

# **A Profile of Organic Corn Production in the Midwest and Northeast**

## **PART II: Economics of Organic Corn Production**



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Both of these reports are available online

PART I: Farm Characteristics, Production Practices, and Soil Management Strategies  
[go.osu.edu/orgcorn\\_report1](http://go.osu.edu/orgcorn_report1)

PART II: Economics of Organic Corn Production  
[go.osu.edu/orgcorn\\_report2](http://go.osu.edu/orgcorn_report2)

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## I. Introduction

Organic farming has become an increasingly important component of the U.S. agricultural landscape. Consumer demand for organic food has steadily grown by double-digits annually for several decades (Greene 2017), with over \$50 billion in sales in 2018 (Organic Trade Association, 2019). Driven largely by demand from organic livestock producers, particularly dairies (McBride et al. 2015), acres of organic corn production in the US increased over 55% in five years, from 168,900 acres in 2011 to 261,008 acres in 2016. States in the Midwestern Corn Belt and Northeast region have been important to this expansion (USDA-NASS 2017; McBride et al. 2015), including the four states included in this study: Indiana, Michigan, Ohio, and Pennsylvania<sup>1</sup>.

However, organic field crops remain a small fraction of overall US production (Greene and Vilorio 2018), comprising less than one percent of overall acreage in 2011 (McBride et al. 2015). Thus, the overall supply of organic food has not kept up with the demand (Oberholtzer et al. 2013), leading to 10 million dollars of organic grain imports in 2016, which could provide an economic opportunity for domestic farmers (Greene and Vilorio 2018). As long as there are price premiums paid for organic products in the marketplace, organic agriculture is likely to be economically competitive or even more profitable than conventional farming (Crowder and Reganold 2015).

While organic farming is growing rapidly, there is little published detailed information about the farming practices used by organic farmers, particularly those who raise grain crops. Until recently, only minimal national and state dollars were allocated to organic research (Niggli 2008) and marketing support (Driscoll and Ichikawa 2017). A growing number of recent studies have explored practices used by working organic farms (McBride and Greene 2009; Nordquist et al. 2011). McBride et al. (2015) used USDA ARMS data to show that organic field crop farms in the US tend to operate smaller acreages and were more likely to use mechanical practices for preparing the soil and for weed control compared to conventional farmers. Organic grain producers also had more diverse crop rotations that integrated small grains and hay crops compared to conventional producers who more frequently had a continuous grain rotation (McBride et al. 2015).

This study was conducted to address some of the gaps in knowledge of certified organic corn production practices. We implemented a survey of certified organic corn growers in four states (IN, MI, OH, and PA) in the spring of 2018. Much of the organic grain as well as conventional grain is produced in Midwestern states (Kuo and Peters 2017). The four states included in this study collectively represented one-third of all US organic corn growers in 2016 and raised over 20% of the nation's organic corn (USDA-NASS 2017). Over 850 farmers responded to the survey (a 57% response rate). The goal was to gather reliable data to describe the types of farms who raise organic corn in the region, to characterize the diverse soil

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<sup>1</sup> According to the most recent USDA Certified Organic Survey, all four of these states ranked among the top ten for corn silage acreage and yields in 2016, and among the top 12 states for grain corn acreage and yields. Combined, Ohio, Pennsylvania, Michigan, and Indiana accounted for 31% of the U.S. farms growing certified organic corn for grain or seed in 2016 and 41% of the farms growing organic corn for silage (USDA-NASS 2017).

management practices they use on their corn fields, and to assess the overall economic performance of organic corn enterprises and differences associated with the use of different production practices.

This report (Part II of a set) focuses on the economics of organic corn production. It is a companion to Part I, which provides an overview of farm characteristics, management practices, and soil management strategies ([See Brock et al., 2019](#)).

The survey was conducted as part of a broader USDA Organic Research and Education Initiative (OREI)<sup>2</sup>. This larger study included on-station and on-farm experimental trials designed to evaluate the performance of ‘soil balancing’ among organic growers in the region. Soil balancing is a widely used (but little studied) practice designed to adjust the ratio of base cations in the soil to improve soil and crop outcomes. Combined with the survey results presented in this report, this project sought to increase our understanding of the use and performance of a range of soil management strategies, particularly soil balancing, in the organic farming community in this region. More about this research and other reports can be found at <http://go.osu.edu/orgcorn>.

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<sup>2</sup> Doohan, D. OREI Proposal Number 2014-05408, Practiced by farmers but untested by scientists: uniting both in participatory research and education to explain the effects of soil balancing. Ohio State University

## II. Methods

We conducted a survey of organic corn growers in Ohio (OH), Indiana (IN), Michigan (MI), and Pennsylvania (PA) during the early spring of 2018. The survey was designed to gather descriptive information about the organic corn industry in this region, with particular attention to how organic farmers manage their soils. We were also interested in evaluating the impact of different management practices on corn yields and the profitability of corn enterprises. The survey contained detailed questions about the overall farm operation, management practices used on a representative cornfield, economic data (yield, prices, and expenditures on their cornfield in 2017), and information about farmers' soil management strategies and decision-making.

The survey was conducted using a modified Dillman method where multiple contacts are used to improve response rates (Dillman et al. 2014). In this study, an introductory letter explaining the purpose of the study was sent in late January, followed by a copy of the survey with a prepaid return envelope a week later. Farmers then received a reminder postcard about two weeks after the arrival of the first copy of the survey. Producers who had valid addresses and who did not respond to the first survey received a second copy of the survey two weeks after the first reminder postcard. Three weeks after the producers received a second copy of the survey, they received another reminder postcard. A third and final copy of the survey was sent to all non-respondents in early April.

To boost awareness and response rates, we contacted several organic certification agencies such as Ohio Ecological Food and Farming Association, Nature's International, Quality Certification Services (QCS info), Global Organic Alliance, and Midwest Organic Services Alliance (MOSA) who helped promote this survey among their clientele.

### A. Response Rates:

Response rates are summarized by state and overall in Table 1. The survey was sent to all farmers on the 2016 version of the USDA Organic Integrity Database who were certified to grow organic corn in the states of IN, MI, OH, and PA (USDA [Integrity database](#)). Of the 1,662 farms included in the original sample, 167 were disqualified because they did not grow corn in 2017 (129), had undeliverable addresses (36), or were no longer farm operators (2). This produced an adjusted sample size of 1,495 farms.

We received useable responses from 859 farms--an overall response rate of 57.4%. Response rates in each state ranged from 47.2% Michigan to 66% in Indiana. The margin of error for estimates of population characteristics across the entire 4-state region was plus or minus 1.7%, with slightly wider margins for individual state-level estimates (Dillman et 2014).

