What's Cropping Up?

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Managing Corn Rootworm in Non-GMO Corn

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Aerial view of lodged corn from extensive corn rootworm larval feeding.

An increasing number of dairy producers are being asked by their milk processors to seriously consider producing milk from dairy cows fed non GMO forages and grains. Many milk producers feel the pressure to comply with the request in order to preserve their milk market. The decision to grow non GMO corn impacts both the weed control program and management of corn rootworm.

Biology:
A review of the biology of corn rootworm is a good starting point for this discussion. Adult corn rootworm emerge from existing corn fields around the first of August, where the larvae have been feeding on corn roots. Adults begin emerging around corn pollen shed and start feeding on corn pollen. After about 3-weeks, the females begin to lay eggs in existing corn fields. The eggs overwinter with the larvae hatching the following May. If the field is planted to corn, then the larvae start feeding on corn roots, but if the field has been rotated to another crop, the newly hatched larvae die. Since eggs are laid in existing corn fields, first year corn has zero risk of corn rootworm damage in NYS. In terms of risk, second year corn fields have a 25-35% chance of risk for rootworm damage, third year corn a 50-70% risk of losses from corn rootworm larval feeding and fourth year corn risk for rootworm losses is between 80-100%.

Adult rootworm scouting procedures are available and help to decide if the field is medium-high risk for larval damage the following growing season. Adult beetle scouting occurs around pollination and is conducted for three subsequent weeks. If beetle counts average 1 beetle per plant and the females have mature eggs, the field is at risk for larval feeding damage.
(https://fieldcrops.cals.cornell.edu/sites/fieldcrops.cals.cornell.edu/files/shared/documents/fcorn_scouting.pdf).

Adult beetle scouting does not account for the subsequent larval mortality when the soils are waterlogged during the hatching period, so using adult counts to estimate risk usually overestimates risk. Assessment of the rootworm larval population after hatch is difficult and very labor intensive.

Pest Management

Management options:
Since first year corn has zero risk from rootworm larval damage, the standard seed treatment (Poncho, Cruiser 250) is all that is needed for protection from germinating-seedling damaging insects. Second through fourth year corn need some protection for potential corn rootworm larval feeding.

Shortened Rotation:
Risk of rootworm feeding damage increases with the duration of continuous corn within a field. Since first year corn has zero risk from rootworm and second year corn has reduced risk (25-35%), a shortened corn rotation reduces the need (and cost) of rootworm management. Producers who can only grow two years of corn before rotating to a non-corn crop can frequently grow corn without any extra rootworm management expense.

High Rate of Seed Treatments:
The high rate of seed treatment (Poncho 1250, Cruiser 1.25) offered for seed corn has activity on corn rootworm larvae. In growing seasons with adequate rain fall and moderate corn rootworm pressure, the high rate of seed treatment will provide adequate protection for the crop. In situations where the field has high rootworm pressure, the insects often overrun the insecticide, resulting in economic root feeding damage. High rates of seed treatments are also challenged to provide adequate control during times of limited rain fall during June-July or in times of excessive rain fall during the same time period. Use of the high rate of seed treatment is best matched to the second and third year of continuous corn when rootworm pressure is lower.

Liquids Soil Insecticides:
The use of liquid soil insecticides (Capture, Force) mixed with the liquid starter fertilizer and applied in-furrow has become a popular option for growers without granular insecticide boxes on their corn planter. Past research in NY has consistently shown that either of these two insecticides applied in this manner are highly variable in control. In talking with farmers who are avid supporters of the use of liquids in this manner, they frequently admit to control failures consistent with the research results. The major issue with this application method is not the efficacy of the insecticide on the rootworm larvae, but the timing of the application with a liquid formulation. Application of a soil insecticide at planting is introducing the soil insecticide into the soil environment three to four weeks before corn rootworm larvae begin to hatch. It has always been a challenge for soil insecticides to still be in the root zone 3-5 weeks after application so the insecticide can be present to kill the newly hatched larvae. Granular insecticides bridge this time period with the slow-release properties of the granule. High-rate seed treatments bridge this time period with the slow-release properties of the seed coating. Liquid insecticides mixed with liquid fertilizer and applied in the seed furrow at planting does not have any slow release properties. Heavy rainfall events in the 3-5 weeks between planting and rootworm hatch flush the liquid insecticide out of the root zone along with the starter fertilizer. Heavy rain fall events during May-early June is not an unusual event in NY. Highly variable efficacy of liquid insecticides applied at planting are more directly linked to the lack of a slow release formulation and being flushed out of the root zone than the efficacy of the insecticide against rootworm. In their best years in research plots, liquid insecticides were also challenged to suppress heavy populations of rootworm larvae. Liquid insecticides applied in-furrow with the starter fertilizer is not recommended for rootworm control in NYS.

