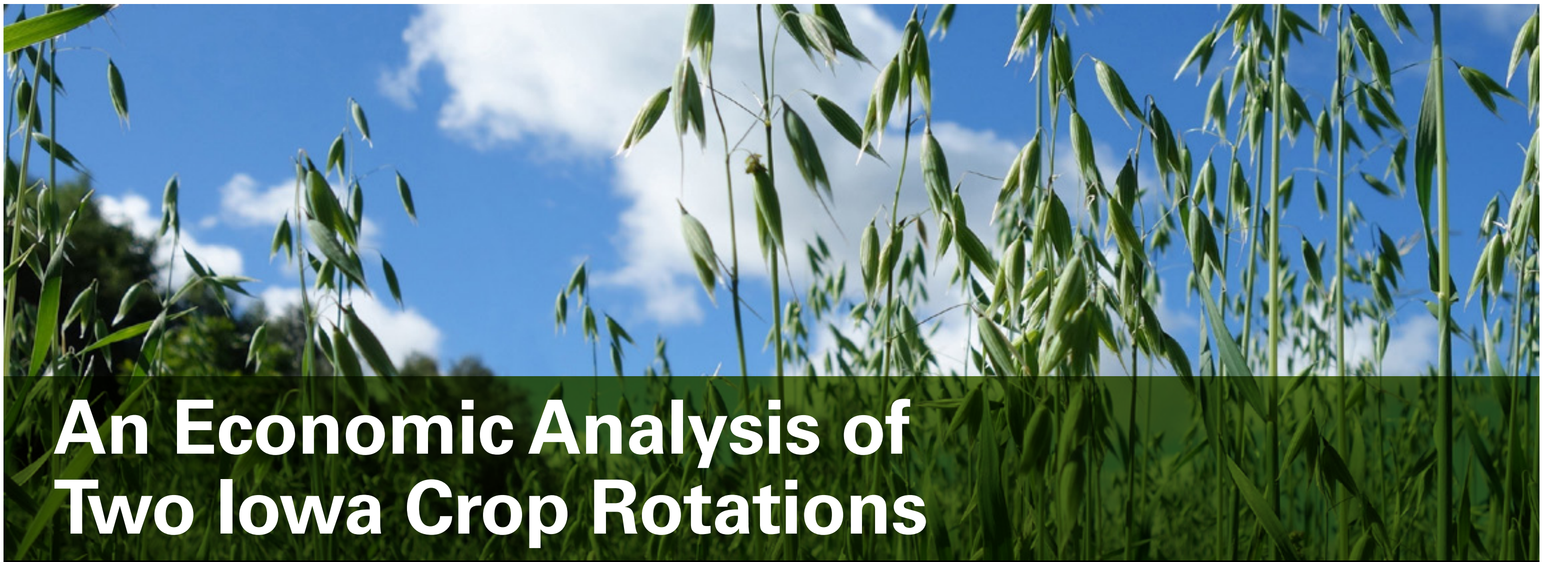

An Economic Analysis of Two Iowa Crop Rotations

According to the United States Department of Agriculture's 2018 Iowa State Agriculture Overview, 23.5 million acres of cropland were planted in Iowa that year.[1] Of that total, 99% were planted to corn (13.2 million acres) and soybean (10 million acres). Because there are numerous agronomic reasons for not planting soybean continuously, these numbers indicate that Iowa cropland consists primarily of a two-crop rotation.

A key question is whether this type of rotation is sustainable from a profitability standpoint. The purpose of any business, including farming, is to provide profits that can be used to cover family living expenses, savings, and business growth. For purposes of this publication we will use the return to management calculation as the amount of dollars available for these items. Return to management is the amount left from gross revenue after all production costs, land charges, and labor (hired and operator-provided) have been paid.

We will assume the farming operation needs to cover $40,000 in family living expenses and $10,000 for savings and business growth. This estimate is consistent with Illinois Farm Business Association data for an average family living expense of $80,000 with half coming from nonfarm income.[2]

If the producer provides their own labor, then the amount of total dollars coming into the farming operation is larger (by the amount of labor provided) than that shown by the return to management amount. Moreover, additional enterprises beyond the cropping system (e.g., livestock) may increase economic returns, allowing for a higher level of family living expenses, savings, and business growth.

