Responses of Range Grass Seeds to Winter Environments

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Highlight: *Seeds of annual and perennial grasses were planted in the field in fall, winter, and spring to test the rapidity of their germination at low temperatures. They were brought from the field into the laboratory at frequent intervals and germinated at 10°C. In general, the longer the exposure to field conditions, the more rapid the subsequent germination. After 1 month of exposure to the winter environment, the ranking of species in order of decreasing rapidity of germination (at 10°C) was as follows: cheatgrass (*Bromus tectorum*), medusahead (*Taeniatherum asperum*), crested wheatgrass (*Agropyron desertorum*), Siberian wheatgrass (*Agropyron sibiricum*), bluebunch wheatgrass (*Agropyron spicatum*), and smooth brome (*Bromus inermis*). The order in which seedlings emerged was the same, except that medusahead emerged earlier than cheatgrass. When seedlings are exposed to drought or to competition with other species, rapidity of germination at low temperatures may be important to their survival.*

The objective of the study was to investigate under rangeland conditions the cold tolerance characteristics of seeds of two annual and four perennial grasses.

We define cold tolerance as the capacity of seeds to germinate rapidly under low temperature winter conditions; we recognize that tolerance in the germination stage may or may not be related to tolerance in later stages of plant development.

Because of the shortness of the spring growing season on many low-elevation rangelands in northwestern United States (Nelson et al., 1970), the range manager faces the question: How early may I safely seed cool-season range grasses? He cannot give a good answer to this question until he knows: (1) how long it takes seeds to germinate at low temperatures; (2) whether or not seeds are injured by exposure to freezing temperatures; and (3) how quickly seeds recover from the effects of freezing temperatures if they have been injured.

Information is available concerning responses of seeds to controlled temperatures (Dewitt, 1969; Ellern and Tadmor, 1966 and 1967; Hulbert, 1955; McGinnies, 1960; Young et al., 1968), but there is a scarcity of information regarding responses of seeds to fluctuating and severe field environments (White and Horner, 1943).

Materials and Methods

The study was conducted on the breaks of the Snake River, 16 miles southwest of Pullman, Washington. The site is at a 1600-ft elevation on an 18% southeasterly slope. The soil is a silt loam. Precipitation records are not available, but the vegetation is similar to that of other areas in southeastern Washington that receive 12 to 14 inches annually. Most precipitation occurs in late fall, winter, and early spring. Summers are usually hot and dry. The area is representative of much of the Pacific bunchgrass type, where bluebunch wheatgrass (*Agropyron spicatum*) and other desirable perennial forage species have been replaced by introduced annuals such as cheatgrass (*Bromus tectorum*) and medusahead (*Taeniatherum asperum*).

Seeds of cheatgrass and medusahead were collected in 1971 at Coyote Grade near Lewiston, Idaho. Seeds of 'Nordan' crested wheatgrass (*Agropyron desertorum*), 'Whitmar' bluebunch wheatgrass, Siberian wheatgrass (*Agropyron sibiricum*, P.I. No. 314508), and 'Manchar' smooth brome (*Bromus inermis*) were produced in Pullman, Washington in 1971. Seeds were treated with 15 mg of thiram (tetramethylthiuram disulfide) per gram dry weight. Samples of 100 seeds were enclosed in flat cotton screen bags (Bleak, 1959), and the bags were placed in the soil at a depth of 2.5 cm in a randomized complete block design. Planting dates were November 5, 1971, and January 10 and March 30, 1972. The experiments were established with six replications, but wind erosion of soil on January 11 damaged one replication in the winter experiment.

Water potential of soil, taken within 0.5 cm below seed samples, was measured in the laboratory with a thermocouple psychrometer. Soil temperature at a depth of 2.5 cm was recorded with a thermograph. Average temperature by 2-hour intervals was estimated from the thermograph chart. Degree-hours was the average temperature above 0° C times

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number of hours. The sum of degree-hours was divided by 24 to give degree-days (Wang, 1960).

Samples of seed were removed from the soil at desired intervals, from the time of planting to the time seeds of most species began to germinate in the field. Seeds were placed in a petri dish on moist blotter paper and germinated at 10° C (Wilson, 1972). Germinated seeds (both root and shoot visible) were counted daily. Cumulative percentage of germination was calculated on the basis of the number of germinable seeds in control samples. Control samples consisted of seeds from air-dry storage, germinated under the same conditions as seeds brought in from the field.

The number of days required for seeds to reach 25% germination (at 10° C) was used to measure the effects of low temperature during previous exposure of seeds in the field. A decrease in number of days required for samples to reach 25% germination is referred to as a hastening of germination or as an increase in rapidity of germination.

