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# Economic Performance of Organic Cropping Systems for Vegetables in the Northeast

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This article provides an economic analysis comparing the profitability and land management capability of four different organic cropping systems designed for vegetable production in the Northeast. Integrated crop budgets were developed to document both receipts and production costs for each system. Using field-level data from trials between 2005 and 2009, we found that individual crops respond differently to the different systems, and that the high intensity system producing six cash crops generated the greatest economic returns. Subsequent sensitivity analyses were performed across a range of key parameters, and the results indicated that profitability was most impacted by yields and crop prices.

***Key words:*** cropping systems; economic analysis; organic production; sustainable agriculture; vegetables.

Although a national standard for organic agriculture was established by the USDA in 2002 and amended by the USDA in 2005 (USDA-NOP, 2005), organic vegetable farming systems are extremely heterogeneous compared to their conventional counterparts. A variety of strategies that comply with the USDA guidelines of organic production practices can be applied ranging from high input systems to those with greater reliance on internal processes. In this research, we examine four such systems that comply with USDA guidelines.

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Organic producers have many options regarding tillage, cropping intensity, cover crops, labor, methods of weed control, and harvesting of crops. Of these factors, cover crops, fertility inputs, weed management and tillage are closely examined here because these activities have important economic and ecological implications in vegetable production. Long term cropping systems studies that accurately simulate organic farms provide a means for analyzing how different management practices influence agronomic conditions and profitability.

Vegetables are an important component of total agricultural production in the Northeast, and notably in New York State. New York ranks fifth nationally in area harvested of principal fresh market vegetables (USDA-NASS, 2011). For instance, New York is the third largest producer of fresh and processing cabbage in the United States, ranks sixth in lettuce production, twelfth in potatoes and sixth in squash (USDA-NASS, 2007). In New York State, vegetable production totaled $361 million in 2010 (USDA-NASS, 2011). National statistics suggest that an increasing share of vegetables grown in the United States is produced following USDA organic guidelines (USDA-Census of Agriculture, 2010). In New York State, approximately 190 farms produced $9.5 million worth of organic vegetables on 1,534 acres in 2008. These data suggest that the average organic farm in New York State has about eight acres in vegetable production; a large share of organic vegetable farms have less than three acres in production (Henehan and Li, 2010). Given the growing importance of organic production in New York agriculture, the objective of this article is to examine the profitability of contrasting approaches for producing organic vegetables on small farms. We use five years of data from an ongoing experiment to analyze the economic effects of four organic cropping systems on yield, farm receipts, production costs, and net returns for cabbage, lettuce, potatoes and squash in the Northeast.

Since 1980, organic farming has been one of the fastest growing segments of U.S. agriculture (USDA-ERS, 2008b). The increase in sales of organic food has been driven mainly by repeated food safety scares, animal welfare concerns, general health concerns, and broader concerns regarding the impact of industrial agriculture on the environment. In addition, the organic food movement is reaching a more mainstream audience and organic consumers now include a wider range of socioeconomic groups (James, Rickard, and Rossman, 2009). Many organic farmers have identified personal health and environmental concerns as motivating factors in their decision to farm organically (Johnson and Toensmeier, 2009). Producers have responded to the boom in consumer demand by increasing the number of organic products. The number of organic products available commercially has grown by 8,593 between 1986 and 2008 (USDA-ERS, 2008a). Retail sales of organic foods have undergone a dramatic rise from $3.6 billion in 1997 to $24.8 billion in 2009. Figure 1 shows that the number of organic fruit and vegetable products introduced annually increased over the same period, and exceeded 60 new products in 2007 and 2008. Fresh organic fruit and vegetable retail sales alone have increased fourfold between 1997 and 2009, and constitute about 38% of total organic sales (Organic Trade Association, 2010). As the organic sector continues to grow, many producers, manufacturers and distributors are expected to continue to expand both nationally and globally (Dimitri, Jaenicke, and Oberholtzer, 2008).

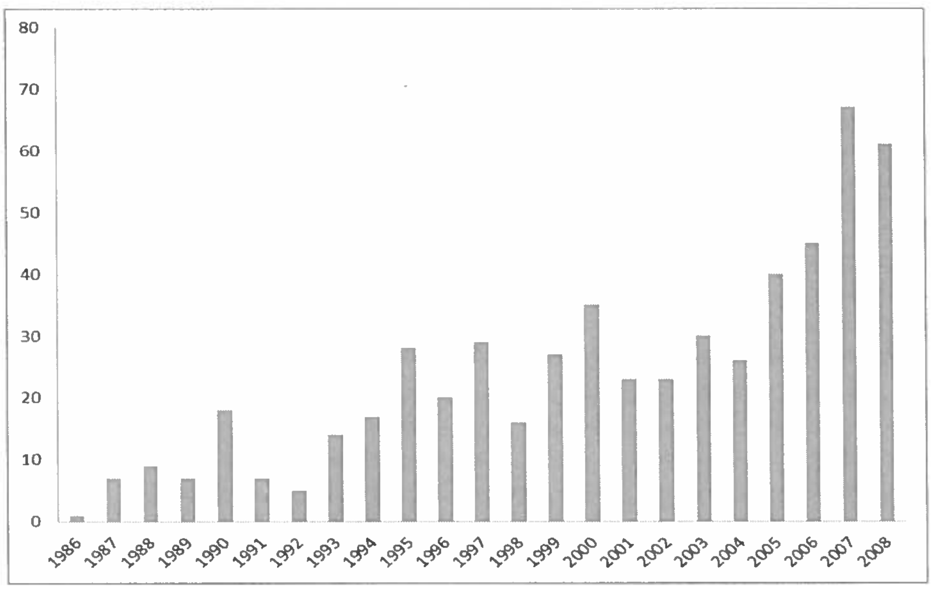


**Figure 1. The Number of Organic Fruit and Vegetable Product Introductions in the U.S. Retail Market (Source: USDA-ERS, 2008a).**

Essentially, organic farming standards involve a commitment to two guiding principles: ecological production and maintaining product integrity. Ecological production involves building soil quality, minimizing pollution, use of natural pest management, and development of a diverse agroecosystem. These goals can be achieved through a range of management practices, including diverse crop rotations, reduced tillage, cover crops, green manures, compost, and biological and mineral pest control products. The second requirement, maintaining organic integrity, involves actions that prevent the contamination of organic produce with prohibited materials and taking steps that prevent the accidental commingling of organic and conventional products. Furthermore, compared to many other labels used for food products (such as "natural" or "local"), use of the term "organic" is highly regulated in the United States. To be in compliance, farmers cannot use synthetic fertilizers and pesticides; they must also take precautions against pesticide drift from neighboring farms and other sources of contamination. Typically, equipment and storage areas employed in organic fruit and vegetable farming are dedicated solely to organic use. Farmers seeking to transition from conventional farming to organic farming must by law keep the land free from synthetic fertilizer, pesticides and other prohibited substances for three years prior to the harvest of the first "certified organic" crop (USDA-NOP, 2005).

