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Performance of Genetically Engineered Vegetables at the Dickinson Research Extension Center

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Summary

Genetically engineered (GE) sweet corn (*Zea mays* L.) and potatoes (*Solanum tuberosum* L.) resistant to insects were compared to traditionally bred cultivars at the Dickinson Research Extension Center (DREC) during the growing season in 2000. Moderate levels of European corn borer (ECB) (*Ostrinia nubilalis*) activity in corn occurred while very limited infestations of Colorado potato beetle (CPB) (*Leptinotarsa decemlineata*) were found at this location. Marketable sweet corn ear yields and ear corn weight was significantly higher for the genetically engineered cultivar compared to the traditionally bred cultivar. No significant difference in tuber yield was detected at this location. In addition to the Center's site, four producers in three counties with the assistance of their respective county agents compared the same sweet corn cultivars studied at DREC. Where moderate to high ECB infestations occurred, ear yields for GE sweet corn were high. When ECB infestations were low, little difference among cultivars was seen. Consumers were notified that sweet corn they were buying was GE. Response was positive towards purchase and consumption of GE sweet corn.

Introduction

Biotechnology, broadly defined, has a long history of use in food production and processing (IFIC, 2000). Pesticide use is a growing concern among consumers. Biotechnology was very low on their list of concerns. A recent survey of U. S. consumer attitudes towards biotechnology by Institute of Food Technologists (2000) indicated that all things being equal, 69% of consumers would prefer to see genetic engineering used to protect produce from insect damage rather than pesticide applications.

Sweet corn is grown on a commercial basis to a limited extent in southwest North Dakota. ECB infest corn in varying degrees every year in this part of the state. Depending on the severity, ECB reduces the marketable quantity and quality of the crop.

Colorado potato beetle in the eastern and some western parts of the United States have developed substantial resistance to specific families of pesticides (Flint, 1986) though none have been reported in western North Dakota.

The purpose of these demonstrations was to provide producers the opportunity to assess first hand GE sweet corn and to assess the extent of yield losses of sweet corn to ECB and potato to CPB. The other purpose of this demonstration was to determine consumer acceptance in southwest North Dakota of GE produce.

Materials and Methods

Sweet corn

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Two sister cultivars of sweet corn were selected for this demonstration. One cultivar, 'Prime Plus' is a traditionally bred sweet corn. The other sweet corn cultivar, GSS-0966VP is genetically engineered to protect the plant from ECB. The *Bacillus thuringiensus* (*Bt*) event used in this sweet corn cultivar is Cry1A(b) and has been approved by USDA APHIS, EPA, and FDA for use in sweet corn. Both Prime Plus and GSS-0966VP have yellow type kernels with the sh2 gene for sugar. Both cultivars have maturity rating of 78 days with predicted ear lengths of eight inches and ear diameter of 1.8 inches.

A randomized complete block design with four replications was used in this demonstration to help with determining real differences in yield and insect infestations (Figure 1). Each plot consisted of six rows with 20 inches between rows and seeded at the rate of two seeds per foot of row on 2 May. Plants were then thinned to one plant per foot. Weed control was by hand and no pesticides were applied to the plots.

Soil analysis indicated that all but nitrogen was adequate for high corn yields. Ammonium sulfate (21-0-0-24) was side banded at the rate of 2.3 pounds per 1000 ft^2 on 21 June. Plots were irrigated as needed.

On 17 and 23 August stalks and ears were harvested for evaluation of ECB injury. Stalks were split, larva counted, recorded. Ears were husked, larva counted and recorded. Ears were considered to be unmarketable when ECB tunneling or larvae were found in the ear (Figure 2).

All sweet corn data from the DREC site was analyzed using SAS Statistical software version 6.12 (SAS Institute Inc., 1996).

