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ORGANIC FIELD CROP PRODUCTION A REVIEW OF THE ECONOMIC LITERATURE

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ABSTRACT

Variation within organic and conventional farming systems is likely as large as the differences between the two systems. Similarities far outweigh differences, however, with the major variation being the use or non-use of chemical fertilizers. In general, more extensive use of rotations and higher labor requirements characterize organic systems. Less energy is consumed with organic in comparison to a conventional system.

Yield differences are very difficult to evaluate between the two systems because of many external factors present in field trials. Crops that require high levels of nitrogen generally have higher yields on the conventional farm, and crops less dependent on nitrogen do well with organic practices. The availability of specialty markets for organic products varies regionally with concentration mainly in vegetable and fruit sales. Most studies reviewed showed mixed findings when analyzing the profitability of the two systems.

Most organic farmers switched from conventional systems because of strong convictions about protecting the environment and high chemical costs. In many areas, conventional practices have contributed to considerable soil erosion and groundwater pollution. In general, organic farming is simply an alternative form of farming without chemicals, with most of the other production practices being similar.

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Introduction

As a precursor to possible future work examining organic farming in New York State, this review of literature brings together a portion of the existing information comparing the farm-level economic aspects of organic and conventional field crop production. In selecting the information sources reviewed, every attempt was made to present a variety of authors and publications while, at the same time, including those works which covered the material of interest in the most comprehensive and useful manner.

Almost without exception, the works reviewed initiated their discussions by providing working definitions of both organic and conventional crop farming. A frequently referred to and apparently generally accepted definition of organic crop farming is one provided by the United States Department of Agriculture in its 1980 report on organic farming:

> Organic farming is a production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock feed additives. To the maximum extent feasible, organic farming systems rely upon crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, mechanical cultivation, mineral-bearing rocks, and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients and to control insects, weeds and other pests.

Cacek and Langner provide an equally acceptable definition of conventional crop farming as "a production system which employs a full range of pre- and post-plant tillage practices (e.g., plow, disk, plant, cultivate), synthetic fertilizers, and pesticides".

The principal source of data on the comparative economic aspects of organic and conventional farming in general, and field crop production in particular, are regional farm-level case studies and direct comparisons between organic and conventional farms. This information has been supplemented by research plot yield data and economic modelling comparisons which make use of available farm and experimental information. In examining the information presented here and in formulating plans for future work comparing the economic aspects of organic and conventional farming practices, it is appropriate to consider certain observations made by William Lockeretz, who is one of the most frequently cited authors on this subject. Based on research with organic and

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conventional farmers Lockeretz et al. (1978) found that production practices are just as likely to vary within these two groups of farmers as they are to vary between them. In other words, it is pointed out that organic and conventional farmers can not be taken to represent two homogeneous populations. The implication is that data generated from case study comparisons of particular organic farms and particular conventional farms should not be extrapolated to conventional and organic farms in general.

Differences in Systems

The majority of the information obtained from the works reviewed can be placed into one of several areas of interest: production costs, crop yields, product marketing, profitability, environmental effects, and farm management. In summarizing this information a recurrent theme is apparent.

Almost without exception, a common conclusion of the publications reviewed was that the similarities between organic and conventional farm operations far outweigh the differences. Summarizing the results of several studies of organic and conventional farms located throughout the Corn Belt, Lockeretz points out that although organic farms make more frequent use of crop rotations, mechanical cultivation and manure application, they were very similar to conventional Corn Belt farms in most of the farming practices that they employed, other than chemical use. It was found that organic and conventional farms resembled each other in their heavy use of purchased inputs and full-size machinery, were of comparable acreage, had similar labor requirements, grew the same major crops (namely corn, soybeans, small grains and hay), obtained comparable yields, sold their products through conventional marketing channels at current prices and were equally profitable. The USDA's report also emphasized that while organic farmers avoid the use of chemical fertilizers they still use modern equipment, improved crop varieties, certified seed, proper waste management methods and soil and water conservation practices.

Similarly, the Council for Agricultural Science and Technology in a 1980 study comparing organic and conventional farming found that:

> In crop and livestock production practices, conventional and organic farming have more in common than not...(in that) certain practices that are appropriate for the conditions and objectives of the operation tend to be common to both conventional and organic farmers. These practices include returning crop residues and animal manures to the soil; growing leguminous crops; using similar breeds of livestock, types of machinery, crop varieties, and methods and rates of planting; and using similar times and methods of harvesting, drying, storing and marketing the products.

