

## NOTICE OF RELEASE OF

# MAJESTIC GERMPLASM AND SPECTRUM GERMPLASM WESTERN PRAIRIE CLOVER

## SELECTED CLASS OF NATURAL GERMPLASM

Douglas A Johnson, B Shaun Bushman,  
Kishor Bhattarai, and Kevin J Connors

## ABSTRACT

Two natural-track selected germplasms of western prairie clover (*Dalea ornata* (Douglas ex Hook.) Eaton & J. Wright [Fabaceae]) have been released for use in revegetation of semiarid rangelands in the western US. Western prairie clover is a perennial leguminous forb that occurs naturally in Idaho, Washington, Oregon, California, and Nevada. Majestic Germplasm western prairie clover originates from seed collected from indigenous plants near Sherar's Bridge in Sherman County, Oregon, whereas Spectrum Germplasm western prairie clover originates from seed collected from indigenous plants near Succor Creek Natural Area in far eastern Oregon in Malheur County, Oregon. Common-garden and DNA data for 22 collections of western prairie clover were used to develop these releases on a genetic basis. Majestic Germplasm was selected to represent the genetic diversity structure of western prairie clover from the western Columbia Plateau and western Blue Mountains Ecoregions. Spectrum Germplasm was selected to represent the genetic diversity structure from the central and eastern Columbia Plateau, central and eastern Blue Mountains, Northern Basin and Range, and Snake River Plain Ecoregions. This is a new species in the commercial seed trade, and these are the first releases of this species.

Johnson DA, Bushman BS, Bhattarai K, Connors KJ. 2011. Notice of release of Majestic Germplasm and Spectrum Germplasm western prairie clover: selected class of natural germplasm. *Native Plants Journal* 12(3): 249–256.

## KEY WORDS

*Dalea ornata*, Fabaceae, rangeland

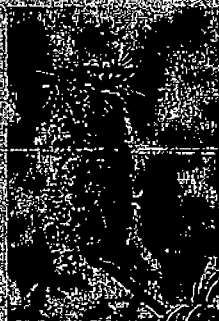
## NOMENCLATURE

Plants: USDA NRCS (2011)

Major Land Resource Areas (MLRA): USDA NRCS (2006)

Insects: ITIS (2011)

Figure 1. Dense stand of western prairie clover growing near Mitchell, Oregon. Photo by Douglas A Johnson



Species: *Dalea ornata* (Douglas ex Hook.) Eaton & J. Wright  
 Common name: Western prairie clover, Blue Mountain prairie clover  
 Plant symbol: DAORZ  
 Accession number: Majestic Germplasm (Do-09) or Sherar's Bridge or SB Population  
 and Spectrum Germplasm (Do-04) or Succor Summit or SS Population

Close-up of flower spike of western prairie clover showing progressive flowering pattern beginning at the base of the spike and ending at the tip.  
 Photo by Corey Ransom

**M**ajestic Germplasm and Spectrum Germplasm were approved for release by the USDA Agricultural Research Service on 11 June 2010. Both releases are natural-track selected pre-variety germplasms.

## JUSTIFICATION

Use of a diversity of species in rangeland revegetation programs in the western US can help minimize weed invasion because these species occupy available niches that could otherwise be colonized by invasive weeds (Pfisterer and others 2004; Walker and Shaw 2005; Brown and others 2008). Legumes are of particular interest because they provide biologically fixed nitrogen, which results in increased plant productivity, enhanced forage quality for herbivores, and important food sources for pollinators (Cherney and Allen 1995; Madison and Robel 2001; Aydin and Uzun 2005; Walker and Shaw 2005). Legumes may also be beneficial for maintaining and restoring natural successional trajectories while providing important ecosystem services (Richards and others 1998; Hobbs and Harris 2001). Few North American legumes, however, are available in the commercial seed trade for rangeland revegetation in the semiarid western US.

*Dalea* L. is a widespread genus of the legume family (Fabaceae) comprising 62 species of prairie clovers in North America (USDA NRCS 2011). Although little research has been conducted with western prairie clover (*Dalea ornata* (Douglas ex Hook.) Eaton J. Wright [Fabaceae]), it is a perennial, insect-pollinated forb that does not contain significant levels of swainsonine, selenium, and nitrotoxins, which are known to be toxic to livestock (Douglas A Johnson, unpublished data). It occurs in 5 western states (Idaho, Nevada, Washington, Oregon, and California) (Isely 1998) and has a relatively upright growth habit that makes it a potential candidate for commercial seed production (Figure 1). Western prairie clover occurs naturally throughout the Columbia Plateau, Blue Mountains,

Northern Basin and Range, and Snake River Plain Level III Ecoregions (Omernik 1987 US EPA 2007). No other plant materials have been released for this species.

