Genetic effects in response to extremes in precipitation in *Arabidopsis thaliana*

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Abstract

Climate change impacts the environment of the Midwestern United States, leading to an unpredictability in rainfall. The precipitation pattern now common to the Midwest region is extremely wet springs and dry summers. This irregularity of precipitation may cause issues with plant growth. In this experiment, we research the effect irregular watering has on the growth of 100 different *Arabidopsis thaliana* recombinant inbred lines (RIL). They were obtained from the *Arabidopsis* Biological Resource Center at the Ohio State University and were bred from a cross of L*er* (Landsberg *erecta*) x Col (Columbia). The phenotypes that we will measure include time to sprout, time to flower, time to seed, survival, stomata density, seed size, and leaf size. An analysis of variance will be used to calculate the variance and heritability of the phenotypes. We will also calculate genetic correlations among the traits and perform a quantitative trait locus analysis to look for areas of the genome that affect the traits. The data will help identify genes and gene regions with an effect on plant fitness in the Midwestern environment impacted by climate change.

Introduction

Some of the most harmful aspects of climate change include changes in precipitation and rising temperature [1]. Researchers studying climate change tend to focus their efforts on studying more drastically arid climates such as the West coast. Although often understudied, climate change produces a different yet also harmful effect on the Midwestern climate in the United States.

In the Midwest, climate change has increased the irregularity of precipitation. Due to the importance of adequate precipitation to seed germination and plant growth, irregular rainfall, alternating from periods of flooding to periods of drought severely limits agricultural life. The Midwest, known as “America’s breadbasket,” produces approximately 90% of the total corn grown in the United States [2]. The irregularity of rainfall has the potential to disrupt agriculture in the Midwest, impacting not only the economy, but also increasing food scarcity. Thus, an experiment is being conducted to study the effect irregular rainfall had on differing phenotypes of the plant species *Arabidopsis thaliana*.

Through the analysis of the heritability of these traits, genetic correlations will be identified and a quantitative trait locus analysis will be performed in order to look for specific areas of the genome that affect the traits [3]. The data will help identify genes and gene regions with an effect on plant fitness in the Midwestern environment impacted by climate change.

Methods

Several phenotypic traits of *Arabidopsis* will be analyzed to determine the plant’s fitness. The control plants will be watered as needed. The experimental plants will experience strenuous water change, with 100 mL of water to each plant during the first week, and a drought period for two weeks after flowering.

The recombinant inbred lines of *Arabidopsis thaliana* were obtained from the *Arabidopsis* Biological Resource Center at the Ohio State University and are a cross of L*er* (Landsberg *erecta*) x Col (Columbia). The seeds for each line were placed in the soil in individual pots (Figure 1). In order to allow for proper germination, temperature (25°C) and light conditions remained consistent between the two trials.

Figure 1: Experimental (left) and control (right) plant beds after 6 weeks of growth, including 1 week of drought conditions for the experimental beds.

After germination, phenotypes will be recorded. The phenotypes that will be measured include time sprout, flower, and seed; survival; stomata density; seed size; and leaf size. Stomatal density will be determined by collecting two leaf samples from each of the strains. An impression will be taken of the leaves which will be used to measure the density of the stomata. Impressions will be obtained by coating the leaf surface with clear nail-polish. The dried layer is carefully taken off, and it is attached to a microscopic slide.

For the genetic analysis, a two-way mixed model analysis of variance will be used to calculate the variance and broad-sense heritability (the ratio of genetic to phenotypic variance) for all traits. The fixed effect is the precipitation condition and the random effect is the recombinant inbred line (RI line). We will perform a quantitative trait locus (QTL) analysis and a genome-wide association study (GWAS) to identify regions of the genome and individual genes that affect the phenotypes, using publicly available genotypes for these RI lines.

