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THE ECONOMICS OF ORGANIC AGRICULTURE: DOES CLIMATE MAKE A DIFFERENCE?

by

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ABSTRACT

The Economics of Organic Agriculture:
Does Climate Make a Difference?

Previous studies favorably compare organic with conventional production techniques, but do not consider climatic impacts on organic crop response. Organic vegetable production is analyzed under rigorous climatic conditions in Florida. Unit production cost was reduced by organic methods in only one of seven crops. Labor-intensive organic production is commercially infeasible in the study area.

The Economics of Organic Agriculture:
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Introduction

Organic agricultural production practices have been a focus of public interest and attention in recent years. This form of production excludes the use of commercial fertilizer formulas and synthetic pesticides. This rising interest can be attributed to three basic reasons. First, the environmental social movement has focused attention on the release of fertilizer and pesticide residues into the environment. Concern has also been expressed about the wholesomeness of food produced with the use of commercial fertilizers and pesticides. "Health food" stores have opened up in many places retailing organically grown products. Second, the energy shortage has focused attention on production alternatives which substitute other forms of energy, including human energy, for fossil fuel energy inputs. Third, an increasing number of individuals desirous of more natural work and surroundings are interested in entering farm production. Organic production is often seen as a low cost, nonpolluting way to produce wholesome foods.

The increased public interest has been followed by economic studies of organic production. Klepper, et.al., reported that crop production returns on the average were not very different between organic and conventional farms in a Midwest sample. However, energy intensiveness measured either on a per dollar of output or on a per acre basis was lower for the organic group. Oelhaf reported little difference in farm prices for organic fruits and vegetables in California compared to those conventionally produced. Farm prices for grains were ten percent higher for the organically grown. The study estimated the cost of conversion to organic production would total about $4 billion for the farm sector. This cost was translated to a 3.3 percent average rise in food prices.

Most of these studies dealing with the biology and/or economics of organic production have limited themselves to investigations in temperate climates. The long frost periods in the temperate zones act as a natural restraint in the reproduction of insect and disease agents. On the other hand, warm and semi-tropical areas of the country face an almost continuous presence and reproduction of these agents. Thus, the potential for yield reducing infestations is higher, and production suffers differentially higher damage as a result of any deficiencies in organic pest and disease control. The economic feasibility of organic production in warm and semi-tropical areas and its comparative advantages relative to both conventional and organic production in temperate zones would depend largely on the effectiveness of organic pest and disease control.

In order to assess the economic performance of organic production in more rigorous climates, a comparative analysis was undertaken for one organic system relative to conventional practices. The biodynamic/French intensive system of horticulture was selected for organic production, since its cultural practices facilitate entry into production by those interested in organic techniques. Its labor intensive practices greatly reduce capital requirements by eliminating the use of almost all machinery. Organic matter and compost are the sole sources of fertilization. Pest control techniques rely on the avoidance of monoculture in the planting area and on proper soil fertility and conditioning. The system's cultural practices are purported to give the cultured plant pest and disease resistant health (Jeavons, pp.70-71), thereby eliminating the need for synethetic chemicals. High plant populations in planting beds prepared with hand tools are also purported to reduce land requirements.

Procedures

Production relationships represent the climatic and agricultural conditions observed in Manatee County, Florida. Located in southwest Florida, the area is subject only to a short frost period during the mid-winter months and is one of the most important late fall and early spring vegetable producing regions of the United States. The crops included in the study are tomatoes, green peppers, cucumbers, squash, collards, cabbage and strawberries. All are grown commercially in the county.

The analysis incorporates a producing unit of nine acres. Nine arces correspond to the upper limit of the smallest physical category reported by the Census of Agriculture. This small-scale unit is assumed to be a more likely alternative than larger units for those considering entry into organic vegetable production.

Data on conventional cultural practices for small-scale producers were obtained from Levins and Downs. Additional data was obtained from surveys of area producers and production and marketing publications (Colette; Florida Crop and Livestock Reporting Service).

