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The effects of variable regimes of temperature and light on the germination of *Atriplex repanda* seeds in the semi-arid region of Chile

Los efectos de regímenes variables de temperatura y luz en la germinación de semillas de *Atriplex repanda* en la región semiárida de Chile

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ABSTRACT

The effects of constant *versus* variable temperature and photoperiod *versus* darkness on germination of *Atriplex repanda* seeds were tested. Germination was higher at variable than at constant temperature and higher in seeds exposed to the light than in those kept in the dark. Seed responses to temperature and light suggest that *A. repanda* is an early successional species in the plant communities in the Chilean arid zone.

Key words: Arid zone, *Atriplex repanda,* seed germination.

RESUMEN

Se compararon los efectos de la temperatura constante *versus* temperatura variable y el fotoperíodo *versus* oscuridad en la germinación de semillas de *Atriplex repanda.* La germinación fue más alta a temperatura variable que a temperatura constante y en semillas expuestas a la luz que en aquéllas mantenidas en la oscuridad. La respuesta de las semillas a la temperatura y a la luz sugieren que *A. repanda* es una especie colonizadora en las comunidades de plantas de la zona árida de Chile.

Palabras claves: Zonas áridas, *Atriplex repanda,* germinación de semillas.

INTRODUCTION

Atriplex repanda (Chenopodiaceae) is a typical inhabitant of the arid zone of Chile that exhibits remarkable adaptations to xeric conditions (Olivares & Gastó 1981). Several researchers have recommended this species for reclaiming arid lands because of its quality as a forage plant (Gastó & Contreras 1972). *A. repanda* has a high protein content in its leaves and stems, high palatability to livestock and it can recover quickly after severe grazing (Olivares & Gastó 1981). However, propagation of *A. repanda* by direct seeding is difficult because of the low germination rate of the seeds (Fernández 1978a). The relationship between seed germination of *A. repanda* and intrinsic and extrinsic factors have been studied (Fernández 1978a, 1978b, 1978c, Fernández & Johnston 1978, 1980, Johnston & Fernández 1978, 1979, Olivares & Johnston 1978, Olivares *et al.* 1980, Johnston *et al.* 1983, 1985). Among the extrinsic factors temperature and light seem to play an important role in the germination of *A. repanda* seeds.

Johnston *et al.* (1985) found no differences in the germination rate of pierced seeds kept in the dark, when they were exposed to constant temperatures ranging from 5 to 38°C. No germination occurred at temperatures under or above that range. In contrast, light increased germination of non-pierced seeds kept in the dark. On the other hand, Olivares & Johnston (1978) found a greater germination of *A. repanda* seeds sown at 0.5 and 1.0 cm depth compared to those seeds sown at 2.0 cm depth. However, that fact was not related to a possible effect of light. At or near the soil surface the temperature is more variable than in deeper soil and therefore it would be expected that seeds with epigeal germination had a greater emergence when they are exposed to fluctuating temperatures. Here we report the results of experiments designed to explore the effects of

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light and fluctuating temperature and the interactions of these factors upon seed germination of *A. repanda*.

MATERIAL AND METHODS

Seeds of *A. repanda* were collected from a population growing in Canela Alta (31°25'S, 71°20'W), IV Region, Chile, in January 17, 1984. Average annual rainfall in Canela Alta is 149.7 mm (MOP 1986). The seeds selected for the experiments measured between 2 and 3 mm in average, and all the damaged seeds were eliminated. The seeds were washed in flowing water for 10 to 25 minutes until the resultant water was translucent in order to remove inhibiting substances present on the seed coat (Johnston & Fernández 1979). Then the seeds were slowly hydrated for 24 h at 25°C. Seed hydration was carried out by placing the seeds between two soaked filter papers, inside a petri dish. Fifty hydrated seeds were laid down on a filter paper in each of sixteen petri dishes. The seeds were irrigated at the beginning of the experiments only with 3 ml of distilled water. Eight of the dishes were kept at a constant temperature (26 ± 1°C) and eight dishes were kept at a variable temperature regime (21°C at night and 25°C at day) in a B-BKE Memmert incubator for ten days, until no further seed germination was observed. A seed was considered germinated when the radicle emerged 5 mm out of the seed. In both temperature treatments four petri dishes were subjected to a photoperiod of 10 h daily by using 40 watts light bulbs located 1 m apart from the experimental setting, and the other four dishes were kept in the dark all the time. To determine the effect of a small pulse of light upon seed germination, eight petri dishes with fifty seeds each were exposed to light for 10 minutes after seed hydration, and then the seeds were kept in the dark for the remaining of the experiment. Four of these dishes were kept at a constant temperature and four at a variable temperature as described above.

The data were analysed by Factorial ANOVA and the proper error terms were used in order to reflect the split-plot design and the random arrangement of the samples. Treatment means were compared by least significant differences (Steel & Torrie 1980).