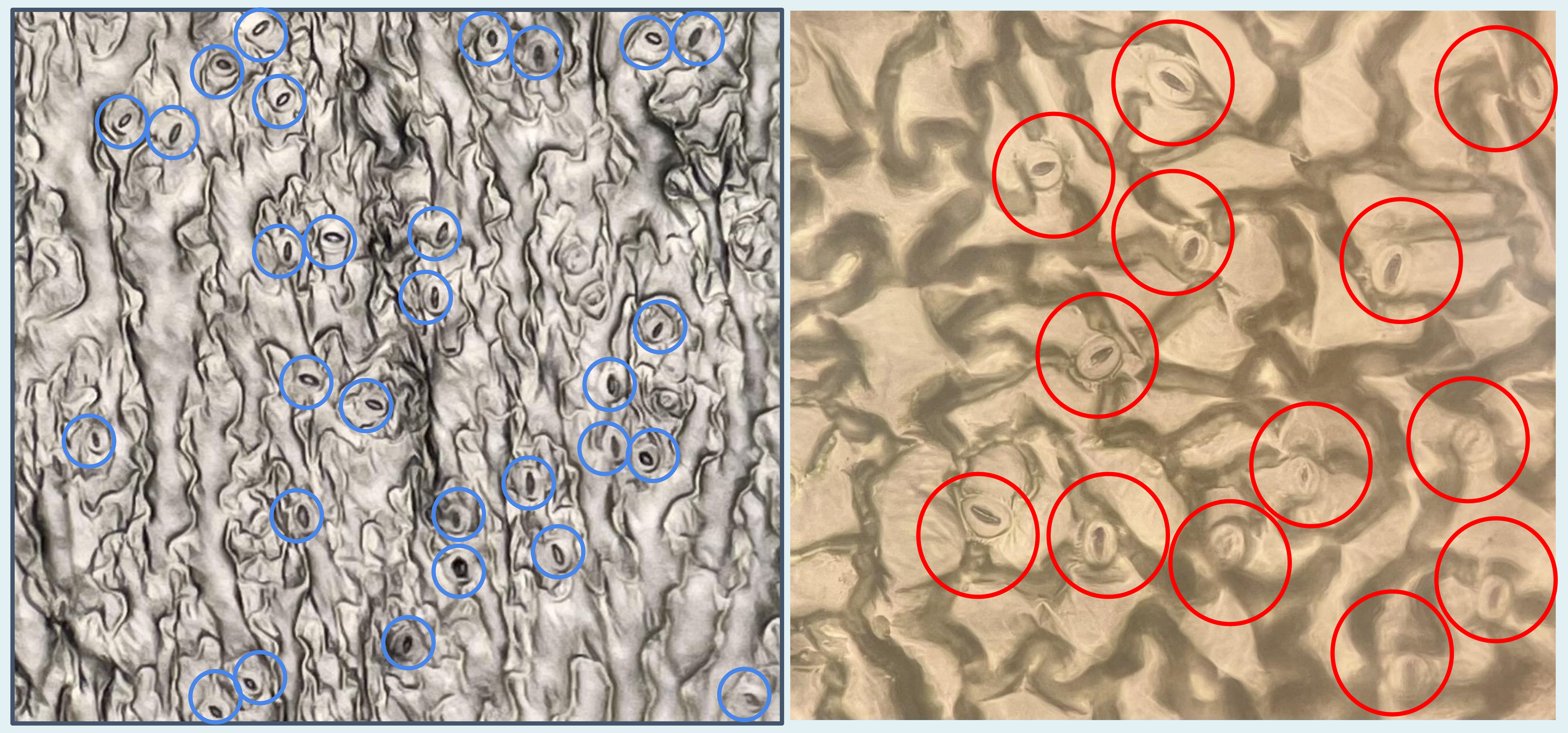

Figure 2: Control leaf impression with highlighted stomata under 40x magnification (blue circles, left) and 100x magnification (red circles, right)

Conclusions

Thus far, we have observed phenotypic differences between the RI lines of *Arabidopsis* and their ability to cope with drought conditions. It is apparent that some strains are coping with the lack of water better than others, and some are able to grow where others barely manage. One common theme among all of the drought plants is a late flowering pattern. In summary, many of these phenotypic observations have the potential to have genotypic explanations. Utilizing QTL analysis and GWAS, it will be determined if certain strains fair better than others under harsh conditions due to stronger genotypic traits. Identifying stronger genes is the key to understanding tolerance of extremes in precipitation.

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Citations

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