**Table 1: Response Rate Information by State and Overall**

	IN	MI	OH	PA	Overall
Original sample frame	349	330	477	506	1662
Disqualified	26	40	47	54	167
Adj sample size	323	290	430	452	1495
Responded	214	137	267	238	858
Percent of Respondents	24.9%	16.0%	31.1%	27.7%	100.0%
Response Rate	66.3%	47.2%	62.1%	52.7%	57.4%
DQ rate	7.4%	12.1%	9.9%	10.7%	10.0%
Accuracy (+ / - %)	3.2%	4.2%	2.9%	3.2%	1.7%

**B. Data cleaning and quality control**

As is common in mail surveys, a small minority of respondents provided answers that were either missing information to some questions or provided information that appeared to be outside the range of reasonable values. Over 75 percent of questions had nearly complete data (<5% missing); another 10 percent had 5-10% missing. A handful of variables had more systemic missing data problems, and results from those items are not included in this report due to the unreliability of the results. In the tables and figures presented in this paper, we generally report the percent of respondents who provided valid values (excluding those whose answers were missing).

**C. Economic Data Collected for Specific Corn Field**

In order to capture systematic information about the production practices used by organic corn growers, all of the economic questions in the survey asked farmers to report income and expenses associated with management of a particular field on which corn was grown in 2017.

On average, these fields were of 13 acres in size (with a median of 8 acres). Most corn fields reported in the survey (80%) were between 3 and 20 acres. For more detailed information on the total acreage of organic corn crop in their farms, refer to Part I of this report ([Brock et al. 2019](#)). If the farmers had reported the costs and revenues for the entire field, we modified the values to reflect the costs and returns for one acre of organic corn crop. The survey respondents reported harvesting the corn crop as grain (70%) and silage (36%) on these fields.<sup>3</sup> A minority of farmers (6%) reported raising sweet corn, popcorn, seed corn, or corn for purposes such as malting and fermentation.

<sup>3</sup> Because some farmers said they harvested some of the field as grain, and some as silage, the total adds up to more than 100%.

## D. Approach to Economic Analysis

The most recent USDA survey of organic farms suggests that organic corn grown for grain and silage had a market value of \$276 million in 2016 (USDA-NASS 2017). However, detailed information about the costs and returns associated with organic corn production is not systematically collected by the federal government.

To address this gap, a significant section of our farm survey captured information designed to assess the economic performance of organic corn production in this 4-state region. Specifically, we asked farmers to provide information about their corn yields, and prices of organic corn (when sold). We used this information to estimate **total revenue** per acre.

Farmers were also asked to provide details about all soil amendments used on their corn field, and information about the cost of these inputs (if purchased). This information was combined with estimates of the market value of unpurchased inputs to calculate total input expenses per acre on these corn fields. We also estimated the cost of corn seeds (based on assumptions of seeding rates and market values), the economic costs associated with fieldwork (based on numbers of field passes for key farm operations reported by farmers, adjusted for the types of equipment they use), and the economic value of farmland (using USDA average rental rates by county). The costs of inputs, seeds, fieldwork, and farmland were combined to generate an estimate of **total expenses** per acre for the corn enterprise.

By subtracting the total expenses (as above) from the total revenues, we estimated the **net returns to labor and management**. Detailed information about the methods used to estimate economic values for production costs and returns are presented in the [Appendix](#).

Our economic estimates also have several limitations. First, we did not include several categories of economic costs that might be considered in a traditional profitability analysis (e.g., utility and energy expenses, storage and transport costs, interest expenses, and insurance costs). These unmeasured costs usually account for 30% of typical crop enterprise budgets in the United States. Additionally, our results are for a single 2017 cornfield reported by farmers in the survey. Differences in market and weather conditions can affect yields, revenues, and costs in other fields within the farm, over time.

In the sections below, we describe the mean, standard deviation, minimum, and maximum estimates for yields, revenues, expenses, and net returns for the organic corn farmers in our sample. We also look at how differences in net returns can be explained based on how the corn is harvested (grain vs. silage) and by various farm characteristics. A total of 749 farms provided complete and reliable information on key economic variables, and the results in this section focus only on those farms.<sup>4</sup>

We classified the farms to allow for comparison of economic performance. See [Part I of this report](#) for more details on this classification according to the:

- a) primary source of revenues: grain farms, dairy farms, and vegetable farms.
- b) source of draught power: horse-drawn, and tractors.
- c) the operators' age and years of experience growing organic crops.

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<sup>4</sup> Specifically, results for the subset of farms included in the economic analysis might differ slightly from those presented in the companion report (since the number of farms included in Part I is larger).

### III. Results

#### A. Corn Yields

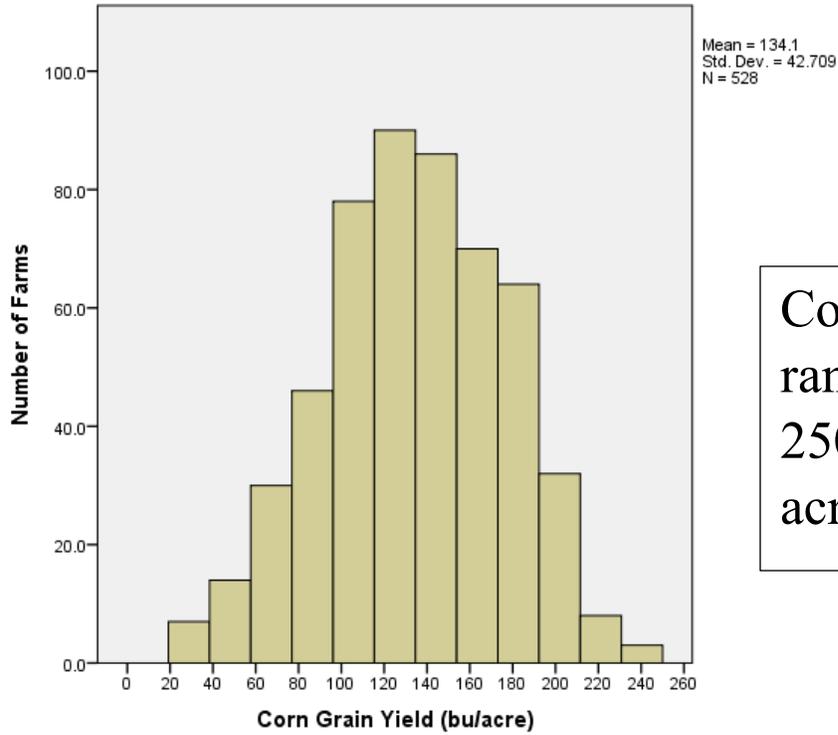
The 526 organic corn farmers in our sample who harvested their corn as grains reported a mean 2017 corn yields of 133.9 bushels per acre, with a standard deviation of 42.6 bushels per acre (Table 2). This yield estimate was higher than the 110 bushels per acre for organic corn grain estimated for this region in the USDA 2016 Organic Survey. Another 223 farms in the study harvested their organic corn as silage, with an average yield of 20.1 tons per acre, and a standard deviation of 6.4 tons per acre. This estimate is also higher compared to USDA estimate of 17.2 tons per acre in 2016 in the same region.

While mean yields help describe the average productivity of our study farms, there was significant variability across our sample of farms. Corn grain yields ranged from 25 to 250 bushels per acre, producing a coefficient of variation (CV)<sup>5</sup> of 32%. Silage yields ranged from 5 to 34 tons per acre (Figure 2), with a CV of 32%. A graphic illustration of the proportion of farms with grain and silage yields in different yield classes is shown in Figures 1 and 2.

