Field establishment and germination of beardless wildrye (Elymus triticoides Buckl.)
by Timothy John Gutormson

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Agronomy
Montana State University

Abstract:
Beardless wildrye use in saline seep abatement has been complicated by inadequate methods for establishment and viability determination. The objectives of this study are to develop standard methods for determining seed viability and to evaluate the use of scarification in field establishment.

Temperatures, moistening agents, light environments, and pretreatments were evaluated to determine optimum germination of beardless wildrye. Seeds from 6 different growing seasons were evaluated in laboratory germination studies. A 0.2% KNO3 solution is the best moistening agent to use when viability testing beardless wildrye. Germination temperatures of 15-25°C and 20°C provide equal estimations of viability when light is used with the 20°C temperature. Beardless wildrye germination was equal in light and dark environments when using the 15-25°C temperature. Stratification prior to germination extends the testing period and does not improve viability estimation. High temperature imbibition (30°C) does not estimate viability better than 15-25°C germination when total testing days are equal. Beardless wildrye germination at 15-25°C or 20°C in a light environment with 0.2% KNO3 for 35 days provides the best viability estimate of all methods tested. A 35 day germination test may not be practical. Germination for 21 days followed by tetrazolium evaluation of remaining seeds is the recommended method.

Evaluation of beardless wildrye scarification was conducted in the laboratory and field using mechanical scarification on dormant and nondormant seed lots. Field plantings were conducted in the spring and fall in saline and nonsaline soils. Laboratory mechanical scarification enhanced beardless wildrye (Elymus triticoides Buckl.) germination and emergence parameters. Rachillas remaining on seeds following scarification can be used to determine degree of scarification. Scarification and subsequent establishment of beardless wildrye follows a quadratic response. Field studies indicated that dormant plantings establish better than spring plantings. Scarification of dormant planted seed does not improve establishment. Scarification enhances seedling growth and improves establishment of spring planted beardless wildrye. Winter seed withdrawal studies indicated that moisture imbibed in the fall is retained for spring germination. Dormant planted scarified seeds may lose viability from microorganism activity: The success of dormant plantings depends on the amount of water imbibed prior to soil freeze and not on the effect of winter stratification.

FIELD ESTABLISHMENT AND GERMINATION OF BEARDLESS WILDRYE

(*Elymus triticoides* Buckl.)

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Timothy John Gutormson

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Agronomy

MONTANA STATE UNIVERSITY
Bozeman, Montana

October 1984

APPROVAL

of a thesis submitted by

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citation, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ACKNOWLEDGMENTS

I express my sincere gratitude and appreciation to Dr. Loren E. Wiesner for his advice, friendship, availability, and patience as my major professor; Dr. J. M. Martin for statistical consultation; Dr. M. Foley for his constructive advice in completion of this thesis; Professor Lee Hart and John Scheetz for their contributions to my graduate program; the S.C.S. Bridger Plant Materials Center for supporting my assistantship; and Professor Ray C. Kinch, Emeritus and Dr. Dennis Tekrony for stimulating my interest in graduate school.

Additional appreciation goes to all my fellow graduate students who made this stay at Montana State University enjoyable.

I also wish to thank Sharon L. Hanson for being my closest friend and encouraging my pursuit of this degree.

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ABSTRACT

Beardless wildrye use in saline seep abatement has been complicated by inadequate methods for establishment and viability determination. The objectives of this study are to develop standard methods for determining seed viability and to evaluate the use of scarification in field establishment.

Temperatures, moistening agents, light environments, and pretreatments were evaluated to determine optimum germination of beardless wildrye. Seeds from 6 different growing seasons were evaluated in laboratory germination studies. A 0.2% KNO_3 solution is the best moistening agent to use when viability testing beardless wildrye. Germination temperatures of 15-25C and 20C provide equal estimations of viability when light is used with the 20C temperature. Beardless wildrye germination was equal in light and dark environments when using the 15-25C temperature. Stratification prior to germination extends the testing period and does not improve viability estimation. High temperature imbibition (30C) does not estimate viability better than 15-25C germination when total testing days are equal. Beardless wildrye germination at 15-25C or 20C in a light environment with 0.2% KNO_3 for 35 days provides the best viability estimate of all methods tested. A 35 day germination test may not be practical. Germination for 21 days followed by tetrazolium evaluation of remaining seeds is the recommended method.

Evaluation of beardless wildrye scarification was conducted in the laboratory and field using mechanical scarification on dormant and nondormant seed lots. Field plantings were conducted in the spring and fall in saline and nonsaline soils. Laboratory mechanical scarification enhanced beardless wildrye (*Elymus triticoides* Buckl.) germination and emergence parameters. Rachillas remaining on seeds following scarification can be used to determine degree of scarification. Scarification and subsequent establishment of beardless wildrye follows a quadratic response. Field studies indicated that dormant plantings establish better than spring plantings. Scarification of dormant planted seed does not improve establishment. Scarification enhances seedling growth and improves establishment of spring planted beardless wildrye. Winter seed withdrawal studies indicated that moisture imbibed in the fall is retained for spring germination. Dormant planted scarified seeds may lose viability from microorganism activity. The success of dormant plantings depends on the amount of water imbibed prior to soil freeze and not on the effect of winter stratification.

