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Drying and storage effects on germination of primed grass seeds

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Abstract

Cheatgrass (*Bromus tectorum* L.) has become the dominant species over large areas of rangeland in the Great Basin region of the western United States. Rapid germination at low temperature may contribute to the competitive success of cheatgrass in areas formerly dominated by native sagebrush and bunchgrass species. The objectives of this study were to determine whether seed priming could be used to stimulate low-temperature germination rate of native bunchgrass seeds and whether any priming effect was retained after drying and storage. Matric-priming was used to enhance germination rate response of 7 Great Basin native perennial grasses: thickspike wheatgrass [*Agropyron dasystachyum* (Hook.) Scribn.], bluebunch wheatgrass [*Pseudoroegneria spicata* (Pursh) Löve], canby bluegrass (*Poa canbyi* Scribn.), sandberg bluegrass (*Poa sandbergii* Vasey.), bottlebrush squirreltail [*Sitanion hystrix* (Nutt.) J.G. Smith], sheep fescue (*Festuca ovina* L.), and basin wildrye [*Leymus cinereus* (Scribn. and Merr.) A. Love]. Priming enhanced germination rate of these species by 4 to 8 days at 10° C. All species except canby bluegrass and basin wildrye could be induced to germinate as quickly as cheatgrass if they were not air-dried after priming. All species except canby bluegrass retained significant germination enhancement after 11 weeks of storage but only bluebunch wheatgrass maintained a germination rate comparable to cheatgrass when seeds were dried for storage.

Key Words: matric-priming, native bunchgrass, germination rate enhancement

Cheatgrass (*Bromus tectorum* L.), a non-native weedy annual, now dominates large areas of former sagebrush/bunchgrass rangeland in the Great Basin region of the western United States (Mack 1981, Young et al. 1987). Rapid germination rate at low temperature is one factor that may contribute to the competitive success of cheatgrass (Wilson et al. 1974). Cheatgrass that germinates in the fall can sustain root growth at temperatures that inhibit root growth of native species (Harris and Wilson 1970). Seeds that do not germinate in the fall may do so early in the spring when temperatures remain too low for native plant establishment (Wilson et al. 1974).

One approach that may decrease the competitive advantage of cheatgrass is to enhance the low-temperature germination rate of seeded native bunchgrass species. Seed priming is a technique by which seeds are partially hydrated to a point where germination metabolism begins but radicle emergence does not occur (Heydecker and Coolbear 1977). Seed priming has been shown to enhance germination rate at temperatures normally suboptimal for germination (Heydecker et al. 1975). Hardegree (1994) used a matric-priming technique to increase low-temperature germination rate of some native bunchgrass species but only tested germination response of freshly primed seeds. Rangeland applications will probably require that freshly primed seeds be air dried after treatment. Redrying generally reduces the priming effect on germination rate (Heydecker and Coolbear 1977). The purpose of this experiment was to determine whether significant germination enhancement is retained in seeds that are redried and stored after the priming treatment.

Materials and Methods

Thickspike wheatgrass [*Agropyron dasystachyum* (Hook.) Scribn.], bluebunch wheatgrass [*Pseudoroegneria spicata* (Pursh) Löve], canby bluegrass (*Poa canbyi* Scribn.), sandberg bluegrass (*Poa sandbergii* Vasey.), bottlebrush squirreltail [*Sitanion hystrix* (Nutt.) J.G. Smith], sheep fescue (*Festuca ovina* L.), and basin wildrye [*Leymus cinereus* (Scribn. and Merr.) A. Love] seeds were purchased from a commercial source which collected the seeds in 1991. Germination tests were initiated in April 1992. These species were selected because they have been identified by the Bureau of Land Management as high-priority species for restoration of deteriorated rangeland in the Great Basin region of the western United States. Germination responses of primed and nonprimed native species were compared to that of 3 nonprimed cheatgrass accessions collected in southern Ada County, near Orchard, Ten-mile Creek, and Kuna Butte, Ida. Seeds in this study were from the same seedlots used by Hardegree (1994) to evaluate the effects of temperature and duration of priming on germination at low temperature.

Seeds were primed and germinated in a priming/germination cup designed for control of matric potential in the seed germination environment (Hardegree and Emmerich 1992a). The priming/germination system consists of a membrane-bottom cup that is in contact with either water or an osmotic solution of polyethylene glycol 8,000 (PEG) inside a clear plastic vial. The cellulose membrane that forms the bottom of the cup has a molecular weight exclusion limit of 3,500, which allows passage of water but not the higher molecular weight PEG. Seeds in the cup equilibrate with the matric potential control surface of the membrane which is in equilibrium with the osmotic potential of the solution reservoir. After priming, germination tests are conducted in the same priming/germination system except that the solution reservoir contains only water and not PEG solution.

