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ENTOMOLOGY SERIES

TIMELY INFORMATION
Agriculture & Natural Resources

Performance of *B.t.* Corn in Central and South Alabama in 2010 (revised)

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Background: There are different kinds of *B.t.* corn,* depending on which *B.t.* genes have been inserted. Some *B.t.* genes protect against stalk borers, others help prevent leaf and ear damage from various caterpillars including corn earworm and fall armyworm. Still other genes protect the roots from western corn rootworm. These genes are bundled together in various combinations, with or without herbicide tolerance genes. See Table 3 for details regarding transgenic products that include *B.t.* insect resistance.

The cost of *B.t.* technology that protects against corn borers and other caterpillars is about $3.70 per acre for products such as YieldGard Corn Borer, Agrisure CB/LL, and Herculex I. The cost of Genuity VT Triple PRO is about $10.50 per acre. Genuity VT Triple PRO contains two genes for above-ground caterpillar resistance, in addition to protection from western corn rootworm.

B.t. corn is really a form of crop insurance that comes in the seed bag. The presence of one or more *B.t.* genes in a corn hybrid will not increase yield potential. Instead, the gene(s) prevent yield losses from certain insects. Therefore, the most important thing to remember is that if the population of the target insect in your field or area is high enough to cause damage, *B.t.* corn will pay off. If the "insect pressure" is not there, then you won't get your money back. So it is a matter of deciding if the risk is high enough to warrant purchasing "insurance."

In 2010 a series of field trials included *B.t.* corn hybrids paired with their non-*B.t.* counterparts (isolines). Four *B.t.* corn traits were tested in 2010: Genuity VT Triple PRO, Herculex I, YieldGard Corn Borer, and YieldGard VT Triple (see Table 3 at the end of this document). This document summarizes the yield results from the Central and Southern Alabama trials, which were not infested with corn borers. An additional document discusses the performance of *B.t.* corn in North Alabama, where there was high pressure from southwestern corn borer and European corn borer.

*Corn that contains insect resistance genes from the bacterium *Bacillus thuringiensis*

Experimental Design: Seven experiments were located in Prattville, Tallassee, Fairhope, or Headland, Alabama in 2010. Each test included hybrid pairs from the same genetic family, RR2 alone or RR2 plus a *B.t.* trait (isolines). Plot size and row spacing varied with location (see Appendix). Each hybrid was replicated four to six times in each test. Only one hybrid pair was common to all six tests. All seed was treated with clothianidin (Poncho or Acceleron) at the rate of 250 mg. a.i./kernel.

Results:

Hybrid performance. Average yields in Tallassee ranged from 83 to 142 Bu/A (Table 1). Average yields in the Fairhope tests ranged from 106 to 142 Bu/A. Average yields in Headland ranged from 139 to 200 Bu/A. In Prattville, yields ranged from 86-92 Bu/A in the standard planting date, and from 26-45 Bu/A when corn was planted later (six weeks after standard planting date).

In five of seven test locationss, Genuity VT Triple PRO hybrids consistently yielded more than their non-*B.t.* counterparts (Table 2). These differences were not always statistically significant (Table 1). In four of seven test locations, Herculex I hybrids consistently yielded more than their non-*B.t.* counterparts, although again, these differences were not always statistically significant. Corn containing the YieldGard Corn Borer or YieldGard VT Triple traits did not consistently yield more than their non-*B.t.* counterparts.

What caused the difference in yields between *B.t.* and non-*B.t.* hybrids? Differences may have been due to the presence of various caterpillars, including but not limited to fall armyworm and corn earworm. In 2010, fall armyworm populations were much higher than usual in Central and Southern Alabama. Herculex I and Genuity VT Triple PRO hybrids provide better fall armyworm control than non-*B.t.* hybrids or YieldGard Corn Borer hybrids (Fig. 1, Table 3). In Prattville, Herculex I and Genuity VT Triple PRO hybrids tended to provide higher stand counts than non-*B.t.* hybrids (Fig. 2, Table 3). Genuity VT Triple PRO hybrids provided better protection from corn earworm damage to the ear than Herculex I, YieldGard corn borer, or non-*B.t.* hybrids (Fig. 3).