CHAPTER I

INTRODUCTION

Beardless wildrye (*Elymus triticoides* Buckl.) is a native, rhizomatous, moderately long lived perennial grass of the western and northwestern United States. It is commonly found on low, wet, depressional areas and is adapted to saline-alkaline soils of medium to heavy texture.

Beardless wildrye is predominantly cross-pollinated and is described as a poor seed producer. Seed production properties have been improved by the release of 'Shoshone' beardless wildrye which has produced up to 447 kg of seed ha^{-1}. The forage is rated as moderately palatable, and yields have exceeded 8963 kg ha^{-1}.

Seed of beardless wildrye germinates slowly due to seed coat imposed dormancy (Knapp and Wiesner 1978). Wagner and Chapman (1970) noted that no germination was detectable after nine days of germination. Knapp and Wiesner (1978) found that increasing oxygen content of the air induced the greatest percentage germination, but this response was not equal to viability.

Poor seedling development reduces stand establishment and has decreased beardless wildrye use in saline seep abatement. The objectives of these studies are: (1) increase the seed coat permeability to improve field emergence and seedlings establishment, and (2) develop standard laboratory germination methods to determine beardless wildrye seed viability.

CHAPTER II

LITERATURE REVIEW

Seed Anatomy

Integument(s) of the developing seed form the testa (cuticle) or the seed coat. The seed coat may inhibit germination by decreasing the oxygen and water permeability (Esau 1977). Cuticle layers and their distribution can be important factors in seed coat permeability (Esau 1977).

Morrison and Dushnicky (1982) describe two cuticle layers in wild oats (*Avena fatua*); the outer cuticle is derived from the inner integument, and the inner cuticle originates from the outer epidermis of the nucellus. A hyaline layer occurs between the cuticle and aleurone layer of wild oats. Wright (1973) observed that the seed coat of 'Lehmann' lovegrass (*Eragrostis lehmanniana* Nees.) was primarily derived from the outer layer of the inner integument. The true seed coat of yellow foxtail (*Setaria lutescens*) is formed from the integuments and appears as a crushed granular structure (Rost 1973). The innermost seed coat layer is formed by the remains of the nucellus. Thornton (1966a and 1966b) described a layered seed coat of pericarp, outer integument, inner integument, and aleurone layer for tall wheatgrass (*Agropyron elongatum*) and buffalograss (*Buchloe dactyloides*). The testa or true seed coat varies in origin and structure and this variation may influence dormancy.

Acid Scarification

Acid scarification is the most widely used method of breaking dormancy in grasses. Sulfuric acid is the primary acid used for scarifying seed coats. Concentration and length of immersion vary among researchers and grass species.

Sulfuric acid scarification increases germination as shown by: Bryan (1918), (*Cynodon dactylon*); Ray and Stewart (1937), (*Paspalum dilatatum*); Burton (1938), (*Cynodon dactylon*) and (*Paspalum notatum* Flugge.); Toole (1939), (*Danthonia spicata* L.); Coukos (1943), (*Andropogon furcatus*), (*Andropogon scoparius*), (*Sorghastrum nutans* (L.) Nash.), and (*Bouteloua curtipendula*); Mathews (1946), (*Panicum anceps* Michx.) and (*Paspalum notatum* Flugge.); Dawson and Heinrichs (1951), (*Stipa viridula* Trin.); Anderson (1953), (*Paspalum notatum* Flugge.); Emal and Conard (1973), (*Sorghastrum nutans* (L.) Nash.); Wright (1973), (*Eragrostis lehmanniana* Nees.); and Wiesner and Brown (1978), (*Elymus triticoides* Buckl.).

Acid scarification of Indian ricegrass (*Oryzopsis hymenoides* Roem. and Schult.) Ricker, has been extensively evaluated, Stoddart and Wilkinson (1938), Toole (1940), Plummer and Frischknecht (1952), Clark and Bass (1970), McDonald (1976), McDonald and Khan (1977), McDonald and Khan (1978), and Zemetra et al. (1983). These studies indicated that acid scarification was beneficial. Sulfuric acid was used by all researchers except Clark and Bass (1970) who used 0.2% nitric acid. Toole (1940) and McDonald (1976) observed that concentrated sulfuric acid caused seedling abnormalities. Abnormalities were not reported by Stoddart and Wilkinson (1938) and Plummer and Frischknecht (1952). Seed size according to Stoddart and Wilkinson (1938) may be the reason for varying results. They found differences in germination and length of immersion between sized and unsized Indian ricegrass seeds. Cuticle thickness may account for varying acid concentration effects. McDonald and Khan (1977) reported that cuticle layers are a partially impermeable barrier.

