QUANTITATIVE GENETICS AND MAIZE BREEDING
DEPARTMENT OF SOIL AND CROP SCIENCES

Final Report: *Texas Location Support of the Genomes to Fields (G2F) Initiative*

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Project Overview

The Genomes to Fields (G2F) project is a public-private partnership involving over 30 cooperators which seeks to translate maize genome information to benefit growers, consumers and society. The goal is to develop approaches to understand the function and relevance of corn genes and alleles across environments; to get at the nature of genotype by environment (GxE) interactions in corn; and to determine how specific genes and alleles affect plant growth during development. It is a recognition that the same variety (and the same genes) are not the best for every environment. The project was initiated by the Iowa Corn Promotion Board in 2013, and the Texas A&M program has played a key role in providing seed and leadership in field activities, increasing relevance of the hybrids screened and methods used to Texas growers. As a large cooperative project, findings are made public for the benefit of growers, companies, researchers and society and no proprietary intellectual property is developed from this experiment.

Growing season weather and impacts:

Despite another wet growing season, all yield trials and project deliverables were successful. No furrow irrigation was needed during the season due to the large amount of rain starting at the end of May and proceeding until after harvest. We did not have flooding from the river as we did in 2015, but downpours occurred which negatively impacted corn yields, probably due to denitrification and prolonged soil saturation or a combination of both. Program yield trials in dryland and irrigated scenarios were harvested with yields means ranging from 93 to 134 BuA. The G2F trial was located on more well drained/higher ground and had a geometric mean of yield at ~109 BuA. This was lower than last year and lower than our expectations given the conditions.

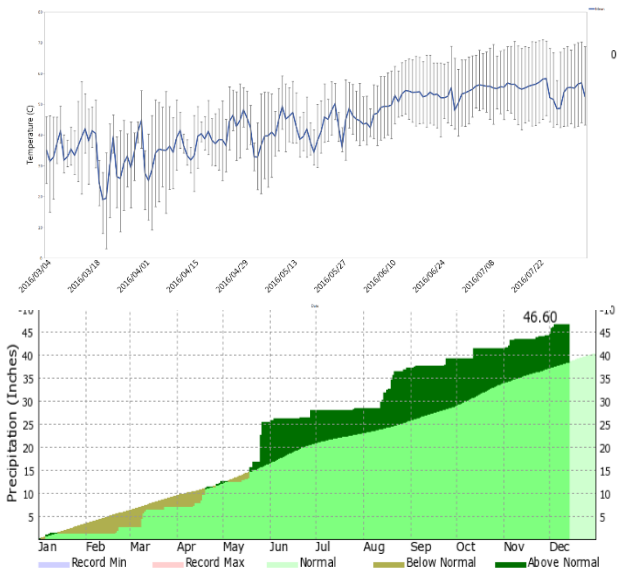

Figure 1. (top) Temperature data from College Station, 2016. (bottom) Rainfall data for 2016 taken from www.weather.gov.

Objective 1: *Participate and collect data on the 2016 G2F trials.*

There was a wide range, however for TAMU, non-TAMU, and commercial check values for all measured traits (Table 1). The analyzed G2F trial yielded high quality results as evidenced by variance component analysis (Table 2). The variation explained by genotype for yield was 71%, which is among the highest we have seen from a test. This means nearly ¾ of all the differences in the experiment were due to predictable genetic differences. This is a great result arising from three things, 1) there was very large variation in the included hybrids, ranging from tropical to Canadian derived material; 2) the combine was set well to be repeatable throughout the field; and 3) there was very little spatial variation (~4% explained by range and row) which is far less than we generally see. The variation explained by pedigree for flowering, plant height and moisture exhibited similar results (Table 1). Stand, and test weight still had greater than 41% variation explained. Ear height variation had ~ 65% residual error which is a lot but is typical for ear heights that are hand measured, as it is hard to get different people to measure these as repeatedly as we would like.

One exciting result was that an ex-PvP tester crossed to a tropical line developed from our breeding program (CML442-B/CML343-B-B-B-B-B-B)-B-B-1-1-B-B-B-1-B12-1-B19 yielded statistically the same as the local check DeKalb 64-69 as did another hybrid created from two of our elite lines Tx714/Tx777. However, the point of the G2F experiment is not to focus on any one location but to combine data across all 30+ locations to understand how to both adapt hybrids broadly, and more importantly, identify genetic factors that affect local adaptation.

Table 1. Descriptive statistics.

