

PRAIRIE CLOVER AND BASALT MILKVETCH SEED PRODUCTION IN RESPONSE TO IRRIGATION

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Summary

Legumes are important components of rangeland vegetation in the Intermountain West due to their supply of protein to wildlife and livestock and contribution of nitrogen to rangeland productivity. Seed of selected native legumes is needed for rangeland restoration, but cultural practices for native legume production are largely unknown. The seed yield response of three native legume species to irrigation was evaluated starting in 2011. Four biweekly irrigations applying either 0, 1, or 2 inches of water (a total of 0, 4, or 8 inches/season) were tested. Over the 7-year study, *Dalea searlsiae* (Searls' prairie clover) seed yield was maximized by 13-17 inches of water applied plus fall, winter, and spring precipitation per season. *Dalea ornata* (Blue Mountain or western prairie clover) seed yield was maximized by 13-16 inches of water applied plus fall, winter, and spring precipitation per season. Seed yield of *Astragalus filipes* (basalt milkvetch) did not respond to irrigation.

Introduction

Native wildflower seed is needed to restore rangelands of the Intermountain West. Commercial seed production is necessary to provide the quantity of seed needed for restoration efforts. A major limitation to economically viable commercial production of native wildflower (forb) seed is stable and consistent seed productivity over years.

In natural rangelands, variations in spring rainfall and soil moisture result in highly unpredictable water stress at flowering, seed set, and seed development, which for other seed crops is known to compromise seed yield and quality.

Native wildflower plants are not well adapted to croplands; they are often not competitive with crop weeds in cultivated fields, and this could limit wildflower seed production. Both sprinkler and furrow irrigation can provide supplemental water for seed production, but these irrigation systems risk further encouraging weeds. Also, sprinkler and furrow irrigation can lead to the loss of plant stand and seed production due to fungal pathogens. By burying drip tapes at 12-inch depth and avoiding wetting the soil surface, we designed experiments to assure flowering and seed set without undue encouragement of weeds or opportunistic diseases. The trials

reported here tested the effects of three low rates of irrigation on the seed yield of three native wildflower legume species (Table 1) planted in 2009.

Table 1. Wildflower species in the legume family planted in the fall of 2009 at the Malheur Experiment Station, Oregon State University, Ontario, OR.

| Species | Common names | Growth habit |
|---------------------------|--|--------------|
| <i>Dalea searlsiae</i> | Searls' prairie clover | Perennial |
| <i>Dalea ornata</i> | Western prairie clover, Blue Mountain prairie clover | Perennial |
| <i>Astragalus filipes</i> | Basalt milkvetch | Perennial |

Materials and Methods

Plant establishment

Each of three species was planted in 4 rows 30 inches apart in a 10-ft-wide strip about 450 ft long on Nyssa silt loam at the Malheur Experiment Station, Ontario, Oregon. The soil had a pH of 8.3 and 1.1% organic matter. In October 2009, 2 drip tapes 5 feet apart (T-Tape TSX 515-16-340) were buried at 12-inch depth to irrigate the 4 rows in the plot. Each drip tape irrigated two rows of plants. The flow rate for the drip tape was 0.34 gal/min/100 ft at 8 psi with emitters spaced 16 inches apart, resulting in a water application rate of 0.066 inch/hour.

On November 25, 2009 seed of three species (Table 1) was planted in 30-inch rows using a custom-made small-plot grain drill with disc openers. All seed was planted on the soil surface at 20-30 seeds/ft of row. After planting, sawdust was applied in a narrow band over the seed row at 0.26 oz/ft of row (558 lb/acre). Following planting and sawdust application, the beds were covered with row cover (N-sulate, DeWitt Co., Inc., Sikeston, MO), which covered four rows (two beds) and was applied with a mechanical plastic mulch layer. The field was irrigated for 24 hours on December 2, 2009 due to very dry soil conditions.

After the newly planted wildflowers emerged, the row cover was removed in April 2010. The variable irrigation treatments were not applied until 2011.

Each year, plots were hand-weeded as necessary. Seed from the middle two rows in each plot was harvested manually (Table 2).

Irrigation for seed production

In April 2011, each strip of each wildflower species was divided into 12 30-ft plots. Each plot contained four rows of each species. The experimental design for each species was a randomized complete block with four replicates. The three treatments were a non-irrigated check, 1 inch of water applied per irrigation, and 2 inches of water applied per irrigation. Each treatment received 4 irrigations applied approximately every 2 weeks starting at bud formation and flowering. The amount of water applied to each treatment was calculated by the length of time necessary to deliver 1 or 2 inches through the drip system. Irrigations were regulated with a controller and solenoid valves.

The drip-irrigation system was designed to allow separate irrigation of the species due to different timings of flowering and seed formation. The irrigation treatments of the two *Dalea*

spp. were applied together. The *Astragalus filipes* was irrigated separately to correspond to the timing of its flowering and seed set. Flowering, irrigation, and harvest dates were recorded (Table 2).