Table 1. Ranking of species in order of decreasing cold tolerance as measured by four criteria of species behavior during germination: I, days to 25% germination (at 10°C) for control seeds not exposed to field environments; II, days germination was hastened per degree-day of exposure in the field at temperatures above freezing; III, days germination was delayed during exposure to temperatures below freezing; IV, days germination was hastened after exposure to temperatures below freezing.[1]

I		II		III		IV	
Days to 25% germination of controls[2, 3]		Hastening of germination per degree-day[4]		Delaying of germination (Jan. 24 to Jan. 27 or 31)[2, 5]		Hastening of germination (Jan. 31 to Feb. 15)[2, 3]	
Bte	3.8[a]	Tas	0.104 ± .017	Bin	0.32	Bte	....[6]
Tas	5.5[b]	Ade	0.099 ± .007	Asi	0.42	Tas	....[6]
Bin	6.6[c]	Asp	0.099 ± .007	Ade	0.46	Ade	2.64[a]
Ade	6.9[cd]	Asi	0.098 ± .008	Asp	0.68	Asi	2.40[a]
Asi	7.3[d]	Bte	0.092 ± .037	Tas	1.10	Asp	1.94[a]
Asp	8.1[e]	Bin	0.074 ± .016	Bte	1.26	Bin	1.10[b]

[1] Abbreviations are: Ade = crested wheatgrass; Asi = siberian wheatgrass; Asp = bluebunch wheatgrass; Bin = smooth brome; Bte = cheatgrass; Tas = medusahead.
[2] Values are from winter experiment.
[3] Values labeled with the same letter do not differ significantly (0.05 level) according to Duncan's multiple range test.
[4] Values are the slope and 95% confidence limits of the slope calculated from data of the spring and fall experiments (Fig. 3).
[5] Germination was not significantly delayed (0.05 level) for Bin, Asi, and Ade, according to Duncan's multiple range test.
[6] Cheatgrass and medusahead had begun to germinate in the field by February 10.

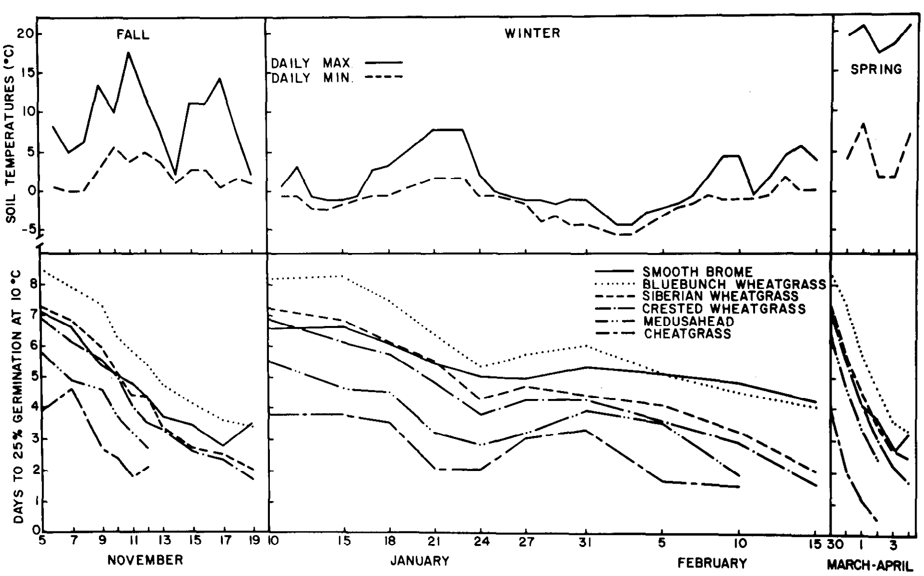

Fig. 1. *(Upper) Daily maximum and minimum soil temperatures at a depth of 2.5 cm during fall, winter, and spring. Values were plotted to indicate temperatures during the 24-hour period before seed sampling. Temperatures shown for January 19, 20, and 21 were estimated from air temperatures at Lewiston, Ida., and Pullman, Wash. (Lower) Days to 25% germination (at 10°C) of seeds removed from soil in the field on the indicated sampling dates. Seeds were planted November 5, January 10, and March 30. Values shown on these dates are for control samples. Seeds of cheatgrass, medusahead, crested wheatgrass, and Siberian wheatgrass had begun to germinate in the field when sampling was discontinued.*

Results and Discussion

Exposure of seeds to winter conditions in the field had little effect on final germination percentage (10° C for 20 days) of crested wheatgrass and Siberian wheatgrass, but reduced the germination of other species. Final germination percentages for control samples were: Siberian wheatgrass, 94%; bluebunch wheatgrass, 87%; crested wheatgrass, 86%; medusahead, 79%; smooth brome, 74%; and cheatgrass, 65%. After exposure of seeds in the field for 5 weeks, final germination percentages (10° C for 20 days) were: Siberian wheatgrass, 93%; crested wheatgrass, 86%; bluebunch wheatgrass, 76%; smooth brome, 67%; medusahead, 70%; and cheatgrass, 49%.

