Demonstrating New Technologies for Improved Corn Rootworm Management

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Abstract:
On-farm demonstrations were initiated at the Cornell Musgrave Farm, Aurora and the Cornell Teaching and Research (T&R) Farm, Harford, to present, compare, and evaluate new and emerging corn rootworm (CRW) management strategies. In this third year of a continuing project, two ca. 0.7 acre field sites (Musgrave Farm field "X" and Animal Science Teaching and Research NYSEG field**)** were planted to corn receiving one of the following treatments: no soil insecticide (control), conventional soil insecticides: Force 3.0 G, Lorsban 15G or Counter 20 CR, and insecticide seed coatings: Gaucho (seed corn maggot rate), Prescribe (CRW rate), or TI-435. In addition to these treatments used in previous years, a second check (no soil insecticide with a fungicide seed treatment), and the soil insecticides Aztec 2.1, Capture 2EC, and Regent 80 WG were added. Treatments were compared for relative corn rootworm protection. Year 3 objectives have been completed and a summary of activities is presented.

Introduction and Justification:
Over the past decade, the western corn rootworm (CRW) has become established as the predominant insect pest of field corn in New York. The western CRW is more economically damaging than the ubiquitous northern CRW species. This potential for higher losses has increased grower awareness and concern of potential risks of CRW. Corn grown for silage is at particular risk from rootworm injury (Davis 1994).

Crop rotation is the most effective tactic to avoid CRW losses. This option, however, is not always possible given a farm's cropping or annual livestock feeding needs, constraints on land resources or other factors. CRW active soil insecticides, a second management option, can be relatively expensive, are toxic to handle and may not always provide adequate control.

Colonization by the western corn rootworm in NY over the past decade has been responsible for dramatic increases in overall soil insecticide use. A 1985 pesticide survey reported that 13.8% of NY's corn acreage received a soil insecticide (Specker et al 1986). By contrast, a 1994 NY PIAP survey found that 70.3% of corn for grain acres and 17.3% of corn for silage acres were routinely treated with an insecticide. Presumably a significant proportion of these insecticide applications were for CRW management (Partridge et al 1995).

Several advancements in CRW management are currently in development and are expected to be commercially available in the near future. In 1999, transgenic hybrids resistant to CRW were tested on a national level. Companies developing these hybrids originally projected commercial release in 2001 to 2002. Current estimates target commercial release in 2003 or 2004. Given the economic importance of CRW, it is anticipated that grower interest in these hybrids will be high.

Bt hybrids for European corn borer (ECB) control first became commercially available in 1996. Some analyst's project that market penetration by these new CRW resistant releases will quickly exceed the 20 - 25% national corn acreage market share currently occupied by transgenic ECB Bt-corn hybrids. Some predictions estimate as high as 75% market share.

In addition to transgenic hybrids, some insecticide seed coating treatments for controlling CRW are in various stages of development. Gustafson, Inc. (Dallas, TX), Inc. has a new insecticide seed treatment, imidacloprid, under development which at a low rate is effective against seed corn maggot (Gaucho) and at a higher rate is effective against low to moderate CRW populations (Prescribe). Bayer, Inc. (Kansas City, MO) is developing a new insecticide, clothianidin (TI-435), now in commercial and university trials. These treatments offer the potential benefits of efficacy, combined with a user-friendly CRW insecticide delivery method and an environmentally sensitive low a.i. rate per acre. Properly deployed, these novel tactics offer much promise to enhancing our CRW management options. Capture 2EC and Regent 80 WG are soil applied insecticides recently registered in NY . Aztec 2.1%, may be registered in the future.

This demonstration presents and compares root damage and yield effects of these new CRW management options compared to conventional CRW soil insecticides and the untreated control. The results from this demonstration have been featured at annual farm field day event(s) and shared with a larger clientele audience through CCE outreach efforts such as the Cornell Field Crop Dealer meetings and other CCE venues. This project complements other studies designed to develop and test CRW insecticide-resistance management strategies (Cox and Shields, Shields and Calvin).

Objectives:

1. To introduce and compare effectiveness of new CRW management technologies.
2. To enhance development and outreach of new CRW management technology information and provide a timely forum for the discussion of benefits and concerns associated with their use.