Granular Soil Insecticides:
Granular soil insecticides applied at planting were the primary management strategy before the introduction of seed treatments and rootworm-active GMO trait in the corn. They remain a very effective tool to manage corn rootworm and were left behind due to the convenience of the newer technologies. For producers who have insecticide boxes for their planters, granular soil insecticides provide a more reliable management tool than either high-rates of seed treatments or liquid insecticide applied in-furrow with the liquid fertilizer. Each different granular insecticide has its strengths and weaknesses and I will try to summarize them below.

We initiated a 3-year study at the Aurora Research Farm in 2015 to compare different sequences of the corn, soybean, and wheat/red clover rotation in

Force 3G:
Force 3G is a widely used soil insecticide in corn production. It performs best when soil moisture is adequate to in excess due to its low solubility in water. If a producer calibrates accurately, use rates can be reduced to 75% of the label rates for moderate rootworm populations. In dry years, even a full label rate faces challenges controlling rootworm populations due to the insecticide's low solubility in water. Force is effective across all soil PH ranges.

Counter 15G, 20G:
Counter 15G, 20G is an effective soil insecticide against corn rootworm larval populations. This insecticide performed best in dry to moderately wet soils, but was challenged to perform adequately under conditions of excessive rainfall. Counter has a higher solubility in water than Force and effective across all soil PH ranges. With the introduction of ALS inhibitor herbicide, Counter was shown to have a serious interaction leading to plant injury. An introduction of a 20 CR (controlled release) granular was attempted with variable results. Due to the herbicide interactions, the use of Counter was significantly reduced by producers.

Lorsban 15G:
Lorsban 15G has been an effective soil insecticide against low to moderate populations of corn rootworm larvae. However, this insecticide is PH sensitive and cannot be used in soil PH above 7.8. In the high PH soils at the Cornell Musgrave Farm, Lorsban was deactivated by the high PH before rootworm hatch. In soils with PH of 7 or lower, this material can provide effective control against low to moderate rootworm population levels.

Summary:
If producers are serious about growing non-GMO corn, they need to invest in granular insecticide boxes for their planter if they do not have them. Granular insecticides are the only reliable way to control corn rootworm larvae across corn rootworm population levels and weather conditions. Liquid insecticides in liquid fertilizer applied at planting demonstrates highly variable control and is a poor investment. High rate of seed treatments are effective against low to moderate population levels of rootworm larvae and are sensitive to soil moisture levels. Granular insecticides provide the most consistent control of corn rootworm. However, in most situations, the corn planter operator needs to have a Pesticide Applicator License.

Crop Production

Low Weed Densities in Conventional and Organic Soybean in 2017

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Conventional soybean (center) had virtually no visible weeds along the entire 100 foot plot. Organic soybean (left) had a few visible weeds towering over the crop.

conventional and organic cropping systems under recommended and high input management during the 3-year transition period (2015-2017) from conventional to an organic cropping system. We provided a detailed discussion of the various treatments and objectives of the study in a previous soybean article (http://blogs.cornell.edu/whatscroppingup/2015/09/16/emergence-early-v2-stage-plant-populations-and-weed-densities-r4-in-soybeans-under-conventional-and-organic-cropping-systems/). This article will focus on weed densities in soybean at the R3-R4 stage in 2017.

