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ABSTRACT

Relative profitability was compared for five vegetables (sweet corn, green bean, cabbage, tomato, Spanish onion) during the second and third years of transition from conventional to organic production practice. Input and output data developed in field experiments in 1991 and 1992 revealed average organic yields were significantly lower than those from conventional production systems. Decreases ranged from 8 percent for green bean to 45 percent for tomato. Input costs were generally higher for organically grown crops than for those produced conventionally. As a result of the lower yields and higher costs, profits to organic production were significantly lower than conventional at the same output price level. While all five conventionally produced vegetables showed positive profits per hectare ranging from $544 for green beans to $2,063 for cabbages, net returns from organic horticulture were negative for all five crops. The losses ranged from $732 for cabbages to $2,628 for tomatoes. For zero profit, organic produce must be priced from 13% for cabbages to 57% for sweet corn above conventionally produced vegetables. Limitations of the study, such as reliance on research station experiments and the inability of financial budgeting to capture all social costs and benefits of each production system, prevent drawing strong conclusions about the economic viability of organically grown horticulture. Since organic yields are generally lower in the transition period from conventional to organic production, additional economic analysis at a later period will be necessary.

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INTRODUCTION

In 1991, Ontario growers reported total production of 75,516 ha of commercial field vegetable crops, harvesting produce with an estimated farm value exceeding $300 million (OMAF 1992a). The vast majority of this area was managed using conventional production practices; certified organic practices were employed on only a tiny fragment of the total area. Data generated by the Organic Crop Improvement Association (OCIA) of Ontario, the most important organic certifying body in the province, show only 162 ha of certified vegetable production in 1992 (Guard 1993). OCIA Ontario, however, is not the only organic certification body in the province; other certifying organizations include Organic Crop Producers and Processors Ontario Inc. and the Society for Bio-dynamic Farming and Gardening in Ontario (Macey 1992). In addition, certified hectarage may well represent less than 10% of the area on which certifiable production is practised (Mathewson personal communication). Increasing attendance at events arranged by organic societies indicates heightened interest by growers either practising or planning to practise more sustainable production methods.

The number of farmers who have either maintained or resorted to organic or low-input methods of production has partly been a result of increasing sensitivity to potential environmental impacts of conventional farming. The trend also reflects growing concern among many consumers with possible health risks of foods that may contain minute traces of chemicals applied during production. Factors constraining widespread adoption of organic farming practice may include need for increased management, lack of extension support, a bias of farm subsidies toward conventional farming, and, most importantly, lower profits.

For organic farming to be sustainable, it is not enough that it be ecologically sound; it must also provide reasonable financial rewards to the farmer. In the literature on alternative forms of agriculture, there is a major debate on the economics of organic production. Most studies examine changes at the farm level, while others extrapolate the effects of reduced inputs at the macroeconomic level (Buttel *et al.* 1986; Batie and Taylor 1989). To date, most comparisons of organic and conventional farming have concentrated on field crops (e.g. Klepper *et al.* 1977; Berardi 1978; Helmers *et al.* 1986; Goldstein and Young 1987; Lockeretz 1987; Wynen and Edwards 1990; Smolik and Dobbs 1991; Batte 1992). No previous work has been published, to our knowledge, which compares the finanical returns from organic and conventional horticultural crop production.

The need for similar analysis of production systems in horticulture has been expressed (Cacek and Langner 1986; Francis 1990). Concern over food safety is higher for horticultural crops than for grains, since pesticide residues are more easily taken into the human food chain from vegetable and fruit crops than from grains, especially when produce is eaten fresh (Francis 1990). Therefore, consumers may be willing, for example, to pay a higher premium for organically grown tomatoes than for organic wheat flour. Horticultural crop production also is often more labour and management-intensive; organic methods are widely believed to increase such inputs.

Sustainable or organic agriculture is both a way of farming and a philosophy (MacRae *et al.* 1990). One of the principles of organic production is that each farm unit is unique and that after a number of years of organic production (ie. after transition) the system comes into balance. It is also assumed that in this holistic system there are emergent properties which help to make the agroecosystem sustainable and profitable. Among organic practitioners, however, there is no consensus on the "right" or "standard" method or organic farming (Merrill 1983; Scofield 1986). A large and growing literature debates the definition of organic agriculture; synonyms or variants include sustainable, alternative, low-input, ecological, holistic, regenerative and non-conventional farming. Rather than contribute to the debate we would note that most definitions incorporate elements of environmental soundness, food safety and economic viability, combining a philosophy of farming with a suite of farming practices. Organic growers generally replace chemical fertilizers, pesticides and crop specialization with crop and farm-generated organic residues, green manures, mineral-bearing rocks and crop rotation.

From a reductionist scientific perspective one would like to be able "prove", with controlled experiments, the value of some of the organic methods and protocols promoted by organic farmers but because of the underlying principles stated above this is not possible. However a reductionist approach comparing the two systems, while limited, should be able to identify points that are key to understanding some of the processes involved. For example, observation of changes in soil micro- meso- and macro-fauna, soil tilth and organic matter during transition from conventional to organic production comes to mind.

