Pastoral plants for rehabilitation of degraded soil in Tunisia: the case for use of Calicotome villosa and Genista spachiana (Fabaceae)

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Calicotome villosa and Genista spachiana are classified as vulnerable in Tunisia and they are of great interest for the rehabilitation of degraded ecosystems, food for goats and camelids, and for the use of its essential oils in phytotherapy. The aim of this study was to examine the germination characteristics of both species through analysis of the effects of the salt stress and water stress on germination. We monitored and evaluated different germination characteristics (germination percentage, mean time to germination and germination speed) in the presence of the salt and water stress. Calicotome villosa and Genista spachiana can withstand salinity of up to 15 g/l of salt (31–37% germination at 15 g/l) and also tolerate large doses of PEG₆₀₀₀ (30–40% germination at −1.6 MPa: Polyethylene glycol (PEG) is a hydrophilic polymer). The tolerance of the two species to salinity and water stress allows them to be a source of food for goats and camelids during drought.

Keywords: Calicotome villosa, Genista spachiana, arid land forage, salt stress, water stress

INTRODUCTION

Tunisia is among the countries most seriously affected by desertification. Accounting for three quarters of the country (Le Houérou, 1959), southern Tunisia is subdivided into: (i) the arid zone, which covers 5.5 × 10⁴ km² with average annual precipitations between 100 and 350 mm, and (ii) the desert zone, which occupies an area of about 6.5 × 10⁴ km² with an annual average rainfall less than 100 mm (PNUD/FAO, 1979). One of the promising options for restoration of decertified regions in southern Tunisia is to use native shrub and tree species that have multiple functions in the ecosystem. Several species of the legume family (Fabaceae) are of high interest due to their adaptation to arid and semi-arid environments, nitrogen fixing capacity, and ability to grow in poor soils (Ibanez, Passera, 1997). Legumes are of great importance worldwide, especially in countries with a Mediterranean climate like Tunisia, since they contribute to soil fertility and prevention of soil erosion. Several native species of legumes are potentially useful for rehabilitation of degraded ecosystems, food for goats and camelids, and dune stabilization and vegetation. Calicotome villosa is very common in the Mediterranean area (Gibbs, 1968; Tutin, 1972). It is a tall 50–150 cm spiny shrub that produces yellow flowers in spring. It grows especially in North Africa and Spain (Greuter et al., 1989). The species has

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intricate, angular, pubescent branches that are
green when young and become greyish when
mature. It has alternate leaves: the lower leaves
are elongate, oval, trifoliate, and covered with se-
riceous down. The flowers are yellow and have
a bell-shaped calyx, thickly downy legume with
a protuberant upper rib, and round dark oliva-
ceous seeds. *Genista spachiana* is a shrub that
reaches 1–1.5 m and is found in depressions of
deep sandy soil. This species is a dominant pe-
rennial shrub in active sand dunes and stabilized
sand fields in the southern arid zone of Tunisia.
Successful establishment of plants largely
depends on successful germination. Germina-
tion is a crucial stage in the life cycle of plants
and tends to be highly unpredictable over space
and time (Camarada, Valsecchi, 1983). Several
environmental factors including temperature,
salinity, light, and soil moisture simultaneously
influence germination (El-Keblawy and Al-
Rawai, 2005, 2006; Huang et al., 2003; Ungar,
1995; Zia, Khan, 2004). Seed germination be-
haviour in relation to thermal and salt stress is
a very important determinant of the coloniza-
tion capacity of a species (Ungar, 1982, 1995).
Tolerance to salinity during germination is crit-
ical for the establishment of plants growing in
saline soil of arid regions (Khan, Gulzar, 2003;
Ungar, 1995). Increased salinity leads to a re-
duction and/or delay in germination of seeds
of both halophytes and glycophytes. Failure of
germination in saline soils often is a result of
high concentrations of salts in the seed-plant-
ing zone because of the upward movement of
the soil solution and subsequent evaporation at
the soil surface. Seed germination under saline
conditions occurs after high precipitation, when
soil salinity is usually reduced due to leaching
dilution (El-Keblawy, 2004; Huang et al.,
2003; Khan, Ungar, 1996; Redondo et al., 2004).
Although salinity and osmotic stress of arid en-
vironments decrease germination, the detri-
mental effect of salinity and osmotic stress are
generally less severe at optimum germination
temperature (Gorai, Neffati, 2007; Tlig et al.,
2008; Gorai et al., 2009; Maraghni et al., 2010).