On-farm Demonstrations

County agents and cooperating producers in Bowman, Morton, and Golden Valley Counties planted both Prime Plus and GSS-0966VP in non-replicated strips. There was one site each in Bowman and Morton Counties while Golden Valley County had two sites. A single replication of six rows of each cultivar was planted between 22 May and 29 May. Management practices used were the same practices that producers normally used in sweet corn production. The Bowman site received limited irrigation while Morton and Golden Valley sites were planted on dryland. The Golden Valley sites were the driest (data not shown) of these on-farm demonstrations. Harvest and

evaluation was done at the four on-farm locations in a similar manner as it was done at the DREC.

Potato

Two isolines of the same potato cultivar 'Superior' were grown in this demonstration at the DREC. One isoline of the Superior cultivar was normal and the other isoline (NL10-SUP) contained a *Bt* event for CPB resistance.

A randomized complete block design with four replications was used in this demonstration. Plots were 15 feet by 20 feet (Figure 3). Prior to planting the soil was bedded on 30-inch centers. A soil test indicated that adequate fertility was present for an expected yield of 500 cwt. per acre and no additional fertilizer was applied.

Potato seed pieces were planted with an in-row spacing of ten inches and at a depth of four inches on 26 April. Plants were monitored for pests throughout the season. Plots were hand weeded and irrigated as needed. No insecticides were applied.

Plants were defoliated with a weed trimmer on 24 August and then harvested, weighed, and bagged on 5 and 6 September (Figure 4). Each isoline was kept separate in storage. Storage temperature was about 50 to 55^{O}F. Tubers were then removed from storage 5 October to warm to room temperature the week prior to the West River Ag Expo.

A display discussing genetically engineered crops was developed for the West River Ag Expo. As part of the display, *Bt* and normal tubers were washed and sliced into french fries for the public. Viewers of the display were asked to taste french fries made from normal and *Bt* potatoes and comment about any difference in taste.

All potato yield data from the DREC site was analyzed using SAS Statistical software version 6.12 (SAS Institute Inc., 1996).

Results and Discussion

Sweet Corn

GSS-0966VP, the genetically engineered sweet corn cultivar resistant to ECB, produced a significantly higher ear yield and greater weight of ear corn than Prime Plus, the normal sweet corn cultivar (Table 1). Larval density in stalks (Figure 5) was significantly higher for Prime Plus compared to GSS-0966VP but the test did not detect a significant difference in the percentage of barren stalks.

On-farm demonstration plots, though not statistically analyzed, appeared to follow the pattern found in the demonstration at DREC (Table 2). Ear yield at Bowman, and at both Golden Valley sites were greater for GSS-0966VP than for Prime Plus. At one Golden Valley site that was dry through much of the summer, ears were absent on Prime Plus while the ECB resistant cultivar produced an ear on every stalk. Larval density was higher at this site than any other on-farm site in this demonstration. A combination of stress caused by dry weather and insect feeding may have caused normal corn to abort ear set. At the Morton County site, ECB activity appeared to be less

and yield differences at that site were minimal.

Cooperating agents and producers reported that buyers liked the taste of the sweet corn. Consumers especially liked the idea of "no worms" and came back for more. Some consumers still preferred the older cultivars such as 'Peaches and Cream'. Overall consumers were indifferent that the *Bt* corn was a genetically engineered sweet corn cultivar.

Potato

No significant differences in yield were detected in yield (Table 3). CPB were present the last week of June through the first week of July in the normal potato isoline. No CPB were found on the isoline with the *Bt* event. CPB pressure was low and though some defoliation occurred, it was not severe enough to cause yield losses.

Vines for the normal isoline died early compared to the genetically engineered potato. NL 10-SUP is known to require 20 to 30% less nitrogen than normal potato cultivars (Thornton 2000). The normal isoline may have been deficient in nitrogen even though soil tests indicated that adequate nitrogen at the beginning of the season was present for 500 cwt./acre yield. Early die may have been the cause for early vine kill in the normal isoline (Figure 6). Early die is caused by *Vertilicilium* and can become severe when stress from a nutrient deficiency occurs (Flint, 1986).

Consumer acceptance of french fries made from the genetically engineered and the normal potato was high at the West River Ag Expo (Figure 7). Over 700 consumers taste tested fries from these two isolines. Consumers could not tell the difference in taste, color, or texture between the two isolines. Many consumers liked the idea of raising potatoes with less pesticides and using genetic engineering to reduce the amount of pesticides in the environment.

