GSC Advanced Research and Reviews

eISSN: 2582-4597 CODEN (USA): GARRC2

Cross Ref DOI: 10.30574/gscarr

Journal homepage: https://gsconlinepress.com/journals/gscarr/

(Research Article)

Impact of salicylic acid on Echinacea (*Echinacea purpurea* L.) plant germination at different salt levels

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GSC Advanced Research and Reviews, 2024, 21(02), 366–372

Publication history: Received on 13 October 2024; revised on 20 November 2024; accepted on 22 November 2024

Article DOI: https://doi.org/10.30574/gscarr.2024.21.2.0450

Abstract

The purpose of this study was to determine how applying salicylic acid (SA) at different salt (NaCl) concentrations affected the germination and other physiological characteristics of Echinacea (*Echinacea purpurea* L.) seeds. Four distinct SA applications (0, 50, 100, and 150 mM) and four distinct NaCl concentrations (0, 50, 100, and 150 mM) were employed in the study for each application. The following factors were examined in the study: root length (cm), stem length (cm), germination period (day), and germination rate (%).

Higher salt concentrations had a detrimental influence on germination, according to this experiment. Moreover, 50 mM and 100 mM SA treatments showed favorable impacts on germination and other metrics. The germination of fenugreek plants in saline settings has been observed to be positively impacted by the optimum delivery of SA.

Keywords: Echinacea; *Echinacea purpurea L;* Salicylic acid (SA); NaCl; Chemistry

1. Introduction

Native to North America, Echinacea is a herbaceous perennial plant that is frequently used for perennial gardening, wild flower propagation, and occasionally as a cut flower (Wartidiningsih and Geneve, 1994; Fariman et al., 2011). Due to its immunostimulatory, antiviral, and antibacterial benefits for humans (Li, 1998; Percival, 2000), it is also a significant medicinal herb that has recently gained international recognition. Since 1930, it has been used as a medicinal plant to reduce upper respiratory infections in humans and control influenza (Fugeh-Berman, A. 2003). According to Wills and Stuart (1999) and Letchamo et al. (2002), Echinacea is widely grown commercially in the United States, Canada, Europe, Russia, and Australia.

Salinity stress is a type of environmental stressor that belongs to the chemical stress group that affects cultivated plants. The growing environment's high salt content has a number of detrimental impacts (Kara et al., 2019). Enzyme activation problem, nutritional imbalance, membrane dysfunction, general metabolic process disruptions, osmotic incompatibility, water intake imbalance, oxidative stress, and overall developmental failure are some of these adverse impacts (Orcutt and Nilsen, 2000).

According to some research, when Calcium, K, or P-containing compounds are applied externally to plants under salt stress, they compete with sodium in the plant's leaves and roots and decrease its uptake. As the plant's levels of these ions rise to a point where it can withstand stress, the plant's ability to do so also increases (Hasegawa and Bressan,

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2000; Kaya et al., 2001; Kaya and Higgs, 2003). According to a study (Niu and Rodriguez, 2006), *Echinacea purpurea* exhibits good development with rising salt levels in the fall but has poor resistance to salinity in the summer.

Additionally, it has been found that *E. purpurea* exhibits a moderate level of resistance to salinity at low temperatures and periods of low light intensity at various salinity levels, such as CaCl and NaCl (Zollinger et al., 2007). Additionally, it has been reported that NaCl salinity in echinacea decreases plant growth while increasing the accumulation of cichoric and chlorogenic acids in the roots (Montanari et al., 2008).

Both high and low temperatures have been observed to aid in seed germination when salicylic acid is applied (Korkmaz, 2005; Özdener and Kutbay, 2008; Ekinci et al. 2011). Salicylic acid is a phenolic molecule that acts as a phytohormone, assisting in the regulation of several phases of growth and development, including as photosynthesis, respiration, flowering, and senescence, of which germination is a crucial part (Rivas-San Vicente & Plasencia, 2011). Using salicylic acid as a priming therapy has been shown in numerous studies to reduce the effects of salinity on plants (Jini and Joseph, 2017; Anaya et al. 2018).

