NATIVE BEEPLANT SEED PRODUCTION IN RESPONSE TO IRRIGATION IN A SEMI-ARID ENVIRONMENT

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Summary

Beeplants (*Cleome* spp.) are annual species that favor pollinators in the Intermountain West. Cleome seed is desired for rangeland restoration, but little cultural practice information is known for their seed production. The seed yield response of *Cleome serrulata* and *C. lutea* to four biweekly irrigations applying either 0, 1, or 2 inches of water (total of 0, 4 inches, or 8 inches/season) was evaluated over multiple years. *Cleome serrulata* seed yield was maximized by 8 inches of water applied per season in 2011, but did not respond to irrigation in 2012 or 2014. *Cleome lutea* seed yield did not respond to irrigation in 2012 or 2014. Cleome stands were eradicated by flea beetles in 2013.

Introduction

Cleome lutea (yellow beeplant) and *Cleome serrulata* (Rocky Mountain beeplant) are widespread annual forbs in the Intermountain West. They are pollinated by large numbers of bee, wasp and butterfly species (Cane 2008). These two wildflowers have considerable potential for inclusion in rangeland restoration seed mixes to support surviving native pollinator populations, particularly in the first year post-disturbance before seeded or recovering perennials can flower.

The beeplants often grow in disturbed areas where they may occur in large patches as they spread prolifically from seed. Production of these species in agricultural fields or restoration projects has been limited. Seed of both species requires cool-moist prechilling; consequently fall seeding or artificial prechilling and spring seeding are recommended (B & T World Seeds 2011, Lady Bird Johnson Wildflower Center 2015).

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, the annual variation in spring rainfall and soil moisture results 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 also limit 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 *Cleome serrulata* (Rocky Mountain beeplant) and *C. lutea* (yellow beeplant).

Materials and Methods

Plant establishment

Each species was planted in separate strips containing four rows 30 inches apart (a 10-ft-wide strip) and 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 2010, 2 drip tapes 5 ft 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.

Starting in 2010, seed of *Cleome serrulata* was planted in 30-inch rows using a custom-made plot grain drill with disk openers in mid-November each year. All seed was planted on the soil surface at 20-30 seeds/ft of row in the same location each year. 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. Starting in 2011 seed of *C. lutea* was also planted each year. After the newly planted wildflowers had emerged, the row cover was removed in April each year.

Flea beetles were observed feeding on leaves of *Cleome serrulata* and *C. lutea* in April of 2012. On April 29, 2012, all plots of *C. serrulata* and *C. lutea* were sprayed with Capture® at 5 oz/acre to control flea beetles. On June 11, 2012, *C. serrulata* was again sprayed with Capture at 5 oz/acre to control a reinfestation of flea beetles.

Starting in 2013, after the row cover was removed, bird netting was placed over the *C. serrulata* and *C. lutea* plots to protect seedlings from bird feeding. The bird netting was placed over No. 9 galvanized wire hoops.

Weeds were controlled by hand weeding as necessary.

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 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.

The drip-irrigation system was designed to allow separate irrigation of each species due to different timings of flowering and seed formation. Flowering, irrigation, and harvest dates were recorded (Table 1). In 2014, after the four bi-weekly irrigations ended, *C. serrulata* and *C. lutea* received three additional bi-weekly irrigations starting on August 12 in an attempt to extend the flowering and seed production period. On August 12, 50 lb nitrogen/acre, 30 lb phosphorus/acre, and 0.2 lb iron/acre were applied through the drip tape to all plots of *C. serrulata* and *C. lutea.*

Flowering and harvest

The two species have a long flowering and seed set period (Table 1), making mechanical harvesting difficult. Mature seed pods were harvested manually 2 to 4 times each year.

Table 1. *Cleome serrulata* and *Cleome lutea* 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
Cleome serrulata	2011	25-Jun	30-Jul	15-Aug	21-Jun	2-Aug	26-Sep
	2012	12-Jun	30-Jun	30-Jul	13-Jun	25-Jul	24-Jul to 30-Aug
	2013	Full stand loss					
	2014	4-Jun	24-Jun	22-Jul	20-May	1-Jul	11-Jul to 30-Jul
Cleome lutea	2012	16-May	15-Jun	30-Jul	2-May	13-Jun	12-Jul to 30-Aug
	2013	Full stand loss					
	2014	29-Apr	4-Jun	22-Jul	23-Apr	3-Jun	23-Jun to 30-Jul

Results and Discussion

Precipitation from January through July was higher than average in 2011, close to average in 2012 and 2014, and lower than average in 2013 (Fig. 1). The accumulation of growing degree-days (50 to 86°F) was below average in 2011, close to average in 2012, and higher than average in 2013 and 2014 (Fig. 2).

In 2012, a flea beetle infestation on the two *Cleome* species occurred in April and was controlled by insecticide application. Flea beetle feeding occurred earlier in 2013 than in 2012. Upon removal of the row cover in March of 2013, flea beetle damage for both species at seedling emergence was extensive and resulted in full stand loss. Flea beetles were not observed on either *Cleome* species in 2014.

Cleome serrulata

In 2011, seed yields increased with increasing irrigation up to the highest tested of 8 inches (Tables 2 and 3). Seed yields did not respond to irrigation in 2012 or 2014. There was no plant stand in 2013 due to early, severe flea beetle damage. The additional irrigations starting on August 12 in 2014 did result in an extension/resumption of flowering, but seed harvested in mid-October was not mature.

Cleome lutea

Seed yields did not respond to irrigation in 2012 or 2014 (Tables 2 and 3). There was no plant stand in 2013. Early attention to flea beetle control is essential for *Cleome* seed production. The additional irrigations starting on August 12, 2014 did not result in an extension or resumption of flowering.

