

**SUPPORTING DOCUMENTATION FOR RELEASE OF
JACKSON-FRAZIER GERmplasm MEADOW BARLEY
(*Hordeum brachyantherum*)
(source identified class pre-varietal release, natural track)**

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(August 2008)

A. Pre-Variety Name: Jackson-Frazier germplasm.

Experimental Designations: PI-645564 and NRCS accession number 9056373.

Species: *Hordeum brachyantherum* Nevski. Symbol: HOBR2. Synonyms include: *Hordeum brachyantherum* ssp. *brachyantherum*, *Critesion brachyantherum*, *Critesion jubatum* ssp. *breviaristatum*, *Hordeum boreale*, *Hordeum jubatum* ssp. *breviaristatum*, *Hordeum jubatum* var. *boreale*, *Hordeum nodosum*, *Hordeum nodosum* var. *boreale*. The common name is meadow barley.

B. Origin and Breeding History of the Variety (Source Identified Class Germplasm):

Jackson-Frazier Germplasm (9056373) meadow barley originates from a large population (several acres in size) growing in a wetland prairie within the Jackson-Frazier Wetland natural area in Benton County, Oregon: Sec 24 and 13, Township 11S, Range 5W, elevation 69 m (225 ft) above mean sea level. Coordinates: 123°14 min. 30 seconds west longitude, 44°37 min. north latitude. Mean annual precipitation: 107 cm (42 inches). Habitat: clay soil (Bashaw series), level exposure, wetland prairie plant community dominated by grass and grass-like herbaceous species including sedges (*Carex* spp.), tufted hairgrass (*Deschampsia caespitosa*), western sloughgrass (*Beckmannia syzigachne*), spiked bentgrass (*Agrostis exarata*), western mannagrass (*Glyceria occidentalis*) and cattail (*Typha latifolia*). No information exists to suggest that this population was not naturally occurring at the time of initial and subsequent wild seed collections. Seed was originally collected in 1997 by Dale Darris then recollected in 1998 and 2000 by Dale Darris and in 2006 by Sonja Johnson.

Jackson-Frazier germplasm was not purposefully selected, bred, or hybridized. The material has not been directly compared to other populations of meadow barley but has been evaluated for seed yield, production techniques, ability to establish from seed in fields and a grassed waterway, and tolerance to soil saturation and flooding.

Jackson-Frazier Germplasm represents a single natural population consisting in large part of one predominant and one secondary phenotype with distinct morphological and phenological traits. From observations of the G0 parent population and G1 seed increase and the experimental evaluation of G2 plants and

plots established from seed, there is no reason to believe growth and reproductive characteristics are not stable.

C. Description of the Variety:

Jackson-Frazier Germplasm (9056373) falls within the taxonomic limits for *Hordeum brachyantherum* Nevski described in Hitchcock and Cronquist "Flora of the Pacific Northwest" (1973) pages 645-646, Hitchcock et al. "Vascular Plants of the Pacific Northwest" (1969), Part 1, page 603, and Hickman (editor) "The Jepson Manual Higher Plants of California" (1993), page 1266. On April 8, 1998 and again on August 15, 2008, the identification of Jackson-Frazier germplasm as *Hordeum brachyantherum* was confirmed by Richard Halse, Curator of the Herbarium, Oregon State University, Corvallis, Oregon.

Jackson-Frazier germplasm meadow barley grows 24 to 54 inches (60-138 cm) tall in a loose to moderately dense tuft. Plant height is greater than typically described (20-100 cm) for meadow barley. Culms (stems) are erect to spreading and usually bent at the base. Leaves lack auricles, have a short ciliolate ligule, and are glabrous (hairless) or with a few, scattered fine hairs. Leaf blades are 2 to 9 (11) mm wide (Hitchcock 1969), and mostly basal except for 1-3 (4) short leaves midway up the culm (Guard 1995). Additional leaves occur along upright to spreading vegetative tillers arising from the base. The inflorescence (seedhead or panicle) is a narrow, flattened spike. Spikes are mostly erect, narrow, and 1.5 to 4 inches (4-10 cm) long, with three spikelets per node and one floret per spikelet. The central spikelet is fertile and sessile (stalkless) and the lateral ones reduced, on a short pedicel about 1 mm long, and usually sterile but sometimes staminate (Hitchcock, et. al. 1969, Hickman 1993). Both spikelet bracts (glumes) and fertile floret bracts (lemmas) are bristle or awn-like (USDA Forest Service 1937). The brittle central axis (rachis) of the spike easily breaks off (shatters) in segments from the top down at maturity. By mid-summer only the lowest spikelets remain (Guard 1995). Some plants of Jackson-Frazier germplasm have strictly green stems with purple joints, but the predominate phenotypes have blue-green stems (due to a bluish-white waxy coating). Seed maturity also differs by several days between phenotypes. Leaves and spikes range from green to purple-green. These colors may or may not be typical of the species. This cool season grass actively grows during the winter within its area of origin and year round if sufficient moisture is present. It may flower more than once each year under moist conditions, especially if clipped.

D. Evidence Supporting the Identity of the Variety and Statements or Claims Concerning the Variety's Performance Characteristics:

Evaluation and Increase of Three Populations of Meadow Barley

Dale Darris

Introduction

Meadow barley (*Hordeum brachyantherum* Nevski) is a native, perennial, cool season bunchgrass. Two subspecies are currently recognized: ssp. *brachyantherum* and ssp. *californicum* (Hickman 1993, USDA NRCS 2008). The latter is referred to as California barley. Older synonyms include *H. boreale* and *H. nodosum*. Another common name is little barley. This widespread and broadly adapted species occurs from central Canada and Alaska south to California and west to Montana and New Mexico, as well as parts of the midwest, northeast and southeast US. Its elevation range is from sea-level to over 12,000 ft. (3650 m) in the mountains.

Classified as a facultative wetland plant (FACW) in Regions 0 and 9 by the US Fish and Wildlife Service (Reed 1988), meadow barley tolerates poorly drained, anerobic soil conditions (USDA NRCS 2008), for lengthy, if not indefinite periods. Studies by the Corvallis Plant Materials Center indicate that mature plants of certain populations such as Jackson-Frazier germplasm can also tolerate shallow spring and summer inundation (water up to 7 inches deep for several months) or winter flooding (water up to 16 inches for five months)(manuscript). However, the ability to survive both conditions consecutively or indefinitely is yet uncertain and may be unlikely. Typical habitats include moist to wet prairies, salt marshes, and streambanks, as well as drier knolls and rocky ridges (Guard 1995). Meadow barley is found on acid to alkaline soils (pH 5.5-8.5) with textures ranging from sand to clay. Salinity tolerance is considered moderate or high (USDA NRCS 2008, Forest Service 1987). High tolerance may especially be the case for ecotypes found along coastal beaches and in brackish, estuarine habitats of the Puget lowlands where it can be locally abundant. While described as long-lived (Jackman 1965), some individuals and entire stands appear to be naturally short-lived (3-5 years), even under favorable growing conditions. The species is considered shade intolerant and fire tolerant (USDA NRCS 2008).

Meadow barley grows 20-100 cm tall in a loose to moderately dense tuft. The culms (stems) are erect to spreading and usually bent at the base. The leaves lack auricles, have a short ciliolate ligule, and are glabrous (hairless) or with a few, scattered fine hairs, 2 to 9 mm wide (Hitchcock 1969), and mostly basal except for 1-2 short leaves midway up the culm (Guard 1995). Additional leaf blades extend along vegetative tillers arising from the base. The inflorescence (flowerhead or panicle) is a narrow, flattened spike. Spikes are mostly erect, narrow, and 1.5-4 inches (5-10 cm) long, with three spikelets per node and one floret per spikelet. The central spikelet is fertile and sessile (stalkless) and the lateral ones reduced, on a short pedicel about 1 mm long, and usually sterile but sometimes staminate (Hitchcock, et. al. 1969, Hickman 1993). Both

spikelet bracts (glumes) and fertile floret bracts (lemmas) are bristle or awn-like (USDA Forest Service 1937). The central axis (rachis) of the spike becomes brittle and the seed head easily breaks off in pieces (shatters) from the top down as it matures.

The seed heads are bristly and often purplish in color, becoming stubby at maturity which distinguishes it from timothy (*Phleum pratense*), meadow foxtail (*Alopecurus pratensis*), or other grasses with narrow spikes. It loosely resembles common barley (*Hordeum vulgare*) which is an annual usually confined to cultivated areas. Meadow barley is upright, while its closest relative, California barley, is shorter and more spreading.

Meadow barley readily hybridizes with other *Hordeum* species (Baum and Bailey 1990), as well as certain members of the genera *Elymus* (wildrye) and *Agropyron* (Pojar 1994, USDA NRCS 1997). Hybrids with other genera are apparently sterile, but this could be a consideration when determining isolation guidelines for certified seed production, especially with other *Hordeum* species.

As an important wetland grass in western Oregon, western Washington, and northwestern California, uses for meadow barley include restoration of native freshwater and estuarine plant communities, erosion control along streambanks and shorelines, and herbage for wildlife or livestock on poorly drained soils. Its moderate to rapid establishment and broad adaptation merits consideration as quick, competitive cover on seedbeds previously monopolized by reed canarygrass (*Phalaris arundinacea*), or in mixtures with other native wetland grasses like tufted hairgrass (*Deschampsia cespitosa*) and American sloughgrass (*Beckmannia syzigachne*). Palatability or forage ratings for livestock and grazing wildlife are listed from “low” (USDA NRCS 2008), to “fair” (Platts 1987), to “good” or desirable prior to heading out (US Forest Service 1937). It is regarded useful as a temporary nurse crop for longer lived species on dry, infertile sites. The species is occasionally used as a vineyard cover crop in California. Meadow barley can provide wildlife cover and the leaves and large seed are potential food for small mammals and waterfowl. This is among the more broadly adapted and easier to establish of all native grasses in the western US.

