What's Cropping Up?

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Corn Rootworm Resistance to BT-Corn Reported

Elson Shields, Department of Entomology, Cornell University

Since the introduction of BT-corn varieties, concern has been raised by entomologists about the target insect developing resistance to the incorporated toxin and causing significant plant damage to those protected plants. With the initial introduction of BT-corn borer varieties, the concept of a non-treated refuge was also introduced. Insects produced from an untreated refuge are not exposed to the toxin and suppress the development of resistance by interbreeding with any BT toxin survivors.

In the case of corn borer, no resistance to BT incorporated toxin has been identified in the field even though corn borers have been exposed to BT incorporated toxin in the field since the mid-1990s. Area wide populations of corn borer have plummeted throughout the Corn Belt and have remained low for the past 15 years. The insect mating behavior outside the field coupled with the establishment of some refuges within areas seems to have suppressed the development of resistance to the plant incorporated BT. In contrast, this insect is capable of developing resistance in the laboratory within a few generations.

The situation with western corn rootworm appears to be completely different.

Since CRW BT-toxin introduction in 2003, the speed of resistance development has been debated among scientists because corn rootworm has a different mating/dispersal behavior than corn borer and rootworm has a history of developing resistance to other insecticides. Attempts by public scientists to study the potential development of corn rootworm-BT resistance were significantly hampered by seed industry legal restrictions placed on public scientists, limiting both laboratory and field research from the mid-1990s until 2010. Widespread and organized objections by corn entomologists from major agricultural universities in 2010, convinced the seed companies to loosen the legal restrictions limiting research by public scientists involving GMO crops. As a result, the 2009 observation of trait failure in southern Minnesota became public in 2010 and corn rootworm resistance to the BT trait was verified in the laboratory at Iowa State during 2010 and 2011.

Corn lodging due to corn rootworm feeding.

In addition, multiple observations across large areas of the Corn Belt are reporting a rebounding rootworm population in fields planted with BT-CRW corn varieties. Starting in 2009 and extending through 2012, corn entomologists started reporting a rise in the adult rootworm population but widespread root injury has not been reported. This widespread rebound of the insect population strongly suggests that the insect is surviving the toxin better and more larvae are surviving into adult beetles. These observations also suggest that a widespread increase in trait failure maybe “just around the corner.” These recent observations are in contrast to the widespread CRW population crash which occurred in response to the area wide planting of CRW-BT corn between 2004 and 2009. Now that resistance has been documented in the Corn Belt to CRW-BT, the discussion shifts to management alternatives. Since many seed companies have placed their elite yield genetics in varieties along with BT toxins for corn borer and rootworm, growers have little choice but to plant the BT varieties if they want

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higher yielding corn. If the BT toxin is failing, additional management alternatives need to be layered over the BT toxin. Many producers are choosing to apply soil insecticides on top of the BT-CRW corn varieties in order to reduce damage, thereby significantly increasing the cost of rootworm control.

How did resistance develop?

We believe there are two major contributing factors promoting the rapid development of CRW resistance to the BT toxin. 1) The expression of the toxin in the corn plant is not at a high dose level and 2) the widespread refusal of producers to plant a BT-free refuge as required by EPA as a condition of registration.

The less-than-high-dose of toxin in the plant allowed insects with a low level of resistance to survive the toxin, molt into adult insects, mate and lay eggs. The higher the toxin dose, the fewer insects initially survive and generally the longer it takes for the insect to develop resistance. The planting of untreated refuges produce large numbers of unexposed beetles to dilute any genetic resistance, thereby keeping the frequency of the resistance very low.

The lack of BT-free refuges allows the BT-toxin survivors to inter-mate and concentrate the genetic basis for resistance, allowing a larger portion of the population to survive the toxin each year, thus increasing the inter-mating between individuals with a lower level of resistance. As a result, individuals in each succeeding generation have an increased level of resistance to the toxin and have an increased survival. The cycle continues with each subsequent year.

Solutions?

Corn producers and the seed companies in the areas of rising insect resistance to CRW-BT have painted themselves into an interesting corner. It is very unlikely that management strategies can be implemented to reduce the level of insecticide resistance in corn rootworm to BT. Most of the new corn planters purchased do not have soil insecticide applicators, so the use of a soil insecticide to limit rootworm damage is not an option. High rates of seed treatment which work fine in the Northeast have a history of poor performance throughout most of the Corn Belt. The only solution open to most Midwest corn producers is to plant more CRW-BT toxin corn and make the resistance problem worse.

The majority of the documented failures involve only one of the two competing rootworm BT events. Seed companies selling corn varieties with both BT events incorporated into the same plant (SmartStax®) are selling these varieties as a solution to the resistance. When these dual toxin varieties are planted into an area with corn rootworm resistance present to one of the toxins, the use of these dual toxin varieties with their very small untreated refuge (5%) is believed to only accelerate resistance to the second toxin. We believe that when the dual toxin corn varieties are planted in areas of increasing rootworm populations or resistance areas, the untreated refuge needs to be increased to at least 20%.

Resistance in NY?

It is difficult to predict the future development or arrival of CRW-BT resistance in NY. Rapid resistance development is less likely because corn rootworm pressure in NY has never been as high as the Midwestern Corn Belt. As a result, market penetration for corn varieties with CRW-BT toxin has been significantly less with current estimates ranging between 30% and 50%, resulting in a much lower selection pressure on rootworm to develop resistance to the BT toxin. In addition, some NY farmers are still using the rootworm dose of seed treatment to control rootworm rather than planting a CRW-BT corn variety.
Recommendations to reduce the selection pressure on corn rootworm to develop resistance to CRW-BT corn:

1. Only plant CRW-BT corn varieties in fields with high rootworm pressure. These fields are typically continuous corn fields in 3 or longer years of continuous corn. Choose a company which offers “Refuge-in-a-bag”. Susceptible seeds are mixed in the bag and the farmer is not required to plant a separate refuge.

2. Fields with low levels of CRW pressure should be planted to a non-CRW-BT variety. These fields are typically first or second year fields. First year fields do not need any rootworm insecticide, but second year fields may need a high rate of seed treatment or a reduced rate of soil insecticide like Force®.

Triticale as a Cover and Double Crop on a New York Dairy

Nutrient Management

Emmaline Long[1], Ken Van Slyke[2], Quirine Ketterings[1], Gregory Godwin[1], Karl Czymmek[1,3], [1]Nutrient Management Spear Program, [2]Van Slyke Dairy, and [3]PRODAIRY, Department of Animal Science, Cornell University

Introduction

Triticale is gaining popularity as a winter cereal that can be seeded after corn silage harvest in the fall and either terminated as a cover crop in early spring or harvested ("double crop") as high quality forage. The growing interest in triticale as a double crop most likely reflects both the desire to offset some of the costs of establishment and termination of a cover crop, and the desire to increase per acre forage yields, especially in drought years like 2012.

An on-farm field trial was conducted to determine N uptake, C:N ratio (above- and below-ground), and yield of triticale (above- and below-ground) in: (1) the fall after seeding (triticale as a catch crop), (2) the spring when the crop would normally be terminated if used as a cover crop, and (3) at flag-leaf stage, the optimal harvest time for triticale managed as a forage. Forage quality at harvest was also determined.

