What's Cropping Up?

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Comparing Static and Adaptive Nitrogen Rate Tools for Corn Production

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Determining the optimum nitrogen rate for corn production has been an elusive goal for many years, despite its economic significance to farmers and the concerns about environmental impacts. Several tools are available to provide nitrogen rate recommendations for corn growers, and many producers and retailers often wonder how these different recommendation systems compare. These approaches can be categorized as (i) static and (ii) adaptive. Static tools offer generalized recommendations that do not consider seasonal conditions of weather and soil/crop management, while adaptive approaches account for the variable and site-specific nature of soil N dynamics. Using strip trial data from four years of research on commercial farms we compare the recommendations from conventional static approaches in New York (Cornell Nutrient Calculator; CNC) and Iowa (Maximum Return to Nitrogen; MRTN) with the adaptive Adapt-N approach to explore the differences in recommended rates. The strip trials involved only Grower rates vs. Adapt-N rates as treatments, and we consequently cannot make direct conclusions on yield and profitability relative to CNC and MRTN. Therefore, in this article we focus on simply comparing the N rate recommendations from the three different tools.

The Tools

Cornell Nutrient Calculator: The Cornell Nutrient Calculator is a static approach that includes a basic mass balance calculation of N demand (yield-driven crop uptake) and N supply (soil organic matter, manure, previous crops, etc.), combined with efficiency factors. The CNC estimates can be derived from a spreadsheet downloaded from http://nmsp.cals.cornell.edu/software/calculators.html. The CNC nitrogen recommendation for corn is calculated as follows (Ketterings et al., 2003):

$$N_{Required} = (YP_{corngrain} * 1.2 - N_{soil} - N_{sod})/(\frac{f_{eff}}{100})$$

Where $N_{Required}$ is the total amount of N (lbs N/acre) from any source required for optimum crop production. $YP_{corngrain}$ is the yield potential of corn grain in bushels (85% dry matter) per acre. N_{soil} and N_{sod} are the amounts of N (lbs N/acre) expected to be released from mineralization of soil organic matter and a plowed-down sod, respectively, and f_{eff} is a nitrogen uptake efficiency factor that depends on soil type and drainage. $YP_{corngrain}$, N_{soil}, and f_{eff} are available from tabular values based on soil type that are incorporated into the spreadsheet. $YP_{corngrain}$ can also be entered as a default value or based on field yield history. Manure contributions from up to three years past can be incorporated into the recommendations.

MRTN: The Maximum Return to N (MRTN) method is also a static approach which is based on the average economically optimum nitrogen rate (EONR) from multi-site and multi-year field trial data and is promoted in most Midwestern US states (Sawyer et al., 2006). In Iowa, MRTN recommendations are highly generalized into a single state-wide recommendation for either corn-after-corn or corn-after-soybean with adjustments only for the relative prices for grain and fertilizer. However, Deen et al. (2015) found that variations in seasonal weather were three times more impactful on EONR than price ratio fluctuations. MRTN recommendations can be determined using an online calculator (http://extension.agron.iastate.edu/soilfertility/nrate.aspx).

Adapt-N: The Adapt-N tool employs simulation models and biophysical data to combine soil, crop and management information with near-real-time weather data to estimate optimum N application rates for corn. Although it was developed at Cornell University it has recently been licensed for commercial use (adapt-N.com). It is currently calibrated for use on about 95% of the US corn production area and is flexible in terms of nutrient management options with inputs for applications of fertilizer or manure from different sources (dairy, swine, poultry), or rotation crops (sod, soybean, etc.). One of the key user inputs is the site-specific attainable yield, based on long-term yield records.

Adapt-N generates adaptive N recommendations based on a dynamic mass balance approach according to the following equation:

$$N_{rec} = N_{exp\_yld} - N_{crop\_now} - N_{soil\_now} - N_{rot\_credit} - N_{fut\_gain-loss} - N_{profit\_risk}$$

Where N_{rec} is the N rate recommendation; N_{exp_yld} is the crop N content needed to achieve the expected yield. The expected yield is based on producer provided historic field data; N_{crop_now} and N_{soil_now} are the N content in the crop and soil as calculated by the model for the current simulation date; $N_{fut\_gain-loss}$ is a probabilistic estimate of future N gains minus losses until the end of the growing season, based on model simulations with historical rainfall distribution functions; and N_{profit_risk} is an economic adjustment factor that integrates corrections for fertilizer and grain prices, as well as the relative profit risk of under-fertilization vs. over-fertilization.

Adapt-N vs. Cornell N Calculator and MRTN rates

Adapt-N was used in 115 paired field strip trials with three or four nitrogen fertilizer replications conducted mostly on commercial farms (two university research farms were involved) in New York and Iowa during the 2011-through-2014 growing seasons (cf. Fennell et al., 2015; this issue) . Although the experimental design of the study compares N rates for Adapt-N and Grower-selected treatments (which represented conventional practices), we also had an opportunity to compare the adaptive approach of the Adapt-N tool to the respective rates recommended by the CNC and the MRTN methods. Note: Each growing season did not necessarily involve the same fields and management practices, like manure application. The pre-plant or starter fertilizer rates varied and averaged 76 and 56 lbs/ac for the NY and IA trials, respectively.

The CNC estimate included two rates: (i) based on the default yield potentials in the CNC software (which were universally much lower) and (ii) based on expected yield values for the field supplied by the grower, i.e. “realistic” field-specific expected yield. N credits from manure application were directly accounted for in the CNC software.

For the MRTN approach, the rate was adjusted to account for manure credits calculated using the Iowa State University manure management guidelines (PM-1811), which assumes N use efficiency of 100% and 35% for swine and dairy manure, respectively. If the sum of the calculated credits for a trial exceeded the MRTN rate, a zero MRTN rate was assigned.

Table 1. 2011-2014 New York research trial summary of the Cornell Nutrient Calculator (CNC) total N recommendations using default yields and the realistic (field-measured) expected yields (EY); Adapt-N recommendations are based on model estimates using realistic estimated yields while Grower recommendations are based on their current practice.

		Expected Yields			Recommendations (Total fertilizer N)				
Year	n	CNC default	CNC realistic	Diff.	CNC w/ default EY	CNC w/ realistic EY	Diff.	Adapt-N realistic	Grower practice
		------------ bu/ac ------------			-------------------------- lbs/ac ------------------------				
2011	11	132	155	23	110	134	24	101	156
2012	42	130	186	56	106	219	113	130	196
2013	11	127	188	61	116	215	99	166	147
2014	9	128	183	54	104	196	92	137	172
Average	**73**	**129**	**178**	**49**	**109**	**191**	**82**	**134**	**168**

Results

In contrast to the static N recommendation approach, Adapt-N recommended N rates varied substantially from field to field and among growing seasons (Table 1 and 2). Since the strip trials involved an Adapt-N and a Grower-selected rate, they allow us to make conclusions on the performance of these two approaches. In short, results showed that in 83% of all 115 strip trials, Adapt-N recommended a lower N application than the respective Grower-defined rate and these reduced rates resulted in an increased profit in 73% of trials, with an average increase of $26/ac over the Grower rate (Sela et al., in review; [Moebius-Clune et al., 2014]).

