IRRIGATION REQUIREMENTS FOR SEED PRODUCTION OF NATIVE WILDFLOWER SPECIES STARTED IN THE FALL OF 2012

Clinton C. Shock, Erik B. G. Feibert, Alicia Rivera, and Lamont D. Saunders, Malheur Experiment Station, Oregon State University, Ontario, OR, 2014
Nancy Shaw and Francis Kilkenny, U.S. Forest Service, Rocky Mountain Research Station, Boise, ID

Introduction

Commercial seed production of native wildflowers is necessary to provide the quantity of seed needed for restoration of Intermountain West rangelands. Native wildflower plants may not be well adapted to croplands. Native plants are often not competitive with crop weeds in cultivated fields and this could limit wildflower seed production. Both sprinkler and furrow irrigation could 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 hoped 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 12 native wildflower species (Table 1).

Table 1. Wildflower species planted in the fall of 2012 at the Malheur Experiment Station, Oregon State University, Ontario, OR.

Species	Common name	Longevity	Row spacing (inches)
Chaenactis douglasii	Douglas' dustymaiden	perennial	30
Machaeranthera canescens	hoary tansyaster	perennial	30
Phacelia hastata	silverleaf phacelia	perennial	15
Phacelia linearis	threadleaf phacelia	annual	15
Enceliopsis nudicaulis	nakedstem sunray	perennial	30
Heliomeris multiflora	showy goldeneye	perennial	30
Ipomopsis aggregata	scarlet gilia	perennial	15
Nicotiana attenuata	coyote tobacco	perennial	30
Thelypodium milleflorum	manyflower thelypody	biennial	30
Ligusticum porteri	Porter's licorice-root	perennial	30
Ligusticum canbyi	Canby's licorice-root	perennial	30
Cymopterus bipinnatus[a]	Hayden's cymopterus	perennial	30

[a] recently classified as *Cymopterus nivalis* S. Watson "snowline springparsley". Planted in the fall of 2009.

Materials and Methods

Plant establishment

Each wildflower species was planted on 60-inch beds in rows 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 2012, drip tapes (T-Tape TSX 515-16-340) were buried at 12-inch depth in the center of each bed to irrigate the rows in the plot. 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 October 30, 2012 seed of 11 species (except Cymopterus bipinnatus, Table 1) was planted in either 15-inch or 30-inch rows using a custom-made plot grain drill with disk 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. The row cover (N-sulate, DeWitt Co., Inc., Sikeston, MO) covered four rows (two beds) and was applied with a mechanical plastic mulch layer. *Cymopterus bipinnatus* was planted on November 25, 2009 on 30-inch rows as described above.

Weeds were controlled by hand weeding as necessary.

Cultural practices for *Cymopterus bipinnatus*

Starting in March, 2010 the row cover was removed. Immediately following the removal of the row cover, bird netting was placed over the seedlings to prevent bird feeding on young seedlings and new shoots. The bird netting was placed over No. 9 galvanized wire hoops. During seedling emergence, wild bird seed was placed several hundred ft from the trial to attract quail away from the trials. Bird netting was removed in early May. Bird netting was applied and removed each spring. On April 13, 2012 50 lb nitrogen/acre, 10 lb phosphorus/acre, and 0.3 lb iron/acre was applied to all plots of *Cymopterus bipinnatus* as liquid fertilizer injected through the drip tape.

Cultural practices in 2013

Starting on March 29, 2013, the row cover was removed and bird netting applied for the species planted in the fall of 2012. Bird netting was removed in early May. On July 26, all plots of *Machaeranthera canescens* were sprayed with Capture® at 19 oz/acre (0.3 lb ai/acre) for aphid control. On October 31, seed of *Phacelia linearis* was planted as previously described.

Due to poor stand, seed of *Chaenactis douglasii* was replanted on November 1, as previously described. Stand of *Nicotiana attenuata* was extremely poor and seed was unavailable for replanting.

Cultural practices in 2014

Starting on March 27, the row cover was removed from *Phacelia linearis* and *Chaenactis douglasii* beds. Immediately following the removal of the row cover, bird netting was placed over the seedlings to prevent bird feeding on young seedlings and new shoots. Bird netting was removed in early May.

