Agronomic and Economic Performance of Maize, Soybean, and Wheat in Different Rotations during the Transition to an Organic Cropping System

W. Cox;

Cornell University, Soil and Crop Sciences Unit, United States of America

Corresponding author email: wjc3@cornell.edu

Abstract:

Abstract Crop producers transitioning from conventional to organic management must grow crops with organic practices but no price premium during the transition, while incurring higher production costs and lower yields. We evaluated red clover-maize, maize-soybean, and soybean-wheat/red clover rotations in organic and conventional cropping systems with recommended and high inputs to identify the best rotation and management practices during the transition. Organic maize with recommended inputs compared with conventional maize with high inputs in the red clover-maize rotation had similar yields, lower production costs, and higher partial returns. Organic compared with conventional maize in the maize-soybean rotation had lower yields, higher production costs, and lower partial returns. Organic compared with conventional soybean with recommended inputs in soybean-wheat/red clover or maize-soybean rotations had similar yields, production costs, and partial returns. Organic compared with conventional wheat with recommended inputs had lower yields, higher production costs, and lower partial returns. The organic compared with the conventional soybean-wheat/red clover rotation had the least negative impact on partial returns. All organic rotations with recommended inputs had mostly similar partial returns so transitioning immediately, regardless of entry crop, appears most prudent. High input management, which did not improve organic crop yields, would not ease the transition.

Acknowledegment:

JEL Codes: Q01, Q12

#291

Agronomic and Economic Performance of Maize, Soybean, and Wheat in Different Rotations during the Transition to an Organic Cropping System

Submitted paper for the 30th International Conference of Agricultural Economists, July 28-August 2, Vancouver, British Columbia, Canada

Abstract

Crop producers transitioning from conventional to organic management must grow crops with organic practices but no price premium during the transition, while incurring higher production costs and lower yields. We evaluated red clover-maize, maize-soybean, and soybean-wheat/red clover rotations in organic and conventional cropping systems with recommended and high inputs to identify the best rotation and management practices during the transition. Organic maize with recommended inputs compared with conventional maize with high inputs in the red clover-maize rotation had similar yields, lower production costs, and higher partial returns. Organic compared with conventional maize in the maize-soybean rotation had lower yields, higher production costs, and lower partial returns. Organic compared with conventional soybean with recommended inputs in soybean-wheat/red clover or maize-soybean rotations had similar yields, production costs, and partial returns. Organic compared with conventional wheat with recommended inputs had lower yields, higher production costs, and lower partial returns. The organic compared with the conventional soybean-wheat/red clover rotation had the least negative impact on partial returns. Nevertheless, all organic rotations with recommended inputs had mostly similar partial returns so transitioning immediately, regardless of entry crop, appears most prudent. High input management, which did not improve organic crop yields, would not ease the transition.

Introduction

Organic compared with conventionally-produced grains and soybean have substantial price premiums, providing market incentives for organic production (USDA, 2015a). Downward trends in grain crop and soybean prices have prompted some crop producers, who practice a maize-soybean or a maize-soybean-wheat/red clover rotation, to contemplate transitioning from conventional to an organic cropping system. The USDA, however, requires a 36-month transition period that prohibits the use of GMO crops, synthetic fertilizer, pesticides, etc. before the land can be certified as organic and eligible for the organic price premium (USDA, 2012). Furthermore, comprehensive survey data indicated that organic compared with conventional crop production, despite higher profits, had lower yields and higher per-hectare production costs (USDA, 2015b). Consequently, a major deterrent for conventional crop producers who wish to transition to an organic cropping system is higher production costs, potentially lower yields, and the absence of a price premium during the transition. Identification of the best entry crop and subsequent rotation during the transition to an organic cropping system for maintaining cash flow on the farm, especially given the relatively low cash receipts received by maize, soybean and wheat growers in recent years (USDA, ERS, 2017b).

Numerous studies comparing organic and conventional cropping systems have been conducted. In a Minnesota study established in 2002 near Morris MN, organic compared with conventional maize yielded 34% lower, whereas organic compared with conventional soybean yielded statistically similar (but 15% numerically lower) from 2002-2005 when comparing 2-year conventional and organic maize-soybean rotations (Archer et al., 2007). Organic maize yielded lower mostly due to lack of available soil N, associated with low N content of the solid dairy manure applied to organic maize. Despite $425/ha lower seed, fertilizer and pesticide costs, the 2-year organic compared with the 2-year conventional rotation had $128/ha higher production costs associated with higher labor, diesel, manure hauling, and machinery ownership costs. Consequently, the organic compared with the 2-year conventional rotation had $511/ha lower net present value during the transition because of lower yields, higher production costs, and the absence of an organic premium (Archer et al., 2007).

In this same MN study, the entry crop into an organic cropping system had a major impact on risks and returns during the transition phase (Archer and Kludze, 2006). Based on yield data and inputs from the same study, soybean as the entry crop provided a $283 advantage of net present value compared with maize in the maize-soybean organic rotation. In the 4-year organic rotation, wheat as the entry crop provided a $229 advantage over other entry crops (Archer et al., 2007). Nevertheless, a simple dynamic adoption model indicated that transitioning to an organic cropping system as rapidly as possible, regardless of the entry crop, would result in the highest expected long-term profit (Archer and Kludze, 2006).

In another MN study established near Lamberton, organic maize in a maize-soybean-oat/alfalfa-alfalfa rotation yielded similarly as conventional maize in a maize-soybean rotation from 1993-2009 (Coulter et al. 2011). Organic compared with conventional soybean, however, yielded 25% lower in their respective rotations over the same period. Organic compared with conventional maize, despite higher machinery costs, had $86/ha lower production costs because of lower seed costs as well as no herbicide costs (Delbridge et al., 2010). Likewise, organic compared with conventional soybean had $101/ha lower production costs, primarily because of lower weed control costs. When factoring in the organic price premium (2.17 price ratio for maize and 2.27 for soybean), the 4-year organic rotation had $527 net revenue compared with $295 for the 2-year conventional rotation (Delbridge et al., 2010).

Machinery ownership costs, however, were not included in the first analyses of this study. When comparing the 4-year organic rotation with the 2-year conventional rotation, machinery ownership costs averaged $146/ha across organic farm sizes of 130, 225 and 325 ha compared with $183/ha across conventional farm sizes of 225, 455, and 630 ha (Delbridge et al., 2011). The organic rotation had net returns of $114,000 compared with conventional net returns of $72,000 for a 225-hectare farm (Delbridge et al., 2011). The organic rotation also had net returns of $296,000 for the largest farm size (325 ha), compared with conventional net returns of $220,000 for its largest farm size (630 ha), despite the farm-scale advantage for conventional production.

