Seed Sourcing for Restoration on the Colorado Plateau: *Cleome lutea* (Capparaceae)

CHICAGO BOTANIC GARDEN

Lisa Hintz[1]*, Maggie Eshleman[2], Andrea Kramer[3]

[1]The Evergreen State College, Olympia, WA, [2]Northwestern University, Evanston, IL, [3]Chicago Botanic Garden, Glencoe, IL

Introduction

In rangelands of the arid western United States, restoration efforts are often time-sensitive to prevent erosion and establish native flora, thus, sourcing appropriate plant seed is critical. Many reciprocal transplant and common garden studies have shown local adaptation to be strong for numerous species (reviewed by Leimu & Fischer, 2008). Applying locally adapted seed at appropriate sites may increase the success of restoration efforts.

The Colorado Plateau:

- Located in the southwestern United States
- Characterized by extreme elevation gradients, a semi-arid to arid climate and areas of high floral biodiversity (Coblentz & Riitters, 2004)
- Has experienced an increase in wildfire frequency in the recent past (Floyd et al., 2006)
- Comprised of much publically-owned land making large scale restoration feasible

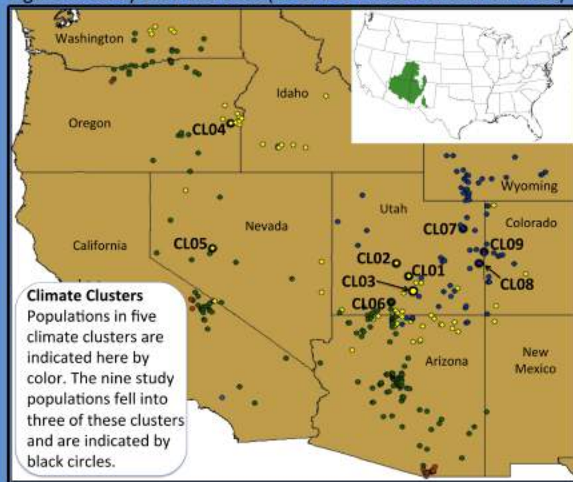
Silique dehiscing to release seeds

Study Question
Will *Cleome lutea* seed sourced from various climatically distinct populations have different morphological characteristics when grown in a common garden?

Here, we examine population variation in *Cleome lutea*, an annual, early seral species with potential to be grown commercially for use in restoration seed mixes.

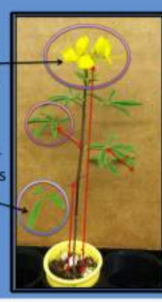
Methods

Figure 1. Study area and sites (Colorado Plateau shown on inset)



We grew seeds of *Cleome lutea* in a climate-controlled growth chamber at the Chicago Botanic Garden. Seeds were sourced from nine populations within three climate clusters (Figure 1) determined using Bioclim data (Worldclim, 2014) and location information from 503 herbarium specimens.

30 replicates each of
9 populations from
4 states and
3 climate clusters in
1 growth chamber for
4 weeks followed by
10 measurements



Results

We analyzed our data using linear mixed effects models to determine differences among populations (Table 1). Measurements of height to apical meristem and root diameter were transformed to meet assumptions of normality. We used generalized linear models to test pairs of 3- and 5-merous leaves (in green on Table 1). We ran post-hoc tests using Tukey's HSD. Flowering phenology data was analyzed with a Chi-squared test (in pink on Table 1). All analyses were performed in R (2013) computer software.

Table 1.

Measurement	DF	P-value
Height to apical meristem	12	P<0.0001
Height to first true leaf	11	P<0.0001
Length of center leaflet of first 5-merous leaf	8	P<0.0001
Width of center leaflet of first 5-merous leaf	8	P<0.0001
Length of petiole of first 5-merous leaf	8	P<0.0001
Aboveground biomass	11	P=0.0011
Diameter at top of tap root	12	P= 0.3672
Pairs of 5-merous leaves	8	P=0.0328
Pairs of 3-merous leaves	8	P=0.9993
Flowering (y/n)	8	P<0.0001

Figure 2.

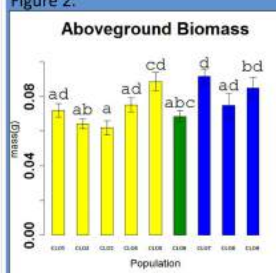


Figure 3.

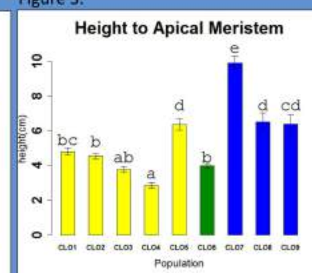


Figure 4.

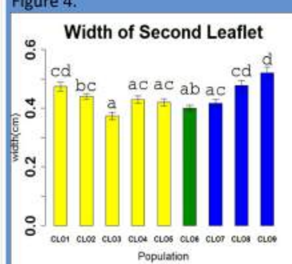
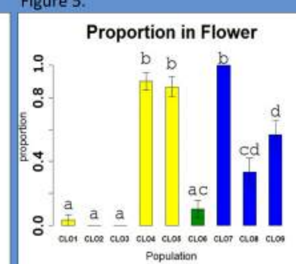


Figure 5.



Our results show significant differences among populations for eight of ten measures; however, these differences are not easily explained by climate cluster (Figures 2-5). While population differentiation is occurring across the study region, our results show differences are just as great within as between climate cluster.

Climate Cluster 1
Climate Cluster 2
Climate Cluster 3

Discussion

- Our results suggest genetic variation relative to site. While these differences may be driven by local adaptation, other factors not testable in this study such as maternal effects and genetic drift, may be impacting our results.
- Because among-population differences *are* present, the use of non-locally sourced seeds may influence the success of this species when used in restoration efforts.
- Additional research is needed to assess local adaptation of *Cleome lutea* in order to better inform appropriate seed sourcing decisions. Future studies should include reciprocal transplant experiments with particular attention to cold stratification requirements, population size, soil type, and hydrology of seed source populations.

Literature Cited:

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Floyd, M.L., Hanna, D., Romme W.H., & Crews, T.E. (2006). Predicting and mitigating weed invasions to restore natural post-fire succession in Mesa Verde National Park, Colorado, USA. *International Journal of Wildland Fire, 15,* 247-259.

Leimu, R. & Fisher, M. (2008). A Meta-Analysis of Local Adaptation in Plants. *PLoS ONE, 3*(12), 1-8.

Data Sources:

WorldClim Global Climate Data (2014). *Bioclim* (datafile). Retrieved from http://www.worldclim.org/bioclim

Acknowledgements:

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*hinlis24@evergreen.edu