Effects of a Climate-mediated Stress on Cereal Leaf Beetle and the Host Plant Wheat

Implications for an Insect-Plant Interaction under Drought

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REACCH Regional Approaches to Climate Change – Pacific Northwest Agriculture

Background

The cereal leaf beetle (CLB), *Oulema melanopus* L. (COL.: Chrysomelidae, Criocerinae) is an introduced, widespread pest of small grains causing economic losses to wheat, oats, and barley throughout North America. Native to Europe and Asia, CLB was first identified in Berrien Co., MI in 1962 [3]. Its has since established throughout large portions of the contiguous U.S, more recently including the Inland and Pacific Northwest (see Fig. 2) where it continues to be an agricultural pest.

Climate models indicate environmental suitability for CLB could increase by mid-21st century [3](Fig. 3), but they do not consider the indirect effects of climate-mediated stress on the beetle through the host plant, wheat (*Triticum aestivum* L.). We are testing the effects of water limitation for wheat on the performance of CLB and the growth of its host plant in a greenhouse setting.

Research Questions

1. Does water limitation for the host plant wheat alter CLB biology or performance?

2. Do host plant water limitation and CLB feeding activity combined have a relative increased negative effect on the growth of wheat?

Methods

Wheat plants (spring club var. 'JD,' Wash. State Univ.) were grown individually in pots containing approx. 111 g (oven-dried) hort. mix for 14 d (30 C daytime temp., 14: 10 photoperiod) with unlimited water supply, then withheld water entirely for 5 d.

- After 19 d, 10 and 40% mL H2O: g dry soil were assigned randomly to plants once every 48 h to simulate drought and replete water availabilities, respectively.
- **High H_2O, Low H_2O, High + CLB, and Low + CLB** treatments were randomly assigned to 60 plants (15 rep./trt. group) for a completely randomized factorial design (H_2O vol. used for "High" and "Low" were 44 and 11 mL, respectively).
- Plant main stem height, wet aboveground biomass, and predawn leaf water potential (each flag leaf/plant) were measured.

CLB adults collected May 2013 from Nine Mile Falls and Connell, WA supplied generation of experimental larvae.

- Neonate larvae hatched within 24 h were placed singly on exp. plants.
- Larvae were observed daily and allowed to feed freely though all instars, then pupate within the soil of potted plants.
- Total leaf area removed per plant by CLB larval feeding was measured using a transparency mm^2 grid overlay under dissecting microscope, and number of leaves fed upon (total/plant) were recorded.

Statistical Analyses Data were analyzed using SAS 9.3 (SAS Institute, Cary NC) GLM/T-Test Procedures; tests for significance ($\alpha = 0.05$) included two-way ANOVA and Student's t-test; comparisons of treatment group means were made using Tukey's HSD.

Context

This is a component of a larger project designed to anticipate and develop adaptation to effects of climate change on agriculture throughout the PNW region (REACCH PNA, http://www.reacchpna.org/)

USDA United States Department of Agriculture National Institute of Food and Agriculture

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Figure 1. Top: cereal leaf beetle adult; bottom left to right: CLB eggs, late-instar larva, and early-instar larvae showing feeding damage (N. Foote, B. Stokes, D. Roberts)

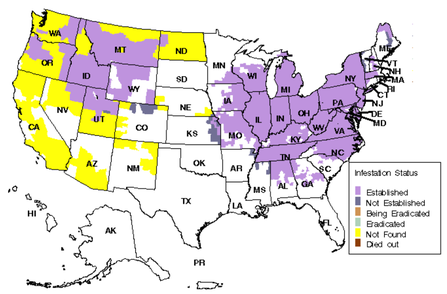

Figure 2. Approximate CLB distribution in the United States

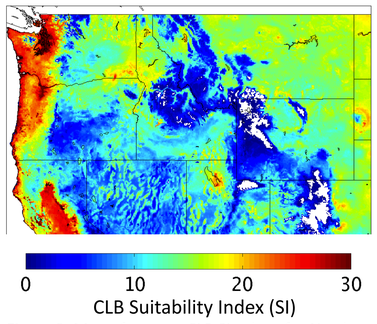

Figure 3. Map of current CLB SI values for Northwest region at an 8 km resolution (1979-2010)

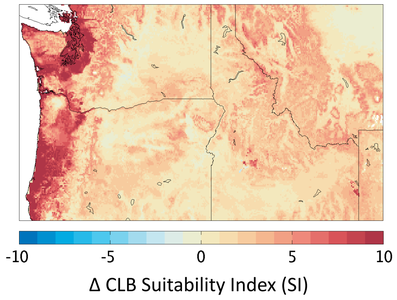

Figure 4. Map of the changes in CLB SI values for NW region under projected climate change (RCP 4.5) to mid-21st century

Results, wheat

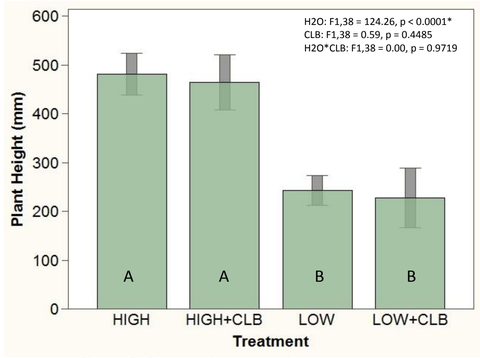

Figure 5. Plant main stem height (mm) by treatment (mean±SE; different letters indicate significant differences)

