Seed Germination of Chinese Desert Plants

K. Tobe*, Zhang Liping** and K. Omasa*

(*:The National Institute for Environmental Studies, Tsukuba 305, Japan)

(**:Institute of Desert Research, Lanzhou 730000, P.R.China)

Abstract

To investigate the effects of global warming on the germination behavior of Chinese desert plants, responses of seed germination to temperature, light illumination and water and salt stresses were examined on *Artemisia ordosica* and *Lespedeza davurica*. The optimal temperature for germination was 20°C for both species. In the dark condition, the final germination rates were higher than 50% under temperature regimes in the range of 15–30°C for *A. ordosica* and 10–30°C for *L. davurica*. This result shows that seed germination of both tested species are relatively insensitive to changes in temperature. Both water and salt stresses resulted in decreases in final germination rates and retardation of germination in both species. Seed germination of *L. davurica* was less affected by both stresses than that of *A. ordosica*. Although some *A. ordosica* seeds germinated when they were wetted with NaCl solutions having water potentials of -0.3 – -0.6MPa, most of the radicles subsequently died in these media. This result suggests that salinization of the soil is critical for the survival of this species. It was concluded that although a temperature rise by itself does not much affect the germination behavior of these species, changes in seasonal distribution of rainfall events and salinization of the soil caused by climate change can have crucial effects on their distribution.

Key words: China, climate change, desert, seed germination

1. Introduction

Climate in deserts is characterized by quantitative scarcity and unpredictability of rainfall events and large seasonal variation in temperature. Therefore, for the establishment of plants in these regions, the seeds must germinate at appropriate times, which ensure the survival of the seedlings. Consequently, even a slight change in seasonal distribution of precipitation in desert regions can cause crucial effects on seed germination and seedling establishment of the species growing there, eventually resulting in changes in vegetation distribution in these regions. Hence, to anticipate possible effects of climate changes on vegetation distribution in these regions, it is important to clarify germination responses of species growing there to changes in environmental conditions.

Therefore, this research investigates the effects of temperature, light illumination and water and salt stresses on the germination of two species growing in arid regions in Inner-Mongolia, China. The tested species are *Artemisia ordosica*, a semi-shrub dominating on semi-fixed sand dunes and *Lespedeza davurica*, a shrub dominating on fixed sand dunes. Each of them dominates at different stages of succession in the recovery from desertification (Kobayashi, 1994)

2. Materials and methods

Seeds of *Artemisia ordosica* and *Lespedeza davurica* were gathered in Shapotou, China on June, 1994 and April, 1994, respectively. Before the experiments, the seeds were stored in a refrigerator at about 5°C. The germination experiments were carried out during the period of

March, 1995-July, 1996.

Before the experiments, either 100, 50 or 25 seeds were placed on three layers of filter papers in each petri dish (inner diameter: 90mm; depth: 20mm), which was covered with a glass lid and placed in an incubator or an environment-controlled cabinet. Seeds in the petri dishes were wetted with water or the solutions described below, and thereafter the number of germinated seeds was counted at 1-day intervals for 11-14 days.

In experiments to test the effects of temperature and light illumination, seeds were wetted with water and their germination was examined under 10 different constant or alternating temperature regimes, in each of which, examination was done in both continuous darkness and 12-hour-light/12-hour-dark conditions. When the temperature was alternated, the seeds were treated with 12h-higher and 12h-lower temperatures and the light was illuminated while the temperature was higher. For the light treatment, the seeds were illuminated with day-light fluorescent lamps, of which the light intensity on the seeds was about $40\mu\text{mol m}^{-2}\text{s}^{-1}$.

In experiments to test the effects of water and salt stresses, seeds were kept in continuous darkness at 25°C for *A. ordosica* and at 20°C for *L. davurica* and were wetted with solutions of polyethylene glycol-6000 (PEG-6000) or NaCl having known water potentials which were respectively prepared according to Michel and Kaufmann (1973) and Lang (1967). After water- or salt-stress treatments for 11 days, ungerminated seeds of *A. ordosica* were transferred onto filter papers wetted with water, and thereafter the number of germinated seeds was counted.

3. Results

For both species, it took 3-6 days after wetting until the germination rate exceeded 50% when the temperature was in the range of 15-30°C (Figure 1). The final germination rate in darkness exceeded 80% for both species when the temperature was 15-25°C and was highest at a temperature of 20°C (Figure 2). Germination of *A. ordosica* was inhibited by light illumination in most temperature regimes, but germination of *L. davurica* was not significantly affected by light except under lower temperature regimes. When the temperature was diurnally alternated, the germination rate of *A. ordosica* seeds was intermediate between the two germination rates for constant temperature treatments at the higher and lower temperatures, but in *L. davurica*, the germination rate was close to that of the constant temperature treatment at a temperature intermediate between the higher and lower temperatures.