In a study established in 1990 at Arlington and Elkhorn, WI, a no-till (NT) conventional maize-soybean rotation compared with an organic maize-soybean-wheat rotation averaged $130 and $408 higher economic mean returns, respectively, in the absence of organic premiums (Chavas et al., 2009). In the presence of government payments and organic premiums, the organic maize-soybean-wheat rotation had $321 and $165 higher economic mean returns, respectively, compared with the conventional NT maize-soybean rotation (Chavas et al., 2009). The conventional NT maize-soybean rotation yield trend, however, averaged 151 kg/ha compared with 101 kg/ha for the organic maize-soybean-wheat rotation from 2009 to 2012 (Baldock et al., 2014), perhaps because of technology advances in the conventional cropping system and/or increased weed competition in the organic cropping system.

In a cropping system study established in 1996 at Beltsville, MD, organic maize in a maize-soybean-wheat/vetch rotation yielded 28% lower compared with conventional NT maize in a maize-soybean-wheat/soybean rotation during the transition years from 1996 to 1998 (Cavigelli et al., 2008). After the transition period, organic compared with conventional maize yielded 40% lower in their respective 3-crop rotations (Cavigelli et al., 2008). The lower organic maize yields were associated mostly with low soil N availability (73%) and weed competition (23%). After the transition period, organic soybean compared with NT conventional soybean yielded 24% lower in their respective 3-crop rotations because of greater weed competition (Cavigelli et al., 2008). In the 3-year period (2000-2002) following the transition, the organic compared with the conventional cropping system, despite lower maize and soybean yields, had $514/ha greater net returns (Cavigelli et al., 2008). Economic risk in the 3-year organic system, however, was 3.9 times greater compared with a 6-year organic rotation (maize/rye-soybean-wheat-alfalfa-alfalfa-alfalfa).

In a study, established at Greenfield, IA, maize and soybean in an organic maize-soybean-oat/alfalfa-alfalfa rotation compared with a conventional maize-soybean rotation yielded similarly during the transition (Delate and Cambardella, 2004), resulting in higher profitability for the organic cropping system because of lower production costs (Delate et al., 2003). In the second phase of the study, maize and soybean again yielded similarly between cropping systems so the organic cropping system was far more profitable because of lower production costs in maize and higher prices received for organic maize and soybean (Delate at al., 2013).

Long-term cropping system experiments, though beneficial, are somewhat limited in the analyses of conventional vs. organic cropping systems because management practices are fixed and the "human" management factor of organic production is missing (McBride et al., 2015). McBride et al. (2015) used Agricultural Resource Management Survey (ARMS) data in 2010 for maize (794 conventional and 451 organic farms); 2009 ARMS data for wheat (1641 conventional and 1458 organic farms); and 2006 ARMS data for soybean (748 conventional and 478 organic farms) to compare conventional and organic crop production. They reported that organic maize, soybean, and wheat production had higher economic costs ($205 to $242/ha; $261 to $309/ha; and $135 to $153/ha higher, respectively) because increases in fuels, repair, capital, and labor did not offset lower seed, fertilizer and chemical costs. Furthermore, organic maize, soybean, and wheat compared with conventional crops yielded much lower (27%, 34%, and 32%, respectively). Consequently, organic compared with conventional producers had higher average economic costs per metric ton or Mg ($76 to $89/Mg, $143 to $164/Mg, and $243 to $287/Mg higher, respectively). Nevertheless, net economic returns were greater for organic compared with conventional maize and soybean producers ($126 to $163/ha, and $54 to $101/ha higher, respectively) because of the organic price premiums (~2.85 and ~2.25 ratios, respectively). Net economic returns for organic compared with conventional wheat, however, were slightly lower ($-5 to -$23/ha), despite the organic price premium (~2.4 price ratio). The survey data indicate that the price premium is crucial for profitability in organic maize, soybean, and wheat production because of lower yields and higher production costs.

A major deterrent to adoption of organic crop production is the uncertainty associated with selection of the best entry crop and subsequent rotation during the 36-month transition when organic premiums do not exist (Archer et al., 2006). Another deterrent is that novice organic crop producers are uncertain of the best organic management practices to use during the transition and beyond (Archer and Kludze, 2007). Two objectives of this study are: 1) to identify the best entry crop and subsequent organic rotation that results in the best partial economic returns to the organic cropping system during the transition, and 2) to evaluate recommended and high input management practices (organic seed treatment, and high seeding and high N rates) to determine if high input management increases weed competitiveness and improves soil N availability for organic crops, the two major constraints to organic crop production, thereby improving partial economic returns during the transition.

Materials and Methods

We initiated a 4-year cropping system study in 2015. Three contiguous experimental sites with similar soils (tile-drained silt loam soils) but different

2014 crops (spring barley, maize, and soybean) were used in the study. The experimental design is a split-split plot with four replications with cropping systems (conventional and organic) as whole plots, rotations (red clover-maize; soybean-wheat/red clover; and maize-soybean) during the transition as sub-plots, and management inputs (recommended and high inputs) as sub-sub plots. Whole plot dimensions were 180 m wide and 30 m long, sub-plot dimensions were 30 m wide and 30 m long and sub-sub plot dimensions were 10 m wide and 30 m long.

Maize and soybean strips were mold-plowed ~ May 20 in both years, followed by secondary tillage the following day. Maize and soybean planting occurred 2 days after plowing. In 2015, green manure strips were culti-mulched in early July and red clover was planted at 30 kg/ha. In organic maize, we used composted chicken manure, a 5-4-3 analysis, as the N source, which was applied 1 day before plowing. We estimated that 50% of the N from the composted chicken manure would be mineralized and available to organic maize. Wheat also received composted chicken manure as its N source.

Table 1 lists the management inputs in maize, soybean, and wheat. Major differences between conventional and organic maize include a) a treated (insecticide/fungicide seed treatment) GMO hybrid, P9675AMXT with the AMXT, LL and RR2 traits, vs. the non-GMO isoline, P9675 (no seed treatment in recommended input but an organic seed treatment, Sabrex, mixed in the seed hopper in the high input treatment), b) 280 kg/ha of 10-20-20 vs. 365 kg/ha of composted manure (5-4-3) as starter fertilizer, c) 135 to 180 kg N/ha side-dressed in 2015 and 0 to 56 kg N/ha when following red clover in 2016 (recommended and high input treatments, respectively) with a liquid N source (32-0-0) vs. the same N rates in organic maize with composted chicken manure applied pre-plant and 4) a single Glyphosate herbicide application for weed control in conventional vs. tine weeding, followed by a close cultivation to the row, followed by two additional cultivations between the rows for organic maize. Seeding rates of 73,000 kernels/ha were used in recommended input and 86,500/ha in high input treatments of both cropping systems.