Trial Set-Up

On September 10, 2010, triticale (King's Agri-Seeds 718 variety) was planted on a dairy farm in Wyoming County, western New York. Four strips were planted across a field to allow for a side-by-side comparison: (1) plots that were seeded with triticale versus (2) a control where no cover/double crop was planted. Plots were 24 corn rows wide (30-inch row spacing) and ran the length of the field (800 ft). At planting, 5,000 gallons/acre of manure were applied, followed by a pass with an AerWay, adding an estimated 36 lbs N/acre. Because the crop was managed as a double crop by the farmer, 215 lbs/acre of urea were applied as a greenup application (4/11/2011), for a total N application of 99 lbs N/acre. At each sampling date, the triticale was uprooted in four areas of 2 feet^2 per plot. Total biomass was separated in roots and shoots, subsamples were analyzed for C:N ratio, and total C and N accumulation were calculated.

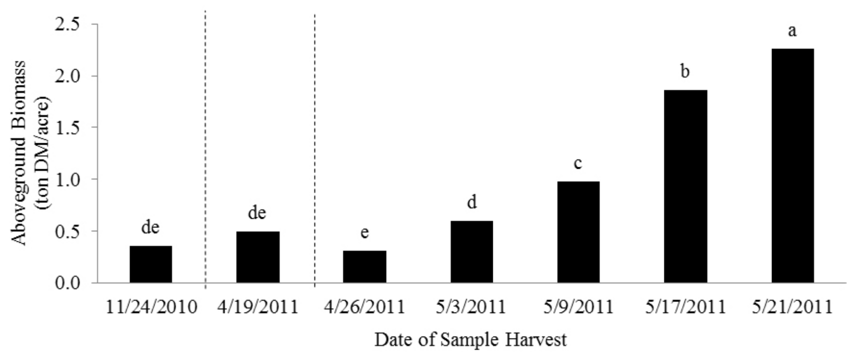

Figure 1: Above-ground biomass measurements of triticale sampled from 11/24/2010 to harvest on 5/21/2011. The first dashed line represents the break between fall and spring. The second dashed line represents the break between sampling as a cover crop and growth as a double crop. Letters that are different indicate significant differences in biomass at P≤0.05.

Table 1: Biomass and carbon (C) and nitrogen (N) accumulation by triticale seeded 9/10/2010 and sampled just after a killing frost on 11/24/2010.

Plant Part	Biomass	C:N Ratio	Total C	Total N
	(ton DM/ac)		(lb/ac)	(lb/ac)
	-----11/24/2010-----			
Above-ground	0.36	13:1	290	23
Below-ground	0.12	21:1	82	4
Total	0.48	.	372	27

Table 2: Biomass and carbon (C) and nitrogen (N) accumulation by triticale seeded 9/10/2010 and sampled on 4/19/2011, a timing typical for cover crop termination.

Plant Part	Biomass	C:N Ratio	Total C	Total N
	(ton DM/acre)		(lb/acre)	(lb/acre)
	-----4/19/2011-----			
Above-ground	0.50	9:1	425	49
Below-ground	0.19	16:1	147	10
Total	0.69	.	572	59

Fall Sampling

Triticale biomass (roots and shoots) was determined on 11/24/2010, after the first killing frost of that year. At the 11/24/2010 sampling, the above-ground biomass was 0.36 ton DM/acre (Table 1 and Figure 1).

The below-ground biomass totaled 0.12 ton DM/acre indicating that of the total biomass accumulated about 75% was above ground. The C:N ratio of the above-ground biomass was 13:1 with a total N pool of 23 lbs/acre (Table 1 and Figure 2). Total amount of N sequestered in the fall (roots

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and shoot combined) was 27 lbs N/acre. This is the amount of N that could otherwise have been lost to the environment over the winter months if no triticale had been seeded. This fall N accumulation was consistent with the 21-29 lbs/acre N measured in various cover crop species seeded after corn silage that same fall (Ketterings et al., 2011).

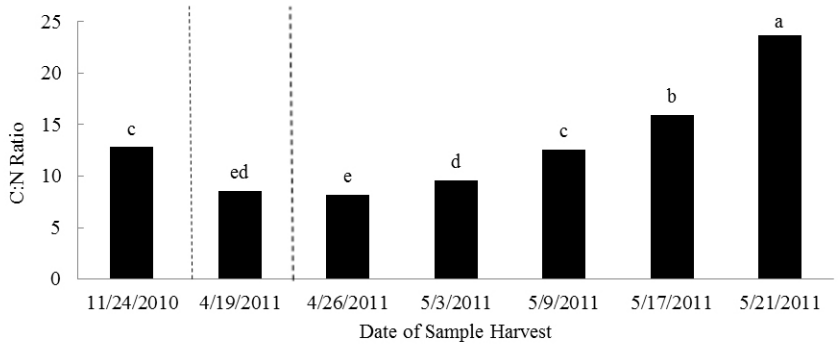

Figure 2: Carbon to nitrogen ratio of above-ground biomass for triticale sampled from 11/24/2010 to harvest on 5/21/2011. The first dashed line represents the break between fall and spring. The second dashed line represents the break between sampling as a cover crop and growth as a double crop. Letters that are different indicate significant differences in C:N ratio at P≤0.05.

Sampling at Cover Crop Termination

The triticale plots were sampled again on 4/19/2012 when the crop would normally have been terminated as a cover crop, and a week after the greenup N addition of 99 lbs N/acre was done. At this sampling date, the above-ground biomass totaled 0.50 ton DM/acre, versus 0.19 ton DM/acre below-ground (Table 2 and Figure 1). Thus, a little over 70% of the total biomass was above ground, similar to the 75% measured for the fall sampling. The total C and N pools (above- and below-ground biomass together) were 572 lb C and 59 lb N/acre. The C:N ratios were low (<25:1), suggesting that the 59 lb N/acre could become available for the corn crop that would follow triticale (Figure 2). The lower C:N ratios as compared to the fall sampling could be reflective of the urea application that took place one week prior to sampling.

Sampling as Double Crop

Triticale was harvested weekly from 4/19/2011 (a timing typical for cover crop termination) until it reached flag leaf stage (optimal harvest time) on 5/21/2011. Above-ground biomass was sampled each week, while below-ground biomass was collected on the final sample date (5/21/11). These measurements showed that once soils started to warm up and dry (early May), the above-ground biomass rapidly increased, at an average rate of 0.6 ton/acre a week. This rate of growth resulted in a total above-ground biomass of 2.26 ton DM/acre on May 21st (Figure 1). Such yields were very similar to yields of various winter cereals grown for forage in the spring of 2012 (Kilcer et al., 2012).

The C:N ratio of above-ground biomass increased from 4/19/2011 onwards, reaching a peak of 24:1 at the double crop harvest date of 5/21/2011 (Figure 2). Carbon content (%) stayed the same throughout the growing season, so the increase in C:N ratio primarily reflected a decrease in %N over time. At harvest, the C:N ratio of the roots was 32:1, suggesting the potential for some N immobilization post-harvest. The total amount of N represented in the above-ground biomass at the optimal

Table 3: Biomass and carbon (C) and nitrogen (N) content and pools for triticale double crop samples taken on 5/21/2011.

Plant Part	Biomass	C:N Ratio	Total C	Total N
	(ton DM/ac)		(lb/ac)	(lb/ac)
	----------5/21/2011----------			
Above-ground	2.26	24:1	1932	82
Below-ground	0.44	32:1	164	5
Total	2.70	.	2096	87

Table 4: Triticale forage analyses conducted by Cumberland Valley Analytical Services, Inc. indicated high quality forage. For comparison, average analyses for triticale, legume, and grass silages reported by DairyOne Forage Laboratory, Ithaca NY, are listed as well.