Will *B.t.* corn pay off? Table 2 shows the estimated economic returns from planting a hybrid containing a *B.t.* corn trait in Central and Southern Alabama at varying corn prices. This data is reported on a farm wide basis, where 80% of the corn could legally be planted to Genuity VT Triple PRO, or 50% could be legally planted to the other *B.t.* hybrids.

Using $4 corn as an example, the median estimated economic return above the cost of the technology, was $19.44 per acre for Genuity VT Triple PRO and $8.85 per acre for Herculex I. A loss of $11.85 per acre was estimated for the YieldGard Corn Borer or YieldGard VT Triple hybrids. Estimated economic returns ranged from a loss of $42 to a profit of $118 per acre for Genuity VT Triple PRO, a loss of $80 to a profit of $47 per acre for Herculex I, and a loss of $55 to a profit of $14 per acre for the YieldGard Corn Borer or YieldGard VT Triple hybrids. Note that the "economic return" does not include other costs of production. For example, even though the *B.t.* technology would have apparently paid for itself at Prattville on the late planting date, the best yielding hybrid averaged only 45 Bu/A, which would not have been profitable when other production costs are factored in.

What is New for 2011? SmartStax hybrids will be more widely available in 2011 (Table 3). SmartStax, developed jointly by Monsanto and Dow, is effectively a combination of the GENVT3P and HXX products. Some hybrids will contain the Agrisure Viptera 3111 or Agrisure 3110 products. These products will provide greater control of corn earworm than the older products. It remains to be seen if the additional control will result in higher yields.

Table 1. Corn Yields from Replicated Field Plots in Central and Southern Alabama, 2010.

			Yield at 15.5% moisture (Bu/A)						
Hybrid Family	Hybrid	*B.t.* Trait*	Tallassee	Fairhope Variety	Fairhope Aflatoxin	Headland Variety	Headland Aflatoxin	Prattville Standard Planting	Prattville Late Planting
Pioneer 33V15	Pioneer 33V14	Non-*B.t.*	113 NS	114 gh	-	159 fg	145 ab	-	-
	Pioneer 33V16	YGCB	116	122 def	-	153 gh	139 b	-	-
DK697	DKC 69-72	Non-*B.t.*	128 S	136 abc	-	193 ab	-	-	-
	DKC 69-71	YGCB	101	131 abcd	-	177 bcde	-	-	-
DKC 69-43	DKC 69-43	Non-*B.t.*	-	114 gh	-	168 cdefg	170 ab	-	-
	DKC 69-40	VT3	-	118 fgh	-	167 defg	163 ab	-	-
SS775**	Southern States 775	Non-*B.t.*	-	-	-	179 bcde	-	-	-
	Southern States 777	VT3	-	-	-	182 abcd	-	-	-
Pioneer 31P41	Pioneer 31P40	Non-*B.t.*	102 NS	106 h	-	167 defg	-	87 a	28 b
	Pioneer 31P42	HXI	104	129 bcd	-	182 abcd	-	91 a	31 b
Pioneer 33M54	Pioneer 33M53	Non-*B.t.*	94 NS	132 bcd	138 a	176 bcdef	142 b	-	-
	Pioneer 33M57	HXI	99	142 a	138 a	176 bcdef	166 ab	-	-
	Pioneer 33M52	HXI	83	135 abc	-	161 efg	-	-	-
Pioneer 31D58	Pioneer 31D57	Non-*B.t.*	103 NS	106 h	-	168 cdefg	-	-	-
	Pioneer 31D59	HXI	109	126 cde	-	183 abcd	-	-	-
Pioneer 33F85	Pioneer 33F85	Non-*B.t.*	-	-	-	175 bcdef	-	-	-
	Pioneer 33F87	HXI	-	-	-	136 h	-	-	-
SS775	Southern States 775	Non-*B.t.*	102 S	119 efg	-	179 bcde	-	92 a	33 ab
	Southern States 749	GENVT3P	142	137 ab	-	169 cdefg	-	84 a	45 a
DKC 67-22	DKC 67-22	Non-*B.t.*	113 NS	113 gh	-	189 abc	-	-	-
	DKC 67-21	GENVT3P	121	131 abcd	-	194 ab	-	-	-
DKC 67-86	DKC 67-86	Non-*B.t.*	100 NS	114 fgh	131 a	193 ab	173 ab	89 a	26 b
	DKC 67-88	GENVT3P	122	140 abc	140 a	200 a	179 a	86 a	35 ab
SS804	SS804	Non-*B.t.*	-	-	-	176 bcdef	-	-	-