The extent of such similarities between organic and conventional farming methods and the results they obtain will become apparent as specific information on costs, yields, marketing, profitability and management is presented.

Cost of Production

Those studies which provided information comparing the costs of production on organic and conventional farms did so primarily by examining the different cropping practices employed with regards to economic costs, operating expenses, labor intensiveness and energy use.

The USDA found that, when compared to conventional farms, organic farms tend to be more labor intensive, make increased use of mechanical weed control, substitute organic waste, green manure crops, crop rotations and/or organic fertilizers for synthetic fertilizers and substitute biological pest control and crop rotations for chemical control of insects and diseases. These differences in cropping practices, however, do not necessarily imply higher production costs. The USDA report states that "Organic farmers generally have lower input costs than conventional farmers".

Economic Costs

Berardi compared the economic viability and environmental impact of conventional and organic wheat production in New York and Pennsylvania. She pointed out that the calculation of the economic costs of farming practices involves a number of assumptions, especially with respect to opportunity costs. More specifically, that the way that these costs are calculated and the assumptions made will directly affect whether a certain practice is determined to be profitable or not. This becomes apparent upon examination of the cost comparisons presented in Berardi's study which found that "The economic costs (which included unpaid family labor and interest charges on land use) averaged 29 percent less per hectare for conventional wheat production than for organic wheat production..." while at the same time cash operating costs were actually lower for organic farms than for conventional farms, $116.39 per hectare compared to $150.67 per hectare. These cash operating costs do not include opportunity costs. The study showed that small organic farmers lowered their cash operating costs by using their own and family unpaid labor, older equipment, their own seed and no commercial fertilizer. It was found that the largest costs for organic farmers were for labor and land use. By comparison, the largest costs for conventional farmers were for fertilizer and certified seed. Berardi did not find any significant difference between machinery costs for the two groups of farmers. Conventional farmers minimized their machinery costs by operating it over a relatively high wheat and other field crop acreage. Organic farmers minimized machinery costs by using less equipment and older equipment.

Operating Expenses

Lockeretz and Wernick, drawing upon data from several studies of commercial organic and conventional farms in the western Corn Belt, stress the similarity between organic and conventional farms which would seem to imply certain similarities in the costs of their operations. Both commercial organic and conventional farms were highly mechanized, shared similar channels for the purchase of inputs and sale of products,

applied practices such as crop rotations, manure applications and mechanical cultivation and neither was particularly labor intensive. In related studies, Lockeretz et al. found that both organic and conventional farms have approximately equal capital investments in land, machinery and grain storage facilities and that depreciation costs on both types of farms were comparable. Conventional farms operating costs were on an average 38 percent higher, with most of the difference in costs being attributed to the commercial fertilizer and pesticide purchases made by the conventional farmers. The organic farms as a group were found to have only slightly higher expenses for field operations such as extra cultivation and manure spreading.

Cacek and Langner, in a summary of available economic data on organic farming, came to the conclusion that most studies, in general, found that operating costs were lower on organic field crop farms than on conventional farms. In contrast, based on a survey of studies comparing organic and conventional farming, Oelhaf concludes that "Nationally, the major field crops cost, on the average, 10 percent more when raised organically".

Labor Requirements

With respect to labor intensiveness on organic and conventional farms the USDA's report on organic farming points out that labor requirements depend on "soil type and topography, types of crops and livestock, type and size of machinery and equipment, and overall labor and management efficiency". It would be reasonable to expect then that labor requirements would vary not only from one organic farm to another but also between organic and conventional farms. In fact, while the report concludes that, in general, organic farms require more labor for their operation than conventional farms, it also emphasized that this labor requirement depends on how effectively weeds, insects and diseases are controlled with mechanical or non-chemical methods. The report makes reference to data from separate studies involving organic and conventional farms in the Corn Belt which found labor requirements to range from only slightly higher to somewhat less on organic farms than on conventional farms depending on the type of crop grown. Labor costs were either similar or slightly lower on organic farms for corn, oats, and wheat and higher on organic farms for soybeans.

The Berardi study on organic and conventional wheat production in New York and Pennsylvania found that "Organic farmers' labor inputs averaged 21 hours per hectare compared to nine hours per hectare for the conventional farmers". In terms of labor productivity, the average for conventional farmers was significantly greater, 13 bushels per hour of labor, compared to six bushels per hour of labor for the organic farmers.

A review and analysis of information comparing organic and conventional farming led Altieri et al. to the conclusion that, in general, organic crop farms have a higher labor requirement than conventional farms although many organic farms are highly mechanized and use only slightly more labor than do conventional farms.

