IRRIGATION REQUIREMENTS FOR NATIVE BUCKWHEAT SEED PRODUCTION IN A SEMI-ARID ENVIRONMENT

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
Ram S. Sampangi, University of Idaho, Parma, ID

Summary

Native buckwheats (*Eriogonum* spp.) are important perennials in the Intermountain West. *Eriogonum heracleoides* (Wyeth buckwheat) and *E. umbellatum* (sulphur-flower buckwheat) (Family Polygonaceae, buckwheat family) are low-growing taprooted sub-shrubs that are widespread in the Rocky Mountains and Intermountain West. The buckwheats add diversity to native seedings where adapted and are particularly valuable due to their ability to establish on highly disturbed sites such as road banks or energy development sites. They are drought hardy, long-lived and spread from seed in the absence of strong competition. These species are important to numerous wildlife species. They support a wide variety of pollinators, including native and domesticated bees and butterflies. Insects associated with the plants provide food for sage-grouse chicks. Many birds and small mammals use the seeds. Birds, deer and other browsing animals forage on the leaves. Domestic sheep seek out the flower clusters.

Buckwheats are useful for low maintenance landscaping. They are attractive year-around, require little water and are easily maintained. Plants are semi-evergreen and flower in early to mid-summer after many other natives have completed their flowering cycle.

Buckwheat seeds are desired for rangeland restoration activities, but little cultural practice information is available for seed production of native buckwheat. The seed yields of *Eriogonum umbellatum* and *E. heracleoides* were evaluated over multiple years in response to four biweekly irrigations applying either 0, 1, or 2 inches of water (total of 0, 4, or 8 inches/season). *Eriogonum umbellatum* seed yield was maximized by no water applied per season in cooler, wetter years and by 5 to 8 inches of water applied per season in warmer, drier years. Averaged over 9 years, seed yield of *E. umbellatum* was maximized by 6.9 inches of water applied per season. Over four seasons, seed yield of *E. heracleoides* was responsive to irrigation only in 2013, a dry year when seed yield was maximized by 4.9 inches of applied water.

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 native rangelands, the natural 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 often are 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 *Eriogonum umbellatum* (sulphur-flower buckwheat) and *E. heracleoides* (parsnipflower buckwheat).

Materials and Methods

Plant establishment

Seed of *Eriogonum umbellatum* was received in late November in 2004 from the Rocky Mountain Research Station (Boise, ID). The plan was to plant the seed in the fall of 2004, but due to excessive rainfall in October, the ground preparation was not completed and planting was postponed to early 2005. To try to ensure germination, the seed was submitted to cold stratification. The seed was soaked overnight in distilled water on January 26, 2005 after which the water was drained and the seed soaked for 20 min in a 10% by volume solution of 13% bleach in distilled water. The water was drained and the seed was placed in thin layers in plastic containers. The plastic containers had lids with holes drilled in them to allow air movement. These containers were placed in a cooler set at approximately 34°F. Every few days the seed was mixed and, if necessary, distilled water was added to maintain seed moisture.

In late February 2005, drip tape (T-Tape TSX 515-16-340) was buried at 12-inch depth between two 30-inch rows of a Nyssa silt loam with a pH of 8.3 and 1.1% organic matter. The drip tape was buried in alternating inter-row spaces (5 ft apart). 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 March 3, 2005 seed of *Eriogonum umbellatum* was planted in 30-inch rows using a custom-made small-plot grain drill with disc openers. All seed was planted at 20-30 seeds/ft of row at 0.25-inch depth. The trial was irrigated with a minisprinkler system (R10 Turbo Rotator, Nelson Irrigation Corp., Walla Walla, WA) from March 4 to April 29 for even stand establishment. Risers were spaced 25 ft apart along the flexible polyethylene hose laterals that were spaced 30 ft apart and the water application rate was 0.10 inch/hour. A total of 1.72 inches of water was applied with the minisprinkler system. *Eriogonum umbellatum* began emerging on March 29. Starting June 24, the field was irrigated with the drip system. A total of 3.73 inches of water was applied with the drip system from June 24 to July 7. The field was not irrigated further in 2005.

Plant stands for *E. umbellatum* were uneven and it did not flower in 2005. In early October, 2005 more seed was received from the Rocky Mountain Research Station for replanting. The empty lengths of row were replanted by hand on October 26, 2005. In the spring of 2006 the plant stands were excellent.