Despite its potential, wider use appears restricted by a lack of available, ecoregion specific seed sources, low seed yields, and limited information on agronomic seed production. Therefore, the purpose of this study is to (1) increase and release one or more natural populations of meadow barley from, and specifically for use in, western Oregon and western Washington ecoregions, and (2) evaluate seed production, processing, germination, and establishment technology.

Methods and Materials

Seed collection:

In 1996 seed was obtained from two natural stands, one in western Oregon and one in western Washington. A third population (Jackson-Frazier wetlands near Corvallis in

Benton Co., OR) was sampled in 1997, 1999, 2000, and 2006. Refer to Table 1 for accession information.

Table 1. Origin of meadow barley accessions

Accession No.	Origin	Habitat Cowardin (1979) system & other descriptors
9056344	West Eugene wetlands, Lane Co., OR	Palustrine, emergent wetland, persistent (wetland prairie)
9056345	Nisqually National Wildlife Refuge, Thurston Co., WA	Estuarine, intertidal, emergent wetland, persistent (upper tidal zone, brackish marsh)
9056373 (Jackson-Frazier germplasm)	Jackson-Frazier wetlands, Benton Co., OR (nature preserve)	Palustrine, emergent wetland, persistent (wetland prairie plus freshwater marsh) AND Palustrine, scrub-shrub, persistent

Establishment for seed production:

1997-2000: For accessions 9056344 and 9056345, an isolated G1 stand of each was established from containerized plants at the Corvallis Plant Materials Center (PMC) in May (5 rows of each) and September of 1997 (1 additional row of each). A field of accession 9056373 (Jackson-Frazier germplasm) was similarly planted from plugs in May of 1999 (3 rows) and September of 2000 (5 additional rows) at the Oregon State University, Hyslop Field Laboratory, Benton County, Oregon (elevation 225 ft.). Refer to Table 2. Soil type for fields 7-6 (9056345) and 7-12 (9056344) was a moderately well drained Woodburn silt loam and the soil for field 2-2 (9056373) was a well drained Willamette silt loam. For all three accessions, wild seed (G0) was used to start plants in 7 cubic inch stubby cell cone-tainers filled with media composed of peat, perlite, a low concentration of starter fertilizer (both major and minor nutrients), wetting agent, and dolomitic lime (Sunshine Mix #1). The seed was de-awned but no physiological conditioning treatment was applied. Containers were fertilized 1-2 times with a balanced liquid fertilizer and transplant quality stock was obtained within eight weeks of sowing in the greenhouse (minimum 65-70°F). No apparent insect or disease problems were noted in the greenhouse or shadehouse. Transplanting to the field was done either mechanically with a 2-row transplanter pulled behind a tractor or manually with a dibble to make the holes. In order to allow for cultivation, row spacing was 28 inches. Irrigation water was applied 3-6X during the growing season for spring transplants only. No irrigation water was used after the year of establishment.

2006-2007: In July 2006 an additional 12 oz of G0 seed of Jackson-Frazier germplasm (9056373) was collected from the Jackson-Frazier wetland in Benton County, Oregon. This seed was used to expand the existing stand on field 2-2 by sowing 6 new rows (.028 acre) in October of 2006. Fifteen lbs of seed per acre were planted using a three row Planet Junior. Additionally, plants produced in stubby cone-tainers over winter were used to add 7 more rows (0.32 acre) in March 2007. Row spacing was 24 inches. By

2007 the combined old and new stand on field 2-2 totaled 0.10 acre. In 2007 and 2008 the seed produced from it were certified as G1 source identified class of Jackson-Frazier germplasm by the Oregon State Seed Certification Service.

In order to conduct an experiment to test the tolerance of carbon-seeded meadow barley to diuron [3-(3,4 dichlorophenyl)-1, 1-dimethylurea] and to produce noncertified G2 seed for field plantings, an additional stand (0.186 acre) of Jackson-Frazier germplasm (9056373) was sown in October of 2007 on field 5-1 of the OSU Hyslop Field Laboratory. Diuron is the most common herbicide used in conjunction with carbon seeding for pre-emergence weed control when establishing new grass fields for seed production. A 6 row Planet Junior equipped with a tank and sprayer nozzles was used to plant the field and apply a narrow band of activated carbon over the seeded rows. The row spacing was 12 inches and the seeding rate was 16 lbs/ac. For more details on the experiment, refer to the report entitled "Carbon-seeded meadow barley tolerance to pre-emergence applications of diuron herbicide for weed control in the establishment of new seed production fields". The southern 2/3 of the field was used for the diuron experiment In 2006-2007.

For newly sown fields of meadow barley, no fertilizer was applied until the following spring when 50 lbs nitrogen (N)/ac were used.

Management of seed increase fields:

1997-2005: Fertilization of established fields of meadow barley consisted of 25 lbs N/ac (as granular 34-0-0-12) each fall and 50 lbs N/ac each March through 2005. Banvel (dicamba) and 2,4D amine were applied according to label instructions as needed in the spring for broadleaf weed control. Cultivation and spot spraying with glyphosate were also used to control weeds between rows, especially annual grasses and volunteer meadow barley seedlings. As a demonstration of annual grass control, an application of Karmex (diuron) at the rate of 2.3 lbs a.i./ac was applied in October 1998 to the two northern rows of meadow barley in fields 7-6 and 7-12. Leaf/stem rust (*Puccinea sp.*) was treated in some years with 1-3 applications of Bravo (chlorothalonil) and Tilt (propiconazole) according to label instructions for grass seed production. When hand harvesting, spikes infected with head smut (*Ustilago sp.*) were avoided. Occurrence of head smut was very low from year to year in Jackson-Frazier germplasm, especially in comparison to accessions 9056344 and 9056345.

Herbicide trial: In order to evaluate the ability of select herbicides to control annual bluegrass (*Poa annua*) in an established field of meadow barley grown for seed, an experiment was superimposed on to the existing field of 9056345 in October 2001. Following research results published by the USDA Agricultural Research Service (Mueller-Warrant 1999) for perennial ryegrass (*Lolium perenne*) seed production in western Oregon, six different combinations of herbicides were chosen for a PMC study. Herbicides included Prowl (pendimethalin), Goal (oxyflourfen), Karmex (diuron), Axiom (fulfenacet + metribuzin), and Rely (glufonsinate-ammonium). Based on the results of the experiment, it was decided that fall application of Prowl (2 lbs ai/ac) plus Axiom

(0.375 lbs ai/ac) was among the best treatments for control of weedy grasses and improving seed yields. Therefore, further evaluation was warranted.

The two fields of 9056344 and 9056345 were eliminated in 2001 and 2002 respectively while the stand of Jackson-Frazier germplasm was left intact. Row cultivation was discontinued in 2002 and annual grasses and volunteer seedlings were controlled in the remaining field (2-2) with experimental fall applications of Axiom plus Prowl for three of the next four years. [Prowl and Axiom were used for research purposes only. They are presently not labelled for seed production of meadow barley].

2006-2008: Fall fertilization was deemed of little or minor value for improving seed yield of Jackson-Frazier germplasm meadow barley and was discontinued. Only 50 lbs N/ac were applied each year in March to Jackson-Frazier germplasm starting in 2006 on field 2-2 and 2007 on field 5-1. The use of 2,4D amine was discontinued and only Banvel (dicamba) or Bison (MCPA plus bromoxynil) were used for broadleaf weed control. Likewise, the experimental application of Prowl plus Axiom for annual bluegrass control ended in 2005 and was replaced by Outlook (dimethenamid-P) in October 2007. The rate used in a single application to fields 2-2 and 5-1 was 18 oz ai/ac. This herbicide is labeled for control of annual weedy grasses in established fields of perennial grasses grown for seed in Oregon (BASF Corporation 2007), which can include meadow barley. Supplemental labeling expires December 31, 2009 unless renewed. Use of Tilt plus Bravo for control of leaf/stem rust was replaced in May-June of 2007 and 2008 with Quilt (azoxystrobin plus propiconazole). It was applied according to label directions. In June 2007 the rust disease on meadow barley foliage was officially diagnosed as stripe rust (*Puccinea striiformis*) by the OSU Plant Clinic.

Harvesting and seed processing:

Information on fields, seed lots, and harvest methods is shown in Table 2. In 1998, 9056344 and 9056345 meadow barley were both swathed on June 22 and threshed with a stationary plot thresher several weeks later. A second harvest of 9056344 only was conducted by hand on August 8 to obtain seed produced by a secondary flush of fertile tillers. In 1999, 9056344 was mechanically harvested twice (July 1 and July 6) using a six foot wide flail-vac seed stripper, while 9056345 was similarly stripped on July 9th and 14th. In 2000, seed of 9056344 was harvested with the flail-vac 3 times (June 21, June 26, July 6) and was 9056345 (June 27, June 30, July 7).

From 2000 through 2005, seed of Jackson-Frazier germplasm meadow barley (field 2-2) was harvested with hand sickles or rice knives between July 1 and July 12 each year. Different rates of seed maturation within the field necessitated harvesting on two separate dates, 3 to 6 days apart. Beginning in July 2006, the flail-vac seed stripper was used to harvest the field twice each year. The second harvest occurred 4 to 7 days after the first.

Small lots of manually harvested seed were run through a hammermill to break up the spikes and spikelets into individual florets of seed, brushed with a small brush machine

(Westrup model LA-H huller-scarifier) to further detach bracts, sterile florets, and awns, and cleaned with a 1 or 2-screen air screen machine (Crippen). For seed that was threshed first, a coarse scalping step was added before the hammermill was used. For seed that was stripped with a flail-vac seed stripper, stems were removed by rough scalping and then the seed was run through a brush machine (using mantle number 12, 14 or 16) before cleaning.