NS= no statistical difference within a hybrid pair (Tallassee). At other locations, means within a column are not significantly different if they are followed by the same letter.

*All Non-*B.t.* hybrids were glyphosate resistant

**SS775 listed twice, in order to see comparison with different *B.t.* types (VT3 or GENVT3P).

Table 2. Estimated Farm-wide Profit From Planting *B.t.* Corn Hybrids in Central and Southern Alabama, 2010.

Test Location*	Hybrid family	Yield (Bu/A) *B.t.*	Yield (Bu/A) Non-*B.t.*	*B.t.* yield advantage (Bu/A)	Farm wide profit ($) if corn price is $2/Bu	$4/Bu	$6/Bu
YieldGard Corn Borer or YieldGard VT Triple (Cry 1Ab protein)							
Fairhope V	DK 697	131.0	136.0	-5.0	-6.85	-11.85	-16.85
Headland V	DK 697	176.7	193.3	-16.6	-18.45	-35.05	-51.65
Tallassee	DK 697	100.9	127.7	-26.8	-28.65	-55.45	-82.25
Fairhope V	Pioneer 33V15	122.0	114.0	8.0	6.15	14.15	22.15
Headland A	Pioneer 33V15	139.1	145.0	-5.9	-7.80	-13.75	-19.70
Headland V	Pioneer 33V15	152.7	158.8	-6.1	-7.95	-14.05	-20.15
Tallassee	Pioneer 33V15	115.8	112.8	3.0	1.15	4.15	7.15
Fairhope V	DKC 69-43	118.0	114.0	4.0	2.15	6.15	10.15
Headland A	DKC 69-43	163.0	170.1	-7.1	-8.97	-16.09	-23.21
Headland V	DKC 69-43	167.4	168.4	-1.0	-2.85	-3.85	-4.85
Headland V	SS775	181.9	179.4	2.5	0.65	3.15	5.65
Median Economic Return					**-6.85**	**-11.85**	**-16.85**
Herculex I **(Cry 1F protein)**							
Fairhope V	Pioneer 31D58	126.0	106.0	20.0	18.15	38.15	58.15
Headland V	Pioneer 31D58	183.5	168.4	15.1	13.25	28.35	43.45
Tallassee	Pioneer 31D58	109.4	103.2	6.2	4.35	10.55	16.75
Fairhope V	Pioneer 31P41	129.0	106.0	23.0	21.15	44.15	67.15
Headland V	Pioneer 31P41	182.1	167.1	15.0	13.15	28.15	43.15
Tallassee	Pioneer 31P41	103.6	102.3	1.3	-0.55	0.75	2.05
Prattville SP	Pioneer 31P41	91.1	86.6	4.5	2.65	7.15	11.65
Prattville LP	Pioneer 31P41	31.1	27.6	3.5	1.65	5.15	8.65
Headland V	Pioneer 33F85	136.4	175.4	-39.0	-40.85	-79.85	-118.85
Fairhope A	Pioneer 33M54	138.5	137.8	0.7	-1.15	-0.45	0.25
Fairhope V	Pioneer 33M54	138.5	132.0	6.5	4.65	11.15	17.65
Headland A	Pioneer 33M54	166.4	142.1	24.3	22.40	46.65	70.90
Headland V	Pioneer 33M54	168.5	176.4	-7.9	-9.75	-17.65	-25.55
Tallassee	Pioneer 33M54	91.0	94.3	-3.3	-5.15	-8.45	-11.75
Median Economic Return					**3.00**	**8.85**	**14.20**

Table 2. (cont.)