The absence of organic commercial vegetable production in Florida presented informational problems, since no data were available on organic cultural practices or yields. Interviews were conducted with users of the biodynamic/French intensive system in California to facilitate a thorough knowledge of its practices. But it was necessary to determine the limitations of organic production in semi-tropical Florida, the necessary modifications of the system for Florida conditions, and the yields to be expected in the study area in association with the system.

The Delphi technique was used to generate this information. The Delphi technique is an approach for systematically developing expert concensus. The concept is based on the premises that 1) the opinions of experts are justified inputs to decision making where absolute answers are unknown or impossible and 2) a concensus of experts will provide a more accurate response than a single expert (Fusfeld and Foster). Interviews were conducted with experts in nematology, entomology, soil sciences and vegetable crops. Additional interviews were conducted with personnel in the Agricultural Research and Education Center in Manatee County. A concensus became readily available.

The information generated with the Delphi technique made possible the formulation of production budgets for the organic practices of the biodynamic/French intensive system. The previously cited sources provided the necessary information for the formulation of production budgets for conventional practices. A cost comparison analysis and activity analysis were performed.

Linear Programming Activity Analysis

A linear programming model is used to estimate the income generating potential of the organic and conventional systems under various levels of resource availability. The objective function is the maximization of net revenue:

$$\text{Max NR} = \sum_i P_i q_i - c_i q_i$$

$$\text{Subject to 1) } \sum_i c_i q_i < K \quad \text{2) } \sum_i d_i q_i < L \quad \text{3) } \sum_i f_i q_i < N$$

Where: P_i = output price of the ith cropping activity
c_i = total cash cost of the ith cropping activity
q_i = output of the ith cropping activity
d_i = land use coefficient of the ith cropping activity
f_i = labor use coefficient of the ith cropping activity
K = operating captial constraint
L = land constraint
N = labor constraint

This objective function represents the maximum cash on hand the farm family would have at the end of a year of production after paying all cash expenses. No allowance is made for either payments to family labor, or returns to investment in land, machinery, buildings or operating capital. Furthermore, 100 percent equity in all farm capital is assumed so that no interest payments are included.

Output prices represent five year average prices during the harvest period. All costs are adjusted to represent 1976 prices.

The resources analyzed include land, family labor, and operating capital. Eight acres are assumed to be available for production. One acre is reserved for homestead and wasteland. The three levels of family labor correspond to one, two, and three man-years of 2000 hours each. The three levels of operating capital considered are: \$1,000, \$5,000 and \$10,000.

Nine model variations are considered for both the biodynamic/French intensive system and conventional practices. Each of the three levels of capital is combined with each of the three levels of labor.

Results

Information obtained through the Delphi technique identified inadequacies in organic pest and disease control. These deficiencies expose the crops to the severe pest and disease conditions of semi-tropical Manatee County resulting in differentially lower yields compared to conventional practices.

Perhaps the most salient example of ineffective organic control are nematodes. The sandy soils of much of Florida are a conducive habitat for these pests. There are two popular organic means of control. One is compost, which is purported to contain nematode-trapping fungi (Rodale, p. 272). A Florida experiemnt incorporated organic matter into the soil at rates as high as 50 tons per acre, but detected no fungal predation of nematodes (Tarjan). Another popular organic control measure is the interplanting of marigolds with the crop (Jeavons, p. 68). In another experiment African marigolds (Tagetes erecta) were interplanted among citrus trees infested with the burrowing nematode (Radopholus similis) (Suit, et. al.). The nematodes were not substantially eliminated although the marigolds themselves did not suffer from nematode damage.

The interviewed panel of experts concluded that yields under organic production practices would approximate the yields prevalent in commercial production prior to World War II. Before 1941 little or no pesticides were recommended for Florida vegetable crops while organic fertilization was common (Spencer). Therefore, the yields assumed for organic production of all crops except collards are state averages for the years 1935-1940. Because no historical data were available for collards, a 35 percent reduction from current yields was suggested.

Although organic production may benefit from some of the technological and genetic changes that have occured since the 1940's, there exist no empirical means for adjusting yields for these factors. The reader is free to adjust yields according to his evaluation of what the positive effects might be.

