Seed traits' influence on establishment and germination in prairie plants

Alyssa Wellman Houde[1] , Rebecca Barak[2,3], Evelyn Williams[2], Meghan Kramer[4], and Dan Larkin[2]

[1]University of Maryland Baltimore County, Baltimore, MD alyssa7@umbc.edu [2]Chicago Botanic Garden, Glencoe, IL [3]Northwestern University, Evanston, IL [4]Berea College, Berea, KY

Introduction

While the Midwest was once dominated by prairie, due to agriculture and urbanization, less than 1% of the area's native land cover remains[1]. Conservation efforts have preserved existing remnants and restoration practitioners have worked to reclaim disturbed areas, but more research on the most effective techniques is still needed[1]. Previous studies suggest that successful plant growth is strongly impacted by the individual's ability to the survive germination and emergence stages - most plant mortality occurring in these first two life stages – and that plant traits may be used to predict a plant's successful establishment at a given site [1][2][3]. However, little research has investigated the impact that seed traits have on percent germination and establishment in the field[2]. By surveying the biodiversity of restored prairies in the Chicago area and compiling seed traits in the lab, we will identify any traits that predict successful establishment. Secondarily, as seed source can have an impact on successfulness of a restoration we examined differences between commercially available and seed bank seeds.

Fig. 1: Orland grassland, one of the restored prairies that we surveyed

Traits Studied:

1. Embryo length to seed length ratio –a larger embryo may provide more nutrients to a young plant and assist in germination[4]
2. Embryo width to seed width ratio – previously unstudied, may provide more resources to seedling.
3. Seed Mass –a larger seed mass might correlate to a larger embryo and higher germination rate[2] .
4. Seed Shape – previously unstudied, could impact a seed's dormancy.

Hypotheses

We hypothesized that:

1) Seed traits can be used to predict a species':
   a. establishment in a restoration
   b. percent germination in a lab
2) There will be a difference between the traits measured in seed bank and commercially produced seeds.

Methods

We sampled biodiversity in 17 different restored prairies across the Chicago region via transect method to calculate percent establishment (determined by the presence of a species at a given site). After consulting the seeding lists at these sites, I marked 13 most commonly planted forb species for further research. The team, then, selected locally collected seeds from the Chicago Botanic Garden's Dixon National Tallgrass Prairie seed bank, and commercial versions were then ordered for comparison. We conducted a 3 week germination trial in which one group of seeds was selectively pretreated with gibberellic acid and a control group was left untreated. The initial germination date and total number germinated was recorded. We measured the masses of the seeds as well as the length, width, and height of the seeds under a dissecting scope. Seed shape was obtained by calculating the variance between these values- allowing seed shape to be represented as a single numerical value (0= spherical, .2= needle-shaped). The team also x-rayed seeds to determine the percent containing an embryo and the embryo to seed size ratios (obtained by dividing the embryo length by the seed length). We ran linear models in R to determine statistical significance and obtain R^2 values.

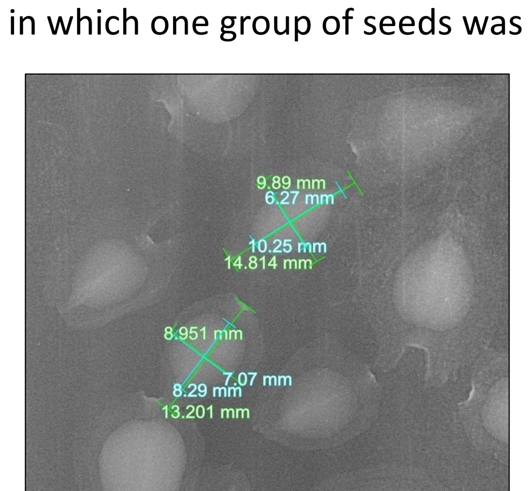

Fig. 2: Seed and embryo length and width taken from an x-ray.