In reseeding disturbed rangelands, some land managers are concerned about the risk of infusing locally adapted gene pools with genes from different populations. This could possibly reduce population fitness by increasing the frequency of maladapted genes in local populations or disrupting co-adapted gene complexes (Hufford and Mazer 2003; McKay and others 2005). Alternatively, infusing genes could have a heterotic effect. For outcrossing species that are sensitive to inbreeding depression, it may be important to increase genetic diversity in some populations to increase population fitness (Hufford and Mazer 2003; Ouborg and others 2006) and possibly provide greater opportunities for adaptation to global change (Rice and Emery 2003). The amount and distribution of genetic variation in naturally occurring populations may be useful in formulating germplasm releases that represent the major genetic diversity patterns for western prairie clover. Such data may enable land managers to make more informed management decisions concerning which germplasm releases should be used for specific rangeland areas.

DNA-marker and common-garden analyses can be used to identify genetic diversity patterns in plant species. DNA markers circumscribe genetically differentiated groupings of collections that can result from historical population factors such as genetic drift, selection, adaptation, and migration (Hufford and Mazer 2003). Genetic structures have been determined for several Great Basin and other plant species from the semiarid western US (Larson and others 2004; Bushman and others 2007; Jones and others 2008; Phillips and others 2008; Bhattarai and others 2010; Bushman and others 2010). Common gardens measure variation for traits, and if correlated to collection sites, can indicate traits and climatic variables contributing to adaptation (McKay and others 2005).

TABLE 1

Site information for 22 collections of western prairie clover (adapted from Bhattarai and others 2010). Each collection comprised seed harvested from a minimum of 100 plants at each site.

| Collection ID      | County and State | Latitude (N) | Longitude (W) | Elevation (m) | Precipitation <sup>2</sup> (mm) | Temperature  |              |           |
|--------------------|------------------|--------------|---------------|---------------|---------------------------------|--------------|--------------|-----------|
|                    |                  |              |               |               |                                 | Minimum (°C) | Maximum (°C) | Mean (°C) |
| Do-01              | Wallowa, OR      | 45°41'       | 116°48'       | 631           | 393                             | 4            | 17.7         | 10.5      |
| Do-02              | Umatilla, OR     | 45°55'       | 119°07'       | 136           | 226                             | 5.5          | 18.5         | 12        |
| Do-03              | Benton, WA       | 45°56'       | 119°20'       | 131           | 211                             | 5.6          | 18.2         | 11.9      |
| Do-04 <sup>3</sup> | Malheur, OR      | 43°24'       | 117°07'       | 1163          | 313                             | 0.1          | 16.4         | 8.2       |
| Do-05              | Benton, WA       | 46°21'       | 119°21'       | 148           | 179                             | 5.3          | 18.2         | 11.8      |
| Do-06              | Walla Walla, WA  | 46°04'       | 118°54'       | 110           | 238                             | 5.5          | 18.8         | 12.3      |
| Do-07              | Franklin, WA     | 46°17'       | 119°11'       | 160           | 196                             | 5.3          | 18.2         | 11.8      |
| Do-08              | Malheur, OR      | 42°47'       | 117°43'       | 1122          | 223                             | 0.6          | 18.5         | 9.5       |
| Do-09 <sup>4</sup> | Sherman, OR      | 45°17'       | 121°01'       | 258           | 272                             | 4.5          | 18.1         | 11.2      |
| Do-11              | Elmore, ID       | 42°53'       | 115°07'       | 884           | 254                             | 2.6          | 18.4         | 10.5      |
| Do-12              | Owyhee, ID       | 42°44'       | 115°54'       | 945           | 214                             | 2.3          | 18.5         | 10.4      |
| Do-13              | Owyhee, ID       | 42°45'       | 115°43'       | 815           | 204                             | 2.7          | 19.1         | 11        |
| Do-14              | Jefferson, OR    | 44°43'       | 121°02'       | 696           | 261                             | 1.6          | 17.6         | 9.6       |
| Do-15              | Canyon, ID       | 43°19'       | 116°35'       | 713           | 205                             | 4            | 19           | 11.5      |
| Do-16              | Crook, OR        | 44°08'       | 120°48'       | 948           | 234                             | -0.3         | 17.2         | 8.4       |
| Do-17              | Wheeler, OR      | 44°37'       | 120°07'       | 1001          | 379                             | 0.6          | 15.9         | 8.3       |
| Do-19              | Asotin, WA       | 46°04'       | 116°59'       | 259           | 337                             | 6.2          | 19.2         | 12.5      |
| Do-20              | Wheeler, OR      | 44°37'       | 120°20'       | 699           | 298                             | 2.2          | 17.9         | 10        |
| Do-21              | Elmore, ID       | 43°02'       | 115°09'       | 960           | 292                             | 2.1          | 17.8         | 9.9       |
| Do-22              | Wheeler, OR      | 44°54'       | 120°24'       | 465           | 259                             | 3.9          | 18.6         | 11.2      |
| Do-23              | Jefferson, OR    | 44°34'       | 121°02'       | 941           | 295                             | 0.1          | 16.1         | 8.2       |
| Do-25              | Crook, OR        | 44°03'       | 120°44'       | 1038          | 239                             | -0.7         | 16.7         | 8         |