Lockeretz et al., drawing upon data from a five year study of commercial organic and conventional farms in the Midwest found that while organic farms required slightly more labor than conventional farms, 12 percent more per unit value of crop produced or three percent more per unit of land, this was not due to any exceedingly labor-intensive practices but to differences in crop mix and cultivation.

The Oelhaf work found that, on a per bushel basis, organic farms required about 20 percent more labor for corn and soybeans production and five percent more labor for small grain production.

Pimentel, Berardi, and Fast, in a 1983 study assessing energy efficiency, yield performance and labor requirement for the production of corn, wheat, potatoes, and apples using organic and conventional farming methods, concluded that labor inputs were substantially higher for organic farming than conventional farming. In corn and wheat production, organic techniques were found to have 22 to 55 percent lower labor productivity than conventional practices. The difference was even greater in the production of apples and potatoes, as labor productivity using organic techniques was 61 to 95 percent lower than with conventional practices.

Energy Consumption

Several works have studied and compared energy consumption, as an input to the production process, between organic farms and conventional farms. The Council for Agricultural Science and Technology's report on organic and conventional farming points out that while conventional farms use more energy per acre than organic farms, largely due to fertilizers and pesticides used, they do so primarily because it is economically advantageous because of the increased productivity. The report cites a two year study of midwestern farms which found energy consumption to be 42 percent as great on organic farms as on conventional farms, and energy consumption per acre of cropland 38 percent as much on organic farms as on conventional farms.

Similarly, the USDA reports that "Organic farmers use appreciably less total energy for producing most crops than do conventional farmers. Considerable quantities of energy are saved on organic farms by the use of crop rotations and the application of organic wastes in place of chemical fertilizers, especially nitrogen".

More specifically, Berardi found that organic farmers' energy use averaged 32 percent less than that of conventional farmers on a per acre basis. On a per bushel of wheat basis this energy consumption was 15 percent less for organic farmers than for conventional farmers due to the lower average crop yield per acre on organic farms. Higher average energy use for conventional farms was due mainly to their use of inorganic fertilizers and certified seed. Organic farms used more energy than conventional farms for machinery and fuel.

The Pimentel, Berardi, and Fast work determined organic corn and wheat production to be 29 to 70 and 35 to 47 percent respectively more energy efficient than conventional production of these crops. In contrast, conventional production of potatoes and apples was found to be

7 to 93 percent more energy efficient than organic production of these crops. As is pointed out in the study, these results suggest that the efficiency of energy use in both organic and conventional farming may vary according to the cropping system.

Lockeretz et al. report finds that organic farms require about 40 percent as much fossil fuel to produce one dollar's worth of crops as do conventional farms. The main reasons for the higher energy use on conventional farms were heavy fertilizer use (especially nitrogen) and having a larger proportion of their land in corn production. The greatest use of energy on organic farms was for field operations. However it was determined that the energy consumed on organic farms for additional manure spreading, raising of cover crops and green manures, and extra cultivation was much less than the energy consumed in the making of the fertilizers and pesticides used on conventional farms.

Oelhaf concluded, "Organic farming in general uses less energy than conventional American farming, but some particular operations require more energy" such as mechanical weed control. Organic farms, it was observed, reduced energy inputs largely through the substitution of organic wastes and biologically fixed nitrogen for chemical fertilizers. Altieri et al. points out however that increased use of fuel and machinery to apply manure and cultivate on organic farms may offset, at least in part, the energy savings from decreased use of synthetic fertilizers.

Crop Yields

Several of the works reviewed provided information with respect to the comparison of crop yields on organic farms to crop yields on conventional farms. The USDA report begins its discussion of crop yields by emphasizing the limitations inherent in drawing comparisons between organic crop yields and conventional crop yields. The report points out that the results of studies comparing crop yields should not be taken as representative of organic farms and conventional farms in general as crop yields depend on a wide variety of factors including soil fertility, seed varieties, climatic conditions, weed, pest, and disease control, the availability of labor, harvesting methods and other management practices. The report does, however, refer to a number of case studies which found that most of the participating organic farmers reported comparable crop yields on a per-acre basis with conventional farms in their area. These organic farmers explained that yields had been markedly reduced during the transition period from conventional to organic farming. After rotation systems became established in the fourth or fifth year, however, yields began to increase and eventually equaled the yields that they had obtained with conventional methods.

