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 6-year period of study, *Dalea searlsiae* (Searl's prairie clover) seed yield was maximized by 13-17 inches of water applied plus spring, winter, and fall precipitation per season. *Dalea ornata* (Blue Mountain or western prairie clover) seed yield was maximized by 13-16 inches of water applied plus spring, winter, and fall 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
Dalea searlsiae	Searl's' prairie clover	Perennial
Dalea ornata	Western prairie clover, Blue Mountain prairie clover	Perennial
Astragalus filipes	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 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 to these legumes 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 nonirrigated 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 its flowering and seed set. Flowering, irrigation, and harvest dates were recorded (Table 2).

Seed beetle control

Harvested seed pods of *Dalea ornata*, *D. searlsiae*, and *Astragalus filipes* were extensively damaged from feeding by seed beetles 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.

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 spring and winter precipitation; and 4) applied water plus spring, winter, and fall 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 would have 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 was not responsive to irrigation, so yield responses only to water applied are reported.

Results and Discussion

Precipitation from January through June was close to average in 2012, and 2014-2016, higher than average in 2011, 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, 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, Searl's prairie clover

In 2012, and 2014-2016, seed yields showed a quadratic response to irrigation plus spring, winter, and fall precipitation (Table 5). Maximum seed yields were achieved with 15, 17, 17, and 15.4 inches of water applied plus spring, winter, and fall precipitation in 2012, 2014, 2015, and 2016, respectively. In 2013, seed yields increased with increasing irrigation rate up to the highest tested of 8 inches plus 5.3 inches of spring, winter, and fall precipitation. In 2011, seed yields were highest with no irrigation plus 14.5 inches of spring, winter, and fall 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 spring, winter, and fall precipitation, respectively (Tables 4 and 5). Seed yields in 2011 were highest with no irrigation plus 14.5 inches of spring, winter, and fall 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 basalt milkvetch are related to low plant stand and high seed pod shatter that makes 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.

		Flowering			Irrigation		
Species	Year	Start	Peak	End	Start	End	Harvest
Dalea searlsiae							
	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
Dalea ornata							
	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
Astragalus filipes							
	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, 2006-2016.

	Precipitation (inches)		Growing degree-days (50-86°F)
Year	Jan-Jun	Apr-Jun	Jan-Jun
2006	9	3.1	1,273
2007	3.1	1.9	1,406
2008	2.9	1.2	1,087
2009	5.8	3.9	1,207
2010	8.3	4.3	971
2011	8.3	3.9	856
2012	5.8	2.3	1,228
2013	2.6	1.4	1,319
2014	5.1	1.6	1,333
2015	4.8	2.7	1,610
2016	4.4	2.1	1,458
72-year average	5.8	2.7	1,196[a]

[a]23-year average.

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

Species	Year	0 inches	4 inches	8 inches	LSD (0.05)
		------------ lb/acre ------------			
Dalea searlsiae					
	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
	Average	147.2	217.1	223.7	30.5
Dalea ornata					
	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
	Average	201.5	326.1	332.0	72.6
Astragalus filipes					
	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) 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.

Dalea searlsiae

Year	intercept	linear	quadratic	R^2	*P*	Maximum yield	Water applied plus precipitation for max. yield	Precipitation, spring, winter, fall
						(lb/acre)	(inches/season)	(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

Dalea ornata

Year	intercept	linear	quadratic	R^2	*P*	Maximum yield	Water applied plus precipitation for max. yield	Precipitation, spring, winter, fall
						(lb/acre)	(inches/season)	(inches)
2011	635.9	-12.5		0.11	NS[a]	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	407.8	13.3	5.3
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

Astragalus filipes

Year	intercept	linear	quadratic	R^2	*P*
2011	90.6	-1.6		0.01	NS[a]
2012	19.7	-0.8		0.04	NS
2013	8.5	0.9	-0.2	0.25	NS
2014	56.6	9.4	-0.9	0.08	NS
2015	17.1	-0.8		0.16	NS
Average	43.3	-0.2		0.01	NS

[a]Not significant. There was no statistically significant trend in seed yield in response to the amount of irrigation.