CNC vs. Adapt-N: The CNC method accounts for several variables, including past manure applications and soil types, which, as previously mentioned, are reflected in a different rate for each trial. One issue with the current CNC approach is the selection option for the yield potential (YP), based either on default values or "realistic" yield estimates from historic field-measurements. The CNC default expected yields were on average 49 bu/ac lower than the realistic expected yields (Table 1). Incidentally, New York grower-estimated realistic yields averaged 178 bu/ac, which was generally close to the actual achieved yields at the end of the season, 173 bu/ac on average. The resulting CNC N rate recommendations were highly sensitive to these yield estimates: rates based on realistic yields averaged 82 lbs/ac higher than those based on the default expected yields (191 and 109 lbs/ac, respectively).

Adapt-N recommended rates fell in between those extremes at 134 lbs/ac. (Table 1, Fig. 1a). I.e., the CNC rates calculated using the realistic estimated yields were on average 57 lbs/ac higher than the Adapt-N rates. Based on the results of the comparison of Adapt-N with Grower-selected rates (which were generally excessive but still 23 lbs/ac lower than the

Table 2. 2011-2014 Iowa research trial summary of MRTN recommendations; Adapt-N recommendations are based on model estimates from the Adapt-N tool using realistic estimated yields, while Grower recommendations are based on conventional practice dependent on field history.

		Recommendations (Total fertilizer N)					
		MRTN		Adapt-N		Grower	
Year	n	Manure	Non manure	Manure	Non manure	Manure	Non manure
		---------------------------- lbs/ac ------------------------------------					
2011	9	44	156	30	156	53	168
2012	17	36	151	39	123	64	153
2013	9	78	135	86	140	122	151
2014	7	0	153	87	118	187	159
Average	**42**	**40**	**149**	**60**	**134**	**107**	**157**

CNC rates with realistic yields; Table 1), we infer that the CNC recommendations with realistic expected yields are generally too high. Conversely, using the less-realistic default yields appears to result in overall better N rate recommendations, but still too low in wetter seasons (esp. 2013).

<u>MRTN vs. Adapt-N</u>: The MRTN rates for the Iowa trials were fixed at 188 lbs/ac and 133 lbs/ac for corn-after-corn and corn-after soybean rotations, respectively for the non-manured sites (Fig 1b), while the Adapt-N rates showed a wide range from about 40 to 220 lbs/ac, primarily depending on soil type, organic matter contents and weather conditions. On average the Adapt-N rates for non-manured sites were 15 lbs/ac lower than the respective MRTN rates (134 vs.149 lbs/ac; Table 2).

The Iowa manured sites showed a wide range of fertilizer recommendations for both Adapt-N and MRTN (Fig 1b). On average, the recommended fertilizer rates for Adapt-N were 20 lbs/ac higher than MRTN, with differences especially pronounced in cases involving fall swine manure applications where the Iowa State University calculations assume 100% N contribution for the following growing season, often resulting in very low N fertilizer recommendations. The Grower practice averaged higher than both the MRTN rates and Adapt-N rates, especially for manured fields (67 and 47 lbs/ac higher than MRTN and Adapt-N, respectively). In all, MRTN rates are similar on average to Adapt-N rates, but the former is lower with manure applications and higher without manure. Adapt-N rates varied more based on location-specific conditions.

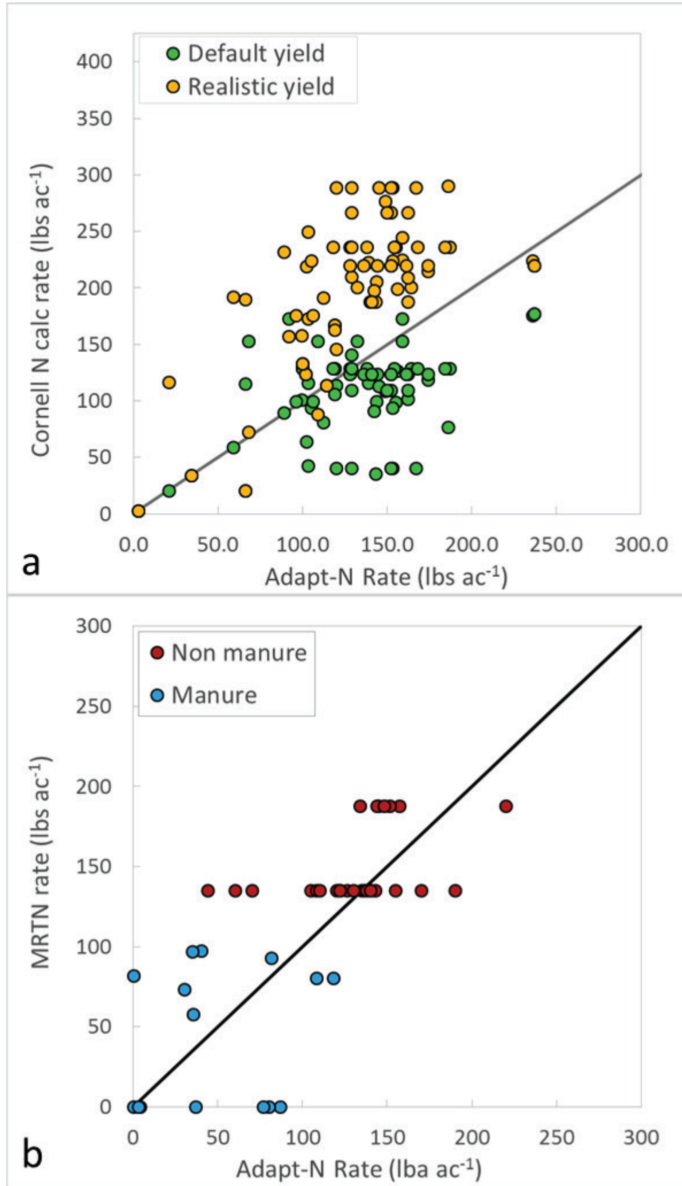

Fig 1: a: Adapt-N rate compared to two different rates recommended by the Cornell N calculator for New York sites (a), based on the default expected yield (green) and based on a "realistic" expected yield defined by the grower (orange). b: Adapt-N rates compared to MRTN rates for Iowa sites. The diagonal (1:1) line represents the Adapt-N rate, and points above or below the line indicate higher or lower rates for the CNC (a) or MRTN (b) than the Adapt-N rate.

