What's Cropping Up?

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White Mold of Soybean: What to expect with variable growth stages

Jaime Cummings and Ken Wise, NYS IPM

It's that time of year where we typically consider fungicide applications for white mold protection in our soybeans. However, this year is a little different. Soybeans across NY range from V4 to R4 this week, making it a challenging decision regarding whether or when to spray. As you know, white mold (Sclerotinia stem rot) is our most challenging and undermanaged disease of soybeans across the state (Fig. 1). It typically rears its ugly head when the rows and canopies close between growth stages R3-R6. We have no silver bullet for this disease, and therefore rely on an integrated management approach for the best results.

Figure 1. White mold infected soybean stem. (Photo by J. Cummings, NYS IPM)

The pathogen produces sclerotia, which are the hard, black survival structures that can easily survive in the soil for at least 10 years, with some reports of up to 20 years. These long-lived sclerotia, and the wide host-range of this pathogen, make crop rotation as a management strategy difficult, if not impossible. Resistance to this devastating disease is moderate, at best, in some elite commercial varieties, but none are immune or strongly resistant. Canopy management is a goal of some growers who struggle with white mold, and efforts include reduced seeding rates and wider rows. There is plenty of evidence that increased airflow in the crop rows can reduce white mold infection, because the disease is favored by the humid conditions of a dense and closed canopy. Research on biological control with a product called Contans WG has shown limited or variable efficacy in New York and Michigan, and requires a multi-year commitment for applications for the best results. However, some NY soybean growers have been successful at reducing white

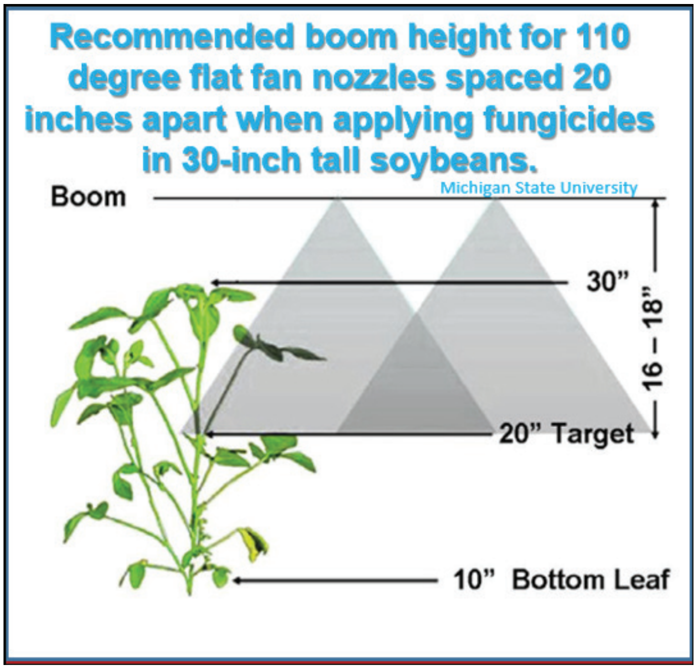


Figure 2. Nozzle recommendations for white mold suppression from Michigan State University.

mold incidence and severity in their fields treated with Contans WG, and consider the results well-worth the $35 per acre cost. Recent research at Cornell by Dr. Sarah Pethybridge (vegetable pathologist) has shown that planting soybeans into roller-crimped rye cover crops can significantly reduce the sporulation of the white mold fungus, resulting in significantly less disease. Paying attention to the expected weather patterns and forecasting models, such as Sporecaster, are also critical in making white mold management decisions, because this disease can be particularly devastating in times of high precipitation or humidity during temperatures below 85°F. Though, we have seen fairly severe epidemics in some fields even in hot, dry years.

Timely foliar fungicide applications with appropriate nozzles for canopy penetration (Fig. 2), in combination with crop rotation, genetic resistance, canopy management, and biological control remains our best approach for managing white mold in soybean fields. The main goal for your fungicide applications should be to get them applied BEFORE you have a major outbreak of white mold in your field. If you have soybeans in a field with a history of the disease, and if the weather conditions are forecasted to be favorable for disease, it's recommended to get a protective fungicide on between the R1 and R3 growth stages. Fungicide applications can be a waste of money after R4. It's important to note that once you have an epidemic in a field, no amount of fungicide will stop or cure the spread.

A number of foliar fungicides are labeled in NY for white mold protection on soybean that are rated 'Good' to 'Very Good' in the Cornell Guide for Integrated Field Crop Management, based on national replicated field

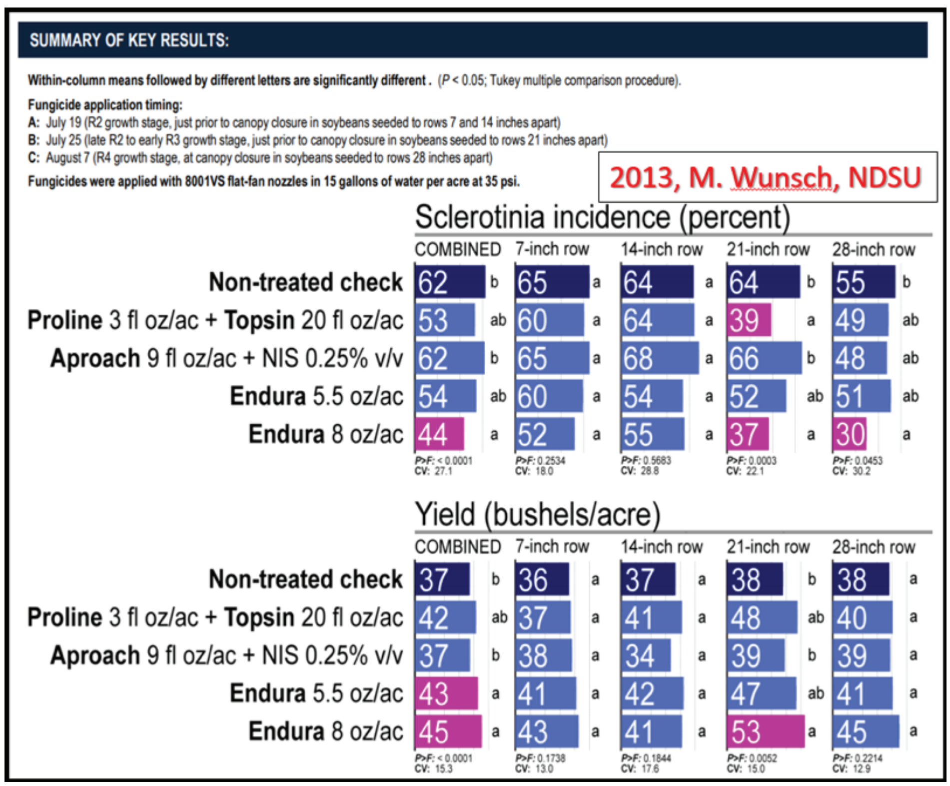
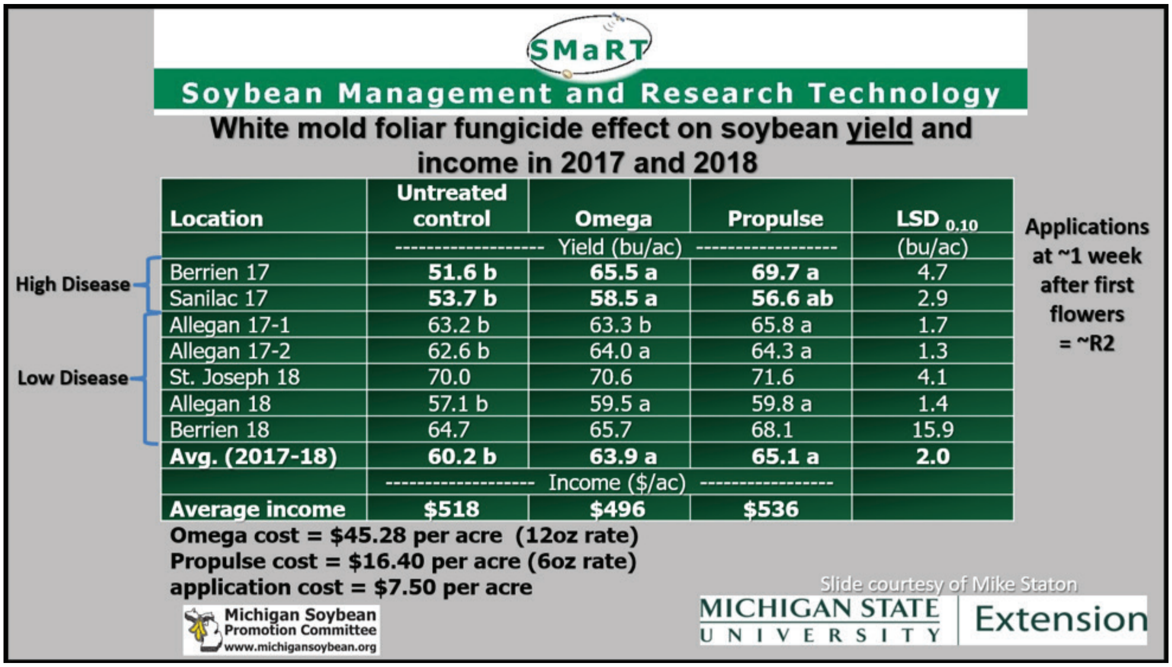


Figure 3. Research from North Dakota State University shows that combining wider row spacing with timely fungicide applications can decrease white mold disease severity and increase yields.



Location	Untreated control	Omega	Propulse	$LSD_{0.10}$
	Yield (bu/ac)			(bu/ac)
Berrien 17	**51.6 b**	**65.5 a**	**69.7 a**	4.7
Sanilac 17	**53.7 b**	**58.5 a**	**56.6 ab**	2.9
Allegan 17-1	63.2 b	63.3 b	65.8 a	1.7
Allegan 17-2	62.6 b	64.0 a	64.3 a	1.3
St. Joseph 18	70.0	70.6	71.6	4.1
Allegan 18	57.1 b	59.5 a	59.8 a	1.4
Berrien 18	64.7	65.7	68.1	15.9
Avg. (2017-18)	**60.2 b**	**63.9 a**	**65.1 a**	**2.0**
	Income ($/ac)			
Average income	**$518**	**$496**	**$536**	

Omega cost = $45.28 per acre (12oz rate)
Propulse cost = $16.40 per acre (6oz rate)
application cost = $7.50 per acre

Figure 4. Field trial results in Michigan show that both Omega and Propulse fungicides each significantly increase soybean yields, particularly when white mold disease pressure is high.

trials. These include Aproach, Endura, and Omega. Other fungicides are rated as 'Fair', including Topguard, Proline, Domark, and Topsin-M. It's important to follow all label recommendations, and note that some products, such as Aproach, recommend two applications when other products may only require a single application.

