Hellenic Plant Protection Journal **18:** 1-9, 2025
DOI 10.2478/hppj-2025-0001

Effect of abiotic factors in seed germination of the medicinal aromatic plant *Ziziphora hispanica* L.

M. Djebbouri[1,2], M. Zouidi[3*] and M. Terras[1]

Summary *Ziziphora hispanica* L. (Lamiaceae) is a medicinal aromatic plant which is native to Algeria in semi-arid regions, Morocco and southern Spain. Despite the medicinal and economic interests as well as the uncertain future that this species may encounter in its natural habitats, various aspects of the biology of its seeds have not been recognized up to date. To fulfill these gaps, seed germination has been studied under the effect of different incubation temperatures, and under the influence of deferential concentrations of water stress and saline stress. The seeds were first incubated at different temperatures (15, 20 and 25°C). Then, at 20°C, germination studies were carried out at various sodium chloride concentrations (0, 25, 50, 75 and 100 Mmol /l) and various solutions of polyethylene glycol (PEG_{6000}) (0, -0.2, -0.4, and-0.6 Mpa). The results showed that *Z. hispanica* seeds were not dormant, and the optimal temperature of germination was 20°C, at which the maximum final germination percentage occurred (94%). A high negative correlation was obtained between the germination percentage and the various concentrations of NaCl. In comparison to other plant species that share its habitats, the results of the water stress impact tests indicate that *Z. hispanica* is very sensitive to water stress, indicating difficulties in germinating in semi-arid and arid regions and that climate change may restrict its natural habitats. The results of this study can serve as guidelines for propagation protocols of this species to support its conservation and cultivation.

Additional keywords: abiotic factors, conservation, germination, *Ziziphora hispanica*

Introduction

Lamiaceae is the fifth largest family of flora in Algeria after Asteraceae, Fabaceae, Brassicaceae and Caryophyllaceae. It is represented by 36 genera in the Algerian flora and 183 taxa (Dobignard and Chatelain, 2010-2013). The genus *Ziziphora* of the Lamiaceae is represented by three species (*Z. hispanica* L., *Z. capitata* L. and *Z. tenuior* L.) in Algeria (Dobignard and Chatelain, 2010-2013).

Ziziphora hispanica is an annual herbaceous plant (Quézel and Santa, 1961-1962) which is native to Morocco, Algeria and southern Spain (Dobignard and Chatelain, 2010-2013, Euro+Med, 2015). In Algeria, it is found in the highlands and the regions of the Saharan Atlas (Quézel and Santa, 1961-1962). It is medicinal and aromatic (Bekhechi *et al.*, 2007; Benlamdini *et al.*, 2014). Several studies have shown its various pharmaceutical activities such as antibacterial (Bekhechi *et al.*, 2007; Rabah *et al.*, 2013; Zenati *et al.*, 2014) anti-fungal (Meratate *et al.*, 2015) or antioxidant (Meratate *et al.*, 2015).

As medicinal plants and their cultivation is becoming popular due to the increased demand for natural products in the world (Tanga *et al.*, 2018), in Algeria, many species of medicinal plants are collected by the local population and herbalists in an anarchic and abusive manner. The combined effect of this overexploitation with climate change makes these species increasingly rare, or threatened with extinction (Bouasla and Bouasla, 2017; Nasrallah *et al.*, 2020). In the arid natural environment which characterizes many regions of Algeria, certain environmental constraints (drought and salinity of the soils) are considered to be the main factors limiting the es-

[1] Laboratory of Water Resources and Environment, Department of Biology, Faculty of Science, University of Saida - Dr Tahar Moulay, Saida, 20000, Algeria.
[2] Conservation of forests in the wilaya of Saida -DGF-Algeria.
[3] Centre de Recherche en Aménagement du Territoire (CRAT), Campus Zouaghi Slimane, Route de Ain el Bey, 25000 Constantine, Algérie.
* Corresponding author: zouidibiologie20@gmail.com
mohamed.zouidi@crat.dz

tablishment and cultivation of plants (Zouidi *et al*., 2020). Moreover, Mediterranean plant communities have exhibited adaptation failures to climate change (Cochrane *et al*., 2015; Dadach and Mehdadi, 2021).