Conclusions

The static N recommendation tools are more generalized compared to adaptive tools like Adapt-N, and do not allow for precision N management specific to each production environment (field, season, management). The 115 strip trials offered an opportunity to make comparisons of Adapt-N with Cornell N Calculator (New York) and MRTN (Iowa) N rate recommendations under real-farm conditions, but did not enable direct analysis of their relative yield and profitability performance.

We conclude that the main issue with the CNC recommendations is the large discrepancy between the N recommendations using the default yield potentials and those based on realistic yield potentials. When using the latter, the yield expectations are more correct but the recommended rates are much higher than the Adapt-N rates and appear to be excessive in most cases. Conversely, recommendations based on default yields average below Adapt-N rates and appear to be too conservative in wetter years. The default yield values appear to be about 40-50 bu/ac below current yields, which have in recent decades increased due to improved crop genetics and management. Updating the default yield values appears logical, but would result in excessive N recommendations in most years. MRTN recommended rates were on average similar to Adapt-N rates, but they were lower with manure applications and higher without manure. In the non-manure cases, MRTN rates were principally higher in some years (2012; 2014). Adapt-N rates varied more based on location-specific conditions, which is important for preventing excesses and deficiencies and reducing environmental impacts.

In all, we conclude that *on average* the static (CNC and MRTN) and adaptive (Adapt-N) approaches resulted in similar N rate recommendations, but they vary considerably depending on growing season weather, soils, management practices and yield assumptions.

Acknowledgements

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Adapt-N Recommendations Reduce Environmental Losses

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Soil nitrogen is spatially and temporally variable and it can be challenging for farmers to determine a location-specific optimum N rate, often leading to excess (insurance) applications. Corn N management is therefore relatively inefficient, with N recovery (the proportion of applied N taken up by the crop) often being less than 50%. The nitrogen that is lost through leaching and runoff has a massive negative effect on groundwater aquifers and aquatic biota in streams and estuaries downstream. The Chesapeake Bay and Gulf of Mexico are notable concerns and ambitious nutrient reduction goals have been established. Another major concern is the gaseous nitrogen loss that can result in high emissions of nitrous oxide (N2O), a potent greenhouse gas for which agriculture is the main anthropogenic source.

These increased N fluxes into the environment have significant economic and environmental costs. There are a number of approaches to reduce such N losses, including reduced N applications, cover cropping, buffer strips, etc. Arguably the most important one is the better estimation of the optimum N rate so that excess N applications can be avoided.

Adapt-N and Strip Trials

The optimum N rate depends on numerous factors including the timing and amounts of early season precipitation, previous organic and inorganic N applications, soil organic matter, carry-over N from previous cropping seasons, soil texture, rotations, etc. Adapt-N is a simulation tool that combines such location-specific soil, crop and management information with date-specific weather data to estimate optimum N application rates for corn. It thereby allows for precision N management specific to each production environment (field, season, management). The tool was developed at Cornell University and has been licensed for commercial use (adapt-N.com).

The Adapt-N tool also has environmental utility as it simulates leaching losses from the bottom of the root zone and gaseous losses into the atmosphere due to denitrification and ammonia volatilization. Both leaching and gaseous losses are simulated based on soil water dynamics and the use of N loss equations that are modified by temperature and water conditions.

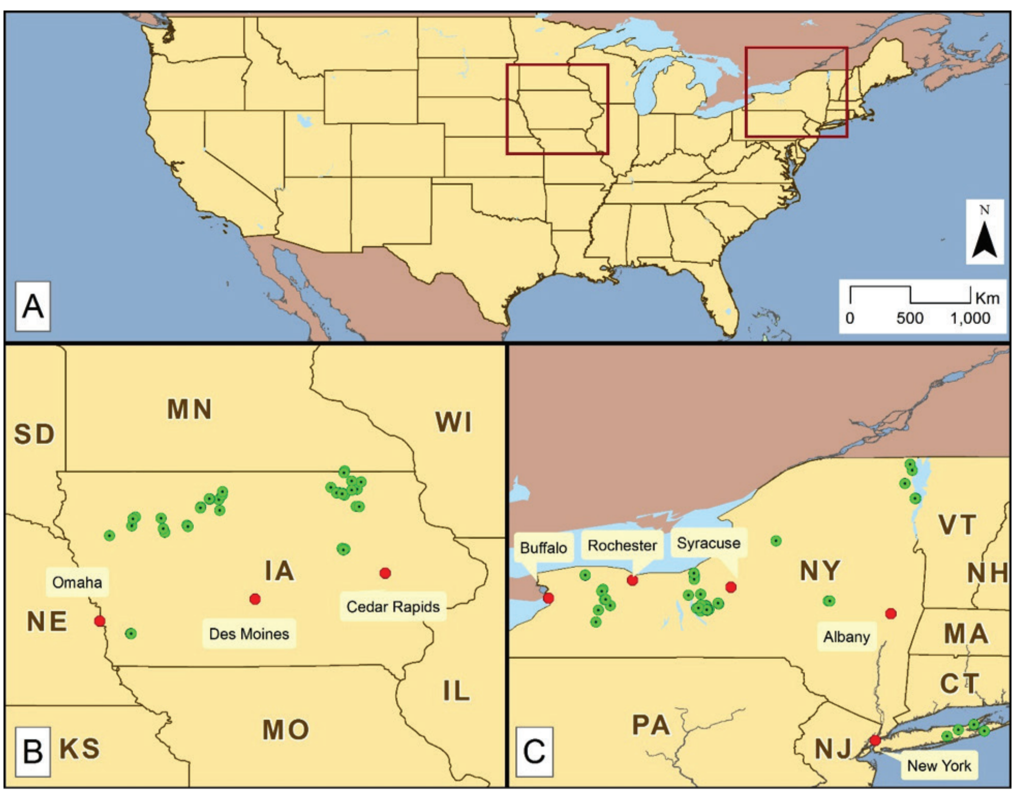

Fig 1: Locations (in green) of the Adapt-N strip trials in US (A), Iowa (B), and New York (C).