This study was conducted to better under-
stand seed germination requirements of *Calico-
tome villosa* and *Genista spachiana*. The effects
of a wide range of salinity and drought levels
on the germination percentage, speed rate (ve-
locity), and mean time to germination of three
provenances of each species were studied to de-
termine their individual effect and the interac-
tion between these factors on germination.

**MATERIALS AND METHODS**

**Plant Material**

Seeds of *Calicotome villosa* were collected in
2013 from two natural habitats, namely Me-
knassi and Bouhedma, while seeds of *Genista
spachiana* were collected from Rtiba. Seeds
of the three provenances differ in morphology
(Table 1). Before the germination tests, dam-
aged and insect-infected seeds were discarded,
and the empty ones were eliminated using floa-
tation in distilled water. Seeds were separated
from fruits and soaked in water for 24 h. These
seeds were sterilised with Benlate (1 g/l) for
20 min and then with 50% sodium hypochlo-
rite for a few minutes and rinsed three times
with distilled water.

**Salinity and drought treatments**

To determine the tolerance of germination
under the salt stress, seeds were sown in NaCl
solution at different concentration: 0 (distilled
water), 3, 6, 9, 12, and 15 g of NaCl added to one
litre of distilled water. The water-stress treat-
ments used were 0 (control), –0.03, –0.1, –0.7,
–1, and –1.6 MPa obtained by adding PEG
6000
to one litre of distilled water. Seeds were placed
in sterile Petri dishes with two discs of filter
paper saturated with distilled water for control
and with NaCl solutions for treatments. NaCl
solutions were renewed every 48 h under sterile
conditions in order to avoid salt accumulation
(Rahman et al., 2008). Five replicates of 20 seeds
each were used for each treatment with 10 ml of
test solution. Seeds were allowed to germinate
in relative humidity of 80% at 25 °C in complete
darkness for 30 days (Maraghni et al., 2010).
A seed was considered to have germinated
when the emerging radicle elongated to 2 mm
(Redondo-Gomez et al., 2007).
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**Methods of germination expression**
Mean time to germination (MTG) calculated as follows:

$$MTG = \sum n_i \times d_i / n$$

where “n” is the total number of germinated seeds during the test, “$n_i$” is the number of germinated seeds on day “$d_i$”, and “i” is the number of days during the germination period (between 0 and 30 days).

**Statistical analysis**
Germination data were arcsine transformed before statistical analysis to ensure homogeneity of variance. Data were analysed using SPSS for Windows, version 11.5 (SPSS, 2002). A two-way analysis of variance (ANOVA) was carried out to test the effects of main factors (effect of salinity on the provenance and effect of drought on the provenance) and their interaction on the final germination percentage. Tukey HSD test was used to estimate significant differences between means.

**RESULTS**

**Effects of salt stress on seed germination**
Salinity significantly ($P < 0.0001$) affected the percentage of germination of *Calicotome villosa* and *Genista spachiana* (Table 2).
Germination in distilled water was the highest. However, it decreased significantly with an increase in NaCl concentrations (Fig. 1). Seeds germinated rapidly in distilled water during the first five days; however, germination was delayed to eight days at concentrations greater than 3 g/l. The highest germination percentage was in distilled water followed by 3, 6, 9, 12 and 15 g/l NaCl. There was a strong negative relationship between germination and salinity. The germination velocity calculated using the Kotowski coefficient showed that the rate decreased with an increase in salinity (Fig. 2).

The results of the ANOVA showed that the salt stress (NaCl treatments) had a significant effect \((P < 0.001)\) on the germination percentage and on mean germination time (Table 3).

Germination was significantly reduced by high NaCl levels and there were no great differences in the final germination percentage between 3 and 9 g/l, thus the germination percentage was reduced with increasing NaCl to levels above 12 g/l (Tukey’s multiple test). A two-way ANOVA of the germination rate indicated a significant effect of salinity but not an interaction between species and salinity (Table 3).