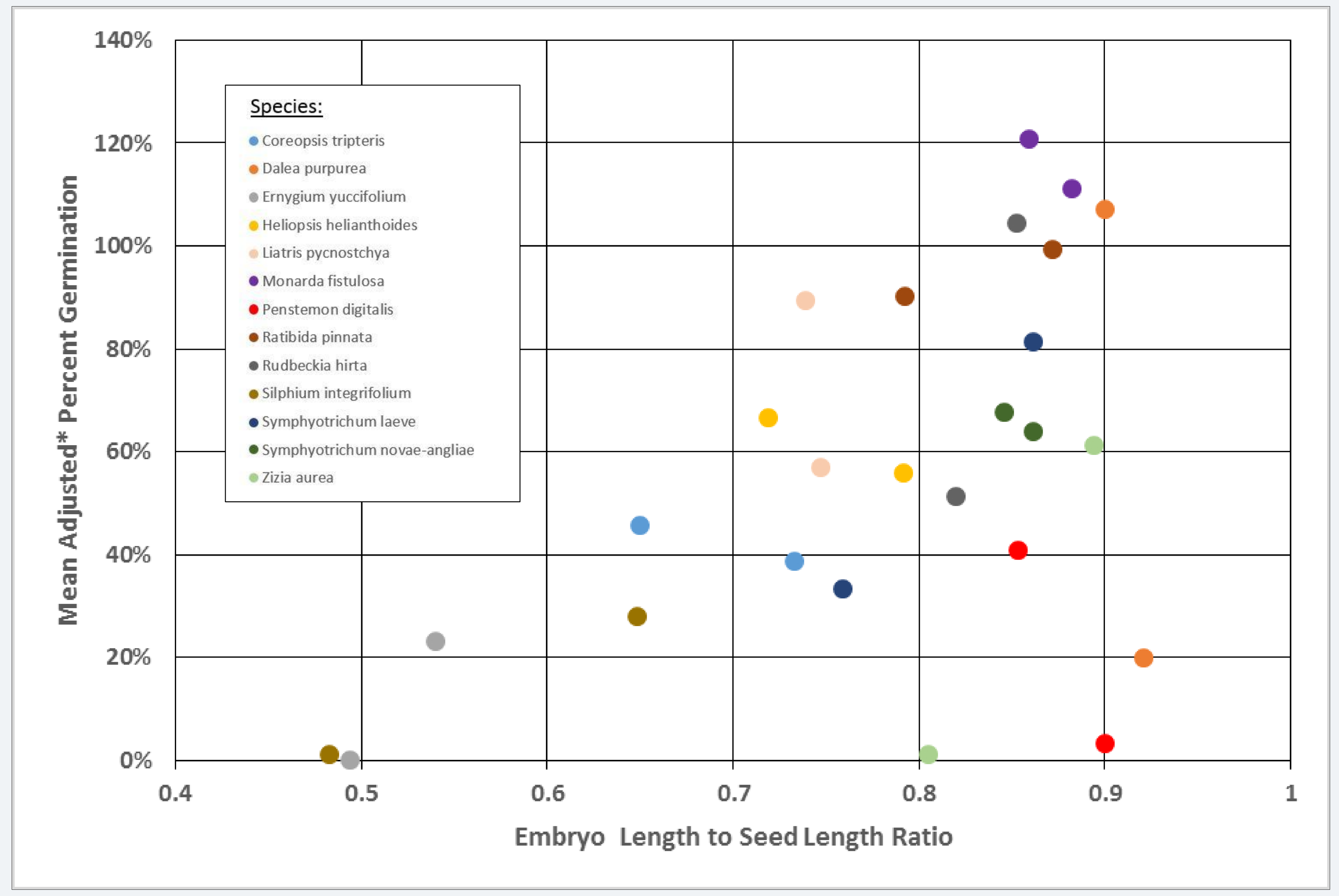

Fig. 3: Embryo length to seed length ratio against the mean adjusted* percent germination of all non- treated (control) seeds. A larger embryo and smaller seed coat correlates to a higher percent germination. **R^2= .204**

