

## Field-Scale Studies Comparing the Base Genetics of Corn Hybrids with Double and Triple-Stacked Hybrids.

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The first genetically engineered (GE) corn hybrid, commercialized in 1996, expressed a Bt toxin that targeted European corn borer. A hybrid with resistance to Roundup

was released in 1997, followed by a hybrid with resistance to the herbicide, glufosinate, in 1998. Another Bt hybrid to control corn rootworm was introduced in 2003.

**Table 1. Genetically engineered (GE) corn hybrids by selected states and in the United States, 2000-2008**

State	Insect-resistant (Bt) only									Herbicide-tolerant only								
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2000	2001	2002	2003	2004	2005	2006	2007	2008
	<i>Percent of all corn planted</i>									<i>Percent of all corn planted</i>								
Illinois	13	12	18	23	26	25	24	19	13	3	3	3	4	5	6	12	15	15
Indiana	7	6	7	8	11	11	13	12	7	4	6	6	7	8	11	15	17	16
Iowa	23	25	31	33	36	35	32	22	16	5	6	7	8	10	14	14	19	15
Kansas	25	26	25	25	25	23	23	25	25	7	11	15	17	24	30	33	36	30
Michigan	8	8	12	18	15	15	16	19	15	4	7	8	14	14	20	18	22	24
Minnesota	28	25	29	31	35	33	28	26	19	7	7	11	15	17	22	29	32	29
Missouri	20	23	27	32	32	37	38	30	27	6	8	6	9	13	12	14	19	21
Nebraska	24	24	34	36	41	39	37	31	27	8	8	9	11	13	18	24	23	24
North Dakota 1/						21	29	29	24						39	34	37	34
Ohio	6	7	6	6	8	9	8	9	12	3	4	3	3	4	7	13	12	17
South Dakota	35	30	33	34	28	30	20	16	7	11	14	23	24	30	31	32	34	30
Texas 1/						21	27	22	20						42	37	37	31
Wisconsin	13	11	15	21	22	22	22	19	14	4	6	9	9	14	18	18	23	26
Other States 2/	10	11	14	17	19	19	20	20	20	6	8	12	17	21	19	25	33	32
U.S.	18	18	22	25	27	26	25	21	17	6	7	9	11	14	17	21	24	23
State	Stacked gene varieties									All GE varieties								
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2000	2001	2002	2003	2004	2005	2006	2007	2008
	<i>Percent of all corn planted</i>									<i>Percent of all corn planted</i>								
Illinois	1	1	1	1	2	5	19	40	52	17	16	22	28	33	36	55	74	80
Indiana	*	*	*	1	2	4	12	30	55	11	12	13	16	21	26	40	59	78
Iowa	2	1	3	4	8	11	18	37	53	30	32	41	45	54	60	64	78	84
Kansas	1	1	2	5	5	10	12	21	35	33	38	43	47	54	63	68	82	90
Michigan	*	2	2	3	4	5	10	19	33	12	17	22	35	33	40	44	60	72
Minnesota	2	4	4	7	11	11	16	28	40	37	36	44	53	63	66	73	86	88
Missouri	2	1	2	1	4	6	7	13	22	28	32	34	42	49	55	59	62	70
Nebraska	2	2	4	5	6	12	15	25	35	34	34	46	52	60	69	76	79	86
North Dakota 1/						15	20	22	31						75	83	88	89
Ohio	*	*	*	*	1	2	5	20	37	9	11	9	9	13	18	26	41	66
South Dakota	2	3	10	17	21	22	34	43	58	48	47	66	75	79	83	86	93	95
M7Texas 1/						9	13	20	27						72	77	79	78
Wisconsin	1	1	2	2	2	6	10	22	35	18	18	26	32	38	46	50	64	75
Other States 2/	1	1	2	2	6	6	10	14	22	17	20	27	36	46	44	55	67	74
U.S.	1	1	2	4	6	9	15	28	40	25	26	34	40	47	52	61	73	80

\* Less than 1 percent.

1/ Estimates published individually beginning in 2005.

2/ Includes all other States in the corn estimating program.

## Crop Management

**Table 2. Corn yields of the base genetics and the double and triple-stacked corn hybrids, averaged across two companies, on four fields in a corn-corn rotation in New York in 2007 and 2008.**

Hybrid	Cayuga	Livingston	Jefferson	Onondaga	Mean
<b>2007</b>					
<b>Bu/acre</b>					
Base Genetics	161	188	114	190	163
Double-Stacked	161	197	122	184	166
Triple-Stacked	166	191	125	195	169
LSD 0.05	NS	6	10	NS	5
<b>2008</b>					
Base Genetics	184	203	165	159	178
Double-Stacked	181	200	176	179	184
Triple-Stacked	185	205	169	166	181
LSD 0.05	NS	NS	11	5	3

Adoption rates of Roundup Ready corn were initially slow as indicated by only 7% acreage in the USA in 2001 (Table 1). Early-season weed pressure before Roundup application can significantly reduce yields so growers were probably reluctant to adopt Roundup Ready corn. European corn borer, a key pest in the Western Corn Belt and the Southeast, is an occasional pest in Eastern and Northern regions so the adoption was low in those states, resulting in only 18% adoption of Bt corn in the USA by 2001 (Table 1).

Corn rootworm, however, is a destructive and consistent pest in continuous corn fields in all regions. Consequently, Bt corn for corn rootworm control contributed greatly to increased acreage of GE corn since its 2003 introduction because growers preferred Bt corn over use of soil or seed-applied insecticides. In 2002, stacked hybrids (containing the Bt genes for corn borer and/or corn rootworm and/or the glyphosate-resistant gene) were introduced further increasing the acreage of GE corn. Increased adoption of stacked hybrids (2 percent in 2002 and 40 percent in 2008, Table 1) reflects grower preference for these traits as well as increasing lack of availability of non-stacked hybrids. By 2008, 80 percent of U.S. corn acreage was planted with some type of GE hybrid; half of these acres were stacked

hybrids (Table 1).

