QUANTITATIVE GENETICS AND MAIZE BREEDING
DEPARTMENT OF SOIL AND CROP SCIENCES

TEXAS A&M UNIVERSITY

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Status Report I: *Hybrid Development and Testing TAMU Lines for Yield towards Commercialization*

Investigators

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*update: Mr. Jeff Savage, Dr. Murray's Research Assistant, resigned his position in early April, Mr. Jacob Pekar replaced him in mid-July and has been a valuable addition bringing a wealth of agronomy and hybrid seed production experience including previous employment with Dr. Webb Wallace. Jacob is working towards finishing his MS project from Texas A&M University–Kingsville in May and plans to begin an employee degree PhD program at Texas A&M in Fall 2014.

Project Overview

The primary goal of this project was to further test and increase seed of material that can lead to increased yield and decreased stress developed in Texas for Texas producers. Overall it was a very successful season with a large amount of data supporting decisions for release of 18 lines. We thank the Texas Corn Producers Board for supporting this valuable research and want to emphasize the support is critical for our continued maintenance of breeding goals and capacity of the program. This capacity allows us to be competitive in attracting additional resources from federal and state agencies which overall furthers proposed corn research, Texas corn publicity, and gives Texas a seat at the table in future decisions.

Objectives 1&2: ***(1)*** *Test 30 specific TAMU hybrid combinations that have been identified as most successful in additional environments; work with industry to develop a path towards rapid commercialization.* ***(2)*** *Test more than 400 new hybrids from crosses between our best TAMU inbreds and relevant commercial inbred lines (many traited) to find winning combinations for yield.*

Due to a very successful production of seed in 2012 we planted many of our most previously successful hybrids in multiple locations. In total, 743 different hybrids were tested this year over all locations under this project. The primary focus was to test the smallest and best subsets in the most locations when sufficient seed was available (our biggest challenge); instead of 30 TAMU inbred lines, a core set of 67 were identified that had sufficient seed to test. The majority of the 743 different hybrids were new (Objective 2) but from combinations between proven TAMU lines with relevant commercial tester inbreds; these new hybrids were generally only evaluated in one or two tests. The focus on expanded testing locations of the best hybrids will allow these to more quickly be made available for growers, while testing new hybrids allows us to find new combinations that may be even better.

In order of planting dates- **Weslaco (Rio Farms):** A 184 entry two row, two replicate test; a 126 entry one row, two replicate test and a 37 entry one row, one replicate test were planted at Rio Farms, both the yield and data were good. **Weslaco (AgriLife):** A 10 entry one row, three replicate test of the best hybrids was planted on the station and was hand harvested, the data were very good. A 50 entry two row, two replicate test was planted for Dr. Xu. Additionally, one of our most successful inbreds (Tx777) in hybrid combination was officially

entered into the Texas Corn Performance Test. http://varietytesting.tamu.edu/corn/2013varietytrials/yield_results/2013%20Monte%20Alto%20Corn%20Final%20Table.pdf . **BH Genetics**: Three dryland tests were planted by BH genetics: 1) a 72 entry two row, two replicate test in Ganado, the data was good 2) a 25 two row, two replicate test in Ganado specifically for inbred seed companies to observe that suffered freeze damage but provided great data 3) 5 entries were planted in ten locations across the state, the data was good. This is the best of many potential opportunities to expand commercial interest in TAMU material. **College Station:** Too many tests were planted in College Station to list them all, a partial list includes:

- Early planting dry land tests had timely rains and minimal freeze damage. These tests were good to very good.
  - 227 entry two row, two replicate tests
  - 52 entry one row, one replicate tests
- Early planting irrigated tests were planted in a second field. Much of this field at this planting date suffered substantial freeze damage which reduced yield but the data obtained were still good to great.
  - 199 entry two row, two replicate test
  - 91 entry one row, two replicate test
  - 92 entry one row, one replicate test
- Later plantings missed the late freeze and had better than expected yield but the uniformity of the tests were good.
  - 49 entry, two row, two replicate test
  - 66 entry one row, two replicate test
  - There were 9 other medium and large tests that were also planted

San Patricio County: A 52 entry two row two replicate test of Roundup Ready hybrids was planted on Charles Ring's Farm by Dennis Pietch. This test was poor due to a lack of rain but useful data was still obtained. **Thrall:** An 80 entry two row two replicate dryland test was planted on Stiles Farm in Thrall cooperatively with Dennis Pietsch and had good results. Also a 10 entry demonstration planting was included for Stiles Farm field day. **Corpus Christi:** Although a test was packaged for Corpus, it was determined to be too dry to plant this year so Corpus was not planted. **Halfway:** A 50 entry two row two replicate test was planted by Dr. Wenwei Xu and the data are still being processed.