In early November 2009, drip tape was buried as described above in preparation for planting *E. heracleoides.* On November 25, 2009 seed of *E. heracleoides* was planted in 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 (N-sulate, DeWitt Co., Inc., Sikeston, MO) that 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 *E. heracleoides* had emerged, the row cover was removed in April, 2010. The irrigation treatments were not applied to *E. heracleoides* in 2010. Stands of *E. heracleoides* were not adequate for yield estimates; gaps in the rows were replanted by hand on November 5, 2010. The replanted seed was covered with a thin layer of a mixture of 50% sawdust and 50% hydro seeding mulch (Hydrostraw LLC, Manteno, IL) by volume. The mulch mixture was sprayed with water using a backpack sprayer.

Irrigation for seed production

The planted strips were divided into plots 30 ft long (*Eriogonum umbellatum* in April 2006 and *E. heracleoides* in April 2011). Each plot contained four rows of each species. The experimental designs were randomized complete blocks 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 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. After each irrigation, the amount of water applied was read on a water meter and recorded to ensure correct water applications. Irrigation dates are found in Table 1.

Flowering, harvesting, and seed cleaning

Flowering dates for each species were recorded (Table 1). The *Eriogonum umbellatum* plots produced seed in 2006, in part because they had emerged in the spring of 2005. *Eriogonum heracleoides* started flowering in 2011. Each year, the middle two rows of each plot were harvested when seed of each species was mature (Table 1). Seed was harvested with a small plot combine. *Eriogonum umbellatum* and *E. heracleoides* seeds did not separate from the flowering structures in the combine. In 2006, the unthreshed seed of *E. umbellatum* was taken to the U.S. Forest Service Lucky Peak Nursery (Boise, ID) and run through a dewinger to separate seed. The seed was further cleaned in a small clipper seed cleaner. In subsequent years, the unthreshed seed of both species was run through a meat grinder to separate the seed. The seed was further cleaned in a small clipper seed cleaner.

Cultural practices

On October 27, 2006 50 lb phosphorus/acre and 2 lb zinc/acre were injected through the drip tape to all plots of *Eriogonum umbellatum*. On November 17, 2006, November 9, 2007, and April 15, 2008 all plots of *E. umbellatum* had Prowl® at 1 lb ai/acre broadcast on the soil surface for weed control. On March18, 2009 Prowl at 1 lb ai/acre and Volunteer® at 8 oz/acre were broadcast on all *E. umbellatum* plots for weed control. On December 4, 2009 and November 17, 2010 Prowl at 1 lb ai/acre was broadcast on all plots of *E. umbellatum*. On November 9, 2011 and November 7, 2012 Prowl at 1 lb ai/acre was broadcast on all plots of both species. On April 3, 2013 Select Max® at 32 oz/acre was broadcast for grass weed control on all plots of *E. umbellatum.* On February 26, 2014 Prowl at 1 lb ai/acre and Select Max at 32 oz/acre were broadcast on all plots of both species. In addition to herbicides, weeds were controlled with hand weeding as necessary.

Table 1. *Eriogonum umbellatum* and *Eriogonum heracleoides* flowering, irrigation, and seed harvest dates by species in 2006-2014, Malheur Experiment Station, Oregon State University, Ontario, OR.

		Flowering			Irrigation		
Species	Year	start	peak	end	start	end	Harvest
Eriogonum umbellatum	2006	19-May		20-Jul	19-May	30-Jun	3-Aug
	2007	25-May		25-Jul	2-May	24-Jun	31-Jul
	2008	5-Jun	19-Jun	20-Jul	15-May	24-Jun	24-Jul
	2009	31-May		15-Jul	19-May	24-Jun	28-Jul
	2010	4-Jun	12-19 Jun	15-Jul	28-May	8-Jul	27-Jul
	2011	8-Jun	30-Jun	20-Jul	20-May	5-Jul	1-Aug
	2012	30-May	20-Jun	4-Jul	30-May	11-Jul	24-Jul
	2013	8-May	27-May	27-Jun	8-May	19-Jun	9-Jul
	2014	20-May	4-Jun	1-Jul	13-May	24-Jun	10-Jul
Eriogonum heracleoides	2011	26-May	10-Jun	8-Jul	27-May	6-Jul	1-Aug
	2012	23-May	30-May	25-Jun	11-May	21-Jun	16-Jul
	2013	29-Apr	13-May	10-Jun	24-Apr	5-Jun	1-Jul
	2014	1-May	20-May	12-Jun	29-Apr	10-Jun	3-Jul

Results and Discussion

Precipitation from January through June in 2009, 2012, and 2014 was close to the average of 5.8 inches (Table 2). Precipitation from January through June in 2006, 2010, and 2011 was higher than the average of 5.8 inches. Precipitation from January through June in 2007, 2008, and 2013 was lower than the average of 5.8 inches The accumulated growing degree-days (50-86°F) from January through June in 2006, 2007, 2013, and 2014 were higher than average (Table 2, Figs. 1 and 2).