Rotation 1: Conventional Corn – Soybean

Budget Development

Enterprise budgets for corn and soybean here were based on long-term research and a series of publications developed by Iowa State University Extension and Outreach specialists.[3, 4] Yields at the Iowa State research farms, however, are typically higher than state average yields. After talking with producers around the state, yields were adjusted downward to more accurately reflect typical yields the past few years for higher producing soils in Iowa. Field notes and activities were translated to costs. Some costs were adjusted to reflect recent price changes. Estimated costs of production for corn and soybean are listed in Table 1.

Economic Returns

Economic returns were calculated based on the marketing year crop prices for 2013-18. These resulted in an average of $3.64 per bushel for corn and $9.86 per bushel for soybean.[5]

Economic returns can be determined by starting with total receipts and subtracting cost items. For example, total receipts less production costs excluding land and labor determines what the return to land, labor, and management would be for the rotation (Table 2). Note the fertility expense includes nitrogen at a recommended rate and phosphorus and potash at a removal rate.

The conventional corn-soybean rotation is assumed to be a stand-alone cropping system and not part of an integrated crop-livestock farming operation. Moreover, manure is assumed not to be readily available. Therefore, all nutrients that leave the farm through crop sales must be replaced through purchased inputs.

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The estimated return to land, labor, and management for corn and soybean is $251 and $276 per acre, respectively.

The returns take into consideration the estimated cost of production as outlined in Table 1.

Because labor hours to conduct fieldwork operations are small (less than one hour per acre), the labor charge assumed for producing corn and soybean is about $9 per acre.[6] The resulting return to land and management for corn is estimated at $242 per acre and soybean at $267 per acre. Note that time to conduct management activities such as marketing and seed or pesticide selection is not included with the labor hours. The economic returns to these types of decisions are a return to management, not labor.

Table 1. Estimated costs of production for conventional corn and soybean per acre, 2013–2018.

	Corn following soybean	Herbicide tolerant soybean following corn	50-50 rotation
Machinery[a]	$86	$67	$77
Seed	108	52	80
Fertilizer	103	45	74
Pesticides[b]	31	28	29
Drying	40		20
Labor	9	9	9
Land	259	259	259
Other[c]	36	25	31
Total	$672	$485	$579
Yield	180	50	
Cost per bushel	$3.73	$9.70	

[a] Field operations for corn include N application, tandem disk, field cultivate, plant, spray, and harvest (combine, haul, and handle); field operations for soybean include chisel plow, tandem disk, field cultivate, plant, spray (2x), and harvest (combine, haul, and handle).

[b] Corn seed: 30,000 @ $3.60/1000; soybean seed: 1 bushel @ $52/bushel; corn fertilizer 131 lb. of N @ $.42/lb.; P and K -$49/ac; soybean P and K fertilizer -$45/ac.

[c] Includes crop insurance, miscellaneous, and pre-harvest interest expense.

Table 2. Estimated economic returns to corn and soybean per acre, 2013–2018.

	Corn following soybean	Soybean following corn	Rotation
Gross sales[a]	$655	$493	$574
Less production costs	404	217	310
Return to land, labor, management	$251	$276	$264
Less labor	9	9	9
Return to land and management	$242	$267	$255
Less land charge	$259	$259	$259
Return to management	-$17	$8	-$4

[a] Corn sales: 180 bushels @ $3.64/bu; soybean sales: 50 bushels @ $9.86/bu.

An assumed land charge of $259 per acre is subtracted from both corn and soybean to determine the return to management. The return for both corn and soybean is -$17 per acre for corn and $8 per acre for soybean. If the land is rented, then the rental charge should be included in the production costs, as it is a cash expense. If the land was purchased and the total of interest payments, property taxes, and upkeep or improvements was greater than $255 per acre ($259 cash rent per acre plus the return to management of -$4 per acre), the producer would incur a loss on the acres they were purchasing, assuming the corn-soybean rotation was continued.

Keep in mind that the production estimates we are using reflect long-run practices. Machinery expenses, including a fixed component, for corn and soybean are $86 and $67 per acre, respectively. So, delaying expenses such as depreciation (a non-cash production cost) could increase economic return to management over the short-run. Not paying for the operator's labor would add dollars back as well.

