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Economic Performance of Organic Cropping Systems for Vegetables in the Northeast

Stephanie Chan, Graduate Research Assistant
Charles H. Dyson School of Applied Economics and Management
Cornell University, NY, 14853
E-mail: sc969@cornell.edu

Brian A. Caldwell (contact author), Research Support Specialist
Department of Horticulture
Cornell University, NY, 14853
Tel: +1.607.280.3652
E-mail: bac11@cornell.edu

Charles L. Mohler, Senior Research Associate
Department of Crop and Soil Sciences
Cornell University, NY, 14853
E-mail: clm11@cornell.edu

Bradley J. Rickard, Assistant Professor
Charles H. Dyson School of Applied Economics and Management
Cornell University, NY, 14853
E-mail: b.rickard@cornell.edu

Introduction

USDA regulations concerning organic production practices are now well defined, but are flexible and allow a wide range of production 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 Cornell Organic Cropping Systems Project was established in 2004. It features two long term field experiments on certified organic land, one each for vegetable and grain crops. In each of the field experiments, four organic cropping systems are compared using soil, weed, pest, production, crop quality, and economic measures.

The Organic Vegetable Cropping Systems experiment uses a randomized block design with 4 cropping system treatments, two entry points into the rotation (that is, 2 of the 4 rotational crops are grown in a given season) and 4 replications (32 plots total). Plots are 25' by 65'. Tillage is by moldboard plow, rotovator, and harrows, except for System 4 (see below).

- System 1: High intensity cropping. This system simulates a land limited farm where the goals are to maximize income via intensive cropping. Six crops are grown in a four year rotation. Compost is the primary nutrient source, as there are few seasonal windows to grow cover crops. For weeds the goal is to attain good yields by freeing crops from weed competition, but not necessarily to prevent weed seed production.

- System 2: Intermediate intensity cropping. This system simulates a farm that is too land limited to use System 3, but wishes to obtain most of its nitrogen (N) from legume cover crops. One cash crop is grown each year. For weeds the goal is similar to System 1, but opportunities are taken for preventive weed management when convenient.

- System 3: Bio-extensive cropping. This system simulates Pennsylvania growers Eric and Anne Nordell’s bio-extensive farming system in which cash crops are grown only in alternate years. Between cash crop years long cover periods build organic matter and a fallow period reduces the weed seedbank. N comes primarily from cover crops. Tillage is reduced through shallow plowing and harrowing. For weeds the goal is to flush out the seed bank and to prevent weed seed production.

- System 4: Ridge-till cropping. This system uses ridge tillage. Instead of plowing, permanent ridges are alternately built and scraped off with special equipment to control weeds and prepare for planting. Ridge bases are not disturbed. This allows controlled wheel traffic and consequent better soil quality in the row. N is obtained primarily from cover crops. For weeds the goal is similar to System 2.

The basic premise of the experimental cropping systems is to retain the weed management, nutrient, and soil quality benefits of the Nordell's high cover crop (Bio-Extensive) system but investigate ways of growing more frequent cash crops. All systems follow a similar basic rotation,

Winter squash → Cabbage → Lettuce → Potato,

except that fallows plus cover crops are substituted for a cash crop every other year in System 3, and peas and spinach are double cropped with cabbage and lettuce respectively in System 1.

Legume cover crops include hairy vetch, red clover, and field peas. Non-legumes are rye, wheat, and buckwheat. Compost applications vary depending on the estimated N input from cover crops and the N needs of the cash crop, but due to its lack of legume cover crops, System 1 typically receives twice as much compost than other treatments. Insect populations are monitored by scouting. When insects exceed threshold levels, we apply appropriate products approved by our organic certifier.

Please see http://www.hort.cornell.edu/extension/organic/ocs/vege/index.html for a full explanation of the experiment and the growing systems.

Data from the vegetable 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.

Approach

The economic analysis used here examines the financial implications of adopting each of the organic vegetable cropping systems based on field data between 2005 and 2009. Our analysis compares the effect of different approaches to crop management 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 machinery 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 farm 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 marketable 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. 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 calculated 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 1,500 hours available per season. For each crop in each system we track and report the total operator hours required for 0.1 acres. 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.

Results

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. 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. Yield during the cash crop season was higher in System 3 (Bio-extensive) during the production years compared to the other systems, but because it also required a cover crop/fallow year to obtain those yields, average yield and gross receipts per 0.1 acre unit were low. Despite this, System 3 (Bio-extensive) 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 its associated fallow) with System 3 (Bio-extensive), but this option would command lower returns to labor and land than System 4 (Ridge-till).

