**Final Progress Report for “Soybean Breeding and Genetics”**

Aaron Lorenz

**Objectives**

1. Develop general-purpose (both conventional and glyphosate tolerant) and food-type soybean varieties adapted to Minnesota, and new sources of pest and disease resistance for application to Minnesota-adapted varieties.
2. Continue testing public and private soybean varieties available to Minnesota soybean producers.
3. Discover and develop new sources of resistance to soybean pests and diseases.
4. Continue to develop and expand use of UAV-enabled high-throughput phenotyping for IDC resistance ratings and maturity notes.

**Progress report**

**Objective 1**

This project forms the core support of our breeding program, which is used to leverage many other funds from diverse sources, and for many projects. This final report will describe the progress made at each stage of the breeding pipeline, and end with a summary of materials transferred, licensed varieties, presentations, and publications.

* All breeding nurseries and yield trial plots were successfully planted during May and early June.
  + 122 unique parents (113 conventional, 9 RR) were planted in the crossing block and 156 crosses were designed between breeding lines selected for high yield, early maturity, high protein, small seed (natto), large seed/high protein (tofu), aphid resistance, SCN resistance, high oleic, among other traits. All crosses were successfully made, and ample F1 seed of 151 crosses was sent to the Chile winter nursery for generational advancement. The winter nursery was successful and F2 seed was successfully sent back from planting in May 2020. The winter nursery this year was a new location, and we did receive less seed than we normally do, which may compromise some breeding efforts in the future.
  + The breeding nursery, where generational advancement occurs, consisted of the following numbers for each generation during the summer of 2019: 166 F2 populations (143 conv, 13 RR); 9 conv F3 populations; 133 F4 populations (120 conv, 13 RR). Pod picks on all F2 populations were successfully conducted and populations were advanced to the F3 generation for planting in the Chile winter nursery. The F3 plants were pod picked in Chile and advanced to the F4 generation for planting in Saint Paul in 2020. These will form plant rows next year, and include breeding populations formed for purposes of aphid resistance, genetic diversity research, early maturity, high sucrose, SCN resistance, high oleic, high protein, and specialty seed traits such as small or large seeds.
  + F3 and F4 breeding nurseries were successfully advanced via plant pulls for planting into plant rows in 2020. Through the use of molecular markers at the single F4 plant stage, we were able to reduce the number of plant rows down to 9125. The reasons attached to breeding populations in 2019 F4/F3 nurseries included SCN resistance, small/large seeds, high protein, aphid resistance, genetic diversity, modified carbohydrate, and high oleic.
  + 1599 new breeding lines were planted in preliminary yield trials (PYTs) at two locations. Lines were placed according to the maturity score in the plant row stage. Early maturing lines were planted at Crookston and Moorhead; intermediate lines were planted at Rosemount and Morris; and late lines were planted at Lamberton and Waseca. Yield, maturity, and quality data were successfully collected. A total of 319 lines performed well enough to be advanced to second year yield testing in 2020.
  + 352 breeding lines were planted in advanced yield trials at three MN locations. Early lines were planted at Crookston, Moorhead, and Shelly; intermediate lines were planted at Rosemount, Danvers, and Becker; late lines were planted at Lamberton, Westbrook, and Waseca. Data on yield, maturity, and quality were all successfully collected, except in northern MN where a very wet harvest season prevented us from harvesting some locations. One hundred and seventy lines performed well enough to advance to general regional trials and third year of testing for food-type trials in MN; All regional and advanced tests were successfully packaged and planted in 2020.
  + The 2019 regional tests were successfully conducted, including our lines and lines from regional co-operators were planted. The regional trials included 204 lines from the MN breeding program, plus many others from co-operators. Several lines performed well enough to be advanced to another year of regional testing. A couple highlights from the most advanced lines include:
    - **M11-314101** – This is a RM 1.8 variety with high protein and superior yield, and Rps1k phytophthora resistance. This is being tested by commercial partners.
    - **M11-297035** – A RM 1.3 variety with large seeds, higher protein, and good yield suitable for soymilk/tofu production.
    - **MN1901CN**: This a new variety being released previously under the experimental name of M08-365100. This line has high yield and SCN resistance, adapted to southern MN.

Below is table of lines currently being purified and which are available through MTAs for company evaluation:

|  |  |  |  |
| --- | --- | --- | --- |
| **Line** | **Traits** | **FL/PUB/HIL** | **Rel. Mat. (Approx)** |
| M08-332003 | Protein | P-G-F | 1.3 |
| M11-297035 | Large, protein | W-G-Y | 1.3 |
| M07-296048HOLL-1 | High oleic, low lin | P-T-Y | 0.5 |
| M07-297007HOLL-1 | High oleic, low lin | M-T-M | 1.5 |
| M11-314101 | Protein | P-G-Y | 1.8 |
| M11-320-1018 | Natto | P-G-Y | 0.0 |
| M10-159-2022 | Natto | W-G-Y | 0.5 |
| M11-105060 | Natto | M-T-Y | 1.0 |
| M10-159-4011 | Natto | W-G-Y | 0.3 |
| M10-159-1007 | Natto | W-G-Y | 0.2 |

It’s difficult to document the impact of the breeding program in terms of acres planted and value of seed harvested because this information is proprietary to our licensees. One way we can document impact is through examination of seed transfers and agreements signed. Below is a summary of those signed in 2019. The information of the requestor is kept confidential.