**Table 2: Average Yields, Prices, and Total Revenues per acre (n=749)**

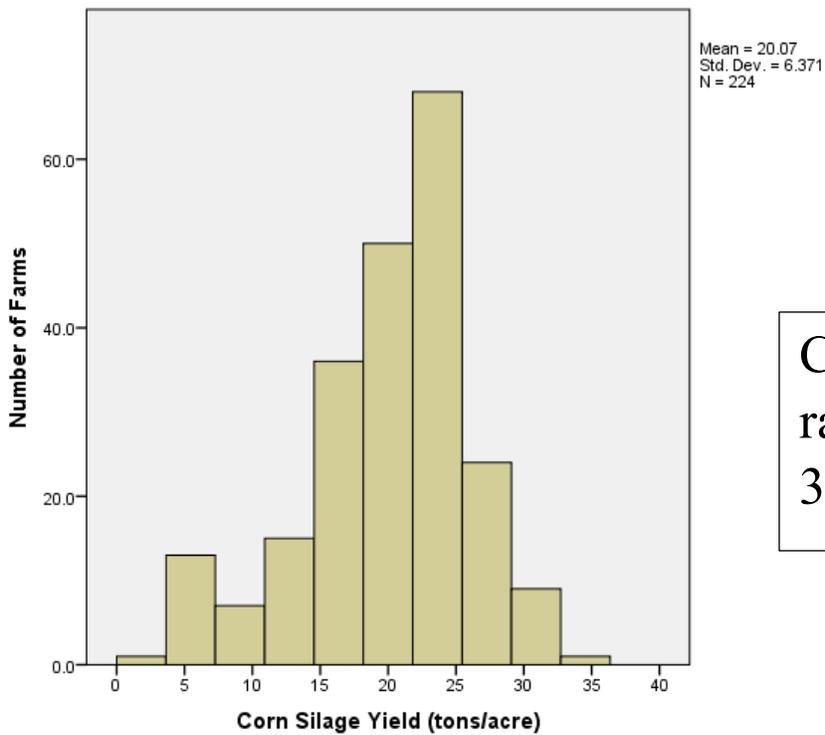
	<u>Corn Grains (n=526)</u>			<u>Corn Silage (n=223)</u>		
	Mean	Standard Deviation	CV <sup>5</sup>	Mean	Standard Deviation	CV <sup>5</sup>
Yield	133.9 bu	42.6 bu	32%	20.1 tons	6.4 tons	32%
Price	\$9.44/bu	\$0.99/bu	10%	\$69.99/ton	1.26/ton	2%
Total Revenues	\$1,266.84	\$422.83	33%	\$1,405.33	\$446.22	32%

<sup>5</sup> Coefficient of variation (CV) is the standard deviation divided by the mean value. The CV shows the lower and upper bounds of the yield (in percentage) range for 'each standard deviation' from the mean value.



Corn grain yields ranged from 25 to 250 bushels per acre.

Figure 1: Number of farms with different levels of corn grain yields (n=526)



Corn silage yields ranged from 5 to 34 tons per acre.

Figure 2: Number of farms with different levels of corn silage yields (n=223)

## **B. Total Economic Value of Corn Crop**

We collected responses on the sales quantity and prices received for their organic corn harvested during 2017. Roughly 36 percent of farms reported corn sales (n=268). By USDA standards, about half of the corn grains and a fifth of the silage would be sold in the markets with the remaining being reserved for on-farm use (USDA-NASS 2017).<sup>6</sup>

For farmers who sold corn, the survey collected information about the prices they received for their grain (n=261) and/or silage (n=6). The average price received for organic corn grain among our study farmers in 2017 was \$9.49 per bushel (with 96% of the reported prices ranging between \$7.50-\$11.50 per bushel). Only a handful of farmers reported silage sales – with an average price of \$69.99 (and a range of \$55-\$80 per ton). The ratio of organic corn silage to grain prices in our sample was 7.4, like the ratios observed in the conventional corn markets of 7.65 (Berger, 2017).

We combined information about yields and prices from individual farms to calculate the economic value of their 2017 corn crop. For the farmers who did not sell organic corn in 2017, we used the survey sample averages for grain and silage sales listed above to estimate the implicit value of their crop.

These prices and the average yields reported above result in estimated average total revenues of \$1,266 and \$1,405 per acre for grain and silage corn, respectively (Table 2). Across our entire sample, average revenue for organic corn was \$1,308, with a minimum of \$105 and a maximum of \$2,640 per acre. Most variation in estimated total revenues stems from variation in yield rather than prices. Because most corn was not actually sold in our sample, our estimates of revenues reflect the economic value that would have been realized had the corn been sold at normal market rates.

## **C. Estimated Corn Production Expenses**

As noted above, the survey captured information about a wide range of soil amendments and fertilizers that were applied to the respondents' organic corn field in 2017. These included volumes (and prices if purchased) for manure, compost, NPK fertilizers and products, calcium amendments, micronutrients, microbial stimulants, and inoculants, etc. When farmers reported the prices paid for these amendments and fertilizers on the survey, we used this value in estimating their corn input expenses. When a price was not given (or when the products were provided by the farm – e.g., manure), we combined information about the volume applied with prices estimated from sample data and publicly available market information from internet searches to estimate the economic costs associated with each product applied to their organic corn field (see [Appendix](#) for details about input cost assumptions).

The mean estimated expenditures on different categories of soil amendments among our sample farms is shown in Table 3. It is worth noting that average cost estimates for each category of input reported in the table include many farmers that did not apply those inputs. The second and third columns in Table 3 provide information about the proportion of organic farms that used each input category and shows the average expenditure for that input for those who actually applied it to their fields.

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<sup>6</sup> In our sample, roughly 36 percent of farms reported selling corn at the time of the survey (n=268). It is possible that farmers sold corn from their 2017 harvest after the survey data was gathered in Feb-Apr 2018.

**Table 3: Mean expenditures on various soil amendments, overall and by harvest approach**

Characteristic	TOTAL SAMPLE			Method of Harvest	
				Grain	Silage
	Average expense for all respondents	Farms who reported expense	Average expenditure for those who apply	Average	
<b>Expenditures on Soil Amendments (\$/acre)</b>					
Manure & Compost	\$ 78.92	94.3%	\$ 83.61	\$ 81.38	\$ 73.13
NPK fertilizers	\$ 26.71	31.8%	\$ 83.71	\$ 26.71	\$ 26.71
Calcium products	\$ 14.13	27.3%	\$ 51.61	\$ 13.55	\$ 15.49
Micronutrients	\$ 8.75	20.5%	\$ 42.57	\$ 6.81	\$ 13.34**
Microbial products	\$ 4.28	18.2%	\$ 23.40	\$ 4.03	\$ 4.86
Fish products and Foliar Applications	\$ 5.88	15.3%	\$ 38.49	\$ 5.74	\$ 6.23
Other expenses	\$ 10.83	9.9%	\$ 109.62	\$ 11.60	\$ 9.02
<b>Total Combined Soil Amendment Expenses</b>	<b>\$ 149.51</b>	<b>100.0%</b>	<b>\$ 149.51</b>	<b>\$ 149.82</b>	<b>\$ 148.78</b>

\*\* Statistically different (at 1% significance level) between corn grain and corn silage harvests

The total average amount spent on all soil amendments and fertilizers on organic corn fields in 2017 was \$149.51 per acre. The amount spent on these inputs by farmers harvesting corn as grain or silage were very similar (except for micronutrients – where farmers spent more if they were raising silage). Results suggest that most farmers (94%) applied manure and/or compost on their corn fields and that the economic value of manure and compost was the largest single input expense for corn production in 2017 (\$84 per acre). Among farms with livestock, it was unusual for them to purchase manure for their corn fields. However, among farms without livestock, organic corn growers frequently purchased manure (particularly chicken litter) and/or received manure from neighboring farms with excess manure.