Seeds were primed by equilibrating them for 7 days at 25° C and water potentials of −2.5 MPa for bluebunch wheatgrass and basin wildrye, −2.0 MPa for thickspike wheatgrass and sheep fescue, −1.5 MPa for bottlebrush squirreltail, and −1.0 MPa for sandberg blue-

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grass and canby bluegrass. These conditions were estimated to induce the maximum germination enhancement among seed-priming treatments tested in a previous experiment (Hardegree 1994). Sixty-three sets of 30 seeds each were primed for bluebunch wheatgrass, thickspike wheatgrass, bottlebrush squirreltail, and basin wildrye. Sets of 35 seeds each were primed for the smaller *Poa* and *Festuca* species. Vials used for priming were arranged in 9 randomized blocks inside a controlled-temperature room under both fluorescent and incandescent lights (18.8 W m^{-2}) for 12 hours day^{-1}. After priming, sets of 9 priming/germination cups for each species were immediately switched to vials containing pure water and monitored for germination at 10° C for 21 days. A germination test was also initiated at this time for 9 replicate samples of non-primed seeds for each native species and the 3 cheatgrass accessions. All priming/germination cups that were not switched to water were taken out of the priming vials and placed on absorbent paper toweling on the laboratory bench and the seeds were allowed to air dry for 7 days. After 7 days, another germination test was initiated for 9 sets of primed/dried seeds and for an equivalent set of nonprimed seeds of each species. The seeds from the remaining primed/dried treatments were transferred into paper envelopes and stored at room temperature in the laboratory. A germination test at 10° C was initiated for a new set of primed/dried and nonprimed seeds every 2 weeks for the next 10 weeks.

Ten °C was selected as the cold temperature test environment because some of these seedlots germinated less than 5% after 21 days of hydration at 5° C (data not shown). Wilson (1972) recommended 10° C as a low-temperature test environment for germination rate of species that do not normally germinate well at lower temperatures. Wilson et al. (1974) used a 10° C laboratory test to evaluate field effects on low-temperature germination rate of range grass seeds.

Seeds were dusted with fungicide (2,4,5,6-tetrachloro-1,3-benzenedicarbonitrile, wettable powder) at the beginning of the priming treatment. Primed seeds, primed/dried seeds, and nonprimed seeds were also treated by immersion in a few drops of fungicide suspension (2.5 g wettable powder per 100 ml of water) at the beginning of each germination test. Seeds were retreated with additional fungicide suspension if they developed fungal growth. Excess fungicide suspension was suctioned from the membrane after treatment.

Germinated seeds were counted daily and removed from the cups when they exhibited ≥2 mm radicle extension. Total germination percentage and days elapsed to 50% of total germination, as an index of germination rate, were recorded for each vial. Quadratic regression analysis was used to determine whether low-temperature germination rate changed over the storage period for both primed/dried seeds and for seeds in the nonprimed treatments (Evans et al. 1982). Regression equations were recalculated deleting quadratic and linear terms that were not significant ($P \leq 0.10$). Lower order terms that were not significant were left in the equation if a higher order term was significant. Days elapsed to 50% of total germination was estimated from the regression equations and model confidence intervals ($P \leq 0.05$) determined for each species and treatment combination. Mean germination response and 95% confidence intervals were also calculated for freshly primed seeds that were not redried after treatment. Primed and primed/dried treatments were considered to be significantly different from the nonprimed control treatment if their modeled confidence limits did not overlap the predicted value for the control treatment during the equivalent 21-day germination evaluation. There was very little variability in germination rate among cheatgrass accessions. A single regression model and confidence limits were, therefore, calculated from the aggregated cheatgrass data.

There was relatively little variability in total germination percentage as a function of storage time for either the control or primed/dried treatments. Mean values and 95% confidence intervals were, therefore, calculated for total germination percentage of nonprimed control, primed, and primed/dried treatments disregarding storage time effects.

Results

Priming significantly enhanced total germination percentage of thickspike wheatgrass, bottlebrush squirreltail, and basin wildrye seeds that were not dried after treatment (Table 1). Total germination of freshly primed seeds of bluebunch wheatgrass, canby bluegrass, sandberg bluegrass, and sheep fescue did not differ from nonprimed seeds (Table 1). All species showed either a decrease or no change in total germination of primed seeds when they were dried and stored (Table 1). After drying, total germination of primed seeds was either lower than, or could not be distinguished from total germination of nonprimed seeds for all species except basin wildrye (Table 1). Cumulative germination curves indicated that after 21 days, a plateau had been reached in total germination for all species and treatments except for the nonprimed control treatment of basin wildrye (data not shown).