But remember that although each of these shifts can be made to increase short-term returns to management, they are not long-term solutions. Keep in mind there is a distinct difference between cash flow and economic profitability. The adjustments just mentioned will affect cash flow positively. However, all costs must be included to determine the long-run survivability of a farming operation, or any other business.

Rotation Summary

If we go back to our family living assumption of $40,000 per year for a family of four and add $10,000 for business growth and savings, the net income goal should be around $50,000 per year. Using the -$4 per acre return to management for a corn-soybean rotation, a farmer would never attain the income goal, regardless of how many acres they farmed.

Alternative price, yield, or production cost assumptions could substantially change the land requirement. Moreover, off-farm income, livestock enterprises, or other farm-related income such as custom farming all would reduce the land required to cover family living expenses.

Rotation 2: Organic Corn-Soybean-Oat/ Alfalfa-Alfalfa

A wide variety of organic rotations could be used in Iowa. Most range from three to seven years in length and include corn, soybean, small grain, and a forage crop. Typically, the small grain provides a lower economic return to the rotation. Therefore, multiple options such as oat, triticale, barley, or flax should be analyzed as part of the rotation. Perennial legumes such as red clover and alfalfa can be grown for one year as a plow-down crop or used for multiple years as a hay crop, depending upon the need of the producer (e.g., livestock feed), market availability, and/or terrain (e.g., need to reduce erosion).

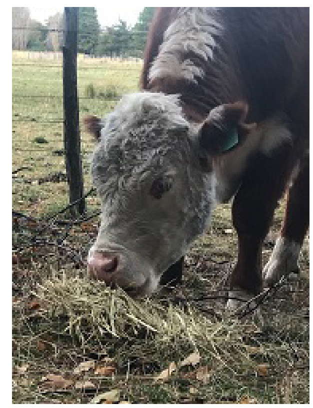
The four-year rotation (corn-soybean-oat/alfalfa-alfalfa) presented in this publication has been researched at the Neely-Kinyon ISU Research Farm since 1998.[7] Rye is planted following corn harvest as a cover crop. Results indicate statistically similar corn and soybean yields between the organic and conventional rotations over the 20 years of this research. Organic farmers, however, indicate they attempt to plant later (sometimes two to three weeks later) than their conventional neighbors to avoid potential contamination from GMO pollen and possible loss of their organic price premium.[8] Iowa State University research has indicated that later planting reduces yield potential.

In addition to late planting, organic farmers indicate some additional loss due to lower levels of rapidly mobile nitrogen compared to conventional crop production practices. Because of these common organic practices, current organic producers indicate organic corn yields should be assumed to be 153 bushels per acre rather than the 180 bushels per acre assumed for Rotation 1.

Weed control is an issue in organic soybean production; organic farmers indicate receiving lower yields than their conventional counterparts. Therefore, based on current organic producers' comments, soybean yield was reduced from 50 to 40 bushels per acre. These assumptions represent a 15 and 20% reduction in yield for organic systems compared to conventional corn and soybean yields, respectively.

Field operations differ substantially for organic rotations compared to a conventional corn-soybean system. Because organic producers cannot use conventional herbicides for weed management, they rely on a series of mechanical operations, including multiple field cultivations and rotary hoeings (see footnote 1 from Tables 1 and 3 for a comparison of the assumed field operations for each crop within the rotations). The addition of alfalfa to the rotation requires the organic producer to use a moldboard plow to turn under the alfalfa stand prior to planting corn. Weed management for organic soybean can be a challenge; soybean fields are commonly walked or hand-hoed to exert control in areas where weeds are particularly a problem. The substitution of mechanical and hand operations for purchased chemicals increases labor requirements. Therefore, per-acre machinery and labor costs are normally higher for an organic rotation than a conventional corn-soybean system due to more field operations.

Fertility for organic rotations comes from two sources: the crops within the rotation and manure sources. The goal for the organic production system is that the legumes within the rotation and manure provide enough nutrients to the four different crops that external sources of nutrients (other than the manure) are not needed.[9] It was assumed the chicken manure provided 60-30-50 (NPK) per ton applied.[10] The corn crop receiving the manure paid the same per pound nutrient cost as the conventional corn producer paid for chemical nutrients. The application of the manure was a field operation and incurred fixed and variable machinery expenses.