Corn preceded soybean in the rotation in this study. The fields were plowed on May 17 and then cultimulched on the morning of May 18, the day of planting. We used a White Air Seeder to plant the treated (insecticide/fungicide) GMO soybean variety, P22T41R2, and the non-treated non-GMO variety, 92Y21, at two seeding rates, ~150,000 (recommended input) and ~200,000 seeds/acre (high input). The varieties are not isolines so only the maturity of the two varieties and not the genetics are similar between the two cropping systems. We treated the non-GMO variety in the seed hopper with the organic seed treatment, Sabrex, in the high input organic treatment. We planted soybean in the typical 15” row spacing in the conventional cropping system and the typical 30” row spacing (for cultivation of weeds) in the organic cropping system.
We applied Roundup (Helosate Plus Advanced) on June 21 at ~32 oz. /acre for weed control in conventional soybean (V4 stage) under both recommended and high input treatments. We used the rotary hoe to control weeds in the row in recommended and high input organic soybean at the V1-2 stage (June 2). We then cultivated close to the soybean row in both recommended and high input organic treatments at the V3 stage (June 12) with repeated cultivations between the rows at the V4-V5 stage (June 22), the V5-V6 stage (June 28), the R1 stage (July 5), and the R2-3 stage (July 20). We estimated weed densities at the R4 stage (August 14th) by counting all the visible weeds along the 100 foot plot across the entire 10 foot plot width.

Conventional soybean had very few visible weeds in 2017 with most plots totally weed-free, regardless of input treatment (Table 1). Weed densities in the preceding conventional corn crop were also very low in the dry 2016 growing season, fewer than 0.40 weeds/m^2 in all treatments (http://blogs.cornell.edu/whatscroppingup/2016/07/27/emergence-plant-densities-v3-stage-and-weed-densities-v14-stage-of-corn-in-conventional-and-organic-cropping-systems-in-2016/). Evidently, robust soybean vegetative growth associated with the wet June and July conditions coupled with a low number of seeds in the weed seed bank allowed conventional soybean to outcompete the relatively low number of emerging weeds after a timely Roundup application in 2017.

Although weed densities were greater in organic compared with conventional soybean in 2017, organic soybean had relatively low weed densities, averaging less than 0.50 weeds/m^2 in fields that had a spring grain or soybean as the last conventional crops in 2014 (Table 1). Unlike the 2015 and 2016 growing seasons, high and recommended input treatments had similar weed densities in organic soybean, despite the different seeding rates. Organic corn, the preceding crop, also had relatively low weed densities in 2016, fewer than 1.25 weeds/m^2 in all treatments. Although weed densities were low, leaf area and biomass of all weeds in organic soybean were quite high. Unfortunately, August turned dry at the Aurora Research Farm (1.47 inches of precipitation) so the robust weeds would compete with organic soybean for the dwindling available soil water supply during the critical R4-R5 stage in soybean development. Organic and conventional

Table 1. Weed densities at the R4 stage under conventional management (P22T41R2-GMO variety treated with insecticide and fungicide) and organic management (P92Y21-non-GMO variety with no seed treatment) at recommended input (~150,000 seeds /acre seeding rate) and high input (~200,000 seeds/acre plus the organic seed treatment, Sabrex, in the organic cropping system) treatments in fields with different last conventional crops in 2014. Red highlighted values are significantly higher for comparisons within a column (i.e. previous crops), based on the interaction LSD.

	LAST CONVENTIONAL CROP (2014)		
TREATMENTS	SMALL GRAIN	CORN	SOYBEANS
	Weed densities-R4 stage (weeds/m2)		
CONVENTIONAL			
Recommended	0.01	0.02	0.02
High Input	0.02	0.01	0.04
ORGANIC			
Recommended	0.35	**1.30**	**0.40**
High Input	0.33	**1.28**	**0.49**
LSD-% 0.05	NS	0.52	0.35

soybean, however, yielded similarly in 2015 when dry August conditions prevailed (1.36 inches) (http://blogs.cornell.edu/whatscroppingup/2015/11/09/soybean-yield-under-conventional-and-organic-cropping-systems-with-recommended-and-high-inputs-during-the-transition-year-to-organic/). It will be interesting to see if that holds true in 2017.