Irrigation for seed production

In March of 2010 for *Cymopterus bipinnatus* and March of 2013 for the other species, the strip of each wildflower species was divided into 12 30-ft-long 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 per irrigation, and 2 inches of water per irrigation. Each treatment received four irrigations that were applied approximately every 2 weeks starting with flowering of the wildflowers. 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 each species due to different timings of flowering and seed formation. All species were irrigated separately except the two *Phacelia* spp. and the two *Ligusticum* spp. Flowering, irrigation, and harvest dates were recorded (Table 2) with the exception of *Nicotiana attenuate*, which did not germinate, and the *Ligusticum* spp., which did not flower. All species were harvested manually, except *Phacelia hastate*, which was harvested with a small plot combine. *Machaeranthera canescens* seed was harvested by cutting and windrowing the plants; after drying for 2 days the plants were beaten on plastic tubs to separate the seed heads from the stalks. Seed of all species was cleaned manually.

Table 2. Native wildflower flowering, irrigation, and seed harvest dates in 2013 and 2014 by species. Malheur Experiment Station, Oregon State University, Ontario, OR.

	Flowering			Irrigation		
Species	start	peak	end	start	end	Harvest
			2013			
Chaenactis douglasii	23-May	30-Jun	15-Jul	22-May	3-Jul	2-Jul, 22-Jul
Machaeranthera canescens	13-Aug		1-Oct	17-Jul	28-Aug	2-Oct
Phacelia hastata	17-May		30-Jul	22-May	3-Jul	30-Jul (0 in), 7-Aug, 19-Aug (8 in)
Phacelia linearis	3-May	16-May	15-Jun	2-May	12-Jun	2-Jul
Enceliopsis nudicaulis	30-Jun		15-Sep	3-Jul	14-Aug	8-Aug to 30-Aug
Heliomeris multiflora	15-Jul		30-Aug	5-Jun	17-Jun	8-Aug, 15-Aug, 28-Aug
Cymopterus bipinnatus	5-Apr		15-May	12-Apr	22-May	10-Jun
Ipomopsis aggregata	31-Jul	very little flowering		31-Jul	11-Sep	
Thelypodium milleflorum		No flowering				
			2014			
Chaenactis douglasii	20-May		15-Jul	13-May	24-Jun	
Machaeranthera canescens	20-Aug	17-Sep	5-Oct	22-Jul	2-Sep	6-Oct
Phacelia hastata	5-May		10-Jul	29-Apr	10-Jun	14-Jul
Phacelia linearis	5-May	4-Jun	1-Jul	1-May	10-Jun	7-Jul
Enceliopsis nudicaulis	5-May	1-Jul	30-Jul	6-May	17-Jun	14-Jul to 30-Aug
Heliomeris multiflora	20-May	20-Jun	30-Aug	13-May	24-Jun	15-Jul to 15-Aug
Cymopterus bipinnatus	7-Apr		29-Apr	7-Apr	20-May	16-Jun
Ipomopsis aggregata	22-Apr	13-May	30-Jul	23-Apr	3-Jun	20-Jun
Thelypodium milleflorum	22-Apr	5-May	10-Jun	23-Apr	3-Jun	2-Jul

Results and Discussion

Precipitation from January through July in 2013 (2.6 inches) was below and in 2014 (5.1 inches) was close to the 66-year average of 6.1 inches (Fig. 1). The accumulation of growing degree-days (50-86°F) was higher than average in 2013 and 2014 (Fig. 2).

Stands of *Chaenactis douglasii, Ligusticum porteri,* and *L. canbyi* were poor and uneven and did not permit evaluation of irrigation responses. *Thelypodium milleflorum* is a biennial and set seed in 2014. *Ipomopsis aggregata* had very little flowering in 2013, but flowered and set seed in 2014. *Cymopterus bipinnatus* did not flower in either 2010 or 2011, and had very little flowering in 2012.

Seed yield responses

In 2013, seed yields of *Machaeranthera canescens* showed a quadratic response to irrigation with a maximum seed yield at 2.4 inches of water applied (Tables 3 and 4). In 2014 and averaged over 2 years, seed yields of *M. canescens* did not respond to irrigation.

Seed yields of *Phacelia hastata* showed a quadratic response to irrigation with a maximum seed yield at 5.4 and 7.5 inches of water applied in 2013 and 2014, respectively (Tables 3 and 4).

Seed yields of *P. linearis* showed a quadratic response to irrigation in 2013 with a maximum seed yield at 6.2 of water applied. In 2014, seed yields of *P. linearis* did not respond to irrigation.