Weed management for an organic rotation is accomplished through mechanical operations and the use of crops in the rotation. Small-grain crops like oat are used to control weed populations. Small grains are planted with high plant populations and tend to be competitive with many weed species, though weed management in oat stubble can be problematic.

Production costs given the management practices described in the previous paragraphs are summarized in Table 3. Organically grown corn incurred lower ($57 per acre or approximately 8.5% lower) production costs than the conventional system, whereas soybean production costs were only slightly lower for the organic rotation ($458 versus $485 per acre).

Because organic yields for corn and soybean were assumed to be lower than conventional, cost per bushel for organic corn was higher ($4.02 versus $3.73 per bushel). Organic soybean cost per bushel was substantially higher in the organic rotation ($11.45 versus $9.70 per bushel). The organic rotation average production cost, however, was considerably lower ($494 versus $579 per acre) than in the conventional system.

Table 3. Estimated costs of production for organic corn, soybean, oats, and alfalfa per acre, 2013–2018.

	Corn	Soybean	Oats/Alfalfa	Alfalfa	Rotation
Machinery[a]	$107	$87	$96	$132	$106
Seed	76	60	52	52	82
Fertilizer[b]	88				
Drying	34				8
Labor	18	28	15	15	19
Land	259	259	259	259	259
Other[c]	33	24	6	18	20
Total	$615	$458	$428	$476	$494
Yield per acre	153	40	80/1.0/1.0	4.5	
Cost per bushel/ton	$4.02	$11.45	NA	$105.78	

[a] Field operations for corn include moldboard plow, tandem disk, apply manure, field cultivate, plant, rotary hoe (2x), row cultivate (2x), and harvest (combine, haul, and handle); field operations for soybean include disk stalks, plant rye, disk rye (2x), field cultivate, plant, rotary hoe (2x), row cultivate (2x), and harvest (combine, haul, and handle); field operations for alfalfa include field cultivate, harrow, drill, cultipack, combine, haul, and handle oats, bale and haul oat straw, mow, rake, bale, and haul alfalfa; and mow, rake, bale, and haul hay (3x).

[b] Corn seed: 32,200 @ $2.37/1000; soybean seed: 1 bushel @ $42/bu; rye seed: 1.25 bushel @ $14.44/bu; oat seed: 2.5 bushels @$9.68/bu; alfalfa seed: 16 pounds @ $4.98/lb; fertility is provided by chicken manure: 3,105 lbs at $.0283/lb. Oat and alfalfa seed cost was divided equally between the oat/alfalfa and alfalfa enterprises.

[c] Includes crop insurance, miscellaneous, and pre-harvest interest expense.

Table 4. Estimated economic returns to organic corn, soybean, oats, and alfalfa per acre.

	Corn	Soybean	Oats	Alfalfa	Rotation
Gross sales[a]	$1,599	$938	$628	$773	$985
Less production costs	338	171	154	202	217
Return to land, labor, management	$1,261	$767	$474	$571	$768
Less labor	18	28	15	15	19
Return to land and management	$1,243	$739	$459	$556	$749
Less land charge	259	259	259	259	259
Return to management	$984	$480	$200	$297	$490

[a] Corn sales: 153 bushels @ $10.45/bu.; soybean sales: 40 bushels @ 23.45/bu.; oat sales: 80 bushels @ $4.73/bu.; oat straw sales: 1 ton @ $103.33/ton; first year alfalfa sales: 1 ton @ $146.67/ton; second year alfalfa sales: 4.5 tons @ $171.67/ton.

Economic Returns

As was the case with the conventional rotation, several income assumptions were made. Organic crop prices are not as widely listed and tracked as conventional crop prices. Spot prices are reported by the Agricultural Marketing Service (AMS) of the US Department of Agriculture.[11] These spot prices were approximated for each of the years 2013-2018 for organic corn, soybean, and oats. Where data holes occurred, they were filled by relationships that occur between the prices. For example, organic soybeans have two prices in the budgets. The first is the food bean price; the second lower price reflects the price for feed beans. While the relationship for these two prices varies from year to year, over time the feed price is approximately 90% of the food price. For times when it was difficult to find an adequate number of organic oat prices, a percentage of the organic price was used. Historically when organic corn prices are high (i.e., $10 a bushel or higher), the oat price is approximately 44.3% of the corn price. When organic corn prices are lower (i.e., under $10 per bushel), oat prices are roughly 57.7% of the organic corn price.