Indeed, a central principle of organic farming is the concept that the overall productivity of the farm depends on the health of the soil. A well balanced, biologically active soil will provide the crop with nutrients for optimum production with minimal pest and disease problems (Macey 1990). In 1990, personnel in the then Soil Pesticides Section of the London Research Centre initiated a program to monitor changes in the soil during the 5-year transition from conventional to organic vegetable production. Although primarily designed to monitor soil phenomena (arthropod populations, biological activity, structure, fertility, etc.), accurate records of vegetable yields and expenditures on material and labour have allowed us to analyze the economics of the early transition period in the context of the ORCON (ORganic-CONventional) experiment.

This paper is not meant to be a definitive work comparing organic and conventional vegetable production but does present preliminary observations on the relative costs during early transition from conventional to organic vegetable production. Using data from the second and third production years of the ORCON experiment, comparative budgets were developed for five vegetable crops in order to measure economic profitability. Relative costs of production were developed and premiums, necessary to make organic production as profitable as conventional production, calculated. Sensitivity analysis of wage rate, compost cost and yield was also undertaken.

MATERIALS AND METHODS

System Descriptions

Field plots were established in 1990 on the research farm of the London Research Centre in London, ONT (42° 59' 17" latitude N, 81° 14' 3" longitude W). Five vegetables (sweet corn, green bean, cabbage, tomato, Spanish onion) are being grown in a 5-year rotation in Embro loam (57.2% sand, 23.5% silt, 19.4% clay; 3.62% organic matter; pH 7.25). Preceding crops grown on the experimental block included double-cut red clover/vines (1989, 1988, 1987), snap bean/alfalfa (1986) and soybean (1985).

Individual experimental plots measure 8 m square and are separated from adjacent plots by grass walkways at least 2.5 m wide. The factorial experiment is a randomized complete block design with 4 blocks; vegetables (5) and production practices (2) were randomly assigned to the 10 plots within each block. Growing conditions were markedly different each year. From May-August 1991 (second transition year), temperature averaged 19.5°C and rainfall totalled 317.5 mm; the same parameters for 1992 (third transition year) were 16.1°C and 463.8 mm respectively.

Each year vegetable cultivars, planting densities and planting dates were identical for organic and conventional plots (Table 1). Both organic and conventional vegetables followed the same 5-year, sweet corn, Spanish onion, tomato, cabbage, snap bean, sweet corn rotation (Coleman 1989). Soil pH and concentrations of P, K and Mg were analyzed each autumn by the Dept. of Land Resource Science, U. of Guelph, for soil samples, collected separately from plots producing each vegetable in both production systems. A tractor-mounted rototiller provided primary tillage in all plots.

Table 1. Production Parameters for Vegetables and Inter-Crops in ORCON Experiment, 1991-1992

	Sweet Corn	Green Beans	Cabbage	Tomatoes	Spanish Onions
1991					
Cultivar	Early Gold & Silver	Speculator	Market Prize	Basketvee	Riverside Sweet
Planting Date	04/06	30/05	13/06	22/05	08/05
Number Rows[z]	8	8	7	3x2 row beds	13
Row Spacing[z]	0.9 m	0.9 m	1.0 m	0.5 m (row) 1.0 m (bed)	0.6 m
Plant Spacing[z]	22-25 cm	5-8 cm	50 cm	50 cm	15 cm
Harvest Date	20/08	22/07-01/08 (4 picks)	06/09	06/08-30/08 (4 picks)	26/08
Harvest Area[z]	2 rows	2 x 6 m	2 rows	2 rows (1 bed)	2 rows x 2
Inter-Crop:					
Type	soybean	crimson clover	crimson clover	oats	crimson clover
Cultivar	Maple Glen	common	common	common	common
Planting Density	13.5 kg/ha	10.4 kg/ha	9.2 kg/ha	155 kg/ha	10.0 kg/ha
Planting Date	10/07	24/07	10/07	05/09	03/07
Vegetable Stage	9-10 leaves	35-38 cm	head initiiation	post harvest	8-11 leaves
1992					
Cultivar	Early Gold & Silver	Speculator	Tristar	ONT 7710	Vega
Planting Date	04/06	08/06	04/06	28/05	13/05
Harvest Date	01/09	25/08-08/09 (4 picks)	20/08	31/08-23/09 (4picks)	14/09
Inter-Crop:					
Type	soybean	oats	hairy vetch	oats	hairy vetch
Cultivar	Maple Glen	common	common	common	common
Planting Density	13.5 kg/ha	155 kg/ha	12.5 kg/ha	155 kg/ha	13.5 kg/ha
Planting Date	07/07	15/09	07/07	16/09	07/07
Vegetable Stage	7 leaves	post harvest	head initiiation	harvest	7-8 leaves

[z] Production information identical in 1991 and 1992

Nitrogen (N) application to conventional vegetables was as specified by OMAF (OMAF 1990; OMAF 1992b) for optimum productivity; phosphorus (P) and potassium (K) requirements were calculated by subtracting results of soil analysis from optimum fertility recommendations (OMAF 1990; OMAF 1992b). Amounts, timing and types of fertilizers (manufactured by C.I.L. Canada, Inc.) applied are listed in crop budgets in Tables 2-6. Pesticides were applied to conventional plots using a hand-held, CO_2-pressurized field sprayer using volumes, nozzles and pressure appropriate for the pest being controlled. Subsequent analysis of soil and vegetable samples verified that low pressure pesticide application at wind speeds $\leq$ 8 km/hr eliminated drift to adjacent plots. Applied pesticides are again listed in crop budgets in Tables 2-6. Inter-row cultivation and supplementary hoeing, if necessary, controlled weeds escaping herbicide application in conventional plots.