			Averages reported by DairyOne Forage Laboratory		
Variable	Units	Study harvest	Triticale	Legume silage	Grass silage
Crude protein	%	13.2	14.2	21.4	15.2
Acid detergent fiber	%	34.6	38.1	34.6	37.6
Neutral detergent fiber	%	57.7	58.4	44.3	57.7
30-hr NDF digestibility	%NDF	64.6	61.7	50.4	62.2
Crude fat	%	2.8	3.7	3.8	4.0
Ash	%	8.8	10.4	11.0	9.3

time for harvest was 82 lbs N/acre (Table 3). This is a substantial amount of N removed with harvest, suggesting that N management of the double crop is important. However, between sampling at the time of typical cover crop termination (just a week after urea application) and actual harvest as a forage, only 33 lbs N/acre was taken up while 99 lbs N/acre had been applied (Table 2, Table 3). It is possible that up to 40% of the urea-N applied was lost to the air (Al-Kanani et al., 1991; Bouwmeester, et al., 1985) as the urea was surface applied on moist soil (1.6 inches of rain in the 10 days prior to application) and there was no rain for three days following the green-up application of urea (NRCC, 2012). In addition to the likely loss of N at greenup, it is also possible that leaching losses were substantial post application as in the 40 days between N application and harvest the site received approximately eight inches of rain, several inches over the 30-yr average rainfall for this time period (NRCC, 2012). Initial N uptake in the week after application and a combination of N volatilization and leaching losses could account for the small uptake efficiency of the urea. These results emphasize the importance of conducting on-farm N rate studies for winter cereals, such a triticale, grown as a double crop in future years.

After triticale harvest on 5/21/2011, subsamples for each triticale plot were sent to Cumberland Valley Analytical Services, Inc. for analyses for crude protein, acid detergent fiber, neutral detergent fiber (NDF), 30-hr NDF digestibility, crude fat and ash (Table 4). The 30-hr digestibility shows the high quality of the forage that was harvested.

Conclusions and Implications

The triticale was able to take up a total of 27 lbs N/acre in the fall. This is N that otherwise could have been lost over the fall and winter months. Nitrogen uptake at the time of cover crop termination in April was 59 lbs N/acre. This conserved N pool could contribute to the N supply for the corn that followed as the C:N ratio of the cover crop biomass was less than 25:1. However, results could have been impacted by a greenup N application one week prior to sampling. Triticale harvested as a forage added 2.26 tons/acre DM of high quality forage to the per acre season yield, effectively increasing the total season yield (corn plus triticale) by 27%. Nitrogen removal with triticale harvest was large (82 lbs N/acre) but considerably less than the total N applied (36 lbs N/acre with manure plus 99 lbs N/acre at greenup), and the return to the greenup N application was low. Thus, additional research is needed to determine the optimal N rates for triticale both at seeding and at greenup, and to determine if triticale can be managed with manure only. In 2013, N rate studies will be conducted on farm fields that were seeded to triticale in the fall of 2012 to provide an initial answer to these questions.

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Acknowledgments

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Weed Management

Acetochlor Herbicide Will Be Registered in New York State

Russell R. Hahn and R. J. Richtmyer III, Department of Crop and Soil Sciences, Cornell University

In 1997, applications to register acetochlor herbicide products in NY were denied. This decision was based on risks associated with the potential use of this herbicide, and on the lack of compelling benefits resulting from its use. At that time, DEC's review of acetochlor identified oncogenic effects, potential groundwater contamination, and toxicity to non-target aquatic plants and animals due to acetochlor runoff to surface water as risks associated with the herbicide.

Table 1. Acetochlor and acetochlor/atrazine premix products that will likely be registered in NY.

Product	Acetochlor	Atrazine	Company
Harness	7 lb/gal	-	Monsanto
Harness Xtra	4.3 lb/gal	1.7 lb/gal	Monsanto
Harness Xtra 5.6L	3.1 lb/gal	2.5 lb/gal	Monsanto
Degree Xtra	2.7 lb/gal	1.34 lb/gal	Monsanto
Warrant	3 lb/gal	-	Monsanto
Surpass	6.4 lb/gal	-	Dow AgroSciences
Keystone	3 lb/gal	2.25 lb/gal	Dow AgroSciences

Improved Regulatory Profile

Since 1997, EPA's toxicological and environmental profiles for acetochlor have improved significantly, and EPA has dropped the "Restricted Use" designation. This change was largely due to the favorable cancer reclassification for this herbicide. The reclassification expanded the risk cup and led to new food crop tolerances to support labeling for use on soybeans and sweet corn, and for additional rotational crops. Groundwater monitoring has shown that acetochlor is less likely to leach than some currently used herbicides. Monitoring surface water in heavy use areas during peak application periods over many years has shown that surface water concentrations are not likely to pose significant risk to aquatic plants and animals, and that surface water concentrations will seldom exceed chronic water quality standards. As a result of the improved regulatory profile, the Acetochlor Registration Partnership (ARP) between Monsanto and Dow AgroSciences re-applied for New York registration of acetochlor products in August 2011. At this time, the acetochlor registration in NY is pending though eminent. It will likely be a "Restricted Use" herbicide in NY State and likely not for use on Long Island.

Site of Action

Like other chloroacetamide herbicides, dimethenamid-P (Outlook) and S-metolachlor (Dual II Magnum), acetochlor is a Group 15 herbicide. It is thought these Group 15 herbicides inhibit very long-chain fatty acid synthesis. They affect sensitive weeds prior to emergence and are sometimes known as seedling shoot inhibitors. Although a relatively old chemistry, only four weeds have developed resistant populations to this herbicide site of action. Only one of the four, Italian ryegrass, has developed resistant populations in the U.S. As such, these chloroacetamide herbicides continue to be useful in herbicide resistance management programs.

Spectrum of Activity

Chloroacetamide herbicides provide excellent annual grass control and suppress yellow nutsedge. Although each of these herbicides has some activity against annual broadleaf weeds, acetochlor is significantly better on these weeds than the other herbicides. According to *The Agronomy Guide* from Penn State University, relative effectiveness ratings on annual broadleaf weeds show that acetochlor is more effective on velvetleaf, pigweed species, common ragweed, common lambsquarters, smartweed, and eastern black nightshade than the other chloroacetamide herbicides. In fact, it's the only one that provides some velvetleaf control. Acetochlor and premix combinations of acetochlor plus atrazine (Group 5 herbicide) products likely to be registered in NY are shown in Table 1. It is likely that SureStart (Dow AgroSciences) and TripleFLEX (Monsanto), premixes of acetochlor with clopyralid (Stinger - a Group 4 herbicide) and flumetsulam (Python - a Group 2 herbicide), will also be registered. Each of these acetochlor premixes provides broad spectrum weed control in corn and can play an important role in herbicide resistance management.

