicylic acid treatments had significant effect on biological yield in cotton (Table 1). By increasing concentration of foliar application of salicylic acid from S₁=0 to S₄=150 ppm, biological yield increased. At this time, application of calcium chloride only until C₂=1.5 g/L, increased biological yield. Then the highest biological yield was obtained at S₄C₂ treatment (Figure 3). Weight of seed per boll, weight of cotton per boll and number of boll per plant, interaction between calcium chloride and salicylic acid treatments had significant effect on them (Table 1).

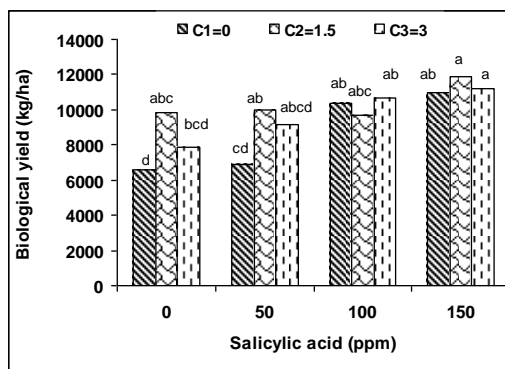


Figure 3: Interaction between salicylic acid and calcium chloride on biological yield

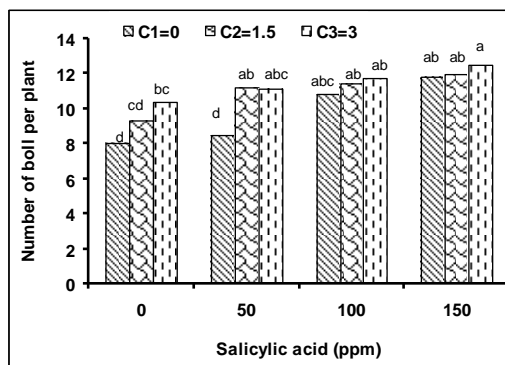


Figure 4: Interaction between salicylic acid and calcium chloride on number of boll per plant

Figure 4 shows that, the number of boll per plant increased by increasing levels of salicylic acid (S_1 to S_4) and calcium chloride (C_1 to C_3), so that the highest of the number of boll per plant was obtained at S_4C_3 (150 ppm salicylic acid and 3 g/L calcium chloride) treatment. The lowest number of boll per plant was related to S_1C_1 (do not use of salicylic acid and calcium chloride) treatment. About weight of seed per boll and weight of cotton per boll, as shown in figures 5 and 6, by increasing level of calcium chloride from C_1 to C_3 , the amount of these two decreased. Especially when salicylic acid is not used. But by increasing salicylic acid from S_1 to S_4 , the amount of these reduction was reduced. Therefore the lowest different between calcium chloride level was observed at S_4 treatment. Figures 5 and 6 showed that the highest amount of weight of seed per boll and weight of cotton per boll were obtained at S_3C_1 and the lowest at S_2C_2 treatments.

3.3 Branch per plant, lint per boll, thousand of seed weight and plant height

Among the two treatments, statistical analysis of data showed that, salicylic acid had significant effect on the branch per plant, lint per boll, thousand of seed weight and plant height. Calcium chloride treatment had significant effect only on lint per boll and it had no significant effect on other traits (Table 1). As shown in Table 2, by increasing the level of salicylic acid from S_1 to S_4 , the amount of these traits increased, and the highest value were obtained at level of S_4 . The increasing value of branch per plant, lint per boll, thousand of seed weight and plant height at the level of S_4 compared to S_1 were 15.1, 23.4, 9.19, 13.7 respectively (Table 2). Calcium chloride treatment only had significantly effect on lint per boll and by increasing the level of calcium chloride, the amount of lint per boll increased. However, at the C_3 compared C_1 , this increase was about 14.5%, but in this study, there was no statistical different between C_2 and C_3 (Table 2).

Table 2: Foliar application of salicylic acid and calcium chloride on plant height, yield components, photosynthesis pigments and ion content in cotton