The USDA organic corn, soybean, and oat prices are FOB at the farm, meaning the buyer pays for shipping from the farm to the buyer's location. The screened soybean price takes into consideration splits and smaller beans and reflects a discounted price because of lower grade specifications. The organic price for oat was estimated as described previously, where oat straw and alfalfa prices were assumed to reflect a premium product rather than an organic product. First-year alfalfa was assumed to have a slightly lower quality and would sell for about 15% less than second-year alfalfa. The straw quality was discounted further and assumed to be 70% of the first-year alfalfa price.

Economic returns can be determined by starting with total receipts and then subtracting cost items from them. For example, total receipts less production costs excluding land and labor determines the return to land, labor, and management for the rotation (Table 4). The estimated returns to land, labor, and management for organic corn and soybean were $1,261 and $767 per acre, respectively. These returns are approximately 5.0 and 2.8 times the conventional returns, respectively. The returns take into consideration the estimated cost of production as outlined in Table 3. The estimated production cost includes the expense of purchasing and applying manure. Many organic farms are integrated crop-livestock systems, where the fertility needs of the crops are met by a livestock enterprise or enterprises with the goal of a nutrient balance.

No livestock enterprise is assumed to exist in this case; therefore, manure is purchased from an outside source to achieve a nutrient balance, as previously discussed.

Field operations for the organic system were selected by evaluating organic systems research and through conversations with organic producers. The labor hours to conduct organic crop fieldwork operations were determined to be higher than the conventional system, averaging 1.5 hours versus .69 hours per acre.

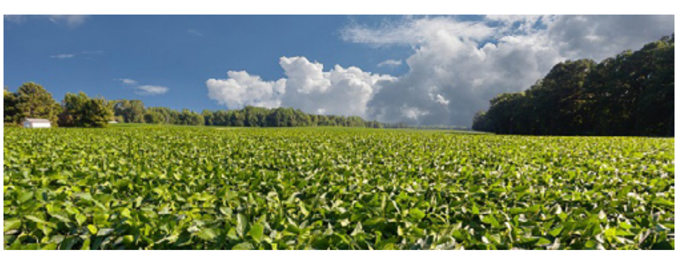
The soybean crop was the largest user of labor due to an additional 1 hour per acre for hand-weeding. The resulting return to land and management for corn is estimated at $1,243 per acre and soybean at $739 per acre. The four-crop rotation average return to land and management was $749 per acre, $494 per acre higher than the average for the conventional corn and soybean rotation.

Note that time to conduct management activities such as marketing and seed selection are not included with the labor hours. The economic returns to these types of decisions are a return to management, not labor. Organic certification fees are normally on a per-acre basis and for the four-crop rotation would average between $3 and $4 per acre. This cost would fall into the miscellaneous category in the budgets.

Land charges of $259 per acre were subtracted from all crops to determine the return to management. The returns ranged from $200 per acre for oats/alfalfa to $984 per acre for corn. The average return to management for the organic rotation was $490 per acre.

Rotation Summary

Using the net income goal of $50,000 per year and a $490 per acre economic return, a farmer would have to farm approximately 102 acres to meet this goal from the farming operation alone. Alternative price, yield, or production cost assumptions could substantially change the land requirement. Moreover, off-farm income, livestock enterprises, or other farm-related income such as custom farming all would reduce the land required to cover family living expenses.



Summary and Conclusions

With higher market prices, rotations that can lower production costs at least moderately without reducing yields may have an edge in profitability, as long as profitability can be maintained on the non-corn and soybean crops. Moving toward crops and production practices that provide premium prices, such as organic corn or soybean, increased returns to management substantially from -$4 to $490 per acre. The dramatic increase in returns per acre would allow a farmer to reach an overall economic goal with significantly fewer acres.

The comparisons of economic returns in this publication depend on the assumptions outlined. For example, the conventional corn-soybean farmer purchased commercial fertilizers. Conventional growers can and do use manure as a fertility source, and by doing so could reduce the overall cost of production for the rotation depending on the source and price.

If the assumptions in this publication are correct, the potential economic return to management to the organic rotation is significantly higher than the corn-soybean rotation. Why then don't more farmers change to the organic rotation?