Test Location*	Hybrid family	Yield (Bu/A) *B.t.*	Yield (Bu/A) Non-*B.t.*	*B.t.* yield advantage (Bu/A)	Farm wide profit ($) if corn price is $2/Bu	$4/Bu	$6/Bu
Genuity VT Triple PRO **(Cry1A.105 and Cry 1Ab proteins)**							
Fairhope V	DKC 67-22	131.0	113.0	18.0	20.40	49.20	78.00
Headland V	DKC 67-22	193.7	187.8	5.9	1.04	10.48	19.92
Tallassee	DKC 67-22	120.9	112.6	8.3	4.88	18.16	31.44
Fairhope A	DKC 67-86	140.0	131.3	8.7	5.52	19.44	33.36
Fairhope V	DKC 67-86	140.0	114.0	26.0	33.20	74.80	116.40
Headland A	DKC 67-86	178.9	173.4	5.5	0.40	9.20	18.00
Headland V	DKC 67-86	200.2	193.0	7.2	3.12	14.64	26.16
Tallassee	DKC 67-86	122.0	100.5	21.5	26.00	60.40	94.80
Prattville SP	DKC 67-86	86.4	89.2	-2.8	-12.88	-17.36	-21.84
Prattville LP	DKC 67-86	34.9	26.1	8.8	5.68	19.76	33.84
Fairhope V	SS775	137.0	119.0	18.0	20.40	49.20	78.00
Headland V	SS775	168.9	179.4	-10.5	-25.20	-42.00	-58.80
Tallassee	SS775	141.8	102.4	39.4	54.64	117.68	180.72
Prattville SP	SS775	83.7	91.6	-7.9	-21.04	-33.68	-46.32
Prattville LP	SS775	45.1	33.1	12.0	10.80	30.00	49.20
Median Economic Return					**5.52**	**19.44**	**33.36**

*Fairhope V= Fairhope *B.t.* Variety Test, Fairhope A= Fairhope Aflatoxin test; *Headland V= Headland *B.t.* Variety Test, Headland A= Headland Aflatoxin test; Prattville SP=standard planting date, Prattville LP=late planting date

