**Objectives:**

* **Goal 1**: replicating the phenotyping effort of daytime canopy conductance that was undertaken in the previous years on 2 mapping populations sharing the hub parent IA3023
* **Goal 2**: conducting joint QTL mapping of loci controlling daytime canopy conductance on all mapping populations simultaneously to identify stable, robust QTL
* **Goal 3:**phenotyping nighttime canopy conductance in the two mapping populations
* **Goal 4:**conducting QTL mapping on the 2 populations to identify the genetic basis of nighttime canopy conductance

**Achievements:**

1. Goal 1 was achieved. We have successfully replicated the phenotyping of both mapping populations, representing F5-derived 140 recombinant inbred (RIL) lines (plus their 2 parents) descending from the hub parent IA3023 and LG03-3191 (NAM25) and IA3023 and LG94-1906 (NAM34). This effort consisted of conducting 7-hr long measurements on more than 900 plants, each of which was phenotyped at an unprecedented temporal resolution using the GraPh platform (Tamang and Sadok 2018; Tamang et al. 2019).
2. Goal 2. We have undertaken multiple rounds of data analyses to test the stability and robustness of the detected QTL for daytime canopy conductance. While we are currently finalizing data analysis, a key outcome is the confirmation over multiple years of data from both populations that QTL controlling canopy conductance in soybean were detected. **This is, to the best of our knowledge, the first time such canopy conductance QTL are identified in any crop or plant species. Alleles of the QTL that maximize canopy conductance present a unique resource for the U of M breeding program to enhance the yield potential of MN-adapted soybean cultivars.**
3. Goals 3 and 4. Using the GraPh platform, we successfully phenotyped nighttime canopy conductance for the two mapping populations on a total of over 900 plants. This new objective, which was not initially part of the previous 2 years, was established as a result of the discovery of non-negligible nighttime transpiration in soybean. **The genetic analysis confirmed for the first time the existence of QTL controlling nighttime canopy conductance. Alleles of the QTL that minimize nighttime canopy conductance could further enhance the benefits of maximizing daytime canopy conductance and therefore present an additional valuable resource for the U of M breeding program to release the next generation of soybean cultivars with enhanced yield potential.**
4. Additional new discovery: new QTL controlling whole-plant leaf area in soybean. Because we need to normalize transpiration rate with total leaf area to calculate canopy conductance, we have developed a protocol for high-throughput phenotyping of whole-plant leaf area. In doing so, we have discovered and confirmed a previously undetected QTL controlling whole-plant leaf area in soybean. This QTL will be useful in our genetic analysis to distinguish between the effects on water use resulting from variation in canopy conductance and those resulting from differences in leaf area. **This data will enable us to make sure that QTL underlying canopy conductance which will be pyramided in the breeding program are independent from those related to leaf area.**

Overall, the project delivered on all of the initial goals and generated novel findings and genetic markers that are promising. After finalizing the data analysis, these markers will be transferred to the U of M soybean breeding program and will be leveraged to released cultivars that maximize the ability of the plants to capture CO2, water and nutrient, while minimizing seemingly wasteful nighttime water loss. 

**Challenges:**

1. The COVID-19 pandemic has slowed down the later rounds of data analysis.
2. Unfavorable growth conditions in the greenhouse issues resulted in the need for replicating an entire phenotyping experiment, which was successfully conducted.