There have been a lot of soybean white mold fungicide efficacy trials in other states that have similar weather patterns and epidemics to ours, including Michigan, Wisconsin and N. Dakota. Dr. Michael Wunsch of N. Dakota State University demonstrated that increased row spacing in combination with timely application of Endura fungicide resulted in significantly lower disease incidence and higher yields compared to narrow rows and the non-treated control (Fig. 3). Mike Staton of Michigan State University demonstrated that a comparison of the fungicides Omega and Propulse showed that they both significantly increased yields compared to the non-treated control, especially in trials with high disease pressure, but that Propulse

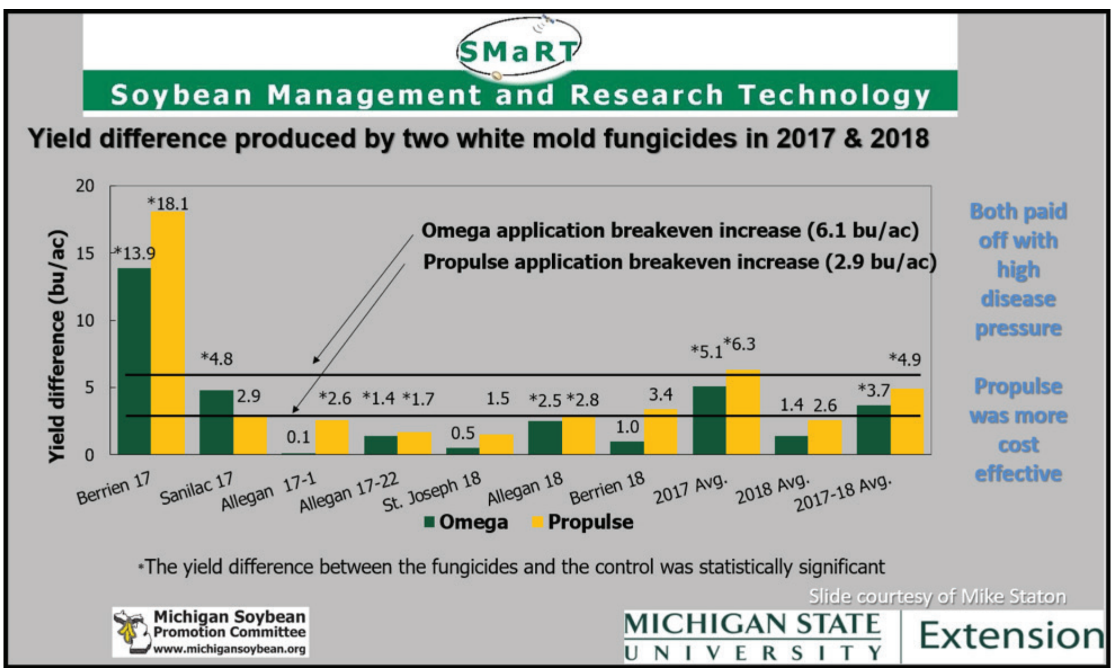


Figure 5. White mold fungicide trials in Michigan demonstrate the economics of fungicide applications in fields with high and low disease pressure.

was a much more cost-effective option (Figs. 4 and 5). Dr. Damon Smith of University of Wisconsin evaluated the effect of various fungicide combinations and application timings on disease incidence and yield, and found significant improvements in yields from applications of Propulse + Delaro, Proline + Stratego, and a double application of Delaro (Fig. 6). All registered products evaluated in these trials are labeled for use against white mold of soybeans in NY.

Table 1. Fungicides labeled for white mold in soybeans in NY with approximate costs of product per acre and general efficacy ratings from the Cornell Guide to Integrated Field Crop Management. Assume an additional average $12-13 application cost per acre. Product prices listed are based on information from only one or two dealers, and may vary by location.

Product	Price of Product per Acre	Efficacy Rating in Cornell Guide
Aproach	$13-$24	good (double application)
Delaro	$30	not rated (looks fair in WI)
Domark	$7	fair
Endura	$7-$21	very good
Omega	$47	not rated (looks very good in MI)
Proline	$13-$25	fair
Propulse	$26	not rated (looks very good in MI)
TopGuard	$15	fair
Topspin	$9	fair

Though we have a number of fungicides labeled for use on white mold in NY, not all field crop dealers carry all products, and pricing may vary by location. When opting to utilize a fungicide application as part of your integrated management strategy for white mold, keep in mind that there are wide ranges in efficacy and cost among products. A quick inquiry with only two sources provided prices or price ranges per acre of some of the products you may consider using, as outlined in Table 1 (in alphabetical order, at the highest labeled rates).

Considering the abnormally wide range in growth stages and canopy closure as we experience or approach flowering in our soybean fields, I think we can expect some difficulty in managing white mold in some locations this year. One of the most perpetuated fallacies I hear is that white mold *requires* soybean flowers for infection. Even though this is consistently mentioned in fact sheets and other resources, it is not entirely true. A soybean plant at any growth stage can succumb to infection by the white mold fungus if the conditions are favorable and if the spores are in the air. However, soybean flowering usually coincides with canopy closure, and this canopy closure encourages a humid environment

Table 7. White mold disease incidence, disease severity index, and grain yield for soybean treated with fungicide or not treated with fungicide in Wisconsin in 2017, trial #2.

Treatment and rate/A (crop growth stage at application)[x]	Disease Incidence (%)[y,w]	White mold DSI (0-100)[z]	Yield (bu/a)[w]
Propulse 3.34SC 6 fl oz (R1) Delaro 325SC 8 fl oz (R3)	18.8 c	32.8	52.3 a
Proline 480SC 3 fl oz (R1) Stratego YLD 4.18SC 4 fl oz (R3)	23.3 bc	43.3	52.0 a
Delaro 325SC 8 fl oz (R1 + R3)	22.3 bc	43.6	48.3 ab
Experimental 1 (R1 + R3)	36.0 ab	63.1	42.8 bc
Topguard EQ 4.29SC 5 fl oz (R1 + R3)	29.8 abc	52.5	42.6 bc
Experimental 1 (R2)	36.3 ab	59.2	42.3 bc
Experimental 1 (V5 + R2)	38.4 a	64.4	40.8 bc
Topguard EQ 4.29SC 5 fl oz (R2)	29.2 abc	46.9	39.8 c
Proline 480SC 3 fl oz (R1)	40.1 a	51.4	39.2 c
Delaro 325SC 8 fl oz (R1)	36.1 ab	55.3	38.1 c
Non-treated check	38.6 a	61.9	36.6 c
Topguard EQ 4.29SC 5 fl oz (V5+ R2)	39.7 a	66.7	36.2 c
LSD (α=0.05)	14.6	ns[v]	7.6

[z]White mold DSI was generated by rating 30 arbitrarily selected plants in each plot and scoring plants with on a 0-3 scale: 0 = no infection; 1 = infection on branches; 2 = infection on main stem with little effect on pod fill; 3 = infection on main stem resulting in death or poor pod fill. The scores of the 30 plants were totaled for each class and divided by 0.9

[y]Percentage of symptomatic plants relative to the total stand.

[x]Induce 90SL (Non-ionic surfactant) at 0.25% v/v was added to the fungicide treatment.

[w]Means followed by the same letter are not significantly different based on Fisher's Least Significant Difference (LSD; α=0.05).

[v]ns = not significant (α=0.05)

Figure 6. A table from University of Wisconsin outlines fungicide efficacy data on disease suppression and yield for various fungicides products and application timings. (Not all products evaluated in this trial are labeled for use in NY)

within the rows which does enhance disease initiation and progression. And, shed flower petals do provide a nice food source for germinating spores. But, again, the flowers are <u>not</u> required for infection.

Although I have seen some nice soybean fields this year that were planted on time, either before or between all of the spring rain events we experienced, much of the soybean planting across the state was delayed this year due to wet conditions. That means there may be closed canopies with flowering soybeans across the road from fields with much younger or smaller plants. If the weather favors white mold with moderate temperatures, precipitation and humidity, the disease may initiate in one dense, flowering field and spread among many others. Or, it may initiate in a field where the plants are stunted with a fairly open canopy, if it's a field with a history of this disease and favorable weather conditions. It's anyone's guess at when and where a white mold epidemic may happen this year given the variable growth stages and ranges in canopy closure.

Don't despair, there's still hope. I haven't heard many reports of white mold yet from across the state, which means you still have time to make management decisions. Get out in your fields to scout, and pay attention to the weather. Know what growth stages your soybeans are at and how your canopies are looking, and what your neighbors' beans are doing. If you have a history of white mold in your fields, and you know that the weather forecast for your area is favorable for the disease, then consider the most cost effective fungicide application to protect your crop. If you expect dry conditions in a field without a history of white mold, then you can probably skip the fungicide application. You know your fields best. But, be aware that the variable growth stages this year may add an unexpected layer of complication to white mold management and timing of fungicide applications.

Thank you to Jeff Miller and Josh Putman of CCE, and Danny Di-Giacomandrea of Bayer for assistance with fungicide price ranges.

Integrated Pest Management

Statewide Corn Trials Underway: Do We Need Neonicotinoid Seed Treatments in NY?

Jaime Cummings
NYS Integrated Pest Managment

Most corn and soybean growers in New York plant seed treated with insecticides. But are those treatments really needed in every field? The recent scrutiny on neonicotinoids (aka: neonics) causing harm to pollinators has brought this question to the forefront. Given all the negative attention that neonicotinoid have received in the media in recent years regarding pollinator health, it's no surprise that they are on the chopping block in some NY legislative bills. These bills follow similar bans on neonics that have already taken place in Europe and Canada. Neonics have a bad reputation as having negative effects on bee health. Think about all the news you've seen or heard about the "bee-pocalypse". And, it's true that they can be lethal to bees and other beneficial pollinators, especially if applied to crops at incorrect timings or under the wrong conditions. They are insecticides, after all, and they are effective at killing insects, the good ones and the bad ones. But, let's not forget about the bad ones they are intended to target to help farmers raise healthy and productive crops to feed livestock and all of us. It's important that we consider both the positive and negative effects of these seed treatments when determining an overall need and value in our agricultural systems.

Neonic insecticides are used in many cropping systems, from fruits and vegetables to ornamentals to corn and soybeans to protect against some troubling pests. Neonics are available as seed treatments, soil drenches or foliar sprays to various crops, depending on the target pests and formulation of the products. And farmers everywhere have been using them for years, often as part of an integrated pest management program, to help minimize losses to some destructive pests. They were so widely adopted because they are effective pest management tools and because they were perceived as having a reduced overall negative impact on the environment and human health compared to many of the older insecticide chemistries, such as the organophosphates. But then it became apparent that these neonics, though safer for human health than many other insecticides, were taking a toll on beneficial insects, especially our bees that we rely on for pollinating many of our important food crops. And we need to pay attention to that issue and determine ways to mitigate those risks.