NPK fertilizers and producers were the second highest category for average input expenses.<sup>7</sup> Among the 32% of farmers who applied NPK fertilizer products, the economic cost of those inputs was similar to that spent on manure and compost (\$84 per acre). However, because a smaller fraction of farms used these fertilizers, the overall average spent on NPK fertilizers across our entire sample was lower (\$27 per acre). Between 15 and 27 percent of organic corn growers used calcium products, micronutrients, microbial products and/or fish products/foliar applications on their corn fields in 2017. For those who used these products, they spent between \$23 and \$52 per acre (see Table 3). When these costs are averaged across all organic farms in our study, the amount spent ranged from \$4 to \$14 per acre.

<sup>7</sup> NPK fertilizers include forms of elemental or mineral N, P, or K that are permitted for use in USDA certified organic farms, many of which are sold as blended fertilizer products. It does not include manure, which is counted above.

## D. Seeds, Land Rents, and Fieldwork Expenses

In addition to the economic cost of soil amendments and fertilizer applications, we estimated the value of three other major categories of corn production expenses for each of our study farms. First, we sought to value the land used for corn production. Because most farms owned the land they operated, we used county-level estimates of cropland rental rates from the USDA to estimate the economic costs that each farm would have had to spend if they were paying for the use of their cropland.

Second, we estimated the economic cost of fieldwork involved in organic corn production. In the survey, we asked detailed questions about the number of passes each farmer made on their organic corn field for tillage, planting, cultivation, and harvest activities. We also asked for details about the machinery and equipment they used to carry out these fieldwork activities. Fieldwork expenses reflect the economic value of fuel, labor, and depreciation associated with each type of activity. Conceptually, it is also similar to the value of hiring the work to be done by a custom operator. An estimate of average economic cost per acre of each “pass” across the field was derived from publicly available sources that account for whether or not the farmer is using tractor or horse-drawn equipment. Details can be seen in the [Appendix](#).

**Table 4: Machinery used for fieldwork.**

Type of Machinery Use	Horse-Drawn		Tractor-Powered	
	Average Number of Passes (per acre)	Average cost* (\$ per pass)	Average Number of Passes (per acre)	Average cost* (\$ per pass)
Application of soil amendments	1.38	\$ 7.52	1.41	\$ 7.92
Tillage	3.25	\$ 10.61	3.13	\$ 16.53
Application of bio-pesticides or other products to plants	0.45	\$ 4.30	0.31	\$ 6.32
Planting	1.07	\$ 5.65	1.07	\$ 16.73
Cultivation	2.4	\$ 5.49	2.56	\$ 6.85
Harvesting (grains)	1.2	\$ 14.98	1.04	\$ 39.17
Others	0.14	\$ 6.31	0.29	\$ 9.40

\* average estimated cost

Average farm machinery cost estimates were:

- \$133 per acre for tractor powered farms--similar to estimates by McBride et al. (2015) who calculated the capital<sup>8</sup> and fuel related expenses of organic corn production to be \$135 per acre.
- \$71 per acre for horse drawn equipment (HDE) farms; horse drawn equipment costs were estimated to be 20-60% cheaper than tractor equipment depending on the type of operation.

<sup>8</sup> Also includes the expenses associated with buildings, storage silos, and other overheads.

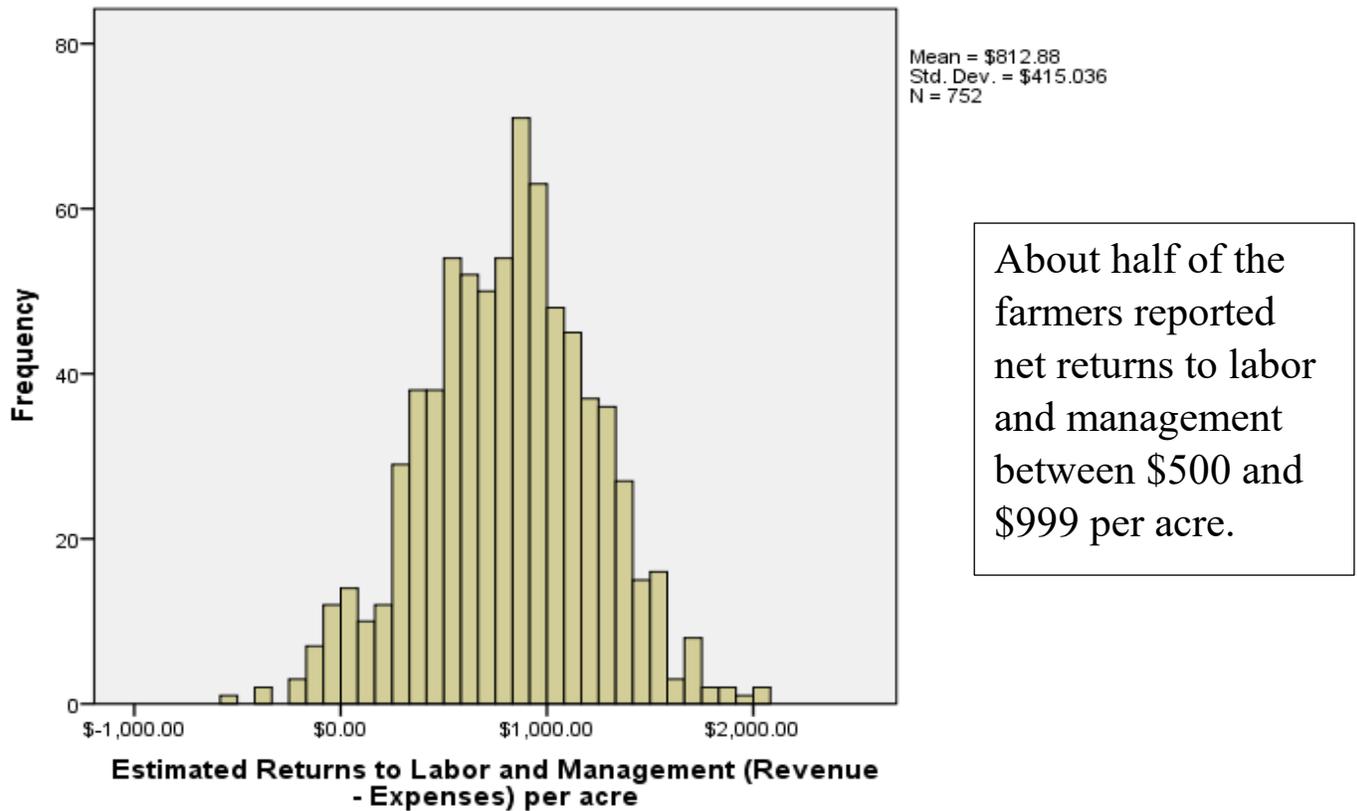
There is a slight positive, significant correlation (0.18) between fertilizer and farm machinery expenses. The farmers who spend more on fertilizers and soil amendments are also more likely to increase their machinery use.