Degree of Indian ricegrass acid scarification varies. Plummer and Frischknecht (1952) and Zemetra et al. (1983) reported that harsh acid scarification (one that removes most of seed coat) produce good results in greenhouse studies, but were not successful in the field. Zemetra et al. (1983) felt that breaking of the seed coat was so drastic that the seed could not withstand overwintering stress. McDonald (1976) observed that storage of acid scarified Indian ricegrass (*Oryzopsis hymenoides* Roem. and Schult.) seeds did not reduce viability; however, Burton (1938) found that eight month old acid scarified bahiagrass (*Paspalum notatum*) seed lost viability and suggested scarifying just prior to planting.

Ray and Stewart (1937), Mathews (1946), and Anderson (1953) concluded that acid scarification of grass seed caused an easier entry for moisture into the seed, thus allowing faster germination. McDonald and Khan (1977) found that acid scarification decreased abscissic acid levels of intact seeds of Indian ricegrass. They later (1978) found that removal of the seed coat by acid scarification was necessary for activation of peroxidase, alpha-amylase, and ribonuclease activity.

Acid scarification is a valuable tool for determining seed viability (Bryan 1918, McDonald 1976). Its value for field plantings is questionable (Zemetra et al. 1983).

Mechanical Scarification

Mechanical scarification of grass seed has been investigated using a variety of methods and species. The methods commonly used are pinpricking, removing lemma and palea, scarifying with abrasive materials, and hammermilling.

Spring establishment of green needlegrass plantings (*Stipa viridula* Trin.) is poor (Dawson and Heinrichs 1951, Fendall and Carter 1965). In this species seed dormancy contributes to poor stand establishment (Fendall and Carter 1965). Dawson and Heinrichs (1951) report that two types of dormancy are present in green needlegrass, physiological and physical. Many researchers (Dawson and Heinrichs 1951, Fendall and Carter 1965,

Wiesner and Kinch 1964) have reported that physical dormancy of green needlegrass is associated with the seed coat because puncturing the seed coat and mechanical removal of the lemma and palea resulted in the highest germination of all scarification treatments. Differences in water uptake between intact and dehulled seeds were detected; however, after ten hours water absorption was not significantly different (Dawson and Heinrichs 1951, Fendall and Carter 1965, Wiesner and Kinch 1964).

Oxygen uptake by germinating green needlegrass seeds is limited by the lemma and palea (Fendall and Carter 1965). Mechanical damage to reed canarygrass (*Phalaris arundinacea* L.) caryopsis increased oxygen uptake (Landgraff and Junttila 1979). Treatments such as alternating temperature, chilling, and red light also increased oxygen uptake (Landgraff and Junttila 1979). Vose (1962) reported that dormancy in reed canarygrass can be overcome by scarifying and pinpricking. He postulated that scarification allowed for leaching of a water soluble inhibitor.

Roberts (1961) found that rice (*Oryza sativa* L. ssp. indica) seed germination increased 65% when hulled. He concluded that increased germination by hull removal is related to the gas restriction properties of the hulls. The hull either restricts the outward diffusion of some gaseous inhibitor, or it restricts diffusion of gaseous elements needed for germination.

Wright (1973), Haferkamp and Jordan (1977), and Haferkamp, Jordan, and Matsuda (1977) reported that mechanical scarification of Lehmann lovegrass (*Eragrostis lehmanniana* Nees.) increased germination. Needle scarification increased germination by 40% and the location of pricking had no effect on germination (Wright 1973). Cylinder scarification (Wright 1973, Haferkamp and Jordan 1977) is the most effective mechanical scarification treatment for increasing Lehmann lovegrass germination. Lehmann lovegrass scarification increased the seed coat permeability to water and oxygen (Haferkamp and Jordan 1977).

Haferkamp, Jordan, and Matsuda (1977) reported that the moisture uptake rate and germination were increased by scarification. ATP levels were enhanced by mechanical scarification (Haferkamp et al. 1977). Germination of scarified Lehmann lovegrass seeds increased at all oxygen concentrations (Haferkamp et al. 1977).

Zemetra et al. (1983) evaluated scarification for field plantings using three ages of Indian ricegrass seed. The use of sulfuric acid or commercial cylinder scarifier plus GA_3 increased emergence of the one-year old seed. Emergence of six month old seed was increased with the commercial cylinder scarifier plus GA_3 as compared to the six-month control. Field trials using scarified seed varied greatly when compared to greenhouse emergence. Scarification by rubbing seeds between sandpaper and a hard rubber surface gave the best field emergence of two year old seed. Conversely, Plummer and Frischknecht (1952) found that sandpaper scarification which removed lemma and palea of Indian ricegrass was not an effective method for field establishment. Toole (1940) observed injury to the exserted embryo of Indian ricegrass following mechanical scarification; this may explain the poor results obtained by Plummer and Frischknecht (1952). Zemetra et al. (1983) reported differences in field emergence and greenhouse emergence of acid scarified seed. Apparently, winter conditions and pathogen invasion were detrimental to acid scarified seed establishment. Kinch (1963, 1966) demonstrated that clipping the distal end of western wheatgrass (*Agropyron smithii*) seeds increased dark germination by 7-16%. However, seed lot viability was not obtained by this method. Bass (1955) reported western wheatgrass viability could be obtained by rupturing the membrane over the embryo with a needle. Piercing the integumentary layers of dormant tall wheatgrass seed increased germination (Thornton 1966a). The location of piercing has no effect on germination. Buffalograss dormancy can be relieved by clipping the burs at the distal end. Clipping facilitates gas exchange which Thornton (1966b) indicates as the cause of buffalograss dormancy.