### Effects of osmotic potential on germination

Osmotic potential significantly \((P < 0.001)\) affected the percentage of germination of *Calicotome villosa* and *Genista spachianna* (Table 4), which was highest in distilled water. However, the germination percentage decreased significantly with an increase in osmotic potential.

![Fig. 1. Mean germination percentage of *Calicotome villosa* and *Genista spachianna* seeds in various NaCl concentrations (0, 3, 6, 9, 12, and 15 g/l) at 25 °C. Values (mean ± SEM)](image-url)
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Table 3. Two-way ANOVA of the effects of salinity (S), species (T), and their interaction on germination characteristics of Calicotome villosa and Genista spachianna

| Variable | Characteristics of germination | F-value | P-value | Signification |
|----------|--------------------------------|---------|---------|---------------|
| Species  | Germination percentage         | 1.985   | 0.145   | NS            |
|          | Kotowski coefficient           | 0.591   | 0.557   | NS            |
|          | Mean time to germination       | 4.976   | 0.009   | **            |
| Concentration | Germination percentage | 11.673 | 0.000 | *** |
|          | Kotowski coefficient           | 12.503  | 0.000   | ***            |
|          | Mean time to germination       | 29.097  | 0.000   | ***            |
| Species * Concentration | Germination percentage       | 0.225   | 0.993   | NS            |
|          | Kotowski coefficient           | 0.234   | 0.992   | NS            |
|          | Mean time to germination       | 1.259   | 0.270   | NS            |

Significant difference from control at * P < 0.05, ** P < 0.01, *** P < 0.001 by Tukey’s multiple test. NS = not significant (P > 0.05).

Table 4. Mean germination percentage of Calicotome villosa and Genista spachianna seeds after their transfer from 0, –0.03, –0.1, –0.7, –1, and –1.6 MPa at 25 °C. The data are means ± SE. Different letters indicate significant differences between treatments (osmotic potential) at P < 0.05 according to the Tukey’s multiple test

| Species                     | Osmotic potential (MPa) |
|-----------------------------|-------------------------|
|                             | 0         | –0.03     | –0.1      | –0.7      | –1        | –1.6      |
| Calicotome villosa of Bouhedma | 78 ± 4.062<sup>a</sup> | 65 ± 10.840<sup>b</sup> | 65 ± 8.944<sup>ab</sup> | 56 ± 3.674<sup>abc</sup> | 41 ± 9.407<sup>bc</sup> | 30 ± 4.743<sup>c</sup> |
| Calicotome villosa of Meknassi | 74 ± 4.848<sup>a</sup> | 79 ± 4.359<sup>a</sup> | 65 ± 6.892<sup>ab</sup> | 56 ± 6.595<sup>ab</sup> | 43 ± 8.746<sup>c</sup> | 38 ± 7.517<sup>c</sup> |
| Genista spachianna of Riba   | 78 ± 4.062<sup>a</sup> | 65 ± 6.892<sup>ab</sup> | 55 ± 4.743<sup>ab</sup> | 48 ± 8.746<sup>ab</sup> | 42 ± 9.566<sup>c</sup> | 40 ± 9.618<sup>c</sup> |

<sup>a,b,c</sup> Values in the same row with the same superscript are not significantly different (P > 0.05).
Seeds germinated rapidly in distilled water during the initial first days; however, the start of germination was delayed for 10 days at concentrations than 3 g/l (Fig. 3).

Delay in germination increased with increasing osmotic potential (Fig. 4). The highest germination percentage was in distilled water followed by 0, –0.03, –0.1, –0.7, –1, and –1.6 MPa. However, at –0.03 MPa Calicotome villosa seeds from Meknassi had a germination rate higher than that at 0 MPa. There was a strong negative relationship between the germination percentage and the osmotic potential for both species. The Kotowski coefficient showed that the rate decreased with an increase in osmotic potential. For all three provenances to Calicotome villosa and Genista spachianna, the water stress (PEG) had a significant effect (P < 0.001) on the germination percentage, mean germination time (MGT) and the Kotowski coefficient (Table 4). The germination percentage and speed decreased with a decrease in water potential, this decrease was significant at lower –1 Mpa. The germination percentage for Calicotome seeds from Meknassi was the highest among all treatments (79 was at 0.03 MPa). Also, the germination percentage exceeded 50% at –1 MPa.