As with most of the USA, GE corn dominates the market in NY (acreage not available). In NY, however, European corn borer is an occasional pest and western corn rootworm does not typically result in such severe damage as it does in the Midwest USA. With that in mind, we evaluated field-scale studies on four farms in NY in continuous corn and corn-soybean rotations comparing the base genetics of two hybrids (37F73 from Pioneer and DKC52-62 from Dekalb) with double-stacked (37F75 and DKC52-63) and triple-stacked (37F76 and DKC52-59) counterparts.

When averaged across four farms and two hybrids, triple-stacked hybrids (Bt endotoxin for both European corn borer and western corn rootworm and the Roundup Ready trait) compared with the base genetics yielded 6 bu/acre higher in 2007 and 3 bu/acre higher in 2008 in continuous corn (Table 2). Despite low corn rootworm pressure at all sites (data not shown), triple-stacked hybrids yielded greater on one farm in 2007 and on one farm in 2008. Nevertheless, when averaged across years and sites, triple-stacked hybrids yielded only 2.7% greater than the base genetics. Likewise, double-stacked hybrids yielded greater on one farm in 2007 and in two farms in 2008 with a 2.7% yield advantage over the base genetics. This suggests that most of the yield increase came from control of European corn borer as opposed to corn rootworm in

**Table 3. Corn yields of the base genetics and the double-stacked corn hybrids, averaged across two companies, on four fields in a corn-soybean rotation in New York in 2007 and 2008.**

Hybrid	Cayuga	Livingston	Jefferson	Onondaga	Mean
<b>2007</b>					
<b>Bu/acre</b>					
Base Genetics	133	179	174	210	174
Double-Stacked	130	180	181	217	177
LSD 0.05	NS	NS	5	NS	NS
<b>2008</b>					
Base Genetics	194	212	167	131	176
Double-Stacked	208	208	175	128	180
LSD 0.05	NS	NS	NS	NS	NS

**Table 4. Grain moisture of the base genetics and the double and triple-stacked corn hybrids, averaged across two companies, on four fields in a corn-corn rotation in New York in 2007 and 2008.**

Hybrid	Cayuga	Livingston	Jefferson	Onondaga	Mean
<b>2007</b>					
%					
Base Genetics	24.0	21.0	18.2	24.7	22.0
Double-Stacked	27.9	22.3	19.1	25.8	23.7
Triple-Stacked	27.6	22.7	18.9	25.5	23.7
LSD 0.05	1.7	1.2	NS	NS	0.6
<b>2008</b>					
Base Genetics	21.8	22.3	21.1	31.6	24.5
Double-Stacked	23.8	24.1	23.0	33.3	26.1
Triple-Stacked	21.4	23.1	23.3	32.7	25.6
LSD 0.05	0.5	0.5	0.6	1.0	0.3

continuous corn. This was particularly true at the Onondaga site in 2008 where significant corn borer damage and lodging occurred in the base genetics (data not shown).

When averaged across four farms and two hybrids, double-stacked hybrids did not yield higher than the base genetics in either year of the study and only on one farm in 2007 in the corn-soybean rotation (Table 3). Almost no lodging and corn borer pressure was evident on any farms in the corn-soybean rotation (or continuous corn) in 2007 (data not shown). In 2008, significant lodging was observed on two farms but lodging appeared to be more associated with anthracnose stalk rot as opposed to corn borer damage at one site, resulting in some lodging in the Bt hybrids. Consequently, the 3 bu/acre yield increase was not significant.

Grain moistures ran higher in the GE hybrids compared with the base genetics in continuous corn and the

corn-soybean rotation in 2007 and 2008 (Table 4 and 5). Differences in grain moistures between GE hybrids and the base genetics were more pronounced in 2008 when dry-down was a slow-extended process. Growers who have challenges in dry-down of grain because of their location should consider selecting a hybrid 3-5 days earlier in maturity when selecting GE hybrids.

### Conclusion

We did note improved corn rootworm ratings with triple-stacked hybrids compared to the base genetics but root damage ratings were mostly less than 0.35 on all farms, indicating almost no rootworm damage in our studies in 2007 and 2008 (data not shown). Although rootworm can result in significant damage to corn fields in NY, the overall occurrence and degree of damage on NY farms seems to be less than in the Midwest USA. Likewise, we did note less lodging with double and triple-stacked hybrids but lodging was very limited in six of the eight tests across the two years. Corn borer is an occasional pest in NY so damage shows significant location and yearly variability.

On the one farm in 2008 where corn borer and lodging was significant, the Bt hybrids had less lodging, which greatly improved harvesting efficiency. We will conduct an economic analysis on the data (yield, hybrid price, and grain moisture) and will present the results in a future news article.

**Table 5. Grain moisture of the base genetics and the double-stacked corn hybrids, averaged across two companies, on four fields in a corn-soybean rotation in New York in 2007 and 2008.**

Hybrid	Cayuga	Livingston	Jefferson	Onondaga	Mean
<b>2007</b>					
%					
Base Genetics	25.6	21.1	20.6	27.7	23.7
Double-Stacked	27.8	21.8	21.3	29.4	25
LSD 0.05	0.6	0.7	NS	1.0	0.4
<b>2008</b>					
Base Genetics	22.5	21.3	22.3	29.8	24.0
Double-Stacked	24.5	23.6	23.6	32.9	26.1
LSD 0.05	0.6	0.7	NS	1.0	0.5