The establishment of medicinal plant cultivation procedures is an alternative measure to ensure the preservation of floristic diversity on the one hand, and the availability of these medicinal plants for commercialization on the other (Rebbas *et al*., 2012; Tanga *et al*., 2018). Multiplication of plant species by seed for commercial propagation, including several medicinal plants, is a simple method (Laghmouchi *et al*., 2017). However, many abiotic factors, such as salt stress, temperature, and water stress affect the germination of medicinal plant seeds (Gorai *et al*., 2011; Said-Al Ahl and Omer, 2011; Laghmouchi *et al*., 2017). Indeed germination is one of plant growth stages more sensitive to salt, severely inhibited by increased salinity (Sosa *et al*., 2005). According to several authors (Botía *et al*., 1998; Jamil *et al*., 2006, Medjebeur *et al*., 2018), salinity affects seed germination by reducing osmotic potential to such an extent that it delays or prevents the absorption of water necessary for the mobilization of nutrients necessary for germination and/or the toxic effects of Na^+ and Cl^- which can be toxic to the embryo. Therefore, information regarding seed germination could be of immense help in the domestication of wild medicinal plants (Sharma and Sharma, 2017).

To our knowledge, no published research has investigated the influence of abiotic factors on the germination of seeds of *Z. hispanica*. In this study, and in order to provide useful information for conservation programs and to promote its cultivation and reintroduction, we assessed the effect of temperature, saline stress and water stress on the germination of *Z. hispanica* seeds.

Materials and methods

Seed collection area

In this study, ripe seeds of *Ziziphora hispanica* L. (Fig. 1) were collected in the Saida region in northwest Algeria in the summer of 2020 (Fig. 2). The climate of this region is semi-arid with typical Mediterranean climatic characteristics, i.e., low precipitation (between 300 and 370 mm/year), a wet and cold winter, and a dry and hot summer (Djebbouri and Terras, 2019).

Collection and preparation of seeds

The largest number of *Z. hispanica* plants were found in the Saida region (more than 200 individuals distributed in 13 locations) where from the seeds were collected (Fig. 2). In the laboratory, the seeds were immediately peeled manually and then sterilized with 5% bleach (sodium hypochlorite) for 1 min, followed by an abundant rinse with distilled and air-dried water before being used in the germination experiments.

Experimental design

To determine the optimum temperature for germination and to test seed dormancy and viability, seed germination of *Z. hispanica* was studied under different incubation temperatures of 15°C, 20°C and 25°C. For water stress four concentrations of PEG_{6000} were used, corresponding to osmotic pressures of -0, -0.2, -0.4 and -0.6 Mpa (Michel and Kaufmann, 1973). To examine the impact of salinity stress, the germination of the seeds was studied under solutions of increasing NaCl concentrations (0, 25, 50, 75 and 100 mmol L^{-1}). For water stress, four concentrations of PEG_{6000} were used, corresponding to osmotic pressures of -0, -0.2, -0.4 and -0.6 Mpa (Michel and Kaufmann, 1973). The germination tests were carried out in Petri dishes, each containing 5 ml of test solutions at 20°C because the temperature experiment revealed that the optimum temperature of germination was 20°C. Each experiment consisted of 90 seeds divided into 3 replicates with 30 seeds per Petri dish.

Expressions of germination results and statistical analyses

Two germination parameters were calculated after 30 days of germination (germination was stabilized on day 21^{st}):

Figure 1. *Ziziphora hispanica* L. (full bloom and seeds).