Data from each test was analyzed individually and data from all tests was combined and analyzed jointly (Table 1). Many of the best hybrids performed well as expected from previous years data. Of great interest, although not a focus of the study, TAMU material was found to be far more resistant to Southern Rust than what is currently commercially available. Little *Aspergillus flavus* or other ear-rots were observed in any location. The top TAMU inbreds, Tx777 and Tx775 outperformed all but a few commercial varieties in a few locations and had superior aflatoxin and rust resistance to what is commercially available. Based on the results of this year and past year's data we are writing a release proposal for a total of 13 yellow lines and five white lines which in combination have out yielded commercial hybrids over past years. It was anticipated that this release proposal would be submitted in early 2014 but it seems more likely it will be in the summer of 2014.

Objective 3: *Produce inbred seed and additional seed for testing in crosses between TAMU inbreds and relevant commercial inbred lines (mostly traited).*

This year 70 of the best Texas A&M inbred lines were planted with four rows in the crossing block with 15 commercial and ex-PVP inbred tester lines, many with traits. All 70 lines had at least one cross and many had four or more. In total there were 316 unique bags of hybrid crosses (of which a proportion are duplicated crosses, reciprocal crosses or second bags of seed for the same crosses - to be determined in 2014 planting preparations). Still, hybrid seed production was poor compared with 2013, largely because of the delay in germination and poor correspondence in the times of flowering between male and female plants. Overall, nearly 3000 plots were planted in our nursery from various projects including those supported by the TCPB this year resulting in 3722 unique bags of nursery seed. When including a large genetic mapping population, over 500 nursery plots were planted and over 5000 unique bags of seed were produced. Importantly, 200 of the plots were for seed increase to gear up for release of the most promising lines. These summer seed increases were outstanding thanks to very dedicated student workers - and we have enough seed to formally release most of the lines of interest.

The Weslaco winter nursery was planted August 8th and 19th, later than preferred because of the delayed maturity and dry down of the summer nursery and the lack of a Research Assistant in early July. In total, 2800 plots were planted across various experiments. The crossing block was planted with 30 of the best TAMU lines and 18 testers including some with traits and transgenics. Over 10 inches of rain were received over a week early in the season with a set of additional rains that kept the ground saturated for multiple weeks. This created a serious weed issue and reduced early season vigor; while the weeds were eventually controlled the plants lacked vigor. Our group was down for a span of 17 days pollinating in late September and early October. As of 12/20/2013 the winter nursery in Weslaco was approximately half harvested with the other half left to harvest in January because of delayed maturity and dry down. The results of the winter nursery so far harvested, including the creation of hybrids for testing next year, was moderate to poor, but better than expected given the poor early season field conditions. It is hoped that our top hybrids, and especially new TAMU x TAMU hybrids will have enough seed for substantial tests next year.

Objective 4: *Train students and participate in cooperative tests.*

This year, five graduate students, four undergraduates, one visiting professor, two Research Assistants, and one high school worker worked in the TAMU corn breeding program. Additionally two other graduate students employed by wheat and cotton were trained for two days on corn breeding. In the coming 2014 year we will additionally have three to four new graduate students, one visiting professor, and one additional research assistant demonstrating real growth of the program.

Multiple cooperative tests were planted, mostly in College Station, Weslaco and Halfway some are under other grants and proposals but TCPB support has been critical to help maintain people and resources to perform these trials.

Some of the major additional projects include:

- Under our AMCOE proposal four multi-investigator hybrid and inbred yield and aflatoxin trials were planted in College Station and Weslaco and inoculated. In one of these hybrid tests, the Southeast Regional Aflatoxin Trials (SERAT), the same TAMU hybrids proposed for release were also the top yielders in both College Station and

North Carolina (Table 3 - not all data has been compiled from all locations yet). This has led to a large multi-state USDA-NIFA aflatoxin project that is proposed to be awarded but not yet been formalized or announced.