A new germination trial was initiated with those seeds which did not germinate in the photoperiod and the dark treatment. Four petri dishes with fifty seeds each from the dark treatment were subjected to the photoperiod treatment for ten days to break possible seed dormancy (Bewley & Black 1982). Equal number of replicates of the photoperiod treatment were kept in the dark for the same period. Seed germination means of these two treatments were compared by one-way ANOVA.

RESULTS

The effects of temperature and light regime upon seed germination of *A. repanda* through the time is shown in Figure 1. Both temperature and light treatment had a significant effect on seed germination. Germination was higher at a variable temperature than at a constant temperature ($F_{(1,3)}$ = 22.01; $P<0.01$) and in those seeds exposed to light than in seeds kept in the dark ($F_{(1,6)}$ = 59.12; $P<0.01$) (Table 1). However, there

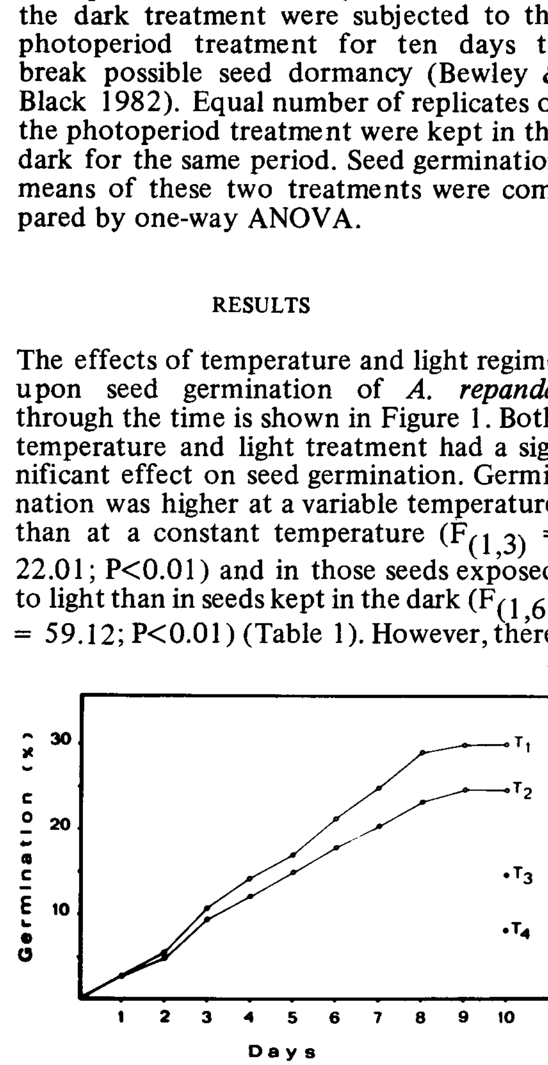

Fig. 1: Germination of *Atriplex repanda* seeds over time. Observations were begun 24 h after seed hydration. T_1: variable temperature x photoperiod treatment; T_2: constant temperature x photoperiod treatment; T_3: variable temperature x dark treatment; T_4: constant temperature x dark treatment. Observations of T_3 and T_4 were done at the end of the experiment only. See the text for further explanations about treatments.

Germinación de semillas de *Atriplex repanda* a través del tiempo. Las observaciones se comenzaron después de 24 h de hidratadas las semillas. Los tratamientos son: T_1: temperatura variable x fotoperíodo; T_2: temperatura constante x fotoperíodo; T_3: temperatura variable x oscuridad; T_4: temperatura constante x oscuridad. Las observaciones de T_3 y T_4 se hicieron al final del experimento solamente. Vea el texto para mayores explicaciones acerca de los tratamientos.

TABLE 1

Average percentage of germination of *Atriplex repanda* seeds subjected to different treatments. See the text for further explanation about treatments.
Porcentaje promedio de germinación de semillas de *Atriplex repanda* sometidas a tratamientos diferentes. Vea el texto para mayores explicaciones acerca de los tratamientos

TREATMENTS	% GERMINATION
*Main Effects**	
Constant Temperature (CT) (26ºC)	17.5
Variable Temperature (VT) (25ºC day/21ºC night)	22.0
Photoperiod (Ph) (10 h light/14 h dark)	27.8
Darkness (D)	11.8
Interaction Effects	
D x Light Stimulus (LS) (10 min)	18.0
CT x Ph	26.5
VT x Ph	29.0
CT x D	8.5
VT x D	15.0
CT x D x LS	15.5
VT x D x LS	21.5

* To calculate the means we considered all the data in which the main effect was present, that is, including those values of the interaction effects.

was no significant interaction effect on the treatment ($F_{(1,6)}$ = 0,92; P>0.05). In those seeds kept in the dark, a small pulse of light (10 min) after seed hydration promoted a greater germination compared to the seeds without a luminic stimulus ($F_{(1,6)}$ = 10.96; P<0.01). However, the percentage of germination was lower than the germination of seeds subjected to the photoperiod treatment (Table 1). The temperature treatment had no significant effect on those seeds kept in the dark ($F_{(1,3)}$ = 3.73; P>0.05), but it has been reported that temperatures around 8ºC would eliminate the inhibitory effect of darkness (Johnson *et al.* 1985).