Trial Results

Although field research with acetochlor has been conducted in NY over many years, only results from 2012 experiments will be discussed here. In one experiment, field corn, DKC42-72, was planted May 15 near Aurora and preemergence (PRE) herbicides applied the following day. This experiment included an acetochlor only product (Harness 7EC). It also compared a premix of acetochlor plus atrazine (Harness Xtra 5.6L) with a premix of S-metolachlor plus atrazine (Bicep II Magnum) which is a familiar standard product used for broad spectrum weed control in corn. No significant rain was recorded the first week after treatment (WAT); however, herbicides were activated by 1.05 inches of rain the second WAT. Weed control ratings were made 25 days after treatment (DAT) prior to mid-postemergence (MPO) glyphosate applications. As shown in Table 2, control ratings showed that Harness 7EC (acetochlor alone) controlled about 50% of the three annual broadleaf weeds, common ragweed, common lambs quarters, and wild mustard. It also controlled 97% of the giant foxtail. The premixes, Harness Xtra 5.6L and Bicep II Magnum controlled 99-100% of all four weeds. There were no differences in corn yields among these treatments. These yield results were expected since each of these treatments received MPO glyphosate applications to control any escaped weeds. The average yield of these treatments was 161 Bu/A compared with 91 Bu/A fore the untreated check.

Table 2. Annual grass and broadleaf weed control ratings 25 days after treatment (DAT) with preemergence corn herbicides and grain corn yields in 2012 near Aurora, NY.

	Rate	% Control 25 DAT				Yield
PRE Herbicides	Amt/A	Ragweed	Lambs	Foxtail	Mustard	Bu/A
Harness 7EC*	2.2 pt	50	50	97	55	158
Harness Xtra 5.6L*	2.3 qt	99	99	100	100	158
Bicep II Magnum*	2.1 qt	100	99	99	99	166
Untreated Check	-	0	0	0	0	91
LSD (0.05)		15	15	3	15	21

*Treatments received a MPO application of 22 fl oz/A of Roundup PowerMax.

In a second experiment, corn (DKC42-91) was planted May 24 and a PRE application of 2.6 qt/A of Keystone (acetochlor plus atrazine) received 1.05 inches of rain the first WAT. This premix provided 100 and 98% common ragweed and giant foxtail control 14 WAT respectively. This late season control did not benefit from a MPO glyphosate application as in the other experiment. Corn yield for the Keystone treatment was 183 Bu/A compared with 117 Bu/A from the untreated check. Although acetochlor does not provide a new site of action, it does bring products that provide broader spectrum weed control than similar products available to NY corn and soybean growers.

Crop Management

Yield Responses to Seeding Rates for Grain Corn in Field-Scale Studies in New York

Bill Cox and Geoff Reeves, Department of Crop and Soil Sciences, Cornell University

When soil conditions are conducive to 90% plant establishment (May and June planting dates), we currently recommend seeding rates of 30,000 kernels/acre for grain corn on silt loam and silty clay loam soils in New York. We base these recommendations on numerous studies beginning with a 3-year study from 1991-1993 (*What's Cropping Up?*, Vol. 4, No.2, p.3), followed by a 3-year study from 2003-2005 (*What's Cropping Up?*, Vol. 16, No.2, p.1), field-scale studies from 2006 through 2010 (*What's Cropping Up?*, Vol. 21, No.1, p.4-5) and a more recent small plot study in 2010-2011 (*What's Cropping Up?*, Vol. 22, No.1, p.6-7). Nevertheless, many growers plant corn for grain at seeding rates ranging from 33,000 to 37,000 kernels/acre. Consequently, we initiated 2-year field-scale studies on four farms in 2011 to validate our seeding rate recommendations under grower conditions.

We evaluated two hybrids ('DKC49-94 GENSS' and 'P9807HR') on four farms (a 20-inch row site in Cayuga Co., a twin row site in Orleans Co., and two 30-inch row sites) at four seeding rates (25,000 to 40,000 kernels/acre at 5000 kernel/acre increments, except at the 20-inch site where the range was 27,000 to 42,000 kernels/acre).Silt loams were the predominant soils at all sites except for silty clay loam at the Seneca Co. site. Growers performed all field operations including land preparation, planting, spraying, fertilizing and harvest. Each study ranged from about 7.5 to 18 acres in size. Primary tillage at the four sites included strip tillage at the 20-inch row site in 2011 and chisel tillage in 2012, disc tillage at the twin row site, moldboard plow at one 30-inch row site (Livingston Co.), and no-till at the other 30-inch row site (Seneca Co.). Planting was delayed until late May or early June at all sites in 2011 (except May 11 at Seneca Co.) because of excessively wet April and May conditions. All sites were planted in mid-May in 2012 (except mid-April at Cayuga Co.).

In 2011, final plant establishment of both hybrids averaged 76% at Cayuga Co, 92% at Orleans Co., 96% at Livingston Co., and 95% at Seneca Co. Quadratic regression equations were developed based on the yield response to seeding rates for each hybrid. Regression equations predicted maximum yields at 36,800 and 40,000 kernels/acre for the two hybrids at Cayuga Co. and 40,000 kernels/acre for both hybrids at Livingston Co.in 2011 (Figure1). Despite relatively high yields at Orleans and Seneca Co., yields generally did not respond to seeding rate (except for a predicted maximum yield at 30,500 kernels/acre for the DEKALB hybrid at Seneca Co).

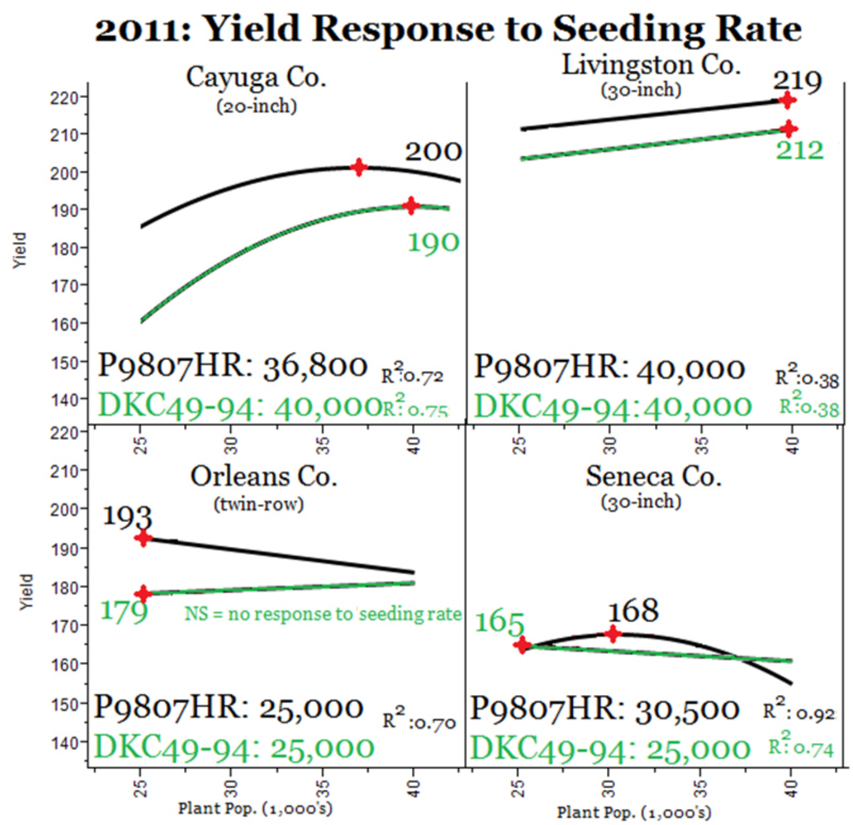

Figure1. Yield responses of two hybrids at four sites and four seeding rates in 2011. Highlighted values indicate the seeding rate where maximum yields are predicted.

