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Effect of Soil Moisture on Arrowleaf Balsamroot, **Balsamorhiza sagittata *(Pursh) Nutt. Establishment***

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Summary

Purpose:
- Understanding the effects of variables, like the availability of soil moisture on the germination and establishment of balsamroot, could provide insights into the successes of balsamroot's role in restoration plantings, or influence restoration planning.

Questions:
- When are soil moisture fluctuations most critical for balsamroot establishment?
- What does that mean for balsamroot in a restoration context? What about under changing climate conditions?

Approach:
- Use a greenhouse study to track growth and survival of balsamroot seedlings during their first season, across a range of soil moisture treatments.

Preliminary Results:
- Seedling emergence data suggests soil moisture is critical in the first few weeks of a seedling's life. Over the first treatment period, more plants emerged in high moisture treatments than low, and both were significantly different than the medium groups (P= 0.00462 and 2.09e-06. respectively). Further analysis is ongoing.

Study Organism

Arrowleaf Balsamroot, *Balsamhoriza sagittata*
Balsamroot's copious blooms, numerous leaves, long lifespan, and resilience once established, make it popular in restoration seed mixes, although balsamroot displays erratic germination in restoration sites (Gucker & Shaw 2018).

Figure 1. Growth Stages of Arrowleaf Balsamroot. (a) Seeds are dormant and require extended cold, wet conditions to germinate. (b) Balsamroot emerges in the spring and goes dormant during the hot, dry summer. (c) The first 3 years are devoted to growing a taproot (Monson et al. 2004). (d) In their first year, they rely on only 1-3 true leaves to build their root.

Methods

Pre-treatment

- Seeds from Thorn Creek Native Seed Farm pre-treated with 800mg/L gibberellic acid to reduce dormancy period (Bujak & Dougher 2017)
- Placed in 4˚C refrigerator for 65 days.

Planting

- 25 seeds were planted in each 5"x12" pot, with 12 pots being used in each treatment. Pots were calibrated to the upper target of their desired soil moisture range before planting (Dumroese et al. 2015), see Table 1.
- Pots were randomly assigned trays, and trays were shuffled weekly across 4 greenhouse benches. Plants thinned to 2/pot after 3 weeks.

Data Collection

Every other day
- Pot weights, supplemented with DI water to maintain % capacity range

Weekly
- Overall plant health assessed on a 1-5 scale, with 1=dead/senescent, 5=green and healthy (Fig 2a).
- Plant emergence tracked with color coded toothpicks and leaf development recorded (Fig 2b).

Every 3 weeks
- Leaf photos taken, and leaf area measured with Imagej software (Fig 2c)
- Pots recalibrated by bottom watering to new target capacity (Fig 2d).

At the end of 15 weeks
- Plants destructively harvested to measure root biomass (Fig 2e).
- Roots were washed free of potting media, dried at 40˚C, and weighed (Fig 2f, g).

Table 1. Experimental Layout. Color of treatment corresponds to timing of treatment application. Percent's indicate range of water holding capacity pots were watered to during treatment window.

	Weeks 1-3	Weeks 4-6	Weeks 7-9	Weeks 10-12	Weeks 13-15
Treatment 1	L (70%-60%)	M (80%-70%)----------			
Treatment 2	H (90%-80%)	M (80%-70%)----------			
Treatment 3	M (80%-70%)-----	L (70%-60%)	M (80%-70%)----------		
Treatment 4	M (80%-70%)-----	H (90%-80%)	M (80%-70%)----------		
Treatment 5	M (80%-70%)----------		L (70%-60%)	M (80%-70%)----------	
Treatment 6	M (80%-70%)----------		H (90%-80%)	M (80%-70%)----------	
Treatment 7	M (80%-70%)----------			L (70%-60%)	M (80%-70%)----
Treatment 8	M (80%-70%)----------			H (90%-80%)	M (80%-70%)----
Treatment 9	M (80%-70%)----------				L (70%-60%)
Treatment 10	M (80%-70%)----------				H (90%-80%)
Treatment 11	M (80%-70%)----------				

Figure 2. Data Collection. (a) Representative examples of each score on the qualitative plant health scale. (b) Colored toothpicks track the week each plant emerged. Development was designated as cotyledon only or true leaf. (c) Photos taken with phone mounted measuring device to maintain consistent distance and angle from camera. (d) Changing treatments at the end of 3 weeks. Pots were weighed and bottom watered to establish new capacity range. (e) Roots carefully separated with the help of several volunteers. (f) Care was taken to preserve fine lateral roots. (g) Excess media was washed away in soapy water and rinsed.

Results

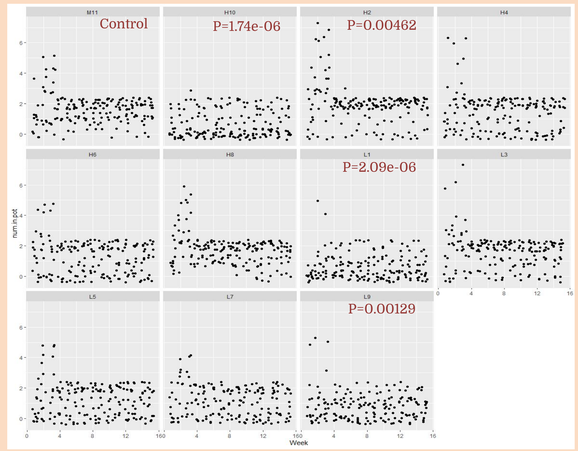

Figure 3. Plant emergence by week per treatment. Data plotted with ggplot, analyzed with a glm in R 3.6.2. Each dot represents a single pot in the treatment group.

- The first low-water treatment (L1) and first high-water treatment (H2) were significantly different than the control group (M11). This means that more plants emerged in the higher treatment, and less plants emerged in the lower water treatment, than the medium moisture conditions.
- Treatments L9 and H10 also showed significant differences than the control group, both having fewer plants emerge. This is an unexpected result, as both treatments were held in the same medium moisture range as the control group during the first few weeks of the study, when plants were emerging. More investigation is needed to understand this result.

Ongoing Analysis

Further data analysis will parse:

- Effects of higher or lower moisture on the timing of first leaf emergence, plant health, leaf area, and root biomass.
- Whether the first few weeks are the only time soil moisture fluctuations matter.
- Whether what happens in the first few weeks of a balsamroot's life sets the stage for how it grows throughout the season.
- I will make inferences regarding what this means for balsamroot in restoration projects or under changing climatic conditions.

References

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