Conversions: 1 m = 3.3 ft; 1 mm = 0.04 in; (°C × 1.8) + 32 = °F

<sup>2</sup> Climate data (means from 1961 to 1990) were obtained from the Moscow Forestry Sciences Laboratory (2009).

<sup>3</sup> Wildland-collected seeds of Do-04 were used to constitute the G0 generation for Spectrum Germplasm.

<sup>4</sup> Wildland-collected seeds of Do-09 were used to constitute the G0 generation for Majestic Germplasm.

## COLLECTION SITE INFORMATION

The parental population of Majestic Germplasm originates in the Deschutes River watershed of north-central Oregon (collection Do-09), whereas the parental population of Spectrum Germplasm originates in eastern Oregon near the Idaho border (collection Do-04). Locations and characteristics of the collection sites are presented in Table 1 and Figure 2. The soil at the Do-09 collection site is classified as a loamy-skeletal, mixed, superactive, mesic Lithic Haploxerolls (component: Lickskillet; soil map unit name: Lickskillet-rock outcrop complex, 40 to 70% south slopes) (USDA NRCS 2009). The soil at the Do-04 collection site has not been classified.

## DESCRIPTION

*Dalea* L. is separated from other genera in the Amorpheae tribe of Fabaceae based on its base chromosome number of  $\times = 7$  (rarely 8) and 2 collateral ovules (Barneby 1977). Western prairie clover is a tap-rooted, perennial, and herbaceous plant that reaches a height of 30 to 61 cm (12 to 24 in). A cluster of stems arises from a crown, and the stems die back during late fall and early winter (Figure 3). Compound leaves are alternate and odd-pinnate and contain 5 or 7 oval-shaped leaflets. Flowers are typically purple to pink in color with 5 petals that occur in dense, cylindrical-shaped spikes. The flowers bloom upward from the base of the spike to the tip during a 3-wk period in

late May and June. Flowers near the tip can reach flowering just as the lower seeds begin to mature and dehisce. The plant is primarily insect pollinated. Seed pods are closed and usually contain one seed.

## METHOD OF DEVELOPMENT

A total of 22 seed collections of western prairie clover were obtained from Washington, Idaho, and Oregon during the summer of 2005 (Table 1). Latitudes for the collection sites ranged from 42°44'N to 46°21'N, longitudes ranged from 115°07'W to 121°02'W, and elevations ranged from 110 to 1122 m (360 to 3680 ft) above sea level. Seedlings from each of the collections were grown in a greenhouse, and DNA was extracted from the shoot apical regions of 8 individual plants for each collection (Bhattarai and others 2010). An additional 8 plants of purple prairie clover (*Dalea purpurea* Vent. [Fabaceae]) from seed originating from 5 prairie-remnant sites in southern Wisconsin (Oak Prairie Farm, Pardeeville) were sampled for comparison. Informative amplified fragment length polymorphism (AFLP) DNA primer pairs were used to estimate the population structure and genetic diversity among the western prairie clover accessions. This assessment generated 474 AFLP markers (bands). Population structure analyses were conducted on these data (Bhattarai and others 2010).

During spring 2006, 2 common-garden sites were established in northern Utah (Hyde Park and Millville) from greenhouse-grown transplants of each collection (Bhattarai and others 2010). The experimental design at each of the field sites was a randomized complete block with 8 replications, and collections were assigned randomly within each replication. Each replication included 5 individual plants of each collection, for a total of 40 plants of each collection at each location. Plants of purple prairie clover were included at each location for comparison. Plants were allowed to establish during 2006, and field data were obtained during 2007 and 2008. Plant characteristics evaluated at the common-garden sites included dry-matter yield, number of inflorescences, plant height, foliage diameter, and flowering date. These field data were subjected to analysis of variance.