Table 1. Mean values and confidence interval widths ($P \leq 0.05$) for total germination percentage of nonprimed, primed, and primed and dried seeds. Data for primed and dried seeds were aggregated across all levels of storage duration.

Species	Nonprimed	Primed	Primed and dried
		(%)	
Thickspike wheatgrass	82 ± 2	88 ± 5	84 ± 2
Bluebunch wheatgrass	87 ± 2	91 ± 6	85 ± 2
Canby bluegrass	85 ± 2	85 ± 5	78 ± 2
Sandberg bluegrass	71 ± 3	72 ± 7	68 ± 4
Bottlebrush squirreltail	67 ± 3	78 ± 9	57 ± 3
Sheep fescue	59 ± 4	58 ± 8	49 ± 4
Basin wildrye	59 ± 3	73 ± 6	71 ± 3
Cheatgrass	62 ± 2	—	—

Priming significantly increased germination rate (decreased days elapsed to 50% of total germination percentage) for all species even after drying and storage (Fig. 1). The longest storage duration of canby bluegrass was the only primed treatment that did not retain significant germination enhancement after 11 weeks of storage (Fig. 1). Most rapid germination was always associated with freshly primed seeds. Priming had a relatively greater effect on germination rate than on total germination percentage. Days elapsed to 50% of total germination percentage for freshly primed seeds ranged from about 30% of control levels for bottlebrush squirreltail and sandberg bluegrass to over 65% for basin wildrye seeds (Fig. 1). Germination rate enhancement of freshly primed seeds ranged from over 8 days for bottlebrush squirreltail to only 4 days for bluebunch wheatgrass (Fig. 1).

Freshly primed seeds of all species except canby bluegrass and basin wildrye germinated more rapidly than the cheatgrass accessions (Fig. 1). After drying, only bluebunch wheatgrass maintained a germination rate comparable to that of the cheatgrass accessions.

Discussion

Seed priming has been widely used to enhance the germination response of agricultural crop species (Bradford 1986). Priming studies of rangeland species are more limited. Keller and Bleak (1968), Bleak and Keller (1972), and Kastner et al. (1981) found that presowing hydration had beneficial effects on germination response of some intermountain grass species. Wilson (1973) enhanced germination rate of an introduced bunchgrass by equili-