Seed yields

Eriogonum umbellatum

In 2006, seed yield of *Eriogonum umbellatum* increased with increasing water application, up to 8 inches, the highest amount tested (Tables 3 and 4). In 2007-2009 seed yield showed a quadratic response to irrigation rate. Seed yields were maximized by 8.1, 7.2, and 6.9 inches of water applied in 2007, 2008, and 2009, respectively. In 2010, there was no significant difference in yield between the irrigation treatments. In 2011, seed yield was highest with no irrigation. The 2010 and 2011 seasons had unusually cool (Table 2, Fig. 2) and wet weather (Fig. 2). The accumulated precipitation in April through June of 2010 and 2011 was the highest over the years of the trial (Table 2). The relatively high seed yield of *E. umbellatum* in the nonirrigated treatment in 2010 and 2011 seemed to be related to the wet spring. The negative effect of irrigation on seed yield in 2011 might have been related to the presence of rust. Irrigation could have exacerbated the rust and resulted in lower yields. In 2012, seed yield of *E. umbellatum* increased with increasing water application, up to 8 inches, the highest amount tested. In 2013 and 2014, seed yields showed quadratic responses to irrigation rate. Seed yield was maximized by 5.7 inches and by 5.3 inches of water applied in 2013 and 2014, respectively. Averaged over 9 years, seed yield of *E. umbellatum* showed a quadratic response to irrigation rate with the highest yield achieved with 6.9 inches of water applied.

Eriogonum heracleoides

Seed yields did not respond to irrigation in 2011, 2012, and 2014 (Tables 3 and 4). In 2013, seed yields showed a quadratic response to irrigation with a maximum seed yield at 4.9 inches of water applied.

Conclusions

Subsurface drip irrigation systems were tested for native wildflower seed production because they have two potential strategic advantages: a) low water use, and b) the buried drip tape provides water to the plants at depth, precluding most irrigation-induced stimulation of weed seed germination on the soil surface and keeping water away from native plant tissues that are not adapted to a wet environment.

Due to the arid environment, supplemental irrigation may often be required for successful flowering and seed set because soil water reserves may be exhausted before seed formation. The total irrigation requirements for these arid-land species were low and varied by species. *Eriogonum heracleoides* responded to irrigation only in 2013, a drier than average year. In the other years, natural rainfall was sufficient to maximize seed production in the absence of weed competition. Seed yield of *E. umbellatum* showed quadratic responses to irrigation rate varying from 0 to 8 inches, depending on year.

Acknowledgements

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Table 2. Early season precipitation and growing degree-days at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006-2014.

	Precipitation (inches)		Growing degree-days (50-86°F)
Year	Jan-Jun	Apr-Jun	Jan-Jun
2006	9.0	3.1	1120
2007	3.1	1.9	1208
2008	2.9	1.2	936
2009	5.8	3.9	1028
2010	8.3	4.3	779
2011	8.3	3.9	671
2012	5.8	2.3	979
2013	2.6	1.4	1118
2014	5.1	1.6	1109
70-year average	5.8	2.7	1010[a]

[a]24-year average.

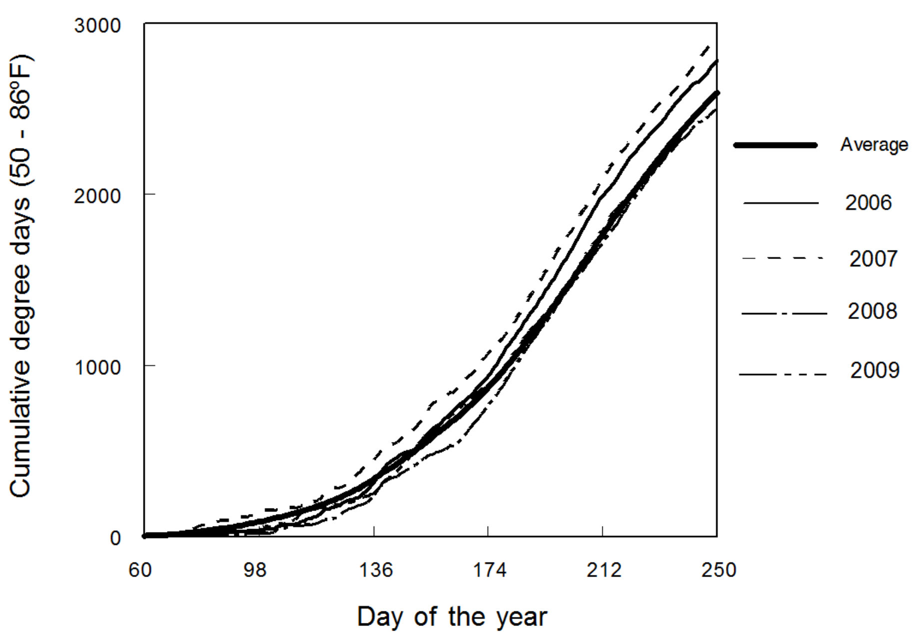

Figure 1. Growing degree-days (50-86°F) for 2006-2009 and the 24-year average. Malheur Experiment Station, Oregon State University, Ontario, OR.