Weed control

On October 27, 2016, Prowl® at 1 lb ai/acre was broadcast on all plots of all species for weed control. On April 21, 2017, Prowl at 1 lb ai/acre and Poast® at 30 oz/acre were broadcast on all plots of all species.

Seed beetle control

Harvested seed pods of *Dalea ornata*, *D. searlsiae*, and *Astragalus filipes* were extensively damaged from feeding by seed weevils in 2013 and 2014, indicating that control measures during and after flowering would be necessary to maintain seed yields. On May 21, 2015, Capture® 2EC at 6.4 oz/acre (0.1 lb ai/acre) and Rimon® at 12 oz/acre (0.08 lb ai/acre) were broadcast in the evening to minimize harm to pollinators. On May 28, 2015, Rimon at 12 oz/acre was broadcast in the evening to minimize harm to pollinators. Seed beetles were not observed during flowering in 2016 and 2017.

Statistical analysis

Seed yield means were compared by analysis of variance and by linear and quadratic regression. Seed yield (y) in response to irrigation or irrigation plus precipitation (x , inches/season) was estimated by the equation $y = a + b \cdot x + c \cdot x^2$. For the quadratic equations, the amount of irrigation (x') that resulted in maximum yield (y') was calculated using the formula $x' = -b/2c$, where a is the intercept, b is the linear parameter, and c is the quadratic parameter. For the linear regressions, the seed yield responses to irrigation were based on the actual greatest amount of water applied plus precipitation and the measured average seed yield.

Seed yields for each year were regressed separately against 1) applied water; 2) applied water plus spring precipitation; 3) applied water plus winter and spring precipitation; and 4) applied water plus fall, winter, and spring precipitation. Winter and spring precipitation occurred in the same year that yield was determined; fall precipitation occurred the prior year.

Adding the seasonal precipitation to the irrigation response equation has the potential to provide a closer estimate of the amount of water required for maximum seed yields. Regressions of seed yield each year were calculated on all the sequential seasonal amounts of precipitation and irrigation, but only some of the regressions are reported below. The period of precipitation plus applied water that had the lowest standard deviation for irrigation plus precipitation over the years was chosen as the most reliable independent variable for predicting seed yield. For *Astragalus filipes*, seed yield did not respond to irrigation; consequently, seed yield responses only to water applied are reported without trying to find the optimal amount of irrigation plus seasonal precipitation.

Results and Discussion

Precipitation from January through June was close to average in 2012 and 2014-2016, higher than average in 2011 and 2017, and lower than average in 2013 (Table 3). The accumulation of growing degree-days (50-86°F) was increasingly higher than average from 2012 to 2016, close to

average in 2017, and was below average in 2011 (Table 3). Flowering and seed harvest were early in 2015 and 2016, probably due to warmer weather and greater accumulation of growing degree-days.

***Dalea searlsiae*, Searls' prairie clover**

In 2012, and 2014-2016, seed yields showed a quadratic response to irrigation plus fall, winter, and spring precipitation (Table 5). Maximum seed yields were achieved with 15, 17, 17, and 15.4 inches of water applied plus fall, winter, and spring precipitation in 2012 and 2014-2016, respectively. In 2013, seed yields were very low due to seed weevils. In 2011, seed yields were highest with no irrigation plus 14.5 inches of fall, winter, and spring precipitation. In 2017, seed yields did not respond to irrigation. Averaged over the 7 years, maximum seed yields were 227 lb/acre achieved with 16.1 inches of water applied plus fall, winter, and spring precipitation.

***Dalea ornata*, Blue Mountain or western prairie clover**

Seed yields showed a quadratic response to irrigation in 2012-2016 with a maximum seed yield at 16.1, 13.3, 14.9, 14.9, and 14.6 inches of water applied plus fall, winter, and spring precipitation, respectively (Tables 4 and 5). Seed yields in 2011 were highest with no irrigation plus 14.5 inches of fall, winter, and spring precipitation. In 2017, seed yields did not respond to irrigation. Averaged over the seven years, maximum seed yields were 350 lb/acre achieved with 15.3 inches of water applied plus fall, winter, and spring precipitation.

Both *Dalea searlsiae* and *D. ornata* showed either a negative response or no response to irrigation in 2011 and 2017, years with higher than average fall, winter, and spring precipitation.

***Astragalus filipes*, basalt milkvetch**

Seed yields responded to irrigation only in 2013, when 4 inches of applied water was among the irrigation rates resulting in the highest yield (Tables 4 and 5). Low seed yields of *Astragalus filipes* were related to low plant stand and high seed pod shatter that made seed recovery problematic.

