Responses of Crested Wheatgrass Seeds to Environment

A. M. WILSON

Highlight: *Characteristic of crested wheatgrass that favors establishment on harsh rangeland sites is the ability to germinate under conditions of low temperature and of intermittent drought. Subsequent germination was hastened as a result of exposure of seeds to favorable moisture and a temperature of 2 C. Subsequent germination was also hastened as a result of exposure of seeds to water potentials as low as -40 bars. During severe drought, seeds retained much of the advantage they had gained during periods of favorable moisture. After drought, seeds made rapid gains when moisture again became favorable.*

The objective of this study was to learn what physiological traits or adaptations of crested wheatgrass seeds seeds enable them to germinate under adverse rangeland conditions.

On these lands, seeds are often exposed to high and low temperatures and severe drought. An understanding of responses to these conditions would serve as a basis for selecting or modifying seedbed environments in order to increase the probability of success. Furthermore, a knowledge of critical physiological traits in the germination stage would be useful in developing plant materials that are better adapted for seeding on difficult sites.

Previous work indicates that crested wheatgrass seeds germinate under a wide range of temperature and moisture conditions (McGinnies, 1960). Metabolic processes start and stop when crested wheatgrass seeds are exposed to periods of precipitation and drought in the field (Wilson et al., 1970). Hastened emergence, due to seed pretreatment, is not lost when crested wheatgrass seeds are dried (Keller et al., 1970).

In the present study, critical physiological traits of crested wheatgrass were identified by studying the relationship between germination processes and environmental variables.

Materials and Methods

Seeds of Nordan crested wheatgrass (*Agropyron desertorum* [Fisch. ex Link] Schult.) were produced at Pullman, Wash. in 1969, and were 1 to 2 years old when used in this study. They were treated with 20 mg of thiram (tetramethylthiuram disulfide) per gram dry weight to prevent microbiological contamination.

In laboratory study of the effects of moisture stress, seeds were allowed to absorb water vapor from air at constant water potentials of -20, -40, and -60 bars, as previously reported (Wilson, 1971).

Paired samples of 100 seeds were enclosed in flat screen bags for planting in a silt loam soil at Pullman, Wash. A wooden frame surrounding the field plot was used for accurately covering seeds with 2.5 cm of soil.

At desired intervals both paired samples of seed were removed from the soil. One sample was promptly placed on moist blotter paper in petri dishes and germinated at 5 C. The other was stored in dry ice for later measurements of α-amylase activity.

Hastening of germination, a measurement for evaluating responses of seeds to environment, was defined as the number of days field or laboratory samples reached 50% germination ahead of air-dry control samples (Wilson, 1972). α-amylase activity, a second test for evaluating seed responses to environment, was determined by the iodine method (Chrispeels and Varner, 1967; Wilson, 1971).

Soil temperatures at a depth of 2.5 cm were recorded with a thermograph. The average temperature for each 2-hour period was read from the thermograph chart, and degree-hours was calculated by multiplying temperatures above 0 C times the number of hours. The sum of these values was divided by 24 to give degree-days.

Soil samples were taken within 0.5 cm below seed samples, and soil water potentials were measured in the laboratory with a thermocouple psychrometer (Campbell and Wilson, in press).

Results

Response to Temperature

At constant temperatures in the laboratory, hastening of germination at 2, 5, or 23 C increased with time of incubation (Fig. 1). Over this range of temperatures, the rate of gain was proportional to temperature.

In an October field experiment (Fig. 2), soil water potential remained greater than -2 bars and average daily minimum and maximum soil temperatures were 4 and 16 C, respectively. Seeds had made

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The author was a plant physiologist, Plant Science Research Division, Agricultural Research Service, U. S. Department of Agriculture at Pullman, Washington.

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The author's present address is Crops Research Laboratory, Agr. Res. Serv., U. S. Dep. Agr., Fort Collins, Colorado.