Each year fertility (% N, %P, %K) of research farm-generated compost (grass clippings, spoiled hay, composted leaves, cow manure, crop residue, soil) was measured by Dept. of Land Resource Science, U. of Guelph. Prior to planting each spring, compost sufficient to provide N for optimum vegetable productivity (OMAF 1990; OMAF 1992b) was then uniformly added to each plot. When added compost did not contain quantities of P and K indicated by results of soil analysis, supplementary ground rock phosphate (0-3-0; Canton Mills Inc., 160 Main St., Minnesota City, MN, USA) and/or greensand (0-0-7; Zook & Ranck Inc. R.D. #1, Gap, PA, USA) was also spread uniformly over each plot. Both compost and supplementary fertilizers were then incorporated by a single pass of the tractor-mounted rototiller.

Inter-row cultivation, supplemented as necessary by hoeing, controlled weeds in organic plots. Thuricide HPC, applied to cabbage, (Table 4) was the only control measure for insects applied to organic plots; no control measures for diseases were applied to organic plots. (Note: More aggressive control measures for insects and disease have been applied to organic plots in subsequent years of the study).

Intercrops and cover crops, established in organic plots, contributed a degree of soil protection, weed suppression, organic matter and fixed nitrogen (Macey 1992) to those plots. Intercrop type, planting date and density are shown in Table 1. To minimize competition effects, intercrops were not planted until the main vegetable in each plot was well established (Table 1). Prior to planting intercrops, each plot was row-cultivated to loosen soil and remove weeds. Intercrops were sown with a single row Planet Jr. planter, no closer than 15 cm to vegetable rows.

Harvest dates and areas for each vegetable are shown in Table 1. Vegetables from guard rows and row ends were not included in harvest analysis. Harvested produce was graded according to the "Fresh Fruit and Vegetable Regulations of the Canada Agricultural Products Standards Act". Harvest data were analyzed by analysis of variance for a one (tomato) or two factor (sweet corn, snap bean, cabbage, Spanish onion) randomized complete block design, using production practice as the main effect and row replicate, where appropriate, as the second factor (MSTAT Development Team 1988). Marketable yields were then transformed to t/ha for presentation.

Budget Preparation

Data from the ORCON experiment were combined with Ontario provincial farm survey data to construct synthetic budgets for growing the five vegetable crops under conventional and organic systems. Output prices for conventionally produced horticulture were taken from Dickson *et al.* (1991), and represent the nominal average of province wide averages from 1986 to 1990. Price data for organically grown vegetables are scarce. One retail source reported that organic vegetables were generally priced 20 percent higher than non-organic produce (King 1991). For the baseline results, output price was assumed to be identical for the two production systems. This is a realistic assumption because during the transition period the produce would not be eligible for certification, and a premium would not be realized. Output price was then varied to determine the sensitivity of the results to its changes.

Baseline yields for conventional production are taken from the OMAF estimations (Dickson *et al.* 1991) and reflect five-year averages of production across the province of Ontario. Yields from the conventional research plots were generally much higher than province-wide averages, in part reflecting production under optimal conditions specified in OMAF guidelines. Baseline yields for organic production were calculated by adjusting the provincial (conventional) estimates by the organic/conventional yield ratio obtained in the research experiments.

Pesticide costs and application costs were obtained from OMAF (1991a; 1991b). Fertilizer prices were based on province-wide averages from survey data. For the baseline results, the hourly labour rate used was $7.25 for unskilled labour, and $8.25 for machinery operator labour. Sensitivity analysis was also carried out on this parameter.

Labour for organic production was calculated by deleting irrelevant operations from OMAF (conventional) budgets, and adding or adjusting relevant operations based on ORCON records. For organic weed control costs, the number of row cultivations was doubled. In the case of cabbages, tomatoes and Spanish onions, hand hoeing requirements on organic plots were estimated by multiplying the OMAF figure by a factor obtained by ORCON experimenters. For sweet corn and green beans, where hand hoeing was not included in conventional production, it was assumed that 40 hours of hand hoeing were required in the organic system.

The price of compost, an important input in organic production, is difficult to estimate because the market is very thin. The budgets include an estimate taken from a mushroom farm, which produced "spent" compost for sale in 1992 at $150 per dump truck delivered (equivalent to $5.75 per cubic yard, or $21.50 per ton). Superior compost is also available from garden centres at much higher cost ($20 per cubic yard), but it is unlikely that organic farmers would purchase at this price. A survey by Stonehouse (1984) on the economics of compost use showed great variation in the market value of organic wastes- from as low as $4.00 per tonne (in 1984) for composted sludge to $85 per tonne for bagged potting medium. This study thus chose a value in the lower end of this range. Sensitivity analysis on this parameter is presented below.

Equipment costs of most field operations and capital depreciation were taken from Dickson *et al.* (1991). Although ORCON experimenters recorded manual and machine input use, the small size of the plots and consequent reliance on manual labour was not representative of production on a commercial scale. Although machinery age and farm size may differ between the farming systems, machinery costs were assumed to be identical for organic and conventional budgets. Some observers contend that organic producers tend to use less equipment, and that they tend to buy used equipment, suggesting that machinery costs may be lower in an organic system. However, this equipment may be used on smaller farms making the per-hectare equipment expense more costly. The issue of size of organic farms vis-a-vis conventional is not clear. Evidence from the U.S. suggests that farmers who practice low-input strategies have larger farms (Francis 1990), yet a Canadian source (Hill 1984) indicates that the average acreage of southern Ontario organic farms is smaller than the average conventional system farm.

