KANSAS SOYBEAN COMMISSION FINAL REPORT OF PROGRESS

Title: "Develop valuable soybean varieties and germplasm for use as genetic resources for companies and for direct on-farm production"

Accomplishments for FY2021 (March 1, 2020 – February 28, 2021)

Variety Development

Population development

- About 60 new populations were created in 2020 using over 25 different parents.
- Nine of the single cross populations involved **drought resistant** parents.
- About 2/3s of the single cross populations involved parents tolerant to **STS** herbicides.
- About 2/3s of the single cross populations involved at least one parent resistant to **soybean nematodes**.
- Seventeen single cross populations involved at least one parent that possessed genes from a plant introduction that has not contributed to the genetic improvement of US northern soybean varieties to increase the **genetic diversity** of US germplasm to increase, or at least, maintain genetic gain.
- Eleven populations involved incorporating **glyphosate tolerance** into a new GT line.
- Twenty-one populations involved parents with above average **seed protein**.
- Five populations were developed to incorporate the n**on-nodulating** trait into adapted germplasm to better characterize the importance of nitrogen fixation and nitrogen fertility in modern soybean varieties.
- Ten populations were created to incorporate **high oleic and low linolenic acid** traits into elite germplasm.

Yield trials

- We completed evaluations of over 9000 **genotypes** in over 12,000 plots in Kansas
- Over 1200 K-lines were evaluated in our preliminary trials.
- Over 200 K-lines were evaluated in our KS advanced yield trials.
- Over 400 (including 29 K-lines) breeding lines from programs across the country were evaluated in our KS Uniform Tests and Uniform Preliminary yield trials.
- Over 900 genotypes, (experimental breeding lines and **plant introductions**) were evaluated in our drought, remote sensing, and diversity yield trials.

SCN Screening Populations

Primary soybean cyst nematode (SCN) screening populations included HG Types 7, 2.7, and 1.2.3.5.6.7. Female indices (FI) on the HG Type 1.2.3.5.6.7 population were >10% on all indicator lines except PI 437654 (line 4), while female indices on the HG Type 7 population were <10% on all indicator lines except PI 548316 (line 7). The third screening population, HG Type 2.5.7, is characterized by female indices >10% on PI88788 (line 2), PI209332 (line 5) and

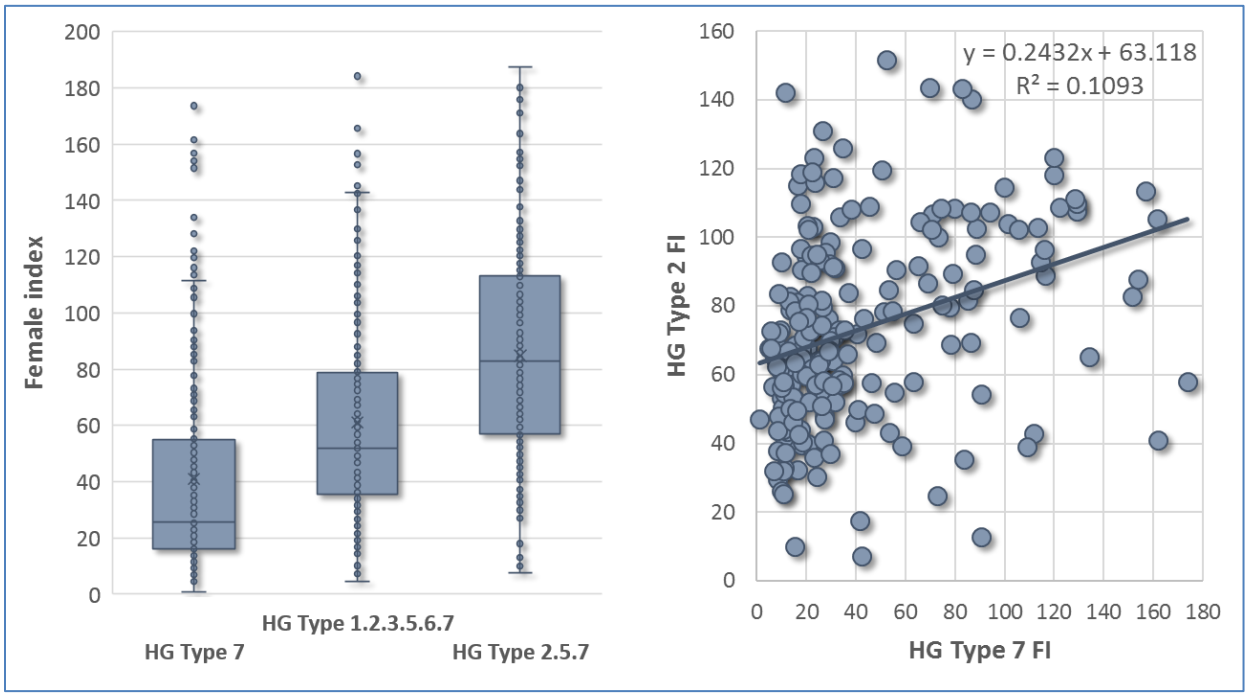
PI 548316 (line 7). Variation in female indices on PI 88788 (line 2) is of particular importance, since this line is the most common source of deployed SCN resistance.

