Effects of Water and Salt Stress on Seed Germination of Gymnocarpos przewalskii (Postprint)

Authors: Wei Zhenyan, Huang Haixia, Ouyang Erqian, Yang Qiqi, Lian Zhuanhong

Date: 2018-11-08T00:00:00+00:00

Abstract

Seeds of Gymnocarpos przewalskii were used as experimental material to analyze the effects of simulated water stress (PEG-6000) and salt stress (NaCl) on seed germination under osmotic potentials of -0.3, -0.5, -0.7, -0.9, and -1.2 MPa, with distilled water as control (0 MPa), in order to determine drought and salt tolerance. Results showed that both stresses significantly inhibited germination of G. przewalskii seeds. Polyethylene glycol (PEG) stress significantly reduced germination index, vigor index, and radicle length; germination rate decreased significantly at osmotic potentials $\leq$ -0.7 MPa. Under NaCl stress, germination index and radicle length decreased significantly; germination rate decreased significantly at osmotic potentials $\leq$ -0.9 MPa. Germination index, vigor index, and radicle length were sensitive to water and salt stress and could serve as primary indicators for evaluating drought and salt tolerance during seed germination in G. przewalskii. Under iso-osmotic conditions, at osmotic potentials of -0.7 MPa and -0.9 MPa, seed germination rate, vigor index, and plumule length under PEG stress were significantly lower than those under NaCl stress; at osmotic potentials $\leq$ -0.7 MPa, germination potential and germination index of PEG treatment were significantly lower than those of NaCl treatment, indicating that osmotic stress rather than ion toxicity was the primary factor affecting G. przewalskii seed germination. The critical value for seed germination tolerance to PEG stress was -0.8 MPa, with a limit value of -1.1 MPa; the critical value for NaCl stress tolerance was -1.5 MPa, with a limit value of -2.2 MPa, indicating that salt tolerance exceeded drought tolerance during the seed germination stage of G. przewalskii.

Full Text

Abstract

In this study, the effects of simulated water (PEG-6000) and salt (NaCl) stresses on seed germination of *Gymnocarpos przewalskii* were analyzed to determine its drought and salt tolerance. Osmotic potentials of -0.3, -0.5, -0.7, -0.9, and -1.2 MPa were designed, with distilled water as control (0 MPa). The results showed that seed germination of *G. przewalskii* was significantly inhibited by both stresses. PEG stress significantly reduced the seed germination index, vigor index, and radicle length. When the osmotic potential was $\leq$ -0.7 MPa, the germination rate decreased significantly. Germination index and radicle length also decreased significantly under NaCl stress. When the osmotic potential was $\leq$ -0.9 MPa, the germination rate was significantly reduced. Germination index, vigor index, and radicle length were sensitive to salt and water stresses and could be used as the main indices to evaluate the drought and salt tolerance of *G. przewalskii* seeds. Under iso-osmotic conditions, when the osmotic potentials were -0.7 MPa and -0.9 MPa, the germination rate, vigor index, and hypocotyl length under PEG stress were significantly lower than those under NaCl stress. When the osmotic potential was $\leq$ -0.7 MPa, the germination potential and germination index under PEG treatment were significantly lower than those under NaCl treatment, indicating that osmotic stress rather than ionic toxicity was the main factor affecting seed germination. The critical and limit values for seed germination were -0.8 MPa and -1.1 MPa under PEG stress, and -1.5 MPa and -2.2 MPa under NaCl stress, respectively. This indicated that the salt tolerance of seed germination of *G. przewalskii* was higher than its drought tolerance.

Materials and Methods

1.1 Seed Collection

In July 2017, seeds of *Gymnocarpos przewalskii* were collected from the arid desert region of Minqin County, Gansu Province (approximately 39°N latitude). The collection site is characterized by an annual precipitation of 110 mm, annual evaporation of 2644 mm, and mean annual temperature of 7.8°C.

1.2 Stress Treatments

Polyethylene glycol (PEG-6000) and NaCl solutions were prepared to simulate water and salt stress, respectively. Five osmotic potential levels were established: -0.3, -0.5, -0.7, -0.9, and -1.2 MPa. The corresponding NaCl concentrations were 81, 135, 188, 242, and 323 $\text{mmol} \cdot \text{L}^{-1}$, respectively. Distilled water (0 MPa) served as the control.

1.3 Germination Test

Seeds were surface-sterilized and placed in sterile petri dishes lined with two layers of filter paper. Ten milliliters of the appropriate treatment solution was added to each dish. The dishes were incubated at 25°C under a 12-hour photoperiod. Germination was recorded daily for 7 days, and germination rate, germination index, vigor index, radicle length, and hypocotyl length were calculated.

