Seed and Seedbed Ecology of Crested Wheatgrass

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ABSTRACT: The seeds of crested wheatgrass are not particularly adapted for germination under cold seedbed conditions. Germination in the early spring would be an advantage for successful seedling establishment before soil moisture is exhausted in seedbeds. The development of new plant material with the potential for germination at lower seedbed temperatures should greatly aid in the establishment of adapted grasses on rangelands. Until such grasses are developed, the only alternative is to modify environmental parameters of seedbeds through such practices as seeding in deep furrows. Drilling crested wheatgrass seeds into seedbeds with good soil coverage leads to optimum chances for germination and establishment.

INTRODUCTION

Moisture and temperature conditions needed for germination of seeds of perennial grasses are largely out of phase in the big sagebrush (Artemisia tridentata) environment. When moisture is available, it is too cold for germination and growth, and soon after it warms sufficiently for germination, it often is too dry. Often germination is delayed by cold temperatures in the spring, so grass seedlings are not sufficiently established to survive the summer drought. In an environment without warm season precipitation, the onset of the summer drought is a non-interruptive event. Some of the landscape characterizing native perennial grasses, such as bluebunch wheatgrass (Agropyron spicatum), may only have successful seedling establishment in summers with above average precipitation (Harris and Wilson 1970).

In contrast, in an environment with warm season precipitation in which periodic droughts may limit seedling establishment, there is a definite chance of a moisture event occurring to alleviate the drought. Selective pressure of the warm season precipitation environment could favor characteristics that permit endurance of drought so seedlings can persist until the next moisture event. In an environment with near total cool season precipitation, the successful seedling must avoid the summer drought through dormancy. Earlier germination, even by a few days, may make the difference in successfully enduring inevitable summer drought.

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In most wildland situations, it is not possible to add supplemental irrigation water to ensure the establishment of perennial grass seedlings. Lacking the alternative of controlling soil moisture, land managers have two available options: a) they can seed plant material adapted to germinate at low temperatures when soil moisture is available, or 2) they can modify the seedbed to produce environmental conditions conducive to germination.

GERMINATION OF ADAPTED GRASSES IN RELATION TO TEMPERATURE

To ascertain the potential of the first alternative, we recently (Young and Evans 1982) conducted a study on the germination of the commercially available perennial grasses for seeding on rangelands where growth occurs primarily during the cool (moist) season. In all, 71 cultivars, accessions or collections of grasses (with four replications of 25 seeds each) were tested at 55 constant and alternating temperature regimes.

When the data from these germination experiments are segregated into broad groups of species such as wheatgrass, wild ryegrass, fescue, and bluegrass, there is no significant ($P = 0.01$) difference among the germination of the groups (Table 1).

There is one grass that widely occurs on sagebrush rangelands that has markedly better germination than any of the groupings of potential revegetation species. This highly germinable grass is cheatgrass (Bromus tectorum) (Table 1). An alien annual weed, it has invaded many sagebrush range sites in the Intermountain area where it has revolutionized secondary succession (Piemeisel 1951). Cheatgrass provides significant competition to the seedlings of perennial grasses and often

Table 1.--Comparison of mean germination of broad species groups for 55 constant and alternating temperatures (from Young and Evans 1982).

Species groups	Germination[1]
	percent
Wheatgrass	54 b
Wildrye	53 b
Fescue	40 b
Bluegrass	44 b
Cheatgrass	81 a

[1]Means followed by the same letter are not significantly different at the 0.01 level of probability as determined by Duncan's multiple range test.

closes the community to their establishment (Robertson and Pierce 1945). Not only do the seeds of potential revegetation species have to mesh their germination potential with physical parameters of the seedbed in terms of temperature and moisture, but they must also compete with cheatgrass for sites in the seedbed capable of supporting germination.

Species of the crested wheatgrass group [Fairway (Agropyron cristatum), standard (A. desertorum), and Siberian (A. sibericum)] have very similar germination characteristics (Table 2). Seeds of this group have some germination at virtually all the temperature regimes tested. Optimum germination, defined as mean germination not differing statistically ($P = 0.01$) from the maximum observed and one half its confidence interval (Young and Evans 1982), occurred at 7 to 19 percent of the temperature regimes tested. The mean germination of the optima ranged from 74 to 86 percent. Maximum germination of the Fairway and Siberian sources averaged only 76 and 79 percent respectively, compared to 90 percent for the standard crested wheatgrass group (Table 2).

Another method of evaluating the potential for germination at low seedbed temperatures is to calculate the frequency that a given temperature regime supports optimum germination for seeds of all the plant material tested. For the crested wheatgrass group, only the alternating temperature regime of 20°C for 16 hours and 25°C for 8 hours in each 24 hour period had a hundred percent frequency for supporting optimum germination (Table 3).

When the 20/25°C temperature regime is compared with temperatures recorded in field seedbeds of sagebrush sites in the Intermountain area, a wide discrepancy is apparent (see Evans et al. 1970). During the early spring, seedbed temperatures often included 0°C. This type of comparison can be expanded by making a discriminate breakdown of the 55 temperature regimes used in germination testing into groups of seedbed temperatures based on field monitoring (Young and Evans 1982). In this type of comparison, all of the crested wheatgrass group have significantly ($P = 0.01$) lower germination than that of cheatgrass (Table 4).

It is apparent that existing plant material available for revegetation of sagebrush rangelands has marked variability in its potential for germination at cold seedbed temperatures as would be found in the field in early spring. This underscores the importance of hybridization and selection programs to develop such material. Moreover, the competitive advantages of cheatgrass over available revegetation species extends into the realm of field seedbed temperatures.