The USDA report referred to studies performed on farms in the Corn Belt which showed much higher yields with conventional practices in corn and wheat, but slightly lower yields in soybean and oats than were obtained using organic practices. The general conclusions reached by the USDA report with respect to crop yields were that crops which responded to high nitrogen fertilizer rates such as corn, wheat and potatoes are most likely to have lower yields under organic systems unless the nutrient requirements are met with manure or other organic sources. Crops such as alfalfa, soybeans, and oats, which are less

responsive to nitrogen fertilizer are likely to have comparable or even higher yields when produced organically.

Brusko et al. confirms the USDA findings concerning markedly lower crop yields on organic farms during the transition period from conventional farming. Research plots at the Rodale Research Center showed similar drops in yield as first year corn production without chemicals was down 40 percent from previous yields using conventional practices. Brusko et al. also reported that by the fourth year after converting to organic farming practices, corn production had increased to 8.5 percent below the yields previously obtained with conventional methods.

Berardi's study of organic and conventional wheat production found that conventional methods resulted in 29 percent higher yields than organic farming methods. Organic farms in this study averaged 34 bushels per acre while conventional farms averaged 44 bushels per acre. In the 1980 USDA study, when conventional and organic farms were more closely paired based on similar soils, yields were much less different with organic farms obtaining an average of five bushels less per acre than conventional farms.

Studies by Lockeretz et al. provide a wealth of information concerning crop yield comparisons on organic and conventional farms in the Corn Belt region. Several of these works draw attention to the fact that the overall value of crop production per acre depends on yields, crop mix, and relative crop prices. Since the organic farms studied usually practiced a four or five year rotation (corn, soybeans, oats-hay, hay or corn, soybean, corn, oats-hay, hay) while the conventional farms, in contrast, maintained a higher proportion of their acreage in high value crops (corn, soybeans), this difference in crop mix alone contributed to a higher value of production per acre on conventional farms. In one particular study it was found that crop yields were virtually identical for soybeans and wheat, comparable for oats and that the greatest difference between the organic and conventional farms was in corn production. This difference resulted in the average value of crop production per acre for conventional farms being approximately eight percent above that for organic farms. Similar work comparing crop yields on organic and conventional farms found that for the major crops studied, corn, soybeans, wheat, and oats, the conventional farms produced higher mean yields than the organic farms. Over a two year period, 1974-1975, Lockeretz et al. found corn yields were 3 to 7 percent higher, soybean yields six percent higher, wheat yields 23 percent higher and oat yields one percent higher on conventional farms than on organic farms. Additional studies by Lockeretz et al. which looked primarily at corn, soybean, wheat, oat, and hay production over a five year period on commercial organic and conventional farms in the north central region of the country produced results which showed gross crop production per hectare to be from 6 to 17 percent lower on organic farms than on conventional farms.

The results of a farm survey of organic producers which were reported by Oelhaf found that organic field crop production of corn, wheat, oats, barley, sorghum, and soybeans was comparable or slightly lower than yields obtained using conventional farming practices. In support of other studies, Oelhaf also found that during the conversion from conventional to organic farming practices an initial decrease in production generally occurs. In subsequent crop years however the yield

reduction diminishes until reaching an equilibrium level of production under the organic farming methods.

Information summarized and presented by Altieri et al. show that organic farmers had corn yields which were 10 percent less and soybean yields which were five percent less than on paired conventional farms. In addition, it was found that under favorable growing conditions conventional yields were considerably higher than organic yields. In contrast, under less favorable growing conditions such as drought, organic farm yields were as good or better than conventional farm yields.

Marketing

The marketing of organic products has changed dramatically in the last 10 years. A report from New Hope Communications quoted in Alternative Agriculture News says that from 1979 to 1988, sales of organic fruit and vegetables has risen from $21 million to $78 million in natural food stores. Chemical-free meat increased from $4 million to $54 million. The growth is not only in the natural food stores, but organically grown products have now entered the mainstream as more and more supermarkets sell the chemical-free food. Although there has not been a great deal published in recent years about the marketing of organic products, the majority has been focused on California's vegetable and produce markets.

According to Franco, a 1984 survey of California's organic farmers said that the major limiting factor in production was the demand. Today it is supply. As the producer tries to keep up with the demand, tremendous growth has been observed. In 1987, there was a 41 percent increase in the value of organic produce and if current growth rates continue, it is predicted that the wholesale industry could grow to $300 million by 1992.

The majority of the organically supplied markets are localized, much more so than conventionally grown products. Of the distribution systems that do exist, most are in Northern California. As the system grows and matures, the distribution system is expected to become more integrated with the conventional system.