### Data Supporting Release

Detailed analysis and discussion of the results from the AFLP and common-garden studies were presented by Bhattarai

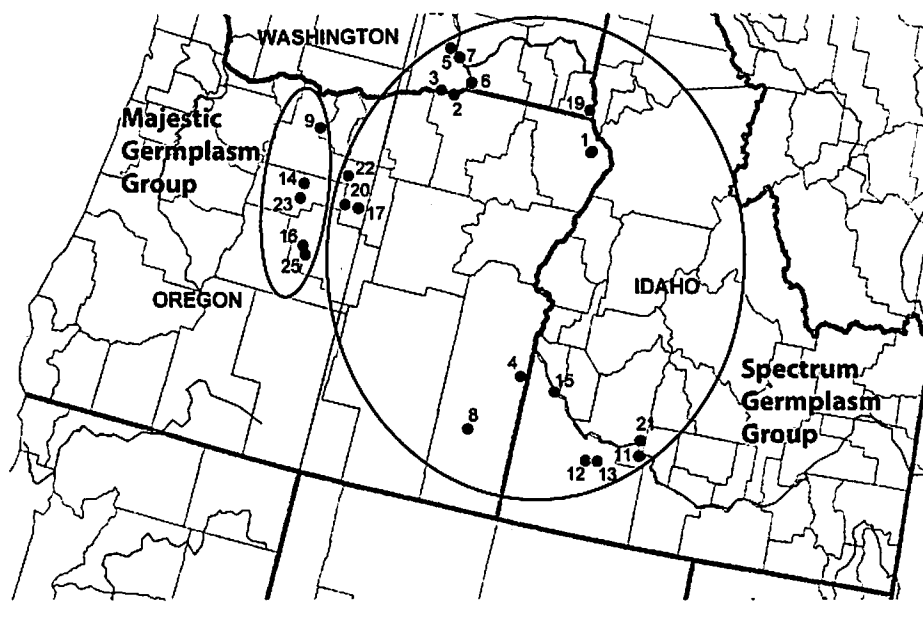


Figure 2. Collection sites of 22 populations of *Dalea ornata* with Majestic Germplasm group representing one genetic diversity structure and Spectrum Germplasm group representing a second genetic diversity structure.

and others (2010). Thus, only a general overall summary is presented here. Bayesian clustering of the AFLP data indicated support for a group of 5 collections from the Deschutes River watershed in central Oregon and a second group of 14 collections covering portions of Idaho, Washington, and Oregon. Using discriminant analysis, flowering date was found to discriminate the 2 groups with plants from the Deschutes River watershed group flowering on average 8 d earlier than plants from the second group.

We evaluated field-performance data for the 2 common-garden studies to identify a representative collection for each of the 2 genetic groups. Significant variation was detected among the collections for all traits measured (Table 2). We selected Do-09 (designated as Majestic Germplasm) to represent the Deschutes River watershed genetic group (Figure 2) because it exhibited the significantly ( $P \leq 0.10$ ) greatest dry-matter yield at both test sites, exhibited the greatest total inflorescence weight at Millville, and had the latest flowering date of the collections within the Majestic Germplasm Group. Collection Do-09 was not significantly different from other top-performing collections within the Majestic Germplasm Group for plant height and foliage diameter at Hyde Park, and number of inflorescences at Millville.

Collection Do-04 (designated as Spectrum Germplasm) was selected to represent the second geographically diverse genetic group (Figure 2) because it exhibited the largest number of inflorescences at Hyde Park. In addition, collection Do-04 was not significantly different from top-performing collections in the Spectrum Germplasm Group for plant height at Hyde Park,



Figure 3. Large, showy flower spikes of western prairie clover. Photo by Douglas A Johnson

number of inflorescences at Millville, and inflorescence weight at Millville.

Wildland-collected seeds of Do-09 (also referred to as the SB or Sherar's Bridge Population) from the Deschutes River watershed of north-central Oregon were used to constitute the  $G_0$  generation for Majestic Germplasm. Wildland-collected seeds of Do-04 (also referred to as the SS or Succor Summit Population) from eastern Oregon near the Idaho border were used to constitute the  $G_0$  generation for Spectrum Germplasm.