In conclusion, weed densities were exceedingly low in conventional soybean, which received a timely single application of Roundup at the recommended rate. Weed densities were much higher in organic soybean but still relatively low. Evidently, a timely rotary hoe operation followed by a close cultivation to the row and repeated cultivations between the row can maintain satisfactory weed control in organic soybean in the 3rd year into an organic cropping system, especially in a year with robust soybean vegetative growth. We expected an increase in weed densities with each successive year in the organic cropping system because of an increase of weed seeds in the weed seed bank, but that has not materialized so far. In 2018, organic soybean will follow corn in a soybean-wheat/red clover-corn rotation with relatively low weed densities in organic corn in 2017 (average of 0.60 weeds/m^2) compared with much higher weed densities in organic corn in a corn-soybean-corn rotation in 2017 (average of ~2.40 weeds/m^2) (http://blogs.cornell.edu/whatscroppingup/2017/08/10/wheatred-clover-provides-n-and-may-help-with-weed-control-in-the-organic-corn-soybean-wheatred-clover-rotation/). This should shed some light on how much the weed seed bank influences weed densities and subsequent yields in organic soybean in the 4th year into an organic cropping system.

Organic Soybeans Yield 55 Bushels/Acre…………… but Conventional Beans Yield 60 Bushels/Acre

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Fig. 1. Conventional soybean (right) had virtually no weeds in 2017 with a single application of Roundup. Organic soybean (far left-middle area are 4 border rows between conventional and organic) had relatively few but fairly robust weeds.

We initiated a 3-year study at the Aurora Research Farm in 2015 to compare different sequences of the corn, soybean, and wheat/red clover rotation in conventional and organic cropping systems under recommended and high input management during the 36-month transition period (2014-2017) from conventional to an organic cropping system. We provided a detailed discussion of the various treatments and objectives of the study in a previous soybean article (http://blogs.cornell.edu/whatscroppingup/2015/09/16/emergence-early-v2-stage-plant-populations-and-weed-densities-r4-in-soybeans-under-conventional-and-organic-cropping-systems/). This article will focus on 2017 yields, the first year that organic soybean would be eligible for the organic premium.

Corn preceded soybean in the rotation in this study. The fields were plowed on May 17 and then cultimulched on the morning of May 18, the day of planting. We used a White Air Seeder to plant the treated (insecticide/fungicide) GMO soybean variety, P22T41R2, and the non-treated non-GMO variety, 92Y21, at two seeding rates, ~150,000 (recommended input) and ~200,000 seeds/acre (high input). The varieties are not isolines so only the maturity of the two varieties and not the genetics are similar between the two cropping systems. We treated the non-GMO variety in the seed hopper with the organic seed treatment, Sabrex, in the high input organic treatment. We planted soybean in the typical 15” row spacing in the conventional cropping system and the typical 30” row spacing (for cultivation of weeds) in the organic cropping system.

We applied Roundup (Helosate Plus Advanced) on June 21 at ~32 oz. /acre for weed control in conventional soybean (V4 stage) under both recommended and high input treatments. The high input soybean treatment in the conventional cropping system also received a fungicide, Priaxor, on August 2, the R3 stage. We used the rotary hoe to control weeds in the row in recommended and high input organic soybean at the V1-2 stage (June 2). We then cultivated close to the soybean row in both recommended and high input organic treatments at the V3 stage (June 12) with repeated cultivations between the rows at the V4-V5 stage (June 22), the V5-V6 stage (June 28), the R1 stage (July 5), and the R2-3 stage (July 20).

We estimated soybean plant densities in all treatments at the V2 stage (June 2), just prior to the rotary hoeing operation. We then estimated soybean plant densities at the V2-3 stage (June 12), just before the first close cultivation between the rows, to determine the extent of rotary hoe damage to soybean. We estimated weed densities at the R4 stage (August 14th) by counting all the visible weeds along the 100 foot plot across the entire 10 foot plot width. We harvested all treatments on September 26 when conventional and organic soybean averaged ~11.0% moisture.