The costs of equipment operation depends in part on the amount of crop harvested. Because the research plot yields were not representative of Ontario farms, the OMAF estimates were used in the synthetic budgets to determine equipment costs, adjusted downward by the organic/conventional yield ratios in the case of the organic budgets.

RESULTS AND DISCUSSION

Cost Comparison

The cost of production for each of the five vegetable crops grown under organic and conventional methods is given in Tables 2 through 6. The budgets aggregate costs into three categories: machinery (capital depreciation, fuel, repairs), labour costs, and purchased

Table 2. Synthetic Sweet Corn Budgets for Conventional and Organic Systems ($ ha^{-1}) in Southern Ontario, 1991

Cost	Organic Quantity	Organic Price	Organic Cost	Conventional Quantity	Conventional Price	Conventional Cost
Machinery						
Depreciation			$261.82			$261.82
Interest			175.37			175.37
Other overhead			148.20			148.20
Repairs			214.69			261.82
Rental			10.13			12.35
Fuel			50.64			61.75
Total Machinery Costs			$860.85			$921.31
Labour						
Plowing	1.11	8.25	$ 9.17	1.11	8.25	$ 9.17
Spread fertilizer	0.32	8.25	2.64	0.32	8.25	2.64
Spread compost	0.48	8.25	3.96			
Incorporate herbicide				0.37	8.25	3.06
Cultivate and level	0.72	8.25	5.94	0.72	8.25	5.94
Plant- Corn	0.82	8.25	6.72	0.82	8.25	6.72
Plant- Cover crop	0.72	8.25	5.94			
Row Cultivation	0.72 (4)	8.25	23.76	1.63 (2)	8.25	26.90
Hand hoeing	40.00	7.25	290.00			
Insecticide application				0.64 (5)	8.25	26.49
Harvest	69.09	7.25	500.91	117.10	7.25	848.99
Transport to market	4.01	7.25	29.05	6.79	7.25	49.25
Total Labour Costs			$878.10			$979.17
Purchased Inputs						
Corn seed	11.12	11.00	$122.27	11.12	11.00	$122.27
Cover crop seed	13.50	0.65	8.78			
Mesh bags	118.00	0.75	88.90	200.00	0.75	150.67
Compost	43.75	21.43	937.50			
Fertilizer						
0-8-0 (broadcast)	363.00	0.06	21.78			
0-0-7 (broadcast)	385.00	0.03	11.55			
34-0-0 (broadcast)				135.00	0.23	31.05
0-0-60 (broadcast)				15.00	0.19	2.85
6-24-24 (starter)				85.00	0.24	20.40
34-0-0 (side-dress)				115.00	0.29	33.35
Pesticides						
Dual 960E (metolachor)				2.75	19.40	53.35
Bladex Nine-T (cyanazine)				2.75	16.39	45.07
Cymbush 250EC (cypermethrin)				0.28 (3)	90.30	75.85
Ambush 500EC (permethrin)				0.23 (2)	150.82	67.87
Total Purchased Inputs			$1,190.77			$602.73
Total Costs			$2,929.71			$2,503.11

Figures in parentheses refers to the frequency of application or operation.
Apparent arithmetic errors are due to rounding.
Quantities of inputs are measured in hours for labour and kg or liters for purchased inputs, except for compost which is measured in tonnes, and bags which are measured in units.

Table 3. Synthetic Green Bean Budgets for Conventional and Organic Systems (\$ ha^{-1}) in Southern Ontario, 1991.

Cost	Organic Quantity	Organic Price	Organic Cost	Conventional Quantity	Conventional Price	Conventional Cost
Machinery						
Depreciation			$24.70			$24.70
Interest			17.29			17.29
Other overhead			61.75			61.75
Repairs			37.05			24.70
Rental			18.53			12.35
Fuel			22.23			14.82
Total Machinery Costs			$181.55			$155.61
Labour						
Plowing	1.11	8.25	$ 9.17	1.11	8.25	$ 9.17
Spread fertilizer	0.32	8.25	2.64	0.32	8.25	2.65
Spread compost	0.48	8.25	3.96			
Incorporate herbicide				0.72	8.25	5.94
Cultivate and level	0.72	8.25	5.94	0.72	8.25	5.94
Plant- Green beans	0.54	8.25	4.48	0.54	8.25	4.48
Plant- Cover crop	0.72	8.25	5.94			
Row Cultivation	0.72 (4)	8.25	23.76	0.45	8.25	3.71
Hand hoeing	40.00	7.25	290.00			
Harvest	262.20	7.25	1,900.95	285.00	7.25	2,066.25
Transport to market	2.27	7.25	16.47	2.27	7.25	16.46
Total Labour Costs			$2,263.27			$2,114.64
Purchased Inputs						
Green bean seed	79.71	3.56	$283.78	79.71	3.56	$283.78
Cover crop seed	10.40	5.00	52.00			
Baskets	264.00	0.75	198.00	287.00	0.75	215.25
Compost	43.75	21.43	937.50			
Fertilizer						
0-8-0 (broadcast)	238.00	0.06	14.28			
34-0-0 (broadcast)				45.00	0.23	10.35
0-0-60 (broadcast)				65.00	0.19	12.35
Pesticides						
Dual 960E (metolachlor)				2.75	19.40	53.35
Patoran 50WP (metobromuron)				3.00	20.19	60.57
Total Purchased Inputs			$1,485.55			$635.65
Total Costs			$3,930.37			$2,905.90

Figures in parentheses refers to the frequency of application or operation.
Apparent arithmetic errors are due to rounding.
Quantities of inputs are measured in hours for labour and kg or liters for purchased inputs, except for compost which is purchased in tonnes, and baskets which are measured in units.

