Texas Corn Producers Board

Project Final Report, Dec. 17, 2015

Project Title: Insect injury, yield, and economic return of Bt and drought tolerant corn under different water availability.

Project Number: SRS 1501734

Principal Investigator: Michael J. Brewer, Research Field Crops Entomologist, Texas A&M Research & Extension Center, Corpus Christi

Co-Prin. Investigators: Mac Young, Ext. Ag. Economist, Farm Assist Program, Corpus Christi, TX; Dana Porter, Ag. Engineering Specialist, Lubbock, TX.

Executive summary. Transgenic field corn expressing recent releases of stacked insecticidal proteins derived from *Bacillus thuringiensis* (Bt) have improved control of fall armyworm and corn earworm. In addition, water is becoming progressively less reliable with the recent wide swings in rainfall/drought episodes occurring throughout Texas, and irrigation constraints particularly associated with Texas High Plains aquifers. Drought tolerance is becoming available as an additional trait in corn hybrids. It is well known that water availability affects yield, and our 2014 research showed that yield and insect injury differs in water-stressed versus non water-stressed corn. Ear damage from corn earworm and fall armyworm increased as water stress increased, with the 50% crop ET treatment showing significantly more ear injury than the other water stress levels. The exception to this rule is the DK 65-81 with DroughtGard and Bt technology, which remained relatively consistent in ear injury through varying levels of water stress. Also, NK N78S 3111 with the advanced Bt trait had significantly less ear injury than the other hybrids; although the moderate insect pressure did not translate into a significant yield increase compared to the other hybrids. Sensitivity to insect feeding was seen under heavy water stress but was not seen in moderate water stress in 2014.The highest yields and cumulative cash flow were seen with the hybrids grown under a crop ET targeted replacement of 90%. . Of special note, the drought resistant hybrid DK65-81 GENDGVT2P provided a yield benefit and more stable economic return across all water regimes in 2014 and maintained its good performance in 2015 under no water stress. The benefits of the Bt technology used for insect control did not show consistent economic benefit under the moderate pressure recorded in both years. Better description of these shifts in insect control as affected by water stress, and the associated economic trade-offs of yield potential, benefits from insect control using transgenic corn, and input costs such as the additional technology cost of the Bt and drought-traited hybrids will help dryland and irrigated corn producers estimate economic return with these hybrids across water availability scenarios applicable across Texas.

Experimental background summary for 2014 and 2015. The test site at the Texas A&M AgriLife R&E Center, Corpus Christi was successfully established, all planned in-season measurements were taken, harvest has been completed, and data and economic analyses has been completed. In 2014, the main plot water regime treatments were successful due to the late planting coinciding with low rainfall for the area. Using above ground drip, we established a non-limiting (~90+% Crop ET) water condition, a slightly to moderately limiting (~70% Crop ET) water condition, and a moderately to severely limiting (~50% Crop ET) water condition. Data on rainfall and irrigation water inputs were processed to calculate water use efficiencies. Overall, we were near the 50% Crop ET target and under-achieved the higher 70% and 90+% targets, but a very good separation of soil moisture was achieved between the main plot treatments. In 2015, the highly unusual rains resulted in achieving only the 90% Crop ET water condition. Hybrids in a split plot were planted that were representative of best Bt technology available. Two hybrids with drought tolerance were planted. We were able to plant seven hybrids in 2014, two with the Leptra (Bt) gene and one without the gene with very similar background, two with the VT2P gene and one without the gene with very similar background, and two with drought tolerance. Discussion with Pioneer confirmed that the hybrid background they provided in 2014 was not well suited to South Texas conditions. These were P1319VYHR and P1498R and are not included in the summary below. In 2015, 9 hybrids were used, including two with drought tolerance, 6 with stacked Bt traits, and 3 comparators without BT or drought tolerant traits. (see table 1)

Measurements were in-season insect damage and plant height, aflatoxin (costs supported by a collaborator) and yield. Data were analyzed with ANOVA per the split plot design. The measurements for the hybrids in some cases behaved different across the water regimes; therefore the hybrids were compared separately for each water regime (Tukey's means separation test) (Table 1).

