Variation in Phenology of Downy Brome

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Introduction

Downy brome (*Bromus tectorum* L.) is an invasive winter annual grass species, widespread throughout the small grain production region of the Pacific Northwest (PNW)[1]. Study objectives were to identify variation in phenology among downy brome accessions and relate phenology to genotypic and climatic variables.

Methods

- Ninety four downy brome and one ripgut brome (*Bromus diandrus* Roth.) accessions were collected in 2010 and 2011 from within small grain fields in the PNW.
- Accessions were transplanted as seedlings to a common garden located near Central Ferry, WA and at the Cook Agronomy Farm near Pullman, WA in November of 2012.
- In November of 2013 the study was repeated at the Central Ferry, WA location.
- An on-site weather station was used at both locations to calculate cumulative growing degree days (GDD), base=0°C, starting January 1st.

$$GDD = \sum \frac{Daily\ Max\ Temp + Daily\ Min\ Temp}{2}$$

- As soon as flowering was observed, panicles were collected from each replicate weekly until early July.
- Seed were removed from panicles and planted in a greenhouse three months after collection to determine if seed were mature at the time of collection.
- Germination was regressed against GDD at time of collection using a two-parameter log-logistic model to estimate the GDD required to produce mature seed.

$$f(x) = \frac{1}{1 + exp^{b[\log(x) - e)]}}$$

- A genotype-by-sequencing approach was used to call single nucleotide polymorphisms (SNPs) in each accession.
- Based on SNPs distribution, accessions were assigned to clusters of similar genotypes using discriminant analysis of principle components (DAPC).
- Based upon both previous GDD estimates for seed set by accession and DAPC results, GDD estimates were recalculated for each cluster (Figure 1).

Methods Flow Chart

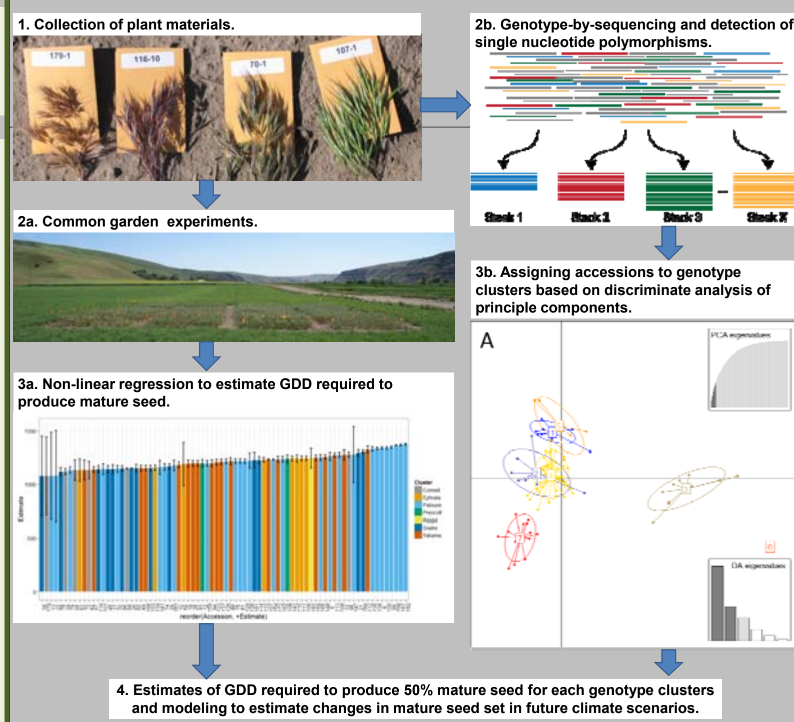

Figure 1. Flow chart diagraming the methods utilized to estimate GDD required for mature seed set and determine clusters of similar genotypes.