Treatments	Plant height (cm)	Thousand of seed weight (g)	Total chlorophyll (SPAD)	Lint per boll (g)	Branch per plant	Oil (%)	Nutrient elements in seed (mg g ⁻¹ dry weight)		
							Nitrogen	Potassium	Sodium
Salicylic acid (ppm)									
$S_1=0$	71.7c	106.7c	47.5c	9.24c	7.33b	2.05c	1.87c	47.26a	48.7a
$S_2=50$	74.5bc	111.2bc	48.5bc	10.26bc	7.73ab	2.29b	2.09ab	42.88a	59.7a
$S_3=100$	78.4ab	113.8ab	49.4ab	11.31ab	8.43ab	2.48ab	2.22ab	44.65a	54.7a
$S_4=150$	83.1a	117.5a	50.2a	12.07a	8.63a	2.55a	2.42a	39.77a	51.8a
Calcium chloride (g L⁻¹)									
$C_1=0$	75.2b	111.1a	48.5a	9.76b	8.17a	2.33a	2.09ab	42.80a	58.03a
$C_2=1.5$	75.9b	112.4a	48.8a	10.98a	7.65a	2.34a	2.39a	44.76a	53.01a
$C_3=3$	79.7a	113.3a	49.4a	11.42a	8.26a	2.35a	1.96b	43.37a	50.29a

Means followed by the same letter are not significantly different within rows and column according to Least Significant Difference (LSD) ($P \leq 0.05$)

3.4 Total chlorophyll and Oil

Statistical analysis of data indicated that salicylic acid treatment had only a significant effect on leaf chlorophyll and seed oil percentage. Calcium chloride and interaction between these two treatments had no significant effect on them (Table 1). By increasing salicylic acid level from S_1 to S_4 , the leaf chlorophyll and seed oil percentage increased. This increase was about 5.37 and 19.2% respectively (Table 2).

3.5 Mineral nutrition in seed (Nitrogen, potassium and sodium)

Among the three elements nitrogen, potassium and sodium in this study, statistical analysis of data showed that, salicylic acid and calcium chloride had significant effect on the percentage of nitrogen in seed and about potassium and sodium, the two treatments of salicylic acid and calcium chloride had no significant effect on them (Table 1). By increasing the level of salicylic acid from $S_1=0$ to $S_4=150$ ppm, the nitrogen content in seed increased. This increase was about 22.7%. Calcium chloride treatment increased the nitrogen content in seed until $C_2=1.5$ g/L and by increasing calcium chloride from C_2 to $C_3=3$ g/L, the nitrogen content decreased (Table 2).

4. DISCUSSION

Salicylic acid plays important roles to defend plants against both biotic and abiotic stresses. It plays diverse physiological roles in plants which such as plant growth, flower induction, nutrient uptake, thermogenesis, stomatal movements, ethylene biosynthesis, photosynthesis, and enzyme activities (Hayat and Ahmad, 2007). The results in this experiment showed that foliar application of salicylic acid increased the chlorophyll content in leaves of cotton and this increase continued until $S_4=150$ ppm (Table 2). Elevated chlorophyll content can improve photosynthesis and thus increasing the biomass and yield in crop plants. In this study, salicylic acid increased lint and grain yield of cotton.

A researcher reported that application of salicylic acid improved photosynthetic capacity in barley under salt stress (El-Tayeb, 2005). Photosynthesis is the most vital physiological processes contributing to plant growth and productivity. In other words, photosynthetic capacity in crop plants is the primary component of dry matter productivity. However, rate of photosynthesis varies with the change in environmental factors thereby affecting plant growth and yield (Nátr and Lawlor, 2005). Studies showed that applied SA increased the photosynthetic rate in different crops, e.g., maize and soybean (Khan *et al.*, 2003).

However in this study, foliar application of salicylic acid had an important role on lint and grain yield in cotton, but application of calcium chloride also had effect on grain and lint yield in cotton. However it had no effect on photosynthesis pigments and the content of nutrient elements in cotton seed, but it improved yield and yield components in cotton and increased them (Table 1). The results showed that, the highest lint yield and grain yield were obtained at S₃C₂ and S₄C₃ respectively (Figures 1 and 2). Also, the highest biological yield, the number of boll per plant and weight of cotton per boll were obtained at S₄C₂, S₄C₃ and S₂C₂ treatments respectively (Figures 3,4 and 6).

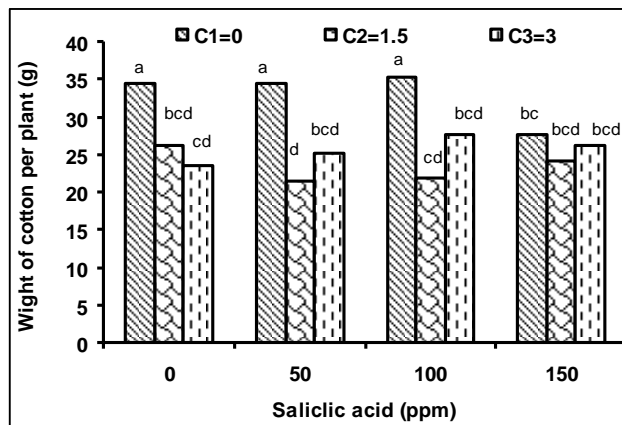


Figure 5: Interaction between salicylic acid and calcium chloride on weight of cotton per plant