Colbry (1970) observed that removal of the lemma and palea and scratching the caryopsis of *Zoysia japonica* provided 91% germination in 14 days as compared to 82% germination in 35 days for unscarified seed. Colbry (1970) concluded that increasing the germination rate was the only advantage of seed covering removal and prechilling was not necessary for fast and complete germination.

Indiangrass (*Sorghastrum nutans* (L.) Nash.) seedling establishment was reduced significantly following rubbing board hull removal (Geng and Barnett 1969). Hull removal also increased caryopses susceptibility to microorganisms (Geng and Barnett 1969). Sautter (1962) reported that sandpaper scarification of switchgrass (*Panicum virgatum* L.) seed increased germination by 84%. Seed scarification produced the fastest germination of all treatments studied (Sautter 1962).

Lemma and palea removal from dallisgrass (*Paspalum dilatatum*) seed gave the best germination percentage of all treatments evaluated (Ray and Stewart 1937). They conclude that scarifying dallisgrass seed will allow increased water uptake.

The caryopsis coverings of bahiagrass limits germination (Anderson 1953). Maximum germination of bahiagrass is obtained by removing the glumes, lemma, palea, and lightly scratching the caryopses. Burton (1939) found that removal of both glumes and palea of bahiagrass, with sandpaper, significantly increased the rate of germination. Mathews (1946) found cylinder and disc scarification did not increase germination of beaked panicum (*Panicum anceps* Michx.) and bahiagrass. Many seeds were entirely dehulled after mechanical scarification and these seeds did not germinate. Acid scarification of bahiagrass weakens the coverings which allow entry of water to the caryopsis and allows germination (Mathews 1946).

Hammermilling promoted germination of dormant caropyses of *Andropogon furcatus, Andropogon scoparius, Sorghastrum nutans,* and *Bouteloua curtipendula* (Coukos 1943).

Hammermilling which removes seed coat parts increased germination of *Andropogon furcatus, Bouteloua curtipendula,* and *Bouteloua gracilia* (Weber 1939).

Mechanical scarification has varied in successfully breaking seed dormancy. Many species and methods have been utilized in laboratory studies. Mechanical scarification methods for field establishment of grass seed is not evident from this literature review.

CHAPTER III

METHODS FOR THE GERMINATION OF BEARDLESS WILDRYE (*Elymus triticoides* Buckl.)

Introduction

Beardless wildrye (*Elymus triticoides* Buckl.) is a native, rhizomatous, moderately long lived perennial grass (Stefferud 1948), whose native range encompasses most of the western and northwestern United States (Hafenrichter et al. 1949). It is commonly found on wet depressional areas and is adapted to saline-alkaline soils of medium to heavy texture (Anonymous 1977).

The germination literature available generally groups *Elymus triticoides* (Buckl.) and *Elymus triticoides simplex* (Scribn. and Will.) together because many of their germination and seedling development characteristics are similar.

Beardless wildrye is cross pollinated (Wheeler 1975), and is a poor seed producing species (Stroh 1968). Seed production properties have been improved in the cultivar 'Shoshone' beardless wildrye which produces up to 447 kg of seed ha^{-1} (Anonymous 1977). The forage yields have exceeded 8963 kg ha^{-1} and the forage is rated as moderately palatable (Anonymous 1977).

Seed of beardless wildrye germinates slowly making establishment difficult; signs of germination are not detectable until the 9th day of germination (Wagner and Chapman 1970). Greenhouse studies by Plummer (1943) indicated that *Elymus triticoides simplex* has much slower root development when compared to other grass species. The slow germination and development of beardless wildrye seedlings causes poor stand establishment (Knapp and Wiesner 1978).

Slow germination of beardless wildrye is caused by the outer coverings of the seed (Knapp and Wiesner 1978). Excision of embryos gave rapid and complete germination and a 100% oxygen atmosphere promoted germination superior to all other treatments not involving scarification (Knapp and Wiesner 1978).

Plummer (1943), Haferkamp and McSwain (1951), and Wagner and Chapman (1970) report germination methods for *Elymus triticoides*. Plummer (1943) promoted germination by an alternating 20-30C (20C for 18 hours and 30C for 6 hours) and a constant 21C temperature for 30 days. Wagner and Chapman (1970) reported that 15-25C and 20C with distilled water gave good germination results in a 21 day test. Haferkamp and McSwain (1951) reported that beardless wildrye should be germinated at 20-30C with light and 0.2% KNO_3 for 35 days. Prechilling effects were evaluated by Wagner and Chapman (1970) and Knapp (1976). Wagner and Chapman (1970) state that prechilling increased seed weight by increasing water uptake; although, this effect is significant only during the last 4 days of the germination period. Stratification enhanced germination; however, the increase in germination may be due to a longer imbibition period (Knapp 1976).