The majority of U.S. farmers interested in converting from conventional farming to organic production have faced barriers to entry because of the high costs associated with conversion and lack of technical knowledge (Wiswall, 2009). During the required three-year transitional period, farmers incur steep upfront costs, but do not receive the price premium of growing a certified organic crop. The upfront costs include potential losses due to high production expenses, reduced yields and reduced prices for lower quality products. Overall, the two major limitations to organic production are time and land, and we explore the returns to both factors in our analysis.

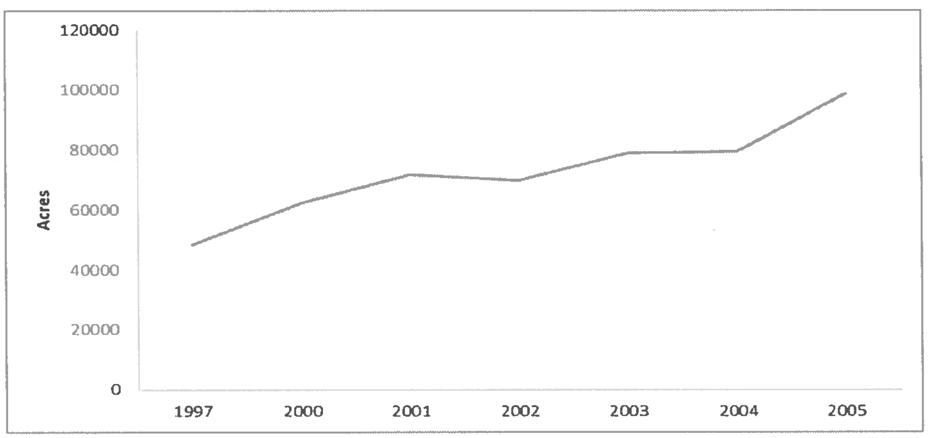


**Figure 2. Land Used for Certified Organic Vegetable Crops in the United States (Source: USDA-ERS, 2008b).**

Despite the rigorous certification process, producers are turning to certified organic farming systems as a way to decrease input costs, lower reliance on nonrenewable resources, capture high-value markets with premium prices, and thereby increase farm income. Consequently the area used to produce certified organic vegetable crops in the United States is increasing rapidly (see Figure 2); organic farmland for vegetables has more than doubled in the United States between 1997 and 2005 and anecdotal evidence suggests that it could double again in the next decade. However, production has not kept pace with consumer demand creating periodic shortages of organic produce (USDA-AMS, 2010).

**The Economics of Producing Organic Crops**

Several studies have examined various production issues related to organic agriculture and agricultural systems that use fewer pesticides and chemicals (e.g., Olesen et al., 2002; Schoofs et al., 2005). Much of the economic literature concerning organic agriculture focuses on consumers' willingness to pay for organic produce relative to conventional food products (e.g., Loureiro, McCluskey, and Mittelhammer, 2001; Giraud, Bond, and Bond, 2005; Hu, Woods, and Bastin, 2009). Also, a growing body of literature investigates a wide range of consumer issues in organic and other niche markets (e.g. Umberger, Thilmany-McFadden, and Smith, 2009; Wang, Curtis, and Moeltner, 2011). Much less work has examined the economics of producing organic crops, and the economics of transitioning into organic production. Most of the economic research in this area has focused on grain crops (e.g., Cavigelli et al., 2009; McBride and Greene, 2009) rather than vegetables crops. This article begins to address this imbalance as it specifically examines the costs and benefits of four contrasting approaches to small-scale organic vegetable production. A better understanding of the effect of management practices on income and costs is critical in assisting farmers with making decisions. Here we calculate crop receipts, costs, net returns to land, and returns to labor for vegetable crops under four alternative cropping systems. Results from our crop budgets highlight potential returns across the systems; in addition, a sensitivity analysis is used to examine how small changes in prices, yields, and input costs impact farm profitability.

We find many examples of enterprise budgets for conventional vegetable production in the United States (e.g., Molinar et al., 2005); however the results typically rely on survey information from producers in a single year. Variations in profitability among different crop budgets are mostly attributable to labor costs and regional costs of growing these crops. In addition, different estimates for retail and wholesale prices contributed to variation in net returns. Conner and Rangarajan (2009) studied costs in two differently managed organic farming systems and their results indicated that costs per acre differed greatly due to crop rotation, scale, marketing, and production costs. Similarly, Ogbuchiekwe, McGiffen, Ngouajio (2004) found that lettuce and cantaloupe yield and net return were greatly affected by crop management practices. We extend this framework to compare different organic production methods across different years and crops, and specifically target small-scale farms. Our approach accounts for crop rotation schedules and diverse organic management systems, and sheds some new light on profitability questions for organic vegetable producers in the Northeast. This should aid both established organic producers and those who are considering a shift to organic production.

Researchers have used enterprise budgets to address profitability questions in agriculture, and to track how changes in inputs affect yields and ultimately farm-level revenue. Delate, Cambardella, and McKern (2008) compared conventional and organic bell pepper growth and yields using strip-tilled or fully incorporated cover crops. Burket, Hemphill and Dick (1997) investigated the effect of cover crops and crop rotation on vegetable productivity. Another study evaluated agroecological and economic effects of "integrated" and organic fruit production (Peck, Merwin, and Brown, 2010). In addition, a series of studies examining costs of production for organic crops have been done by researchers at the University of California, Davis (e.g., Tourte et al., 2009), yet these typically focus on large farming operations that include both organic and conventional production methods. Building on these past models, we follow a similar methodology, but with the additional goal of analyzing the effect of differing inputs and practices on yield and profitability for organic vegetable crops.