In 2013, seed yield of *Enceliopsis nudicaulis* was very low and did not respond to irrigation, but in 2014, seed yield showed a quadratic response to irrigation with a maximum seed yield at 5.4 inches of water applied.

Seed yield of *Heliomeris multiflora* increased with increasing irrigation rate up to the highest tested of 8 inches in 2013 and 2014 (Tables 3 and 4).

Seed yields of *Cymopterus bipinnatus* did not respond to irrigation in 2013. In 2014, seed yields increased with increasing irrigation rate up to the highest tested of 8 inches.

Seed yield of *Thelypodium milleflorum* did not respond to irrigation in 2014.

In 2014, seed yields of *Ipomopsis aggregata* were highest with 4 inches of applied water.

Acknowledgements

This project was funded by the U.S. Forest Service Rocky Mountain Research Station, Oregon State University, Malheur County Education Service District, and supported by Formula Grant no. 2014-31100-06041 and Formula Grant no. 2014-31200-06041 from the USDA National Institute of Food and Agriculture.

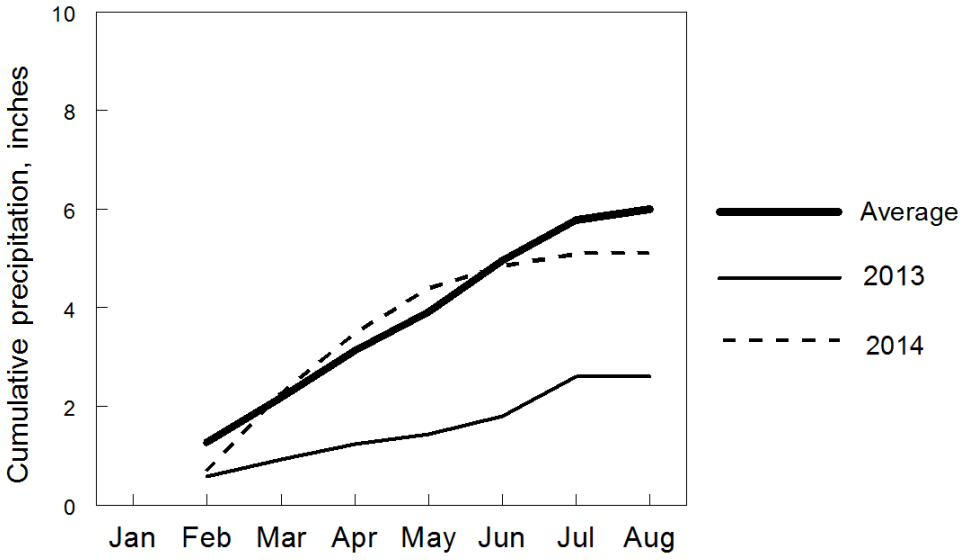

Figure 1. Cumulative annual and 66-year-average precipitation from January through July at the Malheur Experiment Station, Oregon State University, Ontario, OR.