In 2012, final plant establishment of both hybrids averaged 77% at Cayuga Co., 94% at Orleans Co., 96% at Livingston Co., and 88% at Seneca Co. Despite similar final plant establishment and yields in 2012 vs. 2011 (except for yield at Cayuga Co.), grain yields generally did not respond to seeding rates (except at Seneca Co. where maximum predicted yields were at less than 30,000 kernels/acre for both hybrids, Figure 2). Grain moisture and test weight tended to decrease at higher seeding rates but differences were not of sufficient magnitude to be of practical significance.

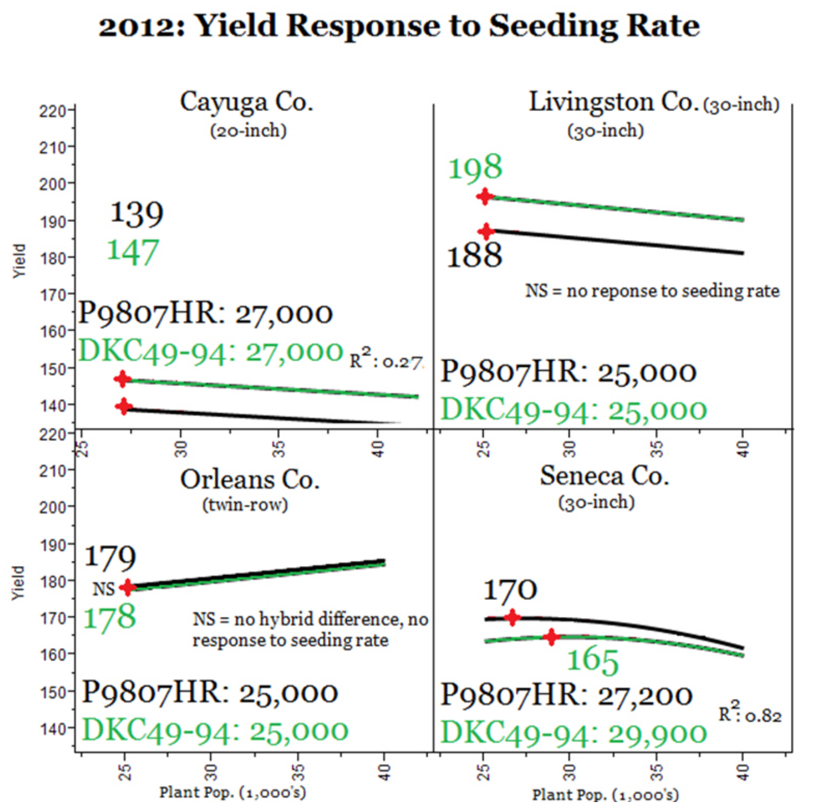

Figure 2. Yield responses of two hybrids at four sites and four seeding rates in 2012. Highlighted values indicate the seeding rate where maximum yields are predicted.

Conclusion

Both years were dry before silking (dryness also continued during the silking period at Seneca Co. in 2011 and Cayuga Co. in 2012), which may have reduced the probability of strong responses to seeding rates. On the other hand, dry conditions before silking greatly reduced the stature of the corn crop and subsequent lodging potential at the higher seeding rates. Nevertheless, there were enough inconsistencies across years, among sites, and between hybrids that we strongly urge growers to strip-test each new hybrid that they purchase at three seeding rates with a minimum of three to four replications in a couple of fields. New planters have variable seeding rate capabilities and most combines are equipped with yield monitors so strip testing new hybrids at different seeding rates is relatively easy and not very time consuming. We suggest that growers on silt loam or silty clay loam soils strip-test at seeding rates of 30,000, 33,000 and 36,000 kernels/acre with one pass for each seeding rate. Repeat the process three to four times in your field for a total of 9-12 strips or passes. The yield information that you record after each pass will give you an idea on how each new hybrid responds to seeding rates on your farm. More importantly, growers can review yield maps (or hire consultants to review yield maps) during the winter months to determine if there are spatial responses to seeding rates in your selected fields. Growers now have incredible research capacity with their modern equipment and a wealth of data that they can mine for future management decisions on corn seeding rates.

Crop Management

Recommended Seeding Rates for Grain Corn Remain at 30,000 Kernels/Acre Based on Partial Budget Analyses of Field-Scale Studies in New York

Geoff Reeves and Bill Cox, Department of Crop and Soil Sciences, Cornell University

When soil conditions are conducive to 90% plant establishment (May and June planting dates), we currently recommend seeding rates of 30,000 kernels/acre for grain corn on silt loam and silty clay loam soils in New York. These recommendations have been based mostly on small plot research without rigorous economic analyses of the data. We evaluated two hybrids at four seeding rates in field-scale studies at four sites in New York to validate these recommendations based on partial budget analyses of the yield data and market prices for corn and input costs associated with seeding rates in the 2011 and 2012 growing seasons.

The companion article (*What's Cropping Up?* Vol.23, No.1, p.8-9) provides most of the management inputs performed by the growers at each of the four sites. In addition, all sites were harvested when grain moisture percent was mostly in the low 20s or high teens. We did note small differences in grain moisture among the four seeding rates so those differences were taken into account for drying costs ($0.06/bushel for each point of drying down to 15%). Also, local hauling costs of the grain ($.20/bushel) were included in the partial budget analyses (the higher the yield the higher the hauling costs). The growers paid about $225/80,000 kernels or bag of seed in the 2 years and the grain prices averaged $6.50 in 2011 and $7.00 in 2012.

Maximum relative profit was predicted at seeding rates of 34,500 and 38,700 kernels/acre at the narrow row Cayuga Co. site in 2011, about 1500 to 2500 kernels/acre less than the predicted maximum yield (Figure1). At Livingston Co., however, where maximum predicted yields were at seeding rates of 40,000 kernels/acre, maximum relative profit was predicted at 25,000 kernels/acre for both hybrids in 2011. Evidently, the increase in yield (8 bushels/acre) from 25,000 to 40,000 kernels/acre did not offset the added seed, hauling, and drying costs. As expected, based on the yield data, relative profit did not