Table 1 reports the comparative yield and cash cost data for organic and conventional practices. Production costs for the organic system are consistently lower in relation to conventional practices. However, the suppressed yields of the organic system tend to result in a higher cost per unit output. Only green peppers have a lower per unit cost for organic compared to conventional production. The cost for collards is the same for both systems.

These comparisons are not indicative of the total cost differentials between the two systems, since labor, an unpaid factor of production is much more intensively used in the biodynamic/French intensive system. Therefore, the costs reported for organic production only partially reflect its level of resource use. Since all the variable costs of capital are included, it follows that a more mechanized organic system would compare more unfavorably with conventional practices.

To further compare the two systems, an analysis of year-to-year yield variance was performed in order to assess risk differentials.

Table 1.--Yields and costs for organically and conventionally produced vegetables in Manatee County, Florida.

Vegetable	Organic Production			Conventional Production			Cost of Organic Production Relative to Conventional Production
	Cash Cost Per Acre	Yield Per Acre	Cash Cost Per Unit	Cash Cost Per Acre	Yield Per Acre	Cash Cost Per Unit	
	Dollars		Dollars	Dollars		Dollars	Percent
Tomatoes	696.88	183 ctns.	3.81	1639.91	818 ctns.	2.00	191
Cabbage	524.08	215 crates	2.44	801.11	490 crates	1.63	150
Squash	314.45	59 bu.	5.33	481.87	150 bu.	3.21	166
Cucumbers	337.11	104 bu.	3.24	583.74	265 bu.	2.20	147
Green Peppers	898.02	272 bu.	3.30	1629.74	435 bu.	3.75	88
Collards	215.30	975 boxes	0.22	331.46	1500 boxes	0.22	100
Strawberries	1144.48	272 flats	4.21	2716.86	1410 flats	1.93	218

Equally sized samples were used for the organic crop and its conventional counterpart. The results are reported in Table 2. The variance for organic peppers is found to be significantly higher ($\alpha = 0.10$) relative to conventional peppers. The variance for organic strawberries is found to be lower relative to conventional strawberries. No significant difference is found between the two systems for all other crops. However, the variation coefficient is higher for all organic yields. Thus, whether risk differentials exist between systems will depend on a producer's risk evaluation of absolute versus relative yield variability. If risk is evaluated on a basis relative to mean yield, organic production will be the higher risk alternative. If risk is evaluated on an absolute variability basis, no generalized conclusions can be drawn.

In addition to these comparative results, the activity analysis remains important because of the great differences in input mix between systems. The analysis indicates the economic performance of the two systems under a particular resource endowment. Potential organic producers may be also willing to engage in organic production despite a lower economic payoff. A great deal of satisfaction may be derived from what is perceived as a more wholesome lifestyle and producing more wholesome food. The activity analysis indicates the returns they can expect with organic and conventional production, Table 3.

The results in Table 3 suggest that operating capital can be severely constraining where conventional practices are used. Between \$5,000 and \$10,000 are needed on a nine-acre farm to meet Florida's 1976 non-metropolitan median money income of \$9,740 (Thompson, p. 135). More than \$5,000 in operating capital are needed to exceed the 1977

Table 2.--Variances and variation coefficients for organic and conventional yields.

Crop	Organic Yield Variance	Conventional Yield Variance	Organic Yield Variation Coefficient	Conventional Yield Variation Coefficient
Tomatoes	6,487	22,077	0.441	0.232
Cabbage	1,514	2,294	0.169	0.106
Peppers	6,985[a]	1,358	0.307	0.081
Cucumbers	1,314	371	0.318	0.075
Straw-berries	1,635[a]	18,796	0.148	0.099

[a]Organic and conventional yields for the crop are significantly different at $\alpha = 0.10$.

Table 3.-- Net revenue maxima, labor and operating capital use as a proportion of availability and shadow prices of operating capital, labor and land using the conventional cultural practices and the biodynamic/French intensive system.