Table 2. Seed production of meadow barley 1998-2008, Corvallis PMC

Accession No.	Field No.	Size (ac)	Seed Lot -harvest yr-	Total Yield (lbs)	Yield (lbs/ac)	Harvest Method	Residue Mgt.
9056345	7-6	.045	SCO-98-344	2.1	47	Swath, thresh	Bale, mow
		.054	SCO-99-344	2.5	46	Flail-vac (2X)	Mow, bale
		.054	SCO-00-344	12.0	222	Flail-vac (3X)	Mow, bale
3 yr Mean					105		
9056344	7-12	.044	SCO-98-345	0.81	18	Swath, thresh	Bale, mow
		.053	SCO-99-345	5.3	100	Flail-vac (2X)	Mow, bale
		.053	SCO-00-345	4.6	87	Flail-vac (3X)	Mow, bale
3 yr Mean					68		
9056373 <i>Jackson-Frazier germplasm</i>	2-2	.015	SCO-00-373	0.12	10	Hand clip	Mow, bale
		.040	SCO-01-373	1.0	25	Hand clip	Mow, bale
		.040	SCO-02-373	4.9	123	Hand clip	Mow, bale
		.040	SCO-03-373	5.5	138	Hand clip	Burn vs bale
		.040	SCO-04-373	4.6	115	Hand clip	Mow, bale
		.040	SCO-05-373	3.0	75	Hand clip	Mow, bale
6 yr Mean					81		
<i>Jackson-Frazier germplasm</i>	2-2	.040	SG1-06-373	5.0	125	Flail-vac (2X)	Field burn
		.040	SG1-07-373	9.0	225	Flail-vac (2X)	Flail chop
		.10	SG1-08-373	25	250	Flail-vac (2X)	Flail chop
3 yr Mean					196		
<i>J-F germpl.</i>	5-1	.186	SG2-08-373	71	382	Flail-vac (2X)	Flail chop

Post harvest residue management:

Residue management by field and year is shown in Table 2. Post harvest residue management through 2005 consisted of baling straw (crop aftermath) and mowing stands to a stubble height of 3-4 inches. However, in 2003 a study was superimposed onto field 2-2 of Jackson-Frazier germplasm to evaluate the effect of propane flaming versus baling and mowing. Refer to report entitled "Effect of a simulated field burn (propane flaming) on plant injury and seed production of Jackson-Frazier germplasm meadow barley". In 2006, crop aftermath on the same field was subject to an open field burn. For 2007 and 2008, residue was cut off and removed with a flail-type forage harvester. Remaining stubble height averaged 3 inches.

Seed germination:

A germination study was conducted in 1997 with the Oregon State University Seed Laboratory using two wild seed lots/accessions of meadow barley, SNC-96-344 and SNC-96-345. Seed of Jackson-Frazier germplasm was not included in the study. Experimental design was a completely randomized design with 4 replications of 100 seeds per replication. Seed treatments consisted of a control, 14 day moist pre-chill (4°C), KNO₃ (0.2% solution), and pre-chill plus KNO₃. Environmental conditions consisted of daily fluctuating temperatures of 15°C (16 hr dark) and 25°C (8 hr light). Statistical analysis included analysis of variance (ANOVA) and a Least Significant Difference (LSD) test at the P=0.05 level of significance. Germination counts were taken at 7, 14 and 21 days. Seed viability was determined by standard tetrazolium chloride (TZ) staining methods.

Standard germination and purity tests were run on three seed lots of Jackson-Frazier meadow barley harvested from 2005 through 2007. A 7-day prechill was included in the 2005 and 2007 tests.

Results and Discussion

Greenhouse and container production practices:

- Sowing and container propagation methods were satisfactory. Seedling emergence was rapid in the containers, usually within seven days under warm (60-90°F) greenhouse conditions and natural daylight. No significant insect or disease pests were noted during greenhouse propagation. Given meadow barley's broad tolerances, this species is likely to perform well with a wide array of potting medias and growing conditions.

Field establishment, management, and production:

- Seed yields were low (Table 2). However, yields of Jackson-Frazier germplasm improved substantially by 2008, more than doubling in average for the last 3 years compared to the first 7. This may be due wholly or in part to improved management practices and harvest techniques. Seed yield was by far the highest (381 lbs/ac in 2008) for the G2 field of Jackson-Frazier germplasm when grown on 12 inch row spacing. If sustainable, this would suggest that a 12 inch spacing is superior to 24 inches.
- Meadow barley appears to have little if any vernalization requirement. When spring sown in containers, plants flowered without exposure to conditions important for floral induction of perennial grasses. Thus, late fall, dormant, or early spring sowing may allow for partial seed harvests the first full growing season, similar to blue wildrye (*Elymus glaucus*).

- To control annual grassy weeds and establish new stands of meadow barley for seed production, the use of the pre-emergence herbicide diuron after carbon seeding appears promising (refer to report on page 20). However, until trials are completed and a label is obtained, meadow barley must be sown without diuron into a firm, weed free seedbed.
- Different row spacings and seeding rates have not been directly compared. However, initial results suggest a narrow 12 inch spacing may produce as much or more seed per acre than a 24 inch spacing. Good stands were obtained with seeding rates of 15-16 pounds/ac.
- A late winter or early spring application of nitrogen fertilizer is a general requirement for good grass seed production in western Oregon. The 50 lbs N/ac rate applied each March on meadow barley is low in comparison to introduced grasses grown for seed. Experimentation is needed to determine the optimal rate and timing to maximize seed yields of meadow barley.
- Insect pests were not a problem during the production of meadow barley, but diseases including stripe rust, ergot (*Claviceps* sp.), and head smut can be problematic in some years. Ergot was severe in 1999 (as much as 10% of the heads infected) on accessions 9056344 and 9056345, as was head smut. Infection rates for both diseases were low in 1998 and 2000 (<1%). Jackson-Frazier germplasm appeared to have lower infection rates of these two diseases. While signs of leaf and stem rust varied widely from year to year among accessions, it was still common on Jackson-Frazier germplasm. It can be controlled with a number of fungicides labelled for grass seed. Quilt (azoxystrobin plus propiconazole) appeared to be reasonably effective.
- Volunteer seedlings of meadow barley and weedy annual grasses such as annual bluegrass and rattail fescue (*Vulpia myuros*) were a problem in the established fields. The fall 1998 application of diuron at 2.3 lbs a.i./ac was effective in controlling annual bluegrass and volunteer meadow barley, but damage (stunting, dieback) was severe in one year old transplanted rows and slight to moderate in two year old rows. From the 2001-2002 herbicide experiment to control annual bluegrass in an established stand, meadow barley demonstrated good tolerance to a number of tank mixes and herbicide combinations at rates and times used, or under research for, other grass seed crops. Several treatments were effective in boosting yields and controlling annual bluegrass, including Prowl plus Axiom. Lowest seed yields and biomass production (as a result of growth suppression by weeds or herbicide injury) and highest occurrences of annual bluegrass were recorded for the control and Rely treatments (data not shown). None of the herbicides or tank mixes used in the study are presently labelled for use on meadow barley. However, the herbicide Outlook is labeled (through December 31, 2009) for established fields of grasses grown for seed in western Oregon and can be applied to meadow barley. It appeared to be very effective in controlling annual grasses and meadow barley seedlings. Crop injury was low and seed yields were high in 2008.

- Most broadleaf weeds were effectively controlled with label rate applications of Bison or Banvel during the year after fall sowing and in established fields of meadow barley. Resistant weeds will require other measures or different herbicides.
- Mechanically harvesting seed produced from meadow barley required special methods. All three populations of meadow barley contained plants which matured seed at different times. Among plants of Jackson-Frazier germplasm, maturity occurred as much as 7 days apart. Furthermore, maturation on each spike is uneven and the seed shatters readily, contributing to a potential loss of yield. Seeds mature from the top of the spike downward, with corresponding disarticulation of the spikelets and segments of the rachis as time proceeds. Finally, conventional swathing (windrowing) and combining (threshing) appeared to be a poor choice because of excessive seed losses in the windrow. To address these issues, the use of a flail-vac seed stripper appeared to be a good choice by allowing for multiple harvests of the same stand. Only mature seed higher on the spike was stripped off on the first pass over the field, allowing for a second or third harvest several days later. In addition, because multiple harvesting captures seed from later maturing plants, it can help preserve genetic diversity from generation to generation.
- With a seed stripper, it was determined that harvesting should commence with the first sign of shattered (disarticulated) tips on 10-25% of the spikes, and when most of the spikes had turned from purple (or green) to tan down to their base. Depending on the stand, as much as 60-70% of the seed appeared to be harvested on the first pass. A second pass, 3-7 days later, may have typically removed another 10-20%.
- Grown on the same soil type at the PMC accession 9056344 matured about one week earlier than 9056345 in 1999 and 2000, which may reflect its more southern origin (Lane Co., OR, versus Thurston Co. WA). Maturity differences among these accessions and Jackson-Frazier germplasm were less comparable because the latter was grown on a different soil type. Soil moisture conditions during spring and early summer greatly affect seed maturation of Jackson-Frazier germplasm, with maturity occurring 2-3 weeks later each year at its origin (the Jackson-Frazier wetlands) compared to the PMC fields.
- Both accession 9056344 and Jackson-Frazier germplasm developed a secondary flush of fertile tillers in July-August in some years. This indeterminate flowering may have been stimulated by swathing or mowing and relate to favorable soil moisture conditions during certain summers. These observations suggest that exploitation of long growing seasons, clipping responses, and post harvest irrigation may provide avenues for multiple harvests and increased seed yields.
- Seed processing of meadow barley is multistep. For most drilling and mechanized broadcasting of seed, spikelets will need to be broken down into individual florets and awns removed or reduced to improve seed flow through equipment. To break apart spikelets, the hammermill was effective but time consuming. This step is not

always required. Seed had to be run through a brush machine (Westrup huller-scarifier) once or twice for substantial awn removal and the breakup of spikelets. Scalping may be required prior to the use of a hammermill and brush machine. A 2-screen air screen machine is sufficient for final scalping and grading.