Table 4. Synthetic Cabbage Budgets for Conventional and Organic Systems (\$ ha^{-1}) in Southern Ontario, 1991.

Cost	Organic Quantity	Organic Price	Organic Cost	Conventional Quantity	Conventional Price	Conventional Cost
Machinery						
Depreciation			$274.17			$274.17
Interest on overhead			182.78			182.78
Other overhead			148.20			148.20
Repairs			301.597			274.17
Rental			13.59			12.35
Fuel			73.56			66.69
Total Machinery Costs			$993.89			$958.36
Labour						
Plowing	1.11	8.25	$ 9.17	1.11	8.25	$ 9.17
Spread fertilizer	0.32	8.25	2.64	0.32	8.25	2.65
Spread compost	0.48	8.25	3.96			
Haul plants and water	0.52	8.25	4.28	0.52	8.25	4.28
Cultivate and level	0.72	8.25	5.91	0.72	8.25	5.91
Plant- Cabbage	19.71	8.25	162.61	19.71	8.25	162.61
Plant- Cover crop	0.72	8.25	5.94			
Row cultivation	0.72(4)	8.25	23.76	0.72	8.25	5.91
Cultivate and sidedress				0.77	8.25	6.32
Hand hoeing	32.00	7.25	232.00	12.35	7.25	89.54
Insecticide application	0.64(3)	8.25	15.84	0.64 (3)	8.25	15.89
Fungicide application				0.64	8.25	5.30
Harvest and transport	130.78	7.25	948.17	161.46	7.25	1,170.61
Total Labour Costs			$1,414.29			$1,478.19
Purchased Inputs						
Cabbage plants	33,345	0.03	$901.55	33,345	0.03	$901.55
Cover crop seed	9.20	5.00	46.00			
Boxes	481.00	1.75	841.750	602.00	1.75	1,053.50
Compost	87.50	21.43	1,875.00			
Fertilizer						
0-8-0 (broadcast)	2475.00	0.06	148.50			
0-0-7 (broadcast)	345.00	0.03	10.35			
11-52-0 (broadcast)				210.00	0.30	63.00
34-0-0 (broadcast)				430.00	0.23	98.90
Pesticides						
Dacthal 75WP (chlorothal dimethyl)				13.00	19.53	261.30
Ambush 500EC (permethrin)				0.14 (2)	150.82	42.23
Agral 90 (wetting agent)				0.60 (2)	9.17	11.00
Bravo 500F (chlorthal dimethyl)				3.20	10.11	32.35
Thiodan 4EC (endosulfam)				1.75	8.97	15.70
Thuricide HPC (Bacillus thuringiensis)	4.00 (3)	12.67	152.04			
Molasses	3.00 (3)	0.25	2.25			
Total Purchased Inputs			$3,977.44			$2,479.53
Total Costs			$6,385.62			$4,916.08

Figures in parentheses refers to the frequency of application or operation.
Apparent arithmetic errors are due to rounding.
Quantities of inputs are measured in hours for labour and kg or liters for purchased inputs, except for compost which is measured in tonnes, and plants and boxes which are measured in units.

Table 5. Synthetic Tomato Budgets for Conventional and Organic Systems ($ ha^{-1}) in Southern Ontario, 1991.

Cost	Organic Quantity	Organic Price	Organic Cost	Conventional Quantity	Conventional Price	Conventional Cost
Machinery						
Depreciation			$281.58			$281.58
Interest on overhead			187.72			187.72
Other overhead			148.20			148.20
Repairs			149.24			281.58
Rental			6.55			12.35
Fuel			40.58			76.57
Total Machinery Costs			$813.87			$988.00
Labour						
Plowing	1.11	8.25	$ 9.17	1.11	8.25	$ 9.17
Spread fertilizer	0.32	8.25	2.65	0.32	8.25	2.65
Spread compost	0.48	8.25	3.96			
Incorporate herbicide				0.37	8.25	3.06
Cultivate and level	0.72	8.25	5.91	0.72	8.25	5.91
Haul plants and water	0.52	7.25	3.76	0.52	7.25	3.76
Plant- Tomato	27.12	7.25	196.62	27.12	7.25	196.62
Plant- Cover crop	0.32	8.25	2.64			
Row Cultivation	0.72 (4)	8.25	23.76	0.72 (2)	8.25	11.88
Hand hoeing	69.00	7.25	500.25	12.35	7.25	89.54
Fungicide application				0.65 (8)	8.25	43.04
Cultivate and side-dress	-			0.77	8.25	6.32
Harvest and transport	387.39	7.25	2,808.60	704.35	7.25	5,106.50
Total Labour Costs			$3,557.35			$5,478.44
Purchased Inputs						
Tomato plants	19,760	0.04	$691.60	19,760	0.04	$691.60
Cover crop seed	155.00	0.24	37.20			
Masters	1,352	0.75	1,013.78	2,458	0.75	1,843.50
Baskets	8,110	0.12	973.23	14,748	0.12	1,701.00
Compost	87.50	21.43	1,875.00			
Fertilizer						
0-8-0 (broadcast)	850.00	0.06	51.00			
0-0-7 (broadcast)	5340.00	0.03	160.20			
34-0-0 (broadcast)				135.00	0.29	39.15
0-0-60 (broadcast)				535.00	0.19	101.65
6-24-24 (starter)				330.00	0.26	85.80
34-0-0 (side-dress)				85.00	0.29	24.65
Pesticides						
Treflan EC (trifluralin)				1.50	11.83	17.75
Sencor 75DF (metribuzin)				0.75	69.75	52.31
Bravo 500F (Chlorothalonil)				3.20 (5)	10.11	161.76
Tricop 53WP (copper)				3.00 (3)	7.25	65.25
Dithane M-45 (mancozeb)				2.25 (3)	8.13	54.88
Total Purchased Inputs			$4,802.01			$4,839.30
Total Costs			$9,173.23			$11,305.74