One objection given by conventional growers is the difference in labor requirements; organic crops take more time per acre. Given the assumptions here, organic rotations do require more hours of fieldwork (1.5 hours per acre for the organic rotation versus .69 hour per acre for the corn-soybean rotation). If a corn-soybean producer can farm 2,000 acres per year in 1,380 hours, the organic producer should be able to farm approximately 920 acres in the same amount of time.

The total return to management for the 2,000-acre conventional farm would be $-8,000 (2,000 acres at -$4 per acre return to management). The total return to management for the 920-acre farm would be $450,800 (980 acres at $490 per acre return to management).

Although the hours per acre are higher for the organic rotation, resulting in a smaller number of total acres farmed, the whole-farm returns to management for the organic farm are still significantly higher than the returns to the corn-soybean producer. The question becomes, could an organic producer farm that many acres and manage the timing issues of pest management and harvesting multiple crops effectively?

Currently there are organic producers in Iowa growing that many acres of these types of crops, so it is possible. The size of an organic cropping system often depends on whether the producer also is involved in an integrated livestock enterprise and the availability of labor to conduct farming operations on a timely basis.

A second frequent objection is that if everyone raises organic products, then the market will be saturated, and premiums will disappear. The organic industry has experienced a double-digit percent annual growth rate for several years, and the future for organic corn and soybean production looks positive. To meet the growing demand for organic crops, imports have increased substantially. The level of imports has limited the upside price potential for domestically produced organic products, but with the continued increase in demand, prices have remained strong. It seems unlikely an increase in organic production (or imports) will occur rapidly enough to distort markets.

It is likely that the main constraint to many farmers in converting to organic production is the increase in management required. Without the use of pesticides and fertilizers that can be applied in a broad time window and have immediate impact, organic producers must manage their weed and fertility program through crop selection, mechanical controls, and hand labor at times. Timing is essential and a mistake can be costly. Organic production is therefore more management-intensive than a conventional corn-soybean rotation. Organic premiums are the mechanism to entice organic farmers to assume this higher level of management.[12]

The increase in economic returns to management with an organic rotation is substantial and would allow a producer to achieve an income goal with much fewer acres. The $50,000 assumed in this publication could be met by farming 102 acres in an organic rotation. The conventional corn-soybean return to management was -$4 per acre over the 2013-2018 period.

For this next discussion, assume the conventional farmer has a 2,000-acre farm producing corn and soybean. Fewer acres translate into a smaller machinery investment. According to data from the Iowa Farm Business Association, machinery investment averaged approximately $400 per acre. The total machinery investment for the organic farm would be $40,800 (102 acres at $400 per acre). Total machinery investment for the conventional corn soybean grower would be $800,000 (2,000 acres at $400 per acre).[13]

In conversations with organic producers, they believe their machinery investment per acre is lower than conventional producers. Organic producers stress that their tractors and implements are older and smaller (i.e., they have and require less horsepower) and their machinery is matched closer to the size of their farming operation. Regardless, the much lower investment for the organic farm would allow those farmers with limited resources to attain economic goals with minimum (or no) debt. Therefore, organic rotations offer beginning farmers an opportunity to gain access to farming without a debt load and risks that can be overwhelming.

The study used data from the period 2013–2018 to determine costs and returns. For conventional crops, these prices are below average. Expanding the period to 2006-2018 would have increased prices and profitability. As with any changes in assumptions, increasing or decreasing prices received or yields would affect the results substantially.

This publication has focused solely on economic results, which vary by the assumptions made. But the choice of which rotation to use often depends upon both economic and non-economic reasons. In many cases, the non-economic reasons to the producer may far outweigh the differences in economic results. For example, many organic producers choose to eliminate chemical use for personal health or environmental reasons. Moreover, the inclusion of small grains and forage crops can reduce erosion on highly erodible land compared to row crops such as corn and soybean.

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This publication was originally created in 2008 by Craig Chase, extension farm management field specialist; Kathleen Delate, organic specialist and associate professor of agronomy and horticulture; Matt Liebman, Wallace Chair for Sustainable Agriculture and professor of agronomy; and Kelvin Leibold, extension farm management field specialist. This update was prepared in 2019 by Craig Chase, manager of the ISU Extension and Outreach Farm, Food, and Enterprise Development Program; Kathleen Delate, professor of agronomy and horticulture; and Olivia Hanlon, undergraduate research assistant.

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