As mentioned above, neonics are used in various ways in many cropping systems. But their use as corn and soybean seed treatments has received a lot of attention because of the known potential for the neonic seed treatments to drift off-target as dust during planting. Because corn and soybeans cover such vast acreage in NY and across the country, mitigating these risks could potentially have a large impact on reducing bee mortality. Therefore, these seed treatments seem a likely, and potentially easy target for negative attention when folks start looking to reduce overall neonic usage. In response, the seed and seed treatment industries working with the EPA, USDA and other organizations started looking into ways that they could reduce the negative impacts that neonic treated corn and soybean seed could have on bees. In 2013, the EPA held a Pollinator Summit to focus on reducing exposure to dust from treated seed. Much research went into this focus group with collaborations between industry,

Hundreds of dead bees near a bee colony, believed to have been exposed to neonics (Photo courtesy of D. Schuit)

Seedcorn maggots feeding on a corn seed. (Photo courtesy of J. Kalisch, University of Nebraska)

academia and governmental regulatory agencies to address the off-target movement of dust from planting neonic treated seeds. I encourage you to read all the details for yourself regarding what they did and what they discovered in the Dust Focus Group and the Seed Treatment Group. For the sake of this article, I will briefly summarize their findings, conclusions and recommendations:

1. **Start with clean, quality seed** with minimal dust to begin with – many major seed companies have high standards for starting with clean seed which allows seed coating to better adhere, resulting in less dust.
2. **Use improved polymers for adhering treatments to seed coats:** seed coating technologies have improved dramatically over the years, meaning that less active ingredient 'falls off' the seed coat.
3. **Use bee-safe seed lubricants**: this minimizes the dust moving to off-target plants. New seed coating polymers and polyethylene wax lubricants for talc replacement can result in 90% total dust reduction and 65% active ingredient reduction in the dust.
4. **Eliminate flowering weeds** in and around fields prior to planting – this reduces the number of flowers that may accidentally have neonic dust that bees may forage on. The goal of many field crop growers is to 'start clean' meaning that they often try to minimize or eliminate competition from weeds prior to planting.
5. **Be aware of wind speed and wind direction** at time of planting – be a good neighbor. Avoid planting on the windiest days (when possible) and be aware of nearby bee colonies and wind direction. There are actually apps available to connect bee keepers with farmers to raise awareness of pesticide applications and locations of bee colonies.
6. **Re-direct the exhaust flow of vacuum planters downward** to minimize off-target movement of dust. Simple modifications can be made to some planters to re-direct the flow of the exhaust down toward the soil, which can significantly reduce dust movement. (Many planters don't exhaust, and most air seeders already exhaust downward).
7. **Follow labeling instructions** for handing, storage, planting and disposal of treated seed and containers.

The findings, improvements and recommendations from this summit can greatly decrease the risk of negative effects of dust from neonic seed treatments on pollinators. However, some people are also concerned about neonics that might move through soil or water showing up in water and non-target plants. Because of these issues, neonic seed treatments might still be banned on corn and soybean in NY, so growers are concerned.

Neonic seed treatments come standard in just about every bag of corn and soybean seed planted. Some say we do need them, others say we don't. If we look back in history a few decades, before the neonic seed treatments became available, farmers in NY struggled with early season pests like the seedcorn maggot, which can significantly reduce stand counts (and yields) under high pest pressure. The seedcorn maggot is favored by situations with actively decomposing organic matter, such as manure applications and terminated cover crops. Both of these situations are quite common in NY corn and soybean production systems. But, since the neonic seed treatments became so widely used, the seedcorn maggot issues have decreased dramatically, and possibly faded from memory.

But it still begs the question: Do we have pest pressure that warrants neonic seed treatments on the vast majority of our acres of corn and soybean every

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https://www.epa.gov/pollinator-protection/2013-summit-reducing-exposure-dust-treated-seed

year? That is a good question. From an integrated management perspective, it's never recommended to rely so heavily on one tool in the tool box for as long as we have with these neonics. We know that our insect pests can develop resistance to insecticides, just like weeds develop resistance to herbicides. There is also some evidence from various academic studies showing that the neonic seed treatments can negatively impact predatory insects, such as ground beetles, and other beneficial insects that serve as natural biological control of some of our other pests, such as slugs.

Skips in a corn row caused by seedcorn maggots eating the corn seed. (Image courtesy of T. Baute, OMAFRA)

Given those reasons, it seems like it might be a good idea to reduce our dependence on neonic seed treatments, and only use them in situations where we know we need them, right? But, on the other hand, it's important to keep in mind that, for now at least, it's not easy to buy corn or soybean seed without a neonic as part of the seed treatment package. It's very efficient and economical for the seed industry to include these standard treatments on their seed, and it's also important for their liability for the guarantees they may offer farmers who purchase their seed. Not to mention that it's not easy to anticipate when and where we need the neonic seed treatments each year. Sure, we know that fields with a history of manure and/or cover crops may be more likely to have seedcorn maggot issues, but there's no guarantee they won't also show up in a clean, tilled field. And, once the crop is planted, it's too late to scout and determine whether or not the seedcorn maggots are going to be a problem. This unpredictability is why the neonics are used as an 'insurance plan' against these sort of pests.

This conundrum is why this is such a highly polarizing debate, and why the proposed legislative bans have some farmers riled up. It's not that farmers want to use or pay for any more pesticides than they need, but the risk can be too high for their bottom line to just stop using them altogether. We need local research to back up any claims for or against the use of insecticidal seed treatments in corn and soybean production, and specifically the need for neonics. Much of the research from other states shows that they may not be necessary after all, because they don't seem to cause a yield benefit. But, upon closer inspection of some of those results, many of those trials didn't have measurable insect pest pressure to produce meaningful comparisons of treatments. And, many of the areas where those trials were conducted do not have the same practices with high organic inputs from manure and cover crops that many NY farms do.

So, it's complicated. A great deal of pollinator risk research is being conducted at Cornell, including a risk assessment of neonic use. The results of that assessment could influence the future of legislation on the availability or restriction of these products. We know the dust from the neonic seed treatments poses a potential threat to pollinators (especially bees). But we also know from the EPA pollinator summit that there are ways to mitigate those risks through improved seed coating and seed lubricant technologies, which have been widely implemented. However, we still don't know if there are other risks from these seed treatments, and we need more concrete evidence to know whether or not these neonic seed treatments are really necessary in such a large percentage of our NY corn and soybean acreage.

Seedcorn maggot damage to soybean (Photo courtesy of University of Minnesota)

That's why we decided earlier this spring to coordinate five statewide large-scale, on-farm trials with NYS IPM and Cornell Cooperative Extension specialists to try to evaluate the effect of these neonic seed treatments on 1) plant populations, 2) yield, and 3) how they compare to the anthranilic diamide seed treatments which could potentially replace them if the neonics are banned. These corn silage trials will be located in eastern, western, northern and central NY, all on farms that have typical NY cropping practices that incorporate manure and/or cover crops. Stand counts will be taken to measure plant populations and to determine insect pest pressure, and yields will be measured to compare the three seed treatments: 1) neonic + fungicide, 2) diamide + fungicide, and 3) fungicide only.

Regardless of our results, we will need multiple years of study to better characterize the pest pressure. Ideally, we would determine methods to predict and monitor seedcorn maggot pressure in individual fields and years for exploring biological, cultural and genetic means for suppressing these insects. However, this has proven challenging, as evidenced by the current situation in Canada.

Stay tuned for the results of these studies later this fall. And, I want to extend my sincere gratitude to all parties involved for coming together to conduct this research on extremely short notice. Thank you to Seedway for donating the seed, to Syngenta for donating the seed treatment products, to the participating farmers who are taking time out of their busy schedules to plant and harvest these trials, and to our CCE and PRO-Dairy collaborators (Joe Lawrence, Mike Hunter, Mike Stanyard, Aaron Gabriel and Janice Degni) for volunteering their time to conduct this important research. THANK YOU!!!

Corn and Soybean Weed Control in a Wet Year

Mike Hunter
Cornell Cooperative Extension - North Country Regional Ag Team

Small common lambsquarters that emerged before the soybean planted in this field. Photo taken in Jefferson County June 2019

The cool, wet month of May and start of June has created some challenging weed management situations for both corn and soybean. Unfortunately, delayed planting seasons force growers to focus so much on getting the corn and soybean planted they may not have had the opportunity to make a timely planned preemergence (PRE) herbicide application.

Here is a common situation that we are already encountering this season. We have a field with corn or soybeans planted and cool conditions have delayed crop emergence but the weeds have already emerged before the PRE herbicide treatment was made. Do we stick to our original plan and apply a PRE herbicide to this field or do we need to make adjustments to the herbicide program?

If your planned PRE herbicide application has been delayed it is very important to carefully consider your herbicide choices and make necessary adjustments if any weeds are emerged at the time of application. With adequate rainfall, PRE herbicides can provide excellent weed control; however, once the weeds are emerged they will generally need some additional product to the tank mix. The additional product could be another herbicide to add to the tank mix or just an adjuvant such as non-ionic surfactant (NIS), crop oil concentrate (COC) or methylated seed oil (MSO). There will be many more options in corn than soybeans.

Corn fields not treated with an herbicide prior to crop emergence need to be looked at carefully. If very small weeds are emerged at the time of the PRE application the answer may be as simple as adding adjuvant to the PRE herbicide. Consult the herbicide label and follow the adjuvant recommendations based on the products in the tank mix.

If the corn has emerged and the annual grasses are over 1 inch tall and the broadleaf weeds are 2 to 3 inches tall it may be necessary to add another herbicide to the PRE herbicide. If the corn is glyphosate tolerant, you may only need to add glyphosate to the preemergence herbicide program. Using this same scenario and it is conventional corn, you will likely need to include a postemergence (POST) herbicide to the PRE herbicide. Examples of POST tank mix herbicides to consider for control of both emerged annual grasses and broadleaf weeds include: Revulin Q, Realm Q, Resolve Q, Capreno, Laudis, Armezon. The effectiveness of these POST herbicides varies with the control of different annual grasses making proper weed identification critical. Again, check the herbicide label prior to making any herbicide applications.

If you are using a PRE soybean herbicide it will likely be an Herbicide Group 2 (Pursuit, Python, Firstrate), 3 (Prowl, Treflan, Sonalan), 5 (TriCor, Dimetric, metribuzin), 7 (Lorox, Linex), 14 (Valor, Sharpen) or 15 (Dual, Warrant, Outlook). Soon after soybeans are planted, there is a narrow window to make certain PRE herbicide applications. Valor (flumioxazin), Sharpen (saflufenacil), metribuzin and any premixes containing these active ingredients must be applied prior to crop emergence. Lorox (linuron) is another PRE soybean herbicide that must also be applied prior to crop emergence. Prowl, Treflan and Sonalan are applied prior to planting soybeans.

Soybean fields not treated with a PRE herbicide after crop emergence and very small weeds have emerged can be more difficult to deal with, especially if a population herbicide resistant tall waterhemp is present. Recently, Dr. Bryan Brown, NYS Integrated Pest Management Program, conducted tall waterhemp herbicide resistance screening trials at Cornell University. Using tall waterhemp seeds collected from three different fields in New York, preliminary results indicate that two populations were resistant to glyphosate (i.e. Roundup, Group 9), three populations resistant to atrazine (i.e. Aatrex, Group 5) and two populations resistant to imazethapyr (i.e. Pursuit, Group 2). Fortunately, none of the tall waterhemp screened were found to be resistant to lactofen (i.e. Cobra, Group 14).

If a population of multiple resistant tall waterhemp is present, our effective herbicide options are limited. The PRE herbicides that will provide control of multiple resistant (Group 2, 5, 9) tall waterhemp include Dual, Warrant, Outlook (S-metolachlor, acetolchlor, dimethenamid-P), Prowl, Treflan, Sonalan (pendimethalin, trifluralin, ethafluranlin) Valor SX (flumioxazin) and Lorox, Linex (linuron). If both the soybeans and multiple resistant tall waterhemp have emerged, our effective herbicide options are very limited. Dual, Warrant and Outlook are the only PRE herbicides listed that can be applied POST; however, these products will not control emerged weeds. In this situation it would be necessary to include either Reflex or Cobra (Group 14) to the tank mix to provide control of the emerged tall waterhemp.