### Seed Germination and Production

The number of seeds of western prairie clover ranged from 256,410 to 467,290 seeds per kg (116,305 to 211,958 seeds/lb) for the 22 wildland-collected accessions. Agronomically produced seed of Majestic and Spectrum germplasms had the same test weight with 270,270 seeds per kg (122,592 seeds/lb).

As is the case with many legume species, hard seed reduces germination of western prairie clover. For example, analysis of 9-mo-old seed of Majestic and Spectrum produced under agronomic conditions showed that 91 and 92%, respectively, was viable hard seed. Germination percentage typically can be increased in hard-seeded legumes by acid or mechanical

scarification. Preliminary laboratory studies with seed of western prairie clover showed that treating hard seed in concentrated sulfuric acid for 5 min resulted in germination levels of 90% or greater. As a result, seed-scarification treatments may be required to improve uniformity of germination for western prairie clover prior to planting.

For acid scarification of seed amounts of about 1.1 kg (2.5 lb) or about 1200 to 1400 ml (40.6 to 47.3 fl oz) by volume, we placed seeds in a 5-l (169-fl oz) glass beaker. Under a fume hood, nondiluted concentrated sulfuric acid (98%) was added to the beaker to cover the seeds, and the seed/acid slurry was stirred with a glass rod. After 5 min, the slurry was poured into a 18.9-l (5-gal) bucket over a sink. The seeds clinging to the beaker were rinsed off the beaker and into the bucket. Water was then added to the bucket until the seed/acid/water mixture equaled about 3 gal, and then the mixture was stirred for several seconds. Most of the water was poured into another bucket and set aside to neutralize. A strainer was used to scoop out enough seeds to fill the strainer about half full, and the seeds were rinsed with running water. (Water was allowed to run down the drain to dilute the acid.) The scarified seeds were then placed on a paper towel to dry.

TABLE 2

Means and differences for dry matter yield (DMY), number of inflorescences, plant height, foliage diameter, inflorescence weight, and flowering date of 22 western prairie clover collections and purple prairie clover (Dp) at Hyde Park and Millville locations (adapted from Bhattarai and others 2010).

| Collection ID                   | Hyde Park |                         |                   |                       | Millville |                         |                           |                        |
|---------------------------------|-----------|-------------------------|-------------------|-----------------------|-----------|-------------------------|---------------------------|------------------------|
|                                 | DMY (g)   | Inflorescences (number) | Plant height (cm) | Foliage diameter (cm) | DMY (g)   | Inflorescences (number) | Inflorescences weight (g) | Flowering date* (days) |
| <b>Majestic Germplasm Group</b> |           |                         |                   |                       |           |                         |                           |                        |
| Do-09 <sup>†</sup>              | 242.3     | 43                      | 34.5              | 65.7                  | 156.4     | 73.6                    | 114.2                     | 170.4                  |
| Do-14                           | 203.4     | 59.5                    | 30.4              | 58.8                  | 113.7     | 68.4                    | 77.4                      | 167.4                  |
| Do-16                           | 195.6     | 44.6                    | 32                | 61                    | 114.6     | 74.3                    | 74.1                      | 165.3                  |
| Do-23                           | 166.7     | 55.7                    | 31.6              | 51.2                  | 114.6     | 83.1                    | 75.7                      | 162.7                  |
| Do-25                           | 188.4     | 48.7                    | 31.7              | 63.5                  | 110.5     | 69.9                    | 83.4                      | 167.5                  |
| <b>Spectrum Germplasm Group</b> |           |                         |                   |                       |           |                         |                           |                        |
| Do-04 <sup>‡</sup>              | 187.5     | 56.8                    | 38.4              | 57.5                  | 113.0     | 81.5                    | 86.1                      | 169.2                  |
| Do-02                           | 180.1     | 32.6                    | 30.5              | 51.2                  | 108.8     | 55.4                    | 46.3                      | 176.6                  |
| Do-03                           | 180.9     | 41.5                    | 34.0              | 56.2                  | 120.2     | 67.8                    | 56.0                      | 173.8                  |
| Do-05                           | 174.0     | 38.3                    | 33.8              | 52.3                  | 98.3      | 51.8                    | 45.1                      | 177.1                  |
| Do-06                           | 186.2     | 29.6                    | 31.3              | 53.8                  | 154.3     | 66.8                    | 66.1                      | 177.9                  |
| Do-07                           | 164.7     | 29.2                    | 31.6              | 53.5                  | 130.9     | 48.7                    | 44.6                      | 174.9                  |
| Do-08                           | 115.6     | 39.7                    | 33.1              | 49.2                  | 91.5      | 60.0                    | 52.2                      | 170.6                  |
| Do-11                           | 98.0      | 27.6                    | 33.1              | 50.7                  | 78.9      | 39.6                    | 36.8                      | 175.8                  |
| Do-12                           | 84.9      | 12.4                    | 33.0              | 45.1                  | 55.6      | 27.3                    | 27.3                      | 176.8                  |
| Do-13                           | 123.1     | 20.9                    | 36.7              | 55.7                  | 98.7      | 41.5                    | 43.4                      | 176.6                  |
| Do-15                           | 132.3     | 33.6                    | 34.2              | 55.6                  | 92.7      | 43.9                    | 44.2                      | 175.4                  |
| Do-17                           | 170.5     | 39.8                    | 26.2              | 61.7                  | 115.2     | 80.2                    | 94.0                      | 169.5                  |
| Do-19                           | 226.9     | 30.8                    | 39.5              | 63.3                  | 187.6     | 67.6                    | 82.8                      | 175.8                  |
| Do-20                           | 210.8     | 37.8                    | 29.5              | 62.2                  | 114.6     | 66.6                    | 99.4                      | 171.2                  |
| Do-21                           | 155.1     | 37.1                    | 35.6              | 57.2                  | 130.8     | 64.0                    | 70.9                      | 172.6                  |
| Do-22                           | 240.1     | 44.5                    | 31.8              | 67.8                  | 147.3     | 86.2                    | 101.8                     | 175.1                  |
| Dp                              | 82.4      | 9.1                     | 33.3              | 41.5                  | 134.8     | 63.2                    | 95.1                      | 179.5                  |
| LSD (0.10)                      | 33.7      | 11.2                    | 2.6               | 4.5                   | 20.9      | 12.6                    | 17.5                      | 2.4                    |