Major differences between conventional and organic soybean include a) treated (insecticide/fungicide seed treatment) GMO variety, P22T41R2 with the RR2Y and SCN traits vs. a non-GMO variety, 92Y21 (organic seed treatment mixed in the seed hopper of the high input treatment), b) 0.38 m vs. 0.76 m row spacing (for cultivation of weeds in organic soybean), and c) a single Glyphosate herbicide application for weed control vs. tine weeding, followed by close cultivation to the row, followed by three additional cultivations between the rows (Table 1). Seeding rates of 370,500 and 494,000 seeds/ha were used for recommended and high input treatments in both cropping systems. Conventional soybean in the high input treatment also received a fungicide (Fluxapyroxad + Pyraclostrobin at ~300 ml /ha) application at the beginning pod stage (late July) for potential disease problems and overall plant health. We did not fertilize soybean because conventional soybean growers typically do not use fertilizer on soybean. We harvested soybean in all three fields on September 23 at ~11% moisture and no-tilled wheat into soybean stubble the following day in 2015. We decided to no-till wheat because of the paucity of visible weeds, especially perennial weeds, in both cropping systems.

Major differences between conventional and organic wheat include a) a treated (insecticide/fungicide seed treatment) soft red winter wheat variety, 25R46, vs. the untreated 25R46 b) 225 kg/ha of 10-20-20 vs. 175 kg/ha of composted chicken manure (fastest the material would flow through the drill) as starter fertilizer, c) and top-dressing with 80 kg N/ha or 56 + 56 kg N/ha (in the recommended and high input treatments, respectively) with ammonium nitrate (33-0-0) in April vs. 80 kg N/ha (April) or 56 kg N/ha (pre-plant) + 56 kg N/ha (April in recommended and high input treatments, respectively) with composted manure (Table 1). We also applied an herbicide (thifensulfuron + tribenuron) in the fall and a fungicide (Prothioconazole + Tebuconazole) in the spring in high input conventional wheat. We frost-seeded red clover at ~30 kg/ha into all the wheat treatments in early March to provide N to the subsequent maize crop in 2017.

Costs for the different management inputs for the three crops in the two cropping systems are listed in Table 2. Production costs for organic maize and wheat will be somewhat inflated because of the use of composted chicken manure as the major N source (~13x higher cost/kg of N compared with liquid N in conventional maize and ammonium nitrate in wheat). We used composted chicken manure in organic maize and wheat because of its known analyses of N-P-K and its ease in calibration and application with a Ghandi spreader. We wished to avoid the problems with the use of solid animal manure in previous studies, which did not accurately estimate the N content (Archer et al., 2007 and Delbridge et al, 2011). Also, conventional maize received only a single application of Glyphosate compared with the typical two or more herbicide applications used by most growers. We do not have resistant weeds to Glyphosate in our fields and the fields were relatively clean so a single Glyphosate application provided excellent weed control. Our weed control costs were thus significantly lower than typical in conventional maize. Consequently, production costs are skewed in favor of conventional maize and wheat.

Soybean prices received by NY farmers averaged $0.34/kg in 2015 and 2016, maize prices averaged $0.156/kg in 2015 and 2016, and the wheat price averaged $0.149/kg in 2016 (USDA, 2017b). Analyses focused on enterprise budget items that differed among the treatments, namely the value of production associated with yield differences as well as cost differences for inputs for maize, soybean and wheat. Returns to variable and fixed inputs that do not differ between conventional and organic soybean production under recommended and high input management were calculated for the three crops. Our selected variable inputs include: seed, fertilizer, and other inputs (inoculant, organic seed treatment, herbicide, and fungicide); labor and machinery operating inputs (repairs and maintenance, fuels and lubricants), excluding tillage, planting and harvesting tasks, except for hauling, where hauling cost is a function of yield (Lazarus, 2016). Cost of production values reported for fixed inputs exclude farm machinery ownership costs for tillage, planting and harvest, land charges, and values of management inputs. Grain moistures did not differ between organic and conventional maize, and grain drying is not required for soybean and wheat so we did not include those production costs in maize.

Previous crop, cropping systems, and management inputs were considered fixed and replications random in the ANOVA model for statistical analyses of agronomic and economic data for individual years using PROC MIXED (SAS, Inst., 1998). For statistical analyses of the partial returns data for the 2-year transition, rotations were considered a fixed variable and a sub-sub plot within cropping systems. Fields with different 2014 crops had yield differences for the three crops but did not have any interactions with cropping systems and rotations so the data from the three fields were pooled. Least square means of the main effects (cropping system, rotations, and management inputs) were computed and the Tukey-Kramer option of the LSMEANS statement was used to determine differences among least square means of the main effects at $\partial = 0.05$. Two-way interactions (cropping system by management inputs and cropping system by rotations) were detected for some measured or calculated variables so the interaction comparisons will be presented. Differences among least square means for cropping system treatments were calculated using Fisher’s protected LSD according to procedures for split-split plot experiments by Little and Hills (1975).

Results and Discussion

Agronomic

Organic compared with conventional maize in the maize-soybean rotation yielded 32% lower in 2015 when averaged across management input treatments (Table 3). Management inputs did not influence yield in either cropping system. Organic compared with conventional maize had ~10% lower plant densities at the 9th leaf stage (V9), when all cultivations to organic maize had been completed, mostly due to cultivation damage. Despite the close and repeated cultivations, organic compared with conventional maize had more than 5x higher weed densities. In addition, organic maize had very low grain N% concentrations (1.06%) compared with conventional maize (1.32%). Excessive precipitation (276 mm) from planting to the silking period (R1) probably leached or denitrified a considerable amount of the N in the pre-plow application of composted chicken manure. In contrast, the experimental site received only 98 mm of precipitation from the side-dressing N application (June 26) to silking (July 27), allowing for most of the side-dressed N to be available to conventional maize. Grain yield had a strong positive correlation with grain N concentrations ($r=0.81$, $n=48$) and a strong negative correlation with weed densities ($r=-0.78$, $n=48$). These results agree with findings that have reported lower organic maize yields during the transition because of limited soil N availability and weed competition (Archer et al., 2007; Cavigelli et al., 2008).

In 2016, however, organic and conventional maize in the soybean-maize rotation yielded similarly and input management did not influence yields (Table 7). Maize yields were low, however, because of exceedingly dry conditions (75 mm) from planting through July. Maize and weed densities were much lower in 2016 compared with 2015 probably because dry soil conditions reduced maize and weed emergence. Grain N% concentrations, however, were much greater because there was no leaching or denitrifying of applied N, as well as the concentration effect of grain N% associated with low yields. Grain yield did not correlate with weed densities nor grain N concentrations in 2016.