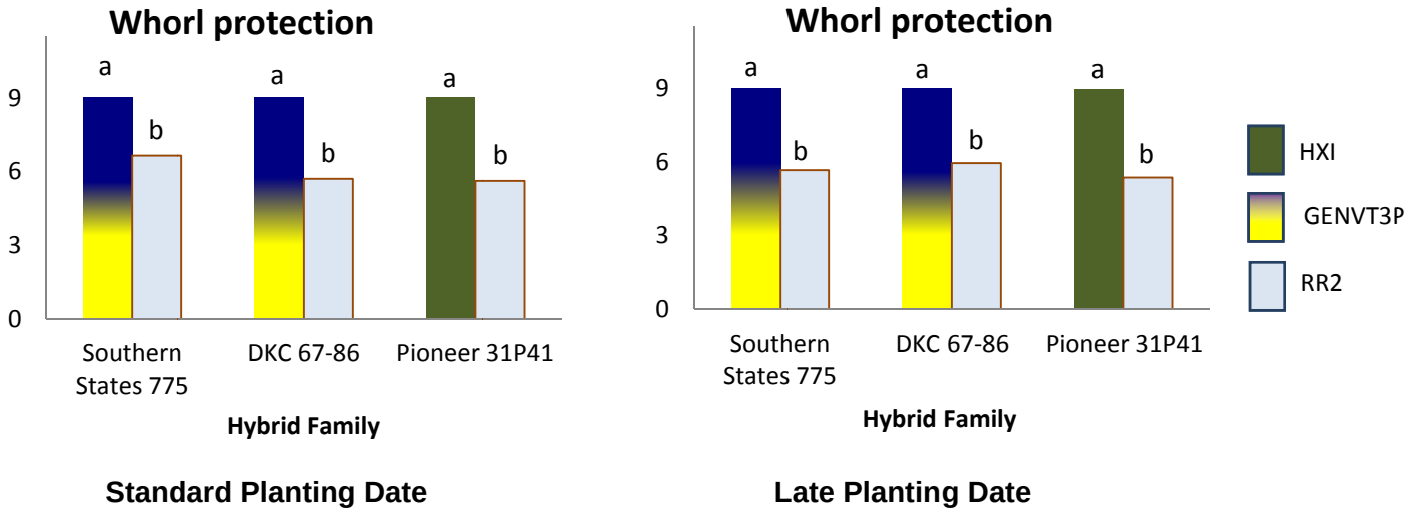

Figure 1. Amount of caterpillar damage in whorl stage corn, Prattville, AL, 2010. 9=No damage, plants protected from caterpillars; 1=severe defoliation, plants not protected from caterpillar damage. Within a planting date, bars with the same letters are not significantly different, *P*=0.05, LSD.

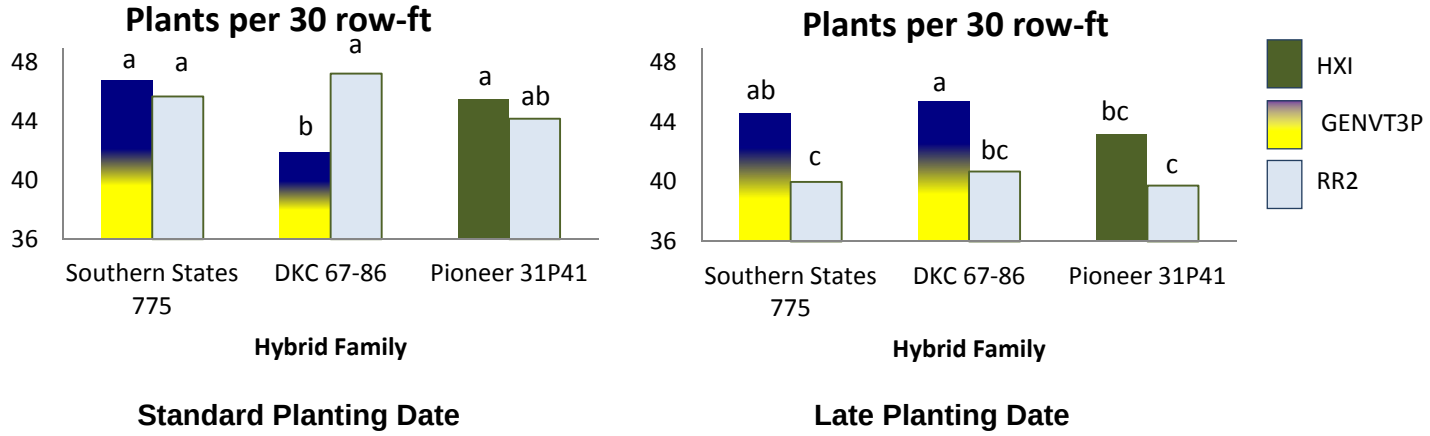

Figure 2. Number of plants per 30 row-ft, Prattville, AL, 2010, at standard and late planting dates. Within a planting date, bars with the same letters are not significantly different, *P*=0.05, LSD.