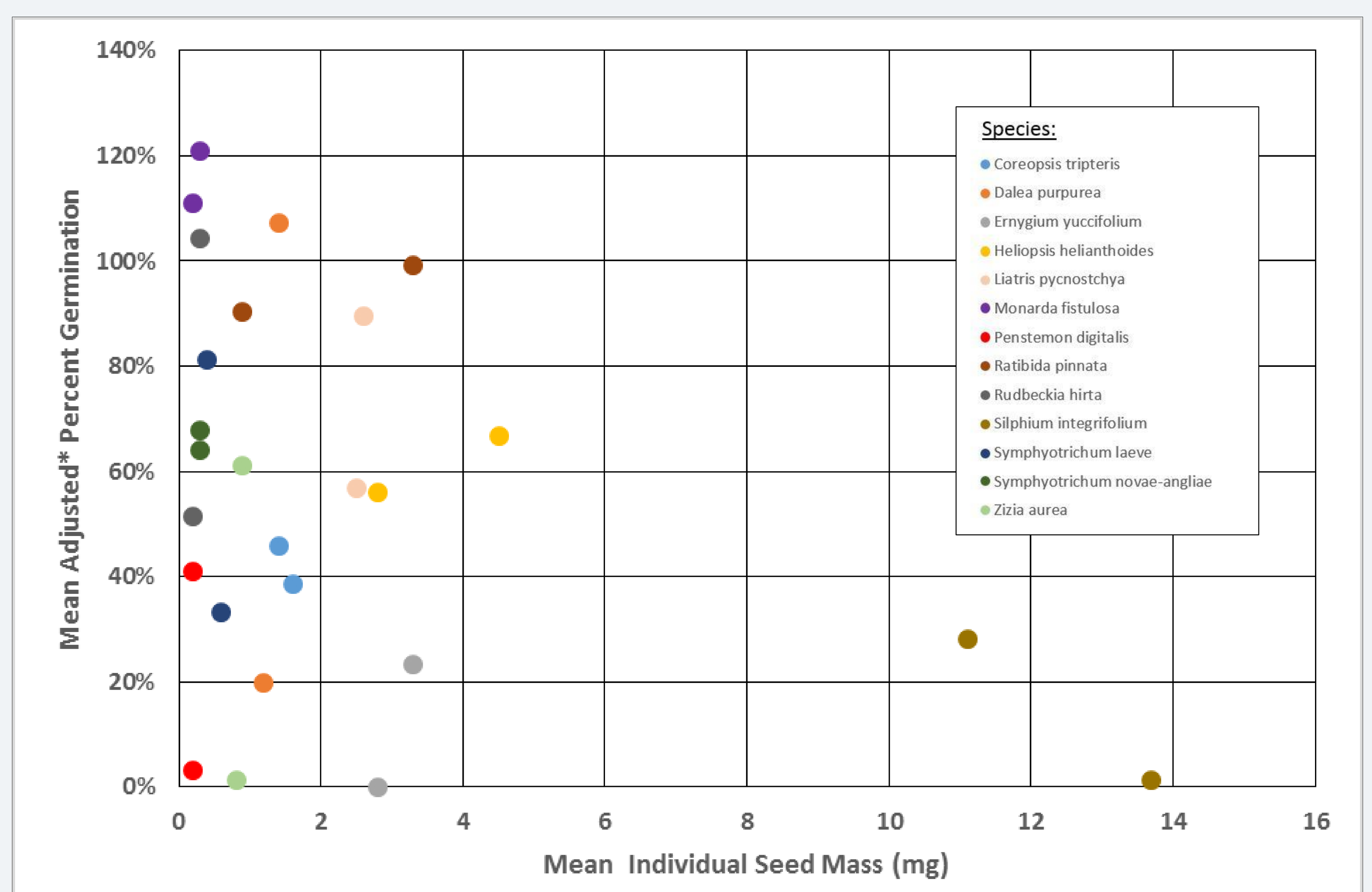

Fig. 4: Mean individual seed mass in mg against the mean adjusted* percent germination of all non-treated (control) seeds. A higher seed mass is weakly correlated with a lower percent germination. **R^2= .118**