Small Farm News reports that the premium prices paid for organic products in California currently average 25 to 30 percent above that of conventional products at the retail level. At the producer level, premiums are even greater with the grower receiving up to 250 percent more for the organic product depending on the crop and season. But even with these premiums and the growth in this industry, it is estimated that organic fruit, vegetable, and nut production is only two percent of the total horticulture production in California.

Steel offers similar information saying that the organic market receives 20 to 30 percent more for their product over conventional. Although most of the premiums are seen on fruit and vegetables, other producers have found their own niche. A farmer in Tennessee and owner of a meat market and restaurant grows and sells only hormone-free beef. His gross sales were up 70 percent last year. Although the corn he

feeds his livestock is not organic, to be a certified organic livestock grower in California, you must feed chemical-free grain. The problem is that there is very little grain available at this time even though, like the rest of the organic industry, there is a great demand for it.

Wollan summarizes the demand vs. supply issue by stating that production will not come close to meeting the demand in the near future. Demand will continue to grow and the supply will become even less dependable and inconsistent than it is right now, and prices will continue to rise. The major supermarket chains will try to enter the organic marketplace but will only be able to sell a limited portion due to the short supply. This is what has happened in New York State, according to Mary Ellen Burris, consumer affairs director for the Wegmans grocery chain as quoted by the Associated Press. "We sold very little (organic products). The product was expensive, the supply was inconsistent and quality variable." After the Alar scare was over, the consumers wanted the product but did not want to pay the premium price. The only stores that will continue to carry the products will be ones with the consistent supply from local grower associations.

While the organic markets in the West are growing, there is no dependence on them in the Midwest. In a 10 year follow-up study of Midwestern organic farms by Lockertz and Madden, they found little importance of special marketing channels. Of the farms surveyed, only 13 percent of the producers who raised cattle used these markets for half of their livestock sales. Of farmers raising crops, only 22 percent used such markets for at least half of their sales. When asked what the major disadvantage of organic farming was, the most important was the unavailability of organic markets.

Profitability

As has been the case with the previous comparisons of other aspects of organic and conventional farming practices, studies performed by Lockeretz et al. provide considerable information concerning the comparative profitability between organic and conventional field crop production. In general, the results of these studies indicate that there can be no more than a small difference between the economic returns per acre received by organic farms and those received by conventional farms. It was found that lower per acre production costs on the organic farms compensated for their lower per acre value of crop production (lower gross production per unit of cropland). The result was that net income per unit of cropland received on organic farms was comparable to that received on conventional farms. More specifically, the studies showed that while organic farms' gross income per unit of cropland was 6 to 17 percent less than that for conventional farms, their lower costs of production resulted in average net returns on organic farms being a maximum of 13 percent less than on conventional farms.

Cacek and Langner offer similar information citing a 1984 survey by the Regenerative Agriculture Association which found that 88 percent of the 213 organic field crop farmers responding to the survey reported that net income had stayed the same or increased when they reduced the use of chemical inputs on their farms. The remaining 12 percent

reported net income had declined. In summarizing the results of a number of farm to farm comparisons and research studies based on experimental plots, Cacek and Langner found that, in general, economic returns from organic field crop production were comparable to those from conventional production. Furthermore, they concluded that organic farming is economically feasible and can compete with conventional farming, at least in certain geographic regions and under certain farming systems or enterprises.

Berardi's work with small-scale wheat production determined the average profitability (defined as revenues less total economic production costs) to be greater for conventional farms, $59.50 per hectare, than for organic farms, $14.55 per hectare. The lower average profitability of organic farms was due primarily to their higher average production costs, $360.92 per hectare, compared to $256.72 per hectare for conventional farms. Economic costs here included unpaid family labor and interest on land use. It is interesting to note, however, that when only the cash operating costs were considered, organic farms had higher net cash returns, their operating costs being $116.39 per hectare compared to $150.67 per hectare for conventional farms.

The USDA report on organic farming which has been referred to previously concludes that returns over costs for field crop production (corn, soybeans) were greater on conventional farms than on organic farms. This lower profitability on organic farms was attributed to the greater crop diversification needed as a result of the central role that crop rotations play in the organic farming system. This means that organic farms tend to have a larger portion of their land in low income crops while conventional farms, which rely to a lesser degree on crop rotations as a farming practice, can usually dedicate the majority of their cropland to high income crops.

Olson et al. best summarized the general conclusions reached by a number of the studies comparing overall profitability of organic and conventional farming practices by pointing out that the normal train of thought is that the lower production costs of organic farming allows individual organic farmers to compete on the basis of net income even though organic crop yields are lower than conventional crop yields.