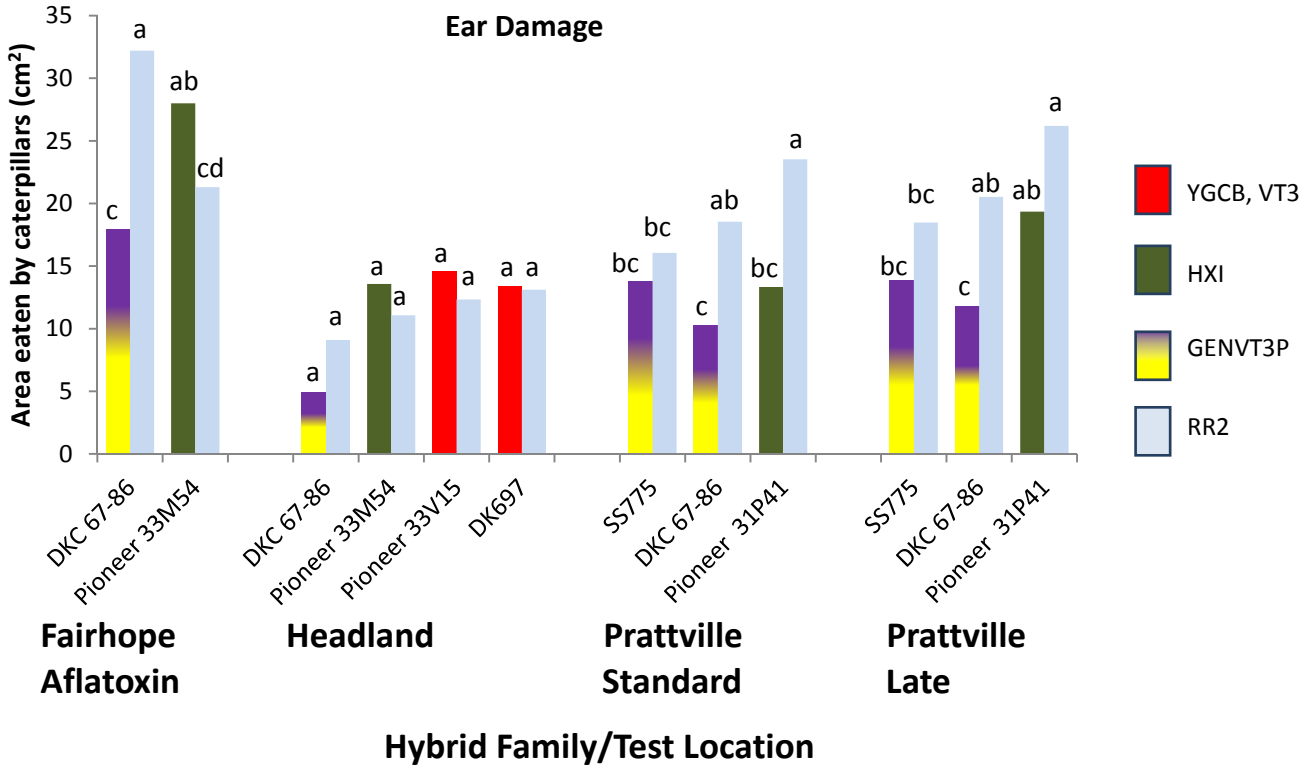

Figure 3. Ear damage caused by caterpillars, Fairhope, Prattville, and Headland AL, 2010. Within a test, bars with the same letters are not significantly different, *P*=0.05, LSD.

Summary

Always pick hybrids that are well adapted for your farm and make sure the hybrid has good disease resistance. Always consider the yield potential of the hybrid family involved. Then think about what other value-added traits are available, such as herbicide resistance or *B.t.* corn technology. Results from the 2010 yield trials showed that insect pressure was high enough for Genuity VT Triple PRO and Herculex I to have paid off in most locations in Central and Southern Alabama. The exceptions were in the Headland Variety test and the Prattville Standard Planting Date test. Always use caution when looking at data from a single year. More tests will be conducted in 2011.

These tests were funded by grants from the Alabama Wheat and Feed Grain Committee.

