High-throughput Phenotyping of Soybean Iron Deficiency Chlorosis using Unmanned Aerial Vehicles

Austin Dobbels APS Thesis Proposal Seminar
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Introduction:

Many field tasks in a soybean breeding program are labor intensive, time consuming, and subjective to the human eye. These tasks include the phenotyping of thousands of plots for traits such as plant health, height, maturity, and lodging. In recent years, there has been a growing interest in the utilization of aerial high throughput phenotyping (HTP) platforms, especially for use in germplasm assessment within breeding programs. While many traits can be measured using these platforms, the main goal of this project is to use unmanned aerial vehicles to improve plant assessments of soybean iron deficiency chlorosis (IDC).

In the Midwest, soybean IDC contributes to yield losses that can add up to $260 million annually (Peiffer et al. 2012). It has been shown that stress due to IDC occurs throughout Minnesota, especially in northwest Minnesota in the Red River Valley. Soybean IDC symptoms include interveinal chlorosis and overall stunting of the plant. The chlorosis symptoms are due to the lack of iron in the leaves which is typically caused by high pH soils or soils with high calcium carbonate content. The iron is in the soil, however, it is unavailable because it is not in the soluble form needed by the growing plant. Soybean growers can overcome drastic yield penalties of IDC by growing tolerant soybean varieties, planting companion crops, reducing other forms of plant stress, and supplementing soil with iron chelates (Kaiser et al. 2011). The preferred method is growing a tolerant variety, which is why there is continued interest in the development of IDC tolerant varieties by soybean breeders. To accomplish this breeding objective, thousands of potential soybean varieties are screened each year for IDC severity. This screening has traditionally been accomplished using a 1-5 visual severity scoring system where a score of 1 is given to tolerant lines and a score of 5 is given to susceptible lines (Cianzio et al. 1979). Intra-rater variability due to the subjectivity of the human eye can result in less accurate phenotypic measurements, and thus, researchers are investigating alternative image-based methods for quantifying IDC severity (Naik et al. 2017). New automated rating systems hold potential to be more objective and reliable for phenotyping IDC stress.

Research Objectives:

The first goal of my research is to develop an image-based high-throughput phenotyping system using UAVs to accurately quantify IDC stress (Objective 1). This phenotyping method will be used to answer questions related to the genetics, agronomy, plant physiology, and soil science of IDC, as well as be integrated into screening procedures for variety development. The main project objectives for my Ph.D. research are as follows:

1. *Increase the throughput and accuracy of soybean IDC phenotyping using aerial imagery*
2. *Assess variation in a recombinant inbred line population (Anoka x Anoka Tolerant) using the high throughput phenotyping system*
3. *Investigate remote sensing as a tool to differentiate soybean iron deficiency chlorosis and soybean cyst nematode stress*
4. *Find time-scale differences in near isogenic lines (NILs) varying in IDC tolerance using time-lapse cameras*

Preliminary Results:

In the summer of 2016, plots were planted near Danvers, MN at the University of Minnesota soybean breeding IDC nursery. Nearly 3,500 plots were visually scored at two time points during the growing season. In addition, a DJI Phantom UAV was flown over the field to test if a basic digital camera could be used to predict IDC severity. Imaging analysis software was used to extract the canopy area of each plot as well as the mean red, green, and blue values from the plant leaves. In total, 69% of the variation in visual IDC score was explained by the UAV image data. It was also found that the severity explained by the UAV-based imagery explained as much of the variation as other ground based systems such as NDVI data collected from a crop circle. Work is in progress to improve our phenotyping efforts.

References:

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