Implications of Demonstration

Genetically engineered vegetables may provide opportunities to growers to raise high-value insect free crops in western North Dakota. When dry weather occurs in combination with moderate to high levels of ECB activity, sweet corn producers may lose up to 100 percent of their production. Consumer attitudes in south west North Dakota towards GE vegetable crops was favorable and may very well be similar to the findings of the IFIC (2000) survey.

Cooperating Producers

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Table 1. Sweet corn yield comparison of Prime Plus and GSS-0966VP at the Dickinson Research Extension Center, Dickinson, ND, 2000.

[1]Cultivar	Stalk larval density	Barren stalks	Ears without larva	[2]Ear yield	Yield
	no/stalk	%	%	no./100ft^2	lbs/100ft^2
Prime Plus	2.9	11.8	81.1	32.0	14.7
GSS-0966VP	0.0	0.0	100.0	50.5	20.4
Mean	1.4	5.9	90.5	41.3	17.6
CV%	47.9	207	2.9	8.1	6.3
LSD $_{.05}$	1.5	NS	6.0	7.5	2.5

[1] Prime Plus is a normal sweet corn hybrid. GSS-0966VP is a BT sweet corn hybrid.
[2] Ear yield is the number of ears per 100 ft2 free of European corn borer larva and damage.

Table 2. Sweet corn yield comparison of Prime Plus and GSS-0966VP at Bowman, Morton, and Golden Valley locations in 2000.

	----------Prime Plus ----------				---------- GSS-0966VP ----------			
Location	Stalk larval density	Ear larval density	Ears density	[1]Ear yield	Stalk larva density	Ear larva density	Ears density	[1]Ear yield
	no/stalk	no/ear	no/stalk	no./100 ft^2	no/stalk	no/ear	no/stalk	no./100 ft^2
Bowman	1.3	0.8	1.0	11.6	0.0	0.0	1.0	26.7
Morton	0.4	0.3	1.4	50.7	0.0	0.0	1.5	50.0
Golden Valley #1	1.6	2.1	0.7	6.7	0.0	0.0	1.0	23.3
Golden Valley #2	3.0	[2]--	[2]--	0.0	0.1	0.1	1.0	25.0

[1] Ear yield is the number of ears per 100 ft^2 free of European corn borer larva and damage.
[2] No ear set occurred at this site for normal sweet corn.

Table 3. Tuber yield of two potato isolines of 'Superior' large round white potato at Dickinson Research Extension Center, Dickinson, ND, 2000.

Isoline	Yield	Yield
	lbs/100 ft^2	cwt/acre
Normal Superior	82.2	358.2
BT Superior	98.8	430.2
Mean	90.5	394.2
CV%	13.0	13.0
$LSD_{.05}$	NS	NS

Figure 1. Sweet corn plots at the Dickinson Research Extension Center, July 11, 2000.

Figure 2. European corn borer damage in ear and shank of Prime Plus sweet corn, August 21, 2001.

Figure 3. Potato plots at the Dickinson Research Extension Center garden, July 11, 2001.

Figure 4. Potatoes were harvested, weighed, and bagged for storage. Identity of the potato was preserved through the storage period.

Figure 5. *Bt* sweet corn cultivar 'GSS-0966VP' split corn stalk is on top and normal sweet corn cultivar 'Prime Plus' is split corn stalk on bottom. Note European corn borer injury in corn stalk.

Figure 6. Genetically modified cultivar 'Superior' potato vines are green while the normal potato cultivar isoline vines are dead August 21, 2001.

Figure 7. Normal potato isoline is on left and genetically modified potato is on right. Three hundred pounds of the genetically modified and normal potatoes were sliced, deep fried in NuSun sunflower oil and served as french fries to over 700 people during the West River Ag Expo, 12 - 13 October 2001. Consumers were given the choice of french fries made from normal potatoes and genetically modified potatoes. Expo attendees enjoyed French fries from both isolines equally well.

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