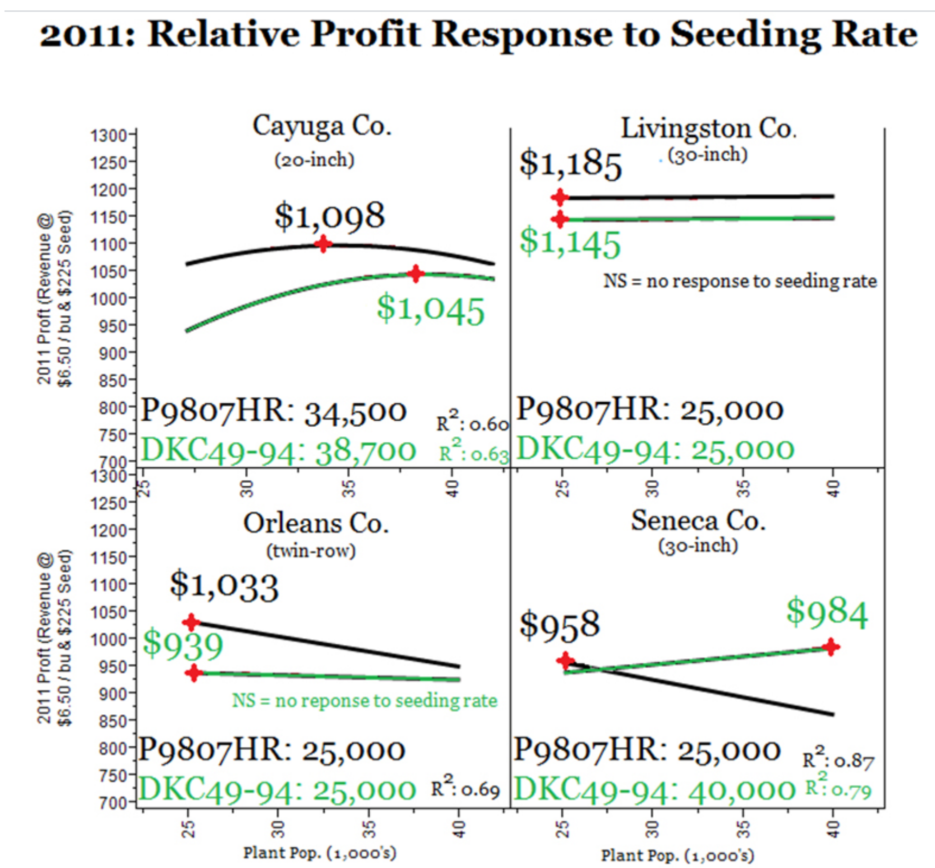

Figure1. Relative profit of two hybrids at four sites at four seeding rates, based on partial budget analyses in 2011. Highlighted values indicate the seeding rate where maximum relative profits are predicted

Crop Management

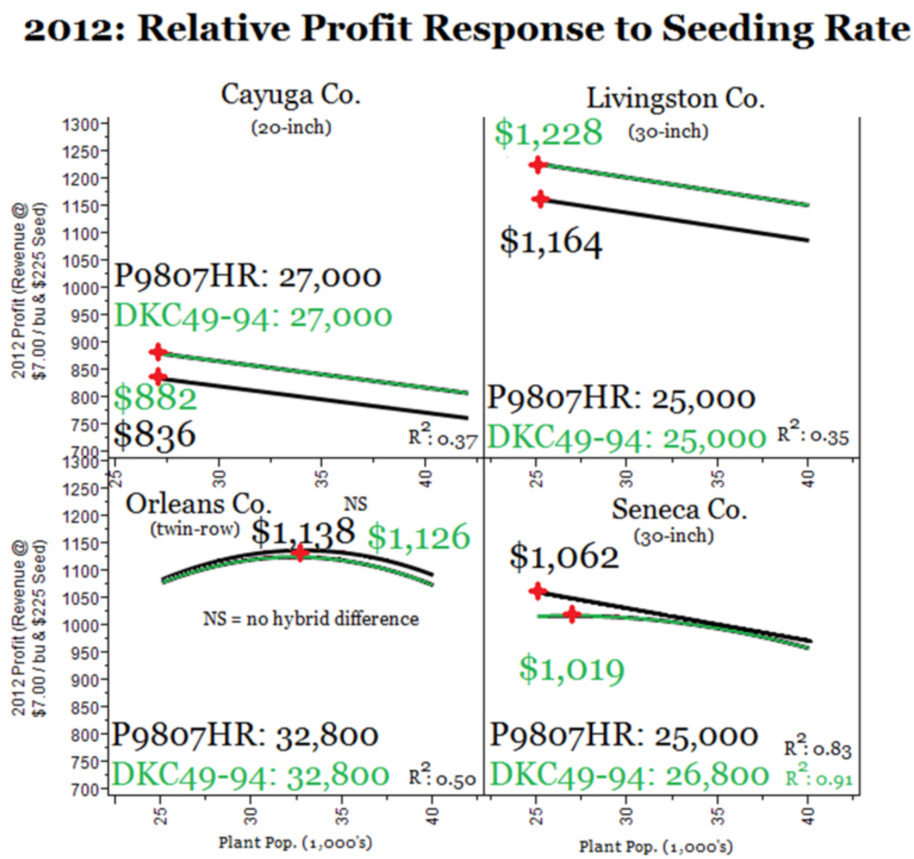

Figure 2. Relative profit of two hybrids at four sites at four seeding rates, based on partial budget analyses in 2012. Highlighted values indicate the seeding rate where maximum relative profits are predicted.

respond to seeding rates at the twin-row site in Orleans Co. in 2011. At the no-till Seneca Co. site, however, a hybrid x seeding rate interaction was noted with the DEKALB hybrid showing a positive linear response with a predicted maximum relative profit at a 40,000 kernel/acre seeding rate, despite a maximum predicted yield of only 30,500 kernels/acre (there was a 5 bushel/acre yield increase from 30,000 to 35,000 and 40,000 kernels/acre). The Pioneer hybrid, however, showed a negative linear response with a maximum relative profit at the 25,000 kernel/acre seeding rate.

In 2012, maximum relative profit was mostly unresponsive to seeding rates (Figure 2). At the Cayuga Co. site, both hybrids showed negative linear responses to seeding rates and at the Livingston Co. site, neither hybrid showed a relative profit response to seeding rate. At the twin row site, however, maximum relative profit was predicted at 32,800 kernels/acre for both hybrids. Evidently the non-significant yield increase (8 bushels/acre) from 25,000 to 35,000 kernels/acre partially offset the increase in seed, drying, and hauling costs resulting in predicted maximum relative profit at 32,800 kernels/acre. At the Seneca Co. site on a heavier soil (silty clay loam), maximum relative profit showed a negative linear response for the Pioneer hybrid and a muted response to seeding rates (26,800 kernels/acre) for the DEKALB hybrid.

Conclusion

Based on the results of this study, we will continue to recommend seeding rates of 30,000 kernels/acre on silt loam and silty clay loam soils in NY. We recognize, however, that years, locations, hybrids, and soil variability within fields strongly influence the response of corn to seeding rates. Many growers now have yield maps that provide them complete information on how their fields have yielded given current inputs. We strongly urge growers to conduct replicated strip-testing of seeding rates for all their new hybrids on fields of their choice to evaluate how hybrids respond to seeding rates on their farms. In addition, growers will also be able to gain valuable information on whether there are spatial responses to seeding rates in their fields.

Nutrient Management

Manure Injection Rate Study at Table Rock Farm

Quirine Ketterings[1], Greg Godwin[1], Willard DeGolyer[2], Karl Czymmek[1,3], [1]Nutrient Management Spear Program, Department of Animal Science, Cornell University, [2]Table Rock Farm, and [3]PRODAIRY, Department of Animal Science, Cornell University

Introduction

Four identical trials (different fields) were conducted at Table Rock Farm in 2010-2012 to evaluate the impact of manure application rate (spring injection) on corn silage yield, quality, and soil and environmental indicators (soil nitrate, phosphorus (P) and potassium (K) and corn stalk nitrate test (CSNT). The objective of the study was to determine if a corn silage yield or quality increase could be obtained with a spring manure application rate higher than the 9,000 gallons/acre spring injected manure that the farm was using. The three rates compared in this study were 9,000, 12,000 and 15,000 gallons/acre.

How was the research conducted?

Plot boundaries were defined in the spring prior to manure application, with four replications of each manure rate treatment. Plots were 30 feet wide and varied in length from 550 to 900 feet. Baseline soil fertility samples were taken for each plot (15 cores per plot, 0-8 inch and 0-12 inch depths). Soil samples were analyzed for pH, organic matter, and Morgan extractable nitrate, P, K, calcium (Ca), magnesium (Mg), zinc (Zn), manganese (Mn), and aluminum (Al) at the Cornell Nutrient Analysis Laboratory (2010) and the Maine Soil Testing Service (2011-2012). The analyses for the Illinois Soil Nitrogen Test (ISNT) were done at the Nutrient Management Spear Program (NMSP) laboratory. Results showed very high P levels for the trials in 2010 and high P levels for the 2011-2012 trials. The 2011-2012 sites were lower in organic matter and pH as well but within optimal ranges for corn production (Table 1).