Modifying the Existing Environment

Because we lack plant material that can germinate at low seedbed temperatures, modifying the physical seedbed is the practical alternative. McGinnies (1959) demonstrated that deep furrowing aided in the establishment of seedlings of perennial grasses on rangelands. Detailed micro-environmental monitoring studies by Evans et al. (1970) enumerated the environmental parameters that are modified by deep furrowing.

In terms of seedbed temperatures, the influence of deep furrowing is to moderate the temperature extremes, both maximum and minimum. Deep furrowing is not going to bring early spring seedbed temperatures into the high-frequency optimum regimes for crested wheatgrass germination, but it will greatly enhance the potential of the seedbeds to support germination of perennial grasses.

The development of modified arms for the rangeland drill (Asher and Eckert 1973) makes it possible to modify seedbeds, in suitable soils, by deep furrow seeding.

MOISTURE RELATIONS

Temperature relations in germination constitute only a portion of the environmental parameters interacting to control seedling establishment of

Table 2.--Comparison of germination parameters for accessions or cultivar groups of Fairway and standard crested wheatgrass and Siberian wheatgrass. Data generated from quadratic response surfaces based on germination at 55 constant and alternating temperatures.[1]

Germination parameter	Fairway	Standard	Siberian
	-----------	percent	-----------
Mean germination	56	59	55
Regimes with some germination	98	99	100
Mean of regimes with some germination	57	59	55
Regimes with optimum germination	19	15	27
Mean of optima	75	86	74
Maximum germination	76	90	79

[1]No significant difference in mean germination among groups.

Table 3.--Frequency of temperature regimes that supported optimum germination for accessions or cultivar groups of Fairway and standard crested wheatgrass and Siberian wheatgrass.

Cold period temperature (°C) 16 hours	Warm period temperature (°C) 8 hours 0	2	5	10	15	20	25	30	35	40
	----Frequency of optima - Percent---									
0						13	13			
2						13	13			
5						13	25			
10					18	63	75	25		
15					25	88	80	50		
20						88	100	50	25	
25							63	38		
30										
35										
40										

crested wheatgrass on rangelands. Available soil moisture and transfer of the moisture from the soil substrate to the seed are highly significant parameters in germination.

Much of the current theory concerning moisture dynamics in seedbeds has been developed by J.L. Harper and his students (Harper et al. 1965, Harper 1977). Harper proposes that seeds must take up moisture from the substrate faster than they lose moisture to the atmosphere. To accomplish this transfer and retention, there must be good contact between the substrate and the seed for hydraulic conductivity. To avoid moisture loss to the atmosphere, the seed must be buried in the soil. Translated to field terms, the best chance of obtaining a stand of crested wheatgrass comes by seeding at the correct depth in a good, firm seedbed.

Not even the seeds of cheatgrass are immune to the dynamics of soil moisture in the seedbed. Cheatgrass seeds require either fortuitous burial in surface microptopography of the seedbed, or litter coverage in order to germinate (Evans and Young 1970 and 1972). Both factors improve seedbed moisture relations for germination.

Germination on the Seedbed Surface

The seeds of grasses generally require soil coverage, litter coverage, or fortuitous placement in relation to seedbed microtopography in order to obtain the required environmental prerequisites for germination. Seeds of other types of plants can germinate on the soil surface, and some of these species are important to the establishment of crested wheatgrass seedlings on sagebrush rangelands.

Seeds of Russian thistle (Salsola iberica) follow a high risk germination strategy where a multitude of seeds are produced and a highly evolved dispersal system finds the right seedbeds. The germination of Russian thistle seeds is so rapid and such a simple process that seedling establishment can occur during the course of a single moisture event (see Evans and Young 1983 for discussion of

Table 4.--Comparison of germination of seeds of Fairway and standard crested wheatgrass, Siberian wheatgrass and cheatgrass in relation to a discriminate breakdown of seedbed temperatures.

Seedbed temperatures	Fairway	Standard	Siberian	Cheatgrass
	----------percent[1]----------			
Moderate	70 b	78 b	69 b	93 a
Colder than moderate	40 b	33 b	42 b	68 a
Widely fluctuating	54 b	53 b	57 b	84 a
Warmer than moderate	46 b	51 b	38 b	70 a

[1]Means in rows followed by the same letter are not significantly different at the 0.01 level of probability as determined by Duncan's multiple range test.

Salsola germination). Because of its dispersal and germination systems, Russian thistle can become a summer weed problem on ground being prepared for seeding crested wheatgrass or during the seedling year of the wheatgrass stand.

Several species of mustard can also become weeds during the seedling year of crested wheatgrass. Notable among these is tumble mustard (Sisymbrium altissimum). Seeds of this species can germinate on the surface of seedbeds apparently because of mucilaginous seed coats. This mucilage forms when the seed absorbs moisture and apparently retards the loss of moisture to the atmosphere. Unfortunately, it has not been possible to transfer this attribute to seeds of desirable grasses.

PERSPECTIVE IN CRESTED WHEATGRASS SEED ECOLOGY

There is a great need for plant breeders to develop new cultivars of adapted grasses which have the potential for germination and growth at low temperatures. Until such cultivars are developed, it is possible to manipulate environmental parameters in seedbeds through such techniques as deep furrow drilling. The drawbacks and limitations of broadcast seeding of crested wheatgrass seeds are obvious when moisture relations necessary for germination are considered.

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