The purpose of this study was to ascertain the impact of applying, salicylic acid on the germination of Echinacea (*Echinacea purpurea L.*) seeds at varying salt concentrations.

2. Material and methods

The study was carried out in 2024 at the Medicinal and Aromatic Plants Laboratory of Balıkesir University Altınoluk Vocational School. Seeds of Echinacea were employed as plant material. In the study, priming applications (SA), four distinct concentrations (0, 50, 100, and 150 mM) NaCl and priming application were taken into consideration. Salt stress was produced using analytical grade NaCl. The seeds were surface sterilized in a 5% sodium hypochlorite solution for ten minutes before to germination (Uyanık et al., 2014). According to Nazarian (2016), seeds that had been surface sterilized were held in varying concentrations of SA solutions for 12 hours in order to prime them. After that, they were dried on drying papers at room temperature for 24 hours in order to restore their original moisture content. Following these treatments, the seeds were sown in petri plates at a temperature of 20±1 °C. Seeds were first deemed viable based on ISTA (1996) guidelines. Four-by-twenty-five seeds were germination tested for fourteen days in petri dishes sandwiched between two layers of blotting paper (ISTA, 1996). This study looked at the following values: average germination time (cm), root length (cm), stem length (cm), germination power (%), germination rate (%), and germination index (%). By dividing the total number of sowed seeds by the number of germinated seeds acquired on the 7th and 14th days, germination power and germination rate were calculated (Akıncı and Çalışkan, 2010). The TARIST statistical tool was used to statistically examine the experiment's data. The means were compared using the LSD test.

3. Results

3.1. Effect of Salicylic Acid on Germination Rate

The investigation showed that the differences between NaCl doses, salicylic acid doses, and the NaCl x SA interaction should be examined at the 5 % significant level with regard to the germination rate of Echinacea seeds in different concentrations of NaCl solution (Table 1).

Table 1 Salicylic acid's impact on the rate of seed germination (%)*

NaCL /SA	0 mM	50 mM	100 mM	150 mM	Means
0 mM	75.00 b	78.00 a	78.00 a	64.00 d	73.75 a
50 mM	71.00 c	75.00 b	75.00 b	60.00 e	70.25 b
100 mM	66.00 d	69.00 cd	70.00 c	52.00 f	64.25 c
150 mM	50.00 fg	53.00 f	61.00 e	47.00 g	52.75 d
Means	65.50 c	68.75 b	71.00 a	55.75 d	

LSD $_{NaCl}$: 2.486; LSD $_{SA}$: 1.875; LSD $_{Int.}$: 3.451; *There is no statistical (p ‹0.05) differences between values with the same letters in the same colums.

When the average NaCl concentrations were examined, the highest germination rate was 73.75 % at 0 mM NaCl and the lowest was 52.75 % at 150 mM NaCl.

The greatest germination rate, 71.00 %, was observed at 100 mM salicylic acid (SA), while the lowest germination rate, 55.75 %, was observed at 150 mM SA, when comparing the average salicylic acid dosages. Investigating the NaCl x SA interaction revealed that the germination rate was 47.00 % in the 150 mM x 150 mM interaction and 78.00 % in the 0 mM x 50 mM and 0 mM x 100 mM interaction.

3.2. Effect of Salicylic Acid on Germination Time

The study's findings suggested that, in order to account for variations in NaCl dosages, salicylic acid dosages, and the NaCl x SA interaction, the germination times of Echinacea seeds in NaCl solution with different concentrations should be evaluated at the 5 % significant level (Table 2).

When the average NaCl concentrations were examined, the earliest germination period was 4.96 days in 0 mM NaCl and the latest germination time was 6.78 days in 150 mM NaCl.