Due to the variation in reported methods for germination of *Elymus triticoides* this study was undertaken to define the germination requirements that provide the best estimation of beardless wildrye seed viability.

Materials and Methods

Nine beardless wildrye seed lots varying in dormancy level and production environment were utilized (Appendix, Table 24).

Germination experiments were conducted in 13 by 13.5 cm plastic boxes with two 15 by 12 cm blue blotters. Treatments were replicated four times with 100 seeds replicate^{-1}. The experimental design was a randomized complete block. Dark germination conditions

were obtained by wrapping boxes with aluminum foil. Alternating germination temperatures cycled for 8 hours at the high temperature and 16 hours at the low temperature. Germination, stratification, and high temperature imbibition studies were conducted in the dark unless otherwise stated. Germination counts were made every seven days for 21 days unless otherwise stated. Evaluation of normal seedlings were conducted in accordance with the AOSA Rules for Testing Seeds (1982).

To determine the effect of blotter moistening solutions on germination 30 ml of deionized water, distilled water, tap water, and 0.2% KNO_3 were applied to blotters in light and dark environments using seed lots 1 and 8. Germination was conducted at 15-30C alternating temperatures.

Two germination temperature studies were conducted using 20C, 15-25C, and 15-30C in light and dark environments with seed lots 1, 4, 6, and 8 in study one and seed lots 2, 3, 4, 5, 6, 7, and 8 in study two. The second temperature study did not contain a dark environment. The blotter moistening solution used for the temperature experiments was 0.2% KNO_3.

Beardless wildrye seeds were stratified at 4C for 7, 10, and 14 days on blotters moistened with 0.2% KNO_3. Seed lots 1-8 were used in all stratification studies. Germination following seed stratification periods of 7 and 10 days was conducted at 15-25C. Seeds stratified for 14 days were germinated at 20C and 15-25C. The length of the total test period was 35 days. The control treatment was germinated for a total of 35 days to equal the length of the prechill test.

High temperature imbibition at 30C for 3 and 5 days prior to germination with 0.2% KNO_3 was evaluated. After imbibition seeds were germinated at 15-25C for 21 days. Control treatments were germinated at 15-25C for 24 and 26 days respectively to compensate for the imbibition periods. Seed lots 1, 4, 5, 6, 7, and 8 were utilized in this study.

Treatment mean comparisons were separated with a protected LSD P = .05.

Results and Discussion

The 0.2% KNO_3 blotter moistening solution significantly promoted beardless wildrye seed germination compared with the other solutions tested (Table 1). Distilled, tap, and deionized water were not significantly different in promoting germination (Table 1). Most dormant grasses germinated in accordance with AOSA Rules for Testing Seeds are germinated with 0.2% KNO_3. Crosier and Cullinan (1941), Anderson and Drake (1944), Drake (1951), and Colbry (1953) report that 0.2% KNO_3 gave better germination of their respective grass species than did water. These results indicate that 0.2% KNO_3 is the most appropriate moistening agent for beardless wildrye germination.

Table 1. Effect of Distilled, Tap, Deionized Water, and 0.2% KNO_3 on Beardless Wildrye Germination at 15-30C using Seed Lots 1 and 8.

Moistening Agents	Mean Percentage Germination
Distilled water	33 A
Tap water	36 A
Deionized water	36 A
0.2% KNO_3	59 B
LSD = .05	5.63

Three regimes were used to determine the optimum temperature for beardless wildrye germination; 20C and 15-25C were the most favorable when light was present (Table 2).

Table 2. Mean Percentage Germination of Beardless Wildrye When Germinating at Temperatures of 20C, 15-25C, and 15-30C in a Light Environment.*

Temperature C	Mean Percentage Germination
15-30	57 A
15-25	62 B
20	65 B
LSD = .05	3.60

*Seed lots 2, 3, 4, 5, 7, and 8 were utilized.

Previously, Wagner and Chapman (1970) reported that 20C and 15-25C were better temperatures for germination of two beardless wildrye strains than 15-30C and 15C. Plummer (1943) reported that a 21C mean temperature gave 92% germination of *Elymus triticoides simplex*; however, an alternating 20-30C gave 96% germination. Colbry and Wiseman (1961), Andersen (1941), and Shenberger (1961) all reported that moderate alternating temperatures (15-25C) promoted germination as compared to wide extremes in temperature alternations (15-30C). The short duration at 30C in Plummer's alternating cycle or a slow alternation to 30C may be the reason for germination comparable to 20C.

Toole (1976) demonstrates that western wheatgrass dormancy is promoted by long periods on the high temperature phase of an alternating cycle. Colbry and Wiseman (1961) reported that sharp temperature alternations favor germination of ryegrass. These data indicate no difference in germination between a constant temperature of 20C and an alternating temperature of 15-25C for beardless wildrye when germinated in the light (Table 2). Based on these data beardless wildrye germination is optimum at either 15-25C or 20C when light is present. The reason why *Elymus triticoides* does not germinate better with the alternating temperature of 15-25C is not clear. Possibly the alternation is not needed and an actual mean temperature of 20C provides adequate water uptake and oxygen absorption for germination.