- For seed production of most perennial grasses, thermal or non-thermal removal of post harvest residue is important for improving seed yields the following growing season. Under this assumption, crop residues of meadow barley were removed each summer after harvest. An experiment comparing propane flaming with conventional mowing and baling was conducted in 2003-2004. Propane flaming injured plants and reduced seed yields. However, anecdotal observations from an open field burn in 2006 indicated no detrimental effects from this treatment. The use of a flail-type forage harvester was also an effective means to remove crop aftermath. An experiment comparing the most common methods is needed.

Seed germination:

- The seed germination study indicated that special physiological conditioning may be required for some seed lots or ecotypes (i.e. 9056345, estuarine origin) of meadow barley (Refer to Table 3.) and that 14 days of moist pre-chilling does not fulfill it. However, germination was modestly but significantly improved ($P=0.05$) by 4-6% with the use of KNO_3 for lot SNC-96-345, but about 40 percent of the live seed still failed to germinate. Seed may require further treatment, such as osmotic conditioning or more lengthy stratification periods. Seed lot SNC-96-344, from a freshwater population, showed little if any need for further conditioning and KNO_3 did not significantly improve germination ($P=0.05$). This difference suggests that further evaluation of physiological requirements for germination of meadow barley is needed. It may be that estuarine populations differ in their requirements from freshwater ones. For example, an estuarine population may be acting more as a halophyte, a plant which grows and reproduces in salty soil. $NaCl$ treatments are known to increase (or decrease) germination in some halophytes (Baskin and Baskin 1998). Until more is known, it is suggested that seed lots be tested for total viability with a tetrazolium (TZ) test prior to use. For restoration, it may be advisable to only use seed of ecotypes from like environments.
- Jackson-Frazier germplasm was not tested for seed dormancy but results from standard germination tests suggest dormancy is low to nonexistent. Results of three seed germination and purity tests are shown in Table 4. Based on these results and other observations, spring seeding of this population is possible although fall seeding is generally preferred.

Table 3. Results of 1997 meadow barley seed germination study

Accession No.	Seed Lot No.	TZ ¹ (%)	Seed Germination (%) by Treatment ²			
			No prechill H ₂ O	No prechill H ₂ O+KNO ₃	14 day prechill H ₂ O	14 day prechill H ₂ O+KNO ₃
9056344	SNC-96-344	92	88 ^a	87 ^a	90 ^a	91 ^a
9056345	SNC-96-345	88	44 ^b	48 ^a	43 ^b	49 ^a

¹TZ=tetrazolium test as an indicator of total seed viability.

²numbers with the same letter are not significantly different (LSD test) at the P=.05 level. Letters apply to "within" seed lot data only.

Table 4. Results of seed germination and purity tests of Jackson-Frazier germplasm

Seed lot -harvest yr-	Test date	Germ. %	Purity %	Inert %	Other crop %	Weed seed %	Remarks
SG1-05-373	9/14/06	90	99.16	0.79	0.03	0.00	7 day pre-chill
SG1-06-373	4/16/08	85	97.89	1.27	0.50	0.34	No pre-chill
SG1-07-373	4/16/08	76	95.71	4.26	0.03	<0.01	7 day pre-chill

NOTE: The use of commercial names in this report is not an endorsement by NRCS of that product.

Effect of a Simulated Field Burn (Propane Flaming) on Plant Injury and Seed Production of Jackson-Frazier Germplasm Meadow Barley

Dale Darris and William Young III*

Introduction

Field burning is a long standing method of removing post harvest residue (crop aftermath) from several grasses grown for seed in the Willamette Valley of Oregon. Ideally, open field burning is done after seed harvest but prior to fall regrowth by the grass plant. The goals are to control certain seed diseases (blind seed, ergot) or insect pests, destroy weed and volunteer crop seed, recycle nutrients, remove straw and decadent foliage, improve effectiveness of soil applied herbicides, or increase seed yields by enhancing floral induction within the grass plant (mostly fine fescues). Concerns over air quality and smoke hazards beginning in the late 1980s resulted in the phase down of open field burning and its replacement with other means of residue management such as baling, raking, removal with a loafer, close mowing, composting, vacuuming, and flail chopping (Lies 2002).

While field burning and alternative non-thermal methods of post harvest residue management have been extensively investigated by University, USDA, and other researchers for several high value introduced grasses grown for seed in Oregon, little work has been done with native species in the region. The purpose of this study was to

determine the effect of a single propane burn (bale + propane burn) versus a bale only treatment on plant injury and seed yield of Jackson-Frazier germplasm meadow barley (*Hordeum brachyantherum*) under cultivation for seed.

Methods and Materials

An existing 8 row, G1 seed increase field of Jackson-Frazier (9056373) meadow barley on field 2-2, Hyslop Field Laboratory, Benton County, Oregon, was used for the experiment. The field was originally established in 1999 using vegetative plugs. The study was done in cooperation with the Crop and Soil Science Dept., Oregon State University. A propane field flamer was used to apply the burn treatment on September 15, 2003 (photo). Each plot was 12 ft. wide by 18 ft. long. The meadow barley stand was mowed and baled after seed harvest and prior to burning to remove a high percentage of the residual straw load. Treatment 1 was the control (bale only) and Treatment 2 was bale + propane burn. The meadow barley seed increase field and superimposed plot area continued to be uniformly treated with the standard regime of fertilizer, before, during, and after the experiment. The regimen was 25 lbs/ac of actual nitrogen in the fall and 50 lbs/ac of actual nitrogen in March. Annual grasses and volunteer seedlings were treated for control in October 2003 with a tank mix application of Axiom (flufenacet + metribuzin) and Prowl (pendimethalin) [These herbicides were not labeled for meadow barley at the time of application but applied for experimental purposes]. There were few broadleaf weeds in 2003 requiring only minor manual control in spring and summer.

Experimental design was completely randomized with 4 replications per treatment. Data for relative seed production were collected by sub-sampling 10 randomly selected meadow barley plants per plot. Seed sampling occurred in July 2004. Additional data (March 2004) consisted of a: (1) visual score of weed abundance (1-10 with 10 having the fewest weed seedlings), (2) visual score of crop seedling volunteers (1-10 with 10 having the fewest crop seedlings), (3) visual score of recovery (vigor-abundance of spring regrowth as an indicator of burn injury on a scale of 1=dead to 10=no outward sign of burn injury, plants appear fully recovered), (4) percent mortality (based on total number of all plants in each plot with no regrowth from basal crown), and (5) percent plant injury (based on total number plants in each plot with irregular or "partial" recovery from the crown). Yield per plot and per acre was estimated by calculating the total surface area occupied by the sub-samples within each plot (8 sq. ft.). Data analysis consisted of ANOVA and the F test at the P=0.05 level of significance. Transformation of percent and scoring data was deemed unnecessary.



Burned and unburned plots of 9056373 meadow barley immediately after September 15, 2003 propane burn. Photo by Amy Bartow.

Results and Discussion

Results of the study are reported in Table 1. Seed yield was significantly less and plant injury (March 2004) significantly higher in the burn and bale treatment compared to the bale only treatment at the $P=.05$ level of significance. There was no statistically significant difference between the two treatments in terms of plant mortality, regrowth, and the occurrence of weeds and volunteer seedlings of meadow barley.

Table 1. Results of 2003 simulated field burn experiment with 9056373 meadow barley.

Treatment	seed yield (lbs/ac)	% mortality	% injury	weeds	crop volunteers	regrowth
Bale only	226	1.6	29.2	1.3	2.0	6.5
Bale+burn	147	3.2	41.4	1.3	1.3	6.5
P value	.0381	.196	.0491	1.00	.168	1.00
C.V.	22.9	64.8	19.9	40.0	41.7	15.4

Propane flaming of remaining stubble and crop residues occurred in mid-September after baling and prior to the commencement of fall rains and the appearance of significant new regrowth. Under the prevailing conditions of this experiment, the bale and burn method caused greater plant injury and reduced seed yields of Jackson-Frazier germplasm meadow barley the following growing season compared to the bale only treatment. Heat intensity and/or the duration of heat applied by the flamer were detrimental, despite the species' known tolerance to prescribed fire. In contrast, anecdotal observations of an actual open field burn in August of 2006 on the same field with a full straw load appeared to cause little if any injury, mortality, or reduction in seed yield compared to long term use of non-thermal residual removal methods (baling, mowing, flail chopping). In conclusion, use of a propane flamer for post harvest thermal treatment of Jackson-Frazier meadow barley is not recommended, but the use of open field burning for residue management should not be precluded at this time. Any beneficial or detrimental effect of open field burning compared to non-thermal methods remains to be determined.

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Evaluation of Summer Inundation Tolerance of 11 Wetland Grasses Under Four Static Water Depths

Dale Darris

Introduction

For many wetland plants, the ability to tolerate flood inundation and anoxic soil conditions during spring and summer may be more critical to survival than similar conditions during winter when plants are dormant or less actively growing and their oxygen demand is lower. Flooding dramatically reduces the amount of oxygen diffusion into the soil pores. Combined with aerobic plant and microbial respiration, soil oxygen levels are rapidly depleted. Plants have evolved various physiological (metabolic) and physical (anatomic) adaptations to cope with anaerobic conditions in the rhizosphere. These adaptations are known to vary among species of wetland plants, including grasses. Besides soil oxygen levels, water depth or the degree to which a plant is submerged is known to affect growth and survival as well. While other experiments have focused on plant tolerance to seasonal (winter) inundation, the purpose of this study was to evaluate the ability of one introduced and ten native wetland grasses to grow and flower during spring and summer under five static hydrologic conditions. The five conditions were: moist and freely draining soil, continuous saturation, 3.5 inches of inundation, 7 inches of inundation, and 14.5 inches of inundation. Results from such a study may benefit wetland and riparian restoration by providing additional guidance on what grasses to plant where along a shoreline or other sites with a gradation in water depth.