For economic analyses, the Financial And Risk Management (FARM) Assistance strategic planning model was used to evaluate the per acre economic returns of the hybrids. Scenarios simulated were based on the 7 hybrids and 3 moisture stress levels. Yield data from the field experiment were used. Seed costs were set based on estimates gleaned from current non-discounted costs. Examples of seed costs: DK66-97 and DK65-81 at $260/bag ($65/acre), DK66-94 at $230/bag ($57.50/acre). An average year market price was estimated comparing local prices to national average prices over the last five years. Based on a comparison of local to national average corn prices, the average local market price was determined to be a +$.25/bushel premium over the national average prices. This premium was added to the projected FAPRI (Food and Agricultural Policy Research Institute) national marketing year average prices for 2014-23. Average mean yields for each trial and moisture stress levels were based on actual results from the replicated trials. The base year for the 10-year analysis of the representative farm is 2014 and projections are carried through 2023. The projections for corn price trends follow projections provided by the Food and Agricultural Policy Research Institute (FAPRI, University of Missouri) with costs adjusted for inflation over the planning horizon. Net cash farm income (NCFI), one measure of profitability or net return, is the measure of used in this analysis to compare hybrids. While NCFI normally does not include non-cash items, estimated depreciation overhead costs from the Texas AgriLife Extension budget were included along with all estimated production and overhead costs.

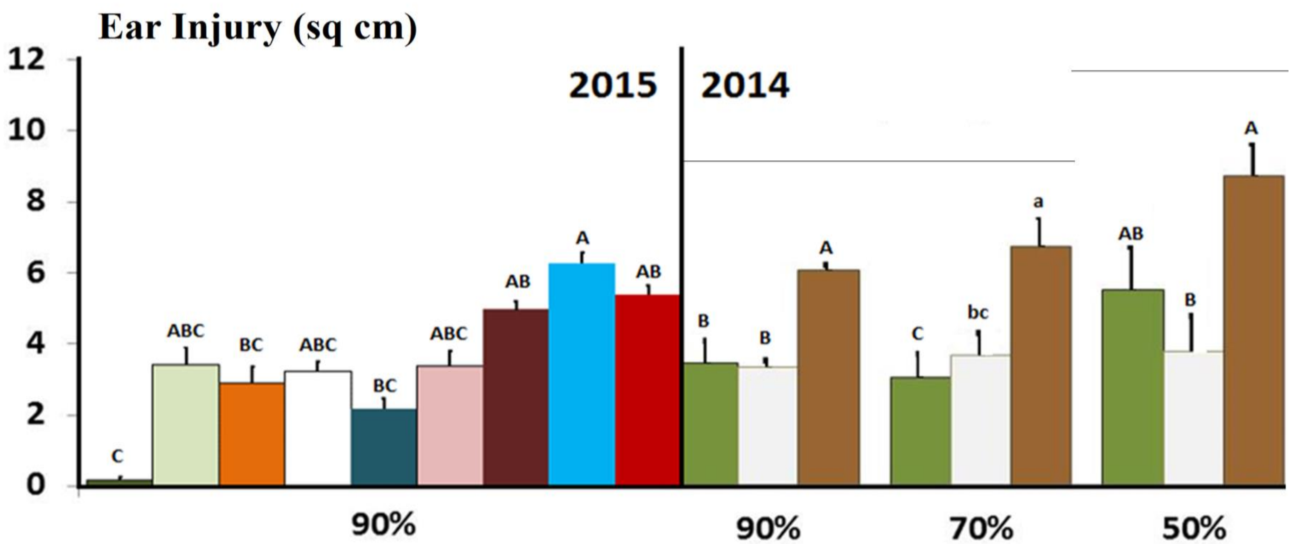
	Hybrid		Value-Added Trait	Bt Protein	Drought Tolerance	Days to Maturity
2014	DK 66-97		GENVT2P	cry1A.105 x cry 2Ab2	N/A	116
	DK 65-81		GENDGVT2P	cry1A.105 x cry2Ab2	DroughtGard	115
	DK 66-94		RR	N/A	N/A	116
2015	NK N78S		3111	cry1Ab x vip3Aa20	N/A	116
	DK 64-69		GENVT3P	cry1A.105 x cry 2Ab2	N/A	114
	BH 8688		DG2P	cry2Ab2	DroughtGard	114
	DK 65-81		GENDGVT2P	cry1A.105 x cry 2Ab2	DroughtGard	115
	DK 62-08		GENSS	cry1A.105 x cry1Fa2 x	N/A	112
	BH 8700		SS	cry1A.105 x cry1Fa2 x	N/A	115
	DK 67-55		RR2	N/A	N/A	117
	BH 8700		RR	N/A	N/A	115
	NK N78S		GT	N/A	N/A	116

Table 1. Hybrids and seed technology used in the 2014 and 2015 trials, the color coding matches the graphs in the results below. The color coding of hyrids is consistent across graphs below.