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. A double crop of snap peas followed by cabbage was grown the first rotation season under System 1 (High Intensity). Cabbage was the first crop in System 2, (Intermediate Intensity) and System 4 (Ridge-till). A cover crop was grown in System 3 (Bio-extensive) in that spot in the rotation instead of a cash crop. The marketable yield of cabbage varied little among the different systems (Table 2). System 1 also produced a second cash crop in the same season; 483 pounds of marketable 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 income, and also 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 all systems; in addition, spinach was grown after lettuce in System 1 (High Intensity). Again, System 1 (High Intensity) generated the highest net return and the highest return to labor, due to the second crop of spinach. 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. Overall, System 1 (High Intensity) was the most profitable management system and required the greatest number of hours for growing and harvesting the crops. Although System 3 (Bio-extensive) had a high field yield in the production year (56 cases), because it required two years to produce this, its average yield per 0.1 acre was the lowest for any system (28 cases).

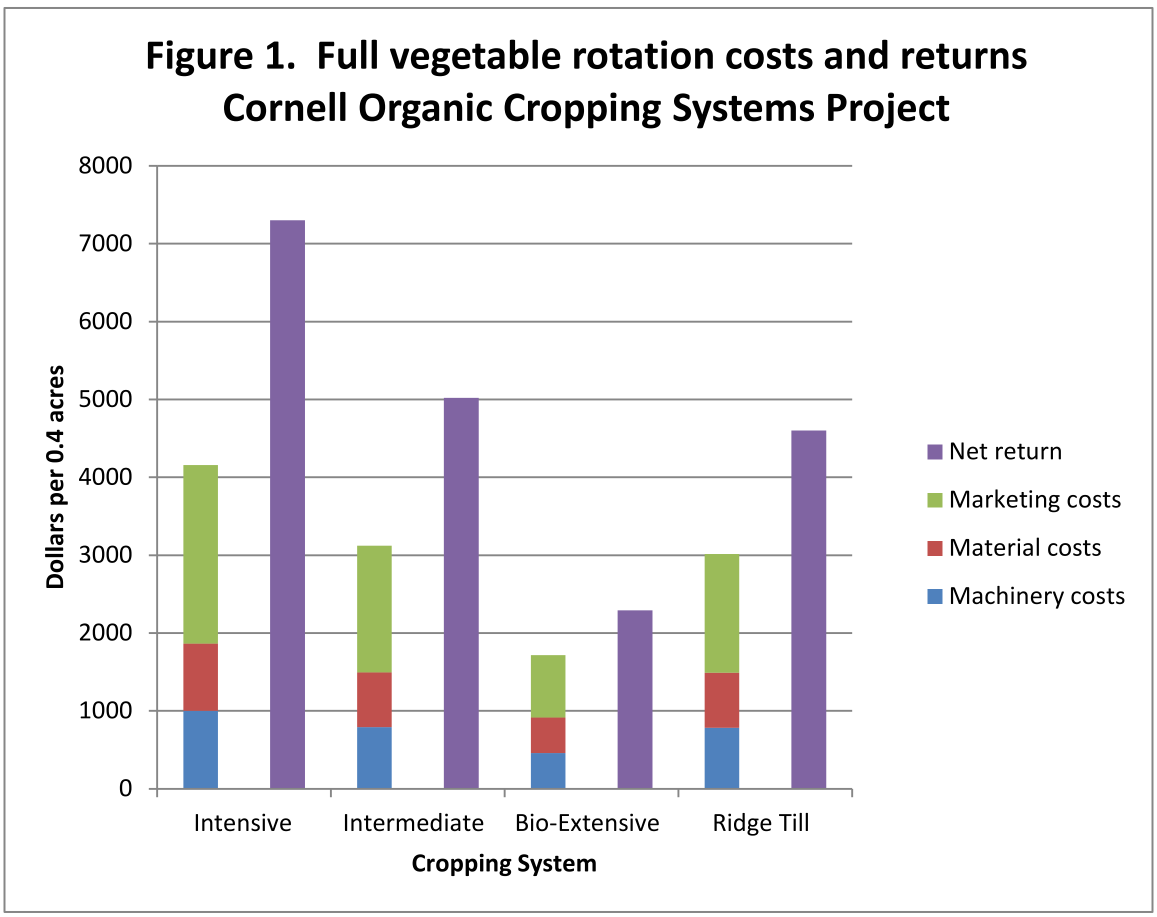
Potatoes were the third cash crop in the rotation and were grown in System 1 (High Intensity), System 2 (Intermediate Intensity), and System 4 (Ridge-till). As with cabbage, System 3 (Bio-extensive) was in cover crops and fallow at this point in the rotation. Potatoes were the least profitable crop in the OCS experiment. Marketable yield, which strongly influenced profitability, differed among systems; 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 labor 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 hour for potatoes.