By analyzing the typical dosages of salicylic acid, the earliest germination periods were 5.25 days in 50 mM SA and 5.21 days in 100 mM SA; the latest germination day was 6.22 days in 150 mM SA.

The NaCl x SA interaction was found to have the earliest germination dates of 4.36 days for the 0 mM x 100 mM interaction and 7.20 days for the 150 mM x 0 mM interaction.

Table 2 Salicylic acid's effect on the germination period of seeds (days)*

NaCL /SA	0 mM	50 mM	100 mM	150 mM	Means
0 mM	5.10 g	4.85 h	4.36 k	5.52 f	4.96 d
50 mM	5.35 f	4.55 ik	4.72 hi	5.86 ef	5.12 c
100 mM	6.12 e	5.24 fg	5.08 gh	6.58 c	5.76 b
150 mM	7.20 a	6.35 d	6.67 c	6.90 b	6.78 a
Means	5.94 b	5.25 c	5.21 c	6.22 a	

LSD_{NaCl}: 0.136; LSD_{SA}:0.068; $LSD_{Int.}$: 0.283; *There is no statistical (p ‹0.05) differences between values with the same letters in the same colums.

3.3. Effect of Salicylic Acid on Root Length

The study found that variations in the quantities of salicylic acid, NaCl, and the NaCl x SA interaction were examined at the 5 % significant level when comparing the root length of Echinacea seeds in NaCl solution with different concentrations (Table 3). When examining average NaCl concentrations, the longest measured root length was 1.78 cm in 0 mM NaCl, and the shortest was 1.14 cm in 150 mM NaCl.

Table 3 Salicylic acid's impact on root length (cm)*

NaCL /SA	**0 mM**	**50 mM**	**100 mM**	**150 mM**	**Means**
0 mM	1.75 bc	1.82 a	1.84 a	1.72 c	1.78 a
50 mM	1.63d	1.78 b	1.82 a	1.65 d	1.72 b
100 mM	1.38 f	1.44 e	1.72 c	1.32 g	1.47 c
150 mM	1.05 i	1.15 hi	1.18 h	1.16 h	1.14 d
Means	1.45 c	1.55 b	1.64 a	1.46 c	

LSD_{NaCl}: 0.051; LSD_{SA}:0.074; $LSD_{Int.}$: 0.036; *There is no statistical (p ‹0.05) differences between values with the same letters in the same colums.

The biggest root length was 1.64 cm in 100 mM SA, the shortest was 1.46 cm in 150 mM SA, and the smallest was 1.45 cm in 0 mM SA, according to an analysis of the usual salicylic acid dosages. The longest root lengths in the NaCl x SA were 1.84 cm in the interaction between 0 mM and 100 mM, 1.82 cm in the interaction between 50 mM and 100 mM, and 1.82 cm in the interaction between 0 mM and 50 mM. In contrast, in the 150 mM x 0 mM interaction, the smallest root length was 1.05 cm.

3.4. Effect of Salicylic Acid on Stem Length

According to the study's findings, Echinacea seed stem length in NaCl solution at different concentrations should be compared at the 5 % significant level for both the NaCl x SA interaction and the dosages of salicylic acid and NaCl (Table 4).

Table 4 Salicylic acid's effect on stem length (cm)*

NaCL /SA	0 mM	50 mM	100 mM	150 mM	Means
0 mM	1.51 c	1.58 b	1.62 a	0.67 h	1.35 a
50 mM	1.37 de	1.44 d	1.41 d	0.58 i	1.20 b
100 mM	0.89 g	1.09 f	1.33 e	0.45 k	0.94 c
150 mM	0.63 g	0.65 h	0.64 hg	0.41 l	0.58 d
Means	1.10 c	1.19 b	1.25 a	0.53 d	

LSD $_{NaCl}$: 0.133; LSD $_{SA}$:0.042; LSD $_{Int.}$: 0.038; *There is no statistical (p ‹0.05) differences between values with the same letters in the same colums.