## A Description of the Cropping Systems

The organic cropping systems (OCS) used in this experiment were developed by scientists and farmers in the Northeast to represent well-managed but contrasting organic vegetable production systems. Three systems use easily adopted methods for mass replication by commercial organic growers, while one uses highly specialized equipment that is not commercially available. From its inception, the project has been a collaborative multidisciplinary effort between a group of organic vegetable farmers that comprise our advisory team and university researchers. The experiment is conducted on a gravelly loam soil on a certified organic experiment station farm near Freeville, New York.

The OCS were designed to emulate real-world producer decisions and practices, and consisted of four distinctive systems. The four systems varied in terms of their use of land and labor, and we explicitly measure returns to both factors of production in our analysis. The experiment uses a randomized split-plot design with four cropping systems as the main plot factor, two entry points into the four-year crop rotation as the split-plot factor, and four replicate blocks for a total of 32 plots. Each plot is 25 feet by 65 feet. The systems follow a similar basic rotation of cash crops involving cabbage, lettuce, potatoes, and winter squash (as shown in Figure 3). Some additional short season crops are interpolated into one system and fallow and cover crops are substituted for certain crops in another system.

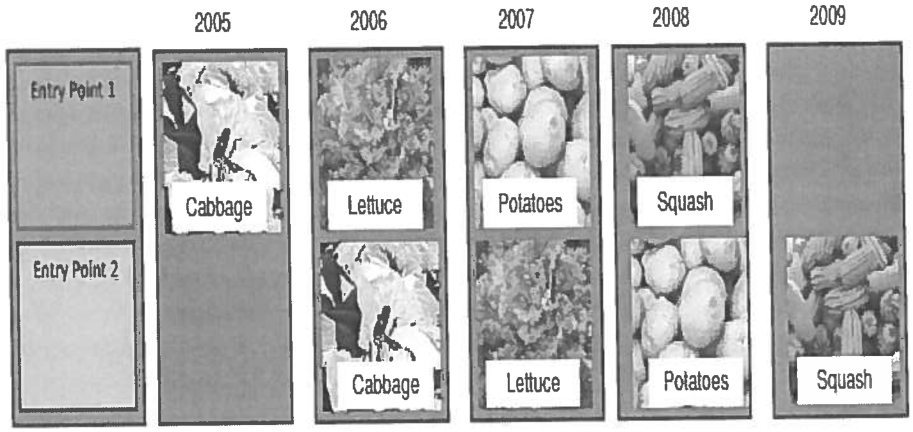


**Figure 3. Illustration of Crop Rotation in the OCS Vegetable Experiment**

System 1 is the High Intensity Cropping System. This simulates farms with limited arable land and focuses on maximizing income via intensive cropping. In addition to cabbage, lettuce, potatoes, and winter squash, this system includes two additional cash crops. Snap peas are grown before cabbage and spinach is grown after lettuce for a total of six crops in four years. Compost is the primary nutrient source. Moldboard plow, rotary tiller, chisel plow, and harrows are used for tillage. Weeds are controlled primarily by cultivation.

System 2 is the Intermediate Intensity Cropping System. It simulates a relatively land-limited farm, but obtains most of its nitrogen from legume cover crops. A single cash crop is grown annually. Similar to System 1, weed competition is limited by cultivation, but additional preventative weed management measures are also used.

System 3 is the Bio-extensive Cropping System in which cash crops are grown every other year. In the alternate years, cover crops and fallow periods build soil organic matter and are used to reduce the weed seed bank. Nitrogen is primarily derived from legume cover crops. Shallow plowing and rotary tilling are used to reduce tillage. This system flushes weeds out of the weed seed bank and prevents further weed seed production by hand rogueing weeds that escape cultivation. It simulates a farm that is substituting land for other inputs and is modeled after a well-established farm in Pennsylvania (Nordell and Nordell, 2007).

System 4 is the Ridge-till Cropping System, which uses ridge tillage instead of plowing. One crop is grown each year, and cover cropping practices are similar to the Intermediate Intensity Cropping System. Ridges are built with a potato hiller after crop harvest, and the cover crops are scraped into the valleys prior to planting the next crop. This system reduces the degree of soil disturbance and the energy used for tillage relative to other systems. The ridge bases are undisturbed by tillage or wheel traffic to improve soil quality in the crop row. Nitrogen is provided mostly from cover crops. Ridge tillage is not a typical practice in vegetable production, and ridge scraping equipment, while simple, is not widely used.

The cropping systems differ in tillage methods, cover crops, cropping intensity, applied nutrients, and weed management strategies. Environmental factors such as soil and climate are held constant, as are pest management, crop varieties and irrigation. Cropping intensities vary across the four systems. System 1 (High Intensity) produces six crops in four years, System 2 (Intermediate Intensity) and System 4 (Ridge-till) produce one cash crop per year, and System 3 (Bio-extensive) produces two cash crops in four years. The degree of inversion during tillage is highest in System 1 (High Intensity) and lowest in System 4 (Ridge-till). Pairwise comparisons of System 2 (Intermediate Intensity) and System 3 (Bio-extensive) provide insight into the benefits of fallowing for weed control and soil quality. Comparing System 1 (High Intensity) and System 2 (Intermediate Intensity) yields information on the effect of nutrient inputs on various soil parameters and biological populations. The comparison between System 2 (Intermediate Intensity) and System 4 (Ridge-till) allows for a test of the benefits of reduced tillage on the development of soil quality, and possible reductions in labor and energy usage.

**The Cost-Benefit Analysis**

The economic analysis used here develops a framework to outline the financial implications of adopting each of the organic cropping systems for the crop rotation using field-level data between 2005 and 2009. The first entry point began in 2005 producing cabbage, and it followed with the production of lettuce in 2006. A second entry point was introduced in 2006 and it also began producing cabbage. Our analysis enables a comparison of the effect of different crop management treatments on yield, total receipts, three cost categories, and net returns.