The Adapt-N tool was used in 115 paired field strip trials with two to seven replications conducted mostly on commercial farms (two university research farms were involved) in New York and Iowa during the 2011 through 2014 growing seasons (Fig. 1). Trials were distributed across both states under a wide range of weather conditions, and involved grain and silage corn, with and without manure application, and rotations of corn after corn and corn after soybean. The pre-plant or

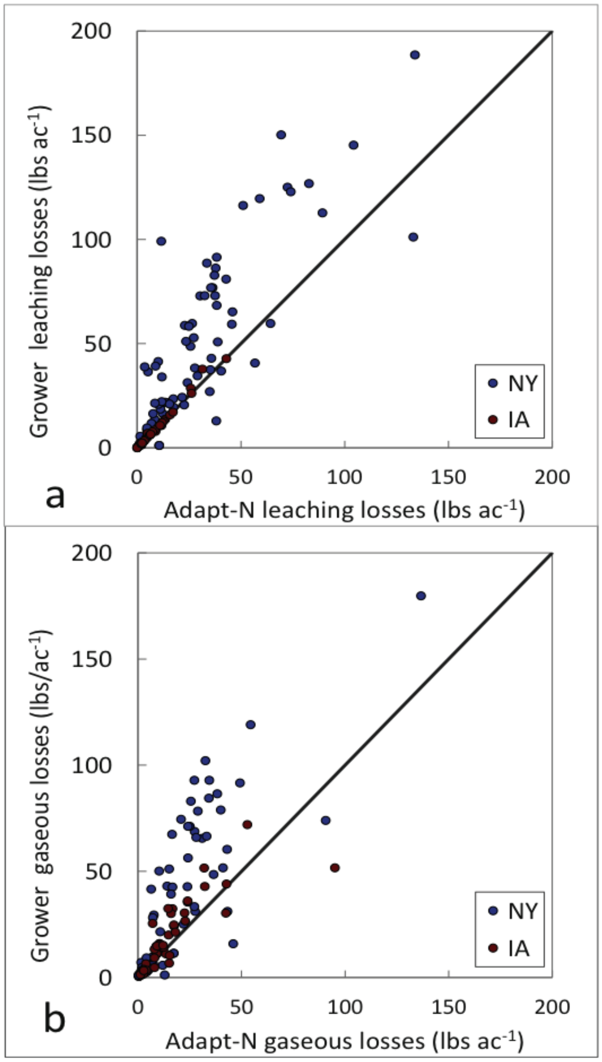

Fig 2: Adapt-N and Grower simulated leaching (a) and gaseous (b) losses. Points above the diagonal (1:1) line indicate higher losses for the Grower than the Adapt-N plots. Average reductions in leaching were 39% for NY and 3% for IA trials. Average reductions in gaseous losses were 46% for NY and 18% for IA trials.

starter fertilizer rates averaged 76 and 56 lbs/ac for the NY and IA trials, respectively. In each trial, the treatments were defined by the amount of N applied at sidedress, where the rates were:

(i) the Adapt-N recommendation for the date of sidedress, and
(ii) a Grower-selected rate, which typically represented their conventional practice.

We determined corn yields and associated profit differences for the two treatments. In order to directly compare the environmental fluxes resulting from Adapt-N and Grower sidedress N applications, we ran full season simulations (up to December 31st) for all 115 trials and estimated the environmental fluxes that occurred after the application of sidedress N.

Results

Complete results for this study are presented in Sela et al. (in review). We measured clear agronomic benefits from the precision approach of the Adapt-N tool over the Grower treatment: N rates were on average reduced by 40 lbs/ac (34%), while average yields were actually 2 bu/ac higher. This resulted in $26/ac higher profits on average over all 115 strip trials.

For all trials in both states, simulated total N losses (leaching and gaseous combined) were on average reduced by 24.9 lbs/ac (38%) for the Adapt-N recommended rates compared to the Grower-selected rates (Fig 2), in line with the lower applied N rates. Simulated total N losses for the Iowa trials were on average somewhat lower than for the New York trials, presumably due to different climate and soil conditions.

Leaching losses: The average simulated leaching losses of 35.3 and 22.6 lbs/ac (Figs. 2a and 3a) for the Grower and Adapt-N treatments, respectively, are comparable to measured leaching losses from other experiments in the literature. Adapt-N rates resulted in an average reduction of 19.6 lbs/ac (39%) in New York and .3 lbs/ac (3%) in Iowa in simulated leaching losses compared to the Grower rates, and reductions were consistently higher for the New York trials. This can be attributed to several characteristics of the New York sites, including (i) generally wetter climate with much pre- and post-season precipitation, (ii) lower denitrification losses relative to leaching due to generally coarser soil textures, and (iii) shallower rooting depths causing less water and N uptake in the lower soil profile. Simulations were terminated on December 31 of each year, so are underestimates of actual benefits in both states, as further N leaching may still have occurred during spring and winter prior

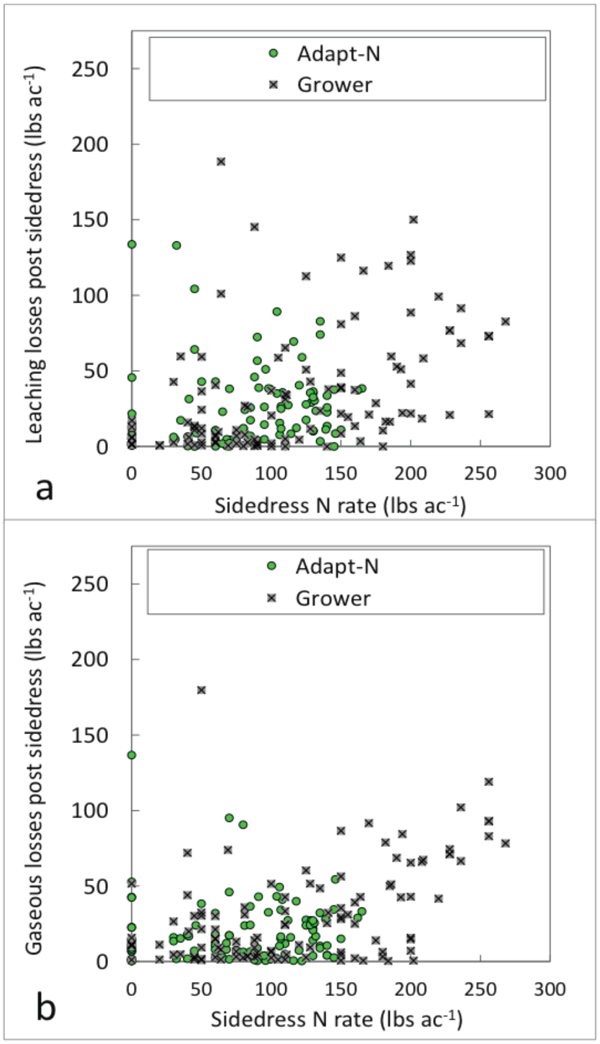

Fig 3: Relationship between N applied at sidedress and simulated post-sidedress leaching losses (a) and gaseous losses (b). Higher Grower rates were generally associated with higher N losses.

to the next growing season.

Gaseous losses: Simulated gaseous losses (Figs. 2b and 3b) were also lower for the Adapt-N compared to the Grower treatment (average reduction of 12.9 lbs/ac; 39%). The 2011 and 2012 seasons for the New York trials resulted in >50% reductions in simulated gaseous losses when using Adapt-N vs. Grower rates. Again, benefits were generally greater in New York than Iowa, although the relative reduction in gaseous losses in Iowa were greater (18%) than the reduction in leaching losses (3%).