Organic and conventional soybean in the soybean-wheat/red clover or maize soybean rotations yielded mostly similar in 2015 and 2016, respectively (Table 4). There was a cropping system x management input interaction in 2015, however, because the fungicide application in the high input conventional treatment increased yields, probably because of improved plant health. Yields in both years were relatively low because of limited precipitation (80 mm) from beginning pod development to beginning seed-fill in 2015, and the extreme drought conditions entering August in 2016 (NOAA, 2016). Organic and conventional soybean had similar plant densities in 2015, but organic plant densities were lower in 2016. Soybean plant densities, however, exceeded the plant density threshold (250,000 plants/ha) where yields decline. Also, organic compared with conventional soybean had greater weed densities in both years. Organic weed densities, however, averaged less than 0.60 weeds/m^2, too low for yield losses. Consequently, seed yields did not correlate with plant densities and weed densities, except for a weak correlation with plant densities (r=0.31, n=48) in 2015. The organic soybean yield data mostly agree with a MN study that showed that organic and conventional soybean yielded similarly during the transition (Archer et al., 2007).

Wheat yields had a cropping system x management input interaction (Table 5). Conventional compared with organic wheat in the soybean-wheat/red clover rotation with recommended inputs yielded 11.5% higher in 2016, but yields between cropping systems were similar with high inputs. Yields were low because dry conditions (150 mm of precipitation) prevailed from the tillering stage (April 1) until harvest (July 7). Surprisingly, organic compared with conventional wheat in the recommended input treatment had greater early plant establishment and fewer fall and spring weeds. Conventional wheat, however, had an average grain N% of 2.03 compared to only 1.66% N in organic wheat, suggesting less available soil N for organic wheat. Grain yield, however, did not correlate with grain N% probably because dry soil conditions and not soil N availability was the major yield driver in 2016.

Economic

Maize revenue, a direct function of yield, had similar statistical relationships as yield so conventional compared with organic maize generated more revenue in 2015 but similar revenue in 2016 with no differences between input treatments (Tables 3 and 6). Organic compared with conventional maize, averaged across the 2 years, had higher selected production costs when comparing their respective recommended and high input management treatments (Table 6). As expected, organic compared with conventional maize had lower seed costs because of the lack of seed treatment and GMO traits. Organic compared with conventional maize had higher fixed costs, as well as higher labor, and repair and maintenance (tractor, weed control equipment, and fuels and lubricants) costs. These higher costs are associated with the 4-time use of labor and equipment for mechanical weed control in organic maize compared with 1-time use of labor and equipment for herbicide application in conventional maize.

Organic compared with conventional maize also had higher fertilizer costs because of the much greater cost for composted chicken manure relative to conventional starter fertilizer and N fertilizer. Most of the composted chicken manure as an N source was applied in 2015 (none in 2016 except for 56 kg N/acre in the high input treatment) when a green manure crop (red clover) was not in place. Most organic crop producers do not use composted manure as an N source but rather use solid manure from their own livestock or from a neighbor's livestock. Consequently, the higher production costs in organic compared with conventional maize ($247 and $744/ha in recommended and high input treatments, respectively) greatly differ with the $87/ha lower organic maize production costs reported in a study that used solid dairy manure (Archer et al., 2007).

Conventional compared with organic maize had much greater partial returns in 2015 because of higher yields and lower production costs (Table 7). If cash flow is of a major concern to the grower, maize should not be the entry crop in the transition to organic crop production unless there is an animal manure source on the farm or close by or a green manure crop in place. In 2016, when maize followed red clover, a cropping system x management input interaction was significant. Organic and conventional maize with recommended inputs had similar partial returns. Organic maize with recommended inputs, however, had greater partial returns compared with conventional maize with high inputs, a management practice frequently used by conventional growers. In contrast, organic maize with high inputs (organic seed treatment, high seeding rates and 56 kg N/ha of composted manure), had lower partial returns compared with both conventional maize input treatments. Again, the 13x higher N/kg cost of composted chicken manure is almost solely responsible for the lower partial returns of organic maize with high input management. If the grower wishes to plant maize during the transition, the partial returns data indicate that the grower should plant a green manure crop first, followed by maize as the second crop. This strategy, however, would eliminate maize as the first crop eligible for the organic premium in 2017, which could reduce long-term economic benefits (Archer and Kludze, 2006).

Soybean revenue did not differ among cropping systems nor management inputs in either year, except for higher revenue with high input management in 2015 (Tables 4 and 8). Organic compared with conventional soybean had lower variable costs when comparing respective treatments (Table 8). Organic compared with conventional soybean had lower seed and other input costs (inoculant in conventional, organic seed treatment in organic high input, herbicide and fungicide in conventional high input), which offset higher remaining variable costs (labor, repairs and maintenance, and fuels and lubricants,). As with maize, organic compared with conventional soybean had higher fixed input costs as well as repair and maintenance costs, associated with the greater use of equipment for repeated cultivations for weed control relative to a single herbicide application.

Organic compared with conventional soybean had slightly higher ($13.50/ha) total selected production costs with recommended input management but slightly lower ($47/ha) costs in high input management. Other cropping system studies have also reported similar or lower total production costs for organic soybean (Delate and Cambardella, 2004; Delbridge et al., 2010; Delbridge et al., 2011) mostly because of lower seed and pesticide costs. Archer et al. (2007), however, reported $128/ha higher production costs in organic compared with conventional soybean because lower seed and pesticide costs did not offset higher labor, diesel, and machinery ownership costs. McBride et al. (2015) also reported that organic soybean producers had higher economic costs ($262 to $309/ha) compared with conventional producers.

Soybean partial returns in 2015 and 2016 did not differ among cropping systems nor management inputs because of mostly similar yields with mostly similar production costs (Table 7). Organic soybean, especially with recommended inputs (no organic seed treatment to improve plant establishment or higher seeding rates to improve weed control) thus is an excellent entry or second year crop in the transition to an organic cropping system. Our economic data agree with another study that indicated that soybean is the preferred entry crop (Archer et al., 2007). A major advantage of using soybean as the entry crop is that soybean does not require N fertilizer so the prospective organic grower who does not own livestock will not have to find an organic N source, as in the case of maize or wheat.

Wheat revenue had a cropping system x management input interaction, similar to yield (Tables 5 and 9). Total production costs were more than 2-fold greater in organic compared with the respective conventional wheat management systems (Table 9). The use of composted manure as starter fertilizer but more importantly as an N source is the major reason for the much greater variable and total production costs in organic wheat. As with maize, most organic growers would probably not use composted manure as an N source. Consequently, the $416 to $595/ha higher production costs for organic compared with conventional wheat in our study are much higher than the $243 to $257/ha higher production costs reported by McBride et al. (2015).