Organic vs. conventional soybean densities averaged ~4.25% higher at the V1 and V2-3 stages (Table 1). As mentioned in a previous article (http://blogs.cornell.edu/whatscroppingup/2017/06/06/soybean-emergence-and-early-plant-densities-v1-v2-stage-in-conventional-and-organic-cropping-systems-in-2017/), we attributed the differences in plant densities to different varieties as opposed to different cropping systems. Weed densities were exceedingly low in conventional soybean, which received a timely single application of Roundup at the recommended rate (Table 1). Weed densities were much higher in organic soybean but still relatively low. As mentioned in a previous article, (http://blogs.cornell.edu/whatscroppingup/2017/08/31/low-weed-densities-in-conventional-and-organic-soybean-in-2017/), we did not expect the higher (than conventional) but relatively low weed densities in organic soybean to greatly influence yield.

Nevertheless, conventional soybean did yield ~8% greater than organic soybean in 2017 (Table 1). This is the first time in the 4-year study that conventional soybean did yield greater than organic soybean. Yield did have a negative correlation with weed densities (-0.52) perhaps because only 1.48 inches of precipitation was recorded at Aurora in August, the R3 to R5 stage in soybean in 2017. Another contributing factor may have been the difference in row spacing between the two cropping systems. In a previous study at the same site (https://scs.cals.cornell.edu/sites/scs.cals.cornell.edu/files/shared/documents/wcu/WCU20-2.pdf), 15-inch soybean yielded 8.5% greater than 30-inch soybean.

Table 1. Plant densities of soybean at the 1st leaf (V1) stage (before rotary hoeing) and V2-V3 stage (after rotary hoeing); weed densities at full pod (R4) stage; and seed yield under conventional management (P22T41R2 treated with insecticide and fungicide and a Roundup application at the V4 stage for weed control) and organic management (P9621-non-GMO variety with one rotary hoeing and four cultivations for weed control) at recommended input (~150,000 seeds /acre rate) and high input (~200,000 seeds/acre plus a fungicide application in conventional and plus an organic seed treatment in the organic cropping system) following three different last conventional crops in 2014. The LSD value is the interaction LSD, which only allows for comparisons within columns (not across columns or within rows). Red highlighted values are significantly higher for comparisons within a column (i.e. previous crops), based on the interaction LSD.

	LAST CONVENTIONAL CROP (2014)		
TREATMENTS	**SMALL GRAIN**	**CORN**	**SOYBEAN**
	Plant densities-V1 stage (plants/acre)		
CONVENTIONAL			
Recommended	118,166	123,000	123,667
High Input	142,166	140,365	144,833
ORGANIC			
Recommended	120,833	116,071	123,333
High Input	153,667	153,862	157,833
	11,217	8,401	12,236
	Plant densities-V2-3 stage (weeds/m²)		
CONVENTIONAL			
Recommended	118,771	123,372	118,771
High Input	147,789	134,967	147,789
ORGANIC			
Recommended	126,689	116,089	126,689
High Input	155,212	148,463	155,212
	13,162	10,517	7,909
	Weed densities-R3 stage (weeds/m²)		
CONVENTIONAL			
Recommended	0.01	0.02	0.02
High Input	0.02	0.01	0.04
ORGANIC			
Recommended	**0.35**	**1.30**	**0.51**
High Input	**0.33**	**1.28**	**0.40**
LSD 0.05	NS	**0.52**	0.32
	Seed Yield (bushels/acre)		
CONVENTIONAL			
Recommended	**63**	**59**	**61**
High Input	**60**	**58**	**58**
ORGANIC			
Recommended	56	55	55
High Input	55	54	53
LSD 0.05	**4**	**2**	**4**

High input soybean did not yield greater than recommended input soybean in the conventional cropping system (Table 1). The conventional treatment was planted at 200,000 seeds/acre and received a fungicide application at the R3 stage. Unlike 2015 when August conditions were dry (1.36 inches) and the fungicide application may have improved plant health, leading to an 8% yield increase (http://blogs.cornell.edu/whatscroppingup/2015/11/09/soybean-yield-under-conventional-and-organic-cropping-systems-with-recommended-and-high-inputs-during-the-transition-year-to-organic/), the fungicide application did not increase soybean yield in 2017. As in numerous other studies, we did not observe a yield increase with seeding rates at 200,000 seeds/acre compared with the recommended 150,000 seeds/acre in conventional soybean.