Additional HG Type 2.5.7 populations, representing the dominant HG Type in Kansas and surrounding states, were collected from across the state and increased in the greenhouse for use in screening trials.

SCN Resistance Screening

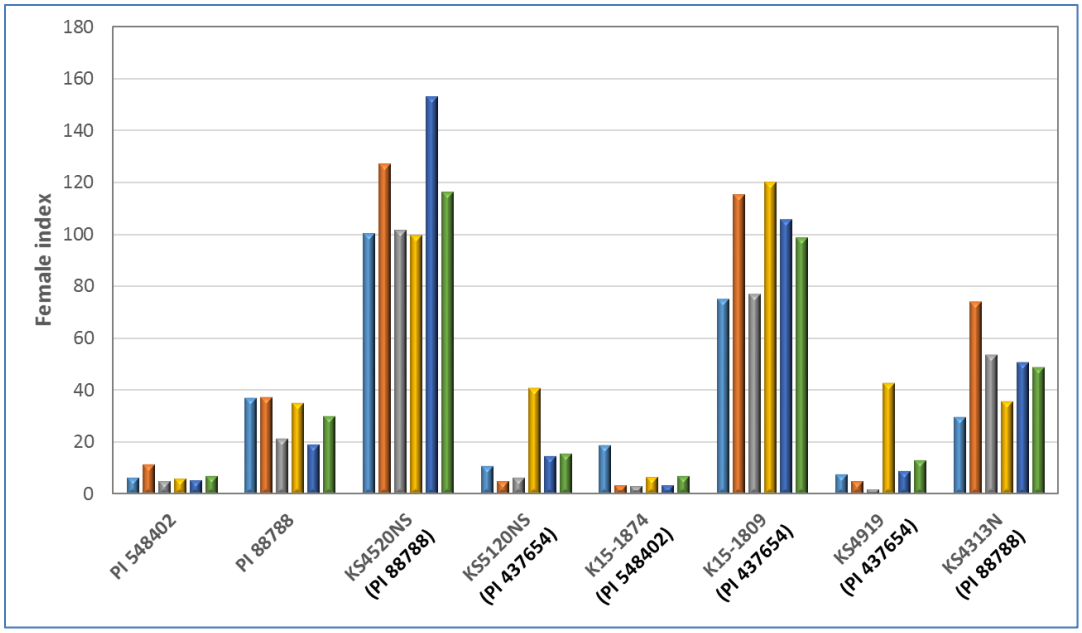
Breeding lines: Soybean resistance to HG Type 7 was evaluated in replicated screening trials for ~220 advanced breeding lines. Approximately 60% of breeding lines displayed moderate or better levels of resistance (FI ≤ 30) to the HG Type 7 population, while only ~3% of breeding lines displayed moderate or better levels of resistance (FI ≤ 30) to HG Type 2 populations (Figure 1 left panel). Female indices for the HG Type 7 population were not a good predictor of FI for HG Type 2 populations (Figure 1 right panel).

Figure 1.