Methods and Materials

The study was conducted in 2005 at the Plant Materials Center, Corvallis, Oregon. Beginning in January 2005, plants of 10 native grasses and one introduced grass were grown from seed in a greenhouse. Seed was first germinated in trays then the resulting seedlings were planted into cone-tainers and finally transplanted into 5 1/2 inch square pots. Stones were placed in the bottom and on top of each pot to prevent floatation.

Species:

1. 9056346 water foxtail, *Alopecurus geniculatus* (considered an introduced species)
2. 9079263 slender hairgrass, *Deschampsia elongata*
3. 9079230 annual hairgrass, *Deschampsia danthonioides*
4. 9079303 western panicgrass, *Dichanthelium acuminatum*
5. 9079208 western mannagrass, *Glyceria occidentalis*
6. 9056312 western sloughgrass, *Beckmannia syzigachne*
7. Willamette germplasm tufted hairgrass, *Deschampsia caespitosa*
8. 9056372 fowl (tall) mannagrass, *Glyceria striata* (*Glyceria elata*)
9. **Jackson-Frazier germplasm meadow barley**, *Hordeum brachyantherum*
10. 9078219 spike bentgrass, *Agrostis exarata*
11. 9079193 pale false mannagrass, *Torreyochloa pallida* var. *pauciflora*

The five hydrologic treatments were:

1. freely draining moist soil . Pots watered daily.
2. saturated - water maintained at level of soil in pot. Pots held in shallow tubs.
3. 3.5 inch H₂O depth maintained above soil level in pot. Pots held in tanks.
4. 7 inch H₂O depth maintained above soil level in pot. Pots held in tanks.
5. 14.5 inch H₂O depth maintained above soil level in pot. Pots held in tanks.

Experimental Design included 3 replications with each pot equal to 1 replication. Replications and treatments could not be randomized because freely draining and saturated pots had to be maintained separately from the three "flood" treatments. Concrete bricks were used to station the plants at the designated water depths in each tank. Plants were monitored and watered daily. Data was collected on foliage length, plant vigor (1-10 with 10 as best), and growth stage (phenology) six times between May and October 2005. Mortality was considered to have occurred when "live" or green foliage was no longer detected above soil line in the pot (100% senescence) and recovery seemed unlikely if hydrologic conditions were permanently maintained. Phenology was recorded as 1=vegetative, 2=boot, 3=jointing, 4=floral emergence, 5=anthesis, 6=immature seed (milk, dough), 7=mature seed, and 8=post maturity.

Results and Discussion

While the experiment was outdoors, the pot culture, static water levels, and growing conditions (tanks) represent an artificial environment and not a natural wetland. Because the experiment was conducted during the spring and summer months, water conditions were closer to that of a permanent shallow marsh than a wetland prairie in

western Oregon. Such prairies are typically droughty in summer, moist in the fall and spring and intermittently to permanently flooded with extended periods of saturated soil in winter. The use of potted specimens in this experiment may be somewhat analogous to circumstances where the plants in a wetland are “established” before inundation takes place. Such a condition may not occur in nature except in controlled wetlands or marshes that are drier one year (the establishment year) and wetter the next. Given the restrictions, extrapolation of results from this study to the natural environment is limited. However, observations can give some indication of relative flood tolerance among species. Except for meadow barley, data is not presented here.

Water foxtail maintained excellent vigor and produced seed under all conditions except the 14.5 water depth where it failed to flower and produce seed and died before October. Foliage and stem length increased in response to increasing water depth and by August the plants formed a large floating “mat” with nodal root and shoot formation occurring along submerged portions of the stems.

Tall manna grass performed well under all treatments except at the 14.5 inch depth where vigor declined most rapidly over summer. However, foliage length was still greatest under this treatment in response to the greater water depth. Like tufted hairgrass, it failed to flower under any treatment because of a lack of vernalization. Some formation of roots occurred at the nodes along submerged portions of the stems.

Spike bentgrass performed similarly well under the freely draining, saturated soil, and shallow 3.5 inch inundation depth treatments. However, In contrast to the uniformity of these results, foliage/stem length increased substantially, mortality was higher (67%), and vigor declined more by the end of summer at the 7 inch depth. The species failed to survive past June at the 14.5 inch depth. Little or no flowering occurred under any treatment.

Pale false manna grass maintained similar excellent vigor throughout the summer across all treatments except for the 14.5 inch depth where vigor was lower and the plants eventually died by October. Foliage length/plant height generally increased with water depth including the 14.5 inch depth.

Slender hairgrass grew best and produced seed only in the freely drained treatment. While it also produced seed in the saturated soil treatment, vigor declined steeply over the summer. For the most part this species failed to survive the summer under any inundation.

Annual hairgrass grew best and flowered under the freely draining and saturated soil treatments. In 3.5 inches of water, vigor declined drastically by the end of June but plants still managed to flower. At the two deepest water levels, the species died before the end of June and never flowered. Because the species is an annual, no plants were still alive by August, regardless of treatment.

Western panicgrass grew and flowered best under the freely draining and saturated soil treatments. Performance declined with 3.5 inches of inundation but plants still flowered. Only one plant at the 7 depth and no plants at the 14.5 inch depth survived past the end of June.

Western mannagrass grew well and produced seed under all treatments, with vigor and foliage/stem length substantially increasing with water depth. Under inundation the species produced an often abundant submerged root mass with additional shoots and roots forming at stem nodes.

The growth and vigor of western sloughgrass progressively declined with increasing saturation and water depths, yet it still survived, grew taller with increasing water depth, and reliably produced seed under all conditions except the 14.5 inch depth where two of three specimens died by August.

Tufted hairgrass survived and maintained good vigor through the summer only under the freely draining and saturated soil treatments. This suggests that this long lived wetland species is intolerant of shallow summer flooding. It did not flower under any treatment due to a strong vernalization requirement.

Results for Jackson-Frazier germplasm meadow barley appear in Table 1. Jackson-Frazier germplasm meadow barley maintained its highest vigor throughout the summer in the freely draining treatment. While vigor declined more by October in the saturated soil, 3.5 inch depth, and 7 inch depth treatments, plants still flowered and produced seed in all cases, suggesting apparent tolerance to such conditions. The population did not demonstrate a pattern of increasing or decreasing foliage length/plant height with increasing water depth. However, at the 14.5 inch level plants grew little and died by end of June indicating this depth may be beyond its adaptation range. Under the limited parameters of this study, it appears Jackson-Frazier germplasm meadow barley may tolerate spring-summer inundation better than slender hairgrass, western panicgrass, and tufted hairgrass. Flood tolerance appears similar to western sloughgrass, spike bentgrass, and water foxtail, and less than western mannagrass, tall mannagrass, and pale false mannagrass.

Table 1. Effect of soil saturation and three inundation water depths on growth and phenology of 9056373 meadow barley.

Meadow Barley Treatment	Foliage Length (cm)					
	5/02/05 Day 0	5/16/05 Day 14	6/01/05 Day 30	6/28/05 Day 57	8/09/05 Day 99	10/5/05 Day 156
Freely draining (control)	34	39	47.7	93.3	86	no data
Saturated soil	31.7	36.7	50.7	78.3	73.7	no data
3.5 in. depth	33.7	38	58	83.7	81.5	no data
7.0 in. depth	36.3	45.3	56	86.3	85.3	no data
14.5 in. depth	32	35.3	41	dead	dead	dead
Meadow Barley Treatment	Plant Vigor (1-10)*					
Freely draining (control)	10	9	9.7	8	5.7	7
Saturated soil	10	9.7	8.3	7.7	5.7	3.3
3.5 in. depth	10	9.3	9.7	5	4	1
7.0 in. depth	10	9	7.3	5.7	5	3
14.5 in. depth	10	7	4.3	dead	dead	dead
Meadow Barley Treatment	Growth Stage (1-8)**					
Freely draining (control)	1	2.3	3	3.7	7	no data
Saturated soil	1	3	3.3	5	7	no data
3.5 in. depth	1	2	3.3	4.3	5***	no data
7.0 in. depth	1	2	3.3	5	7	no data
14.5 in. depth	1	2	2.3	dead	dead	dead

*Plant Vigor: scale of 1-10, 10 = best. **Growth Stage: 1=vegetative, 2=boot, 3=stem elongation, 4=floral emergence, 5=anthesis, 6=immature seed (milk, dough), 7=mature seed, 8=post maturity. Data represents mean of 3 replications.

***1 of 3 plants flowered.

Carbon-Seeded Meadow Barley Tolerance to Pre-emergence Applications of Diuron Herbicide for Weed Control in the Establishment of New Seed Production Fields

Bill Brewster* and Dale Darris

Introduction

Control of both broadleaf and grassy weeds is a major factor in the successful establishment of new stands of grasses grown for seed in western Oregon, including native grasses. Application of a narrow strip of activated carbon slurry over newly sown rows (referred to as carbon banding or carbon seeding), followed by a broadcast application of diuron herbicide is a well documented, legal, and effective means of pre-emergence weed control for such plantings. However, current labels for any related diuron products do not include native species of grasses grown for seed in Oregon. In

certain cases, herbicide labels may be extended to other species when supported by research data and approved through the 24C process resulting in a special local needs label. Specific experiments and documentation plus manufacturer concurrence are needed to obtain a diuron label for carbon seeding additional species, including meadow barley (*Hordeum brachyantherum*). The purpose of this study is to evaluate the tolerance of Jackson-Frazier germplasm meadow barley to four rates of diuron herbicide applied after carbon seeding. This work is cooperative between the Oregon State University Crop and Soil Science Department and the Plant Materials Center, Corvallis, OR.