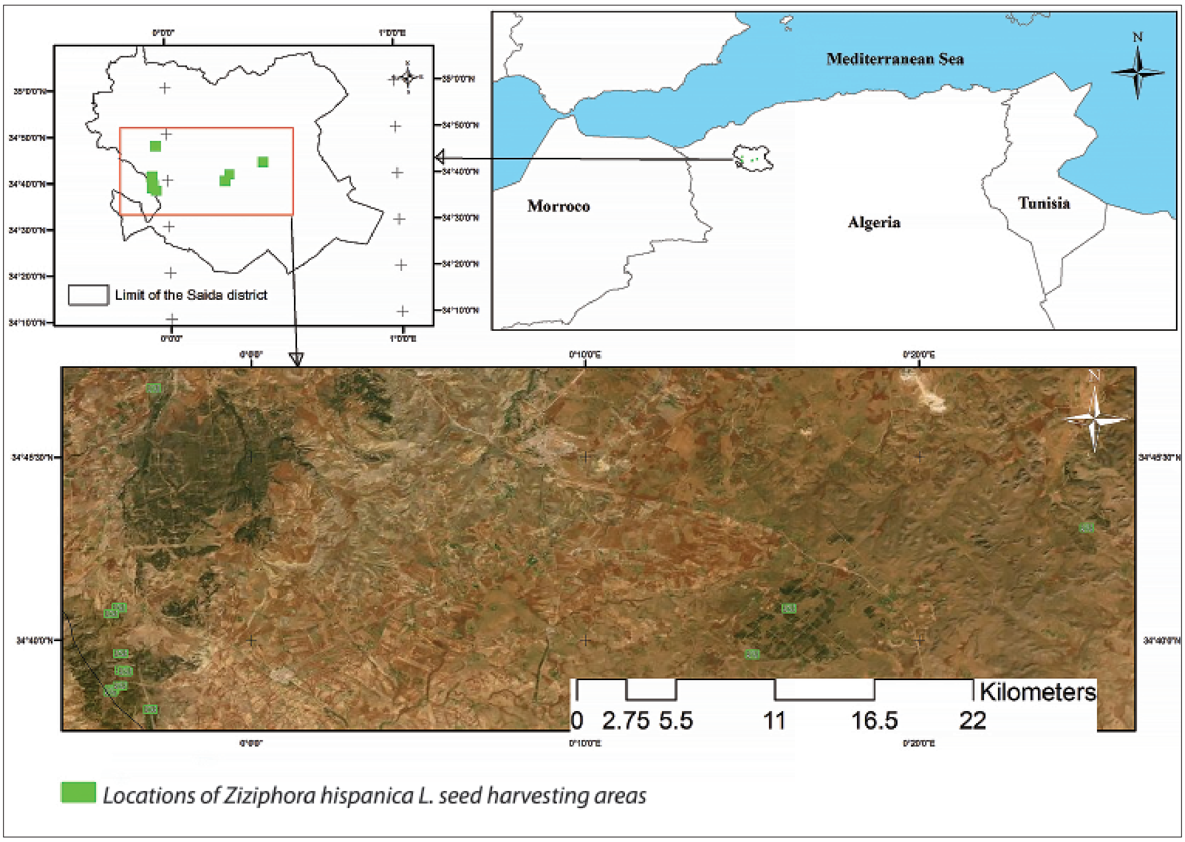

Figure 2. Locations of seed harvesting areas *Ziziphora hispanica* L. in Algeria.

Percentage of germination (GP%) = (number of germinated seeds / total number of seeds) x 100

Mean time of germination (MTG) according to the formula given by Ellis and Roberts (1981):

$MTG = \sum n \times D / \sum n$

Where n: number of newly germinated seeds at time,

D: number of days since the start of the germination test,

Σn: number of seeds that germinated during the germination test.

The lower the MTG value, the faster is the germination (Melendo and Giménez, 2019). Germination percentages and average germination time were calculated with GerminaQuant software (Marques *et al*., 2015). The values for each treatment were calculated as averages of three replicates and were subjected to an analysis of variance (ANOVA). Significant differences between the mean values were tested using the Duncan test. The SPSS version 24 software was used in all analyses and the significance level was set to 0.05.

Results

Effect of temperature on seed germination

The germination rate as a function of the tested temperatures varied significantly (p <0.001). At temperatures of 15 and 25°C, the GP% ranged between 23.33% and 74.44% respectively (Fig. 3). The highest GP% was observed at 20°C (94.44%). The mean MTG at the different test temperatures are shown in Figure 3; it was lower at 20°C compared to 25°C (Fig. 3).

Effect of water stress on seed germination

The highest GP% was recorded in control seeds (96.66%). At the osmotic pressure of -0.2 MPA, the GP% was reduced to 43.33% corresponding to a 55.17% drop compared to the control. The GP% decreased with the increase in the osmotic pressure of the imbibition medium. At the pressure of -0.4 MPA, the reduction in germination reached 96.55%. The germination was completely inhibited at -0.6 MPA (Fig. 4).

Like GP%, the MTG required for germination of *Ziziphora hispanica* L. seeds increased with osmotic pressure. The control seeds germinated faster than those treated with different PEG concentrations (Fig. 4). They required an average of 5.96 days to germinate, whereas, at higher osmotic pressures (-0.2 Mpa and -0.4 Mpa), they germinated after a longer time, 6.99 and 11.33 days, respectively (Fig. 4).