Organic compared with conventional wheat had much lower partial returns because of similar or lower yields and much higher production costs (Table 7). Many wheat growers in the eastern USA manage wheat with high inputs (high seeding rates, fall herbicide, high split-applied N rates, and late spring fungicide). Organic wheat with recommended inputs compared more favorably with typical conventional wheat management with high inputs ($212/ha lower partial returns). Organic wheat compared with organic maize and soybean as second-year crops in the transition had much lower partial returns. Conventional wheat compared with conventional maize or soybean, also had lower partial returns, which explains in part the record low hectares of wheat planted in the USA in 2017 (USDA, 2017b). Winter wheat, however is an ideal rotation crop that disrupts weed and insect cycles in maize and soybean so must be evaluated in context of an organic rotation.

When comparing partial returns of the three crop rotations (red clover-maize, maize-soybean, and soybean-wheat/red clover) during the transition, the organic red clover-maize rotation with recommended inputs had similar partial returns as the conventional red clover-maize rotation with recommended inputs and greater partial returns compared with the high input treatment (Table 10). Most conventional growers, however, who do not transition to organic production, would not practice such a rotation so comparisons should be made between the organic red clover-maize rotation with the conventional maize-soybean or conventional soybean-wheat/red clover rotations. The organic red/clover-maize rotation with recommended inputs had $1134/ha lower partial returns compared with the conventional maize-soybean rotation with recommended inputs and $965/ha lower compared with the high input treatment. We did not apply composted chicken manure as an N source to organic maize with recommended inputs in 2016, but rather utilized red clover as the N source. Therefore, production costs are not inflated and partial returns not deflated in this comparison.

The organic maize-soybean rotation with recommended inputs had identical partial returns as the organic red clover-maize rotation with recommended inputs (Table 10). Consequently, partial returns of both organic rotations compared with the conventional maize-soybean rotation was identical. The substitution of a green manure crop for maize as an entry crop instead of continuing a maize-soybean rotation thus did not improve partial returns over the 2-year transition period.

The organic compared with the conventional soybean-wheat/red clover rotation with recommended inputs had $548/ha lower partial returns (Table 10). Many soybean and wheat growers in the Eastern USA, however, use high input management on both crops. The organic soybean-wheat/red clover rotation with recommended inputs compares more favorably with the conventional soybean-wheat red clover rotation with high inputs ($229/ha lower partial returns). If cash flow is of major concern to the grower during the transition, soybean was the best entry crop followed by wheat in this study. This agrees with the findings in a MN study (Archer et al., 2006). When comparing partial returns of all three organic rotations with recommended inputs, however, differences were less than $100/ha. Consequently, the red clover-maize, maize-soybean, and soybean-wheat/red clover rotations would have essentially the same cash flow impact on the farm during the transition. This agrees with the findings of Archer et al. (2006) who reported that transitioning growers should begin the transition process immediately, regardless of the entry crop.

In 2017, however, when crops are eligible for the organic premium, organic compared with conventional maize with recommended inputs in the soybean-wheat/red clover (and now-maize) rotation yielded 15% higher. Organic maize in the soybean-wheat/red clover-maize rotation with recommended inputs also yielded similarly to conventional maize in the maize-soybean rotation in 2017. If the grower selected the soybean-wheat/red clover rotation during the transition, the grower would reap much greater partial returns in the first year after the transition because of similar or greater maize yields, lower production costs (no composted chicken manure) and an organic price premium (~2.4 price ratio). Organic compared with conventional soybean in the red clover-maize-soybean rotation yielded 8% less with recommended or high inputs in 2017. Nevertheless, the grower who used a red clover-maize rotation during the transition, would also reap greater profits with organic soybean with recommended inputs in 2017 because the 8% lower yield would be offset by lower production costs and the organic price premium (2.25 price ratio).

Conclusion

The two major constraints to organic field crop production are soil N availability and weed competition. Soybean was thus an excellent entry crop in the transition to organic production because it provides its own N and is more competitive with weeds than maize, allowing for satisfactory weed control with mechanical weed control methods in our study. High seeding rates did not improve organic soybean weed control in our study. We have grown organic soybeans for 3 years, and have observed limited increased weed competition (~1.0 weeds/m^2 in the very wet 2017 growing season). Reliable soil N availability and relatively low weed densities in the 3rd year of our study bode favorably for long-term sustainability of organic soybean production with recommended inputs.

Maize as an entry crop, however, was more problematic because providing available soil N in the first year was a challenge and maize is less competitive with weeds (compared with wheat or soybean). Once red clover was in place (green manure crop in the transition year or inter-seeded into wheat in the second year), organic compared with conventional maize with recommended inputs yielded similarly in the dry 2016 growing season and 15% greater in the wet 2017 growing season. Interestingly, red clover not only provided N to the maize crop but appeared to reduce weed densities (fewer than 0.7 weeds/m^2 in 2017), which bodes well for long-term sustainability of this rotation.

Organic compared with conventional wheat no-tilled into soybean stubble had more rapid emergence, better early plant establishment, and fewer weeds. Organic wheat, however, in a maize-soybean-wheat/red clover rotation, must rely on manure as an N source. Wheat takes up most of its N from mid-April through late May in the eastern USA when cool temperatures prevail, which may inhibit mineralization of organic N. Nevertheless, organic wheat with recommended inputs compared with conventional wheat with high inputs yielded similarly. Organic compared with conventional wheat in 2017 again had more rapid emergence, greater stand establishment, and fewer fall weeds.

Organic maize and wheat had greater production costs than typical because of the use of composted chicken manure to ensure comparable N rates applied to organic and conventional maize and wheat. Partial returns to organic compared with conventional maize and wheat during the transition were thus lower than typical, especially in maize where our conventional weed control costs are much lower than typical. The 2016 growing season, however, was exceedingly dry, which greatly favors organic crop production (Delbridge et al., 2011), which may have contributed to the similar yields between organic and conventional maize and soybean and only a 11.5% lower organic wheat yield with recommended inputs. Consequently, partial returns between organic and conventional cropping systems in our study during the transition did not differ greatly from other studies (Archer et al., 2007; Delbridge et al., 2011).

References

Archer, D.W., and H. Kludze. Transition to organic cropping systems under risk. In: Proc. American Agricultural Economics Assoc. Annual Meeting, July 23-26, 2006, Long Beach, CA. 24 p.

Archer, D.W., A.A. Jaradat, J.M-F. Johnson, S. Lachnicht Weyers, R.W. Gesch, F. Forcella, and H.K. Kludze. 2007. Crop Productivity and Economics during the Transition to Alternative Cropping Systems. Agronomy Journal 99:1538-1547.