Operating Capital Constraint	Labor Constraint	Net Revenue Maximum	Maximum Revenue Less Depreciation	Labor Use As A Proportion Of Availability	Operating capital use As a Proportion of Availability	Maximum Shadow Price of Operating Capital	Maximum Price Price of Labor	Maximum Shadow Price of Land
	Man-years			Percent	Percent		Per hour	Per acre
				Conventional				
$ 1,000	1	$ 1,892.82	176.18	19.2	100.0	$ 1.70	$ 1.16	0
1,000	2	2,087.15	18.15	15.2	100.0	1.70	1.16	0
1,000	3	2,281.49	212.49	13.9	100.0	1.70	1.16	0
5,000	1	2,457.67	5388.67	17.5	100.0	1.30	2.87	0
5,000	2	8,332.55	6263.55	38.8	100.0	1.31	2.12	0
5,000	3	8,835.98	6766.98	25.6	100.0	1.31	2.12	$ 94.54
10,000	1	8,195.06	6126.06	60.9	56.1	0	20.27	94.54
10,000	2	12,927.11	10,858.11	52.5	89.6	0	13.17	0
10,000	3	14,398.63	12,329.63	43.8	100.0	0.51	2.45	416.37
				Biodynamic/French Intensive System				
$ 1,000	1	246.80	246.80	55.8	34.8	0	0.60	0
1,000	2	495.09	495.09	55.8	69.8	0	0.60	0
1,000	3	723.00	723.00	54.3	100.0	0.42	0.50	0
5,000	3	743.38	743.38	55.8	21.0	0	0.60	0

[a]Colette [1] has estimated the depreciation of a one-row equipment complement for small vegetable farms to be $2,069.

United States poverty income of $4,980 for a farm family of four (Thompson, p. 150). It is also indicated that more labor than one person can provide is needed for production work during peak seasons in order to meet the median income. Given these requirements under the condition of 100 percent equity, the result indicates that an above poverty to medium range income can be achieved on a nine-acre vegetable farm using conventional techniques. Surplus labor is available during the off-seasons for possible off-farm part-time employment.

Table 3 also reports the solutions obtained for the organic practices of the biodynamic/French intensive system. The labor and capital combinations not appearing for the biodynamic/French intensive system led to redundant solutions and were thus excluded. No reductions to net revenue are made because the manual techniques of the system make capital depreciation almost inexistent.

The economic infeasibility of labor-intensive organic production in the study area is indicated by the fact that the highest net revenue maximum is less than $750. The maximum shadow price of an hour of labor is $0.60. Even when ignoring returns to other inputs, net revenue per hour of labor averages only $0.22 for all solutions.

Any off-farm employment would be much more remunerative. The earnings of a 2,000 hour man-year of labor paid at the 1976 minimum wage of $2.20 per hour is $4,400. For the net revenue of the labor-intensive organic enterprise mix to equal this income level, output price levels would have to increase almost eightfold. Alternatively, yields would have to increase five to sixfold.

It is interesting to note that despite the labor-intensive practice of the organic system, no solution uses more than 56 percent of the available labor.

Conclusions

The comparative analysis indicates that semi-tropical agricultural conditions impose a rigorous environment for vegetable crops. Inadequacies in the organic control of pests and diseases place severe restrictions on crop productivity, and thereby, tend to result in a higher cost per unit of output. These results contrast to those reported by Klepper, et.al., and Oelhaf for conditions in temperate zones. An analysis of yield variance also indicates a higher risk associated with organic production if risk is evaluated relative to variation around the mean yield.

The activity analysis indicates that labor-intensive organic vegetable production is economically infeasible in the study area. The biodynamic/French intensive system would be viable only as a form of hobby farming where there exist adequate outside sources of income and only recreational or leisure time is used. The small capital requirements would preclude the need for large investment in order to initiate production. As a hobby, the system can be used to produce low cash cost organic vegetables which may be difficult to acquire elsewhere.

A final conclusion is that a low to medium range income can be achieved from eight acres of production in the study area. The warm climate generates a long crop season which allows an intensified use of land resources. However, satisfactory income levels of income can be achieved only if insect and disease pests are kept under control. Experience in the area has shown that this can be achieved only through chemical as well as biological control.

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