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11/8/2019

Nebraska Soybean Board
Year-End Summary Research Report Form For Multi-Year Projects

Please use this form to summarize the practical benefits of your research project and what has been accomplished.

Your answers need to convey why the project is important and how the results ǿǐƚƚ impact soybean production.

Note that this form must be submitted with the 4th Quarter Report in all multi-year projects.

Project Title: Soybean Breeding & Genetics Studies for Nebraska

Principal Investigator: George Graef

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1. What was the focus of the research project or educational activity?

This project involves applied research and development to (1) Produce high-yielding soybean varieties adapted to Nebraska and the Midwest; (2) Develop germplasm and cultivars for use in specialty markets; (3) Develop germplasm and cultivars with improved compositional quality; and (4) Evaluate and develop germplasm and cultivars that are resistant to iron deficiency chlorosis, soybean mosaic virus, bean pod mottle virus, phytophthora root rot, and soybean cyst nematode.

2. What are the major findings of the research or impacts of the educational activity?

From October 2018 through September 2019 we shared seeds of more than 100 lines from the breeding program with companies, USDA, and other universities through Material Transfer Agreements (MTAs) for evaluation and crossing. During 2019, there were new MTAs for 29 high-yield lines to other universities for use in their breeding programs, 43 high-yield and specialty soybean varieties from our breeding program to five commercial companies for use in their breeding programs, and 54 of our ultra-high protein lines to one company for analysis and evaluation, and significant interest from another company with whom I am following up after 2019 harvest.

We continue to make great progress improving yield in soybeans for our Nebraska production environments and across the north central region. Our lines topped the 2018 USDA Uniform Regional Tests in MG I, MG II, and MG III. We continue to dominate the MGI, MGII, and MGIII tests with top yielding lines in the preliminary tests, many also with excellent resistance to SCN and phytophthora. Two Nebraska lines are now yield checks in the MGI and MGII tests. We had the #1 yielding line in each of those tests, and the majority of the top 10 lines. A new MGIII line was the #1 yielding line in the MGIII SCN Regional Tests, U15-606207, has near immunity to SCN, and excellent phytophthora root rot resistance.

We advanced 74 lines in the 2019 USDA Uniform Regional Tests and SCN tests. For advanced lines in the increase and purification process, we grew 45 increase plots, 14 variety purification plots, and 4 breeder seed increase plots. The breeder seed increases will yield between 100 and 200 units of seed that we give to Foundation Seed/Husker Genetics for distribution to seed producers/licensees, and for production of Foundation Seed. We also grew six 3-acre breeder seed increase plots for top-yielding lines in our LibertyLink program, as well as three new purification blocks. There is much interest in those lines, and good potential for commercialization with some small-scale commercial sales during 2020.

One graduate student will complete his research this year and graduate in December. His work involved improvement of soybean seed composition balance of protein, oil and carbohydrates (soluble sugars) and identification of genomic regions associated with modification of those traits. That work, along with work in a previous set of populations, yielded some very interesting lines with higher protein and oil concentration in the seeds with no negative association with yield.

Two other students will complete their work and graduate during 2020. One large study deals with soybean response to water (drought) and the other works with iron-deficiency chlorosis (IDC). Both studies incorporate data from multi-sensor phenotyping in the field plots, extensive soil mapping and information, weather data, and genotype data to better understand the complexities of soybean response to these two important environmental stresses.

3. Briefly summarize, in lay terms, the impact your findings have had, or will have, on improving the productivity of soybeans in Nebraska and the U.S.

The progress in yield is important because we continue to develop and select from our Nebraska environments top-yielding lines for Nebraska that yield significantly better than the high-yield checks. Their performance holds up over years in Nebraska and is superior across the northcentral region, as shown by the Uniform Soybean Test results. With our multi-location evaluation program at high-yield farm sites in Nebraska, we identify high yield potential and are able to make significant gains in yield with each breeding cycle. Our high-yield lines are used by other programs as parents, and thus contribute to increasing genetic gain and expanding the genetic base in those programs as well. In addition, with over 5.5 million acres of soybean in Nebraska now, our program remains unique in that it develops soybean varieties specifically adapted to Nebraska production environments.