Effect of saline stress on seed germination

The effect of NaCl concentrations on GP% is statistically significant (p< 0.001). Seed GP% decreased in response to increased concentration of NaCl in the imbi-

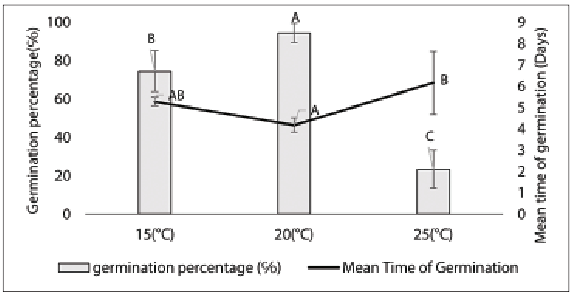

Figure 3. Effect of temperature on percentage and mean time of germination of seeds of *Ziziphora hispanica* L. Bars represent the mean ± S.E. (n = 3). Values with different letters are significantly different at p< 0.05.

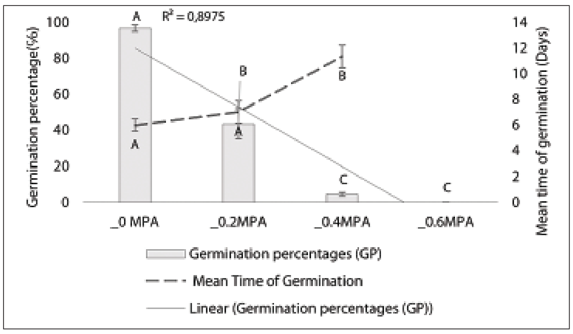

Figure 4. Effect of different water stress on the percentage and the mean time of germination of seeds of *Ziziphora hispanica* L. Bars represent the mean ± S.E. (n = 3). Values with different letters are significantly different at p< 0.05.

bition medium (Fig. 5). The higher the osmotic pressure, the higher was the recorded rate of reduction of germinated capacity (Fig. 5). Indeed, from 25 Mmol /l the influence of salinity was significantly perceptible ($p < 0.001$) with a germination percentage of 66.66% corresponding to a reduction of 26.41%. The germination percentage decreased to a minimum value of 3.33% in seeds treated with 100 Mmol/Na Cl (Fig. 5).

The MTG of Z. *hispanica* seeds increased significantly ($p < 0.001$) with the rise of the salinity of the medium (Fig. 5). In controls, the MTG was 5.58 days whereas germination took 17.66 days at 100 Mmol /l of NaCl (Fig. 5).

Discussion

Effect of temperature

Z. hispanica seeds were not dormant in the context of Baskin and Baskin (2004), since they germinated at high percentages (>74%) over a wide temperature range (15–20°C), with no pre-treatment. This is similar to many other species of the Lamiaceae family in the Mediterranean regions (Laghmouchi *et al*., 2017). Although germination of *Z. hispanica* seeds was possible at temperatures between 15°C and 25°C, a peak of germination percentage was recorded at 20°C.

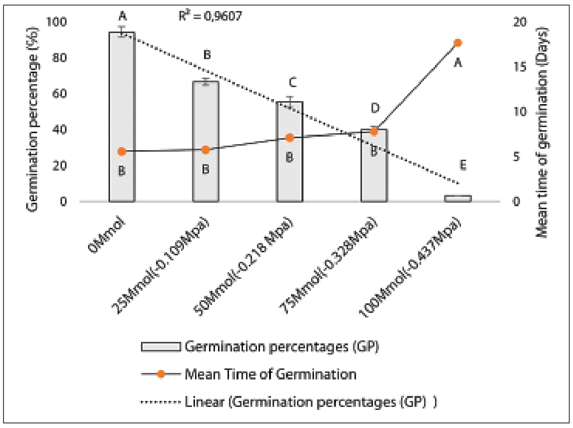

Figure 5. Effect of different saline stress on the percentage and the mean time of germination of seeds of *Ziziphora hispanica* L. Values with different letters are significantly different at $p < 0.05$.

This thermal optimum germination is comparable to some Mediterranean Lamiaceae in arid and semi-arid regions such as *Ballota hirtusa* (Dadach and Mehdadi, 2018), *Marrubium vulgare*, *Sideritis incana* and *Stachys ocymastrum* (Dadach *et al*., 2018), *Thymus maroccanus* Ball. and *Thymus broussonetii* Boiss (Abbad *et al*., 2011). The lowest germination percentage at 25°C indicates that most *Z. hispanica* seeds will probably germinate in late fall and throughout the winter, when temperatures are below 25ºC.