Conversions: 1 g = 0.035 oz; 1 cm = 0.4 in

\* Flowering date is measured from January 1.

† Wildland-collected seeds of Do-09 were used to constitute the C<sub>0</sub> generation for Majestic Germplasm.

‡ Wildland-collected seeds of Do-04 were used to constitute the C<sub>0</sub> generation for Spectrum Germplasm.

Small amounts of soda ash were added to neutralize the water that was set aside in the seedless buckets. The pH of the water can be tested to determine the degree of neutralization. When neutralized, the diluted acid/water mixture can be poured down the drain.

Not all flower spikes of western prairie clover develop and

mature at the same time. In addition, flowers are somewhat indeterminate and bloom upward along the spike for several weeks from about late May through June, depending on location, air temperature, and soil-water content. This may result in flowers at the top of the spike being delayed in blooming compared with flowers at the bottom of the spike. As a result,

seeds at the bottom of the spike may be mature and begin to drop, while seeds at the top of the spike are immature. This pattern of flowering and seed maturation presents a challenge for seed production. A seed grower in Moses Lake, Washington (Benson 2010), sequentially hand-harvested seed from transplants of Majestic and Spectrum germplasms every few days during a 3- to 4-wk seed maturation period in the initial establishment year. He estimated that about 673 to 785 kg per ha (600 to 700 lb/ac) of Majestic seeds could be produced under intensive agronomic production, whereas he estimated a production potential of about 183 kg per ha (163 lb/ac) for Spectrum seeds at his location.

Besides sequentially hand-harvesting seed every few days, another option would be to carefully vacuum-harvest ripe seed from plants periodically during maturation. Alternatively, application of seed-retention chemicals such as Desikote Max and Spodnam (Taminco 2011), Pod-Stik (UAP 2011), or other products could potentially minimize harvest losses due to seed shattering and maximize seed production of western prairie clover.

Seed predation by seed weevils (*Tychius* spp.) [Coleoptera: Curculionidae] or seed beetles (*Acanthoscelides* spp.) [Coleoptera: Chrysomelidae] limits the availability of viable seed of basalt milkvetch (*Astragalus filipes* Torr. ex A. Gray [Fabaceae]) on wildland sites (Youtie and Miller 1986). Application of imidacloprid insecticide enhances seed yield in basalt milkvetch (Bhattarai and others 2008), and it may enhance seed yield in western prairie clover as well. After seed harvest and prior to seed cleaning, sections of insecticide strips (active ingredient Dochlorvos [2, 2-dichlorovinyl dimethyl phosphate] 18.6% and related compounds 1.4%, Hotshot No-Pest strip, United Industries Corporation, St Louis, Missouri) placed in seed bags or bins can be used to reduce seed weevil damage.