When the average NaCl values were examined, the longest stem measured 1.35 cm in 0 mM NaCl and the smallest 0.58 cm at 150 mM NaCl. When the average salicylic acid dosages were examined, the maximum stem length was 1.25 cm in 100 mM SA and the minimum stem length was 0.53 cm in 150 mM SA. Investigating the NaCl x SA interaction revealed the lowest stem length in the 150 mM x 150 mM interaction and the longest stem length in the 0 mM x 100 mM interaction. These measurements were, respectively, 1.62 cm and 0.41 cm.

4. Discussion

Although echinacea seeds grown under stress have a 97 % germination rate, plants grown under stress can have an 82 % germination rate (Bewley, 1997; Samfield et al., 1990). On the other hand, wild echinacea genotypes have a substantially lower germination rate. Dormancy is the cause of the low germination rate in echinacea seeds; nevertheless, it has been observed that applying cold stratification (Wartidiningsih et al., 1994) and ethephon (Feghahati and Reese, 1994) prior to germination breaks dormancy and increases germination rate. Direct field sowing of echinacea seeds results in significant issues with germination and emergence due to their high rate of dormancy (Smith-Jochum and Albrecht, 1987; Altwater, 1980). This issue has been attempted to be resolved chemically and physically, and it has been noted that GA_3 sprays have no effect on germination (Duan et al., 2004; Kochankov et al., 1998) and actually encourage germination (Macchia et al., 2001; Smith-Jochum and Albrecht, 1987).

The parameters examined in this study were found to suffer when rising SA concentrations were combined with growing salt concentrations. Salicylic acid reduces oxidative damage, which helps seeds germinate under high salt stress conditions (Lee et al., 2010).

As shown by (Demirkaya and Arslan 2021), Farahbakhsh (2012), Jam et al. (2012), Soliman et al. (2016), Ramanujam et al. (1998), Mendoza et al. (2002), Tari et al. (2002), El-Tayeb (2005), and Fariman et al. (2011), the findings of this study are in line with the literature.

5. Conclusion

Consequently, it was discovered that the echinacea seeds root and hypotcyl lengths, germination rate and number of days to germination were all adversely impacted by rising NaCl concentrations, but that they peaked in 50 and 100 mM SA treatments. It was discovered that the germination of Echinacea plants in saline conditions might be positively impacted by the correct application of SA.

Compliance with ethical standards

Acknowledgments

We would like to thank Departments of Plant and Animal Production, Balıkesir University, Altınoluk Vocational School, Medicinal and Aromatical Plant Programme for their support in the conduct of this research.

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Akıncı IE, Calıskan U, 2010. Effect of lead on seed germination and tolerance levels in some summer vegetables. Ekoloji Dergisi, 19: 164-172.

[2] Altwater, B. R. 1980. Germination, dormancy and morphology of the seeds of herbaceous ornamental plants. Seed Sci Technol, 8: 523-573.

[3] Anaya F, Fghire R, Wahbi S, Loutfi K, 2018. Influence of Salicylic Acid on Seed Germination of *Vicia faba* L. under Salt Stress. Journal of the Saudi Society of Agricultural Sciences, 17 (1):1-8.

[4] Demirkaya, M. ve Arslan M. 2021. Ekinezya (Echinacea purpurea) Tohumlarının Çimlenmesi Üzerine Ozmotik Koşullandırmanın Etkisi. Bursa Uludag Üniv. Ziraat Fak. Derg., 35(2), 265-276.

[5] Duan, C. R., Wang, B. C., Liu W. Q., Chen, J., Lian, J., Zhao, H. 2004. Effect of chemical and physical factors to improve the germination rate of Echinacea angustifolia seeds. Colloid Surf B: Biointerface 37: 101-105.

[6] Ekinci M, Yıldırım E, Dursun A, 2011. Effects of Different Salicylic Acid and Temperature Applications on Seed Germination in Some Cool Climate Vegetable Species. Türkiye IV. Seed Production Congress, p:154-160, 14-17 June, Samsun.