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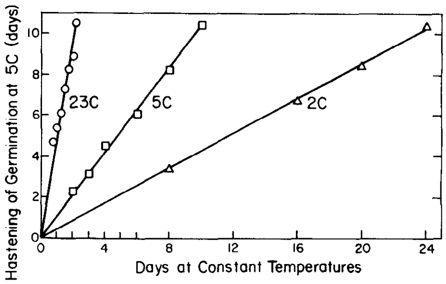

Fig. 1. *Hastening of germination of crested wheatgrass seeds incubated for various times at 2, 5, and 23 C. Values are averages of four replications.*

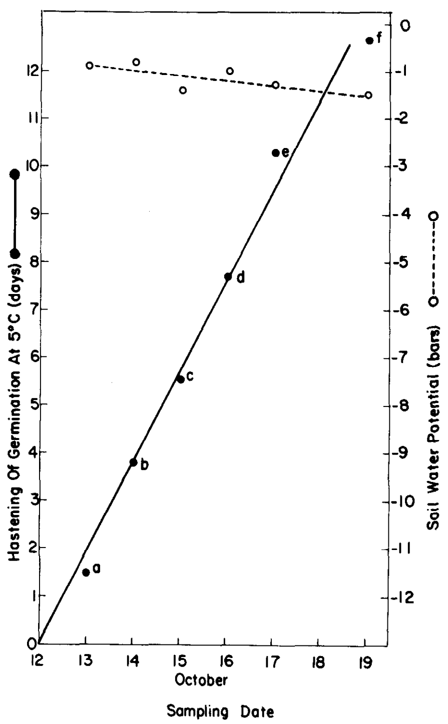

Fig. 2. *Hastening of germination in response to field environments in October, 1970. Water potential and hastening of germination values are averages of eight replications. Points labeled with different letters differ significantly at the 1% level according to Duncan's multiple range test.*

significant gains on each of the sampling dates and began to germinate in the field on the seventh day of the experiment.

In a March-April experiment, when soil moisture was again favorable and when average daily minimum and maximum soil temperatures were 1.0 and 11 C, respectively, seeds made slower gains than in the fall (Fig. 3). They began to germinate in the field on the 12th day of the experiment.

In these laboratory and field experiments in which moisture stress did not inhibit germination, hastening of germination was proportional to degree-days to

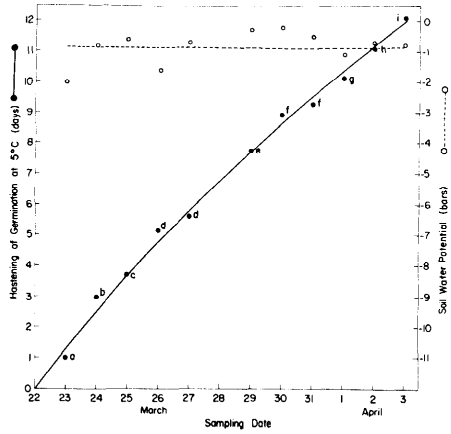

Fig. 3. *Hastening of germination in response to field environments in March and April, 1971. Water potential and hastening of germination values are averages of eight replications. Points labeled with the same letter do not differ significantly at the 1% level according to Duncan's multiple range test.*

which seeds had been exposed (Fig. 4). This relationship continued during the interval from planting to germination and over the temperature range of 0 to 23 C. However, this relationship would not be expected to continue at higher temperatures or during periods of soil moisture stress. Seeds in field and laboratory experiments responded similarly to temperature.

The log of α-amylase activity served as an accurate indicator of seed responses to temperature (Fig. 5). In the March-April experiment, no α-amylase was synthesized during the first 3 days of gain. Thereafter, there was a linear relationship between the log of α-amylase activity and the number of days gained. A similar relationship was found in the October experiment and in the laboratory experiment at 2, 5, and 23 C. Thus, whether the gain occurred during 2 days at 23 C or during 23 days at 2 C, the relationship between days gained and α-amylase activity was essentially the same.

Soil temperatures that remained at or below freezing for 1 month during a winter field experiment apparently did not injure seeds. The lowest soil temperature was -3 C. Limited hastening of germination measurements suggested that seeds made slow gains at 0 C. Seeds gained 10.4 days during brief periods of favorable temperatures in January. By February 3, 60% of the seeds had germinated in the field.