From those seeds which did not germinate under the dark treatment, 36% germinated after they were exposed to the photoperiod treatment for 10 days. But from those seeds which did not germinate in the photoperiod treatment, only 10% germinated when they were kept in the dark.

DISCUSSION

Our results support the hypothesis that temperature and light are regulating factors of germination of *A. repanda* seeds. The effects of these factors were not equivalent since light had a more pronounced effect on germination than temperature. However, these results could be a consequence of the temperature differential (amplitude) used in this experiment. Bewley & Black (1982) report that for *Rumex obtusifolius* (Polygonaceae) and *Lycopus europaeus* (Labiatae) seed germination was higher when the amplitude of the temperature alternation was increased.

In our experiments, even small pulses of light increased significantly the germination of seeds. Dormancy of those seeds which did not germinate in the dark treatment was broken by light. This shows that *A. repanda* seeds are photoblastic (*sensu* Evenari 1965) and suggest that seed germination would be regulated by the far-red phytochrome (Bewley & Black 1982) Seeds of photoblastic species show different light requirements to break dormancy and this could explain the differences in germination rate exhibited by *A. repanda* seeds. These differences could be associated to the far-red synthetized phytochrome, seed coat thickness, pigments of the seed coat or their interactions. Polymorphisms in seed responses to light are characteristic of pioneer species (Bazzaz 1979), and are widespread in the Chenopodiaceae (Bewley & Black 1982).

The temperature treatment had no effect on those seeds kept in the dark, and variable temperature was more effective in promoting germination on those seeds receiving a luminic stimulus, suggesting that these two factors could act coupled. Similar findings have been reported for *Fragaria virginiana* (Rosaceae), *Chenopodium album* and *Lepidium virginicum* (Brassicaceae) (Bewley & Black 1982). Greater germination under a variable temperature regimen and under light conditions suggest that the location of seeds in or on the soil could be important. Our dark treatment mimics the situation of seeds buried in the soil. Those seeds at or near the soil surface are more exposed to light and would be more likely to germinate. At the soil surface, temperature is also more variable than in deeper soil, which also enhances germination (Bazzaz 1979). Low germination of *A. repanda* seeds could be associated with the depth in which the seeds are sown (Olivares & Johnston 1978). The effect of burial depth upon germination has been demonstrated for *Plan-*

tago major (Plantaginaceae) and *Sinapsis arvensis* (Brassicaceae), species which require light for the termination of dormancy. As the depth increased there was a progressive decline in the proportion of seeds germinated (Bewley & Black 1982).

Dense populations of *A. repanda* are usually found close to human settlements, roadsides and railroad tracks. All of these places are characterized by having loose soil and therefore the seeds could be exposed to light more frequently. Human activities would also help increase the soil looseness bringing buried seeds up to or near the soil surface. In July, 1986 we visited again the place in Canela Alta where the seeds of *A. repanda* used in this work had been collected and found that most of the plants constituing the original population had been removed. The soil had been recently plowed for crop seeding, and we observed a flush of new *A. repanda* seedlings caused by the soil disturbance. These seedlings were not present at the time of seed collection. This observation is in agreement with similar findings reported by Olivares & Johnston (1978). In agricultural fields, soil water infiltration and soil aeration are also greater because of plowing activities. Aerobic conditions are important to obtain germination in several species of *Atriplex* (Osmond *et al.* 1980).

Germination of *A. repanda* is epigeal and that behaviour is characteristic of early successional species inhabiting open habitats. Generally, these species require unfiltered light, fluctuating temperatures and reduced CO_2 concentration (Bazzaz 1979). All of these factors have been shown to increase seed germination in *A. repanda.* Spatial distribution of seeds under or between bushes would affect their germination probabilities. Those seeds lying under bushes would be exposed to filtered light and therefore would germinate less than those in the open. Personal observations in the related *A. semibaccata* suggest that that could be the case. The wide temperature range in which *A. repanda* seeds are able to germinate (Johnston *et al.* 1985) is another indication that this species is early successional. These plants are opportunistic and they germinate whenever there is disturbed or open habitat, regardless of the soil temperature conditions.

Based on these antecedents we hypothesize that germination of *A. repanda* is closely linked to disturbance which would ensure the availability of resources and reduce the probability of competition with other native species. *Atriplex repanda* has shown to be a poor competitor with other species (Acuña *et al.* 1978) and that would explain its rarity in more complex plant communities of the arid zone of Chile.

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