Third, we estimated the cost of seeds for planting organic corn. Seeding costs per acre were calculated based on an estimated planting density (which we varied based on relative yield) and market rates for organic corn seeds obtained from public sources. See [Appendix](#) for more details.

The estimated average economic costs associated with all four major categories of expenses, as well as a calculated value for total corn production expenses, are shown in Table 5. Total economic costs of organic corn production among farmers in our sample averaged nearly \$500 per acre in 2017. The land rent and fertilizers/soil amendments are the largest expenditure categories, roughly \$150 per acre each (collectively comprising roughly 60% of the total). Fieldwork and seeding costs were each less than \$100 per acre on average. While the estimated cost of field work was lower for silage corn, the estimated cost of seeds was higher, and no significant difference in production costs between corn harvested as grain or silage was found in our sample. Our estimates were found comparable to the existing cost estimates in the literature (McBride et al. 2015 and USDA-NASS 2015).

### E. Net Returns to Labor and Management

We combined our estimates of economic costs and returns for organic corn fields to calculate a net return to labor and management.<sup>9</sup> Results are shown on Table 5 below. On average, we found that organic corn farms received an average net return of \$811 per acre (income of \$1,307 minus expenses of \$496). We did observe significant variation in net returns per acre across the farms in our study (Table 5 and Figure 3). About half (46%) had net returns per acre between \$500 and \$999 in 2017. A small group (8%) had returns of less than \$250 per acre, and 5% reported net returns of over \$1,500 per acre. Although expenses were similar for corn harvested as grain vs. silage, we estimated greater revenue (and thus higher net returns) for silage production in 2017.<sup>10</sup>



**Figure 3: Distribution of farms, by returns to labor and management in organic corn enterprises.**

<sup>9</sup> Remember that the costs included in these estimates did not include charges for some common production activities (such as heating and drying, transportation, insurance, financing, etc.).

<sup>10</sup> The economic advantage of silage is dependent on our assumption that organic corn silage was worth roughly \$70/ton. Because we had only a small handful of sample points to use to estimate the market value of organic silage, it is possible that we are overestimating the relative economic performance of silage corn. For example, if we assumed silage was worth \$60/ton, the net returns to silage would be less than those for grain.

**Table 5: Average Corn Production Expenses, Total Revenue, and Net Returns per acre, Overall and by Method of Harvest**

Characteristic	All Farms		Method of Harvest	
			Grain	Silage
	average	median	\$/acre	
			Average	
Expenditures on soil amendments	149.51	124.70	149.82	148.78
Estimated cost/value of fieldwork	94.71	85.26	99.33	83.82***
Estimated cost of seeds	98.31	106.67	95.96	103.85***
Estimated cost/value of land (rent)	153.60	145.00	151.62	158.28
<b>TOTAL EXPENSES</b>	496.13	468.14	496.73	494.73
<b>TOTAL REVENUE</b>	1,307.61	1,362.28	1266.84	1403.78***
<b>NET RETURNS TO LABOR &amp; MGT</b>	811.48	833.21	770.11	909.06***

Percent of Farms by Net Returns/Acre

Net loss (< \$0)	3%	2.7%	4.9%
\$0-\$249/acre	5%	5.3%	3.6%
\$250-\$499/acre	14%	16.2%	9.0%
\$500-\$999/acre	46%	48.1%	40.4%
\$1000-\$1499/acre	28%	24.1%	35.4%
\$1500 or more/acre	5%	3.6%	6.7%

Note: \*\*\* = statistically significant difference between grain and silage farms at the p<0.001 level.

## F. Differences in Economic Performance By Farm Experience and Farm Type

Because net returns varied widely across our sample, we used attributes of farmers and farms to explain differences in economic performance. Initially, we compared the economic costs, revenues, and net returns of organic corn growers with different levels of experience (Figure 4). Overall, it seems that years of experience are associated with higher net returns.

Next, we used the survey data to explore differences in economic costs, revenues, and net returns by farm type (Table 6). Descriptions of farm types are included in [Brock et al. 2019](#). In general, livestock farmers earned more than non-livestock farmers, and dairy farmers seemed to place higher value on their organic corn crop compared to vegetables or grain farms. These differences were primarily driven by higher corn yields and net revenues for farms with livestock and/or dairy cows. Livestock and dairy farms reported spending less on fieldwork operations, but more on seeds, resulting in no statistically significant differences in total expenses.

Farmers who used horse-drawn equipment (HDE) were estimated to have lower estimated fieldwork costs due to lower costs associated with horses than tractors; they also reported lower total estimated economic costs per acre than farmers who used tractors. HDE farmers reported higher yields and revenues per acre. Lower expenses combined with higher revenues led to an estimated greater net returns to labor and management on HDE farms compared to tractor farms.