Conclusions

The results of this study show environmental gains from using Adapt-N's precision management approach to estimating in-season N rates across a robust number of fields, soil types and weather conditions in Iowa and New York. In all, the Adapt-N recommended N rates adapted effectively to the varying field and weather conditions, were generally lower than the Grower's regular N rate, and achieved both economic and environmental benefits. Although the benefits varied by year, state and site, the overall environmental losses were reduced by 24.9 lbs/ac (more in NY than IA) through the use of this precision management approach. This implies a reduction of 38% in the post-application N losses. In all, use of Adapt-N can significantly contribute to nitrogen reduction goals. A final note: The potential benefits of its use are likely underestimated in this study, especially for IA, as the participants already represented a progressive group of growers who optimize their own N timing and placement decisions with sidedress applications, while many Midwestern growers still apply most of their nitrogen in the fall or at planting.

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Crop Management

Soybean Yield Under Conventional and Organic Cropping Systems with Recommended and High Inputs During the Transition Year to Organic

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We initiated a 3-year study at the Aurora Research Farm in 2015 to compare the corn, soybean, and wheat/red clover rotation under conventional and organic cropping systems during the 3-year transition period (2015-2017) to an organic cropping system. We used three entry points or previous crops from 2014 to initiate the 2015-2017 study: 1) grain corn, 2) small grain, and 3) soybean. Three of the many objectives of the study are 1) to determine the best previous crop (2014) for the transition, 2) the best crop to plant in the first year (2015) during the transition and 3) do corn, soybean, and wheat respond similarly to management inputs (high and recommended) under conventional and organic cropping systems? This article will discuss soybean yield and seed weight under conventional and organic cropping systems under high and recommended management inputs.

We used a White Air Seeder to plant a treated (insecticide/fungicide seed treatment) GMO variety, P22T41R2 with the RR2Y and SCN traits, in the conventional cropping system under recommended inputs at 150,000 seeds/acre in 15 inch row spacing. We also planted a non-treated, non-GMO variety, 92Y21, in the organic cropping system under recommended inputs at 150,000 seeds/acre but in 30-inch row spacing. We used the typical 15" row spacing in the conventional cropping system, but the typical 30" row spacing (for cultivation of weeds) in the organic cropping system. In addition, P22T41R2 is not an isoline of P92Y21 so only the maturity of the two varieties and not the genetics are similar between the two cropping systems. We also planted both varieties in their respective cropping systems at 200,000 seeds/acre in the high input management treatment, and also included the organic seed treatment, Sabrex, in the seed hopper when planting 92Y21 in the organic cropping system in the high input treatment.

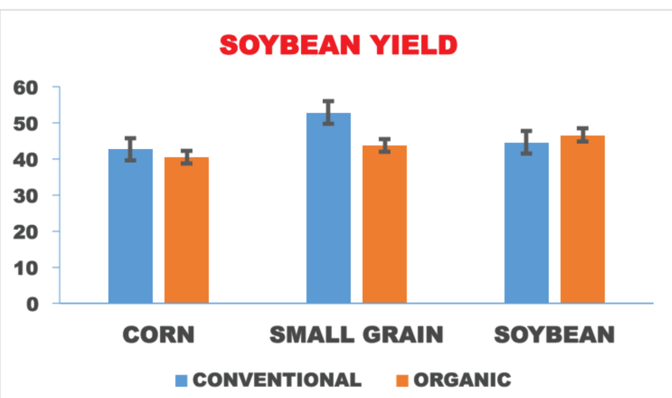

Fig 1: Soybean yields in 2015 following different previous crops (corn, small grain, or soybean in 2014) under conventional and organic cropping systems.

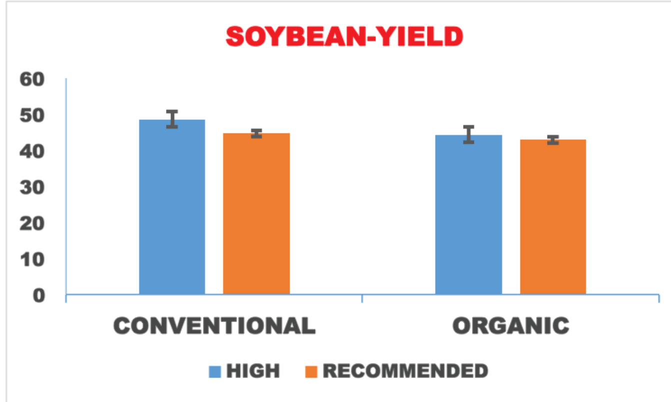

Fig 2: Soybean yields under conventional and organic cropping systems in the high and recommended management treatments.

We applied Roundup (PowerMax) at 32 oz/acre for weed control in conventional soybean at the V3-4 stage (June 27) under both recommended and high input treatments. We used a tine weeder to control weeds in the row in organic soybean under both management inputs at the V1 stage (June 5), when corn was the previous crop, but not in the other two experiments because of limited weed pressure. We then cultivated close to the soybean row in both recommended and high input organic treatments at the V2 stage (June 20); with subsequent cultivations between the rows at the V3 stage (June 25), beginning flowering (R1) stage (July 6), and full flowering (R2) stage (July 16). The high input soybean treatment in the conventional cropping system also received the fungicide, Priaxor at 4 fl. oz./acre at the beginning pod (R3) stage (July 31) for potential disease problems and overall plant health. Because of exceedingly dry summer conditions at the Aurora Research Farm, (2.8 inches of precipitation in July, 1.36 in August, and 1.94 inches from September 1 until September 23, the day of harvest), both varieties attained the R7 stage, physiological maturity, from September 10-12, earlier than normal for the May 23 planting date of this study.

Soybean seed yield showed a previous crop x cropping system interaction (Fig.1). Soybean seed yield was essentially the same following the 2014 corn (42.7 bu/acre) or 2014 soybean (44.5 bu/acre) crops under conventional cropping compared with the organic cropping system (40.4 and 46.6 bu/acre, respectively, Fig.1)). Soybean seed yield, however, was greater under the conventional cropping system (52.8 bu/acre) compared with the organic cropping system (43.7 bu/acre) following the 2014 small grain crop. Early plant populations between the conventional (~155,000 plants/acre) and organic cropping systems (~158,000 plants/acre) were similar and weed control in the organic cropping system (0.2 to 0.3 weeds/m2) was almost as good as in the conventional cropping system (0.12 weeds/m2) following the 2014 small grain crop (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/). Consequently, it is not clear why soybean yielded greater in the conventional compared with the organic cropping system when following a small grain crop.

Soybean seed yield also showed a cropping system x management input interaction (Fig.2). When averaged across all three previous crops, seed yield in the conventional cropping system was greater in the high management treatment (48.6 bu/acre) vs. recommended management treatment (44.7 bu/acre) but similar between management treatments in the organic cropping system (44.3 and 42.9 bu/acre, respectively, Fig.2). Early plant stands in the conventional cropping system under recommended inputs averaged about ~122,000 plants/acre, which in numerous studies in NY have been adequate for maximum yield. Consequently, the increased yield in the conventional cropping system under high management inputs may have been associated with the fungicide application at the R3 stage.