- Additional statewide trials were conducted with our second best material by BH Genetics, as we did not have enough seed for our top hybrids. These performed in the middle bottom of the commercial material overall while they were at the top of some tests.
- A cooperative test across 8 locations in the US was planted as part of our ATLAS NIFA project http://www.maizeatlas.org/
- Two large isolations for making hybrids were planted in our Weslaco winter nursery for a very large project supported by the National Corn Growers Association. This project will involve testing with nearly all US public corn researchers to better understand how diverse environments affect different maize genes. While this is a pilot project, it is anticipated that it will become larger and more formalized in the future and Texas is playing a prominent role since we (Wenwei Xu and Seth Murray) have two of the largest public corn breeding programs in the US and are at the forefront of a changing climate.

Table 1: Grain yield (Bu/ac) trial results over 15 trials in 2013. TAMU lines are inbred lines proposed for release and some previously released TAMU lines. Testers are the commercial inbred used to make experimental hybrids, TAMU by TAMU hybrids are underlined. Twelve commercial check hybrids (the six best are in italics) were chosen based on previous Texas Corn Performance Trials (http://varietytesting.tamu.edu/corn/) and industry recommendations. Numbers in bold outperformed the commercial check mean. Overall LS means estimates for each hybrid in column three were obtained fitting a model including hybrid, trial, row(trial), range(trial), replicate(trial), and trial*hybrid effects. The separate LS means estimates for each hybrid in each trial were obtained fitting a model including hybrid, row, range and replicate effects. Not all hybrids were grown in all trials and only 11 of 15 trials are presented individually.

TAMU line	Tester OR commercial check hybrid	OVER-ALL	CS13-1AF2	CS13-2A2Z	CS13-2DRY	CS13-2TSR	CS13-B1X2	TH13-STLE	SP13-RING	WE13-1B2M	WE13-2A2N	GA13-YTBH	GA13-DEMO
12 COMMERCIAL HYBRID CHECKS MEAN		**128**	**153**	**151**	**150**	**130**	**139**	**82**	**40**	**165**	**152**	**136**	**104**
Tx777	SS2	**171**	-	**165**	**153**	-	**171**	-	-	**215**	**183**	-	-
	Commercial Check #1	**167**	**173**	**211**	**181**	**180**	**206**	73	**43**	**220**	**195**	-	-
Tx149	SS4	**166**	-	**161**	-	-	-	-	-	-	**156**	-	-
Tx741	NSS2	**161**	-	-	-	-	**173**	-	-	-	-	-	-
Tx773	Tx-unreleased AFC	**161**	-	-	-	-	**171**	-	-	-	-	-	-
Tx784	Tx782	**156**	-	-	-	-	**169**	-	-	-	-	-	-
	Commercial Check #2	**147**	**178**	**161**	**164**	**145**	**181**	**96**	**56**	**178**	**162**	**145**	**105**
	Commercial Check #3	**146**	146	**158**	**154**	-	**155**	**90**	**51**	**183**	**176**	-	-
Tx783	Tx-unreleased AFC	**146**	-	-	-	-	**157**	-	-	-	-	-	-
Tx775b	SS4	**146**	-	-	-	-	**156**	-	-	-	-	-	**131**
Tx150	SS1	**145**	-	-	-	-	-	-	-	-	-	-	-
Tx773	SS1	**145**	-	**167**	137	**162**	-	-	-	-	**178**	-	-
Tx780	SS3	**145**	-	**169**	116	-	-	-	-	-	**197**	-	-
	Commercial Check #4	**144**	-	150	**155**	-	**175**	**83**	38	**190**	**163**	-	-
Tx775	Tx777	**144**	-	-	-	-	**158**	-	-	-	-	-	-
Tx779	SS4	**143**	-	150	**163**	-	**153**	65	36	**179**	**170**	-	-
Tx780	SS4	**141**	-	**155**	**157**	-	-	-	-	-	**168**	-	-
Tx149	SS1	**140**	-	**159**	148	-	**155**	-	**43**	**171**	**162**	-	-
Tx777	SS3	**139**	-	**173**	141	-	-	-	-	-	149	-	-
	Commercial Check #5	**137**	**167**	143	147	122	**156**	82	**42**	**177**	**173**	**141**	**128**
Tx773	NSS1	**137**	-	**174**	145	**168**	-	71	14	-	**166**	-	-
Tx784	Tx-unreleased AFC	**136**	-	-	-	-	**144**	-	-	-	-	-	-
Tx779	SS3	**136**	-	**154**	-	-	-	-	-	-	147	-	**135**
Tx741	SS2	**136**	-	145	**151**	-	-	-	-	-	**162**	-	-