This is the final year of a three year project.

Year 1 (2000).

CRW infestations were promoted in the selected study areas at Cornell's Musgrave (Aurora) and Teaching and Research (Harford) farms. A mixture of cucurbits and field corn was planted, ca. 0.7 acres, in mid-June 2000 to attract late-season CRW infestation and encourage egg laying in the two study locations. Late maturing corn fields can attract large numbers of corn rootworm beetles since neighboring, more mature, corn may have stopped producing pollen, the beetles preferred food. Corn rootworm beetles are also naturally attracted to cucurbitacin produced in blossoms of members of the squash family. Standard agronomic practices, site preparation, fertility, seeding rates, herbicide use, etc. were utilized to establish trap crops. See "Demonstrating New Technologies for Improved Corn Rootworm Management" in the 2000 NYS LFC / IPM Reports for more information. (www.nysipm.cornell.edu/grantspgm/projects/proj00/lfc/cox.html).

Year 2 (2001)

Research and demonstration plots of field corn were again planted at Cornell's Musgrave farm (Aurora) and Teaching and Research farm (Harford) to evaluate new technologies managing corn rootworm. Plots were established at Harford on May 24 and at Aurora on May 25. Individual treatments were randomized and planted to one hundred foot rows. The experiment

was replicated four times in a random complete block. Conventional soil insecticides, the Bt CRW resistant hybrid and the seed treatments Prescribe and TI 435 all performed well against corn rootworm damage. See year two results of "Demonstrating New Technologies for Improved Corn Rootworm" at www.nysipm.cornell.edu/grantspgm/projects/proj01/lfc/waldron.html.

Year 3 (2002)
Research and demonstration plots of field corn were again planted at Cornell's Musgrave farm (Aurora) and Teaching and Research farm (Harford) to evaluate new technologies managing corn rootworm. Plots were established at Harford on May 18 and at Aurora on May 15. Field corn was grown using standard agronomic practices appropriate for central NY as previously described in the year 1 and year 2 reports.

A starter fertilizer was utilized at both sites and applied at planting (260# 10-10-10). At the Musgrave site, the nitrogen was provided with a preplant incorporated application of 150# of urea. At the Aurora, the nitrogen was provided with an nitan application at the 4 leaf stage.

Individual treatments were randomized and planted to one hundred foot rows. The experiment was replicated four times in a random complete block. Replications were separated by a twenty-five foot border.

In addition to the seven treatments utilized in previous years, four additional treatments were added to this years study including a second check treated with a fungicide seed treatment, and three soil insecticides, Aztec 2.1%, Capture 2EC and Regent 80 WG. These additional insecticides have recently become registered in NY or are anticipated to be registered in NY in the near future.

Treatments at each location were:
Conventional hybrid (Pioneer 37M81, 97 Day) treated with one of the following:

1. Aztec 2.1% (cyfluthrin, 4 oz / 1000 linear feet, Bayer Corporation, Kansas City, MO) [1]
2. Capture 2EC (biphenthrin [a pyrethroid], 0.3 oz / 1000 linear feet, FMC Corporation, Agricultural Products Group, 1735 Market Street, Philadelphia, PA)
3. Capture 2EC (biphenthrin [a pyrethroid], 0.65 oz / 1000 linear feet, FMC)
4. Clothianidin (TI-435) CRW insecticide seed treatment (clothianidin, 1.25mg/kernel, Bayer) [2, 3]
5. Counter 20 CR, (terbufos, CRW soil insecticide, T-band, 6 oz. / 1000 linear feet, BASF Corporation, RTP, NC) [2]
6. Force 3.0 G (tefluthrin, CRW soil insecticide, T-band, 3 oz. / 1000 linear feet [75% of labelled rate], Syngenta Agribusiness, Inc. Basel, Switzerland) [2, 4]
7. Force ST (tefluthrin, CRW seed treatment insecticide, Syngenta)
8. Gaucho seed coating (imidacloprid, seed corn maggot rate (0.61 mg/kernel, seed corn maggot rate) Gustafson, Inc., Dallas, TX) [2]
9. Lorsban 15G, (chlorpyrifos, CRW soil insecticide, T-band, 8 oz. / 1000 linear feet, Dow AgroScience, Inc. Indianapolis, IN) [2]
10. Prescribe seed coating (imidacloprid, corn rootworm rate (1.34mg/kernel, CRW rate), Gustafson) [2]
11. Regent 80WG (fipronil, 4.2 fl oz / A, Aventis Crop Science USA LP, 2 T.W. Alexander Drive, RTP, NC)