Among control seed samples, the ranking of species in order of decreasing rapidity of germination was as follows: cheatgrass, medusahead, smooth brome, crested wheatgrass, Siberian wheatgrass, bluebunch wheatgrass (Table 1). With the exception of smooth brome, this order was maintained most of the time in fall, winter, and spring experiments (Fig. 1). Thus, under these experimental conditions, rapidity of germination of control samples was related to rapidity of germination of seeds after they had been planted in the field.

In fall and spring experiments, when soil moisture was favorable (-0.7 to -2.7 bars), rapidity of germination was significantly correlated with degree-days of exposure in the field (Fig. 2). In relation

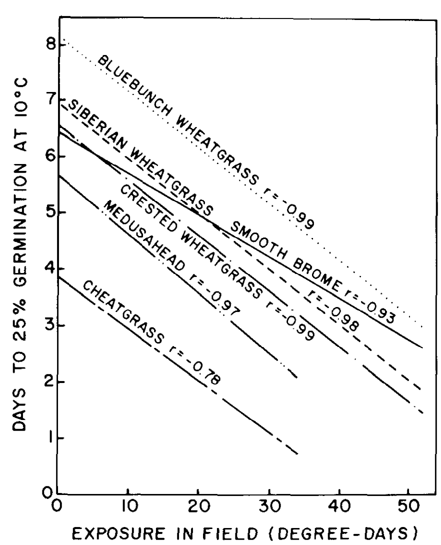

Fig. 2. *Relationship between days to 25% germination (at 10°C) and degree-days of exposure in the field. Data are from fall and spring experiments (Fig. 1).*

to degree-days, seeds responded similarly in the spring and fall. Hastening of germination per degree-day of exposure in the field was greater for medusahead and wheatgrasses than for smooth brome (Table 1). Incomplete temperature records in January precluded a similar analysis of data from the winter experiment.

The relationship between degree-days and rapidity of germination is not an exact one; rather, it is a practical guide for predicting or explaining the responses of seeds to low temperatures. A limitation is that the relationship is not valid when seeds are exposed to drought. The use of 0° C as the reference temperature is arbitrary, and for some species, germination processes probably occur even at 0° C. For other species, the use of a reference temperature higher than 0° C may be appropriate. We have not determined the upper temperature range at which rapidity of germination no longer increases linearly with degree-days of exposure. In crested wheatgrass seeds, the relationship is linear to at least 23° C (Wilson, 1973)

During temperatures below 0° C in late January, germination of seeds of some species was delayed, as compared with germination of seeds removed from soil on dates preceding the cold period. However, at no time did seeds exposed to low temperatures germinate more slowly than control seed samples. The advanced stage of germination of annual grasses on January 24 may account for the delay in their germination on January 27 and 31 (Fig. 1, Table 1). During this period, the delaying of germination of smooth brome, Siberian wheatgrass, and crested wheatgrass was not significant at the 0.05 level.

Annual grasses recovered quickly from the effects of freezing temperatures and began to germinate in the field by February 10. The number of days germination was hastened between January 31 and February 15 was taken as a measure of the recovery of perennial grass seeds from the delaying effects of freezing temperatures. The wheatgrasses recovered more quickly than smooth brome (Table 1).

After 1 month of exposure to the winter environment, the ranking of species in order of decreasing rapidity of germination was as follows: cheatgrass, medusahead, crested wheatgrass, Siberian wheatgrass, bluebunch wheatgrass, and smooth brome (Fig. 1). The dates of earliest emergence of seedlings in the winter experiment were: medusahead, February 28; cheatgrass, March 3; crested wheatgrass and Siberian wheatgrass, March 6; bluebunch wheatgrass, March 9; smooth brome, March 13. Under conditions of this experiment, rapidity of germination was related to date of emergence. Consequently, rapidity of germination at low temperatures may play an important role in the survival of seedlings when they are subsequently exposed to drying of the soil surface or to competition with weedy species.

The results show that seeds of these cool-season grasses were not seriously delayed in their germination during exposure to freezing temperatures and that seeds of most species recovered quickly from the effects of freezing temperatures. Therefore, we conclude that seeds may be safely planted in winter or very early spring on low-elevation rangelands in northwestern United States. This would allow time for seedling growth and development before the beginning of the summer dry season.

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