Figures in parentheses refers to the frequency of application or operation.
Apparent arithmetic errors are due to rounding.
Quantities of inputs are measured in hours for labour and kg or liters for purchased inputs, except for compost which is measured in tonnes, and plants, masters and baskets which are measured in units.

Table 6. Synthetic Spanish Onion Budgets for Conventional and Organic Systems ($ ha^{-1}) in Southern Ontario, 1991.

Cost	Organic Quantity	Organic Price	Organic Cost	Conventional Quantity	Conventional Price	Conventional Cost
Machinery						
Depreciation			$573.04			$573.04
Interest			382.85			382.85
Other overhead			247.00			247.00
Repairs			127.21			254.41
Rental			6.18			12.35
Fuel			86.45			172.90
Total Machinery Costs			$1,422.73			$1,642.55
Labour						
Plowing	1.11 (2)	8.25	$ 18.32	1.11 (2)	8.25	$ 18.32
Spread fertilizer	0.32	8.25	2.64	0.32	8.25	2.65
Spread compost	0.48	8.25	3.96			
Herbicide application				0.65	8.25	5.37
Plant- Spanish onion	126.20	7.25	914.95	126.20	7.25	914.95
Plant- Cover crop						
Hand hoeing	59.00	7.25	427.75	22.23	7.25	161.17
Insecticide application				0.64 (3)	8.25	15.84
Fungicide application				0.64 (2)	8.25	10.56
Harvest and transport	14.28	7.25	103.50	18.54	7.25	134.40
Total Labour Costs			$1,482.99			$1,263.26
Purchased Inputs						
Spanish onion seedlings	160550	0.01	$1,605.50	160550	0.01	$1,605.50
Cover crop seed	10.00	5.00	50.00			
Compost	87.50	21.43	1,875.00			
Fertilizer						
0-8-0 (broadcast)	1740.00	0.06	104.40			
0-0-7 (broadcast)	1385.00	0.03	41.55			
34-0-0 (broadcast)				225.00	0.29	65.25
6-24-24 (broadcast)				550.00	0.26	143.00
Pesticides						
Dacthal 75WP (chlorthal dimethyl)				13.00	19.53	253.89
Cymbush 250EC				0.28 (3)	90.38	149.13
Agral 90 (wetting agent)				0.60 (4)	9.17	22.01
Dithane M-45 (mancozeb)				3.25 (2)	8.13	52.85
Total Purchased Inputs			$3,676.45			$2,291.62
Total Costs			$6,582.17			$5,197.43

Figures in parentheses refers to the frequency of application or operation.
Apparent arithmetic errors are due to rounding.
Quantities of inputs are measured in hours for labor and kg or liters for purchased inputs, except for compost which is measured in tonnes, and seedlings which are measured in units.

inputs (including compost which may or may not be produced on the farm). For most crops, organic production is more costly than conventional by 17% (sweet corn) to 35% (green beans). The exception is tomatoes where much lower organic yields meant proportionally lower harvesting and container costs. The higher cost of organic systems might seem surprising, since it is often described as "low-input" farming. It is difficult to generalize about labour costs. Most sources consider labour use to be much higher with organic production (Klepper *et al.* 1977; Berardi 1978; Domanico *et al.* 1986; Stonehouse *et al.* 1993). Labour costs were similar under organic and conventional for green beans and Spanish onions. Labour costs of organically grown sweet corn, cabbages and tomatoes were lower than the conventional production system partly due to lower yields and hence harvesting costs.

The greatest contrast among costs was seen in purchased input expenditures, which are generally higher for organic production. The difference approximated the cost of application of compost to organic plots less the cost of pesticide application to conventional plots for the same vegetable. This contrast would not exist in the case where organic farmers do not purchase compost but produce it on the farm. Purchased input costs for tomatoes were similar in both systems, largely due to higher costs of masters and baskets associated with greater yields from conventional plots.

Total pest control costs, including cost of herbicide and, where necessary, row cultivation plus hoeing, are shown in Table 7. Illustrated costs are actual costs developed for the ORCON experiment in 1991 and 1992 and only indirectly reflect results of the synthetic budgets (Tables 2-6). The major difference between ORCON costs and the synthetic budgets is higher labour requirements of research plots, especially for organic production.