As in previous years, the high input (200,000 seed/acre seeding rate and organic seed treatment), and recommended input (150,000 seeds/acre) treatments in organic soybean yielded similarly (http://blogs.cornell.edu/whatscroppingup/2016/11/28/organic-soybean-once-again-yields-similarly-to-conventional-soybean-during-the-second-transition-year/). Some organic growers plant soybean at higher seeding rates to help control weeds. Weed densities were similar between the high and recommended input treatments in organic soybean so yields were once again similar for the 3rd consecutive year in this study.

In conclusion, conventional soybean yielded 8% higher than organic soybean for the first time in the 3rd year of this 4-year study. Organic soybean, however, would be eligible for the organic premium this year because 36 months have elapsed since the last application of synthetic fertilizer or pesticides on the fields used in this study. Consequently, organic soybean, despite the 8% lower yield, would be more profitable to the transitioning organic soybean grower in 2017, especially at the recommended 150,000 seed/acre seeding rate and no organic seed treatment.

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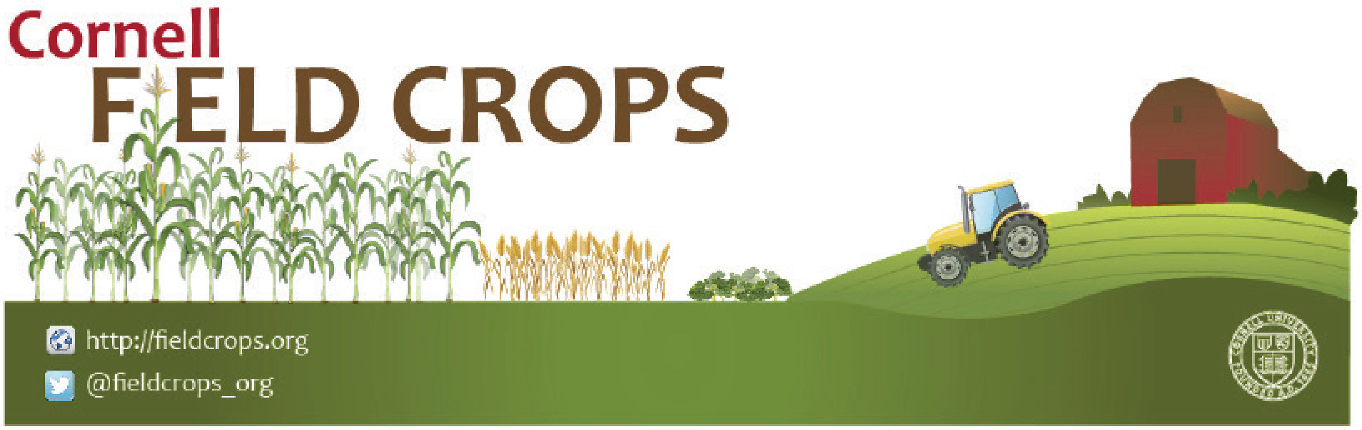

Calendar of Events

OCT 26	Basic Farm Business Management Planning - Greene Co.
NOV 3	2017 NY Women of Agriculture Conference - Syracuse, NY
NOV 8	Field Crop Dealer Meeting - East Syracuse, NY
NOV 8 & 9	First Annual Cover Crops Meeting sponsored by Northeast Cover Crops Council - Ithaca, NY
NOV 28-30	Northeast Regional Certified Crop Adviser Annual Training - East Syracuse, NY
DEC 13 & 14	Empire State Barley & Malt Summit - Liverpool, NY

Have an event to share? Submit it to jnt3@cornell.edu!

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What's Cropping Up? is a bimonthly electronic newsletter distributed by the Soil and Crop Sciences Section at Cornell University. The purpose of the newsletter is to provide timely information on field crop production and environmental issues as it relates to New York agriculture. Articles are regularly contributed by the following Departments/Sections at Cornell University: Soil and Crop Sciences, Plant Breeding, Plant Pathology, and Entomology. **To get on the email list, send your name and address to Jenn Thomas-Murphy, 237 Emerson Hall, Cornell University, Ithaca, NY 14853 or** jnt3@cornell.edu**.**

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