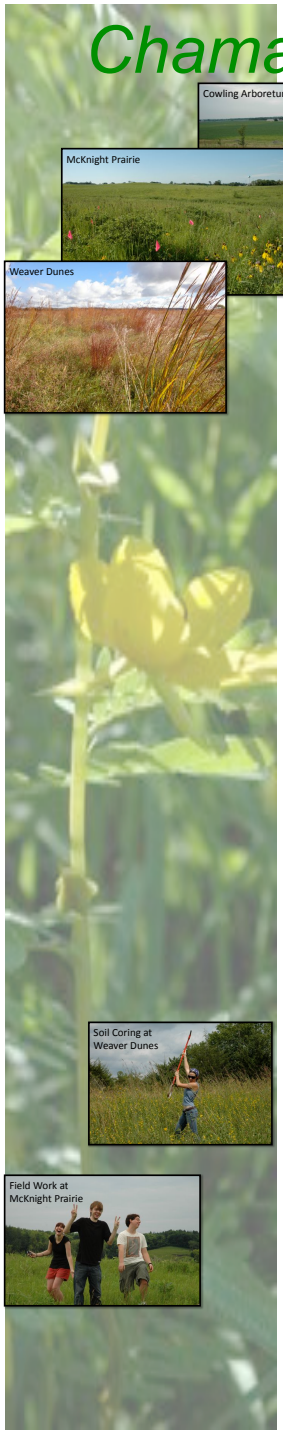
Chamaecrista Flowering: Environmental and Genetic Effects

Marika Xydes, Frazier Mork, Kyla Walter, Anna Snyder, Kristine Nachbor, Hunter Martin, John Breckenridge, Merrill Lutsky, Emma Singer, Anna Newman, and Susan R Singer.
Department of Biology, Carleton College, Northfield, MN US

Identifying environmental and genetic factors that effect flowering time in *Chamaecrista* in both controlled conditions and in prairies.



Introduction

Chamaecrista fasciculata (partridge pea) is an annual prairie legume native to regions from Central Mexico to central Minnesota.

- *Chamaecrista* thrives in sandy, disturbed areas; able to grow on marginal land and/or nitrogen depleted farmland, which makes it an ideal plant to use in mixed prairies grown for biofuels.
- Past *Chamaecrista* studies have been used in climate prediction models suggest how plants of different ecotypes may respond to increasing global temperatures.
- *Chamaecrista*'s phylogenetic position branching near the origin of the legume family makes it ideal for investigating the genetic regulation of shoot development and flowering time. Through a comparative approach, *Chamaecrista* homologs of genes in *Arabidopsis* and *Pisum* flowering time networks can be identified and analyzed. (Ehrenreich et al. 2009, Genetics183:325; Weller et al. 2009, J. Exp. Bot. 60:2493; Wenden et al. 2009, New Phytologist,184:153).

Chamaecrista is a Short Day Plant

In Growth Room Experiments

- *Chamaecrista* flowered earlier under short day conditions than under long day. (short day = 8hrs light. Long day = 12 hrs light.)
- Within each environmental condition, different ecotypes flowered earlier than others (first Minnesota, second Kansas, third Oklahoma). These findings support the previous work of Etterson, Shaw (2001) in field plots.
- Several key morphological differences were identified between short day (SD) vs. long day (LD) plants.

Figure One: Morphological differences between *Chamaecrista* grown in SD and LD conditions.

1. In SD plants the Node of First Open Flower (NFOF) and Node of First Floral Initiation (NFI) were the same. In LD plants they were different.
2. The total number of expanded leaves and total plant height at the time of flowering was much greater in LD plants than in SD.
3. In long day plants the inflorescence was almost always fused to the stem whereas in short day plants the inflorescence emerged straight from the leaf axillary. (Fused vs. Unfused)

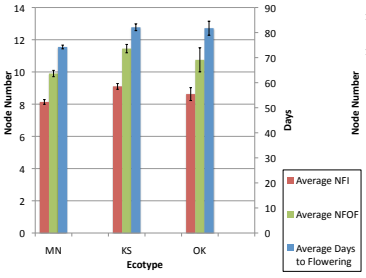


Figure 2. Effect of genotype on flowering under long days.

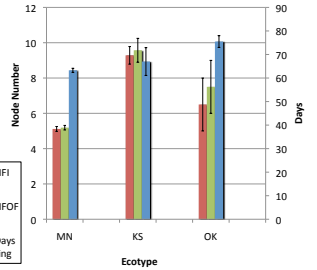
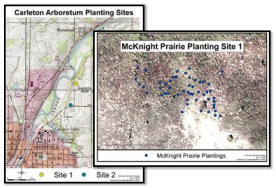


Figure 3. Effect of genotype on flowering under short days.