The effect of light on germination was studied during the temperature comparison experiment. At 20C light induced greater germination than dark but had no effect on germination at 15-25C (Table 3).

The alternating 15-25C temperature was sufficient enough to overcome dormancy in both light and dark environments. Delouche and Bass (1954) conclude that alternating germination temperatures are required to increase seed coat membrane permeability. Alternating temperatures and light may have the same effect on the seed coat. Consequently, a

Table 3. The Influence of Light and Dark Environments on 15-25C and 20C Germination of Beardless Wildrye With 0.2% KNO_3 using Seed Lots 1, 4, 6, and 8.

Environment	Mean Percentage Germination	
	15-25C	20C
Dark	73	65
Light	71	72
LSD = .05	6.01	5.70

constant 20C temperature in the dark would cause minimal change in seed coat permeability. Germination of beardless wildrye can be conducted in light or dark environments at 15-25C; however, germination at 20C requires light.

Stratification increased germination at 15-25C over nonprechilled seed for all three prechilling periods (Table 4). However, when beardless wildrye seeds were germination for time periods equal to the stratification plus germination periods; stratification did not increase beardless wildrye germination (Table 5).

Table 4. Effect of Stratification for 0, 7, 10, and 14 Days on Beardless Wildrye Germination at 15-25C With 0.2% KNO_3 using Seed Lots 1-8.

Prechill Length (days)	Mean Percentage Germination
0	57 A
7	68 C
10	70 C
14	62 B
LSD = .05	2.89

These data indicate that stratification may reduce beardless wildrye germination. Two weeks of stratification plus three weeks of germination gave 63% germination compared to 83% for an equal time period of only germination. The prechilling at 4C may reduce the water imbibition and gas exchange rate. Knapp and Wiesner (1978) state that imbibition temperatures affected germination percentage. Seeds which imbibed water at 30 and 20C had higher germination at 15-25C than seeds imbibed at 1.5C and 10C.

Table 5. Comparison of 14 Days of Prechill Followed by 3 and 4 Weeks of Germination With Germination for 3, 4, and 5 Weeks at 15-25C With 0.2% KNO_3 on Seed Lots 1-8.

Treatments			
Prechill (wks)	Germination (wks)	Weeks Tested	Mean Percentage Germination
2	3	5	63 B
2	4	6	79 D
0	3	3	49 A
0	4	4	75 C
0	5	5	83 E
LSD = .05			3.17

Based on the prechill data it appears that the main function of the prechill period was to allow water imbibition; therefore, a high temperature imbibition study prior to germination was conducted (Table 6).

Table 6. Influence of 3 and 5 Days of 30C Imbibition on Beardless Wildrye Germination at 15-25C With 0.2% KNO_3 for 24 and 26 Days using Seed Lots 1, 4, 5, 6, 7, and 8.

Treatment	Length of Test (days)	Mean Percentage Germination
Control	24	68 A
3 day 30C imbibed	24	69 A
Control	26	81 B
5 day 30C imbibed	26	80 B
LSD = .05		3.33

Three and five days of high temperature (30C) imbibition of beardless wildrye seeds did not increase germination over their respective controls (Table 6). Differences between the 24 and 26 day periods would not be detected if they were equal in test length. Apparently, 30C imbibition does not cause a faster uptake of water or oxygen than the 15-25C germination temperature.

CHAPTER IV

FIELD ESTABLISHMENT OF BEARDLESS WILDRYE (*Elymus triticoides* Buckl.)

Introduction

Beardless wildrye (*Elymus triticoides* Buckl.) is a native, rhizomatous, moderately long lived perennial grass of the western and northwestern United States. In inhabits wet depressional areas and is adapted to saline soils of medium to heavy texture.

Dormancy of beardless wildrye is imposed by the lemma, palea, and true seed coat (Knapp and Wiesner 1978). The testa or true seed coat is formed from the integuments (Esau 1977). Esau (1977) states that cuticular layers and their distribution can be important factors in seed dormancy. The presence of cuticular layers have been reported in monocots by: Morrison and Dushnicky (1982), (*Avena fatua*); wild oats; Wright (1973), (*Setaria lutescens*), yellow foxtail; and Thornton (1966a and 1966b), (*Agropyron elongatum*) tall wheatgrass and (*Buchloe dactyloides*) buffalograss.

Thornton (1966a) states that dormant tall wheatgrass seeds will germinate completely by rupturing the integumentary layers. Bass (1955) obtained total viability of western wheatgrass (*Agropyron smithii*) seed lots by rupturing the membrane over the embryo. Removal of the lemma and palea of green needlegrass (*Stipa viridula* Trin.) seeds promoted germination better than other mechanical scarification treatments (Fendall and Carter 1965).