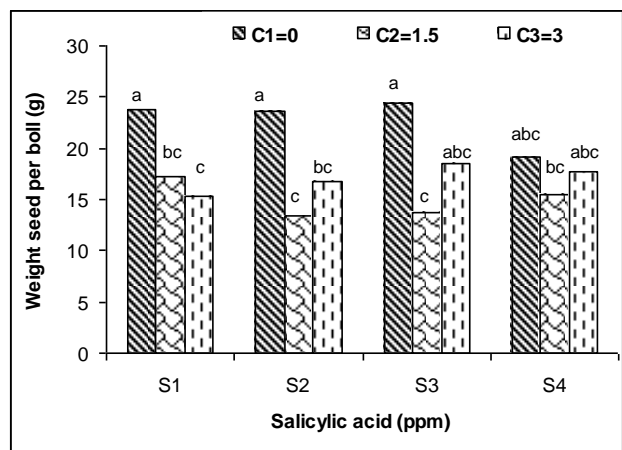


Figure 6: Interaction between salicylic acid and calcium chloride on weight of seed per boll

Calcium appears to play a central role in many defense mechanisms that are induced by environmental stresses and Ca²⁺ signaling is required for the acquisition of plant tolerance (Delian *et al.*, 2014). Calcium is the essential nutrient taken up by the roots and used as direct inorganic osmotic solutes for osmotic adjustment. Exogenous calcium enhances the plant resistance for stresses, such as salt, drought, and heavy metals by inducing the antioxidant enzyme activities (Jiang and Huang, 2001). Calcium also plays a pivotal role in plant cell division, elongation and maintains the permeability of cell membrane (El-Beltagi and Mohamed, 2013).

5. CONCLUSION

In this experiment, it was found that salicylic acid and calcium chloride can improve the growth and function of cotton in a saline soil. Calcium chloride had a positive effect and improved grain yield and yield components in cotton, but this effect was only on C₂=1.5 g/L. After that, its effect decreased with increasing calcium concentration. Instead of calcium chloride, it was found that the foliar application of salicylic acid has a better and greater effect on cotton and its effect was up to S₄=150ppm. And in all the traits that were measured, this trend was observed. Then it can be concluded that, foliar application of salicylic acid until S₄=150ppm and calcium chloride until C₂=1.5g/L had the greatest effect on the cotton plant.

REFERENCES

Abbaszadeh, B., Layeghhaghighi, M., Azimi, R., Hadi, N., 2020. Improving

water use efficiency through drought stress and using salicylic acid for proper production of *Rosmarinus officinalis* L. *Ind Crop Prod.*, 144, Pp. 111893. <https://doi.org/10.1016/j.indcrop.2019.111893>

Cousson, A., 2009. Involvement of phospholipase C-independent calcium-mediated abscisic acid signaling during Arabidopsis response to drought. *Biol Plant.*, 53, Pp. 53-62. doi:10.1007/s10535-009-0008-0.

Dianat, M., Saharkhiz, M.J., Tavassolian, I., 2016. Salicylic acid mitigates drought stress in *Lippia citriodora* L.: effects on biochemical traits biology and essential oil yield. *Biocatal Agric Biotechnol.*, 8, Pp. 286-293. <https://doi.org/10.1016/j.bcab.2016.10.010>

Delian, E., Chira, A., Badulescu, L., Chira, L., 2014. Calcium alleviates stress in plants: Insight into regulatory mechanisms. *Agro Life Sci. J.*, 3, Pp. 19-28.

El-Beltagi, H.S., Mohamed, H.I., 2013. Alleviation of cadmium toxicity in *Pisum sativum* L. seedlings by calcium chloride. *Not Bot Horti Agrobot Cluj-Napoca.*, 41, Pp. 157-168. doi: 10.15835/nbha4118910

El-Tayeb, M.A., 2005. Response of barley grains to the interactive effect of salinity and salicylic acid. *Plant Growth Regul.*, 45, Pp. 215-24. doi.org/10.1007/s10725-005-4928-1

Fan, H., Ding, L., Xu, Y., Du, C., 2017. Seed germination, seedling growth and antioxidant system responses in cucumber exposed to Ca(NO₃)₂. *Hort Environ Biotechnol.*, 58, Pp. 548-559. doi: 10.1007/s13580-017-0025-4

Hayat, S., Ahmad, H., 2007. *Salicylic acid: A Plant Hormone*. Springer, Dordrecht, The Netherlands.