Effect of water stress

Seed germination decreased with increased stress and stopped completely at -0.6 MPa which is considered value of tolerance for germination thresholds. Similar results for seed germination affected by the decline in water potential and high germination rate in the absence of stress, have been reported for several species of the family Lamiaceae in arid regions, such as *Sideritis incana, Stachys ocymastrum,* and *Thymus fontanesii* (Dadach and Mehdadi, 2021) *Thymus maroccanus, T. broussonetii* and *T. serpyllum* (Abbad *et al*., 2011; Dadach *et al*., 2015). Similarly, germination of *Salvia verbenaca*, flourishing in semi-arid Mediterranean climate zones, was also very sensitive to a range of water potential from 0 to -0.6 Mpa: at an osmotic potential of -0.4 Mpa, the germination percentage was 5% and it was completely inhibited at an osmotic potential of -0.6 Mpa (Javaid *et al*., 2018).

Drought tolerance during seed germination is an essential criterion for identifying varieties of species capable of resisting water deficit in the early stages of plant growth (Hamdini *et al*., 2021). In this regard, our results revealed that although *Z. hispanica* is native to the Mediterranean, it will have a great difficulty germinating in arid and semi-arid regions because it would not tolerate a water potential greater than -0.4 Mpa (3.33 %GP). Conversely, *Plantago lanceolata* L. and *Ballota hirsute* Benth, species sharing the same habitats where *Z. hispanica*, are more tolerant to water stress and could germinate at -1 Mpa (Dadach *et al*., 2015: Dadach and

Mehdadi, 2018; Mira *et al.*, 2018).

As the climate change in the Mediterranean Basin results in widespread increases in average temperatures and longer and more frequent drought periods, and decreased rainfall (Pachauri *et al.*, 2014), the germination of *Z. hispanica* has been severely disturbed by water stress. This indicates that climate change restricts its natural habitats and possibly poses a threat to this species.

Effect of salt stress

In arid and semi-arid regions of Algeria, the long-standing drought has clearly led to the salinization of soils. The combination of these two natural stresses is becoming increasingly stressful for the germination and growth of plants in their natural environment (Zouidi *et al.*, 2019). Since the reduction of the germination percentage was significant from the concentration of 25 mmol /L of NaCl and the germination was almost inhibited beyond 100 mmol/l of NaCl, this concentration seems to be the threshold of tolerance to the salinity of this species. The negative response to salinity stress at the germination stage has also been reported for other Lamiaceae species (Laghmouchi *et al.*, 2017; Dadach and Mehdadi, 2018; Dadach *et al.*, 2018; Nedjimi *et al.*, 2020). In addition, similar influence of saline stress at a concentration of 100 Mmol/l of NaCl has been recorded on the germination percentage of semi-arid climate Lamiaceae species growing in Mediterranean climate such as *Marrubium vulgare, Sideritis incana* and *Stachys ocymastrum* (Dadach *et al.*, 2018).

The effect of PEG and NaCl solutions on seed germination under these conditions can be compared with similar osmotic potential. The -0.2 Mpa and -0.4 Mpa PEG solutions had similar osmotic potential with the 50 and 100 Mmol/l NaCl solutions, respectively. Seeds showed similar germination percentages under similar osmotic potentials and this was consistent with what has been reported in other species (Mira *et al.*, 2018, Song *et al.*, 2021).

Conclusion

The results of this study showed that based on its seed germination capacity, Z. *hispanica* seems to be more sensitive under water stress compared to other species that share the same habitats. Thus, future projections of climate change, combined with the abusive collection of this species as a medicinal plant will have a negative impact on the population dynamics of this species in Algeria. However, to extrapolate our results, the effects of temperature, salinity and water stress should be assessed in the laboratory and in the field at later growth stages of this species.

The authors thank the members of Laboratory of Water Resources and Environment, Department of Biology, Faculty of Science, University of Saida and the Forestry Department for this work.

Literature Cited

Abbad, A., Belaqziz, R., Bekkouche, K. and Markouk, M. 2011. Influence of temperature and water potential on laboratory germination of two Moroccan endemic thymes: *Thymus maroccanus* Ball. and *Thymus broussonetii* Boiss. *African Journal of Agricultural Research*, 6(20): 4740-4745.

Baskin, J.M. and Baskin, C.C. 2004. A classification system for seed dormancy. *Seed Science Research,* 14(1): 1-16.

Bekhechi, C., Bekkara, F.A., Abdelouahid, D.E., Liu, K., Casanova, J. and Tomi, F. 2007. Composition and antibacterial activity of the essential oil of *Ziziphora hispanica* (L.) from Algeria. *Journal of Essential Oil Bearing Plants*, 10(4): 318-323.