Soybeans with the herbicide resistant technologies such as Liberty Link (glufosinate tolerant i.e. Liberty), Xtend (dicamba tolerant i.e.Xtendimax, Engenia, FeXapan) and Enlist E3 (2,4-D i.e. Enlist, glufosinate and glyphosate tolerant) provide additional options for POST control of resistant tall waterhemp.

This spring has provided very limited opportunities to plant corn and soybeans due to frequent rainfall and wet field conditions. This challenging spring has also made it difficult to apply planned PRE herbicides in a timely manner. It is important to carefully scout your fields before making any herbicide application to make sure the right products are included in the tank mix.

Water Management

Challenges and Benefits of Riparian Buffers on Water Quality

Christine Georgakakos[1] & Karl Czymmek[2]
[1]Biological and Environmental Engineering, [2]Animal Science and PRO-DAIRY; Cornell University

Riparian buffers are a popular practice implemented in both animal and crop agriculture. A riparian buffer is an uncultivated area surrounding streams or saturated areas. Saturated areas can include both perennially and temporally wetter-than-average parts of the landscape. We tend to prescribe buffers to span a certain distance from the stream, i.e. a 50 ft buffer along small headwater streams in agricultural lands.

The purpose of a riparian buffer is two-fold. Firstly, buffers filter soil and pollutants from water flowing over the soil surface. Permanent grass and other plant species slow the flow of water by friction. As water moves across a buffer, particles settle out and some water infiltrates into the soil, allowing sorption of pollutants to soil particles or otherwise slowing transport directly to a stream of soluble contaminants. The trapped or settled pollutants can be used by buffer plants in the case of nutrients, or tightly bound by soil particles for some non-nutrient pollutants. Some buffer biomasses are harvested as a way to remove nutrients tied up in the plant material. Secondly, when placed in livestock pastures, buffers are fenced to limit animal access to the stream to eliminate placement of urine and feces directly to surface waters or adjacent areas in addition to the benefits already outlined (Figure 1).

In practice there are a variety of factors that may reduce the water quality gains the buffer may be able to achieve. For optimal effect, many factors need to be considered when installing buffers. Buffers cannot filter water that does not flow over the soil surface or if too much water flows through too rapidly. Surface features and high runoff rates that cause flow to concentrate can overwhelm the ability of a buffer to filter, effectively allowing water to by-pass the buffer. For this reason, some conservation professionals advocate variable width buffers: extending permanent vegetation into fields or pastures to increase contact distance of flowing water within the buffer in areas likely to be saturated. Another means by which buffers can be by-passed is via ditches and subsurface drainage from fields or farmsteads where filtration is limited.

Figure 1: Cattle exclusion riparian buffer in the first season after implementation.

Common point sources tend to be tile line discharges, concentrated flow paths through pastures or fields, and overflow from other water routing structures. Any location where buffers are being planned should be inspected for features that can limit buffer effectiveness so that the system can be most efficiently designed for maximum pollutant removal. **Understanding details about each riparian buffer site to assess potential nutrient inputs into streams before implementing a best management practice will help more fully address these issues**.

Buffers in pasture systems raise different issues compared to crop fields. In buffer systems where livestock exclusion is involved, fences are typically installed in a straight line(s), simplifying construction and upkeep. Unfortunately, those lines do not always incorporate areas in the landscape that are likely to become saturated. When these wetter than average areas are not included in the buffer system, animals tend to trample the moist, soft soil, reduce infiltration capacity, and generate swampy, wet areas within pastures. These areas then tend to puddle, and form concentrated flow paths through the buffer. (Figure 2) **An ideal buffer would take into consideration these areas of higher saturation.** Complicating management, these areas are not necessarily perennial, and can change year to year. From a management perspective, it could be potentially difficult as moving fencing to incorporate saturated zones into the buffer

Figure 2: Sample saturated area that short circuits a riparian buffer. To maximize riparian buffer effectiveness, cattle exclusion should be extended beyond the saturated area. The left side of the fence experiences cattle grazing while the right side of the image does not.

is less that desired unless moveable fencing is already included in the management plan. Meandering or movable buffer boundaries may be difficult to implement in many existing management systems, so addressing variable wet areas for animal exclusion would be most convenient if paired with other management practice changes.

Buffers are an effective water quality management tool even if imperfectly implemented. Farmers and planners should strive to identify the areas where buffers can do the most good and locate and eliminate possible by-pass factors for best water quality results. It is important to understand the nutrient inputs to a stream before implementing a riparian buffer so that water quality may be improved as much as possible.

Ideally, when implementing a buffer system, there are a few steps we can take to maximize buffer effectives and minimize short circuiting the buffer: **(1)** identify and try to address point sources flowing through the buffer system, **(2)** include areas likely to become saturated within the buffer zone, and **(3)** be prepared to modify a buffer zone as new saturated areas are developed. These steps should help address the end goal of buffers reducing nutrient pollution to streams.

Forage Management

Best Timing of Harvest for Brown Midrib Forage Sorghum Yield, Nutritive Value, and Ration Performance

Sarah E. Lyons[a], Quirine M. Ketterings[a], Greg Godwin[a], Debbie J. Cherney[b], Jerome H. Cherney[c], Michael E. Van Amburgh[b], John J. Meisinger[d], and Tom F. Kilcer[e]

Introduction

Forage sorghum is a drought and heat tolerant warm-season grass that can be used for silage on dairy farms. Since it requires a soil temperature of at least 60°F for planting, the recommended planting time for New York is early June, unlike corn which is usually planted earlier in the spring. This would allow time for a forage winter cereal harvest in mid- to late-May prior to sorghum planting. Forage sorghum also has comparable forage quality to corn silage for most parameters except for starch, which is typically lower in forage sorghum. The main question for this research was: can forage sorghum be harvested in time for establishment of a fall cover crop or winter cereal double crop in New York? To answer this question, we conducted seven trials in central New York from 2014 through 2017 to evaluate the impact of harvesting at the boot, flower, and milk growth stages versus the traditional soft dough stage on the yield and forage quality of a brown midrib (BMR) forage sorghum variety.

Trial Set-Up

The seven trials were planted between early June and early July on two Cornell research farms in central New York. The sorghum was planted at a 1-inch seeding depth and 15-inch row spacing (15 lbs/acre seeding rate). Two N-rates as urea treated with Agrotain® (Koch Agronomic Services, LLC, Wichita, KS) were broadcast at planting (100 and 200 lbs N/acre) with the goal of having a non-N limiting scenario for these sites. Alta Seeds AF7102 (Alta Seeds, Irving, TX) was used for all trials. Forage sorghum was harvested at the boot, flower, milk, and soft dough stages. Harvest was done using a 4-inch cutting height. Measurements included dry matter (DM) yield and forage quality, including total digestible nutrients (TDN), neutral detergent fiber (NDF) analyzed on an organic matter basis with amylase, 30 hour NDF digestibility ($NDFD_{30}$), non-fiber carbohydrates (NFC), acid detergent fiber (ADF), dry matter (DM), crude protein (CP), and starch content. Forage quality parameters were entered into the Cornell Net Carbohydrate and Protein System (CNCPS) version 6.55, a ration formulation software, for predicting how sorghum harvested at various growth stages would perform in a typical dairy total mixed ration (TMR) compared to corn silage. Forage sorghum, at each of the different growth stages, was substituted for 0, 25, 50, 75, and 100% of the corn silage fraction of the diet, and metabolizable energy (ME) allowable milk and metabolizable protein (MP) allowable milk were predicted.

Results

Timing of forage sorghum harvest impacted both yield and forage quality. Yield did not increase beyond the flower stage for four trials or beyond the milk stage for one trial. For two trials yield continued to increase until the soft dough stage. Averaged across all trials, yield

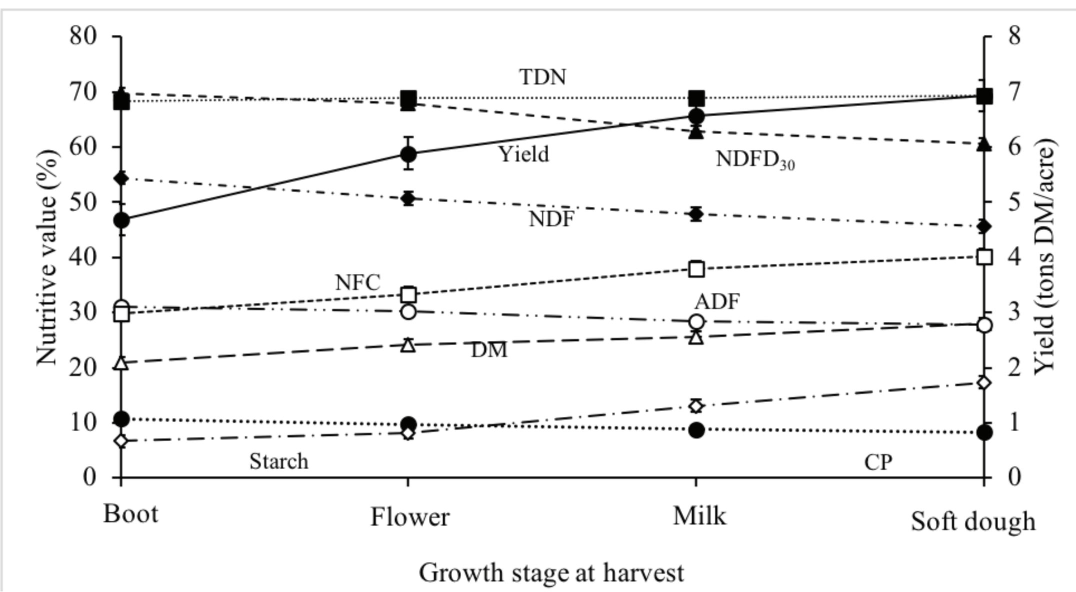

Figure 1: Summary of yield and forage quality of BMR brachytic dwarf forage sorghum as impacted by growth stage at harvest. These are averages of seven trials in central New York from 2014-2017. Quality parameters include total digestible nutrients (TDN), neutral detergent fiber (NDF) analyzed on an organic matter basis with amylase, 30 hour NDF digestibility ($NDFD_{30}$), non-fiber carbohydrates (NFC), acid detergent fiber (ADF), dry matter (DM), crude protein (CP), and starch.

[a] Nutrient Management Spear Program, Department of Animal Science, Cornell University, Ithaca, NY, [b] Department of Animal Science, Cornell University, Ithaca, NY, [c] Soil and Crop Sciences Section of the School of Integrative Plant Science, Cornell University, Ithaca, NY, [d] USDA-ARS Beltsville Agricultural Research Center, Beltsville, MD, and [e] Advanced Agricultural Systems, LLC, Kinderhook, NY

increased from 4.8 tons DM/acre at the boot stage, to 6.0 tons DM/acre at the flower stage, and 6.8 and 7.1 tons DM/acre at the milk and soft dough stages, respectively (Figure 1). These results suggest that, in most cases, forage sorghum can be harvested at the flower or milk stage without losing a substantial amount of yield. With later harvests forage quality parameters of DM, starch, and NFC were increased while CP, NDF, and $NDFD_{30}$ were decreased.