Environmental Effects

Soil erosion and water contamination caused by agricultural practices is a major concern when comparing organic and conventional production. According to the National Research Council, water pollution is probably the most damaging and widespread environmental effect of agricultural production, with the cost of pollution estimated at $2 to $16 billion per year. With agriculture being the largest non-point source of pollution, it is estimated that is accounts for 50 percent of all surface water pollution.

Conventional agricultural practices greatly lead to this problem. Lee and Nielson stated that the use of inorganic nitrogen fertilizers are a major source of nitrate contamination in groundwater. Between 1965 and 1984, fertilizer application rates on U.S. farms doubled. Fleming reports that 60 different agricultural chemicals are known to

exist in groundwater and a survey cited indicated that at least 20 percent of the nation's wells are contaminated from nitrogen fertilizers. Where conventional practices are responsible for the large percentage of pollution, Poincelot points out that organic farming can also cause pollution through the increase in the soil's nitrate concentration because of improper storage or application of manures and sludges.

Poincelot also describes that conventional agriculture makes trade-offs between soil erosion and crop productivity. Soil erosion has lead to crop production loss of 1.25 million acres. Organic farmers maintain the soil through maintenance of organic matter, manure applications and other organic wastes, increasing water infiltration and storage. Through these practices, water run-off and soil erosion is reduced. In a study cited that compared organic and conventional crop-livestock operations in the corn belt, one-third less soil had been eroded by water in the organic farm as compared to the conventional farm. In general, through rotation organic producers save soil.

Reganold et al. (1987) best summarized much of the published data through their study of the long-term effect of organic and conventional farming on soil erosion. They found that the comparison of erosion rates between non-legume based crop rotations and legume based crop rotations showed less soil reduction due to green crops, or organic rotations. For the conventional farms, the loss of topsoil by erosion has shown to reduce organic matter, water holding capacity, soil productivity, and plant yields. Because of the crop rotation system used on the organic farm, the study concluded that organic farming was more effective in reducing soil erosion and increasing water storage, therefore maintaining soil productivity longer than the conventional farm.

Farm Management

Almost without exception the works reviewed placed considerable emphasis on comparing organic and conventional farming with respect to the managerial and agronomic skills required of successful commercial organic and conventional farmers. Most frequently examined were those skills concerned with specific cropping practices and farm enterprise diversification in addition to related areas such as farm finance and farm size, motivating forces behind the adoption of organic practices and special management problems faced by organic farmers.

Production

Lockeretz et al. drawing upon the results from several studies performed on organic and conventional farms in the Midwest conclude that a great deal of similarity exists between farming practices and farm management skills required on both types of farms. The differences in crop rotations, cultivation, manure application, weed and insect control, and harvesting were, once again, ones of degree. In terms of crops grown (corn, soybeans, hay, oats, and wheat) the farms were quite similar implying comparable levels of agronomic skills required on the

part of both organic and conventional farmers. Organic farms were found to use more mechanical cultivation of row crops to control weeds than did conventional farms, however, conventional farms commonly used mechanical cultivation in addition to herbicides to control weeds in row crops. It should also be noted that herbicides were rarely used on such crops as hay, oats or wheat even by conventional farmers. It was also found that both organic farmers and the majority of conventional farmers relied almost exclusively on crop rotations to control insect problems. Specific crop production practices differed greatest for corn which on conventional farms received the highest application rates of fertilizers, herbicides and insecticides. Practices differed less for wheat and soybeans which usually received no insecticides and lower rates of fertilizer application than corn when grown conventionally. In addition, Lockeretz et al. found that fertility management between organic and conventional farms varied little with the exception of the use of chemical fertilizers on conventional farms. Both types of farms applied manure in almost identical quantities and both incorporated legume crops into their rotational systems.

The USDA report concluded that legumes in rotation with small grains and cultivated field crops were an integral part of the management system on organic farms producing field crops. The report points out that this required crop mix, or the need to produce greater amounts of relatively lower valued crops due to these rotational systems, undoubtedly had affected the costs, yields, profitability and management requirements of organic farms.

More generally, in a survey designed to examine the characteristics of organic farmers in New York State, Smith found a great deal of similarity in a number of farming practices. These included manure application, the growing of cover crops, rotations with leguminous and non-leguminous crops and the use of lime. Such similarity in practices would, once again, imply that comparable technical and managerial skills are required by both organic farmers and conventional farmers.