12. Untreated (Check) [2]
13. Untreated (Check) treated with a damping off and seedling blight fungicide protectant
14. *CRW-resistant hybrid*[2]. Bt hybrid comparison data is unfortunately not available this year due to lack of timely availability of the Monsanto Bt seed. Data from previous years indicates the Bt hybrid MON 863 (ca. 100 day hybrid, containing Cry III Bt, Monsanto Corp., St Louis, MO) performed quite well (see our 2001 report). In the 2001 study, the Bt hybrid (MON 863) had a root rating of 1.8 at both the Harford and Aurora locations. We believe that the CRW resistant Bt hybrid(s), if available, would again have performed equally well in 2002. Corn rootworm damage was in general greater in 2002 than that observed in 2001.

[1]Not currently registered for use in NY but Is registered for use as CRW insecticide in PA,
[2]Included in 2001 study
[3]May be registered for use in NY spring 2003?
[4]Reduced rate, 4 oz / 1000 linear ft is full labelled rate

Corn rootworm damage assessment:
On August 15, five plants were randomly selected from the center of each treatment row, and roots excavated, washed, and rated for rootworm injury (Hills and Peters, 1971). Two hundred sixty root systems were evaluated per location.

Field plots were harvested September 18 (Harford) and September 20 (Aurora) for silage yields using a one-row chopper, and weighed with a platform scale. Final yields were adjusted to 65% moisture.

Data analysis:
Rootworm data was analyzed separately by location with treatment as the main effect using a multifactorial analysis of variance (ANOVA) model with Tukey Separation (Proc GLM; SAS Institute ,1996)

Dry weight data was analyzed by ANOVA (Proc GLM; SAS Institute, Cary NC 1996).

Demonstration Outreach. The new corn rootworm management technology demonstration was featured at the Aurora farm field day August 1, 2002. Information generated by this study will be shared with additional clientele through CCE extension presentations this winter.

Results and Discussion

Root Ratings. Nearly half of the insecticide treated plots had root ratings (RR) below the 3.5 economic threshold (Table 2). Most conventional soil applied insecticide treatments and some seed applied insecticides provided protection against corn rootworm. The conventional soil insecticides Counter 20 CR, Force 3G, Lorsban 15G performed well although there were some differences between the Aurora and Harford sites. New soil insecticides Aztec 2.1%, Capture 2EC both the 0.3 and 0.65 oz / 1000 ln ft rates, and Regent 80WG performed well at both locations. The seed treatment Clothianidin (TI435) showed promise for CRW management at both locations. Variable results were obtained with Prescribe and Gaucho. Gaucho is not labeled as a CRW insecticide treatment and was not expected to perform well. Prescribe is recommended for managing low to moderate CRW populations. It is possible that it's poorer performance may

be associated with the moderate to high CRW populations observed at both Harford and Aurora. In trials over several years Force St has not been very effective protecting corn against CRW and was included in this study as an additional check (Shields, unpublished). Capture 2EC (0.3 oz/1000 ln ft) provided a 3.75 RR at the Harford site and Lorsban 15G and Counter 20 CR provided a 4.3 and 3.7 RR respectively at the Aurora site. It is not clear why the Capture results were different at the two locations. It is possible that variations in CRW populations may have played a role. The differences in results obtained for Counter and Lorsban may be related to environmental conditions (Counter, soil moisture and Lorsban, high soil pH). Non-treated plots were 4.5 or greater indicating severe root pruning and economic damage .