Costs and receipts are based on a small scale farm with some mechanization, in which the operator performs all labor and crops are marketed at retail prices. Total costs are subdivided into mechanical costs, material costs and marketing costs. For simplicity, we assume that marketing costs are equal to 20% of gross receipts. Receipts are based on yields observed in the OCS experiment and prices reported by members of our advisory team and published regional reports that survey prices at local farm markets. The total receipts reported in our analysis assume that 90% of the observed yields are actually sold, to account for a portion of the crop that is commonly not harvested on retail-oriented vegetable farms. The prices used here are considered to be conservative by the advisory team, but we use these prices so as not to overestimate the potential net returns. As organic produce becomes more common, the price differential between organic and conventional prices will likely fall, and this is another reason to use conservative prices in the analysis. However, we also consider the effects of higher and lower prices on net returns in a sensitivity analysis. We calculated the average costs to produce each crop in each system using the two years of data collected; this was done to reduce year-to-year fluctuations that we observed. We also averaged yields. For example, we averaged yield and cost data for cabbage from 2005 and 2006.

System 1 (High Intensity) and System 3 (Bio-extensive) required special attention since they had more and less than one cash crop per season, respectively. In the case of System 1 (High Intensity), the second cash crop receipts and expenses were averaged and added to those of the main cash crop each year. So, income and costs for spinach were combined with those for lettuce, and similarly, income and costs for snap peas were combined with those for cabbage. System 3 (Bio-extensive) was more complicated. Two-year averaged receipts and expenses for 0.05 acres of the cash crop plus average expenses for 0.05 acres of the previous fallow year were added together to assess the economics for 0.1 acres of managed area needed to produce the cash crop.

A key advantage of our model is that it is integrated; information on costs related to field operations, inputs and crop performance are inter-connected, and are used to calculate net returns. A lower yield for a crop will result in an associated decrease in labor costs for harvesting, washing, and packaging activities. These lower costs will partially offset the reduction in net returns due to lower yields.

We also include calculations to highlight the returns to labor as part of our analysis, and here we assume that an operator has 1500 hours available per season. For each crop in each system we track and report the total operator hours required for 0.1 acres. Dividing 1500 hours by the total operator hours for a crop yields the number of 0.1 acre units that can be produced per season; dividing this result by 10 yields the number of acres that can be managed with 1500 hours per season. The calculation of net returns per season given 1500 hours of labor is based on total receipts, total costs (machinery, materials, and marketing) plus the acreage-adjusted overhead charges for equipment, land and buildings. The net return per operator hour is simply the net return per season divided by the 1500 hours of available labor.

To illustrate how the results are calculated, we show the details used to assess potential returns across the alternative systems for one crop, winter squash, in Table 1. The marketable yield of squash varied greatly among the different management systems. Cost varied also, but less than gross receipts since yields varied substantially. The average net returns ranged from $351 to $609 per 0.1 acre given a (retail) squash price of $1.25 per pound. System 1 (High Intensity) had the highest aggregate costs and highest costs in the categories of machinery use, materials, fuel, and operator labor. System 4 (Ridge-till) had the highest net return per unit of land. System 3 (Bio-extensive) was characterized by low costs and low net returns. Yields were higher in System 3 (Bio-extensive) during the production years compared to the other systems, but because it required two years to obtain that yield, its average yield and gross receipts were low. Despite low average yield, it did not have the lowest net return per operator hour.

Results in Table 1 also show that System 4 (Ridge-till) provided the highest return to labor if the operator is growing only winter squash. An operator could manage the most acres for squash production (including fallow) with System 3 (Bio-extensive), but this option would command lower net returns and lower returns on labor than System 4 (Ridge-till). A System 4 (Ridge-till) winter squash grower could manage 5.71 acres per season and would generate the highest overall return and return per operator hour. The return on labor generated by System 4 (Ridge-till) is approximately 30% higher than System 2 (Intermediate Intensity) and System 3 (Bio-extensive), and over 80% higher than System 1 (High Intensity). For squash production, we found that in our experiment System 4 (Ridge-till) yielded the best overall economic results.

## Results

The method of analysis described above was used for the other vegetable crops produced in the OCS, and the baseline results are summarized in Table 2. The results are structured to show an enterprise with 0.4 acres; this includes 0.1 acres of each of the crops in the rotation. Spinach and cabbage were the first cash crops grown in the rotation under System 1 (High Intensity); cabbage was the first cash crop grown in System 2 (Intermediate Intensity) and System 4 (Ridge-till). A cover crop was grown in System 3 (Bio-extensive) instead of cabbage. The marketable yield of cabbage varied little among the different systems (as shown in Table 2). System 1 also produced a second cash crop; 483 marketable pounds of snap peas were produced and the receipts and costs for the peas were included in the analysis. Overall, System 1 (High Intensity) had the highest costs in each cost category. Table 2 shows that cabbage and peas grown under System 1 (High Intensity) would generate the greatest return to labor; this result is driven primarily by the additional revenue from selling the second cash crop of peas.

The next cash crop in the rotation is lettuce; in addition, spinach was grown after lettuce in System 1 (High Intensity). Lettuce yield in the production year ranged from 54 (24-head) cases in System 4 (Ridge-till) up to 59 cases in System 2 (Intermediate Intensity). Although System 3 (Bio-extensive) had a high yield in the production year (56 cases), because it required two years to produce this, its average yield was the lowest for any system (28 cases). System 1 (High Intensity) generated the highest net return due to