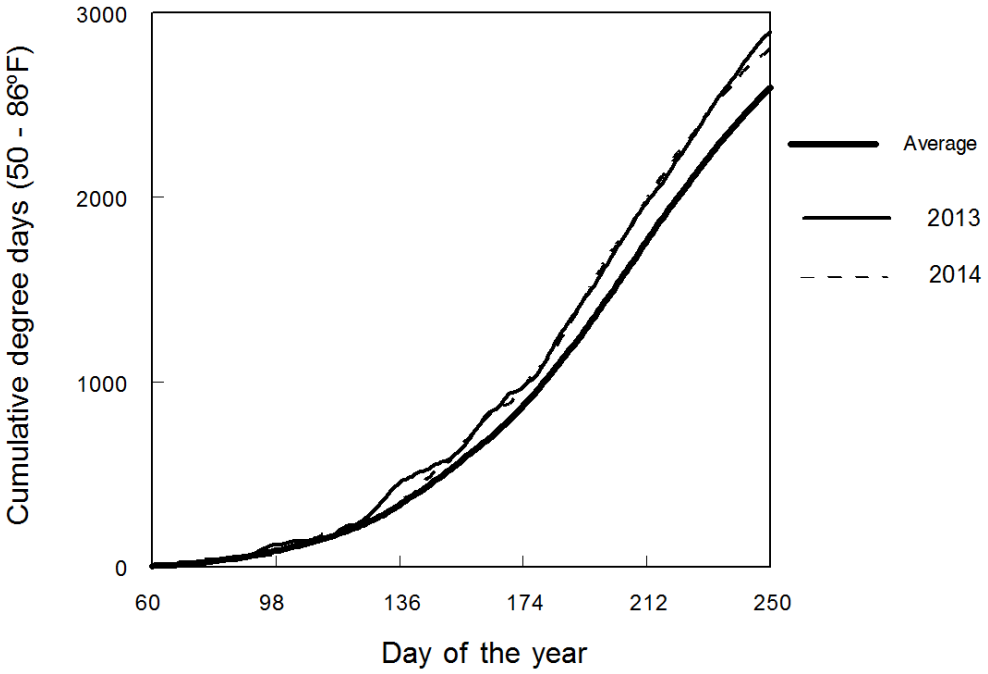

Figure 2. Cumulative growing degree-days (50-86°F) for selected years and 24-year average at the Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 3. Native wildflower seed yield response to season-long irrigation rate (inches). Malheur Experiment Station, Oregon State University, Ontario, OR.

	2013				2014			
Species	0 inches	4 inches	8 inches	LSD (0.05)	0 inches	4 inches	8 inches	LSD (0.05)
	lb/acre							
Machaeranthera canescens	206.1	215.0	124.3	73.6	946.1	1210.2	1026.3	NS
Phacelia hastata	35.3	102.7	91.2	35.7	87.7	305.7	366.4	130.3
Phacelia linearis	121.4	306.2	314.2	96.0	131.9	172.9	127.2	NS
Enceliopsis nudicaulis	2.3	6.8	5.9	NS	1.5	34.6	29.1	20.7
Heliomeris multiflora	28.7	57.6	96.9	NS	154.6	200.9	271.7	107.3[a]
Cymopterus bipinnatus	194.2	274.5	350.6	NS	1236.2	1934.0	2768.5	844.7
Thelypodium milleflorum					200.5	246.2	205.6	NS
Ipomopsis aggregata					47.1	60.9	63.6	9.0

	Average			
Species	0 inches	4 inches	8 inches	LSD (0.05)
	lb/acre			
Machaeranthera canescens	576.1	712.6	575.3	NS
Phacelia hastata	61.5	204.2	228.8	53.0
Phacelia linearis	126.7	239.5	220.7	87.2
Enceliopsis nudicaulis	1.9	26.6	17.5	17.1[a]
Heliomeris multiflora	91.7	129.2	184.3	60.4
Cymopterus bipinnatus	715.2	1104.2	1217.3	NS

[a]LSD (0.10)

Table 4. Regression parameters for native wildflower seed yield response to irrigation rate (inches/season). 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.

Year	intercept	linear	quadratic	R^2	*P*	Maximum yield	Water applied for maximum yield
Machaeranthera canescens						lb/acre	inches/season
2013	206.1	14.7	-3.1	0.54	0.05	223.4	2.4
2014	946.1	122.0	-14.0	0.13	NS		
Average	576.1	68.3	-8.6	0.17	NS		
Phacelia hastata							
2013	35.3	26.7	-2.5	0.66	0.01	107.7	5.4
2014	87.7	74.2	-4.9	0.76	0.01	367.4	7.5
Average	61.5	50.5	-3.7	0.88	0.001	233.8	6.8
Phacelia linearis							
2013	121.4	68.3	-5.5	0.69	0.01	332.5	6.2
2014	131.9	21.1	-2.7	0.11	NS		
Average	126.7	44.7	-4.1	0.48	0.1	247.9	5.4
Enceliopsis nudicaulis							
2013	3.1	0.4		0.16	NS		
2014	1.5	13.1	-1.2	0.6	0.05	37.1	5.4
Average	1.9	10.4	-1.1	0.46	0.1	27.5	4.9
Heliomeris multiflora							
2013	27.0	8.5		0.38	0.05	95.1	8.0
2014	150.5	14.6		0.27	0.1	267.6	8.0
Average	88.7	11.6		0.51	0.01	181.4	8.0
Cymopterus bipinnatus							
2013	194.9	19.6		0.07	NS		
2014	1214.6	190.6		0.41	0.05	2739.7	8
Average	761.2	62.8		0.11	NS		
Thelypodium milleflorum							
2014	200.5	22.2	-2.69835	0.12	NS		
Ipomopsis aggregata							
2014	48.5	2.1		0.23	NS		

[a]not significant. There was no statistically significant difference in yield between the nonirrigated plots and the plots receiving 4 or 8 inches of water.