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Table 2. Native wildflower flowering, irrigation, and seed harvest dates by species. Malheur Experiment Station, Oregon State University, Ontario, OR, 2011-2017.

| Species | Year | Flowering | | | Irrigation | | Harvest |
|---------------------------|------|-----------|--------|--------|------------|--------|---------|
| | | Start | Peak | End | Start | End | |
| <i>Dalea searlsiae</i> | | | | | | | |
| | 2011 | 8-Jun | 20-Jun | 20-Jul | 27-May | 6-Jul | 21-Jul |
| | 2012 | 23-May | 10-Jun | 30-Jun | 11-May | 21-Jun | 10-Jul |
| | 2013 | 13-May | | 15-Jun | 8-May | 19-Jun | 29-Jun |
| | 2014 | 15-May | 4-Jun | 24-Jun | 6-May | 17-Jun | 1-Jul |
| | 2015 | 13-May | 26-May | 16-Jun | 5-May | 17-Jun | 22-Jun |
| | 2016 | 11-May | 28-May | 10-Jun | 3-May | 14-Jun | 16-Jun |
| | 2017 | 23-May | 7-Jun | 30-Jun | 23-May | 6-Jul | 3-Jul |
| <i>Dalea ornata</i> | | | | | | | |
| | 2011 | 8-Jun | 20-Jun | 20-Jul | 27-May | 6-Jul | 22-Jul |
| | 2012 | 23-May | 10-Jun | 30-Jun | 11-May | 21-Jun | 11-Jul |
| | 2013 | 13-May | 21-May | 15-Jun | 8-May | 19-Jun | 28-Jun |
| | 2014 | 15-May | 4-Jun | 24-Jun | 6-May | 17-Jun | 1-Jul |
| | 2015 | 5-May | 26-May | 22-Jun | 5-May | 17-Jun | 25-Jun |
| | 2016 | 3-May | 26-May | 10-Jun | 3-May | 14-Jun | 13-Jun |
| | 2017 | 23-May | 7-Jun | 29-Jun | 23-May | 6-Jul | 5-Jul |
| <i>Astragalus filipes</i> | | | | | | | |
| | 2011 | 20-May | 26-May | 30-Jun | 13-May | 23-Jun | 18-Jul |
| | 2012 | 28-Apr | 23-May | 19-Jun | 11-May | 21-Jun | 5-Jul |
| | 2013 | 3-May | 10-May | 25-May | 8-May | 19-Jun | 28-Jun |
| | 2014 | 5-May | 13-May | 28-May | 29-Apr | 10-Jun | 24-Jun |
| | 2015 | 17-Apr | 13-May | 1-Jun | 21-Apr | 3-Jun | 16-Jun |

Table 3. Early season precipitation and growing degree-days at the Malheur Experiment Station, Ontario, OR, 2006-2017.

| Year | Precipitation (inch) | | | Growing degree-days (50-86°F) |
|------------------|----------------------|-----------------|------------------------|-------------------------------|
| | Spring | Winter + spring | Fall + winter + spring | Jan-Jun |
| 2006 | 3.4 | 10.1 | 14.5 | 1273 |
| 2007 | 1.9 | 3.8 | 6.2 | 1406 |
| 2008 | 1.4 | 3.2 | 6.7 | 1087 |
| 2009 | 4.1 | 6.7 | 8.9 | 1207 |
| 2010 | 4.3 | 8.4 | 11.7 | 971 |
| 2011 | 4.8 | 9.3 | 14.5 | 856 |
| 2012 | 2.6 | 6.1 | 8.4 | 1228 |
| 2013 | 0.9 | 2.4 | 5.3 | 1319 |
| 2014 | 1.7 | 5.1 | 8.1 | 1333 |
| 2015 | 3.2 | 5.9 | 10.4 | 1610 |
| 2016 | 2.2 | 5.0 | 10.1 | 1458 |
| 2017 | 4.0 | 9.7 | 12.7 | 1196 |
| 12-year average: | 2.9 | 6.3 | 9.8 | 23-year average: 1207 |

Table 4. Native wildflower seed yield in response to irrigation rate (inches/season). Malheur Experiment Station, Oregon State University, Ontario, OR, 2011-2017.