**Table 1. Costs and Returns for Squash from Various Production Systems (per 0.1 acre planting)[a]**

| | System 1 (High Intensity) | System 2 (Intermediate Intensity) | System 3 (Bio-extensive) | System 4 (Ridge-till) |
|---|---|---|---|---|
| Receipts | | | | |
| *Marketable yield (lb)* | 693 | 703 | 521 | 834 |
| *Price ($/lb)* | 1.25 | 1.25 | 1.25 | 1.25 |
| *Total receipts ($)* | 865.69 | 879.19 | 651.38 | 1042.31 |
| Costs | | | | |
| *Machinery Costs ($)* | 165.54 | 158.65 | 113.4 | 154.49 |
| *Flail mow* | 4.28 | | 6.42 | |
| *Moldboard plow* | 3.58 | 3.58 | 1.79 | |
| *Rotary mow* | 8.56 | 8.56 | | 8.56 |
| *Disc* | 5.91 | 5.91 | 3.94 | |
| *Cultipacker* | 1.09 | 3.27 | 2.73 | |
| *Apply compost* | 2.89 | 2.89 | 1.44 | 2.89 |
| *Mark rows* | | 1 | 0.5 | 1 |
| *Cultivate squash* | 5.42 | 5.42 | 2.71 | 2.71 |
| *Cultivate squash 2* | 5.42 | 5.42 | 2.71 | 2.71 |
| *Cultivate squash 3* | | 2.71 | 2.71 | 2.71 |
| *Irrigate* | 42 | 42 | 21 | 42 |
| *Lay plastic* | 4.32 | | | |
| *Rotary tiller* | | | 7.49 | |
| *Springtooth harrow* | | | 4.37 | |
| *Spray* | 0.93 | 0.93 | 0.47 | 0.93 |
| *Remove and dispose of plastic* | 4.41 | | | |
| *Trap crop charge* | 9.69 | 9.69 | 4.85 | 9.69 |
| *Misc support time* | 52.5 | 52.5 | 26.25 | 52.5 |
| *Rotary mow* | | | | 0 |
| *Scrape ridges* | | | | 9.3 |
| *Harvest machinery time* | 14.54 | 14.77 | 10.94 | 17.51 |
| *Cover crop* | | | 13.09 | |
| *Re-ridge* | | | | 1.98 |

**Table 1. Costs and Returns for Squash from Various Production Systems (continued)**

| | System 1 (High Intensity) | System 2 (Intermediate Intensity) | System 3 (Bio-extensive) | System 4 (Ridge-till) |
|---|---|---|---|---|
| *Material Costs ($)* | 131.78 | 70.28 | 57.14 | 70.28 |
| *Compost* | 60 | 12 | 7.5 | 12 |
| *Transplants* | 32.27 | 32.27 | 16.13 | 32.27 |
| *Plastic* | 13.5 | | | |
| *Spray* | 15.05 | 15.05 | 7.53 | 15.05 |
| *Trap crop* | 10.97 | 10.97 | 5.48 | 10.97 |
| *Cover Crop* | | | 20.5 | |
| *Marketing Costs ($)* | 173.14 | 175.84 | 130.28 | 208.46 |
| *Total Costs ($)* | 470.46 | 404.77 | 300.82 | 433.23 |
| *Net return ($/season)* | 395.23 | 474.42 | 350.56 | 609.08 |
| *Net return ($/lb)* | 0.57 | 0.67 | 0.67 | 0.73 |
| *Total operator hours required* | 25.68 | 24.93 | 19.16 | 26.28 |
| *Acres managed given 1500 operator hours* | 5.84 | 6.02 | 8.18 | 5.71 |
| *Net return given 1500 hours available ($/season)* | 14,149 | 19,609 | 18,508 | 25,828 |
| *Net return per operator hour ($/hour)*[b] | 9.43 | 13.07 | 12.34 | 17.22 |

[a] In our analysis we assume that the farm operator performs all labor.
[b] This represents the returns per operator hour (assuming 1500 hours were used) and accounts for all expenses including overhead costs.

the second crop of spinach and the highest return to labor. System 1 (High Intensity) also had the highest total costs, which can be attributed to additional machinery and marketing costs associated with the second cash crop of spinach. Overall, System 1 (High Intensity) was the most profitable management system and required the greatest number of hours for growing and harvesting the crops.

**Table 2: Organic Systems Receipts, Costs, Returns, and Management Measures**

| | System 1 (High Intensity) | | | | System 2 (Intermediate Intensity) | | | | System 3[a] (Bio-extensive) | | System 4 (Ridge-till) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cabbage and Peas | Lettuce and Spinach | Potato | Squash | Cabbage | Lettuce | Potato | Squash | Lettuce | Squash | Cabbage | Lettuce | Potato | Squash |
| *Receipts* | | | | | | | | | | | | | | |
| Marketable yield for primary cash crop (lb)[b] | 4,065 | 55 | 1,409 | 693 | 4,154 | 59 | 1,562 | 703 | 28 | 521 | 4,169 | 54 | 1,013 | 834 |
| Marketable yield for secondary cash crop (lb) | 483 | 550 | | | | | | | | | | | | |
| Price for primary cash crop ($/lb)[c] | 0.75 | 48 | 0.89 | 1.25 | 0.75 | 48 | 0.85 | 1.25 | 48 | 1.25 | 0.75 | 48 | 0.87 | 1.25 |
| Price for secondary cash crop ($/lb) | 4 | 3 | | | | | | | | | | | | |
| Total receipts ($) | 4,980.38 | 4,349.97 | 1,260.00 | 865.69 | 3,115.46 | 2,814.48 | 1,333.13 | 879.19 | 1,353.24 | 651.38 | 3,126.94 | 2,568.24 | 878.63 | 1,042.31 |
| *Costs* | | | | | | | | | | | | | | |
| Machinery Costs ($) | 338.54 | 262.25 | 233.2 | 165.54 | 219.09 | 182.83 | 229.7 | 158.65 | 115.84 | 113.4 | 225.13 | 184.22 | 219.47 | 154.49 |
| Material Costs ($) | 206.78 | 371.59 | 155.07 | 131.78 | 187.83 | 303.15 | 140.63 | 70.28 | 171.62 | 57.14 | 195.57 | 300.01 | 140.63 | 70.28 |
| Marketing Costs ($) | 996.08 | 869.99 | 252 | 173.14 | 623.09 | 562.9 | 266.63 | 175.84 | 270.65 | 130.28 | 625.39 | 513.65 | 175.73 | 208.46 |
| Total Costs ($) | 1,541.39 | 1,503.84 | 640.26 | 470.46 | 1,030.02 | 1,048.87 | 636.95 | 404.77 | 558.11 | 300.82 | 1,046.09 | 997.89 | 535.82 | 433.23 |
| Net return ($/season) | 3,438.98 | 2,846.13 | 619.74 | 395.23 | 2,085.45 | 1,765.61 | 696.17 | 474.42 | 795.13 | 350.56 | 2,080.85 | 1,570.35 | 342.8 | 609.08 |
| Total operator hours required | 81.58 | 89.78 | 44.1 | 25.68 | 56.43 | 56.92 | 45.65 | 24.93 | 30.04 | 18.35 | 55.55 | 54.11 | 36.22 | 36.28 |
| Acres managed given 1500 operator hours | 1.84 | 1.67 | 3.4 | 5.84 | 2.66 | 2.64 | 3.29 | 6.02 | 4.99 | 8.17 | 2.7 | 2.77 | 4.14 | 5.71 |
| Net return given 1500 hours available ($/season) | 54,295 | 38,615 | 12,143 | 14,149 | 46,498 | 37,592 | 13,939 | 19,509 | 30,757 | 19,720 | 47,252 | 34,596 | 5,260 | 25,828 |
| Net return per operator hour ($/hour) | 36.2 | 25.74 | 8.1 | 9.43 | 31 | 25.06 | 9.29 | 13.07 | 20.51 | 13.15 | 31.5 | 23.06 | 3.51 | 17.12 |
| Sum of net returns per 0.4 acres ($/season) | | | | 7,300 | | | | 5,022 | | 2,291 | | | | 4,603 |