Squash was the fourth vegetable grown in the rotation, and it was grown in all four systems. 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 labor 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).

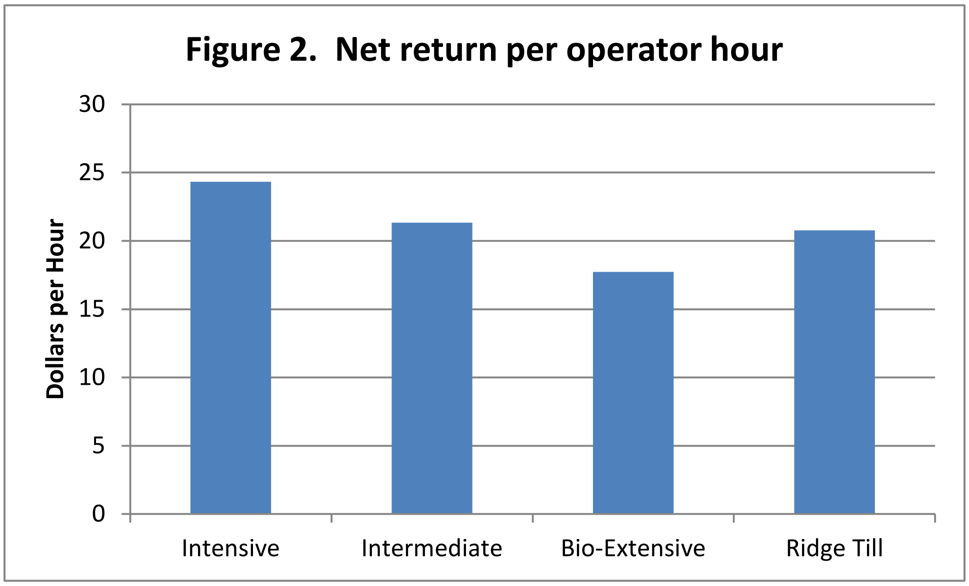
The field trials indicated that in terms of economics, different organic farm management systems performed best for different crops. Net returns per labor hour were highest in System 2

(Intermediate Intensity) for potatoes, highest in System 4 (Ridge-till) for squash, and highest in System 1 (High Intensity) for cabbage (with snap peas) and lettuce (with spinach).

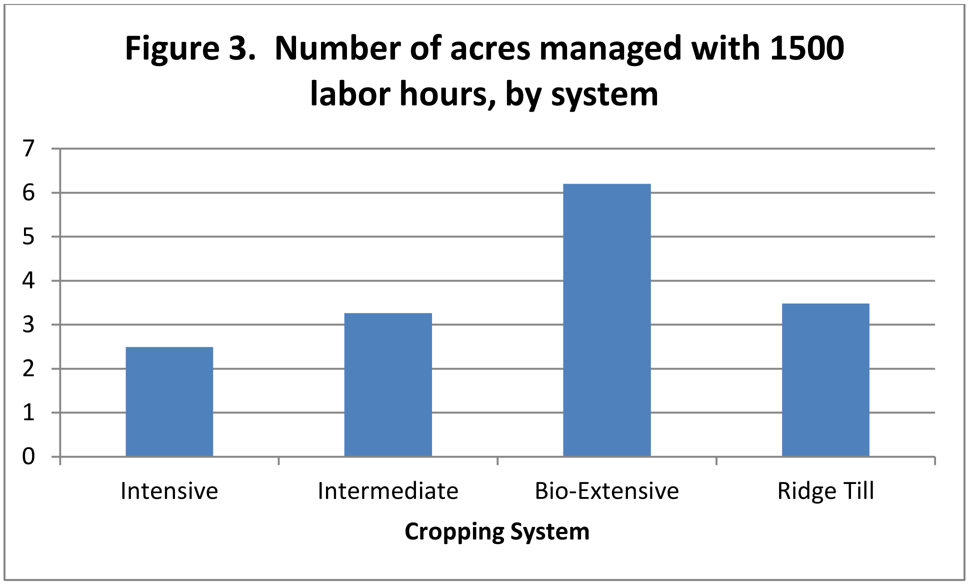
Because most vegetable producers in the Northeast grow their full array of crops each year, we also provide a more holistic analysis in which farms using each of the four systems produce all four phases of the crop rotation in a given year. This mimics the results of farmers who grow cabbage, lettuce, potatoes and squash following the different management practices of the four systems. Overall net returns to land varied widely among systems (Figure 1). Returns to labor varied much less so (Figure 2). 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.