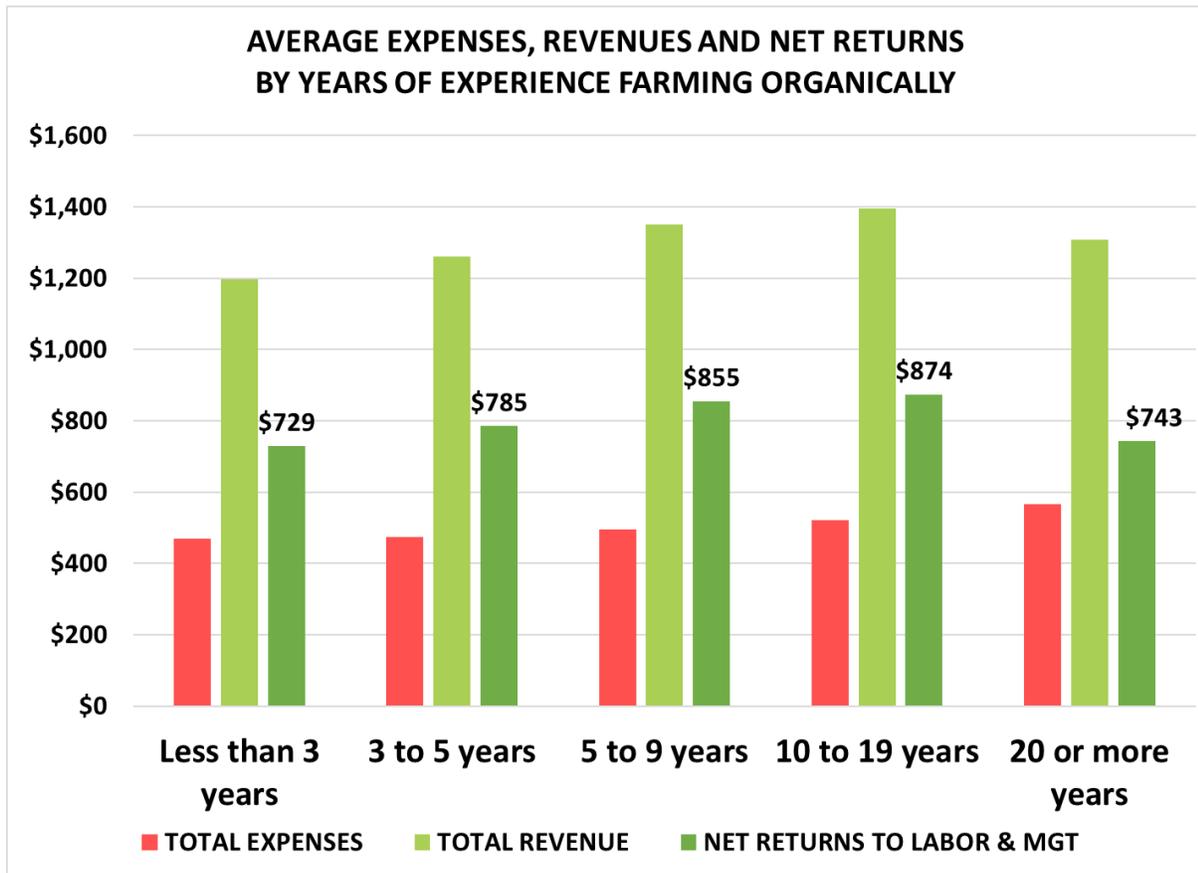


Figure 4: Economic Performance by Years of Organic Farming Experience

**Table 6: Revenues, Expenses, and Net Returns (by farm type)**

Characteristic	Presence of Livestock		By Dominant Farm Enterprise			Type of Equipment				
	Yes	No	Cash Grain	Vegetable	Dairy	Horses	Tractors			
	average dollars per acre									
<b>TOTAL REVENUE</b>	<b>1,346</b>	<b>1,166</b>	<b>***</b>	<b>1,202</b>	<b>1,172</b>	<b>1,398</b>	<b>***</b>	<b>1,349</b>	<b>1,242</b>	<b>***</b>
Soil Amendment Expenses										
Manure & Compost	77	85		85	76	74		71	91	***
NPK fertilizers	27	27		26	33	27		24	31	
Calcium products	14	13		15	14	15		14	14	
Micronutrients	10	6		4	8	11	*	10	6	
Microbiologicals	4	5		5	12	4		4	5	
Fish/Foliar Applications	6	5		6	7	6		5	7	
Other expenses	11	9		14	12	9		12	9	
Total Soil Amendment Expenses (combined)	149	150		155	162	145		141	163	**
Estimated cost/value of fieldwork	91	107	***	112	92	84	***	71	133	***
Estimated cost of seeds	100	93	***	94	91	103	***	100	96	***
Estimated cost/value of land (rent)	152	159		155	145	155		157	148	
<b>TOTAL EXPENSES</b>	<b>492</b>	<b>509</b>		<b>516</b>	<b>489</b>	<b>486</b>		<b>469</b>	<b>540</b>	<b>***</b>
<b>NET RETURNS TO LABOR &amp; MGT</b>	<b>854</b>	<b>657</b>	<b>***</b>	<b>686</b>	<b>683</b>	<b>912</b>	<b>***</b>	<b>880</b>	<b>702</b>	<b>***</b>

Note: statistically significant differences across subgroups using ANOVA chi-squared test denoted by \*\*\* = p<0.001; \*\* = p<0.01; and \* = p<0.05

## G. State Level Differences

Finally, we explored whether the profitability of organic corn production differed across the four states that comprised our study region. Table 7 presents the average revenues, expenses, and net returns for organic corn production by state.

Results show that corn yields varied across the four states, ranging from 124 to 152 bushels per acre for corn grain and 17 to 21 tons per acre for corn silage. Pennsylvania farmers reported higher yields which resulted in higher total revenues of \$1,486 per acre; Michigan farmers reported lower yields and total revenues of only \$1,166 per acre.

**Table 7: Mean revenues and expenses of organic corn production per acre.**

Input	All Four States	Indiana	Michigan	Ohio	Pennsylvania
Corn Grain Yield (bu)*	134.2	130.2	124.4	131.8	151.5
Corn Silage Yield (tons)*	20.1	19.2	17.0	20.2	21.1
<b>Total Revenues</b>	<b>\$1,309.71</b>	<b>\$1,242.18</b>	<b>\$1,165.81</b>	<b>\$1,283.23</b>	<b>\$1,485.68</b>
Manure and compost	\$78.92	\$66.17	\$95.43	\$80.31	\$79.75
NPK fertilizers	\$26.71	\$32.96	\$26.01	\$26.08	\$21.41
Calcium amendments	\$14.13	\$9.03	\$6.38	\$19.76	\$17.37
Micronutrients	\$8.75	\$8.14	\$3.44	\$4.43	\$17.03
Microbial supplements	\$4.28	\$3.95	\$1.70	\$6.41	\$3.83
Fish and foliar supplements	\$5.88	\$4.02	\$4.52	\$5.93	\$8.23
Other nutrients and soil amendments	\$10.83	\$16.16	\$5.02	\$9.41	\$10.75
Soil Amendments Combined	\$149.51	\$140.42	\$142.50	\$152.33	\$158.36
Fieldwork Expenses	\$94.70	\$75.87	\$109.72	\$98.71	\$99.14
Seeding Costs	\$98.35	\$99.69	\$93.00	\$97.74	\$100.91
Land Rents	\$153.36	\$161.01	\$138.51	\$137.24	\$172.16
<b>Total Expenses</b>	<b>\$495.71</b>	<b>\$476.98</b>	<b>\$483.74</b>	<b>\$486.02</b>	<b>\$530.57</b>
<b>Net Returns to Labor &amp; Management</b>	<b>\$814.00</b>	<b>\$765.19</b>	<b>\$682.07</b>	<b>\$797.20</b>	<b>\$955.11</b>
Number of Respondents	750	195	123	223	209

\* The standard deviation (SD) of yield estimates were 42.5 bushels per acre for corn grains and 6.4 tons per acre for silage for the entire sample; the SD values indicate that the individual farm yields could be very different from the estimates provided in the above table.