* 2 lines were transferred to private seed companies for use as parents.
* 3 lines were transferred to 2 public universities for use as parents.
* 51 lines were transferred to private companies for testing of quality and yield preceding possible licensure.
* 36 lines were transferred to other university research projects to serve as experimental materials for studies on pathology, entomology, and genetics.

1. Invention disclosures were filled out for 31 varieties to begin the process of licensing, or transferring lines to companies as parental stock: M12-357057 (ND07-4635 X M06-274098), M13-250056 (M06-288190 X AR09-191018), M13-250046 (M06-288190 X AR09-191018), M06R-614008 (SDX00R-026-42 X N34505R), MCH13R-117072 (M06R-614008 X M06R-613036), M12R-803016 (U07-135601R X M06R-613036), MCH13R-117054 (M06R-614008 X M06R-613036), MCH13-109053 (M06-289264 X M06-380029), M13-118036 (M06-288155 X U09-118017), , MCH13-104087 (M06-288181 X M06-358188), M13-250030 (M06-288190 X AR09-191018), M13-262015 (M03-172059 X LD08-12435a), M08-362045L (MN0606CN x U03-100612), M09-285149 (MN1701CN x E06936), M12R-801080 (M00-530039 X M04R-514129), M11-245026 (M02-385091 X DEUEL), M13-112029 (ND09-3153 X M08-151086), M13-194022 (M06-381085 X HEFENG 50), M13-194051 (M06-381085 X HEFENG 50), M13-194018 (M06-381085 X HEFENG 50), M13-194010 (M06-381085 X HEFENG 50), M12-373033 (AR09-191003 X M06-338016), M11-297035 (M04-295008 X M03-326084), M13-268021 (M06-340057 X A09-754003), M13-276053 (M07-2064093 X M05-297042), M11-320-1018 (M11-320-1018), M10-159-1007 (M05-268004 X MN0103SP), M10-159-4011 (M05-268004 X MN0103SP), M10-159-2022 (M05-268004 X MN0103SP), M11-105060 (M11-105060), M13-104022 (M07-260028 X M05-353086)

I spoke at a few events relevant to the breeding program:

Young Leaders of Japanese Natto Manufacturing. Sept. 7, 2019. St. Paul, MN. (Presented to and led tour for visiting group of Japanese natto professionals)

Crop Pest Management Workshop. 2019. Fundamentals of and current trends in soybean variety development. Dec. 11. Minneapolis, MN.

Dobbels, A.A., L. Volpato, and A.J. Lorenz. 2020. UAS-based of iron deficiency chlorosis tolerance and plant maturity for soybean breeding. Bayer Crop Science UMN Student Visit. January 9, St. Louis, MO.

Lorenz, A.J. 2019. Breeding for tolerance to iron deficiency chlorosis in soybean. Department of Agronomy Seminar, Dec. 12. Ames, IA.

Lorenz, A.J. 2019. Developing resources to advance the implementation of genomic prediction in soybean. ASA-CSSA-SSSA Annual Conference, Nov. 12. San Antonio, TX.

Lorenz, A.J., A. Dobbels, K. Virdi, S. Sreekanta, G. Muehlbauer, R. Stupar. 2019. High-throughput phenotyping using unmanned aerial systems in a soybean breeding program. CROPS Conference, June 4. Huntsville, AL.

**Objective 2**

* An announcement was sent out to commercial seed representatives. We received 140 unique varieties that were entered into at least one of the four tests.
* Plots were planted at each of the three locations within each type of test. Staking, flower/pubescence notes, weeding, harvest, compositional analysis were all successfully completed.
* The report was created on time in November and can be found here at this link:

<https://indd.adobe.com/view/7bafcdad-d10d-49f3-bfda-753594f9d539>

**Objective 3**

* We continue to work with Dr. Dean Malvick on identifying sources of genetic resistance to Rhizoctonia. I am a committee member on his students POS committee and actively assist her research by providing germplasm for studies. Beyond this, we have filled six seed requests from colleagues in Plant Pathology at UMN as well as industry researchers. The genetic variation contained in our germplasm bank is a valuable resource for these researchers.

**Objective 4:** Develop and expand use of UAV-enabled high-throughput phenotyping for IDC resistance ratings and maturity notes.

* Our exploration of UAV for scoring IDC tolerance continues to advance. We published a paper in a peer-reviewed journal on this, and are looking to implement this technology in practice starting next season. The Danvers IDC location was flown by UAVs on a weekly basis the entire growing season. This will be valuable information for learning how genetic variation in IDC tolerance changes throughout a growing season, and what genes control IDC variation at different points in plant development. We have planted and phenotyped (via UAV) a mapping panel of genotypes at two additional IDC sites in MN and ND.
* We’ve also made a fair bit of progress on dating maturity in soybean via UAV. We’ve adapted a method published by Corteva. Using 2018 and 2019 maturity data and images collected at Waseca, we’ve determined they we can reliably predict maturity date within two days. We have a manuscript in preparation.
* Volpato, L., A. Dobbels, A. Borem, and A. Lorenz. 2020. Temporal UAS-based imagery analysis to estimate plant maturity in a soybean breeding program. Plant Phenome (in prep).