Baldock JO, Hedtcke J.L., Posner J.L., and J.A. Hall. 2014. Organic and Conventional Production Systems in the Wisconsin Integrated Cropping Systems Trial: III. Yield Trends. Agronomy Journal, 106, 1509–1522.

Cavigelli M.A., Teasdale J.R., and A. E. Conklin. 2008. Long-term agronomic performance of organic and conventional field crops in the mid-Atlantic region. Agronomy Journal. 100:785–794.

Chavas, J.P., J.L. Posner, and J.L. Hedtcke. 2009. Organic and Conventional Production Systems in the Wisconsin Integrated Cropping Systems Trial: II. Economic and Risk Analysis 1993-2006. Agronomy Journal 101(2): 288-295.

Coulter J.A., Sheaffer C.C., Haar M.J., Wyse D.L., and J.H. Orf. 2011. Soybean cultivar response to planting date and seeding rate under organic management. Agronomy Journal, 103, 1223–1229.

Delate, K., M. Duffy, C. Chase, A. Holste, H. Friedrich, and N. Wantate. 2003. An Economic Comparison of Organic and Conventional Grain Crops in a Long-Term Agroecological Research (LTAR) Site in Iowa. The American Journal of Alternative Agriculture 18:59-69.

Delate K. and C. A. Cambardella. 2004. Agroecosystem Performance during Transition to Certified Organic Grain Production. Agronomy Journal. 96:1288-1298.

Delate, K., C. Cambardella, C. Chase, A. Johanns, and R. Turnbull. 2013. The Long- Term Agroecological Research (LTAR) experiment supports organic yields, soil quality, and economic performance in Iowa. Crop Management doi: 10.1094/CM-2013-0429-02- RS.

Delbridge, T. A., Coulter, J. A., King, R. P., and C.C. Sheaffer. 2010. A profitability and risk analysis of organic and high-input cropping systems in southwestern Minnesota. In: Proc. Agric. Applied Econ. Assoc. Annual Meeting, Denver, CO. 25- 27 Jul. 2010. Univ. of Minnesota, St. Paul, MN.

Delbridge, T. A., Coulter, J. A., King, R. P, Sheaffer, C. C., and L. Wyse. 2011. Economic performance of long-term organic and conventional cropping systems in Minnesota. Agronomy Journal, 103, 1372-1382.

Delbridge, T. A C. Fernholz, W.F. Lazarus, and R.P. King. 2011. A Whole-Farm Profitability Analysis of Organic and Conventional Cropping

Systems. In: Proc. Agric. Applied Econ. Assoc. Annual Meeting, July 24-26, 2011, Pittsburgh, PA.

Lazarus, William F. 2016. Machinery Cost Estimates. University of Minnesota, Extension.

McBride, W., C. Greene, L. Foreman, and M. Alil. 2015. The Profit Potential of Certified Organic Field Crop Production. ERS no.118. July 2015. https://www.ers.usda.gov/webdocs/publications/45380/53409_err188.pdf?v=42212

NOAA. 2016. Drought July 2016. https://www.ncdc.noaa.gov/sotc/drought/201607

USDA, Organic. 2012. What is Organic Certification? http://www.ams.usda.gov/sites/default/files/media/What%20is%20Organic%20Certification.pdf

USDA, ERS. 2015a. Organic Agriculture. http://www.ers.usda.gov/topics/natural-resources-environment/organic-agriculture.aspx

USDA, ERS. 2015b.The profit potential of certified organic field crop production. http://www.ers.usda.gov/media/1875176/err188_summary.pdf

USDA, NASS. 2017a. Crop Values. 2016 Summary. http://usda.mannlib.cornell.edu/usda/current/CropValuSu/CropValuSu-02-24-2017_revision.pdf

USDA, NASS. 2017b. Prospective plantings. http://usda.mannlib.cornell.edu/usda/current/ProsPlan/ProsPlan-03-31-2017.pdf

USDA, ERS. 2017. Farm Income and Wealth Statistics. https://www.ers.usda.gov/data-products/farm-income-and-wealth-statistics/

Table 1. Soil texture/drainage, planting rate, hybrid/cultivar, tillage, starter and N fertilizer practices, and weed control practices for maize, soybean, and wheat in conventional and organic cropping systems with two management treatments (recommended and high input) at a Cornell Research Farm near in central NY in 2015 and 2016.

	CROP					
Descriptor	MAIZE		SOYBEAN		WHEAT	
	REC.	HIGH	REC.	HIGH	REC.	HIGH
	CONVENTIONAL					
Soil texture/ Drainage	Well- drained silt loam					
Planting rate (seeds/ha)	73,100	87,700	370,500	494,000	2,964,000	4,200,000
Seed Treatment	Fungicide/insecticide		Fungicide/insecticide		Fungicide/insecticide	
Cultivar	GMO	GMO	GMO	GMO	Soft white (P24R46)	Soft white (P24R46)
Tillage	Moldboard Plow		Moldboard Plow		No-Till	
Starter Fert. (kg/ha)	280 kg/ha (10-20-20)		None		225 kg/ha (10-20-20)	
N fertilizer-side-dress (kg N/ha)	90-160 kg N/ha(liquid)	135-200 kg N/ha (liquid)	None	None	80 kg N/ha	56+56 kg N/ha
Herbicide application	Glyphosate	Glyphosate	Glyphosate	Glyphosate	None	Yes
Fungicide application	None	None	None	Yes	None	Yes
	ORGANIC					
Soil texture/ Drainage	Well- drained Honeoye silt loam					
Planting rate (kernels/acre)	73,100	87,700	370,500	494,000	2,964,000	4,200,000
Seed Treatment	None	Organic	None	Organic	None	Organic

Cultivar	Non-GMO (Isoline)	Non-GMO (Isoline)	Non-GMO	Non-GMO	Soft white (P24R46)	Soft white (P24R46)
Tillage	Moldboard Plow		Moldboard Plow		No-Till	
Starter Fertilizer	350 kg/ha composted chicken manure (5-4-3)		None		170 kg N/ha composted chicken manure (5-4-3)	
Pre-plant N fertilizer (kg N/ha))	0-160 kg N/ha composted manure	56-200 kg N/ha composted manure	None	None	80 kg N/ha composted manure	56+56 kg N/ha composted manure
Tine weeding	1x		1x		None	
Cultivate	3x		4x		None	

Table 2. Costs of variable inputs, including seed, hopper seed treatments, (inoculant for conventional soybean and Sabrex for organic crops), starter fertilizer, N fertilizer, herbicide, and fungicide in conventional and/or organic soybean, maize, and wheat.