Manure was sampled directly from the manure spreader at the time of application, with three samples taken per field. Samples were analyzed for total N, ammonia N, and total P and K, solids and density at Dairy One (Table 2) with organic N determined as the difference between total N and ammonia N. Spring injection of 9,000 gallons/acre gave estimated available N rates of 112, 79, and 90 lbs N/acre in 2010, 2011 and 2012 respectively (Table 2). Multiplication by 1.33 and 1.67 will result in estimates of available N for the 12,000 and 15,000 gallons/acre rates.

Planting took place 5-10 days after land preparation involving a zone builder (30 inch spacing, 14 inches deep) followed by an Aerway(R) plus rolling basket. To allow fields to dry, there was typically a week between manure injection and zone building. Earlier research in New York showed that manure could replace the need for starter N at planting for regularly manured fields (Ketterings et al., 2012), so no starter fertilizer was used.

Table 1. Initial soil fertility status (0-8 inch depth)*.

Field		pH	OM	ISNT-N	P	K	Mg	Ca	Al	Mn	Zn
			%	ppm	----------	----------	lbs/acre	----------	----------	----------	----------
A	2010	7.1	4.9	382 O	78 VH	451 VH	440 VH	4966	18	21	3.0
B	2010	7.1	4.6	334 M	66 VH	432 VH	439 VH	4519	20	32	3.2
C	2011	6.5	3.5	260 D	25 H	340 VH	269 VH	3060	26	39	1.5
D	2012	6.5	3.9	247 D	11 H	206 VH	383 VH	2795	30	35	2.0

*Soils were analyzed for pH, organic matter (OM) by loss-on-ignition, Morgan extractable P, K, Mg, Ca, Al, Mn, and Zn. The soils were Bath channery silt loam with Mardin channery silt loam (2010), Bath channery silt loam (2011), and Bath channery silt loam with Mardin channery silt loam (2012). For ISNT interpretations: O = Optimal (no response to extra N fertilizer), M = marginal, D is deficient (i.e. soil organic N supply is insufficient).

Table 2. Manure composition in each of the three years of trials at Table Rock Farm.

	Total nitrogen	Ammonia nitrogen	Organic nitrogen	Phosphate equivalent	Potash equivalent	Total Solids	Density	Available with 9,000 gallons/acre*		
	N	N	N	P_2O_5	K_2O			N	P_2O_5	K_2O
	----------	----------	lbs/1000 gallons	----------	----------	%	lbs/gallon	-----	lbs/acre	-----
2010	24.7	12.9	11.7	8.7	22.3	9.4	8.4	112	78	201
2011	15.9	10.8	5.1	6.5	18.3	5.6	8.4	79	59	165
2012	20.0	10.1	9.9	6.9	21.2	6.3	8.2	90	62	191

*Multiplication by 1.33 and 1.67 will result in estimates of available N for the 12,000 and 15,000 gallons/acre rates.

Prior to manure application in the spring, the plots were soil-sampled for general soil fertility (0-8 inch depth) and initial soil nitrate levels (0-12 inch depth). All plots were soil-sampled again when corn was between 6 and 12 inches tall (0-12 inch depth, referred to as pre-sidedress nitrate test or PSNT sampling) and harvest (0-12 inch depth, end-of-season nitrate). Stand density was determined by stand counts taken at PSNT-sampling time. The fields were not sidedressed. At harvest, we determined corn silage yields from the middle 20 feet of each plot and took corn stalk nitrate test (CSNT) samples. A forage subsample was taken for each plot to determine moisture content and forage quality. Forage analyses were done by Cumberland Valley Analytical Services. The CSNT samples were analyzed at the NMSP laboratory.

Results

The yield results indicate no benefit of an increase in manure rate beyond the 9,000 gallons/acre (Table 3), although in 2011, the higher rates averaged 21.4 tons/acre versus 19.5 ton/acre with the 9,000 gallon/acre application rate. This was also the year in which the manure N content was considerably lower (Table 2) and in which soil ISNT indicated additional N was needed for optimum yield (Table 1). Increasing the application rate did not impact stand density or moisture content of the corn silage at harvest and did not result in a DM increase. Yields were good: 21.6 and 21.0 tons/acre for fields A and B, respectively, in 2010, 20.8 tons/acre for field C in 2011 and 21.5 for field D in 2012.

The highest application rate resulted in an increase in PSNT-N over the lowest rate (significant in field B and the four-field average, with similar trends for the other fields). The highest manure rate also significantly increased CSNT-N at all fields except B, as did the middle rate at fields C and D (Table 4). The four-field average suggests CSNT increases of about 500 ppm per 1,000 gallons of manure applied beyond the 9,000 gallon/acre rate (Table 4) although actual increases for individual sites varied from a little less than 200 ppm (field B) to 654 ppm (field D) per 1,000 gallons of manure (Figure 1). Across all fields, PSNT and CSNT increased with manure application rate but the 9,000 gallon/acre application also resulted in PSNTs and CSNTs that were optimal or exceeded critical values, illustrating N was not limiting production, even at the 9,000 gallon/acre application rate.

Crude protein increased with the higher manure rates at fields C and D by 0.7% and 0.6% respectively. The four-field average showed significant differences in crude protein between the lowest and highest rates (Table 5).

Table 3. Stand density at sidedress time, percent moisture content and yield as influenced by rate of spring injected manure. A P-value >0.05 indicates that there is no significant difference among the treatments (manure rates)*.

Field	Manure rate	Stand density	Moisture at harvest	Corn yield (at 35% DM)
	gallons/acre	plants/acre	%	tons/acre
A	9,000	31,172 a	57.6 a	21.7 a
	12,000	30,873 a	57.9 a	20.9 a
	15,000	31,514 a	57.8 a	22.1 a
B	9,000	31,001 a	55.9 a	20.4 a
	12,000	31,113 a	55.6 a	21.3 a
	15,000	30,883 a	57.3 a	21.3 a
C	9,000	32,344 a	65.4 a	19.5 a
	12,000	31,581 a	65.2 a	21.5 a
	15,000	32,670 a	65.7 a	21.4 a
D	9,000	34,957 a	58.2 a	23.5 a
	12,000	34,303 a	59.9 a	22.8 a
	15,000	36,373 a	59.4 a	21.8 a
Average all fields	9,000	32,368 a	59.3 a	21.3 a
	12,000	31,968 a	59.7 a	21.6 a
	15,000	32,860 a	60.0 a	21.6 a

*Average values with different letters (a,b,c) are statistically different (α = 0.05).

Nutrient Management

Table 4. Cornell Morgan soil test nitrate (NO3-) (0-12 inch depth including PSNT) and CSNT as influenced by rate of spring injected manure. A PSNT>21 ppm indicates no additional N is needed. A CSNT is optimum if between 750 and 2000 ppm, marginal if 250-750 ppm.