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.

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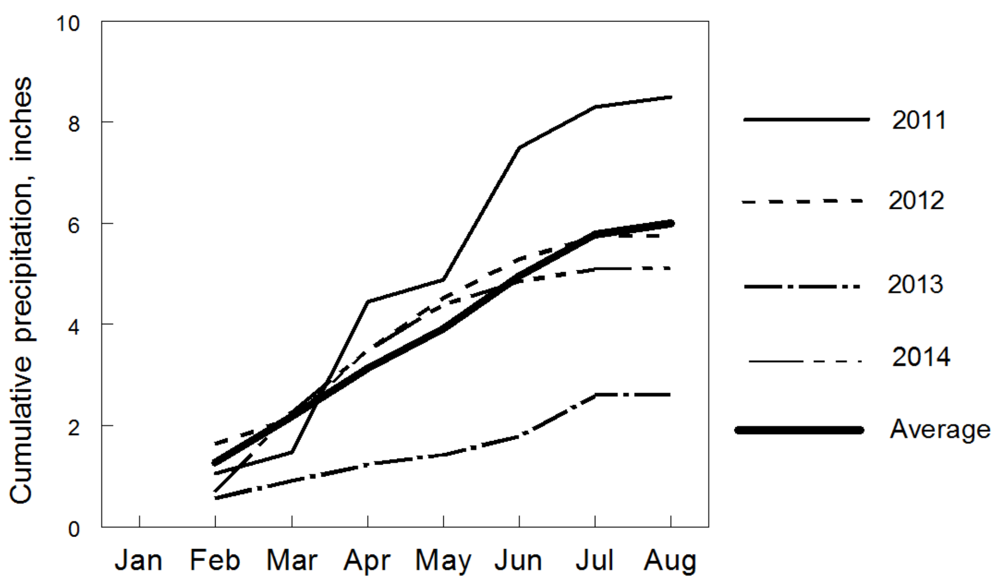

Figure 1. Cumulative annual and 66-year-average precipitation from January through July at the Malheur Experiment Station, Oregon State University, Ontario, OR.

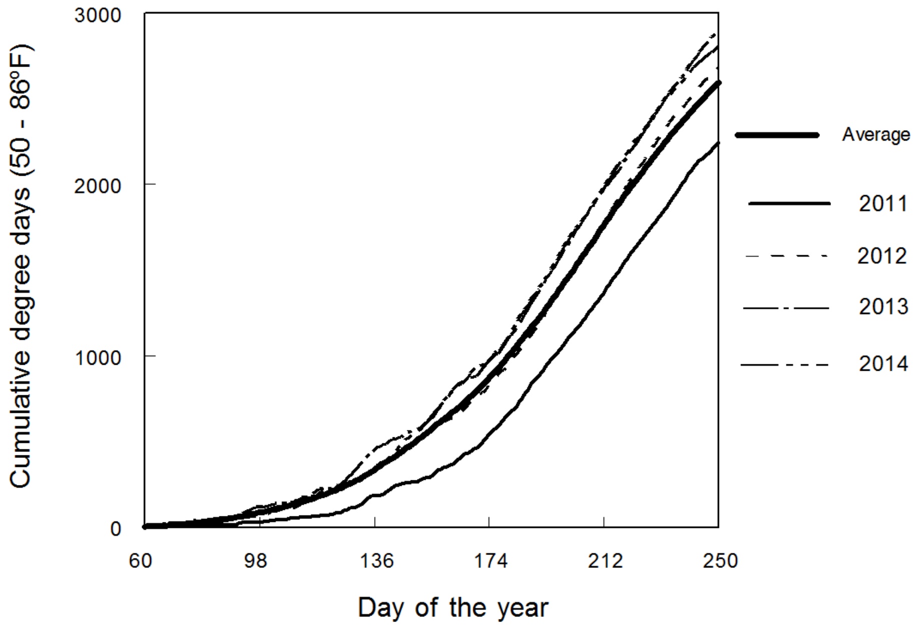

Figure 2. Cumulative growing degree-days (50-86°F) for selected years and 24-year average at the Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 2. *Cleome serrulata* and *Cleome lutea* seed yield response to irrigation rate (inches/season). Malheur Experiment Station, Oregon State University, Ontario, OR.

Species	Year	Irrigation rate 0 inches	4 inches	8 inches	LSD (0.05)
		---------- lb/acre ----------			
Cleome serrulata	2011	446.5	499.3	593.6	100.9[b]
	2012	184.3	162.9	194.7	NS[a]
	2013	No stand			
	2014	66.3	80	91.3	NS
	Average	211.3	221.4	263.1	NS
Cleome lutea	2012	111.7	83.7	111.4	NS
	2013	No stand			
	2014	207.1	221.7	181.7	NS
	Average	159.4	152.7	146.6	NS

[a] not significant, [b] LSD (0.10)

Table 3. Regression parameters for *Cleome serrulata* and *Cleome lutea* seed yield in response to irrigation rate (inches/season). Malheur Experiment Station, Oregon State University, Ontario, OR.

Cleome serrulata Year	intercept	linear	quadratic	R^2	*P*	Maximum yield	Water applied for maximum yield
						lb/acre	inches/season
2011	439.6	18.4		0.35	0.05	586.7	8
2012	175.4	1.3		0.01	NS[a]		
2014	66.7	3.1		0.16	NS		
Average	206.0	6.5		0.33	NS		

Cleome lutea Year	intercept	linear	quadratic	R^2	*P*	Maximum yield	Water applied for maximum yield
						lb/acre	inches/season
2012	102.4	-0.031		0.01	NS		
2014	207.1	10.4	-1.7	0.20	NS		
Average	159.3	-1.6		0.04	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.