Without adjusting for DM intake, 100% inclusion of forage sorghum harvested at the soft dough stage resulted in predicted ME allowable milk (90 lbs) that was similar to the 100% corn silage TMR (92 lbs) across sorghum inclusion amounts (Fig. 2A). The lower starch content of less mature sorghum resulted in reduced ME allowable milk at greater inclusion in the diet, averaging 87, 88, and 89 lbs for 100% inclusion of sorghum at the boot, flower, and milk stages, respectively. Predicted MP allowable milk for all sorghum growth stages was similar to that of corn silage (Fig. 2B).

Conclusions and Implications

Forage sorghum can be a good alternative to corn silage in double-cropping rotations with winter cereals grown for forage in New York. The BMR forage sorghum in this study could be harvested as early as the late-flower to early-milk growth stage without losing significant amounts of yield. However, early harvesting did affect forage quality, resulting in greater $NDFD_{30}$, NDF, ADF, and CP, and less NFC, starch, and DM. Forage sorghum could replace corn silage in a dairy TMR but energy supplements are needed if sorghum is harvested before the soft dough stage due to a lower starch content at the earlier harvest dates. Additional forage may also be needed in a sorghum-based TMR due to changes in fiber digestibility at different growth stages. The higher moisture content of less mature sorghum may also call for adjustments in chop length and/or silage additives, such as inoculants, for proper fermentation.

Additional Resource

Lyons, S., Q.M. Ketterings, G. Godwin, D.J. Cherney, J.H. Cherney, J.J. Meisinger, and T.F. Kilcer (2019). Nitrogen Management of Brown Midrib Forage Sorghum in New York. What's Cropping Up? 29(1):1-3.

Acknowledgements

This work was supported by Federal Formula Funds, and grants from the Northern New York Agricultural Development Program (NNYADP), New York Farm Viability Institute (NYFVI), and Northeast Sustainable Agriculture Research and Education (NESARE). For questions about these results, contact Quirine M. Ketterings at 607-255-3061 or qmk2@cornell.edu, and/or visit the Cornell Nutrient Management Spear Program website at: http://nmsp.cals.cornell.edu/.

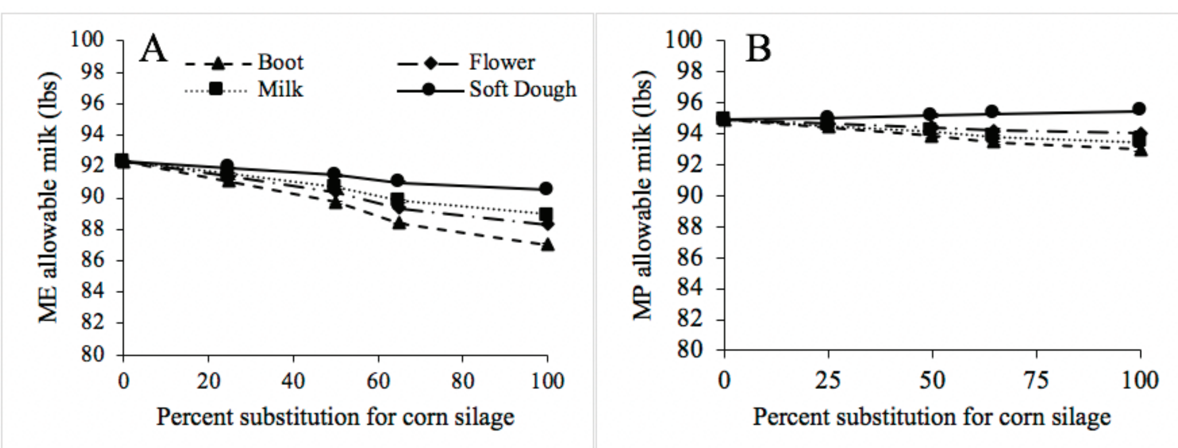

Figure 2: Metabolizable energy (ME) allowable milk (A) and metabolizable protein (MP) allowable milk (B) of BMR brachytic dwarf forage sorghum predicted with the Cornell Net Carbohydrate and Protein System (CNCPS) version 6.55. Harvest took place at four growth stages, and sorghum was substituted for different percentages of corn silage in a typical dairy total mixed ration. Values are averages of seven trials in central New York from 2014 to 2017.

Nutrient Management

Nitrogen Management for Forage Winter Cereals in New York

Sarah E. Lyons[a], Quirine M. Ketterings[a], Shona Ort[a], Gregory S. Godwin[a], Sheryl N. Swink[a], Karl J. Czymmek[a,b], Debbie J. Cherney[c], Jerome H. Cherney[d], John J. Meisinger[e], and Tom Kilcer[a,f]

Introduction

Forage double-cropping, or growing two forage crops in a single growing season, can be a beneficial practice for dairy farmers in New York. Double-cropping corn silage with forage winter cereals, such as triticale, cereal rye, or winter wheat, can add additional spring yield on top of numerous environmental benefits including preventing soil erosion, nutrient recycling, and increased soil organic matter over time - which all promote increased soil health. Winter cereals intended for forage harvest require nitrogen (N) management to reach optimum yield and forage quality. This study was aimed at identifying field and management characteristics that can estimate yield and N needs for winter cereals harvested for forage in the spring.

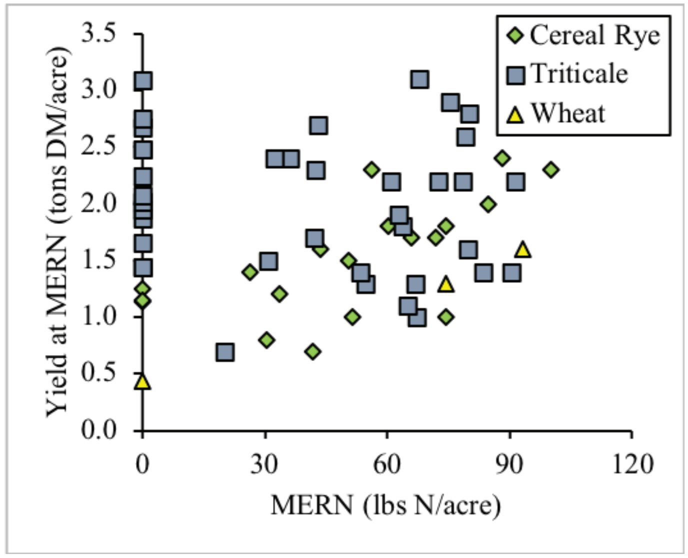

Figure 1: Forage winter cereal most economic rates of N (MERN) and yield at the MERN for 62 N-rate trials in New York from 2013 to 2016. Fertilizer N was applied at spring green-up and forage was harvested at the flag-leaf stag in May.

Field Research

A state-wide study with 62 on-farm trials investigated the spring N needs of forage winter cereals across New York from 2013 to 2016. Each trial had five rates of N (0, 30, 60, 90, and 120 lbs N/acre) applied to farmer-managed forage triticale, cereal rye, or winter wheat at green-up in the spring to determine the most economic rate of N (MERN). All forages were harvested at the flag-leaf stage in May each year. Soil samples were taken at green-up before fertilizer was applied. Farmers supplied information about management practices and field characteristics, such as past manure applications, planting date, and soil drainage. This information, in addition to soil fertility analysis results, was used to develop a decision tree model for predicting MERN classification.

Results

About one-third of the trials did not require additional N (MERN = 0), while the remainder responded to N and required between 60 and 90 lbs N/acre (Figure 1). Yields at the MERN across trials ranged from 0.4 to 3.0 tons DM/acre (1.8 tons DM/acre average). Yield could not be accurately predicted based on information gathered, but the lower-yielding sites (< 1.0 tons of DM/acre) tended to be poorly or somewhat poorly drained and not have a recent manure history.

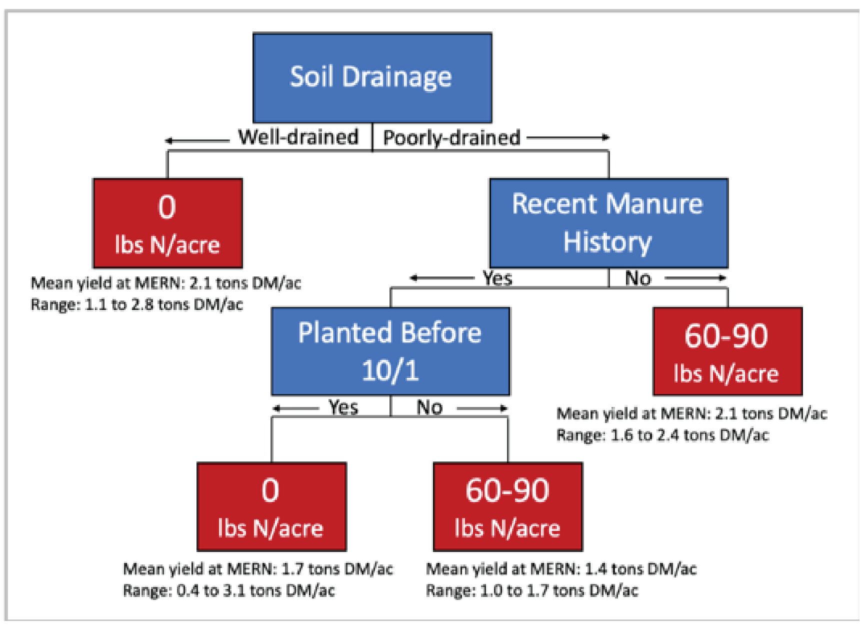

Figure 2: Decision tree for forage winter cereal most economic rate of N (MERN) at spring green-up. If the indicated site or history factor in the blue box is true, move to the left branch in the tree; if false, move to the right branch. The predicted MERN is listed in the red boxes. Recent manure history refers to manure applied within the last year (either spring or fall). This decision tree correctly predicted MERN classifications for 78% of the trials included.

[a] Nutrient Management Spear Program, Department of Animal Science, Cornell University, Ithaca, NY, [b] PRODAIRY, Department of Animal Science, Cornell University, Ithaca, NY, [c]Department of Animal Science, Cornell University, Ithaca, NY, [d]Soil and Crop Sciences Section of the School of Integrative Plant Science, Cornell University, Ithaca, NY, [e]USDA-ARS Beltsville Agricultural Research Center, Beltsville, MD,[f]Advanced Agricultural Systems, LLC, Kinderhook, NY

Farmer-reported soil drainage, manure history, and planting date were the most important predictors of the MERN (Figure 2). Most of the winter cereals grown on fields that were described as well-drained by the farmers did not require additional N at green-up. For the fields reported as somewhat poorly- or poorly-drained, 60 to 90 lbs N/acre were required if the field had not received manure the previous fall. If manure had been applied recently, 60 to 90 lbs N/acre were required for stands that were planted after October 1 versus 0 lbs N/acre if planting had taken place before October 1.

Most forage quality parameters were not impacted by N rate. Neutral detergent fiber (NDF) at the MERN ranged from 42 to 60% of DM (52% average), in vitro true digestibility (IVTD) at the MERN ranged from 81 to 94% of DM (88% average), and NDFD digestibility (48-hour fermentation) at the MERN ranged from 67 to 84% of NDF (78% average). However, crude protein (CP) increased with N rate for most trials, even those with MERNs of 0. Crude protein averaged 13% of DM for the 0 lbs N/acre treatment and 20% of DM for the 120 lbs N/acre treatment (Figure 3). On average, CP increases by 1% for every 15-20 lbs of N applied. These findings suggest that additional N beyond the MERN can increase the CP levels of the forage while not impacting other forage quality parameters.