[7] El-Tayeb MA, 2005. Response of barley grains to the interactive effect of salinity and salicylic acid. Plant Growth Regulation, 45: 215–224.Bewley, J. D. 1997. Seed germination and dormancy. Plant Cell. 9: 1055–1066.

[8] Farahbakhsh H, 2012. Germination and Seedling Growth in Unprimed and Primed Seeds of Fennel as Affected by Reduced Water Potential Induced by NaCl. International Research Journal of Applied and Basic Sciences, 3 (4): 737-744.

[9] Fariman, ZK, Azizi M and Noori, S. 2011. Seed Germination and Dormancy Breaking Techniques for Echinacea purpurea L. J. BIOL. ENVIRON. SCI., 2011, 5(13), 7-10.

[10] Feghahati, S. M. J. Reese, R. N. 1994. Ethylene-, Light-, and prechill-enhanced germination of Echinacea angustifolia seeds. J. Amer Soc. Hort. Sci, 119: 853-858.

[11] Fugeh-Berman A (2003). Echinacea for the prevention of upper respiratory infection. Seminars in integrative Medicine1 (2):106-111.

[12] Hasegawa, P.P., & Bressan, R.A. (2000). Plant cellular and molecular responses to high salinity. The Annual Review of Plant Biology, Plant Molecular Biology, 51:463-499.

[13] ISTA 1996, International rules for seed testing, Edition 1996/6, International Seed Testing Association, Zurich. Switzerland, pp: 196.

[14] Jam B, Shekari F, Azimi M, Zangani E, 2012. Effect of Priming by Salicylic Acid on Germination and Seedling Growth of Safflower Seeds under $CaCl_2$ Stress. Internatıonal Journal of Agrıcultural Research And Revıews, 2: 1097-1105.

[15] Jini D, Joseph B, 2017. Physiological Mechanism of Salicylic Acid for Alleviation of Salt Stress in Rice. Rice Science, 24 (2): 97-108.

[16] Kaya, C., Higgs, D., & Kirnak, H. (2001). The effects of high salinity and supplementary phosphorus and potassium on physiology and nutrition development of spinach. Bulgarian Journal of Plant Physiology, 27(3-4):47–59.

[17] Kaya, C., & Higgs, D. (2003). Supplementary potassium nitrate improves salt tolerance in bell pepper plants. Journal of Plant Nutrition, 26(7):1367-1382.

[18] Kochankov, V. G., Grzesik, M., Chojnowski, M, Nowak, J. 1998. Effect of temperature, growth regulators and other chemicals on Echinacea purpurea (L.) Moench seed germination and seedling survival. Seed Sci Technol ,26: 547-554.

[19] Korkmaz A, 2005. Inclusion of Acettyl Saliycilic Acid and Methyl Jasmonate into the Priming Solution Improves Low Temperature Germination and Emergence of Sweet Pepper. Hortscience, 40(1):197-200.

[20] Lee S, Kim S, Park C, 2010. Salicylic Acid Promotes Seed Germination Under High Salinity By Modulating Antioxidant Activity In Arabidopsis, New Phytologist, 188 (2):626-637.

[21] Letchamo WL, Polydeonny LV, Gladisheva NO, Arnason TJ, Liversey AJ, and Awang, DVC (2002). Factors affecting Echinacea quality. In: Janick, J., Whipkey, A. (Eds.), Trends in New Crops and New Uses. ASHS Press, Alexandria, VA, USA, pp. 514–521.

[22] Li TSC (1998). Echinacea: cultivation and medicinal value. Hort Technology. 8, 22–129.

[23] Macchia, M., Angelini L. G., Ceccarini, L. 2001. Methods to overcome seed dormancy in Echinacea angustifolia DC. Scientia Hort, 89: 317-324.

