**Achievements:**

* Objective 1 was achieved. We have successfully grown 426 plants and used the GraPh precision phenotyping platform (Figure 1) to characterize canopy conductance response curves and whole-plant leaf areas. These plants represent a population of F5-derived 140 recombinant inbred (RIL) lines (plus their 2 parents) descending from the hub parent IA3023 and LG03-3191 (NAM25). This population was phenotyped for the first time for the above traits.
* Objective 2 was achieved. We have applied the same above procedure to successfully phenotype canopy conductance of a population of F5-derived 140 RIL resulting from a cross between the common parent IA3023 and LG94-1906 (NAM34). The total number of plants phenotyped in this experiment consisted of a total of >420 individuals. In comparison to the first year, we have successfully *doubled*the phenotyping throughput of our experiment.
* Objective 3. Multiple rounds of data analyses were conducted over the last quarter in order to test the stability and robustness of the detected QTL for daytime canopy conductance. An encouraging outcome was that combining the data of the 2 first years- we have detected 6 QTL controlling canopy conductance in soybean. While those QTL need to be confirmed in the third year, **this is the first time such canopy conductance QTL are identified in any crop or plant species. Moreover, this finding offers an unprecedented opportunity to maximize yields under MN conditions and potentially, gives MN growers a competitive advantage over other states in accessing a new generation of high-yielding soybean cultivars developed through physiological breeding.**
* New discoveries: our research led to two new discoveries that warranted initially unplanned research that was needed to maximize the chances of success of our initial objectives.
  + Objective 4a: discovery of QTL controlling leaf area. Because we need to normalize transpiration rate response to evaporative demand 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 that leaf area was also controlled by QTL in soybean. To the best of our knowledge, this is the first time that QTL controlling whole-plant leaf area are identified 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.**
  + Objective 5b: discovery that canopy conductance was non-zero during the nighttime. Owing to our newly developed GraPh platform for precision phenotyping, an unexpected, yet important finding of our research conducted during this year was the discovery that canopy conductance was not null during the night for many soybean genotypes. This surprising result has potentially major implications in terms of improving yield potential of Minnesota-grown soybean. Indeed, because there is no opportunity for photosynthesis and therefore CO2 gains during the night, nighttime stomata opening might be detrimental, by reducing water use efficiency. Furthermore, there is evidence to indicate that high nocturnal canopy conductance might be associated with carbon loss through respiration, a process that would consume carbon that would otherwise benefit seed-fill. Considering the significance of these observations, we undertook an experiment where we phenotyped nocturnal conductance on the NAM34 family. **Using this population, we have detected for the first time in QTL controlling nocturnal canopy conductance in soybean. This is a major finding as it indicates the possibility to breed against high canopy conductance during the night to further increase yield potential enabled by high daytime canopy conductance.**As a result of this unexpected but potentially major finding, we added another goal to next year’s phase of the project, consisting in initiating an ad hoc phenotyping effort to confirm those loci.
* Overall, the project delivered on all of the initial goals and generated results and novel findings that are highly promising and further support the relevance of the followed approach to capture QTL that optimize canopy conductance in soybean.

**Challenges:**

1. A significant challenge in our experiments are pathogen attacks (mainly Thrips) in the greenhouse. This led to discarding an entire experiment carried out for objective 1 and replicating that experiment a second time within the same year, which added a significant workload. The data analysis that was recently conducted indicates that while the phenotyping effort was successful on that population (NAM25) we need to replicate the entire experiment for next year.
2. The fortunate discovery of nocturnal canopy conductance as a new, useful trait for the growers has resulted in an increased workload in terms of data analysis and experimentation.

**Tech Transfer:**

* Data from the GraPh precision phenotyping system developed for this project was presented at the Minnesota Ag Expo of 2017 and at a the Gordon Research Conference on Plant Vascular Traits, a highly prominent international meeting held only every 2 years with an attendance of leaders in the field (115 people).