Benlamdini, N., Elhafian, M., Rochdi, A. and Zidane, L. 2014. Etude floristique et ethnobotanique de la flore médicinale du Haut Atlas oriental (Haute Moulouya). *Journal of Applied Biosciences,* 78: 6771-6787.

Botía, P., Carvajal, M., Cerdá, A. and Martínez, V. 1998. Response of eight *Cucumis melo* cultivars to salinity during germination and early vegetative growth. *Agronomie*, 18(8-9): 503-513.

Bouahmed, A., Vessella, F., Schirone, B., Krouchi, F., and Derridj, A. 2019. Modeling *Cedrus atlantica* potential distribution in North Africa across time: new putative glacial refugia and future range shifts under climate change. *Regional Environmental Change,* 19(6): 1667-1682.

Bouasla, A. and Bouasla, I. 2017. Ethnobotanical survey of medicinal plants in northeastern of Algeria. *Phytomedicine,* 36: 68-81. DOI: 10.1016/j.phymed.2017.09.007.

Cochrane, J.A., Hoyle, G.L., Yates, C.J., Wood, J. and Nicotra, A.B. 2015. Climate warming delays and decreases seedling emergence in a Mediterranean ecosystem. *Oikos,* 124(2): 150-160.

Dadach, M. and Mehdadi, Z. 2018. Germination responses of *Ballota hirsuta* seeds under conditions of temperature, salinity and water stress. *Hellenic Plant Protection Journal*, 11: 34-39.

Dadach, M. and Mehdadi, Z. 2021. Drought tolerance of three ethnomedicinal shrubs evaluated based on their seed germination rates at different drought levels induced by using polyethylene glycol, PEG. *Folia Oecologica,* 48(1).

Dadach, M., Mehdadi, Z. and Adjouj, A.L. 2018. Evaluation of the tolerance to temperature and salinity on seed germination of three Lamiacea from Algerian scrubland. *Advanced Research in Life Sciences,* 2(1): 11-15.

Dadach, M., Mehdadi, Z. and Latreche, A. 2015. Effect of water stress on seed germination of *Thymus serpyllum* L. from Tessala mount. *Journal of Plant Sciences*, 10(4): 151.

Dadach, M., Mehdadi, Z. and Latreche, A. 2015. Germination Responses of *Marrubium vulgare* L. under various water stress conditions. *Journal of Applied Environmental and Biological Sciences*, 5(9): 28-33.

Djebbouri, M. and Terras, M. 2019. Floristic diversity with particular reference to endemic, rare orendangered flora in forest formations of Saïda (Algeria). *International Journal of Environmental Studies,* 76(6): 990-1003.

Dobignard, A. and Chatelain, C. 2010-2013. Index synonymique de la flore d'Afrique du Nord.

Ellis, R. and Roberts, E. 1981. The quantification of ageing and survival in orthodox seeds. *Seed Science and Technology* (Netherlands), 9(2): 373-409.

Euro+Med. 2015. The Euro+Med Plantbase Project.

Gorai, M., Gasmi, H. and Neffati, M. 2011. Factors influencing seed germination of medicinal plant *Salvia aegyptiaca* L. (Lamiaceae). *Saudi Journal of Biological Sciences*, 18(3): 255-260.

Hamdini, A., Mehdadi, Z., Dadach, M. and Latreche, A. 2021. Effect of abiotic stresses on germination behaviour of *Ruta chalepensis*. *Botanica*, 27(1): 23–33.

Jamil, M., Deog Bae, L., Kwang Yong, J., Ashraf, M., Sheong Chun, L. and Eui Shik, R. 2006. Effect of salt (NaCl) stress on germination and early seedling growth of four vegetables species. *Journal of Central European Agriculture,* 7(2): 273–282, DOI: https://doi.org/10.5513/jcea.v7i2.370.

Javaid, M.M., Florentine, S., Ali, H.H. and Weller, S. 2018. Effect of environmental factors on the germination and emergence of *Salvia verbenaca* L. cultivars (verbenaca and vernalis): An invasive species in semi-arid and arid rangeland regions. *PLoS One*, 13(3), e0194319.

Laghmouchi, Y., Belmehdi, O., Bouyahya, A., Senhaji, N.S. and Abrini, J. 2017. Effect of temperature, salt stress and pH on seed germination of medicinal plant *Origanum compactum*. *Biocatalysis and Agricultural Biotechnology,* 10: 156-160.