[a] System 3 was fallow for cabbage and potatoes.

[b] Lettuce yields are measured as 24-head cases.

[c] Unit price of lettuce is $48 per 24-head case. The per pound potato price in the first entry point was $1.00 and was $0.75 in the second entry point; the prices shown for each system represent an average weighted price across the two entry points

Potatoes were the third cash crop in the rotation and were grown in System 1 (High Intensity), System 2 (Intermediate Intensity), and System 4 (Ridge-till). As with cabbage, System 3 (Bio-extensive) was fallow at this point in the rotation. Overall, potatoes were the least profitable crop in the OCS experiment, but they are a common crop on many organic vegetable farms in the Northeast. Marketable yield, which strongly influenced profitability, varied among systems in both years; the average marketable yield ranged from 1,013 pounds per 0.1 acre in System 4 (Ridge-till) to 1,562 pounds per 0.1 acre in System 2 (Intermediate Intensity). System 1 (High Intensity) had the highest machinery and material costs due to higher costs associated with a higher compost application. The average net return per season for System 2 (Intermediate Intensity) was double that of System 4 (Ridge-till) and 12% higher than System 1 (High Intensity). The average total hours and acres managed per season were similar for System 1 (High Intensity) and System 2 (Intermediate Intensity). System 4 (Ridge-till) required fewer operator hours because of lower harvest labor, and a farmer could manage more acres under this system. System 2 (Intermediate Intensity) generated the highest return per operator hour for potatoes.

Squash was the fourth vegetable grown in the rotation, and it was grown in all four systems. On average, System 4 (Ridge-till) yielded 834 marketable pounds of squash per 0.1 acre, followed by System 2 (Intermediate Intensity) with 703 marketable pounds of squash per 0.1 acre. System 4 (Ridge-till) had the highest average receipts and costs. Accordingly, System 4 (Ridge-till) had the highest return on operator labor. In addition, System 4 (Ridge-till) was the most efficient cropping system in terms of land and labor management. A farm operator could earn $17.12 dollars per operator hour using System 4 (Ridge-till), about 30% higher than under System 2 (Intermediate Intensity) or System 3 (Bio-extensive), and almost double the earnings under System 1 (High Intensity).

Because most vegetable producers in the Northeast grow several different crops each year, we also provide a more holistic analysis in which farms using each of the four systems produce all four phases of the crop rotation in a given year; the results are summarized in Table 3. This mimics the results of farmers who grow cabbage, lettuce, potatoes and squash following the different management practices of the four systems. If a farm operator is seeking to maximize net returns, System 1 (High Intensity) should be used to grow the full rotation; this generated $7,300 in operator returns per 0.4 acres per season. System 1 (High Intensity) had higher costs than System 2 (Intermediate Intensity), but the additional two cash crop in System 1 (High Intensity) led to higher net returns. The labor and land management analysis in Table 3 shows that System 2 (Intermediate Intensity) had the second highest returns per operator hour. Remarkably, the highly experimental System 4 (Ridge-till) had only slightly lower overall returns and returns per hour of operator labor than System 1 (High Intensity) and System 2 (Intermediate Intensity), which are more traditional organic cropping systems.

**Table 3. Whole Farm Analysis by System[a]**

| | System 1 (High Intensity) | System 2 (Intermediate Intensity) | System 3 (Bio-extensive) | System 4 (Ridge-till) |
|---|---|---|---|---|
| Total receipts ($) | 11,456.04 | 8,142.26 | 4,009.24 | 7,616.12 |
| Costs | | | | |
| *Machinery costs ($)* | 999.53 | 790.27 | 458.49 | 783.32 |
| *Material costs ($)* | 865.22 | 701.88 | 457.53 | 706.49 |
| *Marketing costs ($)* | 2,291.21 | 1,628.45 | 801.85 | 1,523.22 |
| Total costs | 4,155.95 | 3,120.61 | 1,717.86 | 3,013.03 |
| Net return ($/season) | 7,300.08 | 5,021.65 | 2,291.38 | 4,603.08 |
| Total operator hours required | 241.01 | 183.93 | 96.78 | 172.17 |
| Acres managed given 1500 operator hours | 2.49 | 3.26 | 6.2 | 3.48 |
| Whole farm net return given 1500 hours available ($/season) | 36,498 | 32,016 | 26,578 | 31,167 |
| Net return per operator hour ($/hour) | 24.33 | 21.34 | 17.72 | 20.78 |

[a] Analysis based on a farm with 0.1 acres of each crop.

Results in Table 3 show that System 1 (High Intensity) had the lowest ratios of machinery costs and material costs to total receipts, whereas System 3 (Bio-extensive) had the highest ratios of these costs to total receipts. System 3 (Bio-extensive) required the least labor—97 hours for 0.4 acres compared to 241 hours, 184 hours, and 172 hours for the other systems. Thus, in addition to land, System 3 (Bio-extensive) also substituted machinery and materials for labor. This was due largely to the decreased labor requirement during the fallow periods. In fact, the labor requirements in System 3 (Bio-extensive) during the fallow year were typically less than 10% of that needed during the nonfallow years.