Both water and salt stresses resulted in decreases in final germination rates (Figure 3) and retardation of germination for both species. In *A. ordosica*, NaCl and PEG acted differently on the germination of the seeds. When seeds of *A. ordosica* were wetted with NaCl solutions of -0.3—-0.6MPa, some of the seeds showed quite small radicles emerging slightly from the seeds, but the radicles did not elongate further even after the seeds were transferred onto filter papers wetted with water. In this situation, the seeds were not counted in the number of "germinated" seeds in Figure 3a. Further, most of the elongated radicles that had emerged from the seeds treated with NaCl solutions of -0.3 — -0.6MPa could not continue to elongate in these media and eventually died. However, *A. ordosica* seeds treated with NaCl solutions having water potentials of lower than -0.8MPa did not show any traces of emergence of the radicles from the seeds, and transferring these seeds onto filter papers wetted with water resulted in quick germination of 70-80% of the seeds and subsequent elongation of the emerging radicles. When seeds of *A. ordosica* were treated with PEG solutions, the final germination rate began to

Figure 1 Changes in accumulative germination rates after wetting the seeds of (a) *A. ordosica* and (b) *L. davurica* in continuous darkness at 15°C(○), 20°C(□), 25°C(△), and 30°C(◇).

Figure 2 Effect of constant or alternating temperatures on seed germination of (a) *A. ordosica* and (b) *L. davurica*. Each point represents the germination rate after imbibition of 11 days for *A. ordosica* and 14 days for *L. davurica* under continuous dark (●) or 12-hour-dark/12-hour-light (○) condition.

Figure 3 Effects of salt and water stresses on the germination rates of seeds of (a) *A. ordosica* after 12 days of imbibition and (b) *L. davurica* after 14 days of imbibition. Symbols ● and ○ represent means of 4 replicates of salt- and water-stress treatments, respectively, and bars indicate the standard errors.

decrease at a water potential of -0.6MPa and gradually decreased with decreasing water potential (Figure 3a). Transferring the ungerminated seeds that had been treated with PEG solution of -1.2MPa onto filter papers wetted with water resulted in germination of 70-80% of the seeds. Effects of both water and salt stresses were less inhibitory for the germination of the seeds of *L. davurica*; the final germination rates began to decrease at a water potential of -1.0MPa and gradually decreased with further water potential decreases, and was almost zero at water potentials of -1.5MPa for PEG treatment and -2.0MPa for NaCl treatment (Figure 3b).

4. Discussion

The meteorological data at Shapotou Weather Station in 1994 (unpublished data) show that 93% of the annual precipitation in this region is concentrated in the months from April to October and 76% from June to August. The initial effective rainfall in spring would bring about germination of the seeds of these two species, and ensuing precipitation from spring to autumn would promote the growth of the plants until they are mature enough to survive the chilling and drought of winter (Kobayashi, 1994). Because the monthly mean temperature from April to June in 1994 at Shapotou was 14-21 °C, a temperature rise by less than 10°C would not significantly affect the germination behavior of these two species (Figure 2). However, a temperature rise would accompany changes in temporal distribution of precipitation. If, for example, the initial effective rainfall is followed by a long term of drought, the seedlings would not be able to survive. Therefore, changes in precipitation distribution as well as in the amount of precipitation would have a crucial effects on the vegetation in these regions.

The degree of water stress that withholds seed germination of the two tested species was not significantly different from that which withheld germination of the seeds of species growing in wetter habitats (e.g., several crop species in Heather and Hegarty (1979)). This would not be surprising because germination under higher water potentials can increase possibilities that the seedlings can be supplied with enough water to establish. Most radicles that emerged from *A. ordosica* seeds eventually died when they were treated with NaCl solution of -0.3 – -0.6MPa. This result shows that *A. ordosica* radicles are extremely sensitive to salinity and contact with NaCl solutions having a water potential of lower than -0.3MPa (about 0.064 mol NaCl/kg H₂O) is lethal for them. Since a temperature rise causes an increase in water evaporation from the soil, global warming can promote salinization of the soil, eventually depriving *A. ordosica* of its habitats.

References

- Heather, A.R. and Hegarty, T.W., 1979: Sensitivity of seed germination and seedling radicle growth to moisture stress in some vegetative crop species. *Ann. Bot.*, **43**, 241-243.
- Kobayashi, T., 1994: Studies on ecology and water relations of revegetation plants in the Mu-U sandy district, China. *Tech. Bull. Fac. Hort. Chiba Univ.*, **48**, 329-381. (in Japanese with English summary)
- Lang, A.G.R., 1967: Osmotic coefficients and water potentials of sodium chloride solutions from 0 to 40°C. *Aust. J. Chem.*, **20**, 2017-2023.
- Michel, B.E. and Kauffman, M.R., 1973: The osmotic potential of polyethylene glycol 6000. *Plant Physiol.*, **51**, 914-916.