Methods and Materials

The study was conducted on field 5-1 at Oregon State University's Hyslop Farm, Benton County, Oregon, in 2006 and 2007. Seeding of meadow barley occurred on October 12, 2006 at a bulk rate of 15 lbs/ac to ensure a dense enough stand. Activated carbon was applied over the seed row at planting in a one inch wide band at 300 lb per treated acre. Within 24 hours, diuron was applied pre-emergence at four rates to carbon seeded plots. Stands were rated twice for crop injury (January and March 2007). In July 2007, plots were mechanically harvested and the seed cleaned to determine yield. A seed germination test was run on a 50 seed sample from each plot to evaluate herbicide effects on seed viability, if any. The same experiment will be repeated in 2007-2008.

Herbicide: diuron = Direx at 4 lb/gal. Chemical name: 3-(3,4-dichlorophenyl)-1,1-dimethylurea

Crop: *Hordeum brachyantherum*, Jackson-Frazier germplasm meadow barley

Planting Method: carbon seeded with 12 inch row spacing

Site and Design:

Plot width = 6.5 ft. Plot length = 25 ft. Replications = 4. Design: randomized complete block.

Soil description:

OM: 2.51 percent. Texture: silt loam. pH: 5.6. Soil Name: Woodburn. CEC: 15

Application Description:

Application Date: 13/Oct/2006
 Time of Day: 10:00 am
 Application Method: spray
 Application Timing: PRE
 Application Placement: broadcast
 Air Temperature: 65 F
 % Relative Humidity: 60
 Wind Velocity: 4 mph
 Soil Temperature: 60 F
 Soil Moisture: dry
 % Cloud Cover: 0
 Stage: pre-emergence

Application Equipment:

Sprayer: backpack with boom
 Operating pressure: 20 psi
 Nozzle type: flat fan
 Nozzle spacing: 19 inches
 Boom length: 6.5 ft.
 Boom height: 18 inches
 Ground speed: 3 mph
 Carrier: water
 Spray volume: 20 gallons/ac
 Propellant: CO₂

Results and Discussion

Table 1. Effect of diuron rates on injury, germination and seed yield of Jackson-Frazier germplasm meadow barley.

Crop Code		HOB2	HOB2	HOB2	HOB2
Rating Date		19/Jan/2007		7/Mar/2007	10/Sep/2007
Rating Data Type		Injury	Injury	Germination	Seed yield
Rating Unit		%	%	50 seeds	g/150 sq ft
<hr/>					
Treatment					
No. Name	Rate				
1	check 0 lb ai/a	0.0	0.0	44.4	63.8
2	diuron 0.8 lb ai/a	0.0	0.0	46.9	94.0
3	diuron 1.2 lb ai/a	0.0	0.0	47.1	119.3
4	diuron 2.4 lb ai/a	0.0	0.0	47.8	125.8
5	diuron 4.8 lb ai/a	0.0	0.0	48.2	134.3
<hr/>					
LSD (P=.10)				2.21	23.42
CV				3.74	17.31

The 4.8 lb/acre rate of diuron is greater than twice the rate of currently registered uses of diuron for establishing grass stands on this soil type. No herbicide injury was observed on the meadow barley regardless of the rate of diuron applied. Control plots (check treatment) had the lowest seed yields. The seed yield mean increased as the rate of diuron rate increased. None of the treatments reduced seed germination.

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Variation in Seasonal Flood Tolerance of Northwest Native Grasses

Dale Darris and Pete Gonzalves

Introduction

Native grass seed often represents a significant economic expense in wetland restoration and revegetation projects. Selection of site-appropriate species can help ensure a positive return on the investment. Native plant tolerance of inundation has been studied in association with coastal areas, vernal pool communities and reservoir management. However, the response of northwest USA native grass species to prolonged seasonal inundation in excess of 60 days is largely unexplored. Four native wet prairie and six native marsh grasses were evaluated at the Corvallis, Oregon Plant Materials Center for survival, vigor and seed production following various depths of inundation maintained for 149 days from November 4, 2006 to April 2, 2007.

Methods and Materials

Most grasses were seeded July 8, 2005 into 10 cu. in. cone shaped containers using potting media composed of peat moss, perlite, dolomite, gypsum plus a wetting agent (Sunshine #1, Sun Gro Horticulture Canada Ltd.) and amended with a balanced, slow release fertilizer and micro-nutrients. Due to a long seed stratification period required, rice cutgrass was started using rhizome transplants. Experimental design consisted of a randomized complete block with 3 replicates. The rhizomes and one year old seedlings were transplanted at one foot intervals into 45-plant rows two feet apart along the sandy, sloping bottoms of two artificial ponds in May 2006 and periodically irrigated through the summer. When the ponds were flooded in the fall, this created a gradient from moist soil (top 10 cm of soil drained) to 42 cm of inundation. The grasses were evaluated for vigor and seed production in mid summer of their second growing season, 14 weeks after draining the ponds (periodic irrigation was provided).

Wet Prairie Species

Meadow barley (Jackson-Frazier germplasm)	Accession #	9056373
<i>Hordeum brachyantherum</i> ssp. <i>brachyantherum</i>	USDA symbol	HOB RB2
Slender hairgrass		9079263
<i>Deschampsia elongata</i>		DEEL
Spike bentgrass		9079219
<i>Agrostis exarata</i>		AGEX
Tufted hairgrass		9019737
<i>Deschampsia cespitosa</i>		DECE

Marsh Species

Bluejoint	Accession #	9056371
<i>Calamagrostis canadensis</i>	USDA symbol	CACA4
Davy (slimheaded) mannagrass		9079194
<i>Glyceria lepostachya</i>		GLLE2
Fowl (tall) mannagrass		9056372
<i>Glyceria striata</i>		GLST
Pale false mannagrass		9079193
<i>Torreyochloa pallida</i> var. <i>pauciflora</i>		TOPAP3
Rice cutgrass		9079210
<i>Leersia oryzoides</i>		LEOR
Western sloughgrass		9056312
<i>Beckmannia syzigachne</i>		BESY

Results (2007)

Most species were initially completely submerged at the greater depths but davy mannagrass, fowl mannagrass, western sloughgrass and pale false mannagrass grew during winter and displayed good vigor plus foliage at or above water level in early spring 2007. Fowl mannagrass was the only species to actually show increasing vigor with increasing depths at that time.

Wet prairie species performed best under shallow or no flooding. Meadow barley (9056373) vigor and seed production declined with increasing flood depth but, unlike the other wet prairie species, remained significant even at the greatest depths where foliage was submerged all winter. Spike bentgrass exhibited little survival beyond 20 cm depth and slender hairgrass succumbed even where the top few centimeters of soil was drained.

Among the marsh species, the deepest bluejoint and pale false mannagrass plants showed the most summer vigor while peak vigor for fowl mannagrass and davy mannagrass correlated with 15 to 30 cm of flooding. The greatest seed production for pale false mannagrass and davy mannagrass occurred near 40 cm of inundation while it was greatest for bluejoint and fowl mannagrass near 10 cm. These results may be specific to the populations (accessions) and experimental site used in this study.

Discussion (2007)

Preliminary results suggest that anticipated duration of winter flooding at a particular restoration site should be considered when selecting native grass species. With the possible exception of meadow barley, the four wetland prairie species tested at Corvallis were unable to perform well under five months of constant winter inundation at 20 cm or greater. Survival and vigor were generally greater among the marsh species although seed production was mediocre. The project will continue in 2008.

March 29-30, 2007 Average Vigor (scale 1-10, 10 being greatest)

Depth (cm)	HOB RB2	DEEL	AGEX	DECE	CACA4	TOPAP3	BESY	GLST	GLLE2
neg 10-0	7.2	3.5	8.3	8.0	5.6	5.0	4.8	4.3	7.0
0-10	6.1	3.2	7.3	7.5	5.3	6.5	4.7	4.7	6.9
11-21	3.5	X	5.0	5.8	4.6	7.8	4.3	6.5	8.0
21-30	2.3	X	1.2	4.3	2.8	7.0	4.4	7.5	7.5
31-42	1.0	X	1.0	2.3	1.0	9.5	2.5	7.2	7.0

X = majority of plants completely submerged

March 29-30, 2007 Average Foliage Height (cm)

Depth (cm)	HOB RB2	DEEL	AGEX	DECE	CACA4	TOPAP3	BESY	GLST	GLLE2
neg 10-0	21.4	9.0	19.0	18.6	27.2	16.0	21.0	13.5	16.0
0-10	19.6	10.4	18.7	19.6	26.1	19.3	20.7	13.4	18.3
11-21	26.6	X	28.2	30.0	34.4	32.0	34.3	31.3	29.8
21-30	33.0	X	31.0	34.4	32.2	39.0	42.2	43.7	42.5
31-42	X	X	X	X	X	63.5	57.5	56.8	57.0

X = majority of plants completely submerged

July 27, 2007 Average Vigor (scale 1-10, 10 being greatest)

Depth (cm)	HOB RB2	DEEL	AGEX	DECE	CACA4	TOPAP3	BESY	GLST	GLLE2	LEOR
neg 10-0	7.6	1.7	6.3	7.2	5.8	3.7	2.0	1.0	2.6	0.0
0-10	6.7	3.2	6.4	7.6	6.3	4.4	3.7	4.0	4.2	1.0
11-21	6.2	0.4	5.0	7.6	8.0	6.4	4.7	4.5	6.0	3.5
21-30	5.0	0.0	0.8	7.1	7.5	6.0	4.8	5.2	6.3	5.0
31-42	4.8	0.0	0.6	5.3	8.6	8.0	3.5	4.4	2.5	7.0

July 27, 2007 Average Seed Production (scale 1-10, 10 being greatest)

Depth (cm)	HOB RB2	DEEL	AGEX	DECE	CACA4	TOPAP3	BESY	GLST	GLLE2	LEOR
neg 10-0	7.8	1.5	8.5	8.2	3.7	4.3	3.3	0.8	1.0	0.0
0-10	5.9	3.5	7.7	5.6	4.3	3.8	3.7	3.7	1.2	0.3
11-21	5.3	0.3	5.0	4.4	5.0	5.8	4.0	2.5	1.5	1.0
21-30	4.3	0.0	0.7	2.3	3.7	4.5	5.0	2.5	1.0	1.5
31-42	3.5	0.0	0.2	1.0	3.2	6.5	3.0	1.2	3.5	3.0

Evaluation of Select Native Wetland Grasses in Grassed Waterways in Western Oregon

Dale Darris, Mark Mellbye* and Pete Gonzalves

Introduction

Little information is available on the performance of native grasses in a grassed waterway or grass lined ditch in western Oregon. At present, introduced creeping red fescue has shown promise as a waterway grass. It is easy to maintain and can be kept free of most other grasses with the herbicide Poast (sethoxydim). However, it is intolerant of prolonged winter-spring inundation in the bottom of these watercourses. A grass species that is readily established and more tolerant of sustained soil saturation or flooding is needed. This study compares native wetland prairie and marsh grasses against creeping red fescue and 'Seaside' bentgrass in their ability to thrive under prevailing conditions and stabilize the bottom of a waterway in Linn County, Oregon. Cooperators include Kevin Siefert with Linn Soil & Water Conservation District, and landowner George Pugh with Pugh Seed Farm of Shedd, OR.