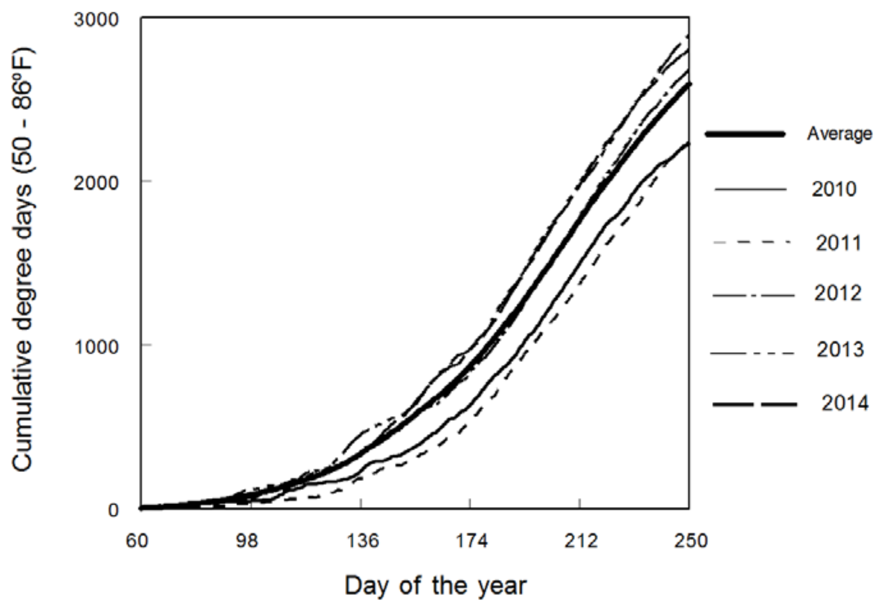

Figure 2. Growing degree-days (50-86°F) for 2010-2014 and the 24-year average. Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 3. *Eriogonum umbellatum* and *E. heracleoides* seed yield response to irrigation rate (inches/season) in 2006-2014. Malheur Experiment Station, Oregon State University, Ontario, OR.

Species	Year	Irrigation rate			
		0 inches	4 inches	8 inches	LSD (0.05)
		lb/acre			
Eriogonum umbellatum	2006	155.3	214.4	371.6	92.9
	2007	79.6	164.8	193.8	79.8
	2008	121.3	221.5	245.2	51.7
	2009	132.3	223	240.1	67.4
	2010	252.9	260.3	208.8	NS[a]
	2011	248.7	136.9	121	90.9
	2012	61.2	153.2	185.4	84.4
	2013	113.2	230.1	219.8	77.5
	2014	257	441.8	402.7	82.9
	Average	161.4	228	239.7	24.9
Eriogonum heracleoides	2011	55.2	71.6	49	NS[a]
	2012	252.3	316.8	266.4	NS
	2013	287.4	516.9	431.7	103.2
	2014	297.6	345.2	270.8	NS
	Average	297.6	345.2	270.8	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.

Table 4. Regression analysis for *Eriogonum umbellatum* and *E. heracleoides* seed yield response to irrigation rate (inches/season) in 2006-2014, and 4- to 9-year averages. 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
Eriogonum umbellatum						lb/acre	inches/season
2006	137.9	27.8		0.68	0.01	360.3	8.0
2007	79.6	28.3	-1.8	0.69	0.05	194.0	8.1
2008	121.3	34.6	-2.4	0.73	0.01	246.0	7.2
2009	132.3	31.9	-2.3	0.60	0.05	242.9	6.9
2010	252.9	9.2	-1.8	0.08	NS[a]		
2011	232.7	-16.0		0.58	0.01	232.7	0.0
2012	61.2	30.5	-1.9	0.65	0.01	185.4	8.1
2013	113.2	45.2	-4.0	0.62	0.05	241.3	5.7
2014	257.0	74.2	-7.0	0.76	0.01	453.7	5.3
Average	161.4	23.5	-1.7	0.82	0.001	241.9	6.9
Eriogonum heracleoides							
2011	61.7	-0.8		0.01	NS		
2012	271.5	1.8		0.01	NS		
2013	287.4	96.7	-9.8	0.64	0.05	525.1	4.9
2014	297.6	27.2	-3.8	0.08	NS		
Average	223.1	40.8	-4.6	0.56	0.05	313.4	4.4

[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.