Tested Variable 1	Tested Variable 2	p- value	R^2 value	F- value
Embryo Length to Seed Length Ratio	Percent Non-Treated (Control) Germination of All Seeds**	0.017	0.183	6.595
Embryo Length to Seed Length Ratio	Percent Non-Treated (Control) Germination of Commercial Seeds	0.032	0.295	6.031
Embryo Length to Seed Length Ratio	Adjusted Percent Non-Treated (Control) Germination* of All Seeds**	0.019	0.204	7.42
Embryo Length to Seed Length Ratio	Adjusted Percent Non-Treated (Control) Germination* of Commercial Seeds	0.010	0.423	9.789
Seed Mass	Adjusted Percent Non-Treated (Control) Germination* of All Seeds**	0.045	0.118	4.345

Note: Linear model was run on data, and the results can be seen above. For all tests, the data had 11 degrees of freedom.
*** Original germination data divided by percent of seeds containing an embryo to adjust for any unfaithful representation of germination potential**
****(Combination of Commerical and Seed Bank Seeds)**

Table 1: This table shows the statistically significant p, R^2, and F values.

Results

While most of the traits do not correlate with the germination rates or the percent establishment, the data suggests a positive relationship between embryo length to seed length ratio and control germination of all seeds and a negative relationship between seed mass and control germination of all seeds. There is also a difference between commercial and seed bank seeds- trends apparent when analyzing the data regardless of seed source and among the commercial seeds did not prove significant among only the seed banks seeds.

Discussion

- The apparent correlation embryo length to seed length ratio and the adjusted percent of germination, may indicate that a larger embryo increases levels of nutrients available to young plants and the likelihood of germination.
- The negative relationship found between seed mass and germination contradicts the above concept. However, species whose seeds had a larger mass also had a smaller length ratio (suggesting a large portion of their mass was seed coat).
- Supporting previous research[5], the data suggests that the importance of seed traits in determining percent germination is largely reduced when seeds are pre-treated with gibberellic acid.
- The germination and trait differences between the seed sources may be attributed to cleaning method (as suggested by the commercial supplier), and storage method and length[6].

Conclusion

When planning restorations, practitioners should consider the importance of seed traits (particularly embryo size) and pre-treatment with a dormancy breaking agent, such as gibberellic acid.

References and Acknowledgements

1. Rowe, H. I. Tricks of the Trade: Techniques and Opinions from 38 Experts in Tallgrass Prairie Restoration. *Restor. Ecol.* 18, 253–262 (2010). **2.** Clark, D. L. *et al.* Plant traits - a tool for restoration? *Appl. Veg. Sci.* 15, 449–458 (2012). **3.** Moles, a T. *et al.* Seedling survival and seed size: a synthesis of the literature. *J. Ecol.* 92, 372–383 (2004). **4.** Vandelook, F. *et al.* The role of seed traits in determining the phylogenetic structure of temperate plant communities. *Ann. Bot.* 110, 629–636 (2012). **5.** Madeiras, A. M *et al.* Germination of Phlox pilosa L. seeds is improved by gibberellic acid and light but not stratification, potassium nitrate, or surface disinfestation. *HortScience* 42, 1263–1267 (2007). **6.** Turner, S. R *et al.* Seed Treatment Optimizes Benefits of Seed Bank Storage for Restoration-Ready Seeds: The Feasibility of Prestorage Dormancy Alleviation for Mine-Site Revegetation. *Restor. Ecol.* 21, 186–192 (2013).

The authors would like to thank: G. Carr, T. Lichtenberger, R. Sherman, P. Yip, M. Jones, A. Hipp, D. Sollenberger, NSF #1461007, NSF Grant #1354426