Since cabbage and potatoes were not grown in System 3 (Bio-extensive), comparing results for just lettuce and squash across the four systems is useful. Based on results in Table 2, if 0.1 acres of lettuce and squash were grown in each system, net returns per hour would be $22.12 in System 1 (High Intensity), $21.41 in System 2 (Intermediate Intensity), $17.72 in System 3 (Bio-extensive), and $21.15 in System 4 (Ridge-till). These results for System 1 (High Intensity), System 2 (Intermediate Intensity), and System 4 (Ridge-till) are similar to those in Table 3, in which all cash crops are included.

Lastly we also provide results for an operation that has the capacity to employ different systems for different crops in Table 4. A mixed-system approach could potentially be beneficial, but it also presents some challenges as some systems cannot fully mesh with each other. For example, System 1 (High Intensity) includes a secondary cash crop of spinach after lettuce that would conflict with cover crops needed for subsequent production of potatoes in other systems, including System 2 (Intermediate Intensity). Similarly, System 3 (Bio-extensive) requires a fallow period every other year, and this precludes the system's inclusion in a mixed-system approach. Thus we limit our mixed system analysis to an examination of the economics of an approach that includes System 2 (Intermediate Intensity) and System 4 (Ridge-till). A mixed-system approach that grows cabbage, lettuce, and potatoes using System 2 (Intermediate Intensity) and grows squash using System 4 (Ridge-till) generates returns that are 2.7% higher than those for System 2, the more profitable of the two component systems. This mixed system, however, provides lower net returns to land and labor than System 1 (High Intensity).

Overall net returns to land varied widely among systems. Returns to labor varied much less so. Net returns per labor hour were highest in System 2 (Intermediate Intensity) for potatoes, highest in System 4 (Ridge-till) for squash, and highest for cabbage (with snap peas) and lettuce (with spinach) in System 1 (High Intensity). If a farm were to adopt one system, then System 1 (High Intensity) would generate the highest total returns to land and labor, largely due to its extra crops of snap peas and spinach.

**Sensitivity Analysis**

The field trials indicated that different organic farm management systems will be best for different crops. The experiment is continuing to determine how crops in the four systems respond to variation in seasonal conditions and observe ecological changes in the systems. Additional research is needed to test how the economic results may change over time and how they would respond to different market conditions.

With the data at hand, however, we can explore how sensitive our results are to changes in the key parameters that are expected to change over time. In fact, many of the parameters for individual crops fluctuated between the two entry points, and data from early years of the second crop rotation of the experiment have shown additional variability in certain costs and yields. Changes in key parameters have the capacity to impact profitability of the several systems dramatically. Table 5 outlines results from an analysis to test how sensitive baseline system net returns in Table 3 are to small changes in yields, prices and selected input costs.

**Table 4. An Analysis for a Mixed System Across Crops[a]**

| Crop | Cabbage | Lettuce | Potato | Squash | |
|---|---|---|---|---|---|
| Best System | System 2 | System 2 | System 2 | System 4 | Total |
| | (Intermediate Intensity) | (Intermediate Intensity) | (Intermediate Intensity) | (Ridge-till) | |
| Receipts | | | | | |
| *Marketable yield (lb)[b]* | 4,153 | 59 | 1,562 | 834 | |
| *Price ($/lb)[c]* | 0.75 | 48 | 1 | 1.25 | |
| *Total receipts ($)* | 3,115.46 | 2,814.48 | 1,333.13 | 1,042.31 | 8,305.38 |
| Costs | | | | | |
| *Machinery Costs ($)* | 219.09 | 182.83 | 229.7 | 154.49 | 786.11 |
| *Material Costs ($)* | 187.83 | 303.15 | 140.63 | 70.28 | 701.88 |
| *Marketing Costs ($)* | 623.09 | 562.9 | 266.63 | 208.46 | 1,661.08 |
| Total Costs | 1,030.02 | 1,048.87 | 636.95 | 433.23 | 3,149.07 |
| Net return ($/season) | 2,085.45 | 1,765.61 | 696.17 | 609.08 | 5,156.31 |
| Total operator hours required | 56.43 | 56.92 | 45.65 | 26.28 | 185.28 |
| Acres managed given 1500 operator hours | 2.66 | 2.64 | 3.29 | 5.71 | 3.24 |
| Net return given 1500 hours available ($/season) | 46.498 | 37,592 | 13,939 | 25,828 | 32,808 |
| Net return per operator hour ($/hour) | 31 | 25.06 | 9.29 | 17.22 | 21.87 |

[a] The first four columns of results are based on an operation that produces 0.1 acres; the final column provides results based on an operation that produces 0.4 acres. [b] Lettuce yields are measured as 24-head cases. [c] Unit price of lettuce is $48 per 24-head case.

Yield is one of the most variable factors in the OCS experiment, and yields have an important effect on profitability (Sellen et al., 1996). We observed year-to-year yield fluctuations within systems from 5% to over 50% for crops in the experiment. Here we consider changes of 10% from the baseline yields in the sensitivity analysis. A 10% increase or decrease in the base marketable yield on a farm growing all crops leads to a roughly 12% increase or decrease in net returns in all systems. Thus, a change in yield has a disproportionately large effect on overall returns.

Retail vegetable prices have fluctuated over the years of the OCS experiment, and we also considered the effects of small changes in retail prices in our sensitivity analysis. Results show that the percentage changes in net returns were greater than the percentage changes in price for all crops. For example, a 10% increase or decrease in the base price for all crops would change net returns by approximately 13% in all four systems and a 10% increase in price produced a similar increase in net returns. Across the range of prices used in the sensitivity analysis we find that System 1 (High Intensity) maintained the highest net returns overall. All systems benefit from increases in prices; however, System 1 also had the most stable net return in the face of price changes.