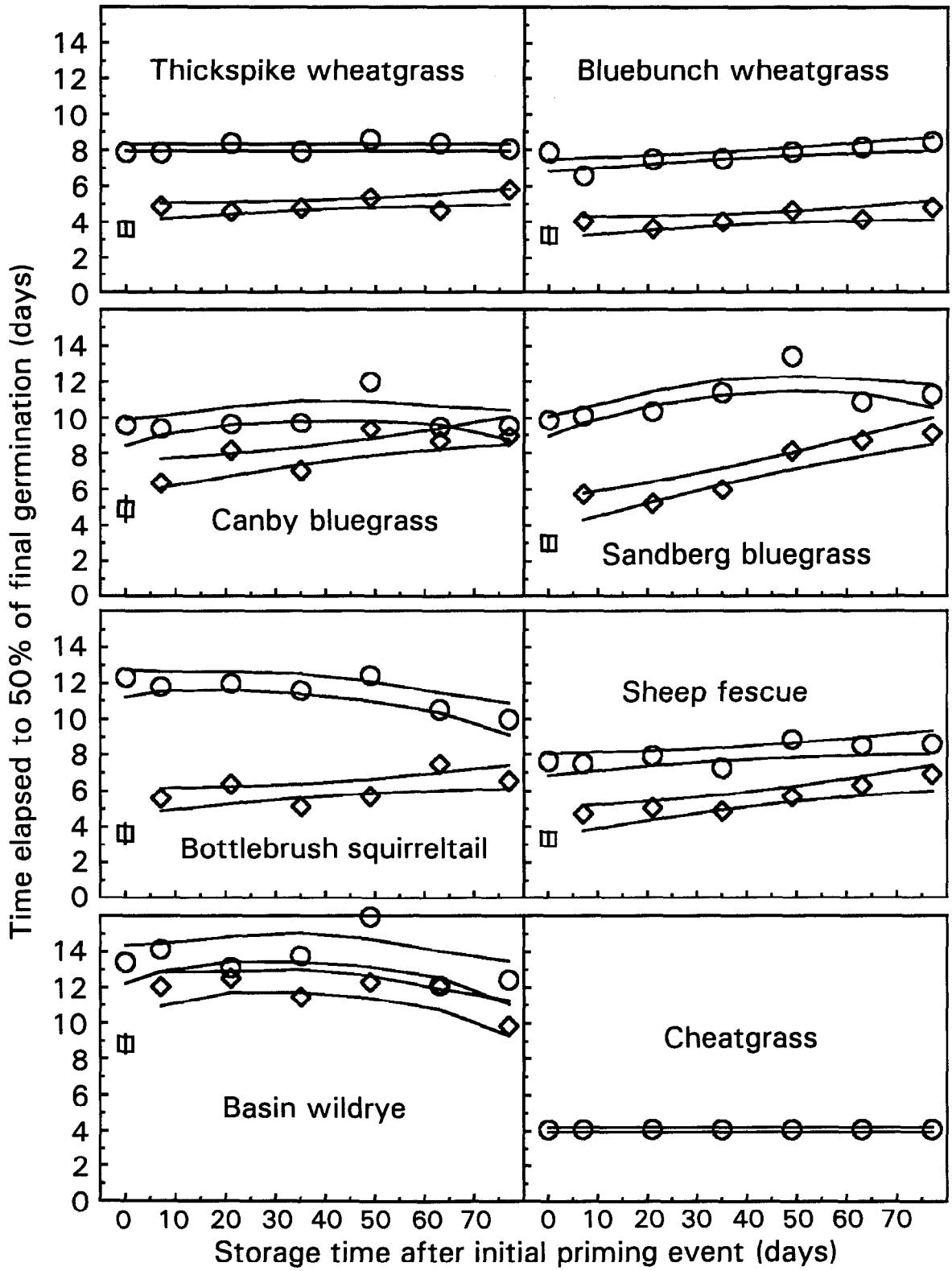

Fig. 1. Days elapsed until 50% of final germination of untreated (o), primed (□), and primed and dried (◇) seeds of 7 native bunchgrasses and cheatgrass. Lines represent confidence limits ($P \leq 0.05$) calculated from quadratic regression analysis. Vertical bars are confidence limits ($P \leq 0.05$) calculated for the mean of primed seeds that were not redried after treatment.

brating the seeds at subgermination water potentials. Hardegree and Emmerich (1992a,b) and Hardegree (1994) used matric-priming to increase germination rate of 11 range grass species but did not dry the seeds after treatment. The current study shows that, for the 7 Great Basin grass species previously tested by Hardegree (1994), primed seeds germinated significantly faster than non-primed seeds even after drying and storage. Only bluebunch wheatgrass, however, maintained a germination rate as high as cheatgrass when the seeds were dried after treatment (Fig. 1). The priming treatments used in this experiment were somewhat arbi-

trary in that only 1 temperature, water potential and treatment duration were tested for each species. Other treatment combinations might result in faster germination of primed and dried seeds.

There are some limitations to the practical application of priming technology to rangeland systems. Economical methods must be developed to treat, process, and store bulk quantities of seeds. The matric-priming system used in this study is not suitable for treating bulk quantities but allows for rapid determination of the seed water content after equilibration at the optimal priming temperature and water potential. Once these conditions have been determined, seeds can be primed in bulk by simple water addition to the appropriate water content under conditions of controlled temperature as described by Heydecker and Coolbear (1977) and Gray et al. (1990).

Both native grasses and cheatgrass are capable of fall emergence but cheatgrass can maintain significant root growth at low winter temperatures (Harris and Wilson 1970). Successful use of primed native seeds may require weed control measures to reduce competititon from fall- and winter-established cheatgrass. Optimal benefit would, theoretically, be obtained by planting freshly primed native grass seeds at the earliest date in the spring when conditions were suitable for germination. The unpredictable nature of seedbed microclimate makes the use of freshly primed seed impractical for spring planting unless supplementary water is available. A more likely scenario would be to plant primed seeds in the late fall, winter, or early spring. It has yet to be determined whether primed seeds retain any germination advantage if they are planted very far in advance of suitable conditions for germination and emergence.

Wilson (1972, 1973) and Wilson et al. (1974) measured a dramatic increase in germination rate of rangeland grass seeds that were exposed to field seedbed conditions. Increased germination rate among seeds stored in the field may represent a form of natural priming in the soil. Wallace (1960) demonstrated that seeds stored in soil at subgermination water content germinated more rapidly when water subsequently became available. Cold and wet soil conditions are similar to some low-temperature hydration treatments used to advance germination rate of certain agricultural species (Heydecker and Coolbear 1977). It may, therefore, be inappropriate to compare primed-seed performance with that of nonprimed seeds and cheatgrass accessions that have been stored dry in the laboratory. Laboratory germination at constant temperature also does not necessarily reflect seed response to variable field conditions. Future research is needed to validate priming effects on field establishment.

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