With the exception of sweet corn in 1991, pest control costs for the organic system exceeded those for the conventional system (Table 7), largely due to higher labour requirements of organic production. Pest control costs were generally highest for Spanish onions where narrow row spacing prevented row cultivation. Waterlogged soil following

Table 7. Costs of Pest Control [z] ($ ha^{-1}) under Organic and Conventional Systems, 1991-1992

	Sweet Corn	Green Beans	Cabbage	Tomatoes	Spanish Onions
1991					
Organic	381	454	743	1,393	1,139
Conventional	644	242	647	972	1,082
1992					
Organic	1,131	687	1,536	1,652	3,506
Conventional	443	202	839	738	1,711
Organic/Conventional Ratio					
1991	0.59	1.87	1.15	1.43	1.05
1992	2.55	3.41	1.83	2.24	2.05
Average	1.57	2.64	1.49	1.84	1.55

[z] Costs of pest control includes manual and machine cultivation, herbicides, insecticides and fungicides incurred at ORCON experimental plots

significantly higher rainfall in 1992 stimulated weed growth and prevented row cultivation, increasing relative costs of pest control in the organic system.

Yield Comparison

Vegetable yields from the ORCON experiment for 1991 and 1992 are shown in Table 8. Averaged over two years, yields from organic plots were significantly lower than yields from conventional plots; reductions ranged from 8% for green beans to 45% for tomatoes. Comparable values reported for organic cereals range from 8.8%-29% (Berardi 1978; Painter 1991; Batte 1992). The relative difference in yields between the two systems was consistent over the two years for cabbage and Spanish onions. Although a similar pattern was noted for sweet corn, reasons for lower sweet corn yields were quite different each year. In 1991, inability to control damage by high populations of European corn borer (ECB) lowered yields in organic plots. In 1992, low ECB populations had a minor effect on sweet corn yield. Cold wet soil following planting promoted seedling diseases; severely reducing seedling establishment from untreated sweet corn seed.

Table 8. Marketable Vegetable Crop Yields (tonnes ha^{-1}) under Organic and Conventional Systems, 1991-1992.

	Sweet Corn	Green Beans	Cabbage	Tomatoes	Spanish Onions
1991					
Organic	11.03	7.94	27.93	39.33	15.68
Conventional	16.84	9.53	34.80	50.73	21.74
1992					
Organic	7.36	6.86	52.48	15.13	18.87
Conventional	13.88	6.85	64.85	48.00	22.78
Organic/Conventional Ratio					
1991	0.65^{z}	0.83	0.80^{z}	0.78^{z}	0.72^{z}
1992	0.53^{z}	1.00	0.81^{z}	0.32^{z}	0.83^{z}
Average	0.59	0.92	0.81	0.55	0.77
1991 Ont Avg ^{y}	7.90	3.92	27.06	23.74	19.31

^{z} - yield from organic plots significantly less than yield from conventional plots ($p < 0.05$)
^{y} - Dickson *et al.* 1991.

Adverse weather also affected green bean yield in 1992. Green beans were replanted following an early summer frost on 21 June. Herbicide residues in conventional plots stunted subsequent regrowth of green beans, reducing yields in those plots. Tomato yields were also affected by cool, wet weather in 1992. As yields plummeted in organic plots infested by anthracnose, timely fungicide applications controlled the disease in conventional plots.

Net Returns Comparison

Gross returns for conventional production of each vegetable were calculated by multiplying the 1991 average Ontario yield (Table 8) by the 5-year average price for the appropriate vegetable (Table 9). Yields for calculation of gross returns for organic production were adjusted downward by the average ratio of yields measured in the ORCON plots (Table 8). Costs developed in the synthetic budgets (Tables 2-6) were then subtracted to determine crop profitability under each production system. The resulting net returns to land and management of the two production methods for each of the five vegetable crops are

Table 9. Vegetable Net Returns ($ ha^{-1}) under Organic and Conventional Systems

Crop		Price ($ $tonne^{-1}$)	Organic	Conventional	Difference
Sweet Corn	Revenue	400	1,864	3,162	
	Costs		2,930	2,503	
	Net Returns		(1,065)	659	1,724
Green Beans	Revenue	880	3,174	3,450	
	Costs		3,930	2,906	
	Net Returns		(757)	544	1,301
Cabbages	Revenue	258	5,654	6,979	
	Costs		6,386	4,916	
	Net Returns		(732)	2,063	2,795
Tomatoes	Revenue	507	6,545	11,898	
	Costs		9,173	11,305	
	Net Returns		(2,628)	593	3,221
Spanish Onions	Revenue	324	4,819	6,258	
	Costs		6,582	5,197	
	Net Returns		(1,764)	1,061	2,825

given in Table 9. All conventionally produced vegetables showed positive profits per hectare ranging from $544 for green beans to $2,063 for cabbages. In contrast, net returns from organic horticulture were negative for all five crops. The losses ranged from $732 for cabbages to $2,628 for tomatoes.

Sensitivity Analysis

The sensitivity of net returns between the two systems was examined by altering the two components which determine gross revenues, price and yield, along with the costs of two important inputs, labour and compost. The level of these variables at which the organic systems would break even and at which their net returns would be the same as under the conventional system were determined for the five vegetable crops. The results of the sensitivity analysis are given in Table 10.

Output Price. In the market place, organic produce generally commands higher prices than conventionally produced alternatives because of higher demand for limited quantities of residue-free produce. In some cases, this premium may be reduced by the inferior appearance of produce grown without pesticides (Henning *et al.* 1991). For zero profit, organic produce must be priced from 13% for cabbage to 57% for sweet corn above conventionally produced vegetables. To be competitive with conventional profits, the premiums must be 41 to 92 percent higher.