| Species | Year | Irrigation rate | | | LSD (0.05) |
|---------------------------|---------|---------------------|----------|----------|------------------|
| | | 0 inches | 4 inches | 8 inches | |
| | | ----- lb/acre ----- | | | |
| <i>Dalea searlsiae</i> | | | | | |
| | 2011 | 262.7 | 231.2 | 196.3 | 50.1 |
| | 2012 | 175.5 | 288.8 | 303.0 | 93.6 |
| | 2013 | 14.8 | 31.7 | 44.4 | 6.1 |
| | 2014 | 60.0 | 181.4 | 232.2 | 72.9 |
| | 2015 | 221.2 | 330.7 | 344.2 | 68.3 |
| | 2016 | 148.7 | 238.8 | 222.3 | 56.0 |
| | 2017 | 222.2 | 223.6 | 206.2 | NS |
| | Average | 157.9 | 218.0 | 221.2 | 13.4 |
| <i>Dalea ornata</i> | | | | | |
| | 2011 | 451.9 | 410.8 | 351.7 | NS ^a |
| | 2012 | 145.1 | 365.1 | 431.4 | 189.3 |
| | 2013 | 28.6 | 104.6 | 130.4 | 38.8 |
| | 2014 | 119.4 | 422.9 | 476.3 | 144.1 |
| | 2015 | 212.9 | 396.7 | 267.2 | 109.6 |
| | 2016 | 246.3 | 307.9 | 312.4 | NS |
| | 2017 | 328.2 | 347.0 | 270.1 | NS |
| | Average | 219.6 | 339.9 | 323.1 | 49.9 |
| <i>Astragalus filipes</i> | | | | | |
| | 2011 | 87 | 98.4 | 74 | NS |
| | 2012 | 22.7 | 12.6 | 16.1 | NS |
| | 2013 | 8.5 | 9.8 | 6.1 | 2.7 ^b |
| | 2014 | 56.6 | 79.3 | 71.9 | NS |
| | 2015 | 17.8 | 12.5 | 11.6 | NS |
| | Average | 38.5 | 35.2 | 36.0 | NS |

^a NS = not significant, ^b LSD (0.10)

Table 5. Regression analysis for native wildflower seed yield (y) in response to irrigation (x) (inches/season) plus fall, winter, and spring precipitation using the equation $y = a + b \cdot x + c \cdot x^2$. For the quadratic equations, the amount of irrigation that resulted in maximum yield was calculated using the formula: $-b/2c$, where b is the linear parameter and c is the quadratic parameter. Malheur Experiment Station, Oregon State University, Ontario, OR, 2011-2017.

| <i>Dalea searlsiae</i> | | | | | | | | |
|-------------------------------|-----------|--------|-----------|-------|-----------------|----------------------------|--|---|
| Year | intercept | linear | quadratic | R^2 | P | Maximum yield (lb/acre) | Water applied plus precipitation for max. yield (inches/season) | Precipitation, fall, winter, spring (inches) |
| 2011 | 383.3 | -8.3 | | 0.49 | 0.05 | 263.3 | 14.5 | 14.5 |
| 2012 | -384.4 | 92.7 | -3.1 | 0.62 | 0.05 | 309.3 | 15.0 | 8.4 |
| 2013 | -4.1 | 3.7 | | 0.54 | 0.01 | 45.1 | 13.3 | 5.3 |
| 2014 | -400.8 | 74.8 | -2.2 | 0.79 | 0.001 | 234.0 | 17.0 | 8.1 |
| 2015 | -515.3 | 101.9 | -3.0 | 0.56 | 0.05 | 350.4 | 17.0 | 10.4 |
| 2016 | -548.3 | 102.8 | -3.3 | 0.56 | 0.05 | 245.2 | 15.4 | 10.1 |
| 2017 | 92.1 | 17.7 | -0.6 | 0.04 | NS ^a | | | 12.7 |
| Average | -232.0 | 57.1 | -1.8 | 0.60 | 0.05 | 226.8 | 16.1 | 9.8 |

| <i>Dalea ornata</i> | | | | | | | | |
|----------------------------|-----------|--------|-----------|-------|-------|----------------------------|--|---|
| Year | intercept | linear | quadratic | R^2 | P | Maximum yield (lb/acre) | Water applied plus precipitation for max. yield (inches/season) | Precipitation, fall, winter, spring (inches) |
| 2011 | 635.9 | -12.5 | | 0.11 | NS | 454.9 | 14.5 | 14.5 |
| 2012 | -815.6 | 154.8 | -4.8 | 0.65 | 0.01 | 431.8 | 16.1 | 8.4 |
| 2013 | -149.4 | 41.9 | -1.6 | 0.88 | 0.001 | 130.4 | 13.4 | 9.4 |
| 2014 | -1258.9 | 233.6 | -7.8 | 0.87 | 0.001 | 486.6 | 14.9 | 8.1 |
| 2015 | -1597.0 | 267.3 | -8.9 | 0.64 | 0.05 | 399.0 | 14.9 | 10.4 |
| 2016 | -1096.9 | 203.5 | -6.9 | 0.55 | 0.10 | 393.0 | 14.6 | 10.1 |
| 2017 | -368.8 | 92.9 | -3.0 | 0.13 | NS | | | 12.7 |
| Average | -659.0 | 131.5 | -4.3 | 0.83 | 0.001 | 349.7 | 15.3 | 9.8 |

^aNot significant. There was no statistically significant trend in seed yield in response to the amount of irrigation.