Results.

Ear damage. In 2014 ear damage from corn earworm and fall armyworm increased as water stress increased, with the 50% crop ET treatment showing significantly more ear injury than the other water stress levels. The exception to this rule is the DK 65-81 with DroughtGard and Bt technology, which remained relatively consistent in ear injury through varying levels of water stress. Ear injury caused by the fall armyworm and the corn earworm in 2015 was highly variable, with the exception NK N78S 3111 with the advanced Bt trait had significantly less ear injury than the other hybrids. Sensitivity to insect feeding was seen under heavy water stress but was not seen in moderate water stress in 2014.

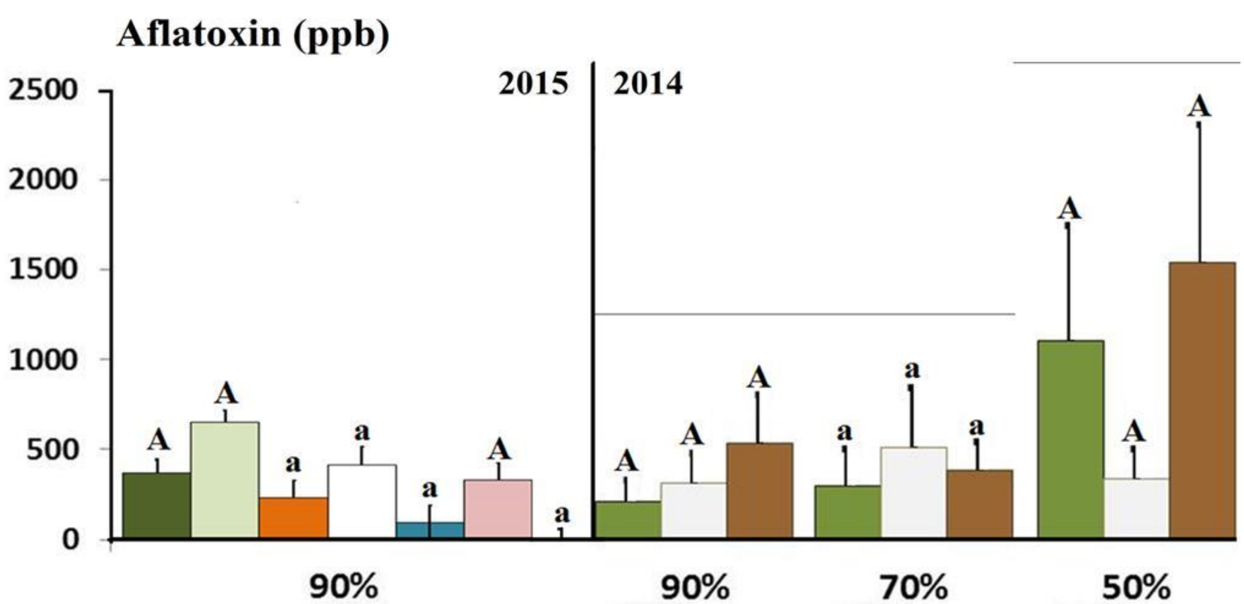
Fig. 1. Ear injury measured in sq cm of kernels eaten by corn earworm and fall armyworm. Means comparisons were done within water regimes (see letters in graphs), and water regimes were compared averaging across hybrids (see horizontal lines in graphs). The color coding of hyrids is consistent across graphs and the table above.