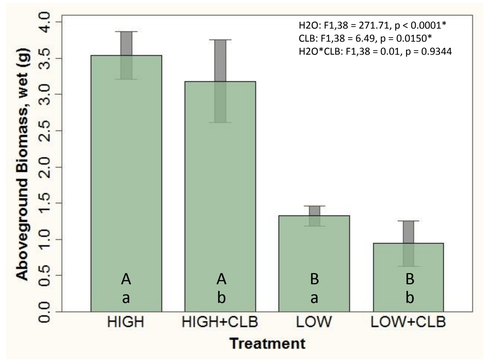

Figure 6. Plant wet aboveground biomass (g) by treatment (mean±SE; different letters indicate significant differences: upper case for main effects of H_2O, lower case for main effects of CLB)

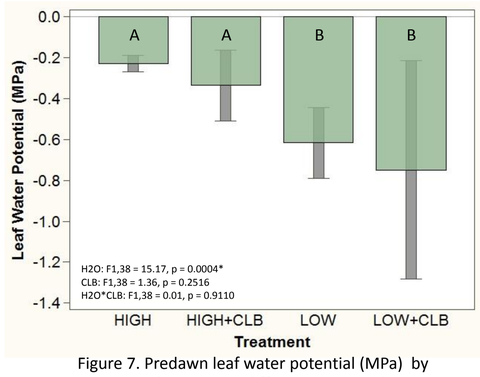

Figure 7. Predawn leaf water potential (MPa) by treatment (mean±SE; different letters indicate significant differences)

Forthcoming Research

- Modification of this experiment to include wheat fitness potential data (i.e., seed weight and viability) and other CLB performance measures (e.g., pupal weight and larval development time)
- A no-choice, whole-plant bioassay in the greenhouse to determine CLB larval feeding *rates* among wheat plants of varying water availability
- A rain-exclusion experiment to provide data on CLB performance and phenology in the field, as well as treatment effects on wheat yield

Results, CLB

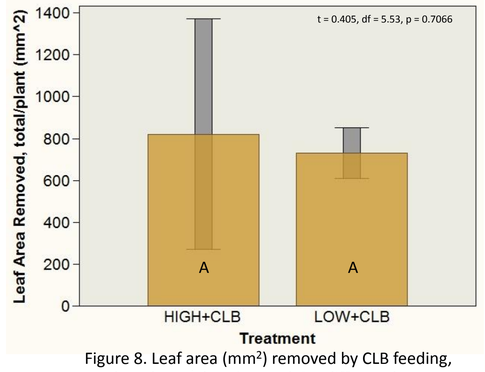

Figure 8. Leaf area (mm^2) removed by CLB feeding, total per larva/plant (mean±SE; different letters indicate significant differences)

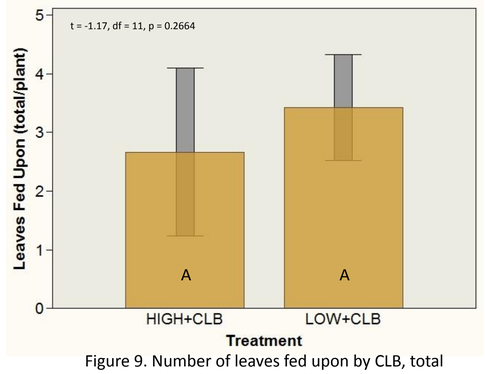

Figure 9. Number of leaves fed upon by CLB, total per larva/plant (mean±SE; different letters indicate significant differences)

Summary

1. All measured plant variables differed significantly by H_2O treatment (Figs. 5-7).
2. Measured CLB variables did not differ significantly by H_2O treatment (Figs. 8, 9).
3. Feeding by CLB larvae significantly lowered wheat wet aboveground biomass, but no other measured plant variables (Fig. 6).
4. Results showed no significant H_2OxCLB interaction effects.

Discussion

- Null results from measured CLB variables may be due to major sample losses from CLB-factor treatments (High+CLB: n=6, Low+CLB: n=7 from n=15), but would otherwise indicate a wide ranging suitability of host plant vigor (i.e., as affected by a 4x difference in water availability) for CLB larval feeding.
- Results show a significant CLB effect on wheat aboveground biomass independent of H_2O treatment at a density of just one CLB larva per plant. These data combined with future testing could potentially contribute to improved predictions of yield loss in wheat from observed CLB densities in the field.
- A trend appears from leaf water potential data (Fig. 7), and might suggest relative increased water loss in the host plant directly incurred from CLB feeding damage (see Fig. 1, bottom right). Under field drought conditions (i.e., with combined high temperature), this may create a situation whereby insect herbivory and environmental stress deliver a compounding negative impact on the host plant.

References

1. Haynes, D. L., and S. H. Gage. 1981. The cereal leaf beetle in North America. Annual Reviews of Entomology. 26: 259-287.
2. NAPIS. 2003. First reported occurrence of cereal leaf beetle, *Oulema melanopus*. National Agricultural Pest Information System, Cooperative Agriculture Pest Survey [online]. Available from http://www.ceris.purdue.edu/napis/pests/clb/imap/clbtime.html.
3. Olfert, O., R. Weiss, S. Woods, H. Philip, and L. Dosdall. 2004. The Canadian Entomologist 136: 277-287.