Heidari, M., Amirfazli, N., Gorbani, H., Zafarian, F., 2019. Calcium chloride and drought stress changed grain yield and physiological traits in sesame (*Sesamum indicum* L.). *Sci Agric Bohem.*, 50, (4), Pp. 211-218. doi.org/10.2478/sab-2019-0029

Khan, M.I.R., Asghe, M., Khan, N.A., 2014. Alleviation of salt-induced photosynthesis and growth inhibition by salicylic acid involves glycinebetaine and ethylene in mungbean (*Vigna radiata* L.). *Plant Physiol Biochem.*, 80, Pp. 67-74. doi: 10.1016/j.plaphy.2014.03.026

Khan, W., Prithiviraj, B., Smith, D. L., 2003. Photosynthetic responses of corn and soybean to foliar application of salicylates. *J Plant Physiol.*, 160, Pp. 485-492. doi: 10.1078/0176-1617-00865

Kobeasy, M.I., El-Beltagi, H.S., El-Shazly, M.A., Khattab, E.A.H., 2011. Induction of resistance in *Arschis hypogaea* L. against Peanut Mottle Virus by nitric oxide and salicylic acid. *Physiol Mol Plant Pathol.*, 76 (2), Pp. 112-118. doi.org/10.1016/j.pmp.2011.07.005

Jiang, Y.W., Huang, B.R., 2001. Effects of calcium on antioxidant activities and water relations associated with heat tolerance in two cool-season grasses. *J Exp Bot.*, 52, Pp. 341-349. doi.org/10.1093/jexbot/52.355.341

Natr, L., Lawlor, D.W., 2005. Photosynthetic plant productivity. In: *Handbook of Photosynthesis*, 2nd (Ed.): M. Pessaraki. C.R.C. Press, New York, USA, Pp. 501-524.

Saruhan, N., Saglam, A., Kadioglu, A., 2012. Salicylic acid pretreatment induces drought tolerance and delays leaf rolling by inducing antioxidant systems in maize genotypes. *Acta Physiol Plant.*, 34, Pp. 97-106. doi.org/10.1007/s11738-011-0808-7

Saheri, F., Barzin, G., Pishkar, L., Boogar, M.M.A., Babaeekhou, L., 2020. Foliar spray of salicylic acid induces physiological and biochemical changes in purslane (*Portulaca oleracea* L.) under drought stress. *Biologia.*, 75, Pp. 2189-2200. doi.10.2478/s11756-020-00571-2

Siddiqui, M.H., Al-Whaibi, M.H., Basalah, M.O., 2011. Interactive effect of calcium and gibberellin on nickel tolerance in relation to antioxidant systems in *Triticum aestivum* L. *Protoplasma.*, 248, Pp. 503-511. doi:10.1007/s00709-010-0197-6

Singh, B., Usha, K., 2003. Salicylic acid induced physiological and biochemical changes in wheat seedlings under water stress. *Plant Growth Regul.*, 39, Pp. 137-141. doi:10.1023/A:1022556103536

Tan, W., Meng, Q.W., Brestic, M., Olsovska, K., Yang, X.H., 2011. Photosynthesis is improved by exogenous calcium in heat stressed tobacco plants. *J Plant Physiol.*, 168, Pp. 2063-2071. doi:

10.1016/j.jpiph.2011.06.009

Upadhyaya, H., Panda, S.K., Dutta, B.K., 2011. CaCl₂ improves post drought recovery potential in *Camellia sinensis* (L) O Kuntze. *Plant Cell Rep.*, 30, Pp. 495-503. doi:10.1007/s00299-010-0958-x

Wang, C., Isoda, A., Wang, P., 2004. Growth and yield performance of some cotton cultivars in Xinjiang, China, an arid area with short growing period. *J Agron Crop Sci.*, 190, Pp. 177-183. doi.org/10.1111/j.1439-037X.2004.00090.x

Zehra, A., Gul, B., Ansari, R., Khan, M.A., 2012. Role of calcium in alleviating effect of salinity on germination of *Phragmites karka* seeds. *S Afr J Bot.*, 78, Pp. 122-128. doi: 10.1016/j.sajb.2011.05.016

Zhou, B., Guo, Z., 2009. Calcium is involved in the abscisic acid induced ascorbate peroxidase, superoxide dismutase and chilling resistance in *Stylosanthes guianensis*. *Biol Plant.*, 53, Pp. 63-68. doi:10.1007/s10535-009-0009-z.