TAMU line	Tester OR commercial check hybrid	OVER-ALL	CS13-1AF2	CS13-2A2Z	CS13-2DRY	CS13-2TSR	CS13-B1X2	TH13-STLE	SP13-RING	WE13-1B2M	WE13-2A2N	GA13-YTBH	GA13-DEMO
Tx777	NSS2	**135**	-	-	-	-	**147**	-	-	-	-	-	-
Tx781	NSS3	**135**	-	138	-	-	-	-	-	-	**161**	134	-
Tx741	SS1	**135**	-	**168**	**151**	-	-	-	-	-	141	-	-
Tx777	SS4	**135**	-	**169**	**161**	-	-	66	25	-	**179**	-	-
Tx775	SS1	**135**	-	**153**	-	-	-	-	-	-	-	-	-
Tx783	Tx-unreleased	**135**	-	-	-	-	**144**	-	-	-	-	-	-
Tx775b	SS2	**134**	-	**163**	146	-	-	-	-	160	148	-	-
Tx779	Tx-unreleased	**133**	-	-	-	-	128	-	-	**186**	-	-	-
	Commercial Check #6	**133**	132	151	144	**173**	**162**	69	33	**174**	131	**137**	72
Tx775a	SS4	**132**	-	**163**	138	-	-	72	33	-	**153**	119	**125**
Tx739	SS4	**132**	-	146	**153**	-	-	-	-	-	152	-	-
Tx783	SS1	**132**	-	**167**	147	-	-	54	-	-	**153**	-	-
Tx150	PHV63	**131**	-	-	-	-	**149**	-	-	159	-	-	-
Tx772	SS1	**131**	-	**158**	136	-	-	-	-	-	-	-	-
Tx775	SS1	**131**	-	-	-	-	-	-	-	-	-	109	**124**
Tx779	SS2	**130**	-	147	**152**	-	-	-	-	-	142	-	-
Tx773	SS5	**130**	-	**152**	144	**132**	-	-	-	-	**154**	-	-
Tx779	SS1	**130**	120	**165**	145	-	-	60	26	-	**155**	108	**104**
Tx775a	SS2	**129**	147	**185**	**156**	**170**	-	62	-	137	124	103	-
Tx784	SS2	**128**	140	**165**	136	-	-	67	-	-	**159**	93	-
Tx784	SS1	127	130	**163**	144	-	-	62	**42**	-	**171**	97	**109**
Tx773	NSS2	125	-	**158**	110	**156**	-	58	-	-	**158**	100	**113**
Tx781	NSS1	122	-	103	110	-	-	**91**	**53**	-	**154**	112	**115**
Tx782	NSS1	114	118	126	120	-	-	72	33	-	105	-	**123**
	Commercial Checks #7-12 were lower												
Test Mean		106	117	135	120	108	125	61	29	136	133	101	**109**
Avg. std. error		14.7	19.8	12.2	10.2	10.0	15.0	5.7	8.5	18.4	15.9	7.2	8.0
Avg. (std. error / mean) per entry		0.17	0.19	0.09	0.09	0.12	0.14	0.10	0.35	0.14	0.12	0.07	0.08
Dryland (D) or irrigated (I)		D, I	I	I	D	I	I	D	D	I	I	D	D
Number of rows per plot		1 to 2	2	2	2	2	1	2	2	1	2	2	2
Number of entries		447	64	195	216	63	91	81	52	116	170	69	25