A two-way ANOVA indicated a significant

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**Fig. 3.** Mean germination percentage of Calicotome villosa and Genista spachianna seeds in various osmotic potentials (0, –0.03, –0.1, –0.7, –1, and –1.6 MPa) at 25 °C. Values (mean ± SEM)

**Fig. 4.** Mean time to germination and Kotowski coefficient of Calicotome villosa and Genista spachianna seeds in various osmotic potentials (0, –0.3, –0.1, –0.7, –1, –1.6 MPa) at 25 °C
Pastoral plants for rehabilitation of degraded soil in Tunisia: the case for use of *Calicotome villosa*... effect of osmotic potential on the germination rate, but not for the interaction between osmotic potential and species germination percentage (Table 5).

**DISCUSSION**

Salinity stress can affect seed germination through osmotic effects (Welbaum et al., 1990) and by ion-toxicity (Huang and Reddman, 1995). More than 50% of the seeds of *Calicotome villosa* and *Genista spachianna* germinated at the lowest salinity stress (9 g/l) and at the lowest water potential (–1 MPa). This suggested that this species can germinate under low water availability. Other study demonstrated that even the seeds of such desert species as *Ziziphus lotus* at a germination rate of 5% at –1 MPa. (Maraghni et al., 2010). Ibanez and Passera (1997) found that *Anthyllis cystoides* seeds germinated at –1.12 MPa (48%). Similar results were reported for other fabaceae species like *Acacia tortilis* which had no germinated seeds at –0.8 MPa (Jaouadi et al., 2010). This tolerance of water potential (–0.8 MPa) was also observed in other Fabaceae and desert species like *Retama raetam* (Youssef, 2009).

Generally, the salt stress affected the germination capacity and speed of *Calicotome* and *Genista* seeds, and these results agree with these of Lachiheb et al., (2004). In our study, seed germination percentage was higher in NaCl than in PEG at the same water potential. He et al. (2009), demonstrated that NaCl and PEG adversely affected germination, but NaCl had a less inhibitory effect on seed germination than an iso-osmotic solution of PEG. In contrast, Katembe et al. (1998) found that higher concentrations of NaCl (–1 MPa) were more inhibitory to germination of two Atriplex species (*A. halimus* and *A. numelaria*). Seeds of *Calicotome villosa* and *Genista spachianna* responded to salinity in two characteristic ways: first, germination was reduced, and second, at very low concentrations, germination was stimulated. Although higher salinity generally decreases germination, the detrimental effect of salinity is less severe at the optimum germination osmotic potential. The salt stress decreased both the rate and percentage of germination of *Calicotome villosa* and *Genista spachianna*, which agrees with several other studies revealing that halophytes, as well as glycophytes, are sensitive to salt during the germination stage (Ungar, 1995; Katembe et al., 1998; Khan et al., 2002; Gorai, Neffati, 2007; Gorai et al., 2011). Considering the percentage of seeds that germinated at –1 MPa and 12 g/l, we conclude that these two fabaceae species are well adapted to germinate under conditions of water and salt stresses. These abiotic stresses are typical of the environments in which they grow. The arid

| Variable            | Characteristics of germination | F-value | P-value | Signification |
|---------------------|-------------------------------|---------|---------|---------------|
| Species             | Germination percentage        | 0.570   | 0.568   | NS            |
|                     | Kotowski coefficient          | 3.782   | 0.027   | *             |
|                     | Mean time to germination      | 5.040   | 0.009   | **            |
| Concentration       | Germination percentage        | 14.051  | 0.000   | ***           |
|                     | Kotowski coefficient          | 6.330   | 0.000   | ***           |
|                     | Mean time to germination      | 14.731  | 0.000   | ***           |
| Species * Concentration | Germination percentage  | 0.436   | 0.924   | NS            |
|                     | Kotowski coefficient          | 0.766   | 0.661   | NS            |
|                     | Mean time to germination      | 2.340   | 0.019   | *             |

Significant difference from control at *P < 0.05, **P < 0.01, ***P < 0.001 by Tukey's multiple test. NS = not significant (P > 0.05).
lands of Tunisia are widely affected by desertification caused particularly by the degradation of the vegetation cover, deforestation, and drought.