## ANTICIPATED CONSERVATION USE

Western prairie clover would be beneficial to include as a component in conservation plantings to enhance biodiversity, provide forage for wildlife and livestock, and biologically fix nitrogen. It also holds promise for use in habitat-enhancement programs for native bee pollinators and managed agricultural pollinators, as well as for the beautification of roadsides, rest areas, and parks. Primary beneficiaries of this germplasm are expected to be land management agencies, ranchers, landowners enrolled in USDA conservation programs, and the seed industry.

## ANTICIPATED AREA OF ADAPTATION

Majestic Germplasm was selected to represent the group that covers the western Columbia Plateau (MLRA 8) and western Blue Mountains Ecoregions (MLRA 10). Spectrum Germplasm

was selected to represent the genetic diversity structure that covers the central and eastern Columbia Plateau (MLRA 8), central and eastern Blue Mountains (MLRA 10), Northern Basin and Range (MLRA 1), and Snake River Plain Ecoregions (MLRA 11).

## AVAILABILITY OF PLANT MATERIALS

G<sub>2</sub> seed of Majestic Germplasm and Spectrum Germplasm will be maintained by the USDA Agricultural Research Service Forage and Range Research Laboratory, Logan, Utah. Seeds through the G<sub>5</sub> generation will be eligible for certification. Seeds will be made available to commercial growers for distribution by the Utah Crop Improvement Association; contact Stanford Young, Utah Crop Improvement Association, Utah State University, Logan, Utah 84322-4820; phone: 435.797.2082; e-mail: stanford.young@usu.edu.

Small quantities of seed will be provided to researchers by request to the corresponding author. Appropriate recognition should be made if this material contributes to the development of a new breeding line or cultivar.

## ACKNOWLEDGMENTS

We gratefully acknowledge the support of the US Department of the Interior Bureau of Land Management Great Basin Native Plant Selection and Increase Project and the USDA Forest Service Rocky Mountain Research Station for providing partial funding for the collection and evaluation of this material.

*Disclaimer:* Mention of a proprietary product does not constitute a guarantee or warranty of the product by the USDA, Utah State University, or the authors and does not imply its approval to the exclusion of other products.

## REFERENCES

- Aydin I, Uzun F. 2005. Nitrogen and phosphorus fertilization of rangelands affects yield, forage quality and the botanical composition. *European Journal of Agronomy* 23:8–14.
- Barneby RC. 1977. *Dalea* images. *Memoirs of the New York Botanical Garden* 27:1–892.
- Benson J. 2010. Personal communication. Moses Lake (WA): BFI Native Seeds. President.
- Bhattarai K, Johnson DA, Jones TA, Connors KJ, Gardner DR. 2008. Physiological and morphological characterization of basalt milkvetch (*Astragalus filipes*): basis for plant improvement. *Rangeland Ecology and Management* 61(4): 444–455.
- Bhattarai K, Bushman BS, Johnson DA, Carman JG. 2010. Phenotypic and genetic characterization of western prairie clover collections from the western United States. *Rangeland Ecology and Management* 63:696–706.
- Brown CS, Anderson VJ, Claassen VP, and 6 others. 2008. Restoration ecology and invasive plants in the semiarid West. *Invasive Plant Science Management* 1:399–413.