Yield. In order for the organic systems to break even, yields must increase by 19% for cabbage and up to 148% for tomatoes. The difference in percentage increase as compared to the break even percentage increase on output price reflects the impact of yields on costs for harvesting and containers. With the exception of cabbage, the break-even yield levels are above the provincial five-year average yields for the respective crops. To be competitive with the conventional systems, yields for all crops must be significantly above the present provincial average.

Table 10. Sensitivity Analysis of Net Returns for Organic Systems

Variable		Sweet Corn	Green Beans	Cabbage	Tomatoes	Spanish Onions
Output Price ($/tonne)	Break even	629 (57)	1,090 (24)	291 (13)	711 (40)	443 (37)
	Equal with Conventional	770 (92)	1,241 (41)	385 (49)	757 (49)	514 (59)
Yield (tonne/ha)	Break even	8.67 (86)	6.13 (70)	26.08 (19)	32.27 (148)	20.37 (37)
	Equal with Conventional	11.09 (138)	7.97 (120)	37.92 (73)	36.66 (182)	23.79 (59)
Wage rate ($/hour)	Break even	-1.65 (-121)	5.16 (-33)	3.74 (-52)	2.02 (-74)	-1.47 (-119)
	Equal with Conventional	-7.46 (-196)	3.30 (-57)	-7.57 (-198)	0.73 (-91)	-7.01 (-190)
Compost cost ($/tonne)	Break even	-2.92 (-114)	4.13 (-81)	13.06 (-39)	-8.60 (-140)	1.27 (-94)
	Equal with Conventional	-17.96 (-184)	-8.36 (-139)	-10.46 (-149)	-15.37 (-172)	-10.85 (-151)

Figures in parentheses are the percentage change from present level.

Wage Rate. The break-even wage rates for organically grown green beans, cabbages, and tomatoes were within ranges at which labour could be hired. The break-even wage rate was negative for sweet corn and Spanish onions under organic farming conditions. An increase in wage rate decreases profit for both organic and conventional farming but the percentage decrease is, on average, higher under conventional than organic farming. Under conventional farming, the percentage decrease in net returns for a one percent increase in the wage rate was highest for tomatoes (9.2%) and lowest for cabbage (0.7%) while under organic farming conditions, it was highest for green beans (3.0%) and lowest for sweet corn (0.8%). The difference between systems and crops is largely a reflection of the importance of labour as a proportion of total cost.

Compost Costs. The break-even compost price for green beans and cabbage is positive and may be within the range of possibility. Organically grown Spanish onions could break even if the compost could be obtained at $1.27 per tonne. However, the break-even price of compost for the other two organic crops was negative, suggesting that even with free compost, farmers would still find production unprofitable.

In summary, for all vegetables studied (sweet corn, green beans, cabbage, tomatoes, Spanish onion), average yields for the second and third years of transition, were lower in the organic production system; yield reductions ranged from 8% for green beans to 45% for tomatoes. Input costs were higher for organically than for conventionally produced vegetables. While conventional production proved profitable for all five vegetables, net returns were negative for all vegetables produced organically. For zero profit, organic produce must be priced from 13% (cabbage) to 57% (sweet corn) above conventionally produced vegetables.

CONCLUSIONS

According to Cacek and Langner's 1986 survey of the economics of organic systems, "Organic farming is economically feasible and can compete with conventional farming, at least in certain geographic areas and for certain farming enterprises" (Cacek and Langner 1986, p. 26). Results of our study, however, indicate that vegetable production early in the transition from conventional to organic production, does not realise economic profitability.

Several limitations of this study, however, must temper conclusions about the economic viability of organic vegetable production. One limitation is the use of relatively small 64 m^2 plots, a compromise among the need for replication, on uniform soil type, for statistical reliability, the number of vegetable crops necessary for a meaningful rotation and plots large enough for significant yields and sampling programs. To compensate, we have attempted to extrapolate collected data to realistic farm situations. An additional feature of full-scale organic production, not encompassed by our current trial, is inclusion of a cash or forage crop in the rotation. Many organic growers, employing such crops to enhance fertility or weed management programs, also recognize financial benefits that may well improve overall profitability of their farms (Macey 1992).

Another limitation is the inability of financial budgeting to capture the true costs and benefits that accrue to organic or conventional production strategies. Short-term financial profitability presents a very narrow focus of the attractiveness of organic farming. Synthetic budgets do not account for benefits of organic practice such as improved soil structure and tilth. Conversely, the budgets do not consider potential environmental and health costs often attributed to conventional production practice. If policy were enacted forcing conventional farmers to incur costs of these externalities, organic farming might well become more attractive. The most important limitation is that our results are preliminary - indicative only of events early in the transition to organic production. There is evidence to suggest organic yields are particularly low early in the transition period (Dabbert and

Madden 1986). Further economic analysis at the end of the first rotation cycle will be essential.

Despite these limitations, this study provides economic information which should be considered by vegetable growers contemplating conversion of all or part of their farm to organic production. Profit may be neither a necessary nor a sufficient condition for the practice of organic farming. The principles of sustainable production through environmental compatibility is so important to some practitioners that they have accepted the probability of reduced financial compensation. Given the likelihood of short-term financial losses, it seems probable that only potential organic practitioners with a genuine commitment to organic principles will initiate the transition to full organic practice.

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