

### Ecological Genetics of Floret Mass Variation in *Bromus tectorum* (Poaceae)

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#### Introduction

*Bromus tectorum* L. (cheatgrass, downy brome) is a highly invasive inbreeding annual grass that dominates millions of hectares of former shrubland in interior western North America. Factors contributing to its success include strong genetic regulation of key adaptive traits coupled with high phenotypic plasticity in response to resource availability (Meyer and Allen 1999a, b). Seed (floret) mass in this species has been shown to significantly impact biomass and reproductive output in the field, demonstrating its adaptive significance (Leger *et al.*, 2009). In this investigation, the role of genetic variation versus seed maturation environment in regulating seed mass was examined in greenhouse studies with multiple populations and inbreeding lines.

#### Methods

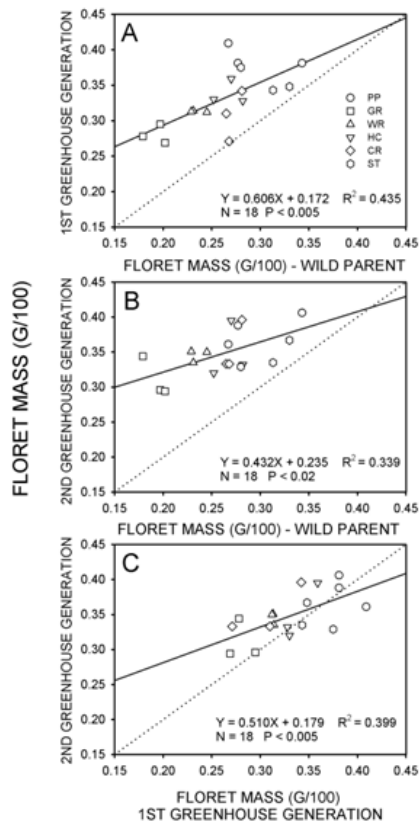
Seeds from individual plants were collected in the field from six *B. tectorum* populations representing a range of habitats. These seeds were weighed in four lots of 25 to obtain mean mass per 100 seeds. A subset of seeds from each plant was sown in container culture to produce a greenhouse-grown generation for further research. The progeny of this first greenhouse generation were then planted in a formal reaction norm experiment. Water stress during late seed maturation was manipulated at three levels to measure reaction norms for seed germination traits (Meyer and Allen 1999a, b), as well as seed mass. The mean seed mass for wild-collected seeds of each of the 18 inbreeding lines was compared with seed mass of two generations of greenhouse-grown seeds using linear regression. Seed mass reaction norms in response to maturation water stress were plotted for each inbreeding line.

#### Results and Conclusions

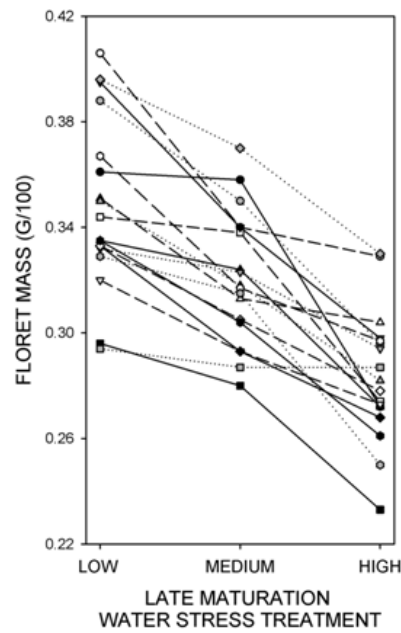
There was a significant positive correlation between seed mass of greenhouse-grown progeny and their wild parents, indicating high heritability (Figure 1). Seed mass showed a plastic increase overall in the optimum growing conditions of the greenhouse. Mean seed mass in the wild generation varied among lines from 0.179 to 0.343 g/100seeds, while in the first greenhouse generation, mean seed mass ranged from 0.271 to 0.409g/100 seeds. Lines with the smallest seeds showed the greatest seed mass increase in greenhouse cultivation (Figure 1A). This effect was even more pronounced in the second generation (Figure 1B). When plants of each line produced seeds under contrasting maturation water stress conditions, there was a general decrease in mass with increasing water stress. Mean seed mass at low, medium, and high water stress averaged 0.348, 0.319, and 0.281 g/100 seeds, respectively. Inbreeding lines varied considerably in the shape of the reaction norm response (Figure 2). For example, one Green River line, which had the lowest seed mass in the low stress treatment, showed no decrease with increasing water stress, while a Potosi Pass line, which had the highest seed mass under low stress, showed a dramatic linear decrease in mass with increasing water stress. These results indicate that inbreeding lines differ genetically in their plastic response to water stress as well as in mean seed mass. This combination of genetic control and phenotypic plasticity serves to ensure seed production under stress but also to maximize seed quality under optimal conditions.

#### References

- Leger EA, Espeland EK, Merrill KR, Meyer SE. (2009) Genetic variation and local adaptation at a cheatgrass (*Bromus tectorum*) invasion edge in western Nevada. *Molecular Ecology* 18:4366-4379.
- Meyer SE, Allen PS. (1999a) Ecological genetics of seed germination regulation in *Bromus tectorum* L. I. Phenotypic variance among and within populations. *Oecologia* 120:27-34.
- Meyer SE, Allen PS. (1999b) Ecological genetics of seed germination regulation in *Bromus tectorum* L. II. Reaction norms in response to a water stress gradient imposed during seed maturation. *Oecologia* 120: 35-43.



**Figure 1.** Changes in floret mass in greenhouse cultivation under optimal conditions for 18 inbreeding lines belonging to six populations of *B. tectorum*: (A) Change from wild-collected seeds to first-generation seeds produced in the greenhouse, (B) Change from wild-collected seeds to second-generation seeds produced in the greenhouse, and (C) Change from first-generation to second-generation-produced seeds in the greenhouse. Solid lines represent regression lines; dashed lines represent 1:1 relationship.



**Figure 2.** Floret mass reaction norms for 18 inbreeding lines belonging to six populations of *B. tectorum* in response to a gradient of water stress treatments applied during late seed maturation. Population symbols as in Figure 1: PP=Potosi Pass NV, GR=Green River UT, WR=Whiterocks UT, HC=Hobble Creek UT, CR=Castle Rock CO, ST=Strawberry Reservoir UT.