Source	Statistic	Days to anthesis (DTA)	Days to silk (DTS)	Plant height inches (PHT)	Ear height inches (EHT)	Yield bushels per acre (BuA)	Moisture %	Test weight	Stand count plants/ plot
TAMU	Min	68.0	67.0	80.0	20.0	103.6	9.7	50.9	48.0
	Mean	72.9	73.0	87.1	31.9	138.9	11.0	55.4	64.6
	Max	77.0	78.0	98.0	42.0	177.6	13.7	59.0	73.0
Others	Min	59.0	60.0	35.0	13.0	0.8	9.2	49.0	20.0
	Mean	71.0	71.0	82.9	29.3	116.4	10.2	55.0	60.5
	Max	77.0	77.0	99.0	91.0	175.3	15.0	59.4	79.0
DKB 64-69	Min	69.0	69.0	75.0	25.0	164.4	10.7	54.6	66.0
	Mean	70.6	69.6	79.6	31.0	187.6	11.2	56.4	71.4
	Max	73.0	71.0	84.0	35.0	213.7	11.6	57.6	75.0

Table 2. Percent total variation explained.

Model	Days to anthesis (DTA)	Days to silk (DTS)	Plant height inches (PHT)	Ear height inches (EHT)	Yield bushels per acre (BuA)	Moisture %	Test weight	Stand count plants/ plot
Pedigree	79.7	79.9	62.1	27.9	70.6	61.9	50.9	41.1
Rep	0	0	0	0.822	0	0.22	0	0
Range	3.5	3.6	2.4	6.1	4.1	0.2	0.4	6.4
Row	1.6	0.1	1.5	0	4.3	22.4	20.6	4.4
Residual	15.2	16.3	34.0	65.1	21.0	15.3	28.2	48.2
R^2	.93	.92	.83	.69	.92	.94	.88	.77

Currently, from both 2016 data in Texas and 2014/15 data across the country, the TAMU maize breeding program has some of the latest flowering material in the G2F trails. An important aspect of these G2F trials is a better understanding of where these hybrids might fit and in identifying earlier flowering material better suited for Texas environments, thus helping producers with increasingly better germplasm. One of the major observations however, is a strong negative correlation between flowering date and yield, showing that earlier hybrids are likely to reduce producers yields. However, this correlation is biased in that the earliest flowering material was developed in Canada and is not adapted to Texas for many reasons. With appropriate breeding, earlier material developed in Texas could be beneficial to Texas growers.

Mr. Pekar, representing the maize program, recently participated in the G2F meeting held in Chicago, IL and the program will remain an active participant in data collection and analysis.

The high-throughput field phenotyping (HTFP) ground vehicle (GV) (Figure 2) saw its first full season of use during the 2016 growing season. It was run through the G2F trial twice, and there were a few UAV flights over this field. Many logistics issues and modifications were discovered and we are actively working closely with the Biological and Agricultural Engineering Department to solve these issues. Two of our undergraduate assistants (Colby Ratcliff and Dalton Askew) are currently helping with fabrication and design as needed with the PM along with other equipment needed with the maize breeding program such as new precision fertilizer applicator and planter modifications/enhancements. Data collected from UAVs, PM, weather stations, and hand measurements are currently in different states of being cleaned and analyzed. The weather station and hand measurement data will be uploaded to the G2F project website within the month.

Figure 2: Ground based phenotyping machine that can measure mature corn without damage. The first of its kind in the world and is expected to save labor

Seed production for the spring 2016 growing season was low in comparison to the 2015 due to a

poor seed set within the isolation block, likely due to the lack of wind pollination. In total we had about 79 hybrids produced in isolation but on average these yielded just 458 grams, enough for ~8 locations. Fortunately, hand pollination within our crossing block yielded good seed set and these were some of the most important crosses to get into G2F for the following year. The Weslaco, TX fall nursery went very well for most of the program material (not supported by this project). Unfortunately the G2F material in our crossing and increase blocks suffered poor germination, likely due to high salinity levels within the soil; although we planted them in the center of the field where we thought they would be safest. It is probable that hand pollinations in this area will yield little seed. Harvesting of our fall nursery has concluded and actual yield weights will be finalized after Christmas.

Objective 2: *Train students and participate in cooperative tests.*

Multiple undergraduate assistants were involved in collecting flowering, yield, and height data points throughout the 2016 season. In 2015 we estimate it took 12 people (faculty, staff, graduate and undergraduate students) over three weeks to complete field measurement notes on plant populations, flowering time, plant height and ear height which are needed to identify the best hybrids, understand experimental field variation, and support graduate genetics research projects. Of this, close to a week was the G2F project supported by TCPB. Since these repetitive manual activities are not a great learning experience for students, we hope to replace these with automated measurements from the ground vehicle or the unmanned aerial vehicles in the future.

