INTERMOUNTAIN WEST NATIVE PLANT SEED PRODUCTION RESPONSE TO IRRIGATION: A SUMMARY

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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.

This research is part of the Great Basin Native Plant Project, a cooperative effort of the U.S. Bureau of Land Management and the U.S. Forest Service Rocky Mountain Research Station to increase the availability of native plant material for rangeland restoration (http://www.greatbasinnpp.org/). The data presented here are the averages of multi-year evaluations of the effects of three low rates of irrigation on the seed yield of native wildflower species (Table 1). Full reports with yearly data can be accessed at the Malheur Experiment Station website at https://agsci.oregonstate.edu/mes.

Materials and Methods

Plant Establishment

Each species was planted in four 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. Two drip tapes 5 ft apart (T-Tape TSX 515-16-340) were buried at 12-inch depth to irrigate the four 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.

Research at the Malheur Experiment Station determined the optimum practices for stand establishment. These practices were used for establishing stands of the different species for irrigation research. In the fall, seed of each 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 to 30 seeds/ft. After planting, sawdust was applied in a narrow band over the seed row at 0.26 oz/ft (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 row cover was removed in April, after the seedlings emerged. Flowering and harvest dates were recorded (Table 1). Seed from the middle two rows in each plot was harvested manually.

Irrigation for Seed Production

In April, each four-row strip of each wildflower species was divided into 12 30-ft plots. 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 four 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.

Weed Control

The herbicides pendimethalin (Prowl®), dimethenamid-P (Outlook®), clethodim (Shadow®), and sethoxydim (Poast®) have been used for weed control after plant establishment. Prowl and either Poast or Shadow were applied once per year, usually in the fall. Starting in 2018, Outlook was added to the yearly herbicide application. In addition to herbicides, hand weeding was used as necessary to control weeds.

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 $y = a + b \cdot x + c \cdot x^2$, where a is the intercept, b is the linear parameter, and c is the quadratic parameter. For the quadratic equations, the amount of irrigation (x') that resulted in maximum yield (y') was calculated using the formula $x' = -b/2c$. 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.

Results

Stand establishment for five of the 33 species tested was problematic (Table 2). Most species tested started producing seed in the first year following fall planting, but some species took 3 years to start seed production. Stand longevity varied and ranged from 1 year for *Nicotiana attenuata*, an annual, to 10 or more years for some of the perennials. Two of the species were biennial, with seed production in the second year. Most species flowered in April, May, or June, but some species flowered early, in March. *Machaeranthera canescens* flowered in late summer and fall.

For some species, yield responses to irrigation were not influenced by precipitation (Table 3). On average, most of these species did not respond to irrigation. For a number of species, yield responses to irrigation were influenced by spring precipitation (Table 4). The amount of water plus spring precipitation that maximized seed yield ranged from 0 to 11 inches, depending on species. For three species, yield responses to irrigation were influenced by spring, winter, and fall precipitation (Table 5).

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Table 1. Growth habit, common names, and flowering and harvest period for native plant species evaluated for responses to irrigation, Malheur Experiment Station, Oregon State University, Ontario, OR.

Growth habit	Species	Common name	Flowering period	Harvest
Perennial	*Achillea millefolium*	common yarrow	May to mid-July	late July
	Astragalus filipes	basalt milkvetch	May	June
	Chaenactis douglasii	Douglas' dustymaiden	mid-May to mid-July	mid-June to mid-July
	Crepis intermedia	limestone hawksbeard	May	late May to early June
	Cymopterus bipinnatus	Hayden's cymopterus	mid-March to April	June
	Dalea ornata	western prairie clover, Blue Mountain prairie clover	mid-May to June	June
	Dalea searlsiae	Searls' prairie clover	mid-May to June	June
	Enceliopsis nudicaulis	nakedstem sunray	May to July	June to August
	Eriogonum heracleoides	parsnipflower buckwheat	May to June	July
	Eriogonum umbellatum	sulphur-flower buckwheat	mid-May to mid-July	July
	Heliomeris multiflora	showy goldeneye	mid-May to July	July
	Lomatium dissectum	fernleaf biscuitroot	April	June
	Lomatium grayi	Gray's biscuitroot, Gray's lomatium	March to April	June
	Lomatium nudicaule	barestem biscuitroot, barestem lomatium	April to May	June
	Lomatium suksdorfii	Suksdorf's desertparsley	April to May	late June
	Lomatium triternatum	nineleaf biscuitroot, nineleaf desertparsley	April-May	June
	Machaeranthera canescens	hoary tansyaster	mid-August to late Oct	October
	Penstemon acuminatus	sharpleaf penstemon, sand-dune penstemon	May	July
	Penstemon cyaneus	blue penstemon	May to June	July
	Penstemon deustus	scabland penstemon, hotrock penstemon	May to June	late July
	Penstemon pachyphyllus	thickleaf beardtongue	May	late June to early July
	Penstemon speciosus	royal penstemon, sagebrush penstemon	May to June	July
	Phacelia linearis	threadleaf phacelia	May to June	June
	Phacelia hastata	silverleaf phacelia	May to June	late June to July
	Sphaeralcea coccinea	scarlet globemallow, red globemallow	May to June	July
	Sphaeralcea grossulariifolia	gooseberryleaf globemallow	May to June	July
	Sphaeralcea parvifolia	small-leaf globemallow	May to June	July
Annual	*Nicotiana attenuata*	coyote tobacco	mid-May to July	late June to mid-Aug
Biennial	*Ipomopsis aggregata*	scarlet gilia	May to July	late June
	Thelypodium milleflorum	manyflower thelypody	late April to early June	late June

Table 2. Years to seed production (from fall planting), stand longevity, and number of failed plantings for native plant species evaluated for responses to irrigation, Malheur Experiment Station, Oregon State University, Ontario, OR.