Acid scarification is one of the primary methods used to break grass seed dormancy. Ray and Stewart (1937), Mathews (1946), and Anderson (1953) concluded that acid scarification of grass seed caused an easier entry for moisture into the seed, thus allowing faster

germination. Zemetra et al. (1983) acid scarified 6 month, 1 year, and 2 year old Indian ricegrass seeds for field plantings and found acid scarification decreased emergence. Additionally, they found that mechanical scarification by rubbing increased field emergence; however, no treatment increased emergence for all ages of seed. Light and moderate acid scarification of Indian ricegrass seed gave excellent field emergence (Plummer and Frischknecht 1952). There was no advantage in fall planting over spring planting when using acid scarified seed. The practical use of acid scarification for beardless wildrye is questionable due to lack of available equipment and the safety factor when using concentrated acid. Acid scarification is a valuable tool for determining seed viability (Bryan 1918, McDonald 1976), but its merit for improving field establishment has not proven successful according to Zemetra et al. (1983).

Mechanical scarification has been used to break dormancy in laboratory studies. Wright (1973) used cylinder scarification to overcome dormancy in Lehmann lovegrass. Seven to 12 seconds of cylinder scarification using 0.25 to 8 ml of lovegrass seed was the most effective treatment. Scarification of switchgrass (*Panicum virgatum* L.) with emery cloth increased germination 84% (Sautter 1962). Wiesner and Brown (1978) found that two minutes of 67% sulfuric acid scarification or 8 seconds of cylinder scarification gave 89% germination of beardless wildrye seed. Using mechanical scarifications for field plantings has received little attention.

Fendall and Carter (1965) state that late fall seedings of green needlegrass have resulted in better stands than spring plantings. Similarly, Dawson and Heinrichs (1952) observed that fall seedings of green needlegrass produced good stands while spring seedings produced poor stands. Spring seedings of acid scarified Indian ricegrass seed produced more seedlings than fall plantings of scarified seed (Plummer and Frischknecht 1952). Seventy-three percent of the successful field plantings of beardless wildrye have been seeded in the late fall or during snow-free periods of winter (Majerus and Scheetz unpublished).

The objectives of this study were to determine the effects of mechanical scarification on the establishment of beardless wildrye for fall (dormant) and spring plantings.

Materials and Methods

Laboratory Studies

Beardless wildrye seed samples were obtained from the Soil Conservation Service Plant Materials Center in Bridger, Montana. 'Shoshone' beardless wildrye seed lots varied in harvest date and dormancy level (Appendix, Table 24).

Four germination studies were conducted on various seed lots using scarification intervals of 0-140 seconds and six replicates of 50 seeds arranged in a randomized complete block design. Two 15 cm by 12 cm blotters were placed in 13.5 cm by 13 cm plastic boxes and were moistened with 30 ml of tap water. Seeds were distributed 0.5-1 cm apart on the blotters and germinated at 20C, dark. Germination counts were made every 3 days during a 21 day germination period unless otherwise stated. Normal seedlings were evaluated in accordance with the Association of Official Seed Analysts (AOSA) Rules for Testing Seeds.

Seed scarification, for germination studies, was conducted with a Forsberg* laboratory scarifier using medium grade emery cloth. Two g of seed treatment^{-1} was scarified at a cylinder speed of 1725 rpm.

Viability of each seed lot was determined by tetrazolium staining of ungerminated seeds. Two replications of 100 seeds were soaked in water for 16 hours, then cut longitudinally and stained with 0.1% tetrazolium chloride solution. Tetrazolium tests were conducted and evaluated in accordance with the Association of Official Seed Analysts (AOSA) Rules for Testing Seeds.

*Trade names are used solely to provide specific information. Mention of a trade name does not constitute a guarantee of the product by the Montana Agricultural Experiment Station nor does it imply an endorsement by the Experiment Station over comparable products that are not named.

Two greenhouse emergence studies were conducted using various seed lots and scarification intervals of 0-140 seconds. Beardless wildrye seeds were planted in 33 cm X 50 cm X 9 cm metal flats using unsterilized loam soil. Twenty-five seeds were planted 1 cm deep in 25 cm rows and the seeds were spaced 1 cm apart within rows. Eight rows or eight treatments were planted flat^{-1}. Soil was packed prior to planting and after seed placement. A randomized complete block design was utilized with seven replications treatment^{-1}. Tap water was used as the soil moistening agent and natural light was utilized. Greenhouse temperature during the various studies varied from 20C to 30C depending on the time of year. Emergence of seedlings was recorded every 48 hours.

Rate of scarification was obtained in the same manner as previously stated.

Dry weight seedling^{-1} was determined six weeks after planting. Seedlings were counted, cut at the soil surface, dried in bags at 100C for 48 hours and weighed.

A study was conducted to correlate the number of rachillas present with percentage germination and greenhouse emergence. Seed lots 1, 4, 5, 6, 7, and 8 were used for this study. Eight scarifications rates at 20 second intervals ranging from 0-140 seconds were tested. Germination and emergence methods used for these studies were similar to those previously stated; except, germination temperature was 15-25C and distilled water was utilized as the blotter moistening solution. Emergence studies had 6 replications treatment^{-1}. Amount of seed scarified was 5 g treatment^{-1}, and the percentage rachillas remaining was determined by counting 10 replications of 25 seeds.