Costs of producing vegetables, notably fuel costs, have changed substantially over the years of the OCS, and changes in fuel costs affect many of the individual machinery operation costs included in our analysis. Changes in fuel costs led to very small shifts in net returns. For example, a 10% increase in fuel costs led to a decrease in net returns that was less than 1%. Fuel prices do not appear to have much impact on net returns because many organic farms are small, use a lot of manual labor, and use less machinery (and fuel) than conventional farms (Dalgaard, Halberg, and Porter, 2001).

Our baseline analysis assumed that marketing costs were 20% of gross receipts. As a result, any decrease in the marketing expenses will decrease the percentage of gross receipts assumed to be required for marketing. Overall, changes in marketing costs led to relatively small changes in net returns. Results in Table 5 show that a 10% decrease in marketing costs across all systems leads to approximately a 3% increase in net returns across the various systems. Of course, if additional marketing efforts were used to promote organic vegetables differently, we might find a more responsive effect from changes in marketing expenses and the prices received.

In addition, an overall sensitivity analysis was conducted. In a worst case scenario, for each system marketable yields and prices fall by 10%, while fuel and marketing costs increase by 10%. In this case, net returns across all systems would decrease by 26% to 28% from the baseline results, and System 1 (High Intensity) maintained the highest net returns. Conversely, in the best case scenario, marketable yields and prices would increase by 10%, while fuel and marketing costs would decrease by 10%. Under these

**Table 5. Examination of the Impact of 10% Changes in Key Revenue and Cost Items on Net Return ($/0.4 acres)**

| Scenario | System 1 (High Intensity) | | System 2 (Intermediate Intensity) | | System 3 (Bio-extensive) | | System 4 (Ridge-till) | |
|---|---|---|---|---|---|---|---|---|
| | $/season | % | $/season | % | $/season | % | $/season | % |
| *Baseline net return* | 7,300.08 | | 5,021.65 | | 2,291.38 | | 4,603.08 | |
| *Marketable yield* | | | | | | | | |
| High +10% | 8,185.16 | 12.1 | 5,657.08 | 12.7 | 2,579.42 | 12.6 | 5,197.52 | 12.9 |
| Low -10% | 6,411.85 | -12.2 | 4,386.27 | -12.7 | 2,003.32 | -12.6 | 4,009.69 | -12.9 |
| *Price ($/lb)* | | | | | | | | |
| High +10% | 8,216.97 | 12.6 | 5,674.48 | 13 | 2,588.91 | 13 | 5,215.20 | 13.3 |
| Low -10% | 6,384.01 | -12.5 | 4,371.72 | -12.9 | 1,997.87 | -12.8 | 3,996.62 | -13.2 |
| *Fuel cost ($ per gallon)* | | | | | | | | |
| High +10% | 7,275.33 | -0.3 | 5,002.89 | -0.4 | 2,284.29 | -0.3 | 4,585.26 | -0.4 |
| Low -10% | 7,321.69 | 0.3 | 5,040.46 | 0.4 | 2,298.47 | 0.3 | 4,621.95 | 0.4 |
| *Marketing costs ($)* | | | | | | | | |
| High +10% | 7,069.39 | -3.2 | 4,858.83 | -3.2 | 2,217.50 | -3.2 | 4,451.28 | -3.3 |
| Low -10% | 7,527.63 | 3.1 | 5,184.52 | 3.2 | 2,365.26 | 3.2 | 4,755.93 | 3.3 |
| *Overall total change[a] ($)* | | | | | | | | |
| High +10% | 9,500.36 | 30.1 | 6,597.17 | 31.4 | 3,005.54 | 31.2 | 6,077.01 | 32 |
| Low -10% | 5,387.99 | -26.2 | 3,655.47 | -27.2 | 1,674.00 | -26.9 | 3,324.85 | -27.8 |

[a] Here we use the term "High" to represent a 10% increase in yields, prices, and costs. Similarly, the term "Low" represents a 10% decrease in yields, prices, and costs. Note, however, that an increase in yield or price increases net return whereas an increase in costs decreases net return, and conversely for a decrease in yield, price and costs.

conditions, all systems would experience gains in net returns of 30% to 32% over those found in the baseline analysis. Net return of System 1 (High Intensity) is somewhat more stable under these scenarios than the others.

## Conclusion and Implications

USDA regulations concerning organic production practices are now well defined, but are flexible and allow a wide range of systems that comply with the standards. Agricultural producers need to carefully assess the trade-offs between the numerous management options and strategies to maximize profitability while also considering biological and social sustainability. The research reported here examines the economic implications of such flexibility by assessing the profitability of alternative organic cropping systems. The OCS experiment compares four different cropping systems that comply with USDA organic standards on an experiment station farm. Data from the experiment enable us to perform an economic analysis that examines profitability and land management capability across the systems. Our results will help small-scale organic farmers develop management plans that meet USDA organic certification requirements and generate profits.

We examine the economic implications in the several systems in a multiple-year crop rotation of cabbage, lettuce, potatoes and squash. Our results indicate that the net returns to both land and labor range widely across the alternative systems for each crop, and that different systems generate the highest net returns for different crops. System 1 (High Intensity) generated the highest net returns per acre or per labor hour for an operation producing all four crops; it would generate more than an operation that adopted a mixed approach using System 2 (Intermediate Intensity) and System 4 (Ridge-till). Overall, the most striking result of our analysis is that whole farm net returns per hour were similar across the four systems, even when yield and returns per acre differed widely. This result indicates that in the absence of constraints on land availability, organic cropping systems that use cover crops and fallows to reduce weeds and improve soil quality may result in little loss of net return to labor for small-scale producers.

We also performed a sensitivity analysis to examine how small percentage changes in the prices, yields, fuel costs, and marketing expenses influence net returns at the farm level. This sensitivity analysis suggests that net returns are more responsive to changes in yields and prices received, and less responsive to changes in input costs. This supports the need for continuing research that focuses on improving yields for organic vegetables. Changes in prices can be achieved through various mechanisms, yet for a niche market such as organic produce they are primarily driven by an increase in demand via new information and promotional efforts that introduce the product to more consumers. Agricultural producers and policy-makers interested in expanding markets and generating revenue for organic produce should look to policies or industry-led initiatives that increase demand for organic vegetable products.

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