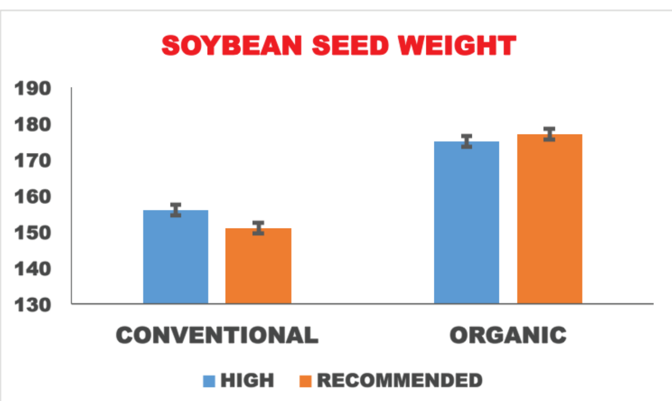

Fig 3: Soybean seed weights under conventional and organic cropping systems in the high and recommended management treatments.

Exceedingly dry conditions, however, ensued after the fungicide application, which probably contributed to the lack of visible disease symptoms from the R3-R8 stage, leading to speculation about fungicide plant health effects. This speculation is further reinforced by the increased seed weight in the conventional cropping system in the high management treatment (156.0 mg) compared with the recommended management itreatment (150.9 mg), but not in the organic cropping system (174.4 and 176.7 mg, respectively, Fig.3). Nevertheless, the return on the 4 bu/acre yield advantage would not offset the input costs associated with 50,000 more seeds/acre, the fungicide, and the fungicide application, resulting in both the high and recommended management treatments similar in partial returns. (The greater seed weight in the organic vs. the conventional cropping system is probably associated with different genetics of the two varieties and not the cropping system).

In conclusion, soybeans, which do not require fertilizer N, was the superior first-year transition crop compared to corn in this study. Soybean plant populations were similar or higher in the organic compared with the conventional cropping system. Although more weeds were observed in the organic compared with the conventional cropping system, weed densities averaged less than 0.9 weeds/m2 in all organic treatments, which probably did not influence yield greatly. Soybean yields were essentially the same under conventional and organic cropping system when following the 2014 corn or soybean crop (but were ~17% lower when following a 2014 small grain crop). Overall, soybean looks to be an excellent first year transition crop from conventional to organic cropping systems because soybean does not require fertilizer N, and is a row crop that is competitive with weeds, especially when comparing it with corn.

Corn Yield Under Conventional and Organic Cropping Systems with Recommended and High Inputs During the Transition Year to Organic

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We initiated a 3-year study at the Aurora Research Farm in 2015 to compare the corn, soybean, and wheat/red clover rotation under conventional and organic cropping systems during the 3-year transition period (2015-2017) to an organic cropping system. We used three entry points or previous crops from 2014 to initiate the 2015-2017 study: 1) grain corn, 2) small grain, and 3) soybean. Three of the many objectives of the study are 1) to determine the best previous crop (2014) for the transition, 2) the best crop to plant in the first year (2015) during the transition and 3) do corn, soybean, and wheat respond similarly to management inputs (high and recommended) under conventional and organic cropping systems? This article will discuss corn yields under conventional and organic cropping systems under high and recommended management inputs.

All three fields (corn, small grain, and soybean as entry points or previous crops) were mold-plowed on May 22. Kreher's composted chicken manure, a 5-4-3 analysis, was selected as the fertilizer for the organic corn in the transition year of this study. We estimated that about 50% of the N from the composted chicken manure would be mineralized and available to the corn crop in 2015. We applied some of the Kreher's composted chicken manure pre-plant to the organic corn plots (50-100 lbs/actual N acre, depending upon the previous crop, and if the plot was the recommended or high input treatment) on the morning of planting, May 23, and then culti-mulched all three studies.

We used a John Deere 7200 MaxEmerge planter to plant a treated (insecticide/fungicide seed treatment) GMO corn hybrid, P9675AMXT with the AMXT, LL and RR2 traits, in the conventional cropping system; and its isoline, the untreated non-GMO, P9675, in the organic cropping system at two seeding rates, ~29,600 kernels/acre (recommended input treatment) and ~35,500 kernels/acre (high input treatment). We applied about 250 lbs/acre of 10-20-20 as a starter fertilizer treatment to corn in the conventional cropping system. In the organic cropping system, we applied about 325 lbs/acre of Kreher's composted manure as a starter fertilizer. We also added Sabrex, an organic seed treatment with Tricoderma strains, in the seed hopper to the non-GMO, P9675, in the high input treatment in the organic cropping system.

We side-dressed the conventional corn at the V6 stage (June 26th) at 80 lbs of actual N/acre (soybean as the previous crop) and 120 lbs/acre (corn and small grain as the previous crop) with liquid N (30-0-0) in the recommended input treatment and 120 to 160 lbs actual N/acre in the high input treatment, respectively. We side-dressed composted chicken manure to organic corn at the V4 stage (June 18) at estimated N rates that would closely match the total N rates (starter and sidedress) in the recommended input treatment (105 lbs/acre total N and 145 lbs/acre total N depending upon the previous crops) and high input treatment (145 and 185 total N/acre depending upon the previous crops) of the conventional cropping system.

We applied Roundup (PowerMax) at 32 oz/acre for weed control in the conventional cropping system in both the recommended and high input corn treatments at the V6 stage (June 27). We used the tine weeder to control weeds in the row in the organic cropping system in both the recommended and high input corn treatments at the V2 stage (June 5), if corn was the previous crop, but not in the other two experiments. We then cultivated close to the corn row in both recommended and high input treatments in the organic cropping system at the V4 stage (June 20) with repeated cultivations between the rows at the V6 stage (June 25) and again at the V9 stage (July 6).

Corn yield showed a previous crop x cropping system interaction (Fig.1). Corn yields in the organic compared

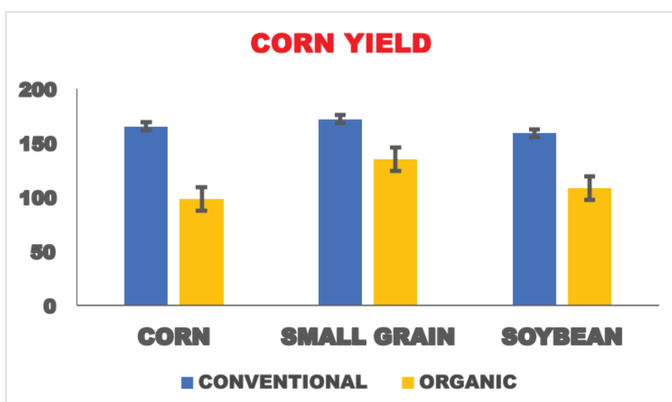

Fig 1: Corn yields in 2015 following the previous crop (corn, small grain, or soybean) in 2014 under conventional and organic cropping systems.