The high ability of *Calicotome villosa* and *Genista spachiana* to germinate over a wide range of environmental conditions provides an opportunity to contribute to future reforestation programmes. *Calicotome villosa* seeds from Meknassi had a higher rate of germination at –0.03 MPa than at 0 MPa compared with non-stressed seeds. Seed germination percentage and the Kotowski coefficient generally decreases as soil water potential decreases (Evans, Etherington, 1990; Oberbauer, Miller, 1982), either by drying or by higher salinity. By increasing water stress, similar results were found for germination of *Diospyros texana* seeds that decreased from about 95% at 0 MPa to 45% at –0.6 MPa (Everitt, 1984). On the other hand, germination of three deciduous semi-shrubs of Artemisia was inhibited severely in PEG₆₀₀₀ solutions at –1.2 MPa (Tobe et al., 2006). An increase in osmolality of PEG₆₀₀₀ solutions results in decreasing both the percentage and the rate of germination *Calicotome villosa* and *Genista spachiana*, indicating that the water stress inhibits germination, which is in agreement with the germination behaviour of most species (Tobe et al., 2006; Gorai et al., 2009; Maraghni et al., 2010). It can be concluded that seeds of *Calicotome villosa* and *Genista spachiana* have the ability to tolerate the salt stress after exposure to NaCl solutions and osmotic potential concentrations. Further investigations are necessary to understand the early establishment of this species under field conditions and to determine if there are differences between the seed germination stage and early seedling growth in response to salinity and drought stress.

**CONCLUSIONS**

Our work demonstrated a relationship between germination properties of seeds and abiotic constraints in *Calicotome villosa* and *Genista spachiana*. *Genista spachiana* is most tolerant to the salt stress in a concentration of 12 g/l. The germination rate of two *Calicotome villosa* provenances and *Genista spachiana* decreases with increasing concentrations of PEG. The water stress affects the germination rate and increases the time required for seed germination of two *Calicotome villosa* and *Genista spachiana*. Even at high concentrations of PEG, seeds of the two species germinated to 30% to 40%. Thus, the species tolerate drought and harsh climatic conditions of the environment. The *Genista spachiana* provenance from Rtiba is more tolerant to water deficit than the *Calicotome villosa* provenance, with the germination rate of 40% at the water potential of –1.6 MPa.

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**References**

1. Badger KS, Ungar IA. The effects of salinity and temperature on the germination of the inland halophyte Hordeum jubatum. Canadian Journal of Botany. 1989; 67: 1420–5.
2. Bayuelo-Jiménez JS, Debouck DG, Lynch JP. Salinity tolerance of Phaseolus species during germination and early seedling growth. Crop Science. 2002; 42: 1584–94.
3. Camarda I, Valsecchi F. Alberie arbusti pondepontanei della Sardegna ed. Gallizzi, Sassari: 403412. 1983.
4. El-Keblawy A, Al-Rawai A. Effects of salinity, temperature and light on germination of invasive Prosopis juliflora (Sw) D.C. J. Arid Environ 2005; 6: 555–65.
5. El-Keblawy A. Salinity effects on seed germination of the common desert range grass, *Panicum turgidum*. Seed Science and Technology. 2004; 32: 943–8.
6. El-Keblawy A, Al-Rawai A. Effects of seed maturation time and dry storage on light and temperature requirements during germination in invasive Prosopis juliflora. Flora. 2006; 20: 135–43.
7. Evans C, Etherington JR. The effect of soil water potential on seed germination of some British plants. New Phytologist. 1990; 115: 539–48.