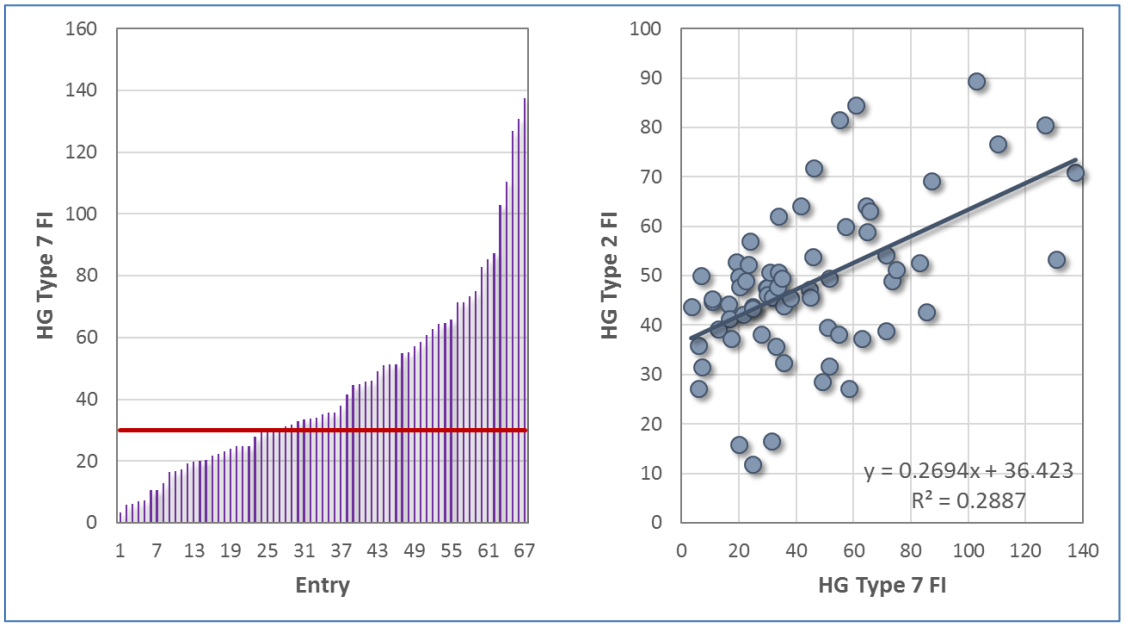
Recent KAES soybean germplasm releases were screened against six HG Type 2.5.7 populations. Two releases with SCN resistance derived from PI 437654 and one release with SCN resistance derived from PI 548402 (Peking) were resistant to moderately resistant to all HG Type 2.5.7 populations (Figure 2). These lines represent critical additions to the available SCN resistant germplasm pool because of increasing prevalence of HG Type 2 populations due to selection on PI 88788-derived varieties.

Figure 2.



Kansas Soybean Performance Test: Soybean resistance to SCN was evaluated in replicated screening trials for 67 entries in the Kansas Soybean Variety Performance Test (KSVPT). Evaluations involved SCN populations that varied in their virulence to the common resistance source PI 88788. Only ~40% of KSVPT entries could be classified as resistant to moderately resistant to the HG Type 7 population, while only 9% (six entries) could be classified as resistant to moderately resistant to the HG Type 2 populations (Figure 3). Female indices for the HG Type 7 population were reasonably predictive of FI for the HG Type 2 populations, confirming that most KSVPT entries shared a common source of resistance (PI 88788).

Figure 3.



Related Projects

The SCN Coalition free soil-testing program for Kansas soybean producers was continued in 2020. Of the approximately 200 samples received, 30% were positive for SCN, with an average egg density of 1,019 eggs per 100 cm^3 soil.

Breeding Technologies

- **Genetic gain.** In 2020, we used genomic predictions for yield, genetic variation, and seed composition to select, intermate and rapidly cycle F1 plants to achieve three cycles of selection in one calendar year. Progeny from the initial base population and the rapid cycling generations are now being developed for evaluation in replicated field trials to characterize the effectiveness of the genomic selection and rapid cycling methodology. We also used the same genomic prediction model to create populations from elite public breeding lines that are predicted to produce superior progeny and have a negligible negative correlation between seed yield and seed protein content. The progeny of these crosses will be compared with progeny produced from our standard selection process in the future.

- **High-throughput phenotyping to increase genetic gain and improve evaluations in stress environments.** We continue to develop models utilizing canopy reflectance and canopy thermal properties to estimate relative soybean maturity, seed yield, drought stress, and disease resistance. Entries in our 2017, 2018 and 2019 progeny rows selected based on remote sensing criteria where slightly higher yielding than random selections in our 2018, 2019 and 2020 preliminary yield trials. This information is being summaried and will be submitted for publication.