It should be noted that study plots were predisposed to corn rootworm egg laying the previous season by late planting with sweet corn and a mixture of cucurbits. See 2000 and 2001 NYS IPM reports. Late pollen sources are attractive to CRW beetles as feeding (and egg laying) locations. Both Harford and Aurora locations sustained significant CRW injury in 2002, while the average root rating injury at the Harford site was greater than that observed at Aurora (Table 2). Previous studies have observed higher corn rootworm populations at Harford than at the Aurora site (Shields unpublished). In 2001, for example, CRW damage ratings were not significant different between any treatment at the Aurora site precluding a need for harvest and yield data (Waldron et al 2002).

Table 2. Corn Rootworm Injury Ratings – Aurora and Harford, NY, August 2002

			CRW RR[1,2]						
TREATMENT	RATE	APPLICATION	HARFORD						
Untreated – max (fungicide seed trt)	*	*, seed	5.55						
Untreated	*	*, *	4.86	a[2]					
Force St	*	*, seed treat	4.7	a					
Prescribe	1.34 mg/k	*, seed treat	4.55	a					
Gaucho	0.61 mg/k	*, seed treat	4.45	a					
Capture 2EC	0.3 oz/1000 ln ft	T-band, spray	3.75		b	c	d	e	
Clothianidin (TI435)	1.25 mg/k	*, seed treat	3.45		b	c		e	
Capture 2EC	0.65 oz/1000 ln ft	T-band, spray	3.35		b	c			
Counter 20 CR	6 oz/1000 ln ft	T-band, granular	3.05			c	d	e	f
Lorsban 15G	8 oz/1000 ln ft	T-band, granular	3			c	d	e	f
Aztec 2.1%	4 oz/1000 ln ft	T-band, granular	2.7				d	e	f
Force 3G	3oz/1000 ln ft	T-band, granular	2.7				d	e	f
Regent 80WG	4.2 fl oz/A	T-band, spray	2.6				d	e	f

			CRW RR[1,2]						
TREATMENT		APPLICATION	AURORA						
Untreated – max (fungicide seed trt)	*	*, seed	4.65	a	b				
Prescribe	1.34 mg/k	*, seed treat	4.55	a	b	c	d		
Force St	*	*, seed treat	4.55	a	b	c	d		
Untreated	*	*, *	4.54	a	b	c			
Lorsban 15G	8 oz/1000 ln ft	T-band, granular	4.3	a	b	c	d		
Counter 20 CR	6 oz/1000 ln ft	T-band, granular	3.7		b	c	d	e	
Capture 2EC	0.65 oz/1000 ln ft	T-band, spray	2.85				d	e	f
Capture 2EC	0.3 oz/1000 ln ft	T-band, spray	2.7					e	f
Gaucho	0.61 mg/k	*, seed treat	2.6					e	f
Aztec 2.1%	4 oz/1000 ln ft	T-band, granular	2.45					e	f
Force 3G	3oz/1000 ln ft	T-band, granular	2.45					e	f
Clothianidin (TI435)	1.25 mg/k	*, seed treat	2.25					e	f
Regent 80WG	4.2 fl oz/A	T-band, spray	2.15					e	f

[1] Root rating scale Hills and Peters, 1971. Economic injury level = CRW Root Rating of ≥ 3.5.
[2] Means followed by the same letter not significantly different p>0.05.

Silage yield. Analysis of silage yield data often showed no consistent differences between treatments. Untreated check plots had the low yields at both locations however these were not significantly different from most other treatments. Site average 42.47 and 38.25 lbs at Aurora and Harford respectively.

The severe drought during the growing season reduced the yield potential of all treatments thereby reducing the differences between the best and the worst treatments.

Table 3. Silage Yield – Aurora and Harford, NY, August 2002

			Dry Weight (lb) [1]					
TREATMENT	**APPLICATION**	**RATE**	**AURORA**					
Gaucho 400	seed treat	0.61 mg/k	52.07	a	b	c		
Clothianidin (TI435)	seed treat	1.25 mg/k	49.03	a	b	c		
Regent	T-Band, spray	4.2 fl oz/A	48.49	a	b	c		
Force 3G TB	T-Band, granular	3oz/1000	47.8	a	b	c		
Capture .6TB	T-Band, spray	0.65 oz/1000	44.57	a	b	c	d	e
Aztec TB	T-Band, granular	4 oz/1000	44.54	a	b	c		e
Force St	seed treat	*	43.98	a	b	c		e
Capture 3TB	T-Band, spray	0.3 oz/1000	42.07	a	b	c		e
Counter TB	T-Band, granular	6 oz/1000	40.77	a	b	c	d	e
Untreated – max (fungicide seed trt)	seed	*	39.01	a	b	c	d	e
Prescribe	seed treat	1.34 mg/k	38.43	a	b	c	d	e
Untreated			31.31			c	d	e
Lorsban TB	T-Band, granular	8 oz/1000	29.98		b	c	d	e