Response to Moisture Stress

Seeds were allowed to absorb water vapor from air at 23 C and at water potentials of -20, -40, and -60 bars.

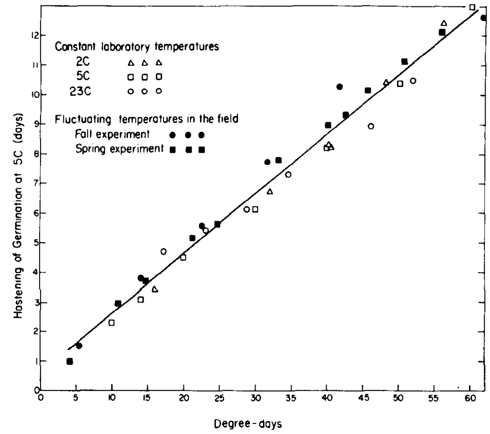

Fig. 4. *Correlation between hastening of germination and degree-days to which seeds had been exposed. Data are taken from Figures 1, 2, and 3.*

During 12 days of incubation at -20 bars, seeds gained an average of 10.9 days (Fig. 6). The rate of gain at -20 bars was one-third of that at 0 bars. After 20 days, at -20 bars, 3% of the seeds had roots and 1% had shoots. Seeds gained 3.0 days at -40 bars and 1.4 days at -60 bars.

α-amylase activity per day of gain was higher in seeds incubated at -20 bars than in seeds at 0 bars (Wilson, 1971). Nevertheless, α-amylase activity was a reasonably good indicator of seed responses to environment over the range of 0 to -20 bars.

During a May-June field experiment, average daily minimum and maximum soil temperatures were 9 and 31 C, respectively. Soil water potential was -3.6

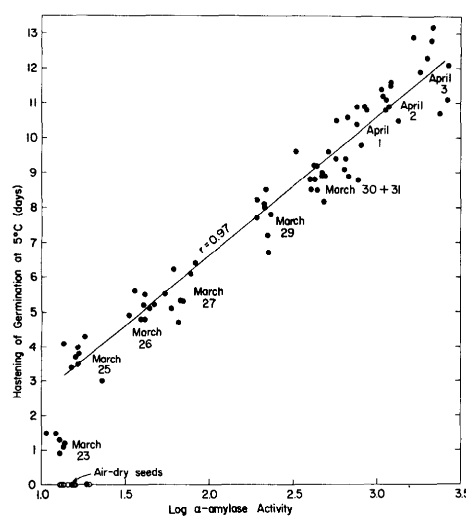

Fig. 5. *Correlation between hastening of germination and the log of α-amylase activity. Points are labeled with the date samples were taken from the field.*

bars when seeds were planted on May 15 (Fig. 7). By May 17, soil at a depth of 2.5 cm had dried to -150 bars. Hastening of germination increased to 3 days during this brief period of favorable moisture, and did not decline during the period of May 17 to June 9, even though seeds were exposed to temperatures as high as 43 C and water potentials as low as -600 bars. Rainfall of 0.4 cm on May 29 increased soil water potential at the 2.5-cm depth to -57 bars, but did not results in further hastening of germination. Soil water potential increased to -0.9 bars on June 8 as a result of 1.2 cm of rainfall, and then decreased to -3.1 bars by June 12. Seeds made rapid gains in hastening of germination during this period of favorable moisture. By June 12, 14% of the seeds had germinated in the field.

During a July field experiment, average daily minimum and maximum soil temperatures were 16 and 33 C, respectively. Soil water potential was -0.6 bars when seeds were planted on July 1 (Fig. 8). By July 3, soil at a depth of 2.5 cm had dried to -3.6 bars and hastening of germination had increased to 6.4 days. By July 4, seeds had lost about 3 days of this gain as a result of the drying of soil to -56 bars. Germination of seeds was not further delayed by the drying of soil to -420 bars.