  While drought conditions were limited in Kansas in 2020, we did experience some moisture stress (Figures 4 and 5) and were able to take visual ratings for wilting along with seed yield, and also use an small unmanned aircraft to collect spectral reflectance data on the plots under evaluation. The outcomes of the 2020 evaluations of lines under drought stress included:
  - Drought episodes experience in August and September.
  - Breeding and commercial entries evaluated for wilting at six locations (Salina, Manhattan, Riley, Ottawa, Pittsburg and McCune). One to three wilting ratings captured per location.
  - Over 1500 KS lines tested in multiple environments with several environments experiencing short-term to intermediate periods of drought stress.
  - Over 100 commercial entries evaluated for drought response from one to three environments including punitive drought tolerant lines provided by Corteva and Bayer. Performance of several commercial lines, and some K-lines was excellent in these environments (Figures 6 and 7).

Figure 4.

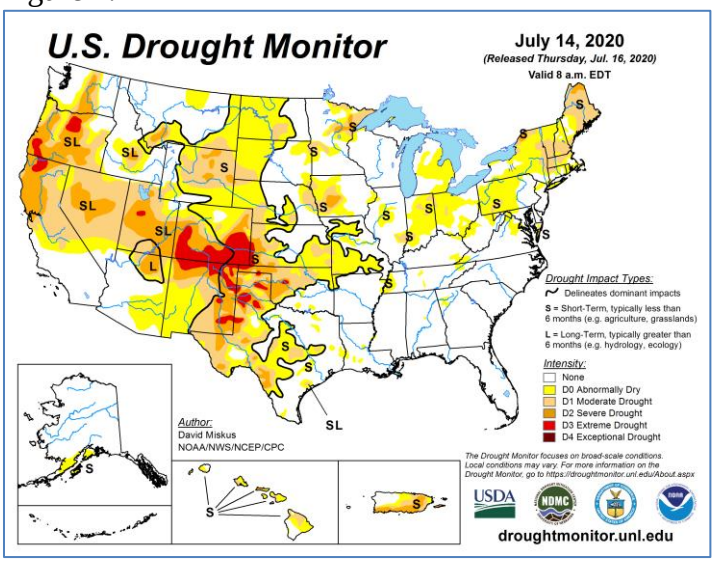


Figure 5.

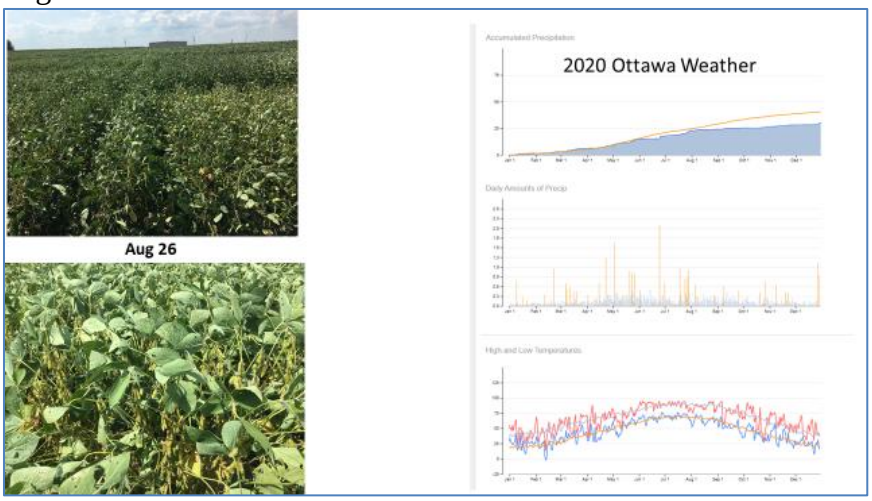


Figure 6.