Figure 1. Oregon State University Cooperative Extension agent Mark Mellbye evaluates Jackson-Frazier germplasm meadow barley established in a western Oregon waterway, June 2007. Photo by Dale Darris.

Methods and Materials

Native and introduced grasses and the seeding rates used for the Benton County, Oregon agricultural waterway grass trial are listed in Table 1. Experimental design is a randomized complete block with 3 replications. Bluejoint was limited to 2 plots due to the small quantity of seed available. A mixture of 95% red fescue and 5% annual ryegrass served as the standard of comparison. All plots were single species except for the standard 95%/5% red fescue/annual ryegrass mix and the rice cutgrass (75%) mixed with annual hairgrass (25%). The annual hairgrass was included to provide some winter cover. Rice cutgrass has seed dormancy and will not germinate until the following spring. The test site was scraped and re-shaped prior to planting into a clean, surface-loose to somewhat compacted seedbed. All plots were 9 ft. wide and 15 ft. long except for the 2 bluejoint plots which were only 9 ft. long. The soil is poorly drained Dayton Silt Loam with seasonal high water table at 0.5 ft above ground to 1.5 ft below ground from November to May. Data collected include seedling counts and visual ratings of plant vigor and stand quality (density, uniformity, size and color).

Seed was mixed with rice hulls and broadcast sown September 26, 2005 with a Scott's 3 ft. wide manual fertilizer/seed spreader (drop type), then gently raked into the soil. Each plot spanned the bottom width of the waterway but not the side slopes. Side

slopes were hydroseeded with the red fescue/ryegrass mix and managed with an annual application of fertilizer in spring, fall application of Poast herbicide, and annual mowing. Study plots were not treated with herbicides or fertilizer.

Unfortunately, an unusually heavy rain event occurred September 30, 2005 washing out the bottom center portion of the experimental plots before an erosion blanket (jute netting) was applied over the top and secured with large staples. This netting subsequently failed during high winter flows allowing further washout of seeds and seedlings along the centerline of the plots. Plots which had shown some success by spring 2006 (spike bentgrass, meadow barley, tufted hairgrass, 'Seaside' bentgrass, slender hairgrass and red fescue with annual rye) were re-seeded (700 PLS/ sq. ft.) with their experimental species October 18, 2006 while the remaining plots were over-seeded with a mixture of tufted hairgrass and meadow barley. All plots were then covered with coir fabric October 20. In the fall of 2007, original plot stands were not mowed but were allowed to naturally re-seed themselves.

Most data were collected only from non-eroded portions of the experimental grass plots. However, in June 2008, seedlings appearing in the center eroded areas were counted as an indication of natural re-seeding activity.

Table 1. Native and introduced grass species, USDA symbol, accession number, and seeding rates for the western Oregon waterway trial.

Grass species planted September 2005	Seeding Rate PLS/sq ft	Seeding Rate PLS lbs/ac
spike bentgrass, AGEX, 9079219 <i>Agrostis exarata</i>	600	4.8
Jackson Frazier meadow barley , HOBR2, 9056373 <i>Hordeum brachyantherum</i> ssp. <i>brachyantherum</i>	200	58.1
Willamette germplasm tufted hairgrass, DECE, 9019737 <i>Deschampsia cespitosa</i>	500	12.1
'Seaside' bentgrass, AGST2 <i>Agrostis stolonifera</i>	600	3.1
slender-spiked mannagrass, GLLE2, 9079194 <i>Glyceria leptostachya</i>	500	16.8
rice cutgrass + ann. hairgrass, LEOR* + DEDA** <i>Leersia oryzoides</i> + <i>Deschampsia danthonioides</i>	300 + 100	36.3 + 4.8
tall mannagrass, GLEL, 9056372 <i>Glyceria elata</i>	500	13.6
slender hairgrass, DEEL, 9079263 <i>Deschampsia elongata</i>	500	9.3
Canada bluejoint, CACA4, 9056371 <i>Calamagrostis canadensis</i>	500	5.4
weak alkaligrass, TOPAP3, 9079193 <i>Torreyochloa pallida</i> var. <i>pauciflora</i>	500	11.2
western sloughgrass, BESY, 9056312 <i>Beckmannia syzigachne</i>	200	36.6
red fescue + ryegrass, FERU + LOPEM2 <i>Festuca rubra</i> + <i>Lolium perenne</i> ssp. <i>multiflorum</i>	500	12.1

*LEOR accession # 9079210 **DEDA accession # 9079230

Results and Discussion

Although the center portion of each plot was washed out in the fall and winter of 2005-2006, the remaining portions allowed for evaluation of seedling establishment, vigor and stand quality. The principle results are presented in Table 2. By 2008, introduced 'Seaside' bentgrass was the most successful species, due in part to its aggressive creeping habit which allowed it to spread into and "repair" the damaged center of the plot. It also began to spread into the red fescue side slopes but was controlled there by use of Poast selective herbicide. Native bunchgrasses (spike bentgrass, meadow barley, and tufted hairgrass) performed well but native marsh grasses (weak alkaligrass, slender-spiked and tall mannagrasses, Canada bluejoint, and rice cutgrass) and creeping red fescue ultimately failed to establish. Through 2008, Jackson-Frazier germplasm meadow barley maintained itself as the best performing native grass in the trial, second only to the introduced species, 'Seaside' bentgrass.

2006

Jackson Frazier germplasm meadow barley had the highest seedling count (27/per sq. ft.) in the first year despite having the lowest seeding rate at 200 PLS/sq. ft. (same as western sloughgrass). Spike bentgrass and tufted, annual and slender hairgrass plots averaged between 6 and 13 seedlings/sq. ft. while 'Seaside' bentgrass averaged 4.7 seedlings/sq. ft. Annual ryegrass seedlings dominated the average 2.7 seedlings/sq. ft. in the red fescue/ryegrass plots.

2007

Casual observation in March 2007 revealed seedling establishment underway throughout the eroded centerline of the experimental plots as the result of the October 2006 seeding. However by June this area was again characterized by a ribbon of nearly bare soil. Possible explanations include 1) another rain event causing wash out, 2) loss due to frost heaving, 3) soil sedimentation on the coir fabric and burying the seedlings, and 4) agricultural herbicide runoff and injury to young plants. Because of poor establishment for a second time along this line, existing plots were not mowed in 2007 but were allowed to produce seed.

Spike bentgrass and Jackson-Frazier germplasm meadow barley were the only two native species to develop strong stands similar to 'Seaside' bentgrass in 2007. Tufted hairgrass and slender hairgrass produced moderate stands while the remaining species were weak or nonexistent. Vigor ratings in June 17, 2007 (not shown) generally paralleled stand quality ratings on that date although western sloughgrass plant vigor averaged a rating of 7.7 despite the mean stand quality rating of only 3.0.

2008

By spring 2008, only four species were clearly established. 'Seaside' bentgrass had the highest rated stand followed in order by Jackson-Frazier germplasm meadow barley, tufted hairgrass, and spike bentgrass. Six native species (spike bentgrass, meadow barley, tufted hairgrass, annual hairgrass, slender hairgrass and western sloughgrass) displayed some ability to naturally re-seed themselves at the site as evidenced by the

June 2008 presence of seedlings in the washed out portions of the plots (data not shown). However, these seedlings were sparse except for those of meadow barley which averaged 6.0 seedlings per foot along the plot centerline.

Results of this study indicate Jackson-Frazier meadow barley, tufted hairgrass, and spike bentgrass may be good choices for native grass waterways in western Oregon. Annual hairgrass may be useful, but mostly for quick, temporary cover for longer lived species in a mix. Fall seeding to protect the very bottom of waterways with their erosive and/or continuous winter flows can be problematic. Possible alternatives include spring seeding when the site is dry enough to enter followed by gentle irrigation or fall planting of tightly spaced plug type seedlings where the damaged area is small enough to allow this relatively expensive approach.

Table 2. Seedling density and stand quality (mean of 3 replications) of native and introduced grass species seeded to a western Oregon waterway.

Grass species*	Seedlings/sq.ft.	Stand Quality (0-10; 10 best)	Stand Quality (0-10; 10 best)
	May 30, 2006	June 18, 2007	June 3, 2008
spike bentgrass*	8.7	7.7 a	6.0 b
Jackson Frazier meadow barley*	27.3	7.7 a	7.0 ab
tufted hairgrass*	10.0	6.0 ab	6.3 ab
'Seaside' bentgrass	4.7	8.3 a	10.0 a
slender-spiked mannagrass*	0.0	0.0 c	0.0
rice cutgrass* + ann. hairgrass*	0.0 + 13.0	1.7 c	1.0 c
tall mannagrass*	0.0	0.0 c	0.0
slender hairgrass*	6.7	5.7 ab	1.0 c
Canada bluejoint*	0.0	0.0 c	0.0
weak alkaligrass*	0.3	0.0 c	0.0
western sloughgrass*	0.2	3.0 bc	1.7 c
red fescue + ryegrass	2.7	2.7 bc	1.0 c
Critical value		48.096	varies
Coefficient of variation		40.72	30.20
* Asterisk indicates native species.			
Means followed by the same letter are not statistically different.			