Students were directly involved in all aspects of agronomic inputs and are included in the decision process on all the program agronomics. Students were included in lab meetings and were encouraged to participate, while also giving opportunities to work on undergraduate research projects. Currently, MS. Clarissa Conrad, who worked as a student worker over the summer, decided to do independent researcher. She is taking the lead on an undergraduate project involving confirmation of QTL and is in the process of extracting DNA for analysis for her project and other projects when needed.

* Photo was taken after scanning a corn field but the photographers preferred this sun direction.

Texas A&M AgriLife Ground Vehicle Team (partial). From L to R:
1) Jacob Pekar (Research Associate, Corn Breeding, Soil and Crop Sci.),
2) Mario Mendez (Thomasson group PhD student, Ag. Engineering)
3) Grant Richardson (PhD student, Corn Breeding, Soil and Crop Sci.),
4) Jeffrey Demieville (Sensors - Undergraduate Student Worker, Thomasson group)
5) Colby Ratcliff (Chief Driver - Undergraduate Student Worker, Corn Breeding)
6) Brandon Hartley (Sensors - Research Associate, Thomasson group)
7) Seth Murray (Prof. SCSC, Corn Breeding)

Not shown: Alex Thomasson (Prof. Ag. Engineering), David Baltensperger (Prof & SCSC Dept. head), William Rooney (Prof SCSC, Sorghum Breeding), N. Ace Pugh (PhD student, Sorghum Breeding, SCSC), David Horne (PhD student, Sorghum Breeding, SCSC)

Current Team in the Texas A&M Maize Breeding and Quantitative Genetics Program

Technical Support

Jacob Pekar – Research Associate & Ph.D. Student – Ph.D. Projects: Inbred aflatoxin SCIN test, Aflatoxin 4 Way and 8 Way population breeding and testcrosses.
B.S. Texas Tech; M.S. University of Kingsville; Started July. 2013 in the maize program.

Justine Christman – Research Assistant & M.S. Student – M.S. Projects: Identifying low phosphorus grain and developing NIRS calibrations. Leading and supported by USDA-NIFA Climate Change Project (PI:
Randy Wisser)
B.S. University of Wyoming; Started Jan. 2014 in the maize program.
David Rooney – Research Assistant
B.S. Texas A&M University; Started May. 2016 in the maize program

Graduate Students

Steven Anderson – Graduate Research Assistant, Ph.D. - M.S. Projects: Mapping quantitative traits in the four parent maize population (1200+ lines)
B.S. University of Central Florida; M.S. Texas A&M University; Started Jan. 2014 in the maize program.
Yuanyuan Chen – Graduate Research Assistant, PhD - PhD Projects: Validating three SNPs for yield in new breeding populations; Confirmation of the aflatoxin resistance of LOX genes in isogenic hybrids.
B. S.Henan Agriculture University, M.S. China Agriculture University; Started Jan. 2014 in the maize program. Graduated fall 2016.
Nancy Wahl – Graduate Research Assistant, PhD - PhD Projects: Meta-Analysis of the SERAT projects. RNA expression in aflatoxin resistant and susceptible lines after inoculation.
Grant Richardson – Graduate Research Assistant, PhD - PhD Projects: High throughput phenotyping for plant height.
Fabian Echeverria – Graduate Research Assistant, PhD - PhD Projects: RNA gene expression in coffee rust resistance and fungicides.
B.S. Institute of Technology of Costa Rica; M.S. University of Costa Rica; Started Jan. 2015 in the maize program.

Undergraduate Student Assistants

Amee Bumguardner - B.S. Soil and Crop Sciences, Graduation date: May 2016; Started May 2013 in the maize program. From: Palacios, TX
Malik Williams – High School student at College Station; Started June 2015 in the maize program. From: Houston/ College Station, TX.
Colby Ratcliff – B.S. Ag. Economics, Graduation date: Dec 2016; Started Aug. 2015 in the maize program. From: Buna, TX.
Clarissa Conrad – B.S. Soil and Crop Sciences, Started May. 2016 in the maize program. From: Dallas, TX.
Caitlin Leakey – B.S. Ag. Science, Expected graduation date: May 2019; Started May. 2016 in the maize program. From: Houston, TX.

Grant Goldstein – B.S. Horticulture, Graduation date: Dec 2016; Started May. 2016 in the maize program. From: Houston, TX.
Dalton Askew – B.S. Human Resources Development, Expected graduation date: May 2019; Started Oct. 2016 in the maize program. From: Buna, TX.