INPUT	**CONVENTIONAL**	**ORGANIC**
	$	
	SOYBEAN	
Seed/140,000	81.95 (including seed treatment)	50.95
Seed treat.	48.80/g (Cell-Tech inoculant)	200/g (Sabrex)
Herbicide	280/l (Glyphosate)	-
Fungicide	2130/l (Fluxapyroxad + Pyraclostrobin)	-
	MAIZE	
Seed/80,000	330 (including seed treatment)	240
Seed treat.		200/g (Sabrex)
Starter fert.	448tonne (Mg)	325/tonne (Mg)
Side-dress N	0.99/kg N	12.76/kg N
Herbicide	280/l (Glyphosate)	
	WHEAT	
Seed/bag	31 (including seed treatment)	24
Seed treat.		200/g (Sabrex)
Starter fert.	448/tonne (Mg)	325/tonne (Mg)
Herbicide	276/ml	
Top-dress N	0.99/kg N	12.76/kg N
Fungicide	1325/l (Prothioconazole +Tebuconazole)	

Table 3. Percent early plant establishment, maize densities at the 9th leaf stage (V9), weed densities at the V14 stage, yield, grain N content and revenue of maize in 2015 in 2016 under conventional and organic cropping systems at recommended and high input management in central NY.

	YEAR		
TREATMENT	**2015**	**2016**	**Mean**
	% plant establishment (of seeding rate)		
CONVENTIONAL			
Recommended	97 a+	81 a	89 a
High Input	97 a	80 a	89 a
ORGANIC			
Recommended	85 c	80 a	83 c
High Input	93 b	79 a	86 b
	Maize densities-V9 stage (plants/ha)		
CONVENTIONAL			
Recommended	72,608 b	56,566 c	64,587 c
High Input	86,635 a	65,606 a	76,121 a
ORGANIC			
Recommended	62,784 c	51,472 d	57,128 d
High Input	80,882 ab	60,623 b	70,753 b
	Weed densities-V14 stage (weeds/m^2)		
CONVENTIONAL			
Recommended	0.47 a	0.27 b	0.37 a
High Input	0.39 a	0.18 b	0.29 a
ORGANIC			
Recommended	2.41 b	1.00 a	1.71 c
High Input	2.13 b	0.64 a	1.39 b
	Yield (kg/ha)		

CONVENTIONAL			
Recommended	10,233 a	7,178 a	8,706 a
High Input	10,557 a	7,790 a	9,174 a
ORGANIC			
Recommended	6,923 b	7,054 a	6,989 b
High Input	7,296 b	7,175 a	7,236 b
	Grain N (%)		
CONVENTIONAL			
Recommended	1.32 a	1.56 ab	1.44 a
High Input	1.33 a	1.68 a	1.51 a
ORGANIC			
Recommended	1.06 b	1.51 b	1.29 b
High Input	1.06 b	1.61 a	1.34 b
	Revenue ($/ha)		
CONVENTIONAL			
Recommended	1596 a	1,120 a	1,358 a
High Input	1647 a	1,217 a	1,430 a
ORGANIC			
Recommended	1,080 b	1,100 a	1,090 b
High Input	1,138 b	1,119 a	1,129 b

[+]Treatment interaction means within the same column followed by the same letter are not significantly different according to Fisher's protected LSD at the 0.05 level.

Table 4. Percent early plant establishment, harvest plant densities, weed densities at the full pod stage (R4), seed yield, and revenue of soybean in 2015 and 2016 under conventional and organic cropping systems at recommended and high input management in central NY.

	YEAR		
TREATMENT	**2015**	**2016**	**Mean**
	% plant establishment (of seeding rate)		
CONVENTIONAL			
Recommended	84 b	90 a	87 b
High Input	92 a	89 a	91 a
ORGANIC			
Recommended	86 b	70 c	78 c
High Input	92 a	78 b	85 b
	Soybean harvest densities (plants/ha)		
CONVENTIONAL			
Recommended	307,967 c	318,167 c	313,067 c
High Input	417,912 a	442,750 a	429,971 a
ORGANIC			
Recommended	338,083 b	284,667 d	311,375 c
High Input	419,258 a	383,250 b	401,254 b
	Weed densities-R4 stage (weeds/m^2)		
CONVENTIONAL			
Recommended	0.24 a	0.44 a	0.34 b
High Input	0.11 a	0.27 a	0.19 b
ORGANIC			
Recommended	0.40 a	0.77 b	0.58 a
High Input	0.61 a	0.60 ab	0.60 a
	Yield (kg/ha)		

CONVENTIONAL			
Recommended	3,007 b	2,735 a	2,871 a
High Input	3,268 a	2,831 a	3,050 a
ORGANIC			
Recommended	2,879 b	2,676 a	2,778 a
High Input	2,979 b	2,655 a	2,817 a
	Revenue ($/ha)		
CONVENTIONAL			
Recommended	1022 b	930 a	976 a
High Input	1,111 a	963 a	1,037 a
ORGANIC			
Recommended	979 b	910 a	944 a
High Input	1013 b	903 a	958 a

$^{+}$Treatment means within the same column followed by the same letter are not significantly different according to Fisher's protected LSD at the 0.05 level

Table 5. Percent stand (early plant establishment), spikes/m2 at harvest, weed densities in the early spring, grain yield, grain N%, and revenue of wheat in 2015-2016 under conventional and organic cropping systems at recommended and high input management in central NY.

WHEAT-2016			
TREATMENT	**% stand**	**Spikes/m²**	**Weeds/m²**
CONVENTIONAL			
Recommended	88 b	500 a	0.46 a
High Input	78 c	509 a	0.01 b
ORGANIC			
Recommended	98 a	503 a	0.05 b
High Input	99 a	563 b	0.04 b
	Yield (kg/ha)	**Grain N (%)**	**Revenue ($/ha)**
CONVENTIONAL			
Recommended	4,314 a	1.95 b	642 a
High Input	3,938 b	2.11 a	586 b
ORGANIC			
Recommended	3,817 b	1.65 c	568 b
High Input	3,828 b	1.66 c	570 b

+Treatment means within the same column followed by the same letter are not significantly different according to Fisher's protected LSD at the 0.05 level

Table 6. Income, selected costs, and partial returns for conventional maize with recommended management (M1) and high input management (M2), and organic maize with recommended management (M3) and high input management (M4) at a Cornell Research Farm in central NY averaged across the 2015 and 2016 growing seasons[1].