Table 3. Relative Efficacy of Various *B.t.* Corn Products (with Emphasis on the Southeastern United States). Version 2011.1[1]

Product Trade Name (Abbreviation)	Corn Earworm (ear)	Fall Army-worm (whorl)	Corn Borers [2] (stalk)	Western Corn Root-worm [3] (roots)	Black Cutworm (seedling)[4]	Lesser Corn-stalk Borer [5]	Refuge Require ment [6]	Original Target Pests (*B.t.* Protein)	Event(s)
***B.t.* Corn for Controlling Above-Ground Caterpillars (Lepidoptera) and Below-Ground Rootworms (Coleoptera)**									
Agrisure Viptera 3111	Excellent	Excellent	Excellent	Fair-Good	Good	Good	20%	Corn earworm, western bean cutworm, black cutworm, and fall armyworm control (Vip3Aa20), corn borer protection (Cry1Ab), Liberty (glufosinate) and Roundup (glyphosate) herbicide tolerance and corn rootworm protection (mCry3A)	MIR162, Bt11, GA21, MIR604
Agrisure 3000GT	Fair	Good	Excellent	Fair-Good	Poor	Good	50%	Corn borer protection (Cry1Ab), Corn rootworm protection (mCry3A), glyphosate herbicide tolerance, Liberty (glufosinate) herbicide tolerance	Bt11, MIR604, GA21
Agrisure CB/LL/RW	Fair	Good	Excellent	Fair-Good	Poor	Good	50%	Corn borer protection (Cry1Ab), Corn rootworm protection (mCry3a), Liberty (glufosinate) herbicide tolerance	Bt11, MIR604
Genuity SmartStax (GENSS) or DowAgro Sciences SmartStax (SSX)	Very Good	Excellent	Excellent	Excellent	Good	Very Good	20%	Corn borer, fall armyworm, corn earworm, western bean cutworm, black cutworm protection (Cry1A.105, Cry2Ab2, Cry1F), Corn rootworm protection (Cry3Bb1, Cry34Ab1/Cry35Ab1), Roundup (glyphosate) and Liberty (glufosinate) herbicide tolerance	MON89034, MON88017, TC1507, DAS-59122-7
Genuity VT Triple PRO (GENVT3P)	Good-Very Good	Excellent	Excellent	Excellent	Poor	Very Good	20%	Corn borer, fall armyworm, corn earworm protection (Cry1A.105 and Cry2Ab2), Corn rootworm protection (Cry3Bb1), Roundup (glyphosate) herbicide tolerance	MON89034, MON88017
Herculex XTRA (HXX)	Poor	Very Good	Excellent	Excellent	Good	Very Good	50%	Corn borer, western bean cutworm, black cutworm and fall armyworm resistance (Cry1F), Corn rootworm resistance (Cry34Ab1/Cry35Ab1), Liberty (glufosinate) herbicide tolerance	TC 1507, DAS-59122-7
YieldGard Plus (YGPL)	Fair	Good	Excellent	Good	Poor	Good	50%	Corn borer protection (Cry1Ab), Corn rootworm protection (Cry3Bb1)	MON810, MON863
YieldGard VT Triple (VT3)	Fair	Good	Excellent	Excellent	Poor	Good	50%	Corn borer protection (Cry1Ab), Corn rootworm protection (Cry3Bb1), Roundup (glyphosate) herbicide tolerance	MON810, MON88017
***B.t.* Corn for Controlling Above-Ground Caterpillars (Moths, Lepidoptera)**									
Agrisure CB/LL	Fair	Good	Excellent	None	Poor	Good	50%	Corn borer protection (Cry1Ab), Liberty (glufosinate) herbicide tolerance	Bt11

Table 3. (cont.)