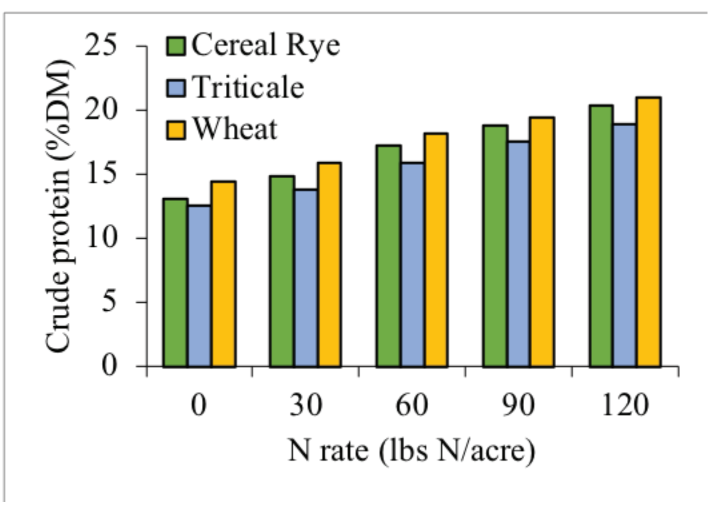

Figure 3: Forage winter cereal crude protein as impacted by N rate applied at spring green-up for 62 trials in New York from 2013 to 2016. Forage was harvested at the flag-leaf stage in May.

Conclusions and Implications

Results from this study emphasize the importance of growing conditions for optimum forage winter cereal performance. In fields that have poor drainage and lack recent manure histories, forage winter-cereals may not yield well and will likely require additional N inputs, while fields with well-drained soil conditions and better soil fertility will support higher yields and better forage quality without needing additional N in the spring. Planting date is also a critical management consideration. Planting late in the fall (after October 1 in this study), may result in lower yields (see also Lyons et al., 2018a). Timely planting (before October 1) in fields with good soil fertility and/or recent manure histories more often resulted in MERNs for N at green-up of 0 lbs N/acre, which would save farmers time and costs in the spring. Nitrogen management at green-up did not greatly affect forage quality except for CP, which increased with N addition even if the additional N did not increase spring yield.

Additional Resources

- Lyons, S.E., Q.M. Ketterings, G.S. Godwin, J.H. Cherney, K.J. Czymmek, and T. Kilcer. 2018a. Spring N management is important for triticale forage performance regardless of fall management. What's Cropping Up? 28(2): 34-35.
- Lyons, S.E., Q.M. Ketterings, G.S. Godwin, K.J. Czymmek, S.N. Swink, and T. Kilcer. 2018b. Soil nitrate at harvest of forage winter cereals is related to yield and nitrogen application at green-up. What's Cropping Up? 28(2): 32-33.

Acknowledgements

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For questions about these results, contact Quirine M. Ketterings at 607-255-3061 or qmk2@cornell.edu, and/or visit the Cornell Nutrient Management Spear Program website at: http://nmsp.cals.cornell.edu/.

Field Crop Production

Organic compared to Conventional Crop Rotations lost $ during the Transition but made more $ in the 2 years after the Transition and in the total 4 Years of the Study

Bill Cox, John Hanchar, Eric Sandsted, and Mark Sorrells

We conducted a 4-year study at the Aurora Research Farm from 2015 to 2018 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. Unfortunately, we were unable to plant wheat after soybean in the fall of 2016 because green stem in soybean, compounded with very wet conditions in October and early November, delayed soybean harvest until November 9, too late for wheat planting. Consequently, corn followed soybean as well as wheat/red cover in 2017 so we compared two sequences of the corn-soybean-wheat/red clover rotation with a corn-soybean rotation (Table 1). Please refer to previous What's Cropping Up? articles from 2015 to 2018 for the various inputs for each crop for each year within each cropping system (https://scs.cals.cornell.edu/extension-outreach/whats-cropping-up/). Also, you can refer to Table 2 for a general overview of the management inputs for each crop within cropping systems across years. This article will first discuss the economics of the three crops in Year 3 or 4 of the study. We will then discuss the economics of the three rotations during the 36-month transition period (Year 1 and 2 of the study), the 2-year period after the transition (when the organic premium is in place), and the total 4 years of the study.

Figure 1: The organic corn-soybean-wheat/red clover rotation was the most profitable rotation from 2015 to 2018.

Tables 3-6 show the revenue, selected costs, and returns above selected costs for corn in 2017, soybean in 2017, and wheat in 2018. The selected costs differed slightly for each crop across years because of changes in input prices (for example fertilizer and fuel prices change somewhat from year to year). The differences in selected costs between cropping systems for each crop, however, are consistent across years so Tables 3-6 are very representative of selected costs of each crop. On the other hand, revenue and returns for each crop differed significantly across years mostly because of different yields (for example, organic corn averaged ~115 bushels/acre in 2015 but ~185 bushels/acre in 2017), but also because commodity prices varied somewhat across years. So use Tables 3-6 as references in the discussion on selected costs for each crop but not for the revenue and returns for each crop in each year. We didn't include the 2018 soybean economics data, however, because the differences in revenue and returns between organic and conventional systems were similar as were comparisons between rotations, and the costs did not vary by more than $6/acre for each treatment.

Table 1. Amended crop rotations in a 4-year crop rotation study at the Aurora Research Farm because of the inability to plant wheat after soybean in the fall of 2016 (green stem in soybean compounded with excessively wet conditions in October and early November prevented a timely soybean harvest and wheat planting). Consequently, we compared a soybean-wheat/red clover (RC)-corn rotation in two sequences with a corn-soybean rotation in conventional and organic cropping systems.

YEAR	CROP ROTATIONS		
2015	RED CLOVER (RC)	CORN	SOYBEAN
2016	CORN	SOYBEAN	WHEAT/RC
2017	SOYBEAN	CORN	CORN
2018	WHEAT/RC	SOYBEAN	SOYBEAN

Organic compared with conventional corn with recommended inputs had ~$15/acre lower selected costs following wheat/red clover (C3 vs. C1 comparison, Table 3) but ~$275/acre higher selected costs following soybean (C3 vs. C7 comparison, Table 3). With high inputs, organic compared with conventional corn had ~$120/acre higher selected

Table 2. Soil texture/drainage, planting rate, hybrid/cultivar, tillage, starter and N fertilizer practices, and weed and disease control practices for corn, soybean, and wheat in conventional and organic cropping systems with two management treatments (recommended and high input) at the Aurora Research Farm from 2015 to 2018.

Descriptor	Crop					
	Corn		Soybean		Wheat	
	Rec.	High	Rec.	High	Rec.	High
	Conventional					
Soil texture/Drainage	Tile-drained Honeoye/Lima silt loam					
Planting rate (seeds/acre)	~30,000	~35,000	~150,000	~200,000	~1.2M	~1.7M
Seed Treatment	Fungicide/insecticide					
Cultivar	9675AMXT		P22T41R2		P24R46	
Tillage	Moldboard Plow		Moldboard Plow		No-Till	
Starter Fert. (lbs./acre)	~250 (10-20-20)		None		~200 (10-20-20)	
N fertilizer side-dress/top-dress (lbs. N/acre)	~50–120 (liquid)	~100-160 (liquid)	None	None	~70 (33-0-0)	~50 + 50 (33-0-0)
Herbicide application	Roundup	Roundup	Roundup	Roundup	None	Harmony Xtra
Fungicide application	None	None	None	Priaxor	None	Prosaro
	Organic					
Soil texture/Drainage	Well- drained Honeoye/Lima silt loam					
Planting rate (kernels/acre)	~30,000	~35,000	~150,000	~200,000	~1.2M	~1.7M
Seed Treatment	None	Sabrex	None	Sabrex	None	Sabrex
Cultivar	P9675		92Y21		P24R46	
Tillage	Moldboard Plow		Moldboard Plow		No-Till	
Starter Fertilizer (lbs./acre)	~320 composted chicken manure (5-4-3)		None		~155 composted chicken manure (5-4-3)	
Pre-plant N fertilizer (lbs. N/acre)	0–120 composted manure	50–160 compost manure	None	None	~70 compost manure	~50 + 50 compost manure
Tine weeding	1×		1×		None	
Cultivate	3×		4×		None	

costs following wheat/red clover (C4 vs. C2 comparison, Table 4) and ~$365/acre higher selected costs following soybean (C8 vs. C6 comparison, Table 4). As expected, organic compared with conventional corn had lower seed costs because the organic hybrid did not receive a seed treatment and did not have GM traits (Tables 3 and 4). Organic compared with conventional corn had higher fertilizer costs because of the much greater cost for composted poultry manure relative to conventional starter and N fertilizer. The fertilizer and selected costs were much greater for organic corn following soybean (C7 and C8, Tables 3 and 4) compared with following wheat/red clover (C3 and C4) because of the greater N requirement for corn when following soybean. Organic compared with conventional corn also had higher labor, repair and maintenance, and fuel and lubricant costs because of the 4-time use of labor and equipment for mechanical weed control in organic corn (rotary hoe 1x and cultivation 3x) compared with the 1-time use of labor and equipment in conventional corn (herbicide application). Organic compared with conventional corn also had greater fixed costs because of greater wear and tear with the 4-time use of tractors and equipment compared to 1-time use of tractors and equipment for weed control purposes.

Organic compared with conventional corn with recommended inputs had ~$70/acre greater revenue when following wheat/red clover in 2017 (C3 vs C1 comparison, Table 3) and similar revenue when following soybean (C7 vs. C5 comparison, Table 3) in the absence of an organic premium. All prohibited inputs (synthetic fertilizer, GM crops, pesticides, etc.), however, had been applied to the three fields in our study by June of 2014, more than 36 months prior to corn harvest in 2017, so organic corn would have been eligible for the organic premium. We will thus use organic prices for 2017 corn and soybean crops grown under organic management in this study. Organic compared with conventional corn with recommended inputs had ~$830/acre greater revenue following wheat/red clover and ~$685/acre greater revenue when following soybean in the presence of the organic premium (Table 3). Likewise, organic compared with conventional corn with high inputs had ~$990/acre greater revenue when following wheat/red clover (C4 vs. C2 comparison, Table

Table 3. Value of production, selected costs, and returns above selected costs of conventional corn with recommended inputs following wheat/red clover (C1) and following soybean (C5) and organic corn with recommended inputs following wheat/red clover (C3) and following soybean (C7) in 2017 at the Aurora Research Farm. Organic treatments are highlighted in red.