Results and Discussion

- GDD estimates were dissimilar by location, all locations were analyzed separately (Figure 2).
- Variation in GDD estimates was greatest at the 2013 Central Ferry location, which also experienced a more mild winter (Figure 3).
- Downy brome produced mature seed earlier, and there was less variation in GDD estimates at the Cook location (Figure 2).
- All replicates were winter killed by a December cold snap at the 2014 Central Ferry location.
- Subsequent trips in March observed plants emerging from seed that had not germinated in November.
- While both Central Ferry locations observed similar GDD accumulation, replicates at the 2014 Central Ferry location were exposed to less winter days as emerged seedlings (Figure 3).
- Individuals produced mature seed later at the 2014 Central Ferry location.
- Population clusters matured, relative to each other, in the same order at each study location
- Early to flower genotype clusters occur more often in the western portion of the small grain production region (Figure 4).
- GDD estimates for mature seed set are similar to what was reported by Ball et al. (2004)[2], however the variation in GDD required for mature seed set was observed to be greater.
- The second flush of seed germination observed in the spring at the 2014 Central Ferry location is similar to previously reported patterns of downy brome emergence[3] where both winter and spring emergence is common among siblings.
- GDD estimates from the 2014 Central Ferry location, compared to the other locations, may be indicative of fall vs spring emergence.
- The variation between locations and genotype clusters may be best explained by the degree of cold exposure and vernalization response[4].
- Downy brome becomes more tolerant to herbicides as physiological growth stage advances[5]. Early to mature genotype clusters may be more tolerant to herbicides at time of application.
- Knowledge of genotype cluster and GDD accumulation may be essential for integrated weed management.
- Modeling of mature seed set in future climate scenarios indicates there may be a narrower window of opportunity to effect control practices.

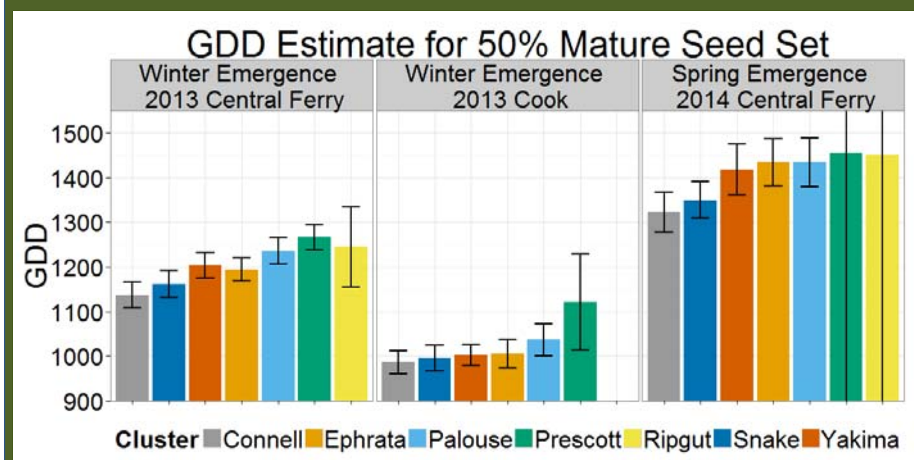

Figure 2. Estimates of GDD required to produce 50% mature seed for each genotype clusters. Missing bars indicate no surviving individuals for cluster and year.

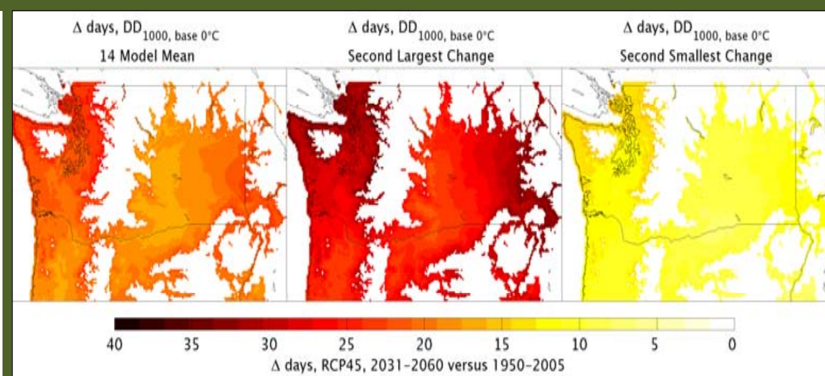

Figure 5. The calendar date when mature seed set occurred was calculated from downscaled climate data covering both a contemporary climate from 1950-2005 and a mid-21st century climate from 2031- 2060. Mid-21st century climate projections considered Global Climate Model simulations for representative concentration pathways 4.5 Wm^{-2} and 8.5 Wm^{-2}. Across all models, mature seed set is expected to occur earlier with changing climate which likely will require earlier control inputs.

Future Research

Research is ongoing to identify the genetic control of vernalization response and differences in maturation time.

Literature Cited

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