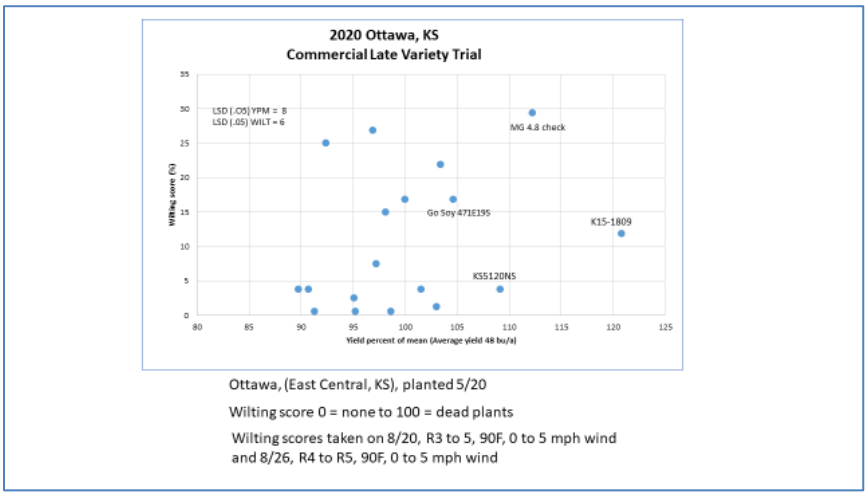
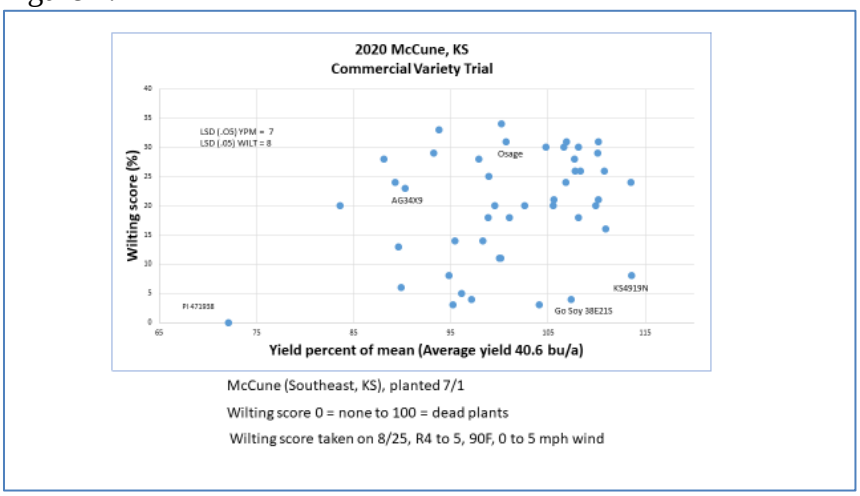


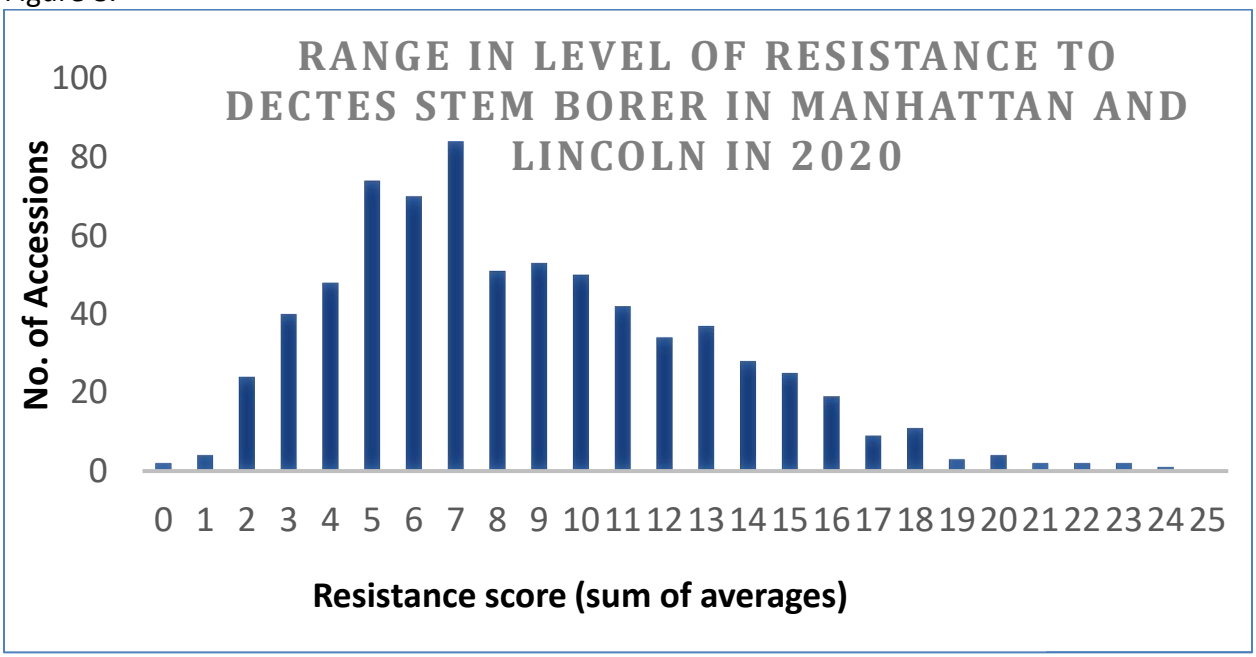
Figure 7.