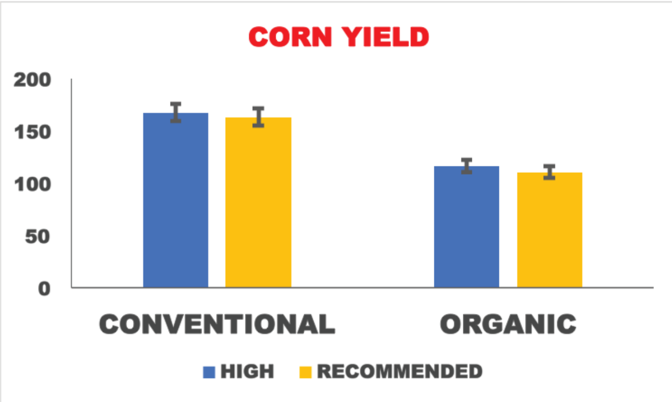

Fig 1: Corn yields under conventional and organic cropping systems under high and recommended management inputs.

with the conventional cropping system was 40% less following the 2014 corn crop (165 vs. 98 bu/acre), 30% less following soybean (159 vs. 108 bu/acre), and 20% less following the small grain crop (172 vs. 135 bu/acre, respectively). As discussed previously (http://blogs.cornell.edu/whatscroppingup/2015/07/23/emergence-early-v4-stage-and-final-plant-populations-v10-psnt-values-v4-and-weed-densities-v12-in-corn-under-conventional-and-organic-cropping-systems/), corn populations were lower at the V9 stage between the organic (~25,000 plants/acre in the recommended and ~31,450 plants/acre in the high input treatments) compared with the conventional cropping system (~28,500 plants/acre in recommended and ~34,265 in high input treatments), and weed densities were much higher in the organic cropping system (~2.25 weeds/m2) compared with the conventional cropping system (~0.4 weeds/m2). Nevertheless, N status of corn crop may have been the most important factor, as indicated by visual symptoms of N deficiency, in the lower corn yields in the organic compared with the conventional cropping system.

Corn yield did not respond to input treatments, regardless of the cropping system (Fig.2). When averaged across the three previous crops, corn in the conventional cropping system yielded similarly in the high input (167 bu/acre) and recommended input treatment (163 bu/acre) and similarly in the organic cropping system (116 vs. 110 bu/acre, respectively). The dry summer conditions at the Research Farm (2.8 inches in July, 1.36 in August, and 0.28 inches from September 1-15, date of physiological maturity or black layer formation) may have contributed to the lack of response of corn to high plant populations and N rates in 2015. We also observed a lack of corn yield response to high seeding and N rates in 2010, a very high yielding year, and in 2011, a very dry year (http://scs.cals.cornell.edu/sites/scs.cals.cornell.edu/files/shared/documents/wcu/WCUVol22No.pdf).

In conclusion, corn should not be the first choice as the first-year transition crop from a conventional to an organic cropping system, based on the results of this study. Corn emerged slower and plant populations were significantly lower in the organic compared with the conventional cropping system. Also, more weeds were observed in corn in the organic compared with the conventional cropping system, which probably contributed to lower yields under organic management. Furthermore, visual observations of the N status indicated that the organic corn may have been short of N throughout the growing season (we will analyze N uptake of conventional and organic corn during the winter months). If there was a lack of N in organic corn, the lack of a red clover crop in place at the beginning of this experiment would have been a major factor. If corn is selected for the first year transition crop, a small grain crop with a red clover inter-seeding may be the best previous crop. Organic corn yields compared with conventional corn yields were only 20% lower following a small grain, even with the use of composted chicken manure as the sole source of N, and not in supplement to a red clover green manure crop.

Crop Management

Wheat Emergence, Early Plant Populations, and Weed Densities Following Soybeans in Conventional and Organic Cropping Systems

Bill Cox[1], Eric Sandsted[1], and Jeff Stayton[2]: [1]Soil and Crop Sciences, School of Integrative Plant Science, Cornell University; [2]Cornell University Agricultural Experiment Station, Musgrave Research

We initiated a 3-year study at the Aurora Research Farm in 2015 to compare the corn, soybean, and wheat/red clover rotation under conventional and organic cropping systems during the 3-year transition period (2015-2017) to an organic cropping system. We used three entry points or previous crops from 2014 to initiate the 2015-2017 study: 1) grain corn, 2) small grain, and 3) soybean. Three of the many objectives of the study are 1) to determine the best previous crop (2014) for the transition, 2) the best crop to plant in the first year (2015) during the transition and 3) do corn, soybean, and wheat respond similarly to management inputs (high and recommended) under conventional and organic cropping systems? This article will discuss days to wheat emergence, fall wheat populations on October 8, the one shoot stage (GS 1), and weed densities on November 3, tiller initiation (GS 2), under conventional and organic cropping systems under high and recommended management inputs.

Wheat is planted in the fall after soybean harvest in the corn-soybean-wheat/clover rotation in New York. We harvested soybean in all three entry points or fields with different 2014 crops (grain corn, soybean, and small grain) on September 23 and no-tilled wheat into soybean stubble the following day. We decided to no-till wheat in the conventional and organic cropping systems because of the paucity of visible weeds, especially perennial weeds.

We used a John Deere 1590 No-Till Grain Drill to plant the treated (insecticide/fungicide seed treatment) Pioneer soft red wheat variety, 25R46, in the conventional cropping system; and the untreated 25R46, in the organic cropping system at two seeding rates, ~1.2 million seeds/acre (recommended input treatment for a September planting date) and ~1.6 million seeds/acre (high input treatment). We applied about 200 lbs/acre of 10-20-20 as a starter fertilizer to wheat in both input treatments in the conventional cropping system. In the organic cropping system, we applied the maximum amount of Kreher's composted manure (5-4-3 analysis) that would flow through the drill, or about 150 lbs of material/acre, as a starter fertilizer to both input treatments. We also broadcast Kreher's composted manure to provide ~60 lbs of actual N /acre (assuming 50% available N from the composted manure) in the high input treatment in the organic cropping system. In addition, we also added Sabrex, an organic seed treatment with Tricoderma strains, to the seed hopper of 25R46 in the high input treatment in the organic cropping system. Finally, we also applied Harmony Extra (~0.75 oz/acre) to the high input conventional treatment at the GS 2 stage (November 5) for control of winter perennials (dandelion in particular).