Marques, F.R.F., Meiado, M.V., Castro, N.M.C.R.D., Campos, M.L.D.O., Mendes, K.R., Santos, O.D.O. D., and Pompelli, M.F. 2015. GerminaQuant: A new tool for germination measurements. *Journal of Seed Science*, 37: 248-255.

Medjebeur, D., Hannachi, L., Ali-Ahmed, S., Metna, B. and Abdelguerfi, A. 2018. Effets de la salinité et du stress hydrique sur la germination des graines de *Hedysarum flexuosum* (Fabaceae). *Revue d'écologie*, 73(3): 318-329.

Melendo, M. and Giménez, E. 2019. Seed germination responses to salinity and temperature in *Limonium supinum* (Plumbaginaceae), an endemic halophyte from Iberian Peninsula. *Plant Biosystems-An International Journal Dealing with all Aspects of Plant Biology*, 153(2): 257-263.

Meratate, F., Lalaoui, A., Rebbas, K., Benmakhbi, L., Bouhadda, A., Souhila, B., Akkal, S., Ouali, E. and Laouer, H. 2015. Antioxidant and antibacterial activities of essential oil and extract of *Ziziphora hispanica* L. of M'sila. *Advances in Environmental Biology*, 9(14): 90-96.

Michel, B.E. and Kaufmann, M.R. 1973. The osmotic potential of polyethylene glycol 6000. *Plant physiology*, 51(5): 914-916.

Mira, S., Veiga-Barbosa, L., González-Benito, M.E. and Pérez-García, F. 2018. Inter-population variation in germination characteristics of *Plantago lanceolata* seeds: effects of temperature, osmotic stress and salinity. *Mediterranean Botany*, 39(2): 89-96.

Nasrallah, Y., Aouadj, S.A. and Khatir, H. 2020. Impact of the exploitation of medicinal plants on biodiversity conservation in Saida and El Bayadh regions, Algeria. *Biodiversity: Research and Conservation*, (60): 11-22.

Nedjimi, B., Souissi, Z.E., Guit B. and Daoud, Y. 2020. Differential effects of soluble salts on seed germination of *Marrubium vulgare* L. *Journal of Applied Research on Medicinal and Aromatic Plants*, 17: 100-250.

Pachauri, R.K., Allen, M.R., Barros, V.R., Broome, J., Cramer, W., Christ, R., Church J.A., Clarke, L., Dahe, Q. and Dasgupta, P. 2014. *Climate change 2014*: synthesis report. *Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change*, Ipcc.

Quézel, P. and Santa, S. 1961-1962. *Nouvelle flore de l'Algérie et des régions désertiques*. Paris.

Rabah, B., Lograda, T., Ramdani, M., Chalard, P. and Feguiredo, G. 2013. Chemical composition and antibacterial activity of essential oil of *Ziziphora hispanica* L. *Global Journal of Research on Medicinal Plants and Indigenous Medicine*, 2(2): 73.

Rebbas, K., Bounar, R. Gharzouli, R., Ramdani, M., Djellouli, Y. and Alatou, D. 2012. Plantes d'intérêt médicinale et écologique dans la région d'Ouanougha (M'sila, Algérie). *Phytothérapie,* 10(2): 131-142.

Said-Al Ahl, H. and Omer, E. 2011. Medicinal and aromatic plants production under salt stress. A review. *Herba Polonica*, 57(1): 72-87.

Sharma, R.K. and Sharma, S. 2017. Seed longevity, germination and seedling vigour of *Rheum australe* D. Don: A step towards conservation and cultivation. *Journal of Applied Research on Medicinal and Aromatic Plants,* 5: 47-52.

Sharma, S., Arunachalam, K., Bhavsar, D. and Kala, R. 2018. Modeling habitat suitability of *Perilla frutescens* with MaxEnt in Uttarakhand—A conservation approach. *Journal of Applied Research on Medicinal and Aromatic Plants*, 10: 99-105.

Song, X., Zhou, G., Shi, L., Ahmad, I., Shi, X., Zhu, G. and Jiao, X. 2021. Comparative effects of salinity and drought on seed germination, seedling growth, photosynthetic productivity, pigments content and antioxidant enzymes of castor bean (*Ricinus communis*). *Crop and Pasture Science*, 72(7): 541-550.