Dectes Stem Borer

Over 700 soybean germplasm accessions were evaluated for response to Dectes stem borer by evaluating stem breakage, presence of stem girdling and presence of stem borer larva in 2020 at Manhattan. Similar evaluations were conducted at the Univ. of Nebraska. Response to the insect varied widely among accessions (Figure 8). Molecular marker analysis of this preliminary data identified significant regions within the genome that were associated with stem breakage and presence of larva in the stem. These evaluations will be repeated in 2021 with additional evaluations for antixenosis and antibiosis screening to be conducted in the future.

Figure 8.



Integration of Transgenic Events into Elite Germplasm

Transgenic lines expressing the Y25 and PrP17 silencing traits for SCN resistance have been introduced independently into Kansas adapted germplasm (Figure 9). K11-2363 and K12-2333 were used as females and the transgenic lines were used as the pollinators. Additionally reciprocal crosses were made between the Y25 and Prp17 lines to combine these traits. Currently the crossings are at the F_3 and F_4 generations.

Figure 9.

Crossing (female X pollinator)	Crossing Status
K11-2363 X hpRNAi-Y25	F_3 generation
K11-2363 X hpRNAi-Prp17	F_4 generation
K12-2333 X hpRNAi-Y25	F_4 generation
K12-2333 X hpRNAi-Prp17	F_4 generation
hpRNAi-Y25 X hpRNAi-Prp17	F_3 generation
hpRNAi-Prp17 X hpRNAi-Y25	F_3 generation
K11-2363 is susceptible and K12-2333 is moderately resistant to SCN Hg type 7	

Opportunities for Training and Professional Development

One graduate student working on objectives related to this project in Agronomy completed his M.S. degree in 2020, and one additional student in Bio and Ag Engineering worked cooperatively using the field plots developed and evaluated through this project also completed an M.S. degree. Currently, one student in Agronomy is pursuing a Ph.D. degree focusing on the application of remote sensing technology in breeding.

Dissemination of Results

Extension publications, news releases, and experiment station reports, field days, extension meetings and tours are used to share the results of this project. Web pages have been developed to disseminate information on new releases and germplasm and pests. Distribution of results of genotype characterization for resistance published online. Distribution of SCN survey results to cliental will provide much-needed information for making informed decisions by producers regarding variety selections for SCN management and by soybean breeders for the development of varieties with improved levels of resistance. Effects of high temperature stress on soybean, and

evaluations of host plant resistance were published at scientific conferences and published in peer-reviewed publications.

Publications for FY21

- **Journal articles**

  Nicholle Hatton, Ajay Sharda, William Schapaugh, Deon van der Merwe. 2020. Remote thermal infrared imaging for rapid screening of sudden death syndrome in soybean. Computers and Electronics in Agriculture, Volume 178, 105738, ISSN 0168-1699, https://doi.org/10.1016/j.compag.2020.105738.

  Aguirre-Rojas, L.M.; Buschman, L.L.; McCornack, B.; Schapaugh, W.T.; Scully, E.D.; Zhu, K.Y.; Trick, H.N.; Smith, C.M. 2021. Inheritance of Antibiosis Resistance to the *Dectes* Stem Borer, *Dectes texanus*, in Soybean PI165673. *Agronomy* **2021**, *11*, 738. https://doi.org/10.3390/agronomy11040738.

- **Thesis**

  Walta, Dylan. 2021. Evaluation of drone imagery as a method for selection criteria in soybean breeding. M.S. Thesis, Kansas State University.

Acknowledgment

The faculty, graduate students and staff cooperating in this project greatly appreciate the opportunity to interact with the Kansas Soybean Commission. We also appreciate the financial support of the Kansas Soybean farmer to develop new varieties, germplasm and information that supports the improvement of soybean production.