8. Everitt BS. Introduction to latent variable models. London: Chapman and Hall; 1984. 107 p.

9. Gibbs PE. Taxonomy and distribution of the genus Calicotome. Notes From Royal Botanic Garden. 1968; 28: 275–86.

10. Gorai M, Gasmi H, Neffati M. Factors influencing seed germination of medicinal plant Salvia aegyptiaca L. (Lamiaceae). Saudi Journal of Biological Sciences. 2011; 18: 255–60.

11. Gorai M, Neffati M. Germination responses of Reaumuria vermiculata to salinity and temperature. Ann. Appl. Biol. 2007; 151: 53–9.

12. Gorai M, Tlig T, Neffati M. Influence of water stress on seed germination characteristics in invasive Diplotaxis harra (Forssk.) (Brassicaceae) in arid zone of Tunisia. Journal of Phytology. 2009; 1: 249–54.

13. Gorai M, Vadel MA, Neffati M. Seed germination characteristics of Phragmites communis: effects of temperature and salinity. Belg. J. Bot. 2006; 139: 78–86.

14. Greuter W, Burdet HM, Long G. Med-Checklist: a critical inventory of vascular plants of the circum-mediterranean countries. Dicotyledones (Lauraceae-Rhamnaceae). Vol. 4. Geneva, Switzerland; 1989.

15. He Xq, Du C, Shao Z, Li Q. Effect of salt and water stress on seed germination of Dianthus chinensis L. Academic conference on horticultural science and technology proceedings. 2009; 12: 60–62.

16. Huang J, Redman RE. Salt tolerance of Hordeum and Brassica species during germination and early growth. Can. J. Plant Sci. 1995; 75: 815–819.

17. Huang ZY, Zhang XS, Zheng GH, Gutterman Y. Influence of light, temperature, salinity and storage on seed germination of Haloxylon ammodendron. J. Arid Environ. 2003; 55: 453–64.

18. Ibanez AN, Passera CB. Factors affecting the germination of albaida (Anthyllis cytisoides L.), a forage legume of the Mediterranean coast. J. Arid Environ. 1997; 35: 225–31.

19. Jaouadi W, Hamrouni L, Souayeh N, Khouja ML. Étude de la germination des graines d’Acacia tortilis sous différentes contraintes abiotiques. Biotechnologie Agronomie Société Environnement. 2010; 14: 643–52.

20. Katembe WJ, Ungar IA, Mitchell JP. Effect of salinity on germination and seedling growth of two Atriplex species. Ann. Bot. 1998; 82: 167–71.

21. Khan MA, Gul B, Weber DJ. Germination responses of Salicornia rubra to temperature and salinity. J. Arid Environ. 2000; 45: 207–14.

22. Khan MA, Gul B, Weber DJ. Seed germination in relation to salinity and temperature in Sarcobatus vermiculatus. Biologia Plantarum. 2002; 45: 133–5.

23. Khan MA, Gulzar S. Germination responses of Sporobolus ioclados: a saline desert grass. J. Arid Environ. 2003; 53: 387–94.

24. Khan MA, Rizvi Y. Effect of salinity, temperature, and growth regulators on the germination and early seedling growth of Atriplex griffithii var. stocksii. Can. J. Bot. 1994; 72: 475–9.

25. Khan MA, Ungar IA. Seed polymorphism and germination responses to salinity stress in Atriplex triangularis Willd. Botanical Gazette. 1984; 145: 487–94.

26. Khan MA, Ungar IA. Alleviation of seed dormancy in the desert forb Zygophyllum simplex L. from Pakistan. Ann. Bot. 1997; 80: 395–400.

27. Khan MA, Ungar IA. Seed germination and dormancy of Polygonum aviculare L. as influenced by salinity, temperature, and gibberellic acid. Seed Science and Technology. 1998; 26: 107–17.

28. Lachiheb K, Neffati M, Zid E. Aptitudes germinatives de certaines graminées halophytes spontanées de la Tunisie méditerranéenne. Cahiers OPTIONS méditerranéennes. 2004; 62: 89–93.

29. Le Houérou HN. Recherches écologiques et floristiques sur la végétation de la Tunisie
méridionale. Institut des recherches sahariennes, Alger. 1959. 229 p.

30. Maraghni M, Gorai M, Neffati M. Seed germination at different temperatures and water stress levels, and seedling emergence from different depths of Ziziphus lotus. South African Journal of Botany. 2010; 76: 453–9.