* Mark Mellbye is an agent with the Oregon State University Linn County Cooperative Extension Service.

E. Area of Adaptation:

Jackson-Frazier germplasm has not been widely field tested. Therefore, the true extent of its area of adaptation is not fully known. However, based on program objectives, the origin of the selection, ecoregion descriptions, and what is known about the species, its ecology and natural range, the "suggested area of use" for this germplasm is described as the Willamette Valley of Oregon and surrounding foothills below an elevation of 1500 ft. This is roughly equivalent to EPA Ecoregion 3 or USDA Major Land Resources Area 2, excluding the Puget valleys of western Washington. This region lies within USDA Plant Hardiness Zones 8a and 8b

(Cathey 1990) and American Horticultural Society Plant Heat Zones 4 and 5 (American Horticultural Society 1997). This temporary “seed zone” may be revised as more information becomes available.

Jackson-Frazier germplasm meadow barley tolerates moderate summer drought as well as seasonal soil saturation, shallow winter flooding for up to five months, and full sun. Its range of soil adaptation has not been determined but the species is known to grow in sand to clay textured soils with a pH range of 5.5 to 8.5. Meadow barley is also recognized for its medium to high salinity tolerance and adaptation to tidal marshes and surge plains, but this cannot be inferred for Jackson-Frazier germplasm meadow barley at this time. Tolerance to fire appears high.

Precautionary Notes:

1. *Jackson-Frazier germplasm is not necessarily a replacement for local or on-site sources of meadow barley for restoration plantings. Individuals with a concern for a particular environment or ecosystem should make their decisions on a case-by-case basis.*
2. *Jackson-Frazier germplasm may be potentially weedy in some regions for certain crops. Yet, in landscapes that are more natural the species readily coexists with other native plants. While meadow barley can move into adjacent, moist disturbed areas, it rarely dominates and often gives way to longer-lived species.*

F. Generations of the Variety That Will be Multiplied and Length of Stand Limitation for Each Generation:

Generations G0, G1, G2, and G3 are proposed for certification. The G0 or parental generation will only be collected by the NRCS or qualified representatives under oversight of the appropriate seed certification agency and with the written permission of the Benton County Natural Areas and Parks Department, Corvallis, Oregon. A G1 seed increase field will be maintained by the NRCS for the production of G1 seed. G1, G2, or G3 production fields can be established and maintained as desired by qualified seed growers and companies. Certified seed produced from all four generations will carry a yellow tag for source identified class, natural track. Stand limitation for each generation shall be 10 years.

G. Describe How G0 Seed is Produced and the Procedure for Maintaining and Producing Additional Seed Stock:

The G0 generation is represented by a natural stand of meadow barley found at the Jackson-Frazier wetlands Natural area in Benton County, Oregon. There will be no management of the stand aside from Park maintenance within the vicinity. It is understood that any natural regeneration within the population and subsequent seed collection does not affect the status of the stand as G0.

G1 seed will be produced indefinitely by the USDA NRCS Plant Materials Center (PMC), as long as there is a demand and need for seed. Isolation distances

prescribed by the Oregon State Seed Certification Service for pre-varietal seed production will be followed. Presently this is 900 ft. from other varieties of meadow barley. Adequate Isolation from other *Hordeum* and *Elymus* species may be required as well. Upon request, certified G1 seed will be distributed by the PMC to commercial growers for G2 and G3 seed production.

Seed Production Methods:

Seed of Jackson-Frazier meadow barley has little if any dormancy and therefore no special physiological conditioning is required. The population can be fall or spring sown in 12-24 inch rows at a rate of 6-8 pure live seed (PLS) lbs/ac. Wider rows may be needed if row cultivation is preferred. The seedbed should be firm and weed free and the seeding depth maintained between 1/8 and 1/2 inch. Fall seeding does not require irrigation, but spring planting may need it. The use of diuron pre-emergence herbicide coupled with carbon seeding is commonly used for establishing new fields of grasses grown for seed but it is not an approved method of planting and initial weed control for meadow barley at this time.

With fall seeding and ideal growing conditions, a partial seed crop can be obtained the first full growing season. Seed yields usually peak in the second or third growing season and can average 200 lbs/ac depending on cultural methods used. If seed production in 2008 (381 lbs/ac) is any indication, a 12 inch spacing may be superior to 24 inches.

No fertilizer is suggested at planting time, but fall sown fields can be treated with 50 lbs nitrogen (N)/ac the following spring. Established fields may be maintained with 50-75 lbs of N/ac applied each February or March. An optional application of 15-20 lbs of N/ac may be made in fall. Optimal fertilization rates are not known, but other nutrients including sulfur and potassium may be needed and should be applied according to soil tests.

Weed control in new and established stands is usually by hand methods, spot treatments of glyphosate, and foliar applications of broadleaf control herbicides labeled for grass seed production. For control of weedy annual grasses, the herbicide Outlook (dimethenamid-P) is labeled for use on established fields of perennial grasses grown for seed in Oregon (BASF Corporation 2007), which can include meadow barley. Supplemental labeling expires December 31, 2009 unless renewed.

Insect pests are usually not a significant problem but diseases can be. Stripe rust (*Puccinea striiformis*) is a common disease of the foliage and can infect Jackson-Frazier germplasm. Infection rates of ergot (*Claviceps purpurea*) and smut (*Ustilago* spp.) have been low but should be monitored. Refer to the latest Pacific Northwest Plant Disease Management Handbook for guidance on control methods and approved fungicides labeled for use on grasses grown for seed.

In the Willamette Valley of Oregon, Jackson-Frazier meadow typically matures seed in early July with some plants maturing as much as a week apart. The recommended method of harvest is a flail-vac seed stripper that uses a rapidly spinning brush to strip and vacuum the seed off the seedheads. Due to uneven seed maturation in the field and in the seedhead itself, a second harvest 4-7 days after the first may be useful. Direct combining or swathing and combining are not suggested methods because of greater loss of seed.

Until more is known, it is suggested that post harvest residue be removed with a baler and the field mowed or removed with a flail-type forage harvester set to leave 3-4 inches of stubble. Open field burning may be an option where and when permitted, but additional research is needed. Propane flaming is not recommended.

In order to facilitate further cleaning, improve seed flow through planting equipment, and reduce storage volume, seed should be processed with a brush machine or other device to break up the spikes and spikelets into individual florets and remove bracts and awns. It may require several runs through a brush machine to do a complete job but the risk of seed damage must be weighed.

Literature cited

American Horticultural Society. 1997. Plant heat zone map. AHS, Alexandria, VA.

BASF Corporation. 2007. Outlook herbicide for use in perennial grasses grown for seed. Supplemental label. BASF Corporation. Research Triangle Park, NC.

Baskin, C.C. and J.M. Baskin. 1998. Seeds, Ecology, Biogeography, and Evolution of Dormancy and Germination. Academic Press. San Diego and other cities..

Baum, B.R. and L. G. Bailey. 1990. Key and synopsis of North American *Hordeum* species. Canadian Journal of Botany. 68: 2433-2442.

Cathey, H.M. 1990. USDA plant hardiness zone map. Miscellaneous Publication 1475, USDA Agricultural Research Service, Washington, D.C.

Cowardin, L.M. et. al. 1979. Classification of Wetlands and Deepwater Habitats of the United States. Publication FWS/OBS-79/31. US Dept. of Interior, Fish and Wildlife Service. US GPO, Washington, D.C. 131 p.

Guard, B.J. 1995. Wetland Plants of Oregon and Washington. Lone Pine Publishing, Redmond, WA, Vancouver, British Columbia, and Edmonton, Alberta, Canada.

Hickman, J.C. (editor). 1993. Jepson Manual, Higher Plants of California. University of California Press, Berkeley and Los Angeles, CA, and London, England.

Hitchcock, C.L. et. al. 1969. Vascular Plants of the Pacific Northwest. Part 1: Vascular cryptogams, gymnosperms, and monocotyledons. University of Washington Press, Seattle and London.

Jackman, E.R. reprinted 1965. Meadow barley. Range Leaflet #3. Cooperative Extension Service, Oregon State University, Corvallis, OR. 2 p.

Lies, M. (editor) 2002. High yield grass seed production and water quality handbook. Oregon Seed Council. Salem, OR. 23 p.

Mueller-Warrant, G. 1999. Combination of methods needed to control annual bluegrass. Seedsman Northwest. March/April, 1999. p. 20-22.

Platts, W.S. et. al. 1987. Methods for evaluating riparian habitats with applications to management. General Technical Report INT-221. USDA Forest Service, Intermountain Research Station, Ogden, UT.

Pojar, J. and A. MacKinnon (compilers and editors). 1994. Plants of the Pacific Northwest Coast. Lone Pine Publishing. Redmond, WA, Vancouver, BC, and Edmonton, Alberta, Canada.

Reed, P.B. Jr. 1988. National list of plant species that occur in wetlands: Northwest (Region 9). Biological Report 88 (26.9). US Dept. of Interior, Fish and Wildlife Service, Washington, D.C. 89 p.

USDA Forest Service. 1937 (reprint 1988). Range Plant Handbook. US GPO, Washington D.C. Reprint by Dover Publications, Mineola, NY.

USDA NRCS. 1997. A vegetative guide to selected native grasses of California. Technical Note PM-40. Davis, CA.

USDA NRCS. 2008. The PLANTS Database (<http://plants.usda.gov>, 7 August 2008). National Plant Data Center, Baton Rouge, LA 70874-4490 USA