	2017 Corn Treatments			
	C1	**C3**	**C5**	**C7**
Value of Production, Revenue	--- $ per acre ---			
Corn for grain (P x Q)[1]	619.85	690.69/ 1450.45	645.26	632.94/ 1329.17
Selected Costs of Production[2]				
Variable Inputs				
Fertilizers & Lime	76.25	46.86	96.25	344.36
Seeds & Plants	123.95	90.65	123.95	90.65
Sprays & Other Crop Inputs	46.95	43.00	48.21	50.10
Labor	0.49	11.73	0.49	11.73
Repairs & Maintenance				
Tractor	0.10	2.85	0.10	2.85
Equipment	0.47	3.54	0.47	3.54
Fuels & Lubricants	0.27	7.18	0.27	7.18
Interest on Operating Capital	6.21	5.15	6.74	12.76
Total Selected Variable Input Costs	254.69	210.95	276.48	523.17
Fixed Inputs				
Tractors	0.70	16.88	0.70	16.88
Equipment	2.24	15.13	2.24	15.13

Land charge				
Value of management				
Total Selected Fixed Input Costs	2.94	32.00	2.94	32.00
Total Selected Costs	257.64	242.96	279.43	555.17
Returns[1]				
Return A[3]	365.16	479.74/ 1239.50	368.78	109.77/ 806.01
Return B[4]	362.21	447.73/ 1207.49	365.83	77.77/ 774.00

Note, due to rounding, totals reported may differ from the sum of the individual items as reported.

[1]Prices received are $3.85 and $8.09 per bushel for conventional and organic corn, respectively. For the organic scenarios, C3 and C7, value of production (price (P) x quantity (Q), and returns are given assuming both conventional price and organic price, respectively.

[2]This reporting of costs focused on those costs that differed among the four corn treatments. The land charge, and value of management input did not differ among treatments, so items are blank. Seed costs differed among treatments due to price per unit differences between non-GMO and GMO seeds. Spray and other crop inputs that differed included pest and disease management materials, and hauling as a function of yield. Labor costs reported included only those attributed to sprays for treatments C1 and C5, and those attributed to weeding tasks for C3 and C7. Labor costs reported do not include labor associated with tillage, planting and harvesting tasks considered constant, not differing among treatments. Similar explanations underlie estimates for the remaining cost items that differ.

[3]Return A is the return to selected variable inputs that do not differ among treatments C1, C3, C5, C7, these are: labor and machinery operating inputs (repairs, fuels and lubricants) for tillage, planting and harvesting tasks excluding hauling.

[4]Return B is the return to selected variable and fixed inputs that don't differ among treatments. Values reported for fixed inputs exclude farm machinery ownership costs for tillage, planting and harvesting tasks as mentioned above, land charges, and values of management inputs.

4) and ~$780/acre greater revenue following soybean (C8 vs. C6 comparison, Table 4). Please keep in mind that organic corn yields averaged ~185 bushels/acre; whereas conventional corn yields averaged ~175 bushels/acre in 2017. In 2015, however, organic compared with conventional corn had much lower revenue because of ~35% lower yields and the organic premium was not in place (first year of the transition). Likewise, in 2016, organic corn had lower revenue because of 7% lower yields, similar or higher selected costs, and no organic premium (2nd year of the transition). So please use Tables 3 and 4 as representative of selected costs but not of revenue and returns above selected costs.

Organic compared with conventional soybean had ~$20/acre higher selected costs with recommended inputs (S3 vs. S1 comparison, Table 5) but ~$5/acre lower selected costs with high inputs (S4 vs. S2 comparison, Table 5). Organic compared

Table 4. Value of production, selected costs, and returns above selected costs of conventional corn with high inputs following wheat/red clover (C2) and following soybean (C6) and organic corn with high inputs following wheat/red clover (C4) and soybean (C8) in 2017 at the Aurora Research Farm. Organic treatments are highlighted in red.

	2017 Corn Treatments			
	C2	**C4**	**C6**	**C8**
Value of Production, Revenue	--- $ per acre ---			
Corn for grain (P x Q)[1]	672.98	791.56/ 1662.28	766.92	736.12/ 1545.85
Selected Costs of Production[2]				
Variable Inputs				
Fertilizers & Lime	96.25	195.61	121.25	463.36
Seeds & Plants	148.66	108.72	148.66	108.72
Sprays & Other Crop Inputs	55.58	62.80	55.21	55.46
Labor	0.49	11.73	0.49	11.73
Repairs & Maintenance				
Tractor	0.10	2.85	0.10	2.85
Equipment	0.47	3.54	0.47	3.54
Fuels & Lubricants	0.27	7.18	0.27	7.18
Interest on Operating Capital	7.55	9.81	8.16	16.32
Total Selected Variable Input Costs	309.36	402.23	334.61	669.15
Fixed Inputs				
Tractors	0.70	16.88	0.70	16.88

Equipment	2.24	15.13	2.24	15.13
Land charge				
Value of management				
Total Selected Fixed Input Costs	2.94	32.00	2.94	32.00
Total Selected Costs	312.30	434.24	337.55	701.16
Returns[1]				
Return A[3]	363.62	389.33/ 1260.04	432.31	66.97/ 876.70
Return B[4]	360.68	357.29/ 1228.04	429.37	34.96/ 844.69

Note, due to rounding, totals reported may differ from the sum of the individual items as reported. See Table 3 for further comments on this table.

with conventional soybean had lower variable costs because of lower seed and other crop input costs, despite higher labor, repair and maintenance, and fuel and lubricant costs (Table 5). As with organic corn, organic compared with conventional soybean had higher fixed costs because of more wear and tear on the machinery with 5 trips (1x rotary hoeing and 4x cultivations) compared to 1 trip over the field (herbicide application) with recommended inputs or 2 trips over the field (herbicide and fungicide applications) with high inputs .

Organic compared with conventional soybean had ~$55/acre lower revenue with recommended inputs (S3 vs. S1 comparison, Table 5) or with high inputs (S4 vs. S2 comparison, Table 5) in 2017 because of ~8% lower yield in the absence of an organic premium (Table 5). In the presence of an organic premium, organic compared with conventional soybean had ~$370/acre greater revenue with recommended or high inputs. Unlike corn that had inconsistent yield differences between organic and conventional corn across years, organic and conventional soybean yield differences did not vary much (similar yields in 2015 and 2016; ~8% lower in 2017; and ~11% lower in 2018). Because of the small differences in yield and selected costs, organic and conventional soybean had similar returns above selected costs in 2015 and 2016 and higher returns in 2017 and 2018. Organic soybean with recommended and high inputs had similar returns in 2017 (S4 vs. S3 comparison) as well as in 2015 and 2016 but somewhat higher returns in 2018.

In 2018, organic compared with conventional wheat had ~$160/acre greater selected costs with recommended inputs (W3 vs. W1 comparison, Table 6) and ~$190/acre greater costs with high inputs (W4 vs. W2 comparison, Table 6). Organic compared with conventional wheat had lower seed costs (same variety but no seed-applied pesticide), but much higher fertilizer costs, associated with the use of composted chicken manure, which costs almost 13x the cost of the ammonium nitrate (33-0-0) used on conventional wheat. Organic compared with conventional wheat with recommended inputs in 2018 had ~$205/acre greater revenue because the yields were similar and

Table 5. Value of production, selected costs, and returns above selected costs of conventional soybean with recommended inputs (S1) and high inputs (S2) and organic corn with recommended inputs (S3) and high inputs (S4) in 2017 at the Aurora Research Farm. Organic treatments are highlighted in red.

	2017 Soybean Treatments			
	S1	**S2**	**S3**	**S4**
Value of Production, Revenue	--- $ per acre ---			
Soybeans (P x Q)[1]	547.77	565.44	492.90 /911.87	506.85 /937.67
Selected Costs of Production[2]				
Variable Inputs				
Fertilizers & Lime				
Seeds & Plants	90.00	120.00	55.71	74.29
Sprays & Other Crop Inputs	13.59	32.65	4.13	14.47
Labor	0.47	0.95	13.02	13.02
Repairs & Maintenance				
Tractor	0.10	0.19	3.41	3.41
Equipment	0.48	0.95	4.24	4.24
Fuels & Lubricants	0.27	0.55	8.51	8.51
Interest on Operating Capital	2.62	3.88	2.23	2.95
Total Selected Variable Input Costs	107.53	159.17	91.25	120.88

Fixed Inputs				
Tractors	0.70	1.41	20.15	20.15
Equipment	2.27	4.54	18.01	18.01
Land charge				
Value of management				
Total Selected Fixed Input Costs	2.97	5.95	38.16	38.16
Total Selected Costs	110.50	165.12	129.41	159.04
Returns				
Return A[3]	440.24	406.27	401.65 /820.61	385.97 /816.79
Return B[4]	437.27	400.32	363.49 /782.45	347.81 /778.63

Note, due to rounding, totals reported may differ from the sum of the individual items as reported.

[1]Prices received are $9.30 and $17.20 per bushel for conventional and organic soybean, respectively. For the organic scenarios, S3 and S4, value of production, revenue, price (P) x quantity (Q), and returns are given assuming both conventional price and organic price, respectively. See Table 3 for further comments on this table.

organic wheat received the organic price premium. Also, organic compared with conventional wheat with high inputs had ~$255/acre greater revenue because of ~7% higher yields and the presence of an organic premium.

Organic compared with conventional wheat with recommended inputs (W3 vs. W1 comparison, Table 6) had ~$45/acre higher return in 2018, despite the ~$160/acre higher selected costs. Obviously the increased revenue, associated with the organic premium, offset the higher selected costs, associated with the use of composted chicken manure. Likewise, organic compared with conventional wheat with high inputs had ~$65/acre higher returns above selected costs (W4 vs. W2 comparison, Table 6). Despite the higher revenue of organic wheat with high vs. recommended inputs, organic wheat with recommended inputs had ~$75/acre higher returns (W3 vs. W4 comparison) because the added revenue from the ~7% yield increase did not

Table 6. Value of production, selected costs, and returns above selected costs of conventional wheat with recommended inputs (W1) and high inputs (W2) and organic wheat with recommended inputs (W3) and high inputs (W4) in 2018 at the Aurora Research Farm. Organic treatments are highlighted in red.

	2018 Wheat Treatment			
	W1	**W2**	**W3**	**W4**
Value of Production, Revenue	--- $ per acre ---			
Wheat (P x Q)[1]	380.00	375.25	585.20	629.09
Selected Costs of Production[2]				
Variable Inputs				
Fertilizers & Lime	78.00	93.00	249.74	325.42
Seeds & Plants	60.98	86.39	47.21	66.89
Sprays & Other Crop Inputs	18.72	55.49	18.72	37.28
Labor		0.91		
Repairs & Maintenance				
Tractor		0.18		
Equipment		0.94		
Fuels & Lubricants		0.75		
Interest on Operating Capital	3.94	5.94	7.89	10.74
Total Selected Variable Input Costs	161.64	243.61	323.56	440.33
Fixed Inputs				

Tractors		1.33		
Equipment		4.46		
Land charge				
Value of management				
Total Selected Fixed Input Costs		5.79		
Total Selected Costs	161.64	249.40	323.56	440.33
Returns[1]				
Return A[3]	218.36	131.64	261.64	188.76
Return B[4]	218.36	125.85	261.64	188.76

Note, due to rounding, values reported for individual items may not add up precisely to the totals reported.

[1]Prices received are $4.75 and $7.32 per bushel for conventional and organic wheat, respectively. See Table 3 for further comments on this table.

offset the higher selected costs, associated mostly with the higher rates of composted manure. Organic compared with conventional wheat, however, had lower returns in 2016 because yields were ~7% lower, selected costs were higher, and the organic premium was not in place (2nd year of transition).