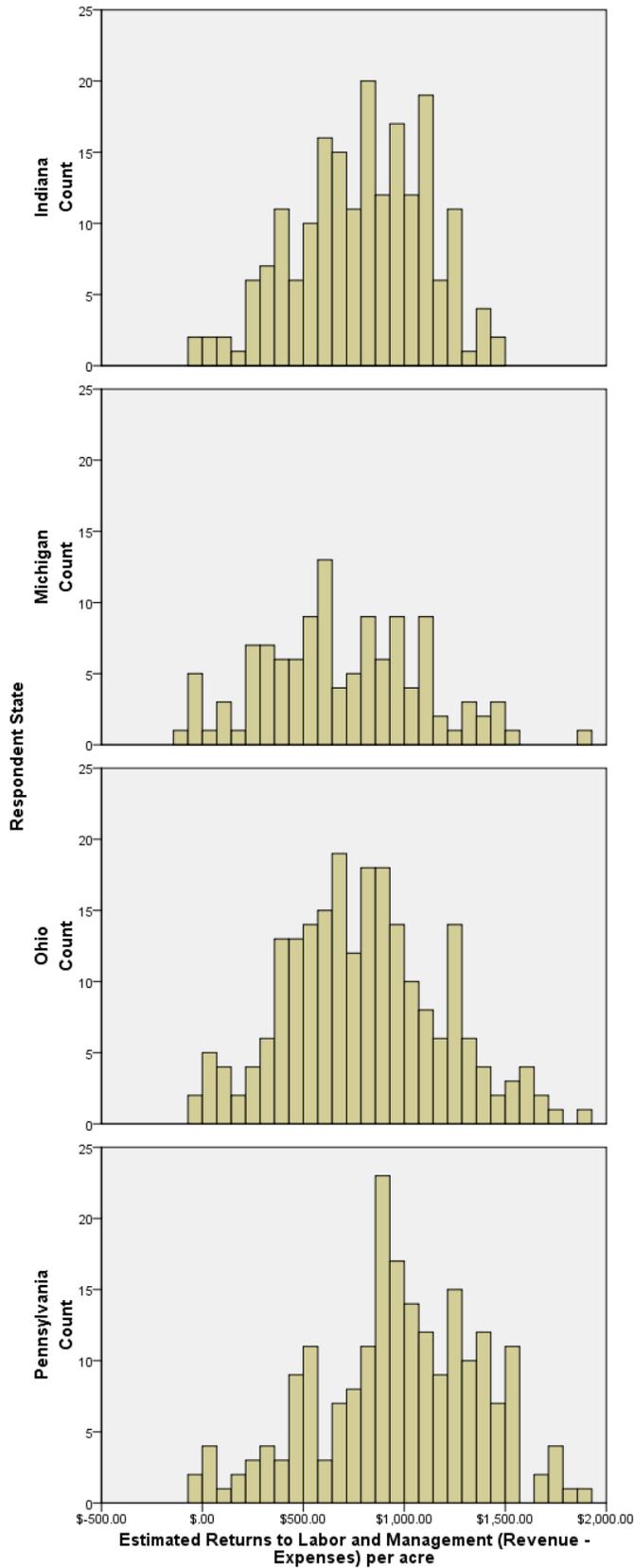
The cost of fertilizer nutrients and soil amendment inputs ranged from \$140 per acre in Indiana to \$158 per acre in Pennsylvania. The machinery use expenses ranged from \$76 per acre in Indiana to \$110 per acre for Michigan farmers. The lower machinery costs in Indiana and Pennsylvania were primarily due to the larger proportion of horse-drawn equipment among the Amish farmers. The average land rents ranged from \$137 per acre in Ohio to \$172 per acre in Pennsylvania. Overall, the total economic corn production costs estimated for the four states ranged from \$477 per acre in Indiana to \$531 per acre in Pennsylvania. The cost components were statistically different between the lowest and highest values reported above, suggesting that the survey respondents used different input combinations that resulted in different cost structures.

Despite the higher cost for inputs, the Pennsylvania farmers reported higher net returns to labor and management. The net returns to labor and management<sup>11</sup> was the highest in Pennsylvania (\$955 per acre), followed by Ohio (\$797), Indiana (\$765), and Michigan (\$682). The combination of higher input expenses and higher net returns in Pennsylvania indicate two issues: (i) greater use of inputs in organic corn production can result in higher yields, and (ii) the economic gains from higher yields can compensate for increased expenses. While some organic farmers pride themselves on minimizing the use of all external inputs, it is certainly the case that organic corn farmers can achieve greater economic gains with purchased soil amendments and fertilizers.

It is important to remember that the figures in Table 7 represent average values, and there are many individual cases in the other states with returns per acre that are higher than that of an average farmer in Pennsylvania. The distribution of farms by net returns to labor and management is shown for each of the four states in Figure 5.

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<sup>11</sup> calculated as the difference between total revenues and the expenses for fertilizers, soil amendments, seeds, machinery use, and land values



Organic corn farmers in Pennsylvania generally reported higher net returns to labor and management than the farmers in other states.

**Figure 5: Distribution of estimated net returns to labor and management per acre by state.**

## **IV. Discussion & Conclusions**

This study represents one of the more in-depth efforts to document the complex and diverse agronomic and soil management practices utilized by organic corn farmers.

Previous literature has demonstrated positive outcomes but significant variability in the profitability of organic grain farms (McBride et al. 2015). Overall, organic corn production in our four-state study area was profitable in 2017. Yield varied widely, but very few farms lost money on the corn enterprises examined in this study.

The vast majority of organic corn grown in the region was raised and harvested as field corn designated to be fed to livestock (harvested both as grain or silage). Not surprisingly, most organic corn growers were also livestock operators, particularly dairy farmers, and the presence of livestock contributed to their ability to utilize diverse crop rotations and maximize the use of home-grown (as opposed to purchased) soil amendments and inputs.

In our sample, organic corn growers who also raised livestock had stronger economic returns to labor and management than cash grain operators. This is consistent with other studies that organic dairy farmers can reduce feed costs by raising their own forages and grains (Dalton et al. 2005).

Organic growers who rely on horses for fieldwork had more positive net returns than farmers who use tractors in 2017. This was mainly due to lower fieldwork expenses compared to farmers using tractors. In this survey, nearly 2/3 of the respondents reported they farmed with horses instead of tractors.

Farmers with more years of experience raising crops organically also had higher net returns on average, suggesting that economic performance for transitioning farms can be expected to improve over time. The amount spent on soil amendments tended to increase with years of experience and tended to increase yields.

As a next step, our team plans to explore links between the use of a wide variety of soil amendments and corn yields on organic corn farms. Soil amendment use comprises an average of 30% of the expenses for organic corn inputs, and not all expenditures can be expected to produce similar gains in yield or other crop performance indicators. Future multivariate models will help account for the distinctive contributions of soil amendments, soil type, and other farm practices on returns to labor and management (Seufert et al. 2012).