- Bushman BS, Larson SL, Peel MD, Pfrender ME. 2007. Population structure and genetic diversity in North American *Hedysarum boreale* Nutt. *Crop Science* 47:1281–1286.
- Bushman BS, Bhattarai K, Johnson DA. 2010. Population structure of *Astragalus filipes* collections from western North America. *Botany* 88:565–574.
- Cherney JH, Allen VG. 1995. Forages in a livestock system. In: Barnes RF, Miller DA, Nelson CJ, editors. *Forages: the science of grassland agriculture*. Volume I. Ames (IA): Iowa State University Press. p 175–188.
- Hobbs RJ, Harris JA. 2001. Restoration ecology: repairing the earth's ecosystem in the new millennium. *Restoration Ecology* 9:239–246.
- Hufford KM, Mazer SJ. 2003. Plant ecotypes: genetic differentiation in the age of ecological restoration. *Trends in Ecology and Evolution* 18:147–155.
- Iseley D. 1998. Native and naturalized Leguminosae (Fabaceae) of the United States. Provo (UT): Brigham Young University. 1007 p.
- [ITIS] Integrated Taxonomic Information System. 2011. URL: <http://www.itis.gov/index.html> (accessed 6 July 2011).
- Jones TA, Larson SR, Wilson BL. 2008. Genetic differentiation and hybridization among *Festuca idahoensis*, *F. roemerii*, and *F. ovina* detected from AFLP, ITS, and chloroplast DNA. *Botany* 86:422–434.
- Larson SR, Jones TA, Jensen KB. 2004. Population structure in *Pseudoroegneria spicata* (Poaceae: Triticeae) modeled by Bayesian clustering of AFLP genotypes. *American Journal of Botany* 91:1789–1801.
- Madison LA, Robel RJ. 2001. Energy characteristics and consumption of several seeds recommended for northern bobwhite food plantings. *Wildlife Society Bulletin* 29:1219–1227.
- McKay JK, Christian CE, Harrison SP, Rice KJ. 2005. "How local is local?" A review of practical and conceptual issues in the genetics of restoration. *Restoration Ecology* 1:432–440.
- Moscow Forestry Sciences Laboratory. 2009. Custom climate data requests. URL: <http://forest.moscowsl.wsu.edu/climate/customData/> (accessed 6 Oct 2009). Moscow (ID): Moscow Forestry Sciences Laboratory, Rocky Mountain Research Station.
- Omernik JM. 1987. Ecoregions of the conterminous United States. Map (scale 1:7,500,000). *Annals of the Association of American Geographers* 77:118–125.
- Ouborg NJ, Vergeer P, Mix C. 2006. The rough edges of the conservation genetics paradigm for plants. *Journal of Ecology* 94:1233–1248.
- Pfisterer AB, Joshi J, Schmid B, Fischer M. 2004. Rapid decay of diversity-productivity relationships after invasion of experimental plant communities. *Basic and Applied Ecology* 5:5–14.
- Phillips NC, Larson SR, Drost DT. 2008. Detection of genetic variation in wild populations of three *Allium* species using amplified fragment length polymorphisms. *HortScience* 43:637–643.
- Rice KJ, Emery NC. 2003. Managing microevolution: restoration in the face of global change. *Frontiers in Ecology and the Environment* 1:469–478.
- Richards RT, Chambers JC, Ross C. 1998. Use of native plants on Federal lands: policy and practice. *Journal of Range Management* 51:625–632.
- Taminco. 2011. People and molecules: pre-harvest management. URL: <http://www.taminco.com/divisions/agro-sciences/preharvest-management.html> (accessed 16 Mar 2011).
- [UAP] United Agri Products Canada Inc. 2011. Pod-Stik: reduce shattering losses. URL: <http://www.uap.ca/podstik/> (accessed 16 Mar 2011).
- [USDA NRCS] USDA Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, Caribbean, and the Pacific Basin. Washington (DC): USDA Agricultural Handbook 296.
- [USDA NRCS] USDA Natural Resources Conservation Service. 2009. Web soil survey. URL: <http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm> (accessed 6 Jul 2011). Washington (DC): USDA NRCS Headquarters.
- [USDA NRCS] USDA Natural Resources Conservation Service. 2011. The PLANTS database. URL: <http://www.plants.usda.gov> (accessed 17 Mar 2011). Greensboro (NC): National Plant Data Team.
- [US EPA] US Environmental Protection Agency. 2007. Level III ecoregions of the conterminous United States. URL: [http://www.epa.gov/wed/pages/ecoregions/level\\_iii.htm](http://www.epa.gov/wed/pages/ecoregions/level_iii.htm) (accessed 16 Mar 2011). Washington (DC): US EPA Headquarters.
- Walker SC, Shaw NL. 2005. Current and potential use of broadleaf herbs for reestablishing native communities. In: Shaw NL, Pellant M, and Monsen SB, editors. *Proceedings, Sage Grouse Habitat Restoration Symposium*. Fort Collins (CO): USDA Forest Service, Rocky Mountain Research Station. *Proceedings RMRS-P-38*. p 46–61.
- Youtie BA, Miller RF. 1986. Insect predation on *Astragalus filipes* and *A. purshii* seeds. *Northwest Science* 60:42–46.

#### AUTHOR INFORMATION

Douglas A Johnson  
Plant Physiologist  
Doug.Johnson@ars.usda.gov

B Shaun-Bushman  
Research Geneticist

Kevin J Connors  
Plant Physiologist

USDA Agricultural Research Service  
Forage and Range Research Laboratory  
Utah State University  
Logan, UT, 84322-6300

Kishor Bhattarai  
Forage Improvement Division  
Noble Foundation  
2510 Sam Noble Parkway  
Ardmore, OK 73401