Product Trade Name (Abbreviation)	Corn Earworm (ear)	Fall Army-worm (whorl)	Corn Borers [2] (stalk)	Western Corn Root-worm [3] (roots)	Black Cutworm (seedling)[4]	Lesser Corn-stalk Borer [5]	Refuge Require ment [6]	Original Target Pests (*B.t.* Protein)	Event(s)
***B.t.* Corn for Controlling Above-Ground Caterpillars (Moths, Lepidoptera) (continued)**									
Agrisure Viptera 3110	Excellent	Excellent	Excellent	None	Good	Good	20%	Corn earworm, western bean cutworm, black cutworm, and fall armyworm control (Vip3Aa20), corn borer protection (Cry1Ab), Liberty (glufosinate) and glyphosate herbicide tolerance	MIR162, Bt11, GA21
Genuity VT Double PRO (GENVT2P)	Good-Very Good	Excellent	Excellent	None	Poor	Very good	20%	Corn borer, fall armyworm, corn earworm protection (Cry1A.105 and Cry2Ab2), Roundup (glyphosate) herbicide tolerance	MON89034, NK603
Herculex I (HXI)	Poor[7]	Very Good	Excellent	None	Good	Very good	50%	Corn borer, western bean cutworm, black cutworm and fall armyworm resistance (Cry1F), Liberty (glufosinate) herbicide tolerance	TC 1507
YieldGard Corn Borer (YGCB)	Fair	Good	Excellent	None	Poor	Good	50%	Corn borer protection (Cry1Ab)	MON810
***B.t.* Corn for Controlling Below-Ground Rootworms (Beetles, Coleoptera)**									
Agrisure RW	None	None	None	Fair-Good	None	None	20%	Corn rootworm protection (mCry3A)	MIR604
Herculex RW (HXRW)	None	None	None	Excellent	None	None	20%	Corn rootworm resistance (Cry34Ab1/Cry35Ab1) Liberty (glufosinate) herbicide tolerance)	DAS-59122-7
YieldGard Rootworm (YGRW)	None	None	None	Good	None	None	20%	Corn rootworm protection (Cry3Bb)	MON863
YieldGard VT Rootworm/RR2 (VTRR2)	None	None	None	Excellent	None	None	20%	Corn rootworm protection (Cry3Bb1) Roundup (glyphosate) herbicide tolerance	MON88017

[1] Most of these insect resistant products are marketed as stacks with herbicide resistant products.
[2] Southwestern corn borer, European corn borer, and sugarcane borer.
[3] There are several species of corn rootworm in the Southeast. Southern corn rootworm is the most prevalent species. These "rootworm" products are not effective against southern corn rootworm. They are effective against western corn rootworm larvae, which occur in areas such as north Alabama and north Georgia
[4] Based on limited data
[5] Lepidopteran *B.t.* traits do not specifically list lesser cornstalk borer as a target pest
[6] See product Insect Resistance Management (IRM) documentation from the seed companies for more details.
[7] The meaning of these terms is somewhat arbitrary. Excellent usually means better than 95 percent control. Poor means about 30% control. Rankings are meant to be relative.

Originally published in Alabama Cooperative Extension System Corn IPM Guide, a chapter of the Alabama Pesticide Handbook (http://www.aces.edu/pubs/docs/A/ANR-500-A). Based on input from the Southern Corn Insect Working Group who meet at the Annual Meeting of the Southeastern Branch, Entomological Society of America.

Appendix: Planting Details

Planting Details

Test	Planting Date	Plot Size	Row Spacing	Irrigation	No. Replications
Fairhope Variety	March 31	2 rows by 25 ft	38 inches	no	6
Fairhope Aflatoxin	March 29	8 rows by 30 ft	38 inches	no	4
Headland Aflatoxin	April 1	8 rows by 30 ft	36 inches	yes	4
Headland Variety	April 1	4 rows by 30 ft	36 inches	yes	6
Tallassee	April 6	4 rows by 25 ft	36 inches	yes	6
Prattville Standard	April 5	8 rows by 30 ft	36 inches	no	4
Prattville Late	May 12	8 rows by 30 ft	36 inches	no	4