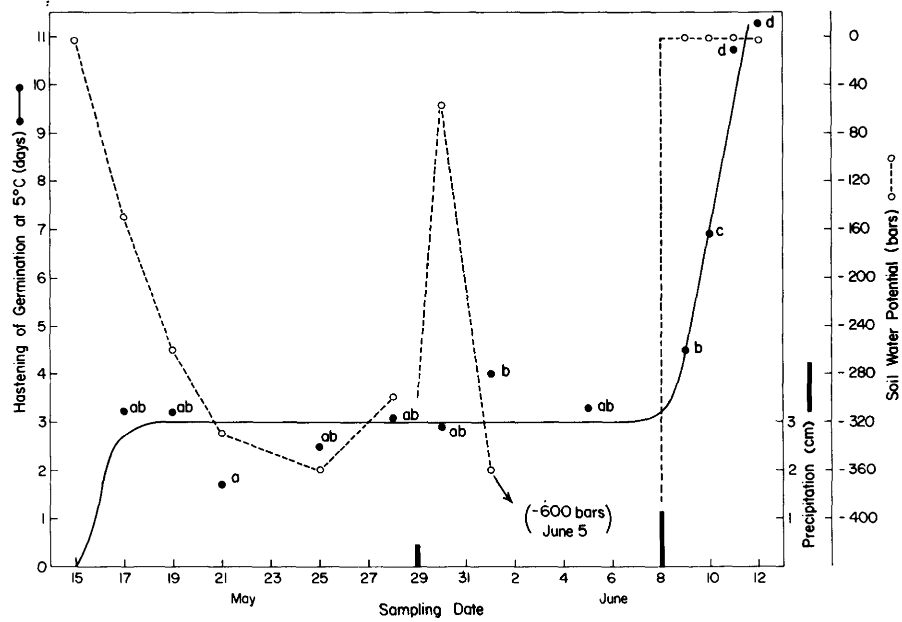

Fig. 7. *Hastening of germination as influenced by field environments in May and June, 1970. Hastening of germination and water potential values are averages of four replications. Points labeled with the same letter do not differ significantly at the 5% level according to Duncan's multiple range test.*

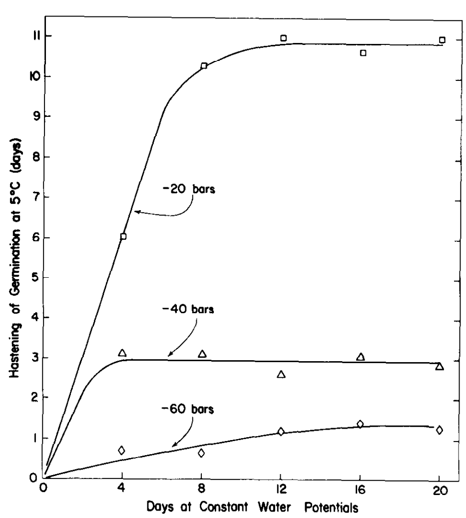

Fig. 6. *Hastening of germination in response to constant water potentials of -20, -40, and -60 bars. Incubation temperature was 23 C Values are averages of six replications.*

The plots were sprinkler irrigated with 1.1 ± 0.1 cm of water on July 7 (Fig. 8). Hastening of germination increased to 7.7 days during a brief period of favorable moisture. Germination of seeds was delayed 2.2 days by July 10 as a result of drying of soil to -160 bars. Rainfall of 1.7 cm on July 13 increased soil water potential to -0.5 bars and resulted in rapid gains in hastening of gèrmination. By July 14, 6% of the seeds had germinated in the field.

In the July experiment, the log of α-amylase activity indicated in a general way how seeds were responding to environment. However, the data suggested that drought delayed germination by 2 to 3 days without resulting in any loss of α-amylase activity.