Table 7 shows the costs, revenue, and returns above selected costs of the red clover-corn, corn-soybean, and soybean-wheat/red clover rotations during the transition period, the first 2 years (2015 and 2016) of the study. (A value in Table 7 equals the sum of the 2015 and 2016 values for that treatment). As explained in previous news articles, we planted red clover alone in the early summer of 2015 and plowed it under in the spring of 2016 to see if a green manure crop would provide agronomic and economic benefits to subsequent organic crops in the rotation. The 2-year organic compared with conventional rotations generally had higher selected costs, especially with high input management, mostly because of the very high costs for the composted manure applied to corn and wheat. Revenue was similar as were returns between conventional ($152/acre) and organic ($179/acre) red clover-corn rotations with recommended inputs. Most conventional growers, however, would not plant a green manure crop so a comparison of the organic red clover-corn rotation vs. the conventional corn-soybean rotation with recommended inputs is more appropriate. In this comparison, the organic red clover-corn rotation had ~$455/acre lower returns, similar to the comparison between the conventional vs. organic corn-soybean rotation. The organic compared with the conventional soybean-wheat/red clover rotation with recommended inputs had ~$220/acre lower returns, which proved to be the most economical organic rotation in this study

Table 7. Estimated selected costs, revenue, and returns above selected costs of red clover-corn (RC-C), corn-soybean (C-S), and soybean-wheat/red clover (S-W/RC) rotations during the transition years (2015 and 2016) in conventional and organic cropping systems with recommended and high input management at the Aurora Research Farm

	SEQUENCE DURING TRANSITION (2015-2016)		
TREATMENT	**RC-C**	**C-S**	**S-W/RC**
	Total Selected Costs ($/acre)		
CONVENTIONAL			
Recommended	300	388	245
High Input	368	490	387
ORGANIC			
Recommended	270	630	419
High Input	609	841	609
	Revenue ($/acre)		
CONVENTIONAL			
Recommended	452 a	1023 a	667 a
High Input	492 a	1057 a	680 a
ORGANIC			
Recommended	448 a	806 b	619 a
High Input	452 a	826 b	634 a
	Returns above Total Selected Costs ($/acre)		
CONVENTIONAL			
Recommended	152 a	635 a	422 a
High Input	123 b	566 a	293 b
ORGANIC			
Recommended	179 a	176 b	200 c
High Input	-157 c	-15 c	25 d

+Treatment means within the same column followed by the same letter are not significantly different at the 0.05 level.

during the transition years. Many conventional growers, however, use high inputs on soybean (200,000 seeds/acre, fungicide/insecticide seed treatment, and foliar fungicide application) and even more so on wheat (high seeding rate, seed treatment, fall herbicide application, split-N application, and foliar fungicide application). A comparison of the organic soybean-wheat/red clover rotation with recommended inputs vs. the conventional soybean-wheat/red clover rotation with high inputs shows only ~$95/acre lower returns during the first 2

Table 8. Estimated selected costs, revenue, and returns above selected costs of the red clover-corn -soybean-wheat/red clover (RC-C-S-W/RC), corn-soybean-corn-soybean (C-S-C-S), and the soybean-wheat/red clover-corn-soybean (S-W/RC-C-S) rotations after the transition period (2017 and 2018) in conventional and organic cropping systems with recommended and high input management at the Aurora Research Farm.

	SEQUENCE AFTER TRANISTION (2017-2018)		
TREATMENT	**RC-C-S-W/RC**	**C-S-C-S**	**S-W/RC-C-S**
	Total Selected Costs ($/acre)		
CONVENTIONAL			
Recommended	272	393	371
High Input	416	506	481
ORGANIC			
Recommended	453	692	379
High Input	599	867	600
	Total Revenue ($/acre)		
CONVENTIONAL			
Recommended	926 b	1149 c	1108 c
High Input	941 b	1295 c	1208 c
ORGANIC			
Recommended	1494 a	2175 b	2308 b
High Input	1563 a	2372 a	2534 a
	Returns above Total Selected Costs ($/acre)		
CONVENTIONAL			
Recommended	654 b	756 b	737 b
High Input	526 c	789 b	728 b

ORGANIC			
Recommended	1041 a	1483 a	1928 a
High Input	964 a	1505 a	1934 a

+Treatment means within the same column followed by the same letter are not significantly different at the 0.05 level.

Table 9. Estimated selected costs, revenue, and returns above selected costs of the red clover-corn-soybean-wheat (RC-C-S-W), corn-soybean-corn-soybean (C-S-C-S), and the soybean-wheat/red clover-corn-soybean (S-W/RC-C-S) rotations during the 4-year period (2015 through 2018) in conventional and -organic cropping systems with recommended and high input management at the Aurora Research Farm.

	4-YEAR SEQUENCE (2015-2018)		
TREATMENT	**RC-C-S-W/RC**	**C-S-C-S**	**S-W/RC-C-S**
	Total Selected Costs ($/acre)		
CONVENTIONAL			
Recommended	572	781	616
High Input	782	996	868
ORGANIC			
Recommended	723	1322	798
High Input	1208	1708	1210
	Total Revenue ($/acre)		
CONVENTIONAL			
Recommended	1379 b	2172 b	1775 b
High Input	1432 b	2351 b	1888 b

ORGANIC			
Recommended	1942 a	2980 a	2927 a
High Input	2015 a	3198 a	3168 a
	Returns above Total Selected Costs ($/acre)		
CONVENTIONAL			
Recommended	807 b	1391 b	1159 c
High Input	650 c	1355 b	1020 c
ORGANIC			
Recommended	1219 a	1659 a	2128 a
High Input	807 b	1490 b	1959 b

+Treatment means within the same column followed by the same letter are not significantly at the 0.05 level.

years of the transition. All rotations in conventional and organic cropping systems with recommended vs. high inputs had greater returns, except for the conventional corn-soybean rotation, which had similar returns.

During the first 2 years after the transition (2017 and 2018) in this study, selected costs were once again mostly higher in the organic compared with the conventional rotations, especially with high input management (Table 8, a value in the table equals the sum of the 2017 and 2018 values for that treatment). Again, the higher costs for composted manure on organic corn and wheat compared to synthetic fertilizer contributed to the higher costs. The organic compared with the conventional cropping system in all three rotations had much greater revenue because of similar to greater corn and wheat yields or slightly lower soybean yields, coupled with the organic premiums. So despite the mostly higher selected costs for organic compared with the conventional rotations, higher costs did not offset the higher revenue, resulting in much higher returns above selected costs for the organic rotations (Table 8). When averaged across input treatments, organic compared with the conventional cropping system had ~$410/acre higher returns in the red clover-corn-**soybean-wheat/red clover** rotation, ~$720/acre higher in the **corn-soybean** rotation, and ~$1200/acre higher in the soybean-wheat/red clover-**corn-soybean** rotation. When averaged across input treatments in the organic rotation, the organic soybean-wheat/red clover-**corn-soybean** rotation had ~$435/acre higher returns than the organic **corn-soybean** rotation and ~$930/acre higher returns than the organic red clover-corn-**soybean-wheat/red clover** rotation. Similar to the transition period, the soybean-wheat/red clover-corn-soybean rotation was the most economical organic rotation during the first 2 years after the transition.

The organic compared with the conventional cropping system had much higher total selected costs in all 4-year crop rotations, which was more than offset by the much greater revenue in all 4-year crop rotations (Table 9). When averaged across input treatments, the organic compared with the conventional cropping system had ~$270/acre higher returns above selected costs in the red clover-corn-soybean-wheat/red clover rotation, ~$200/acre higher returns in the corn-soybean rotation, and ~$955/acre higher returns in the soybean-wheat/red clover-corn-soybean rotation. When averaged across input treatments in the organic rotation, the organic soybean-wheat/red clover-corn-soybean had ~$470/acre higher returns than the organic corn-soybean rotation and ~$1030/acre higher returns than the organic red clover-corn-soybean-wheat/red clover rotation. Obviously, planting a green manure crop was the least profitable organic rotation to select. Despite the lower returns for organic wheat compared with organic soybean or organic corn, the inclusion of wheat/red clover in the organic rotation was far more profitable than just the corn-soybean rotation over the 4-year period. In contrast, the corn-soybean rotation was most profitable for the conventional cropping system.

In the organic cropping system, recommended input compared with high input management had $412/acre higher returns above selected costs in the red clover-corn-soybean-wheat/red clover rotation and $169/acre higher returns in the corn-soybean and soybean-wheat/red clover-corn-soybean rotation. Consequently, the results clearly suggest that organic cropping systems, regardless of rotation, did not respond to high input management in this study. Many organic growers have been advised to use higher than recommended seeding rates with the goal of improved weed control. In our study, we saw statistically fewer weeds with high input management in corn, soybean and wheat but differences were so small that it had no effect on crop yield in this environment. Based on the returns above selected costs in our study, the use of higher seeding and N rates is not justified in the first 4 years of organic soybean-wheat/red clover-corn-soybean rotation on silt loam soils in central New York.

Conclusions

Field crop producers who transition to organic corn, soybean, and wheat production can generate greater returns above selected costs than conventional field crop producers after 4 years under the environmental conditions of this study, if they can successfully manage the cash-flow challenges during the transition period. To help manage the cash-flow challenges, transitioning growers should not apply prohibited inputs in their last conventional crop after late spring/early summer so the 36-month transition period can be accomplished in two growing seasons. Given the growing conditions during this study and the economic analyses reported here, transitioning growers should not use a green manure crop in the first year of transition but rather plant soybean. Soybean does not require N fertilizer, a major constraint to organic corn and wheat production, so growers should begin their transition in a field where soybean is the intended crop. In addition, soybean with the use of aggressive cultivation is also competitive with weeds, the other major constraint to organic field crop production.

Based on the economic results of this study, field crop producers should include winter wheat as the second crop in the transition after soybean. Organic growers may be able to no-till wheat after soybean harvest, if few winter perennial weeds are observed in the soybean crop. Growers should also frost-seed red clover into standing wheat in early spring, a typical practice for many conventional wheat growers.

Economic analyses of this study suggests that field crop producers, who transition to an organic cropping system, should plant corn in the 3rd year, or the first year when crops are eligible for the organic premium. Organic corn typically has a higher premium when compared with premiums for organic soybean and organic wheat. Corn should follow wheat with interseeded red clover, which provides considerable slow-release N to the subsequent corn crop. In addition, the wheat/red clover crops can disrupt weed cycles, as evidenced by the much lower weed densities in organic corn in the soybean-wheat/red clover-corn-soybean rotation compared with the corn-soybean rotation in 2017. In the 4th year of the study, field crop producers should begin the soybean-wheat/red clover-corn-soybean rotation again by planting soybean.

Based on the economic results of this study, field crop producers should use current recommended inputs for conventional crops and not use elevated seeding rates to improve weed control or use higher N rates to provide more available soil N to corn and wheat. Although the organic compared to the conventional cropping system generated greater returns above selected costs in this study, we recognize that commodity prices, farm size, individual/personal beliefs, and other factors influence a growers' decision on whether to transition to an organic cropping system. Furthermore, we recognize that the growing conditions and soils were unique to this study so results could differ for different years or locations in New York.

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AUG 14	Building Resilience into Organic Forage Production - Truxton, NY
NOV 7 & 8	Northeast Cover Crops Council Annual Conference - College Park, MD
NOV 25	Developing an Integrated Approach to Manage Agricultural Weeds - Ithaca, NY

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Cornell University
Cooperative Extension
Soil and Crop Sciences Section
237 Emerson Hall
Cornell University
Ithaca, NY 14853

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