Enterprise Diversification

Several of the works reviewed focused on the degree of enterprise diversification between organic and conventional farms and the effects that this has on overall farm management. Cacek and Langner, for example, concluded that the economic success of organic farms depended in a large part on the ability of organic farmers to diversify their operations. According to Cacek and Langner, such diversification reduced the organic farm's vulnerability to crop failure and fluctuations in market prices and input costs. Based on their research, these authors also suggest the possibility that livestock enterprises may be essential for the optimum economic performance of organic farms.

Similarly a USDA survey of commercial organic farms found that livestock operations were an essential part of most organic farming systems. The extensive use of crop rotations with legumes and cover crops employed on organic farms lends itself to the development of mixed crop/livestock operations. The rationale being that grains and forages produced as a result of these rotations could be fed to livestock and the manure applied to the cropland as opposed to selling the grain and

forages and importing manure from off-farm sources.

Lockeretz et al. provide additional information on the livestock component of organic farms. On the one hand the organic farm's reliance on legume forages as a source of nitrogen makes feasible the establishment of a crop and livestock operation as it is easier to use the forage produced for one's own livestock rather than to sell it. On the other hand, however, Lockeretz et al. suggest that this reliance on rotations of legume crops by the organic farmers may in fact restrict the organic farmer's options in selecting and developing a farm management system to a mixed crop/livestock operation. In this sense conventional farmers would have a greater flexibility to select and alter their operations. In support of these conclusions, Lockeretz et al. point out that in a five year study of commercial organic farms producing field crops in the Midwest, nine out of ten organic farms studied managed a substantial livestock enterprise as compared to 50 percent of the conventional farms studied.

Farm Financial Status

Farm finance and farm size considerations as they relate to the comparison of the management of organic and conventional farms were addressed in several works. The USDA survey referred to earlier showed that most of the organic farmers surveyed owned a large portion of the land they farmed. Consequently, most were not under the same financial pressures to farm as intensively as are farmers who had to meet mortgage payments. As a result, these organic farmers were in a position to experiment and accept less than optimum yields if necessary. The study points out that for this reason, landowners may not be so willing to allow their tenants or farm operators to practice organic farming.

Information provided by Smith confirms this tendency for organic farms to own a greater share of their acreage than conventional farmers. Based on his research Smith found that upwards of 79 percent of organic farmers owned all of their land as compared to the national average of 59 percent for U.S. farmers in general. In addition, it was found that organic farms had slightly lower debt to asset ratios and significantly lower levels of total farm debt than conventional farms.

Blobaum's survey of organic farmers in the Midwest found that they were much less dependent than conventional farmers on banks and other credit institutions. Two-fifths of the farmers responding to a question on bank financing reported that they do not borrow from banks and only 12 percent of 68 farmers in the survey listed other conventional sources of farm credit.

Similarly, Cacek and Langner found that organic farmers need to borrow less to finance their operations because of lower overall costs, especially for fertilizers and pesticides, and because costs and income are more evenly spread out on the typical diversified organic farm.

Farm Size

With respect to differences in farm size between organic and conventional farms the USDA found that "Organic farming operations are not limited by scale" (1980). The study found that while there are a large number of small-scale organic farms, 10 to 50 acres, in the northeastern region of the country, there are a significant number of larger-scale organic farms, 100 to 1,500 acres, in the West and Midwest.

Buttel et al. on the other hand concluded that reduced-input farming practices were particularly well suited to smaller rather than larger farms. Smaller farms could more effectively manage the risks associated with the conversion from conventional to organic farming practices, were more likely to have lower levels of farm debt in addition to having off-farm sources of income and were usually able to more easily satisfy their additional labor requirements.

Motivation

The extent to which the motive for adopting organic farming practices influence the overall management of organic farms as compared to conventional farms was discussed in several works. The USDA survey found that most organic farmers apparently did not use organic practices based on purely economic criteria. Instead they were concerned with the protection of human and animal life and the environment, energy conservation, and the preservation of soil resources. These concerns implied a willingness on the part of organic farmers to accept lower economic returns if necessary to achieve these objectives.

Similarly, Lockeretz and Wernick found that the main reasons given by organic farmers for their adoption of organic farming practices were concern for family and livestock health, soil quality and environmental protection.

In addition to the organic farmer's concern for his own health, that of his family and livestock, and the environmental impacts of chemical inputs, Olson et al. also attributed the interest in organic farming practices as being largely due to increased chemical fertilizer and pesticide costs and high energy prices.

The shift to organic farming practices as a response to farmers' dissatisfaction with increasing input costs associated with conventional chemical-intensive farming has also been emphasized by Cacek and Langner and Buttel et al.