## V. Appendix: Methods used to impute key economic variables.

### *Estimating missing economic costs of soil amendments and fertilizers*

The survey captured information about a wide range of soil amendments and fertilizers that were applied to the respondents' organic corn field in 2017. These included volumes (and prices if purchased) for manure, compost, NPK fertilizers and products, calcium amendments, micronutrients, microbial stimulants, and inoculants, etc. When farmers reported the prices paid for these amendments and fertilizers on the survey, we used this value in estimating their corn input expenses. When a price was not given (or when the products were provided by the farm – e.g., manure), we combined information about the volume applied with prices estimated from sample data and publicly available market information from internet searches to estimate the economic costs associated with each product applied to their organic corn field

**Table A1: Assumed cost of various inputs used to impute economic costs where market value information was missing for particular farms\***

Fertilizer nutrient or Soil Amendment	Dollars Per Pound	Fertilizer nutrient or Soil Amendment	Dollars Per Pound
Boron	0.60	Cow Manure	0.01
Manganese	0.75	Pen pack manure	0.01
Copper	1.94	Gypsum	0.17
Zinc	0.90	Lime	0.01
Sulfur	0.42	HI Cal Lime	0.02
Corn Starter	0.42	Chicken Manure	0.02
Corn Starter Lancaster Ag	0.38	Biodyne	0.02
Generic NPK mix	0.50	Feather Meal	0.58
Nitrogen	0.58	Fish fertilizers	4.72
Phosphorus	0.15	Humates	0.99
Sulfate of Potash	0.59	Fertrell 4-2-4	0.82
Chilean Nitrate	0.56	Fert 5-4-3	0.27
Feather Meal	0.64		

\* these costs were derived from the websites of manufacturers or input wholesalers; the less commonly reported inputs are not reported in this table

### *Estimating economic costs of machinery use*

Most farmers reported the number of passes they made to perform basic field operations on their corn fields, and their primary source of power (tractors vs. horses). These number of passes were converted into cost estimates according to the values given in [Table 4](#). On average, there were a total of 10 field passes per acre with a third of these passes in field preparation and tillage practices and another 2+ passes of inter-cultivation for weed control and application of fertilizers and soil amendments. Planting and harvesting each involved slightly more than one pass to accommodate for replanting and other purposes. The estimated cost per acre for horse-drawn equipment was significantly lower than that of the tractor-drawn equipment.

*Estimating economic costs of land rent and seed costs*

The other estimates for land rents and seed costs were obtained by combining farmer reported values in the survey with secondary estimates from USDA land rents and crop yields.

*Comparison with USDA cost estimates*

The cost estimates presented here for the organic corn crops are comparable to the USDA organic production expenses for 2014 for all organic farms in general (see Table A2). USDA reported that an average organic farm spent \$136.08 per acre on fertilizers, lime, soil conditioners, agricultural chemicals, and other materials (USDA-NASS 2017), which is comparable to the estimate of \$149.51 per acre in this survey, as reported above. The land rent values were \$152.91 per acre and \$153.36 per acre in the USDA and this survey, respectively. The seed material costs were \$66.19 per acre for the average organic farm compared with \$98.35 per acre for the organic corn farms in this survey. The difference is primarily due to the fact that USDA reports the data for all organic farms in general, not just organic corn farms. Also, the inputs reported in this survey comprised only a third of the organic farm expenses. Other inputs such as the interest paid, property taxes, utilities, and other expenses such as marketing – which accounted for almost \$316.99 per acre, or 30 percent of the farm expenses in the USDA organic census data – should also be taken into account while evaluating the organic corn production budgets. Also, the USDA reported as much as 38.7 percent for labor expenses which was not included as part of the above cost estimates.

**Table A2: Comparison with USDA estimates for organic corn**

<b>Input</b>	<b>USDA estimate for organic corn (McBride et al. 2015 – figure 8, \$/ac)</b>	<b>USDA estimate for organic crop in general - 2014 survey averages</b>	<b>Our estimate for 2017 crop in the four-state region (\$/ac)</b>
Land	\$105	\$152.91	\$153.60
Capital and Fuel	\$135	NR	\$94.71 <sup>^</sup>
Labor	\$68	NR	Not estimated
Seed	\$61	\$66.19	\$98.31
Fertilizer	\$58	\$136.08	\$149.51
<i>Sample Size (number)</i>	<i>243</i>	<i>NR</i>	<i>859</i>

<sup>^</sup> Includes only farm machinery related costs; NR = not reported here

*Caveats in cost estimates:* Above table shows how these economic cost estimates can vary significantly depending on the region, sample size, and the enterprise-mix. We found more variations within our own survey sample within each state. Costs not reported here (interest, property taxes, utilities, and marketing expenses) can account for up to 30% of the total revenues in organic crop enterprises or \$300-400/ac for organic corn crops. By 2014 USDA cost estimates, the labor and management costs range up to 39% of the total revenues. The reader is cautioned to consider such caveats while interpreting these summary results.

*Comparison with USDA corn yield and returns data:*

**Table A3: USDA 2016 Corn Yield Data.**

State	Corn Grains			Corn Silage		
	Quantity (bu)	Acres	Yield (bu/ac)	Quantity (tons)	Acres	Yield (tons/ac)
Indiana	713,274	6,463	110.4	36787	1934	19.0
Michigan	1,629,850	15,012	108.6	51545	2724	18.9
Ohio	971,459	9,105	106.7	35125	2340	15.0
Pennsylvania	1,105,981	9,736	113.6	53455	3293	16.2
USA	25,562,804	213,934	119.5	726014	47074	15.4

Source: USDA, 2017

**Table A4: Coefficient of Variation (CV) for Average Revenues, Expenses and Net Returns for Corn Production in Survey Sample.**

	Corn Grains			Corn Silage		
	Mean	Standard Deviation	CV#	Mean	Standard Deviation	CV#
Yield	133.9 bu	42.6 bu	32%	20.1 bu	6.4 bu	32%
Price	\$9.44/bu	\$0.99/bu	10%	\$69.99/ton	1.26/ton	2%
Total Revenues	\$1,266.84	\$422.83	33%	\$1,405.33	\$446.22	32%
Expenses*	\$496.73	\$152.40	31%	\$493.88	\$144.15	29%
Net Returns to Labor and Management	\$770.11	\$397.94	52%	\$911.45	\$437.78	48%

\* Expenses include fertilizer nutrients, soil amendments, seeds, and land rents

# Coefficient of Variation = Standard Deviation / Mean

The average values for the net returns to labor and management were estimated at \$770.11 per acre for corn grain enterprises and \$911.45 per acre for corn silage enterprises. Most of these net returns are unrealized in monetary terms (due to unsold nature); the difference in net returns indicates that the organic corn farmers place a slightly higher value on their silage crop. It is also a result of higher concentration of dairy farmers in the survey sample.

The variations in yields and cost estimates (and prices to a lesser extent) affected the variation in net returns as well, which is captured by the standard deviation values of \$397.94 per acre for corn grains and \$437.78 per acre for corn silage. These SD values indicate CV values of 48-52% which are higher than that of total revenues. The higher CV values for net returns showed that there were many farmers whose lower total revenues had higher production costs (leading to lower net revenues) and farmers whose higher total revenues had lower production costs (leading to higher net revenues). These results indicate the need to identify the latter group of farmers who report higher returns and lower costs, whose production practices can possibly serve as benchmarks for other similar field locations. These larger variations in net returns (varying from negative numbers (losses) to over \$2000 per acre) are visible in the histogram presented for net revenues in Figure 4 shown in the body of the report.

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