Field Studies

Field plantings were made in the fall (dormant) and spring at the Soil Conservation Service Plant Materials Center near Bridger, Montana and at the Arthur H. Post field research laboratory near Bozeman, Montana. Soils at the Bridger location are Haverson

silty clay loams classified in the fine-loamy, mixed (calcareous), mesic family of Ustic Torrifluvents. Soils at the Bozeman location are Amsterdam silt loam variants classified in the fine-silty, mixed family of Typic Haploboralls. Field experiments utilized a randomized complete block design with four replications. Plot size was 6.10 m by 1.83 m (20' X 6') and each plot had four rows spaced 0.305 m apart with two border rows of tall wheatgrass. Soil tests were taken at the field sites to determine saline gradients and fertility levels. Seeding rate for all studies was 78 pure live seeds m^{-1} of row.

Weed control was accomplished by handweeding and a post emergence spraying of 0.092 kg bronate ha^{-1}.

Four field plantings were made at two locations in the fall and spring of 1982 and 1983 respectively. Dates of seeding for fall (dormant) plantings were 10/15/82 Bozeman and 10/11/82 at Bridger. Spring plantings were seeded 4/19/83 at Bridger and 4/21/83 at Bozeman. Treatments consisted of two seed lots and four scarifications rates with and without a Benlate fungicide treatment. Seed lots used in this study were lots 1 and 7. Scarification for these plants was conducted in the same manner as described in the germination studies. Ten g of seed was scarified for germination, emergence, and field studies. Benlate 50 WP fungicide was applied to one-half of the scarified seed by lightly dusting the seed. Emergence data was obtained by counting seedling emergence in a 0.5 m area in the center of the two center rows of each plot. First year forage yields were collected from the two Bozeman plantings. Forage was harvested from a 1 m^2 area of each plot. Second year forage yields were collected from the two Bozeman plantings using a Rem forage harvestor. Harvest area was 3.72 m^2 through the center of each plot.

Laboratory germination was conducted using methods similar to those for laboratory studies except 0.2% KNO_3 and a germination temperature of 15-25C were used. Emergence studies were conducted in the same manner as mentioned under laboratory studies.

An additional spring planting was made at Bozeman in April of 1983. This planting consisted of nine scarification rates and a control using seed lots 1 and 6. Emergence rates, first year forage yields, and second year forage yields were collected using the same methods as described for the previous plantings. Weight of seed scarified was ten g treatment^{-1} to obtain enough seed for planting. Germination studies were conducted similar to those used for the laboratory studies; except germination temperature was 15-25C.

The final field planting was conducted at Bridger in the fall of 1983. Seed lot 7 was scarified with a commercial Forsberg drum scarifier (model 2). Three hundred g of seed was scarified for each treatment. Increasing degrees of scarification were obtained by passing seed through the scarifier several times. Seed being scarified had to be periodically cleaned with an airscreen cleaner to remove inert material. Percentage of rachillas remaining was calculated by counting the rachillas remaining on four replications of 100 seeds treatment^{-1}. Germination studies were conducted similar to laboratory studies except distilled water and a germination temperature of 15-25C was used.

A winter seed withdrawal study was conducted using seed lot 7 with scarified and unscarified treatments. Seeds were weighed and placed in fine nylon mesh packages and buried 1 cm deep in steel flats filled with a loam soil. This study consisted of six flats containing 4 replications arranged in a randomized complete block design. Soil was saturated by placing flats in 3 cm of water for 19 hours and allowing water uptake by capillary action. Following soil saturation flats were allowed to drain and then placed in a 4C chamber for 14 days. After the 14 days of imbibition 5 flats were placed on top of the soil at the Arthur H. Post Research laboratory on 1/3/84. Percentage moisture and germination were determined on the seed in the remaining flat. Moisture content of seeds was determined by washing excess soil from seeds under running water for 60 seconds. Packages were then opened and air dried for 5 minutes before weighing. These seeds were then germinated at 15-25C for 21 days using distilled water as the blotter moistening solution. The

flats placed at the field laboratory were withdrawn one at a time month^{-1} until April 12, 1984 and evaluated as previously stated.

Statistical analysis of data was compiled using the MSUSTAT program developed by Lund (1983). Treatment means were separated using a protected least significant difference (LSD). Correlations were computed from mean values between scarification and establishment parameters using MSUSTAT (Lund 1983). Speed of germination index ratings were calculated as described by Maguire (1962).

Results and Discussion

Germination and Greenhouse Scarification Studies

Preliminary scarification rate studies with 0-45 and 0-70 second scarification intervals indicated that germination and emergence parameters were enhanced by scarification (Appendix, Tables 25-29). Scarification rates of 0-140 seconds generally increased germination and emergence responses; although, higher scarification rates decreased germination and emergence responses (Appendix, Tables 30 and 31).

Preliminary studies showed a broad range of scarification rates which improved beardless wildrye performance. However, a method of correctly determining degree of scarification is needed.