Sosa, L., Llanes, A., Reinoso, H., Reginato, M. and Luna, V. 2005. Osmotic and specific ion effects on the germination of *Prosopis strombulifera*. *Annals of Botany,* 96(2): 261-267.

Tanga, M., Lewu, F., Oyedeji, O. and Oyedeji, O. 2018. Cultivation of medicinal plants in South Africa: A solution to quality assurance and consistent availability of medicinal plant materials for commercialization. *Academia Journal of Medicinal Plants,* 6(7): 168-177.

Zenati, F., Benbelaid, F., Khadir, A., Bellahsene, C. and Bendahou, M. 2014. Antimicrobial effects of three essential oils on multidrug resistant bacteria responsible for urinary infections. *Journal of Applied Pharmaceutical Science*, 4(11): 15-18.

Zouidi, M. Borsali, A.H., Hachem, K., Ayoub, A., Naimi, A. and Hakm, I. 2019. Assessing of the tolerance of *Pinus halepensis* Mill. seeds to water and saline stress at the germination stage. *Forestry Ideas,* 25(1): 160–170.

Zouidi, M., Borsali, A.H., Allam, A., Gros, R., Rebufa, C. and Da Silva, A.M.F. 2020. Comparative Local Case Study of Coniferous Forest Litter of the "*Pinus halepensis* Mill" in Arid and Semi-arid Areas of Western Algeria. *Acta Silvatica et Lignaria Hungarica*, 16(1): 39-50.

Received: 31 October 2021; Accepted: 28 November 2024

Επίδραση αβιοτικών παραγόντων στη βλάστηση των σπόρων του φαρμακευτικού αρωματικού φυτού *Ziziphora hispanica* L.

M. Djebbouri, M. Zouidi και M. Terras

Περίληψη Το *Ziziphora hispanica* L. (Lamiaceae) είναι ένα φαρμακευτικό αρωματικό φυτό, ιθαγενές στην Αλγερία σε ημιξηρικές περιοχές, στο Μαρόκο και στη νότια Ισπανία. Παρά το φαρμακευτικό και οικονομικό ενδιαφέρον καθώς και το αβέβαιο μέλλον που μπορεί να έχει αυτό το είδος στους φυσικούς του βιότοπους, διάφορα θέματα σχετικά με τη βιολογία των σπόρων του δεν είναι γνωστά μέχρι σήμερα. Για να καλυφθούν αυτά τα κενά γνώσης, μελετήθηκε η βλάστηση των σπόρων υπό την επίδραση διαφορετικών θερμοκρασιών επώασης, διαφορετικών συγκεντρώσεων υδατικής καταπόνησης και αλατότητας. Οι σπόροι επωάστηκαν αρχικά σε διαφορετικές θερμοκρασίες (15, 20 και 25°C). Στη συνέχεια, στους 20°C, πραγματοποιήθηκαν μελέτες βλαστικότητας σε διάφορες συγκεντρώσεις χλωριούχου νατρίου (0, 25, 50, 75 και 100 Mmol/l) και σε διάφορα διαλύματα πολυαιθυλενογλυκόλης (PEG6000) (0, -0.2, -0.4, και -0,6 Mpa). Τα αποτελέσματα έδειξαν ότι οι σπόροι του *Z. hispanica* δεν έχουν λήθαργο και η βέλτιστη θερμοκρασία βλάστησης ήταν 20°C, όπου σημειώθηκε το μέγιστο τελικό ποσοστό βλάστησης (94%). Παρατηρήθηκε υψηλή αρνητική συσχέτιση μεταξύ του ποσοστού βλάστησης και των

διαφόρων συγκεντρώσεων NaCl. Σε σύγκριση με άλλα φυτικά είδη που μοιράζονται τους οικοτόπους του, τα αποτελέσματα των δοκιμών επίδρασης υδατικής καταπόνησης δείχνουν ότι το *Z. hispanica* είναι πολύ ευαίσθητο στην υδατική καταπόνηση, υποδεικνύοντας δυσκολία στη βλάστηση σε ημιξηρικές και ξηρικές (άνυδρες) περιοχές και ότι η κλιματική αλλαγή μπορεί να περιορίσει τους φυσικούς του βιότοπους. Τα αποτελέσματα αυτής της μελέτης μπορούν να χρησιμεύσουν ως κατευθυντήριες γραμμές για τα πρωτόκολλα πολλαπλασιασμού αυτού του είδους για την υποστήριξη της διατήρησης και της καλλιέργειάς του.

Hellenic Plant Protection Journal **18:** 1-9, 2025