Growth habit	Species	Years to seed production	Stand longevity	No. of failed plantings
Perennial	*Achillea millefolium*	1	3+[a]	0
	Astragalus filipes	1	5	0
	Chaenactis douglasii	0	4	3 out of 5
	Crepis intermedia	3	5+	0
	Cymopterus bipinnatus	3	4-5	0
	Dalea ornata	1	10+[b]	0
	Dalea searlsiae	1	10+	0
	Enceliopsis nudicaulis	0	3	0
	Eriogonum heracleoides	0	10+	0
	Eriogonum umbellatum	0	14	0
	Heliomeris multiflora	0	8+	0
	Lomatium dissectum	3	12+	0
	Lomatium dissectum '38'	3	7+	0
	Lomatium dissectum '41'	3	7+	0
	Lomatium dissectum 'Riggins'	3	7+	0
	Lomatium grayi	2	14+	0
	Lomatium nudicaule	2	9+	0
	Lomatium suksdorfii	3	7+	0
	Lomatium triternatum	2	14+	0
	Machaeranthera canescens	0	3	0
	Penstemon acuminatus	0	3	0
	Penstemon cyaneus	0	3	1 out of 2
	Penstemon deustus	0	4	0
	Penstemon pachyphyllus	0	3	1 out of 2
	Penstemon speciosus	0	3	0
	Phacelia linearis	0	2	3 out of 5
	Phacelia hastata	0	6+	0
	Sphaeralcea coccinea	0	5+	0
	Sphaeralcea grossularifolia	0	5+	0
	Sphaeralcea parvifolia	0	5+	0
Annual	*Nicotiana attenuata*	0	1	2 out of 7
Biennial	*Ipomopsis aggregata*	1	2	0
	Thelypodium milleflorum	1	2	0

[a] 2 years for non-irrigated plants

[b] 9 years for plants receiving 8 inches of irrigation per year

Table 3. Averages over the years tested of maximum yield, water applied for maximum yield, and spring precipitation for native plant species evaluated for responses to irrigation, Malheur Experiment Station, Oregon State University, Ontario, OR.

Species	Years tested	Years with no response or negative response to irrigation	Average maximum yield	Water applied for maximum yield	Average spring precipitation
			lb/acre	inches	inches
Lomatium nudicaule	9	8	303	0.0	2.8
Lomatium suksdorfii	7	6	924	0.0	3.1
Penstemon acuminatus	4	2	271	0.0	2.2
Penstemon cyaneus	10	9	284	0.0	3.0
Penstemon deustus	10	9	286	0.0	3.0
Penstemon pachyphyllus	10	8	224	0.0	3.0
Eriogonum heracleoides	10	6	297	4.7	3.0
Crepis intermedia	6	4	168	0.0	3.4
Chaenactis douglasii	5	4	208	0.0	3.4
Machaeranthera canescens	4	3	702	0.0	2.9
Astragalus filipes	5	5	39	0.0	4.0
Sphaeralcea parvifolia	5	5	496	0.0	3.3
Sphaeralcea grossularifolia	5	5	340	0.0	3.3
Sphaeralcea coccinea	5	5	321	0.0	3.3
Nicotiana attenuata	2	0	176	4.3	3.5
Thelypodium milleflorum	4	4	150	2.3	2.5

Table 4. Averages over the years tested of maximum yield, water applied plus spring precipitation for maximum yield, spring precipitation, and water applied for maximum yield for native plant species evaluated for responses to irrigation plus spring precipitation, Malheur Experiment Station, Oregon State University, Ontario, OR.

Species	Years tested	Years with no response or negative response to irrigation	Average maximum yield	Water applied plus spring precipitation for maximum yield	Average spring precipitation	Water applied for maximum yield
			lb/acre	inches	inches	inches
Lomatium dissectum	12	1	856	9.8	3.2	6.6
Lomatium dissectum '38'	7	6	536	0.0	3.2	0.0
Lomatium dissectum '41'	7	2	301	8.3	3.2	5.1
Lomatium dissectum 'Riggins'	6	0	440	8.2	3.2	5.0
Lomatium triternatum	14	1	1011	10.9	3.2	7.7
Penstemon speciosus	14	4	162	7.7	3.1	4.6
Eriogonum umbellatum	15	4	203	8.2	3.0	5.2
Achillea millefolium	3	0	107	9.6	3.5	6.1
Cymopterus bipinnatus	6	1	1012	7.9	2.3	5.6
Enceliopsis nudicaulis	8	6	105[a]	0.0	2.9	0.0
Heliomeris multiflora	8	2	106	8.0	2.9	5.1
Phacelia hastata	10	4	108	8.2	2.7	5.5
Phacelia linearis	4	3	183	9.6	2.9	6.7
Ipomopsis aggregata	3	1	270	7.1	3.5	3.6

[a]Highest yields were obtained with no irrigation in years with higher than average spring precipitation.

Table 5. Averages over the years tested of maximum yield; water applied plus spring, winter, and fall precipitation for maximum yield; spring, winter, and fall precipitation; and water applied for maximum yield for native plant species evaluated for responses to irrigation plus spring, winter, and fall precipitation, Malheur Experiment Station, Oregon State University, Ontario, OR.

Species	Years tested	Years with no response or negative response to irrigation	Average maximum yield	Water applied plus spring, winter, and fall precipitation for maximum yield	Average spring, winter, fall precipitation	Water applied for maximum yield
			lb/acre	inches	inches	inches
Lomatium grayi	13	5	664	13.7	9.8	3.9
Dalea searlsiae	10	2	222	16.2	10.1	6.1
Dalea ornata	10	2	289	14.7	10.1	4.6