			Dry Weight (lb) [1]			
TREATMENT	**APPLICATION**	**RATE**	**HARFORD**			
Clothianidin (TI435)	seed treat	1.25 mg/k	45.61	a	b	
Force 3G TB	T-Band, granular	3oz/1000	43.99	a	b	c
Force St	seed treat	*	43.67	a	b	c
Regent	T-Band, spray	4.2 fl oz/A	43.5	a	b	c
Lorsban TB	T-Band, granular	8 oz/1000	41.89	a	b	c
Gaucho 400	seed treat	0.61 mg/k	40.14	a	b	c
Counter TB	T-Band, granular	6 oz/1000	39.7	a	b	c
Capture TB	T-Band, spray	0.65 oz/1000	37.3	a	b	c
Capture 3TB	T-Band, spray	0.3 oz/1000	35.49	a	b	c
Untreated		*	34.29	a	b	c
Aztec TB	T-Band, granular	4 oz/1000	33.62	a	b	c
Prescribe	seed treat	1.34 mg/k	30.96	a	b	c
Untreated – max (fungicide seed trt)	seed	*	27.07		b	c

[1] Yield (lb) / 100 ft row adjusted to 65% moisture

[2] Means followed by the same letter not significantly different p>0.05.

The results of this three year study indicate the new insecticide seed coating and recently registered CRW soil insecticides CRW resistant Bt hybrid technologies hold promise for corn rootworm protection. The insecticide seed coatings Prescribe (CRW rate) and Clothianidin TI-435, and the new soil insecticides Aztec 2.1%, Capture 2EC both the 0.3 and 0.65 oz / 1000 ln ft rates, and Regent 80WG generally showed efficacy comparable to the conventional soil insecticides Force 3.0 G, Lorsban 15G or Counter 20 CR. Prescribe and Clothianidin TI-435 are known to be effective against low to moderate populations of CRW. The Bt CRW resistant hybrid Mon 863 studied in previous years has also had very low root damage rating scores indicating it's potential for managing CRW. Although not labeled as a CRW insecticide, plants protected with the seed coat Gaucho (seed corn maggot rate) did have a lowered CRW root rating than untreated checks. This observation, however, is viewed as an experimental anomaly and not truly reflective of it's potential against CRW.

Over the past decade, the western corn rootworm (CRW) has become established as the predominant insect pest of field corn in New York. The economically damaging capacity of western CRW has increased grower awareness and concern over potential risks of CRW. Corn grown for silage is at particular risk from rootworm injury (Davis 1994).

Current options for managing CRW include crop rotation or use of a soil insecticide at planting. Crop rotation is the most effective tactic to avoid CRW losses. This option, however, is not always possible given a farm's annual cropping or livestock feeding needs, constraints on land resources or other factors. CRW active soil insecticides, the second management option, are relatively expensive, toxic to handle and may not always provide adequate control.

These insecticide seed coat treatments and Bt hybrids resistant to CRW offer the potential benefits of efficacy, combined with a user-friendly CRW insecticide delivery method and an environmentally sensitive low a.i. rate per acre. Properly deployed, these novel tactics offer much promise to enhancing our CRW management options. This demonstration is developing

local data and affords NY growers the opportunity to view these new CRW management options at work in the field. The demonstration has also enhanced discussion regarding the benefits, concerns and constraints of these technologies and field corn IPM in general. The timing of the demonstration is providing extension personnel, growers, and associated agriculture industry personnel with field data in advance of the expected commercial release of new CRW-hybrids and seed treatments (2003 – 2004).

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