	MAIZE TREATMENTS			
Production Value, Income	**M1**	**M2**	**M3**	**M4**
	$ per hectare			
Grain	**1358**	**1430**	**1090**	**1129**
Selected Production Costs[1]				
<u>Variable Inputs</u>				
Fertilizers	194.92	240.51	455.57	992.63
Seeds	301.07	360.84	219.07	262.49
Sprays & Other Crop Inputs	106.53	143.10	79.81	124.25
Labor	1.16	1.16	20.87	20.87
Repairs & Maintenance				
Tractor	0.22	0.22	5.53	5.53
Equipment	0.86	0.86	6.07	6.07
Fuels & Lubricants	0.73	0.73	12.09	12.09
Interest on Operating Capital	13.38	17.54	9.75	28.26
Total Selected Variable Input Costs	**618.37**	**764.96**	**808.76**	**1452.1**
<u>Fixed Inputs</u>				
Tractors	1.60	1.60	32.80	32.80
Equipment	4.47	4.47	30.23	30.23
Land charge	-	-	-	-
Value of management	-	-	-	-

Total Selected Fixed Input Costs	6.07	6.07	63.03	63.03
Total Selected Costs	**624.44**	**771.03**	**871.79**	**1515.2**
Partial Returns	**735**	**659**	**218**	**-387**

[1]This reporting of costs focused on those costs that differed among the four maize treatments. The land charge, and value of management input did not differ among treatments, so items are blank. Likewise, grain moistures did not differ among treatments so drying costs are not included. Seed costs differed among treatments due to price per unit differences between non-GMO and GMO hybrids, and seeding rate differences for recommended versus high input management. 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 C2, and those attributed to weeding tasks for C3 and C4. 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. Costs for M3 and M4 were much higher in 2015 compared with 2016 because the use of composted chicken manure as an N source in 2015 vs. red clover in 2016.

Table 7. Estimated partial returns of maize, soybean and wheat in conventional and organic cropping systems with recommended and high input management in 2015 (maize and soybean) and 2016 (all three crops) in central NY.

	CROP		
TREATMENT	**MAIZE**	**SOYBEAN**	**WHEAT**
	2015 Estimated partial returns ($/ha)		
CONVENTIONAL			
Recommended	923 a[+]	702 a	-
High Input	846 a	656 a	-
ORGANIC			
Recommended	-171 b	614 a	-
High Input	-562 c	614 a	-
	2016 Estimated partial returns ($/ha)		
CONVENTIONAL			
Recommended	545 a	723 a	301 a
High Input	477 b	599 a	23 b
ORGANIC			
Recommended	604 a	636 a	-189 c
High Input	-215 c	588 a	-589 d

[+]Treatment means within the same column followed by the same letter are not significantly different according to Fisher's protected LSD at the 0.05 level

Table 8. Income, selected costs, and partial returns for conventional soybean with recommended management (S1) and high input management (S2); and organic soybean with recommended management (S3) and high input management (S4) at a Research Farm in central NY averaged across the 2015 and 2016 growing seasons[1].

	SOYBEAN TREATMENTS			
Production Value, Income	**S1**	**S2**	**S3**	**S4**
	$ per hectare			
Seed	**976**	**1037**	**944**	**958**
Selected Production Costs[1]				
Variable Inputs				
Fertilizers	-	-	-	-
Seeds	216.94	289.25	134.90	179.88
Sprays & Other Crop Inputs	31.74	77.86	9.95	33.90
Labor	1.09	2.71	25.45	25.45
Repairs & Maintenance				
Tractor	0.22	0.45	6.08	6.08
Equipment	0.81	1.79	8.39	8.39
Fuels & Lubricants	0.75	1.52	17.69	17.69
Interest on Operating Capital	6.27	9.32	5.05	6.78
Total Selected Variable Input Costs	**257.82**	**382.90**	**207.51**	**278.13**
Fixed Inputs				
Tractors	1.58	3.18	35.40	35.40
Equipment	4.33	8.67	34.31	34.31
Land charge	-	-	-	-
Value of management	-	-	-	-

Total Selected Fixed Input Costs	5.91	11.85	69.71	69.71
Total Selected Costs	**263.73**	**394.75**	**277.22**	**347.84**
Partial Returns	**712**	**642**	**667**	**613**

[1]See Table 6 for an explanation of selected production costs.

Table 9. Income, selected costs, and partial returns for conventional wheat with recommended management (W1) and high input management (W2), and organic wheat with recommended management (W3) and high input management (W4) at a Research Farm in central NY in 2015-2016[1].

	WHEAT TREATMENTS			
Production Value, Income	**W1**	**W2**	**W3**	**W4**
	$ per hectare			
Grain	**642**	**586**	**568**	**570**
Selected Production Costs[1]				
Variable Inputs				
Fertilizers	165.49	198.84	601.15	891.61
Seeds	125.52	200.84	97.17	155.49
Sprays & Other Crop Inputs	41.74	131.03	40.01	82.25
Labor	0	2.42	0	0
Repairs & Maintenance				
Tractor	0	0.45	0	0
Equipment	0	0.88	0	0
Fuels & Lubricants	0	1.36	0	0
Interest on Operating Capital	8.35	13.41	18.45	28.26
Total Selected Variable Input Costs	341.08	550.24	756.78	1157.60
Fixed Inputs				
Tractors	0	3.29	0	0
Equipment	0	9.19	0	0
Land charge	-	-	-	-
Value of management	-	-	-	-
Total Selected Fixed Input Costs	0	12.47	0	0

Total Selected Costs	**341.08**	**562.72**	**756.78**	**1157.60**
Partial Returns	**301**	**23**	**-189**	**-588**

[1]See Table 6 for an explanation of selected production costs.

Table 10. Estimated partial returns of three rotations (red clover-maize, maize-soybean, and soybean-wheat) during the transition period (2015 and 2016) in conventional and organic cropping systems with recommended and high input management in central New York.

	SEQUENCE DURING TRANISTION		
TREATMENT	**CLOVER-MAIZE**	**MAIZE-SOYBEAN**	**SOYBEAN-WHEAT**
	Total Costs ($/ha)		
CONVENTIONAL			
Recommended	741⁺	958⁺	604
High Input	909	1211	956
ORGANIC			
Recommended	666	1556	1035
High Input	1503	2077	1505
	Total Revenue ($/ha)		
CONVENTIONAL			
Recommended	1120 a	2526 a	1664 a
High Input	1215 a	2610 a	1697 a
ORGANIC			
Recommended	1100 a	1990 b	1547 a
High Input	1119 a	2041 b	1583 a
	Total Partial Returns ($/ha)		
CONVENTIONAL			
Recommended	379 a	1568 a	1060 a
High Input	306 b	1399 a	741 b
ORGANIC			
Recommended	434 a	434 b	512 c
High Input	-384 c	-36 c	78 d

[1]Maize costs in 2015 are much greater than costs in 2016 because of the use of composted chicken manure as the main N source in 2015 vs. red clover in 2016.