Table 2: Pedigrees of lines for release and background of testers used

Yellow	
Tx741	LAMA2002-42-B-B-B-B-B3-1
Tx773	LAMA2002-58-3-B-B-B-B-B-B-1-B19
Tx774	(CML288/NC300)-B-9-B1-B-B-B)-B-B-1-3-B-1-1
Tx775	(LAMA2002-35-2-B-B-B-B/CG44)-1-3-B-1-1-B24-B5-B16
Tx776	(LAMA2002-35-2-B-B-B-B/CG44)-1-3-B-B14-B10
Tx777	(LAMA2002-23-3-B/LAMA2002-58-4-B)-B-B-2-3-B-B-B-1-B23-B5-B27
Tx778	(LAMA2002-23-3-B/LAMA2002-58-4-B)-B-B-2-3-B-B-B-B12-B5-B24
Tx779	(LAMA2002-22-1-B-B-B-B/LAMA2002-1-5-B-B-B-B)-2-1-B-1-1-1-B19
Tx780	(LAMA2002-10-1-B/(CML288/NC300)-B-9-B1-B-B-B)-B-B-1-3-B-1-1
Tx781	(NC300 x Tx714-B/B104-1/CML343)-2-1-B-B-B-B-B-B-B-B-1-B25-B23
Tx782	(LAMA2002-12-1-B/(CML 325/B104)-B-1-B-B-B-B)-B-B2-3-2-B-B-B-1-B-B11
Tx783	(LAMA2002-61-2-BB/LAMA2002-53-5-BB)-B*5-1-B6-1-B16
Tx784	((B110 x FR2128-B/B104-1/CML343)-B-B-11-B-B-B-B/LAMA2002-42-B-B-B)-B-B-B-B-B-1-B2-1-B22
White	
Tx148	(CML379/CML311-B-1-B-B-B-B/Tx110)-B-1-B-1-B-B-1-B22-B14
Tx149	(CML450-B/Tx110)-B-3-B-1-B-B-1-1-B18-B21
Tx150	(CML442-B/CML343-B-B-B-B-B-B)-B-B-1-1-B-B-B-1-B12-1-B19
Tx151	(CML442-B/CML343-B-B-B-B-B-B)-B-B-1-1-B-B-B4-B22
Tx772W	((A633/Tx130)/A633-B5)-B3-B3-B5-B8-B5-B3-B5
Testers	
SS1 – SS6	Six different commercial testers in the stiff stalk grouping
NSS1 – NSS3	Three different commercial testers in the non-stiff stalk grouping
PHV63	Pioneer ex-PVP

Table 3: 2013 SERAT yield results (lbs per plot) demonstrating top yield in North Carolina (NC13) and College Station, TX (CS13). Other breeder's experimental lines in the test are denoted as *other#*.

TAMU LINE	**TESTER OR COMMERCIAL LINE**	**Significantly different with t-test connecting letters report**	**NC13**	**CS13**
	Commercial Check Avg.		27.4	17.1
Tx777	SS4	A	31.4	18.4
	P31G98	A B	31.1	18.3
Tx777	SS3	A B C	28.7	21.3
	DK697	A B C	28.6	17.4
	P31P41	A B C D	28.2	19.7
Tx779	SS3	A B C D E	27.3	16.3
Tx773	NSS2	A B C D E	27.1	17.3
	BH8740VTTP	A B C D E	26.8	16.1
Tx783	SS1	B C D E	26.2	16.1
Tx-unreleased	SS6	C D E	26.1	12.5
Tx149	SS1	C D E	25.8	17.1
	BH9051RR	C D E	25.7	13.9

		other1	C	D	E	F							25.4	19.5
unreleased	SS6		C	D	E	F							25.2	15.6
Tx149	SS4		C	D	E	F							25.2	16.0
		other2	C	D	E	F							25.1	16.9
		other3	C	D	E	F							24.9	16.9
		other4	C	D	E	F	G						24.7	15.9
Tx149	SS3		C	D	E	F	G						24.7	16.7
		other5	C	D	E	F	G						24.7	13.7
		other6	C	D	E	F	G	H					24.2	18.8
		other7	C	D	E	F	G	H	I				24.0	16.2
		other8	C	D	E	F	G	H	I				23.8	18.8
		other9		D	E	F	G	H	I				23.6	11.8
	BH8910RR/HX			D	E	F	G	H	I				23.6	17.1
		other10		D	E	F	G	H	I				23.4	15.7
		other11			E	F	G	H	I				22.5	15.1
		other12				F	G	H	I	J			20.6	15.5
		other13					G	H	I	J			19.8	10.8
		other14						H	I	J			19.4	11.7
Tx774	SS1								I	J			19.1	13.0
		other15								J	K		17.1	11.4
		other16								J	K		15.9	13.7
		other17									K		13.5	13.3
		other18									K		12.6	11.4
		other19										L	7.6	11.7