Our seed composition results are important because we have shown that 60% seed protein concentration and 26% seed oil concentration are obtainable, the lines were used to expand the NIR calibrations available to researchers throughout the US, and we are following up with more detailed evaluation of the extreme seed compositions and effects on yield and other important agronomic traits. The multiple, large populations, recently evaluated as part of graduate student research projects, have produced hundreds of lines with increased total protein and oil together, with reduced carbohydrates in the seeds. Results from multi-location yield tests of extreme lines show we have recovered increased seed protein and seed oil, with no negative relationship with yield in these populations. That is significant, especially for soybean producers in the western soybean production areas where seed protein tends to be lower, and 60% or more of soybean production enters the export market.

We also have developed a collection of some of the most IDC-tolerant soybean lines available. Together with improved yield and seed composition, resistance to IDC will improve productivity and value on millions of soybean production acres. Many of our high-yield lines have other resistances, like phytophthora root rot, SCN, SMV, and BPMV as well.

4. Describe how your findings have been (or soon will be) distributed to (a) farmers and (b) public researchers. List specific publications, websites, press releases, etc.

We share our performance data with Nebraska Crop Improvement, NuPride and others, including companies and germplasm suppliers, who request information on our new soybean lines. The data for advanced lines in regional tests is shared with all public researchers through the USDA Uniform Soybean Tests Northern States, the SCN Regional Test. Seeds of new soybean lines have been shared with other universities, USDA programs, and companies through MTAs and license agreements for both direct commercialization and for use in their breeding programs.

Publications:

(1) Anderson, E. J., Ali, M. L., Beavis, W. D., Chen, P., Clemente, T. E., Diers, B. W., Graef, G., Grassini, P., Hyten Jr, D., McHale, L. K., Nelson, R. L., Parrott, W. A., Patil, G. B., Stupar, R. M., Tilmon, K. J. 2019. Soybean [Glycine max (L.) Merr.] Breeding: History, Improvement, Production and Future Opportunities. In Advances in Plant Breeding Strategies, Vol 5: Cereals and Legumes., J.M. Al-Khayri, S.M. Jain and D.V. Johnson (Ed.), New York City, NY. Springer.

(2) Jarquin, D., R. Howard, G. Graef & A. Lorenz. 2019. Response Surface Analysis of Genomic Prediction Accuracy Values Using Quality Control Covariates in Soybean. Evolutionary Bioinformatics 15:1-7 doi: 10.1177/1176934319831307

(3) Happ, Mary, Haichuan Wang, George L. Graef, David L. Hyten. 2019. Generating High Density, Low Cost Genotype Data in Soybean [Glycine max (L.) Merr.]. G3 Genes Genomes Genetics doi:10.1534/g3.119.400093

(4) Yuan, Wenan, Nuwan Kumara Wijewardane, Shawn Jenkins, Geng Bai, Yufeng Ge, and George Graef. 2019. Early Prediction of Soybean Traits through Color and Texture Features of Canopy RGB Imagery. Scientific Reports 9:14089 https://doi.org/10.1038/s41598-019-50480-x

(5) Ge, Yufeng, Bryan Leavitt, David Scoby, Geng Bai, George Graef, James Schnable, Norbert Kirchgessner, Suat Irmak, Tala Awada, Vincent Stoerger. 2019. NU-Spidercam: A large-scale, cable-driven, integrated sensing and robotic system for precision phenotyping, remote sensing, and agronomic research. Computers and Electronics in Agriculture 160:71-81 https://doi.org/10.1016/j.compag.2019.03.009

(6) Cafaro La Menza, Nicolas, Juan Pablo Monzon, James E. Specht, John L. Lindquist, Timothy J. Arkebauer, George Graef, Patricio Grassini. 2019. Nitrogen limitation in high-yield soybean: Seed yield, N accumulation, and N-use efficiency. Field Crop Research 237:74-81 https://doi.org/10.1016/j.fcr.2019.04.009

5. Did the NE soybean checkoff funding of your project, leverage additional State or Federal funding support? Please list sources and dollars approved.

Please e-mail this report to the Agriculture Research Division (jmonagham2@unl.edu).