Other Management Problems

The studies by Lockeretz et al. of organic farms in the Corn Belt uncovered several special management problems faced by organic farmers which have not yet been discussed. The difficulties most commonly reported by organic farmers were the lack of up-to-date sources of technical and marketing information of the type readily available to conventional farmers and the unfavorable attitudes of others (neighbors,

other farmers, farm extension agents) toward organic farming practices. From an agronomic perspective, the most serious problems mentioned were weed control and shortages of available manure.

In addition to these special problems, several works, most notable the 1980 USDA Study, mentioned having found that "Many organic farmers (or would-be organic farmers) reported difficulties in convincing loan officers that organic farming can be a viable operation". A similar conclusion was reached by Altieri et al. that "Credit discrimination is seen as a potential problem by a sizable number of organic farmers".

Summary

According to the literature reviewed, organic and conventional systems are just as likely to vary within the two groups as they are to vary between them as the similarities far outweigh the differences. Although organic farms make more frequent use of crop rotation, mechanical cultivation and manure applications, they are very similar to conventional practices with the exception of the chemical use.

The major cost for the organic producer is labor, and for the conventional farmer it is commercial fertilizer and pesticide purchases. In general, the cash operating costs are lower for the organic farmers while the economic costs (including unpaid family labor and interest charges on land use) are higher. Labor costs are generally higher to grow organic products over conventional, but this is highly dependent on the weed, insect, and disease control methods used as well as the crop grown.

Energy requirements vary greatly between organic and conventional practices. Organic farms use more energy for field operations compared to the conventional farm, but total energy consumed is far more on the conventional operation because of the energy required to make fertilizers and pesticides.

It is difficult comparing yields between the two systems because there are many external factors involved such as soil fertility, climate, seed varieties, weeds, and pests. In general, crops which respond to high nitrogen fertilizer rates like corn, wheat, and potatoes have higher yields with conventional practices where crops like alfalfa, soybeans, and oats which depend on nitrogen less are likely to have comparable and even higher yields with organic practices.

The availability of markets for organic products are very regional. In California, the supply cannot keep up with the demand and the industry is expected to grow to 300 million by 1992. The organic products market, which are many fruits and vegetables, are averaging 20 to 30 percent more than the conventionally grown products. In the Midwest, the number one disadvantage of organic farming is the lack of specialty markets where only 22 percent of the crop farmers and 13 percent of the livestock producers sell their commodities through organic markets. In New York State, many organic sections of the grocery markets have been removed due to lack of demand by the consumers and lack of stable markets with variable quality products.

The articles reviewed show two different findings when comparing profitability. Lockeretz, Cacek and Langner concluded that overall, economic returns on organic farms are comparable to conventional because although they generally have lower yields, they also have lower cash operating costs. The USDA, however, concluded that profitability on organic farms was lower due to the greater crop diversity needed in the crop rotation while the conventional farmer could be more specialized in high income crops.

Water contamination is the most damaging effect of agricultural production. Conventional agricultural practices has lead to 1.25 million acres in soil erosion. The biggest difference in soil erosion is due to rotation practices by the organic and conventional producer. Through organic rotation that reduce soil erosion and surface water runoff, there is less contamination of water supplies with nutrients and pesticides. Organic systems are also more efficient at maintaining soil productivity.

There are few differences between the management practices of the two farming systems, but the main difference is the amount of mechanical cultivation practiced on the row crops and the use of chemical fertilizers. Another difference observed was that the organic farmers generally were not under the same financial pressures as the conventional farms, as most of the organic farmers owned their land and had lower debt loads. Surveys showed that the main reason producers switched from conventional to organic production were because of strong conviction for protection of the environment as well as the high costs of chemical fertilizer and pesticide costs.

Conclusions arrived at by Lockeretz et al. based on their extensive research of commercial organic and conventional farms provide an excellent summary to the information presented here. With respect to the general comparison of organic and conventional farming systems it is important to point out that in reality organic farming represents a move toward an alternative conventional system of agriculture and not so much a polar opposite to conventional farming practices (Lockeretz and Wernick 1980, 719-720). "It should be noted that...it is possible to adopt certain features of each (organic and conventional farming)... . It is possible that some system intermediate between our two samples is preferable, in terms of food production, economic returns or environmental impact... .

With specific reference to organic farming, Lockeretz et al. emphasize that not using modern fertilizers and pesticides does not imply "farming the same way farmers did before the introduction of chemicals" (1978). Present day commercial organic farms are highly mechanized, use modern equipment and new cultivation techniques, improved crop varieties, and overall are much more like their conventional counterparts than standard stereotypes would lead one to believe.

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