We will frost-seed red clover into all the wheat treatments in mid to late March when wheat is greening up to provide N to the subsequent corn crop in 2017. We will apply ~60 lbs of actual N/acre (33-0-0, ammonium nitrate) in the recommended input treatment in the conventional cropping system during the early to mid-tillering stage (GS 3) in late March/early April. In the high input conventional cropping systems, we will apply a total of ~100 lbs of actual N/acre (33-0-0) during the spring with some applied at GS 3 and the remainder applied at early jointing stage (GS 6), based on the tiller count at GS 3. We will also apply a timely fungicide (s) to the high input treatment. We will apply Kreher's composted manure to provide 60 lbs of available N/acre in the recommended input treatment in the organic cropping system at GS 3 in late March/early April. We will also apply Kreher's composted manure to provide an additional 40 lbs of available N/acre to the high input treatment in the organic cropping system at GS 3.

When comparing wheat emergence in the two cropping systems under their respective input treatments, emergence was more rapid in the organic cropping system (Table 1). It is not clear why the untreated 25R46 in the organic cropping system emerged more rapidly than the treated 25R46 in the conventional cropping system. Temperatures were exceptionally warm (average temperature of 62.70F) and dry (0.05 inches of precipitation) during the first 6 days after planting. Conceivably, the seed treatment in the conventional wheat made the seed somewhat more impermeable to soil water imbibition, resulting in delayed emergence in the conventional cropping system by ~ 1 day. We also noted the same pattern of emergence between the untreated organic and the conventional soybean seed (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/). It was noted in that news article, however, that soybean varieties differed so a valid comparison of emergence between treated and untreated seed was not possible. On the other hand, corn emergence was more rapid for the treated GMO hybrid, P9675AMXT, in the conventional cropping system compared

Table 1. Days to emergence, plant populations at the 1-shoot stage (GS 1-October 8), and weed densities at the GS 2 stage (November 3) of treated (insecticide/fungicide) 25R46, a soft red winter wheat variety, in the conventional cropping system and untreated 25R46 in the organic cropping system, planted on September 24 at 1.0 million seeds/acre in the recommended input treatment and 1.6 million seeds/acre in the high input treatment. In addition, 25R46 in the high input treatment in the organic cropping system was treated with Sabrex, an organic seed treatment, in the seed hopper at planting time

TREATMENTS	SMALL GRAIN	CORN	SOYBEANS
		Days	
CONVENTIONAL			
Recommended	7.25	8.0	7.5
High Input	7.0	7.5	7.0
ORGANIC			
Recommended	**6.25**	**6.75**	**6.75**
High Input	**6.0**	**6.25**	**6.25**
Plant populations GS 1 stage (plants/acre)			
CONVENTIONAL			
Recommended	1,026,000	1,058,435	1,078,290
High Input	1,247,265	1,227,005	1,252,130
ORGANIC			
Recommended	**1,188,305**	**1,218,900**	1,123,875
High Input	**1,644,177**	**1,705,160**	**1,651,470**
Weed populations GS 2 stage (weeds/m²)			
CONVENTIONAL			
Recommended	**0.03**	**0.26**	**0.05**
High Input	0.02	**0.21**	**0.17**
ORGANIC			
Recommended	0.01	0.02	0.01
High Input	0.01	0.04	0.01

with the untreated non-GMO isoline, P9675 in the organic cropping system (http://blogs.cornell.edu/whatscroppingup/2015/07/23/emergence-early-v4-stage-and-final-plant-populations-v10-psnt-values-v4-and-weed-densities-v12-in-corn-under-conventional-and-organic-cropping-systems/). So perhaps other factors rather than more rapid imbibition contributed to more rapid wheat emergence in the organic cropping system.

When comparing wheat populations at the GS 1 stage in the two cropping systems under their respective input treatments, there was an interaction between cropping systems and management input treatments because of the magnitude of higher populations in the organic cropping system (Table 1). Plant populations averaged ~10.5% higher in the organic compared with the conventional wheat in the recommended management input treatment (seeding rate of ~1.2M seeds/acre). In the high input management treatment (seeding rate of ~1.6M seeds/acre), wheat treated with Sabrex in the organic cropping system averaged ~25% greater than wheat treated with the insecticide/fungicide treatment under conventional management. Perhaps the Sabrex seed treatment greatly improved wheat stand establishment in the organic cropping system when compared with the insecticide/fungicide seed treatment in the conventional cropping system. It must be noted, however, that seed size differed between the untreated 25R46 (~11,500 seeds/lb) and the treated 25R46 (~14,000 seeds/lb) so drill settings were not consistent between the two plantings because we planted according to seeds/acre and not lbs or bushels/acre. Conceivably, changes in drill settings between the two treatments could have contributed so some of the wheat population differences between the two cropping systems.

Another surprising aspect of our data is that the conventional cropping system had greater weed density compared to the organic cropping system (Table 1). It must be noted, however, that weed densities were very low so yields will probably not be compromised except in a couple of the plots in the conventional cropping system under recommended inputs (no herbicide) when corn was the previous crop in 2014. Most of the observed weeds were dandelion with some mallow or cheese weed also observed. Apparently, the last cultivation of soybean on July 16 and the last cultivation of corn on July 6 removed existing or late-emerging dandelions or mallow, whereas the observed weeds in the conventional cropping system apparently emerged after the June 26 Roundup application.

In conclusion, the timely wheat planting (September 24) resulted in excellent wheat stands and the warm November temperatures resulted in an excellent wheat crop in appearance in all the treatments in late November. Overall, the organic wheat looked more robust than the conventional wheat, especially in the high input treatment, because of better stand establishment and perhaps the 60 lbs/acre of actual N applied as composted chicken manure. In addition, the organic compared to the conventional wheat surprisingly had fewer weeds, especially dandelion, in early November under no-till conditions. Soybean followed by wheat may prove to be excellent transition crops in the first 2 years going from conventional to an organic cropping system (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/). Wheat, however, unlike soybean, requires fertilizer N to realize its yield potential, and this may prove to be a limiting factor to organic wheat yields, similar to corn yields. (http://blogs.cornell.edu/whatscroppingup/2015/11/09/corn-yield-under-conventional-and-organic-cropping-systems-with-recommended-and-high-inputs-during-the-transition-year-to-organic/). We will find out how organic wheat fares compared to conventional wheat when we harvest next July (2016).

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Calendar of Events

DEC 1-3	2015 Northeast Region CCA Annual Training
DEC 3	77th Annual Cornell Seed Conference
DEC 8 & 9	New York Farm Bureau State Annual Meeting
DEC 9	Tile Drainage Workshop
DEC 9 & 15-17	Cover Crops: Farmer Discussion Group Meetings
DEC 15 & 16	Calf & Heifer Congress
JAN 3 - 7	2015 Northeastern Branch: Crops, Soils, and Agronomy Annual Meeting
JAN 6	Oneida County Crop Congress
JAN 7	NYS Ag Society's 184th Meeting

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