	Hybrid		Value-Added Trait
2014	DK 66-97		GENVT2P
	DK 65-81		GENDGVT2P
	DK 66-94		RR
2015	NK N78S		3111
	DK 64-69		GENVT3P
	BH 8688		DG2P
	DK 65-81		GENDGVT2P
	DK 62-08		GENSS
	BH 8700		SS
	DK 67-55		RR2
	BH 8700		RR
	NK N78S		GT

Aflatoxin. In 2014 aflatoxin levels increased as water availability decreased except again for DK 65-81 GENDGVT2P, which has the DroughtGard trait. In 2015, aflatoxin levels were extremely variable and levels commonly exceeded commercial concern. Aflatoxin levels in 2015 were unusually high and extremely variable, one possible explanation for this is that *A. flavus* was distributed in a nearby plot and this may have elevated our aflatoxin levels. The dairy/human use cut-off is 20 ppb and the feed use cut-off varies by species (about 300 ppb).

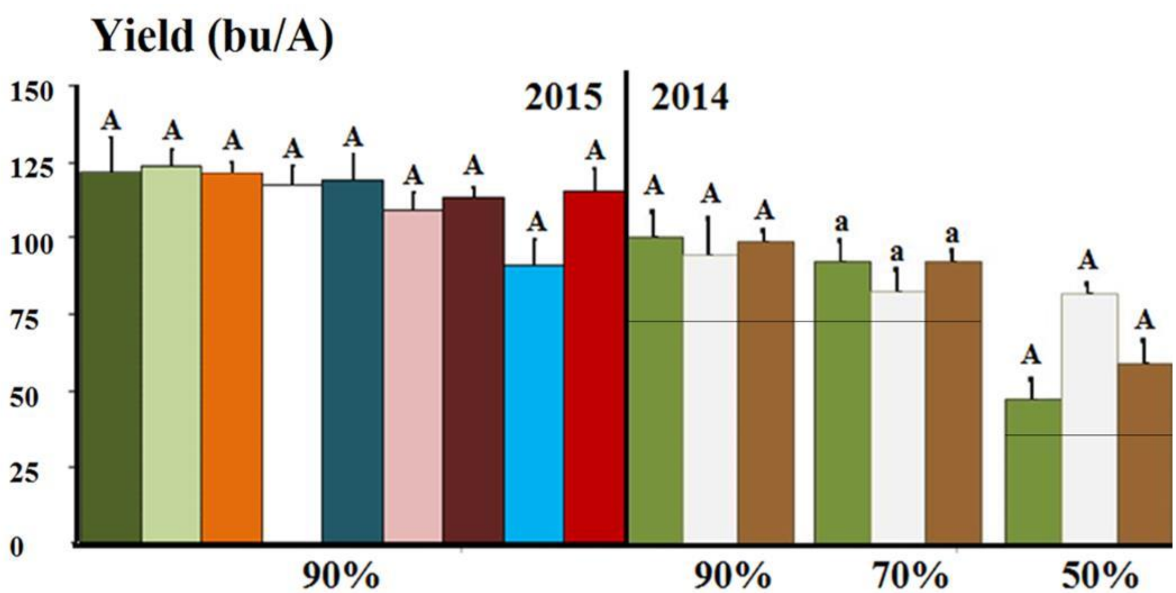
Fig. 2. Aflatoxin measured in harvested grain samples in parts per billion. Means comparisons were done within water regimes (see letters in graphs), and water regimes were compared averaging across hybrids (see horizontal lines in graphs). The color coding of hyrids is consistent across graphs and the table above.



	Hybrid		Value-Added Trait
2014	DK 66-97		GENVT2P
	DK 65-81		GENDGVT2P
	DK 66-94		RR
2015	NK N78S		3111
	DK 64-69		GENVT3P
	BH 8688		DG2P
	DK 65-81		GENDGVT2P
	DK 62-08		GENSS
	BH 8700		SS
	DK 67-55		RR2
	BH 8700		RR
	NK N78S		GT