Discussion

In areas where most of the precipitation falls during low-temperature months, the ability of seeds to germinate at low temperatures may determine whether or not they can be successfully seeded (Ellern and Tadmor, 1966). Hastening of germination at low temperatures appears to be one of the physiological traits that enables crested wheatgrass seeds to germinate on difficult sites. Another trait is the absence of injury to seeds when they are left in frozen soils for periods as long as 1 month. An understanding of these traits may be useful in field practice. In areas where winter temperatures are not severe, such as low-elevation rangelands in northwestern United States, crested wheatgrass may be seeded as early in the fall, winter, or spring as competing species can be controlled and the soil worked. This study indicates that when the soil thaws, seeds begin making significant gains in hastening of germination. Waiting to plant until the soil warms in late spring may leave too little time for seedling growth. Additional research is needed for

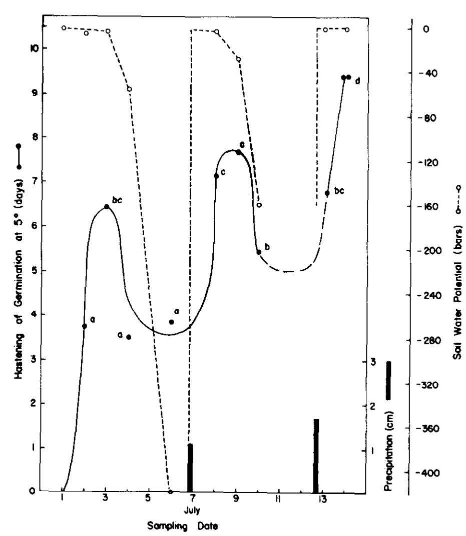

Fig. 8. *Hastening of germination as influenced by field environments in July, 1970. Soil water potentials are averages of four replications and hastening of germination values are averages of eight replications. Points labeled with the same letter do not differ significantly at the 5% level according to Duncan's multiple range test.*

areas that are exposed to very low temperatures during the winter months (Laude, 1956; White and Horner, 1943).

Drought tolerance appears to be another adaptation of crested wheatgrass seeds that enables them to germinate under harsh conditions. This study indicates that during the interval from planting to germination, several weeks at low water potentials does not seriously injure seeds. During exposure to drought, seeds retain much of the advantage they had previously gained. When moisture becomes favorable, metabolic processes continue and seeds make rapid gains in hastening of germination.

In this study, seeds were exposed to drought once or twice. Repeated drying may injure crested wheatgrass seeds (Maynard and Gates, 1963).

A period of favorable moisture, even though soil temperatures may be near 0 C, appears to be the best time for seeding when there is a choice between it and a period of intermittent drought. However, crested wheatgrass seeds appear to be well adapted for areas where there is no alternative except to plant during periods when seeds will sometimes be exposed to drought.

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SRM ANNUAL ELECTION RESULTS

The 2,009 ballots (a record number) cast in the 1972 annual election were counted on December 8. Selected by the membership to serve the Society during the next three years were:

President Elect . . . . . **Peter V. Jackson, III**
Directors . . . . **Daniel L. Merkel**
J. Boyd Price

These new officers will be installed at the forthcoming Annual Meeting in Boise, at which time **Dr. Martín H. González**, the current president elect, will succeed to the presidency. Mr. Jackson will serve as president in 1974 and the two newly-elected directors will serve for the three-year term 1973-1975.

Retiring next month from the Board of Directors are Past President Lorenz F. Bredemeier and Charles L. Leinweber, director. The other director whose term expires this year is Peter V. Jackson, who will now begin–in his new capacity–a *second* three years of service on the Board! The past contributions of these three men to the Society have been significant and are sincerely appreciated.

Mr. Jackson is a native of Montana. A cattle and wheat rancher, he resides in Harrison, Mont., but spends much time in Helena and in travels around the state as coordinator of the Montana Rangeland Resources Program. He is a former state legislator and a current director of the National Association of Conservation Districts. Mr. Merkel and Mr. Price are both associated with the Soil Conservation Service, the former serving as area plant materials specialist, headquartered in Santa Fe, N. Mex., while the latter is state range conservationist for Nevada, located in Reno.

The 1972 Elections Committee, which had the responsibility of counting the ballots, included Roderick K. Blacker, George L. Burnett, Edward C. Dennis, James W. Kellogg, Floyd E. Kinsinger, Jerry R. Martinez, David M. Nichol, Laurence E. Riordan, David V. Sanford, Don Smith, John C. Smith, Gerald D. Widhalm, and Francis T. Colbert, chairman. Ballots and tally sheets are kept on file in the Society office for a period of one year.