Flowering in the Prairies

The growth room experiments focused on how plants of different ecotypes (genetically different) were effected by the environment. In our wild plant study on *Chamaecrista* in the Cowling Arboretum, McKnight Prairie and Weaver Dunes, we focus on how genetically identical plants (all seed came from Weaver Dunes originally) behave in different natural environments to determine a) how controlled condition experiments compare to *Chamaecrista* in the wild, and b) to determine environmental factors that affect flowering time.



GPS coordinates overlaying topographical and satellite images of *Chamaecrista* sites.

Chamaecrista Growth in the Wild

- Twice a week, the number of leaves of 50 plants in the Arb and McKnight were counted (total of 156 plants in the study). After flowering the total plant height, NFI and NFOF were counted at all three sites.
- Soil core samples and biodiversity surveys were done to investigate if the specific soil composition of each site may influence the overall plant morphology and growth. (Soil maps provided by Max Timm and the GIS lab.)

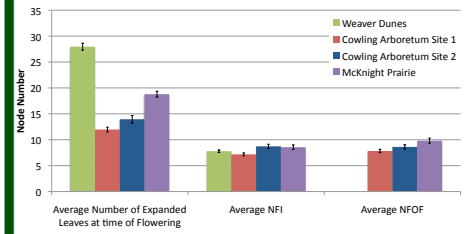


Figure 4. Site effects on flowering and biomass.

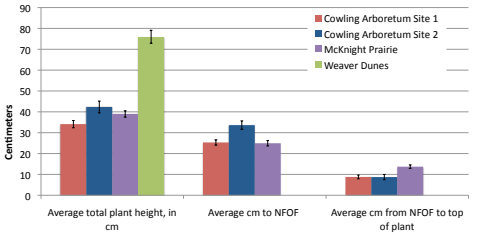


Figure 5. resource allocation in plants flowering at different sites. Growth above and below the NFOF is an indicator of resource allocation. The same patters were obtained with leaf number (data not shown).

Applying Growth Room Findings to Prairie Evidence

- Plants at Weaver Dunes had the largest number of expanded leaves and were the tallest.
- NFI and NFOF locations varied depending on prairie environment, NFI=NFOF not only limited to short day plants.
- The only phenotype exclusively limited to one environmental condition was flower fusion directly to the flower axillary in SD.
- Biomass distribution and internode length below and above NFOF varied between environments.
- Soil composition and micro-ecosystem biodiversity varied depending on environment.

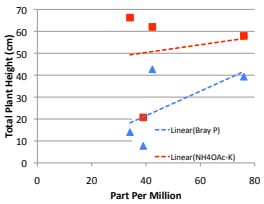


Figure 6. soil core composition averages for Phosphorus and Potassium at all sites. Plant height shown to increase with concentration of P or K. Similar pattern obtained with leaf number (data not shown).

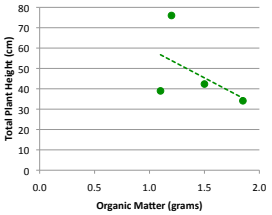


Figure 7. soil core composition averages for organic matter at all sites. Plant height shown to decrease with amount of Organic matter. Similar pattern obtained with leaf number (data not shown).

Conclusions

- *Chamaecrista* is a SD plant, which contrasts with LD *Arabidopsis* and *Pisum sativum* (garden pea) on which previous studies have been done. This expands opportunities for future genetic and plant studies using *Chamaecrista* as a SD plant model.
- Even within similar environments like Arb sites 1 and 2, micro-ecosystem and soil influences can effect plant morphology and flowering time.
- Plants in the wild did not demonstrate the same trait homogeneity for NFI, NFOF, and plant height as LD and SD growth room grown plants.
- Weaver Dunes is the putative genetic origin of McKnight and Arboretum plants. Thus those plants may be best adapted to Weaver Dunes, which may be a reason why *Chamaecrista* plants at Weaver Dunes were tallest and had the largest number of leaves.
- We established that within a genetically identical population of *Chamaecrista* photoperiod, soil composition, and temperature may effect flowering time and plant morphology.

Acknowledgements

I thank Randy Hagen, Carleton Greenhouse Manager, for excellent plant care and the 2009 and 2010 Carleton Genetics Lab students for their analysis of the expression patterns of *Chamaecrista* flowering genes under LD condition. Max Timm and the GIS lab for their work on the GPS plots and maps. Nancy Braker for her help in the Arboretum and on the biodiversity survey. The HHMI who supports the Summer Science Research Fellows. Supported by NSF 0746571 and 0837375.