Field	Rate gallons/acre	--Pre-Application-- 0-12 inches ppm		--PSNT-- 0-12 inches ppm		---At Harvest--- 0-12 inches ppm		CSNT ppm		
A	9,000	11.0	a	58.3	a	17.4	a	599	b	M
	12,000	11.5	a	66.9	a	18.9	a	1,821	ab	O
	15,000	12.2	a	73.5	a	23.7	a	3,952	a	E
B	9,000	10.2	a	40.4	b	16.0	a	1,569	a	O
	12,000	7.6	a	54.1	b	19.1	a	1,713	a	O
	15,000	9.6	a	86.4	a	20.9	a	2,724	a	E
C	9,000	3.9	a	54.3	a	19.9	b	878	b	O
	12,000	3.6	a	57.6	a	32.1	a	3,802	a	E
	15,000	4.0	a	51.2	a	26.1	ab	4,430	a	E
D	9,000	6.0	a	45.7	a	13.7	b	3,279	b	E
	12,000	5.5	a	64.7	a	26.9	a	6,273	a	E
	15,000	5.7	a	60.0	a	29.6	a	7,201	a	E
Average all fields	9,000	9.1	a	49.0	b	15.7	b	1,581	b	O
	12,000	8.2	a	61.9	ab	21.6	a	3,402	a	E
	15,000	9.1	a	73.3	a	24.7	a	4,577	a	E

*Average values with different letters (a,b,c) are statistically different (α = 0.05).

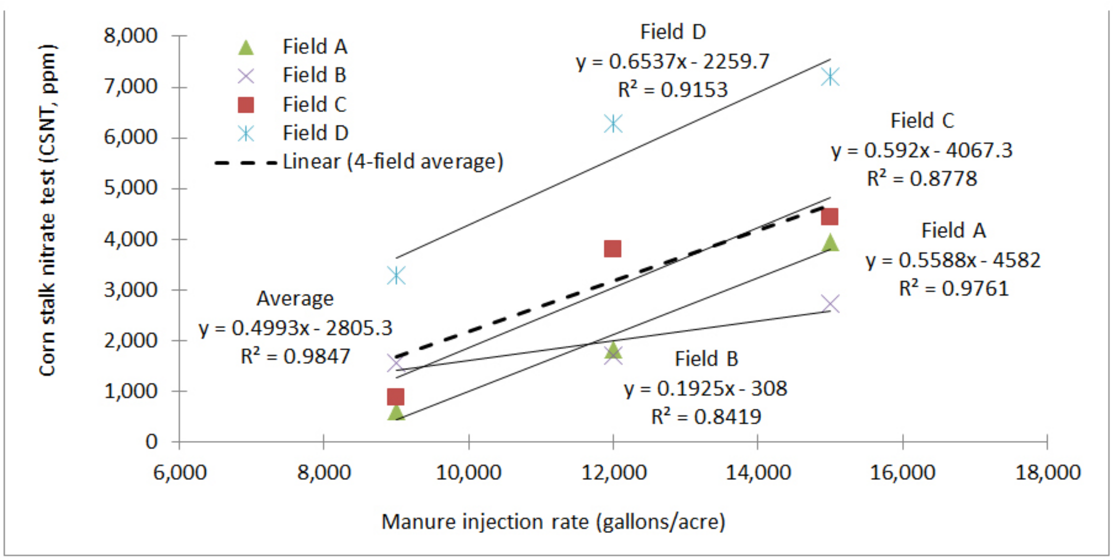

Figure 1: Corn stalk nitrate test results for all four fields (2010 - 2012 growing seasons).

Table 5. Corn silage crude protein, NDF, NDF digestibility, and estimated milk production potential expressed in milk/ton and milk/acre as influenced by rate of spring injected manure*.

Field	Manure rate	CP		NDF		dNDF		Milk/ton		Milk/acre	
	gallons/acre	%		%		% of NDF		lbs/ton		lbs/acre	
A	9,000	7.0	a	35.6	a	63.5	a	3,672	a	27,921	a
	12,000	7.2	a	39.7	a	67.4	a	3,591	a	26,266	a
	15,000	7.6	a	39.6	a	68.2	a	3,612	a	27,912	a
B	9,000	6.6	a	37.4	a	66.6	a	3,676	a	26,228	a
	12,000	6.7	a	40.4	a	66.8	a	3,564	a	26,545	a
	15,000	7.7	a	38.7	a	64.3	a	3,571	a	26,723	a
C	9,000	7.0	b	36.9	a	69.5	a	3,670	a	25,088	a
	12,000	7.7	a	37.4	a	69.5	a	3,622	a	27,237	a
	15,000	7.7	a	37.9	a	69.7	a	3,603	a	27,022	a
D	9,000	7.3	b	44.2	a	69.0	a	3,448	a	28,382	a
	12,000	7.9	a	42.5	a	69.2	a	3,515	a	28,069	a
	15,000	7.9	a	41.1	a	69.3	a	3,549	a	26,963	a
Average all fields	9,000	7.0	b	38.5	a	67.1	a	3,617	a	26,905	a
	12,000	7.4	ab	40.0	a	68.2	a	3,573	a	27,029	a
	15,000	7.7	a	39.3	a	67.8	a	3,584	a	27,155	a

*Average values with different letters (a,b,c) are statistically different (α = 0.05).

Table 6. Cornell Morgan soil test P (0-8 inches) as influenced by rate of spring injected manure.

Field	Rate	Initial		Planting		Sidedress		Harvest	
	gallons/acre	lbs/acre							
A	9,000	75.3	a	88.0	a	89.8	a	81.5	a
	12,000	83.5	a	91.0	a	105.8	a	92.3	a
	15,000	76.5	a	90.8	a	101.3	a	92.3	a
B	9,000	66.3	a	80.8	a	66.5	b	71.3	b
	12,000	66.5	a	79.0	a	84.3	a	**78.5**	ab
	15,000	65.0	a	87.8	a	90.5	a	**82.8**	a
C	9,000	23.8	a	26.5	a	30.3	a	26.0	a
	12,000	24.5	a	27.5	a	28.3	a	26.5	a
	15,000	25.5	a	28.8	a	29.0	a	26.8	a
D	9,000	10.6	a	11.6	a	8.9	b	8.9	b
	12,000	11.3	a	12.7	a	11.6	ab	12.4	ab
	15,000	10.1	a	12.9	a	13.2	a	**12.8**	a
Average all fields	9,000	44.0	a	51.7	a	48.9	a	46.9	a
	12,000	46.4	a	52.6	a	57.4	a	52.4	a
	15,000	44.2	a	55.0	a	58.5	a	53.5	a

Average values with different letters (a,b,c) are statistically different (α = 0.05). A Morgan soil test P value between 9 and 40 lbs/acre is classified as optimal. Treatments where P values are significantly higher ($P<0.05$) at harvest compared to the initial sampling are indicated in bold.

However, estimated milk production was not impacted when forage quality was expressed as estimated milk production per ton of silage or milk production per acre (Table 5) suggesting applications exceeding 9,000 gallons/acre did not increase milk production from this forage.

Conclusions

The manure injection rate studies confirmed that the 9,000 gallon/acre application rate using manure from this individual farm (the rate is likely to vary from farm to farm based on nutrient content and other parameters) is sufficient to meet N needs; higher rates lower the nutrient use efficiency of the application and increase the risk of P buildup over time. Similar trials need to be done at other farms under different growing conditions (soil types, soil fertility levels, weather differences, etc.) before we can draw conclusions regarding manure injection rates for New York State. Such studies will be ongoing in 2013.

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Acknowledgments

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Calendar of Events

March 21, 2013	Adapt-N Intensvie Training Webinar, Multiple Locations TBA
June 6, 2013	Small Grains Management Field Day, Aurora, NY

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Cornell University
Cooperative Extension
Dept. of Crop and Soil Sciences
237 Emerson Hall
Cornell University
Ithaca, NY 14853

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