[24] Mendoza AB, Rodriguez HR, Torres VR, Davila J H, Mezquitic JGR, Tellez EB, Rangel AS, Garcia MAB, 2002. Seed Treatment with Salicylates Modifies Stomatal Distrubution, Stomatal Density, Seedlings. Proceedings of the 16th International Pepper Conference Tampico, Tamaulipas, Mexico, November 10-12.

[25] Montanari, M., Degl'Innocenti, E., Maggini, R., Pacifici, S., Pardossi, A., & Guidi, L. (2008). Effect of nitrate fertilization and saline stress on the contents of active constituents of Echinacea angustifolia DC. Food Chemistry, 107(4):1461-1466.

[26] Nazarian G, 2016. The Effect of Priming Application of Salicylic Acid on the Morphological and Physiological Characteristics of Canola Plant under Salinity Stress, Ege University Institute of Science and Technology, Master's Thesis (Printed).

[27] Niu, G.H., & Rodriguez, D.S. (2006). Salinity and growing medium affected growth and morphology of Gaillardia aristata. Hortscience, 41(4):1071-1071.

[28] Percival SS (2000). Use of Echinacea in medicine. Biochem. Pharmacol. 60, 155–158.

[29] Ramanujam M P, Jaleel V A, Kumaravelu G, 1998. Effect of salicylic acid on nodulation, nitrogenous compounds and related enzymes of Vigna mungo. Biologia Plantarum 41: 307-311.

[30] Rivas-San Vicente M, Plasencia J, 2011. Salicylic Acid beyond Defence: its Role in Plant Growth and Development, Journal of Experimental Botany, 62 (10):3321-3338.

[31] Orcutt, D.M., & Nilsen, E.T. (2000). Physiology of plants under stres: soil and biotic factors. John Wiley & Sons., 684.

[32] Özdener Y, Kutbay HG, 2008. Effect of Salinity and Temperature on Germination of Spergularia marina Seeds and Ameliorating Effect of Ascorbic and Salicylic Acids. Journal of Environmental Biology, 29 (6):959-964.

[33] Samfield, D. M., Zajicek, J. M., Cobb, B. G. 1990a. Germination of Coreopsis lanceolata and Echinacea purpurea seeds following priming and storage. Hort Science, 25: 1605–1606.

[34] Smith-Jochum, C., Albrecht. M.L. 1987. Field establishment of three Echinacea species for commercial production. Acta Hort, 208: 115-20.

[35] Soliman M, Al-Juhani R, Hashash M, Al-Juhani F, 2016. Effect of Seed Priming With Salicylic Acid on Seed Germination and Seedling Growth of Broad Bean (*Vicia faba* L.). International Journal of Agricultural Technology, 12 (6):1125-1138.

[36] Tari I, Csiszár J, Szalai G, Horváth F, Pécsvárad A, Kiss G, Szepesi A, Szabó M, Erdei L, 2002. Acclimation of tomato plants to salinity stress after a salicylic acid pretreatment. Acta Biologica 46(3-4):55-56, Szegediensis.

[37] Uyanık M, Kara ŞM, Korkmaz K, 2014. Determination of Responses of Some Winter Rapeseed (Brassica napus L.) Varieties to Salt Stress during the Germination Period. Journal of Agricultural Sciences, 20 (2014): 368-375.

[38] Wartidiningsih, N, Geneve R. L., Kester, S.T. 1994. Osmotic priming or chilling stratification improves seed germination of purple coneflower. Hortscience, 29: 1445-1448.

[39] Wartidiningsih N, and Geneve RL (1994). Seed source and quality influence germination in purple coneflower [Echinacea purpurea (L.) Moench.]. HortScience. 29 (12): 1443-1444.

[40] Wills RBH, and Stuart DL (1999). Alkylamide and cichoric acid levels in Echinacea purpurea grown in Australia. Food Chem. 67, 385–388.

[41] Zollinger, N., Koenig, R., Cerny-Koenig, T., & Kjelgren, R. (2007). Relative salinity tolerance of intermountain western United States native herbaceous perennials. Hortscience, 42(3):529-534.