Results

2.2 Effects of Water and Salt Stress on Germination Rate

Both PEG and NaCl stresses significantly inhibited the germination rate of *G. przewalskii* seeds, with the inhibition intensifying as osmotic potential decreased [Figure 1: see original paper]. When the osmotic potential was ≤ -0.7 MPa and ≤ -0.9 MPa, the germination rate under both stresses was significantly lower than the control ($P < 0.05$). At -1.2 MPa, the germination rates under PEG and NaCl stresses were 48.3% and 86.2%, respectively. Under iso-osmotic conditions, when the osmotic potential was between -0.7 MPa and -0.9 MPa, the germination rate under PEG stress was significantly lower than that under NaCl stress ($P < 0.05$), indicating that osmotic stress had a greater inhibitory effect than salt stress at these potentials.

[**Figure 1: see original paper**] Effect of water and salt stress on seed germination rate under different osmotic potentials

**** The relationship between seed germination rate and osmotic potential

Treatment	Regression Equation	R^2
PEG	y = 0.788x + 1.101	0.9429
NaCl	y = 0.361x + 1.028	0.9150

Note: x represents osmotic potential (MPa); y represents germination rate.

2.4 Effects on Germination Index

The germination index of *G. przewalskii* decreased significantly under both stress conditions. Under iso-osmotic conditions, when the osmotic potential was ≤ -0.7 MPa, the germination index under PEG stress was significantly lower than that under NaCl stress ($P < 0.05$), suggesting that osmotic stress was the primary limiting factor for germination index.

2.5 Effects on Radicle Length

Radicle length was significantly affected by both water and salt stresses [Figure 2: see original paper]. When the osmotic potential was between -0.3 MPa and

-0.7 MPa, radicle length under PEG stress was significantly shorter than the control. At -0.5 MPa, PEG stress resulted in more severe inhibition of radicle growth compared to NaCl stress [Figure 3: see original paper]. When the osmotic potential was ≤ -0.7 MPa, radicle length under PEG stress was significantly shorter than under NaCl stress ($P < 0.05$). At -1.2 MPa, radicle lengths under PEG and NaCl stresses were reduced by 95.5% and 77.3%, respectively, compared to the control. The relative radicle lengths under PEG and NaCl stresses were 4.5% and 22.7% of the control, respectively.

[**Figure 2: see original paper**] Effect of water and salt stress on seed germination index under different osmotic potentials

[**Figure 3: see original paper**] Effect of water and salt stress on radicle length under different osmotic potentials

[**Figure 5: see original paper**] Effect of water and salt stress on vigor index under different osmotic potentials

[**Figure 6: see original paper**] Effect of water and salt stress on hypocotyl length under different osmotic potentials

References

〔1〕 Chai Yongqing, Cao Zhizhong, Cai Zhuoshan, et al. A study on species diversity of a *Gymnocarpos przewalskii* community in the Subei Desert 〔J〕. *Acta Prataculturae Sinica*, 2010, 19(1): 21-27.

〔2〕 Li Jianguo, Pu Lijie, Zhu Ming, et al. The present situation and hot issues in the salt-affected soil research 〔J〕. *Acta Geographica Sinica*, 2012, 67(9): 1233-1245.

〔3〕 Ma Qiaoli, Sun Yan, Yang Qingchuan, et al. Influence of NaCl and osmotic PEG-4000 stress on seed germination of *Medicago sativa* 〔J〕. *Acta Agrestia Sinica*, 2012, 20(3): 547-552.

〔4〕 Li Juan. The Studies on Species Diversity and Morphology and Anatomy of the Rare Endangered Plants of *Gymnocarpos przewalskii* Maxim 〔D〕. Linfen: Shanxi Normal University, 2012.

〔5〕 Zhang Lingwei, Liu Huiliang, Sheng Jiandong, et al. Effect of burial on seed germination traits of 10 ephemeral plant species 〔J〕. *Arid Zone Research*, 2018, 35(3): 633-639.

〔6〕 Li Li, Zhang Ximing, He Xingyuan. Effects of salinity and water potential on seed germination and radicle growth of riparian *Populus euphratica* 〔J〕. *Arid Zone Research*, 2005, 22(4): 104-109.

〔7〕 Zong Li, Gan Lin, Kang Yuru, et al. Salt and drought stress effect and physiological changes during seed germination and seedling development in *Karelinia caspica* Less. under drought and salinity stress 〔J〕. *Pratacultural Science*, 2017, 34(9): 1855-1862.

〔8〕 Wang Limin, Zhang Xia, Zhang Fuchun. Effects of water and salt stress on seed germination of *Halostachys caspica* 〔J〕 . *Seed*, 2013, 32(12): 6-10.

〔9〕 Chen Peiyu. Effect of Saline-alkali Stress on Germination and Seedling of *Amorpha fruticosa* Seeds 〔D〕 . Zhengzhou: Henan Agricultural University, 2013.

〔10〕 Li Yumei, Jiang Yuntian, Dong Xuesong. Effects of salt stress on seed germination of *Mentha sachalinensis* (Briq.) Kudo 〔J〕 . *Journal of Northeast Forestry University*, 2018, 46(2): 22-28, 34.

Note: Figure translations are in progress. See original paper for figures.