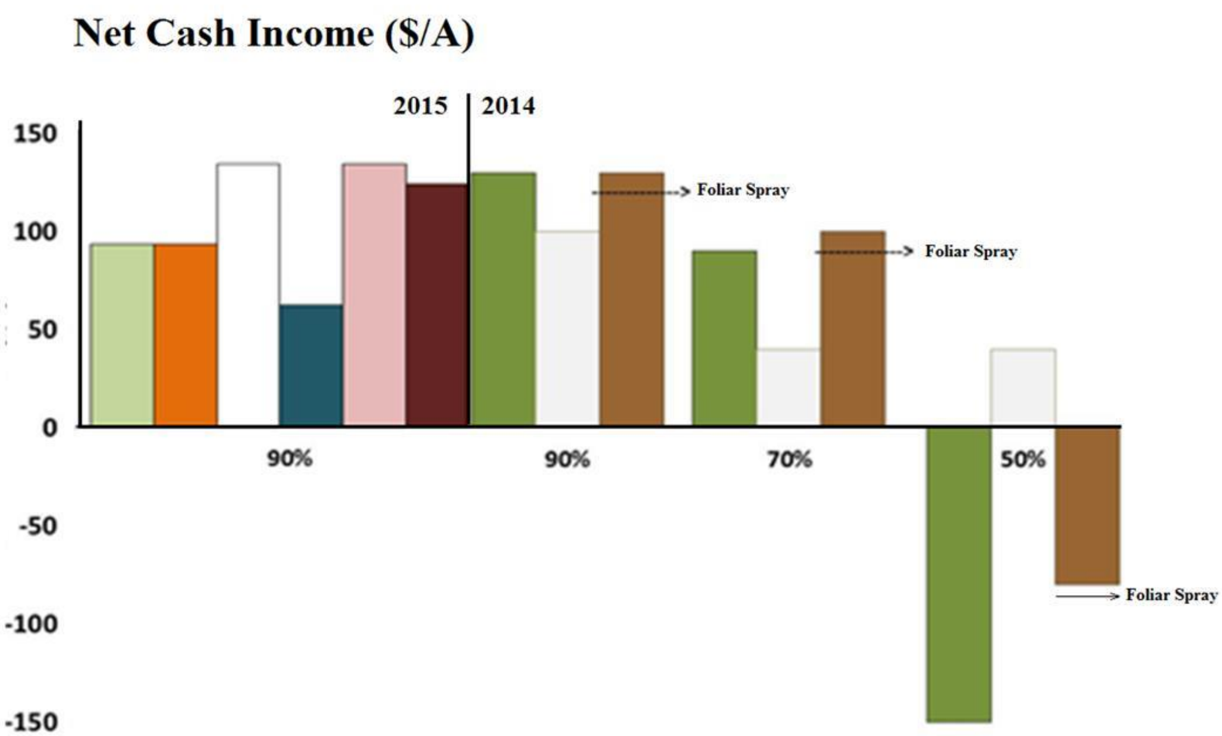
Yield. In 2014, hybrid yields grown under 70% to 90% crop ET had fairly consistent yields. However, the yields were lower when grown under irrigation targeting 50% crop ET. In 2015 Bt traits had variable yields under non water-stressed conditions: all hybrids produced 90 to 125 bu/acre corn with no differences detected.

Fig. 3. Yield measured in bushels per acre adjusted at 14% moisture. Means comparisons were done within water regimes (see letters in graphs), and water regimes were compared averaging across hybrids (see horizontal lines in graphs). The color coding of hyrids is consistent across graphs and the table above.



	Hybrid		Value-Added Trait
2014	DK 66-97		GENVT2P
	DK 65-81		GENDGVT2P
	DK 66-94		RR
2015	NK N78S		3111
	DK 64-69		GENVT3P
	BH 8688		DG2P
	DK 65-81		GENDGVT2P
	DK 62-08		GENSS
	BH 8700		SS
	DK 67-55		RR2
	BH 8700		RR
	NK N78S		GT

Net cash income. To better consider economic value of the technologies, yield and net cash income were re-assorted by the estimated additional seed cost per cost associated with the Bt and/drought tolerance traits. The highest yields and cumulative cash flow were seen with the hybrids grown under a crop ET targeted replacement of 90%. . Of special note, the drought resistant hybrid DK65-81 GENDGVT2P provided a yield benefit and more stable economic return across all water regimes in 2014 and maintained its good performance in 2015 under no water stress. The benefits of the Bt technology used for insect control did not show consistent economic benefit under the moderate pressure recorded in both years.



	Hybrid		Value-Added Trait
2014	DK 66-97		GENVT2P
	DK 65-81		GENDGVT2P
	DK 66-94		RR
2015	NK N78S		3111
	DK 64-69		GENVT3P
	BH 8688		DG2P
	DK 65-81		GENDGVT2P
	DK 62-08		GENSS
	BH 8700		SS
	DK 67-55		RR2