Because of its double-cropping, System 1 (High Intensity) produced the highest return per acre and per labor hour. Remarkably, the highly experimental System 4 (Ridge-till) had only slightly lower returns per hour of operator labor than System 1 (High Intensity) and System 2 (Intermediate Intensity), which are more traditional organic cropping systems. A System 3 (Bio-extensive) farmer manages more land than the others with 1500 hours of labor (Figure 3), but because of lower return per acre, overall return per hour are not as high. Although System 3 (Bio-extensive) produced good yields during the cash crop years, these could not fully compensate for the additional expenses in the fallow year, and returns were lower per hour (27%) and per acre (69%).



Results in Figure 1 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. 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 non-fallow years. System 3 (Bio-extensive) attempts to substitute land, machinery, and materials for labor, but is not fully successful.



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 are similar to those in Table 3, in which all cash crops are included.

Sensitivity Analysis

With the data at hand, 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 differed between the two entry points. Data from early years of the second crop rotation of the experiment have shown additional variability in costs and yields.

Yield is one of the most variable factors in the OCS experiment, and yields have an large effect on profitability. We observed yield differences between years of 5% to over 50% for various crops and systems. 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 given change in yield has a somewhat larger 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.

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 production returns for these small scale farms which use a lot of manual labor, and less machinery (and fuel) than conventional farms. However, transport of the crops to market would likely be strongly affected by fuel prices.

Our baseline analysis assumed that marketing costs were 20% of gross receipts, but this varies for real farms. Overall, changes in marketing costs led to relatively small changes in net returns. A 10% decrease in marketing costs (to 17.8% of the gross receipts) leads to approximately a 3% increase in net returns across the various systems.

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. 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 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

Our results indicate that the net returns to both land and labor range widely across crops and different systems generate the highest net returns for different crops. System 1, a high intensity system with double cropping in 2 of 4 years, generated the highest net returns per acre or per labor hour over the full rotation. Overall, the most striking result of our analysis is that whole farm net returns per hour were fairly 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 similar to System 2 (Intermediate Intensity) or System 4 (Ridge Till) that use cover crops to reduce weeds and improve soil quality may result in little loss of net return to labor for small-scale producers. Under our level of management, the Bio-Extensive approach of System 3 led to lower returns per labor hour. In future articles, our research team will address long-term soil and ecological performance of these systems.

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 ($)	**165.54**	**158.65**	**113.40**	**154.49**
Flail mow	4.28		6.42	
Moldboard plow	3.58	3.58	1.79	
Rotary mow	8.56	8.56		8.56
Disc	5.91	5.91	3.94	
Cultipacker	1.09	3.27	2.73	
Apply compost	2.89	2.89	1.44	2.89
Mark rows		1.00	0.50	1.00
Cultivate squash	5.42	5.42	2.71	2.71
Cultivate squash 2	5.42	5.42	2.71	2.71
Cultivate squash 3		2.71	2.71	2.71
Irrigate	42.00	42.00	21.00	42.00
Lay plastic	4.32			
Rotary tiller			7.49	
Springtooth harrow			4.37	
Spray	0.93	0.93	0.47	0.93
Remove and dispose of plastic	4.41			
Trap crop charge	9.69	9.69	4.85	9.69
Misc support time	52.50	52.50	26.25	52.50
Scrape ridges				9.30
Harvest machinery time	14.54	14.77	10.94	17.51
Cover crop			13.09	
Re-ridge				1.98
Material Costs ($)	**131.78**	**70.28**	**57.14**	**70.28**
Compost	60.00	12.00	7.50	12.00
Transplants	32.27	32.27	16.13	32.27
Plastic	13.50			
Spray	15.05	15.05	7.53	15.05
Trap crop	10.97	10.97	5.48	10.97
Cover Crop			20.50	
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 ($/season)	14,149	19,609	18,508	25,828
Net return per operator hour ($/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.

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	56	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 ($/lb)[c]	0.75	48.00	0.89	1.25	0.75	48.00	0.85	1.25	48.00	1.25	0.75	48.00	0.87	1.25
Price for secondary cash crop ($/lb)	4.00	3.00												
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	229.70	158.65	115.84	113.40	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	562.90	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**	**342.80**	**609.08**
Total operator hours required	81.58	89.78	44.10	25.68	56.43	56.92	45.65	24.93	30.04	18.35	55.55	54.11	36.22	26.28
Acres managed given 1500 operator hours	1.84	1.67	3.40	5.84	2.66	2.64	3.29	6.02	4.99	8.17	2.70	2.77	4.14	5.71
Net return given 1500 hours available ($/season)	54,295	38,615	12,143	14,149	46,498	37,592	13,939	19,609	30,767	19,720	47,252	34,596	5,260	25,828
Net return per operator hour ($/hour)	36.20	25.74	8.10	9.43	31.00	25.06	9.29	13.07	20.51	13.15	31.50	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.