31. Oberbauer S, Miller PC. Effect of water potential on seed germination. Holarct. Ecol. 1982; 5: 218–20.

32. Ourcival JM, Berger A. Equilibrium between soil water potential and predawn water potential of two pre-saharan shrub species of Tunisia. J. Arid Environ. 1995; 30: 175–83.

33. Redondo S, Rubio-Casal AE, Castillo JM, Luque CJ, Alvarez AA, Luque T, Figueroa ME. 2004. Influences of salinity and light on germination of three Sarcocornia taxa with contrasted habitats. Aquat. Bot. 78: 255–64.

34. Redondo-Gómez S, Mateos-Naranjo E, Davy AJ, Fernández-Muñoz F, Castellanos EM, Luque T. Growth and photosynthetic responses to salinity of the salt-marsh shrub Atriplex portulacoides. Ann. Bot. 2007; 100: 555–63.

35. Song J, Feng G, Tian C, Zhang F. Strategies for adaptation of Suaeda physophora, Haloxylon ammodendron and Haloxylon persicum to saline environment during seed germination stage. Ann. Bot. 2005; 96: 399–405.

36. Tlig T, Gorai M, Neffati M. Germination responses of Diplotaxis harra to temperature and salinity. Flora. 2008; 203: 421–8.

37. Tobe K, Li XM, Omasa K. Effects of sodium chloride on seed, germination and growth of two Chinese desert shrubs, Haloxylon ammodendron and Haloxylon persicum (Chenopodiaceae). Aust. J. Bot. 2000; 48: 455–60.

38. Tutin GT, editor. Flora Europea. Cambridge University Press; 1972.

39. Ungar IA. Germination ecology of halophytes. In: Sen, DN, Rajpurohit, KS, editors. Contribution to the ecology of halophytes. Hague: Junk; 1982. p. 143–54.

40. Ungar IA. Seed germination and seed-bank ecology of halophytes. In: Kigel J, Galli G, editors. Seed development and germination. New York: Marcel Dekker; 1995. p. 599–627.

41. Welbaum GE, Tissaoui T, Bradford KJ. Water relations of seed germination in muskmelon (Cucumis melo L.): III. Sensitivity of germination to water potential and abscisic acid during development. Plant Physiol. 1990; 92: 1029–37.

42. Youssef AM. Seed germination of some desert plants from Egypt. Journal of Applied Sciences Research. 2009. 5(2): 144–50.

43. Zia S, Khan MA. Effect of light, salinity, and temperature on seed germination of Limonium stocksii. J. Biolog. 2004; 82: 151–7.

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GANYKLINIŲ AUGALŲ NAUDOJIMAS ATKURIANT NUALINTĄ ŽEMĘ TUNISE: CALICOTOME VILLOSA IR GENISTA SPACHIANA (FABACEAE)

Santrauka

Calicotome villosa ir Genista spachiana yra klasifikuojami kaip pažeidžiami augalai Tuneise. Jie yra labai svarbūs atkuriant nualintas ekosistemas, mačinant ožkų ir kupranugarinių šeimos gyvūnus, taip pat fitoterapijai naudojant eterinius aliejus. Buvo tiriamos abiejų rūšių daigumo savybės (daigumo procentas, vidutinis sudygimo laikas, dygimo greitis) druskingumo ir vandens stygiaus sukeltą stresą sąlygomis. Calicotome villosa ir Genista spachiana gali atlikti iki 15 g/l druskingumą (31–37 % daigumas esant 15 g/l druskos), taip pat toleruoją dideles PEG 6000 dozes (30–40 % daigumas esant 1,6 MPa: polietilenglikolis (PEG) yra hidrofilinis polimeras). Šių dviejų augalų rūsių tolerancia druskingumui ir vandens stygiaus sukeltam stresui leidžia augalams būti ožkų ir kupranugarinių šeimos gyvūnų maisto šaltiniu sausros metu.

Raktažodžiai: Calicotome villosa, Genista spachiana, sausringos žemės pašaras, druskingumo ir vandens stygiaus sukeltas stresas