An Examination of the Economics of Sustainable and Conventional Horticulture

Robin G. Brumfield¹

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SUMMARY. Since World War II, U.S. agriculture has reduced production costs by substituting petrochemicals for labor. Adverse impacts from chemical intensive agriculture include increased pest levels, groundwater and surface water contamination, soil erosion, and concerns about harmful levels of pesticide residues. Sustainable farming programs such as integrated crop management (ICM) and organic farming encourage farmers to use systems that reduce the adverse impacts of chemical agriculture. However, before farmers adopt an alternative system, they must determine that economic benefits from the alternative farming activities exceed the costs incurred. Unfortunately, relatively few studies have compared the cost of organic crop production with conventional production systems. Results of these studies are mixed. In some studies, organic systems are more profitable than conventional systems with organic price premiums, but are not economically viable without price premiums. In one long-term study, the organic system was more profitable than a conventional one if the cost of family labor was ignored, but less profitable if it was included. In some studies, net returns were higher for ICM than for conventional or organic systems, but in others, they were higher. Results also vary on a crop by crop basis.

At the beginning of the 20th Century, the United States was primarily an agrarian society. After World War II, however, agriculture followed the rest of the U.S. economy and adopted an industrial workplace model (Ikerd, 1996). The industrial model reduced the cost of production through economic incentives that incorporated economies of scale, comparative advantage, opportunity costs, specialization, automation, and simplification into work activities. These concepts provided a focus for the U.S. land grant system where researchers, producers, and agricultural support industries worked to increase productivity and reduce costs. U.S. agricultural productivity increased dramatically. In 1940, 17% of the population was engaged in agricultural production. Today, less than 2% of the U.S. population works in agriculture and less than 10% of our disposable income is spent on food.

Department of Agricultural, Food, and Resource Economics, Rutgers, The State University of New Jersey, 55 Dudley Road, New Brunswick, NJ 08901-8520.

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¹Specialist in farm management.

Average U.S. farm size increased from 168 acres (68 ha) in 1990 to 487 acres (197 ha) by 1997 (USDA, 2000). United States agricultural productivity increased dramatically because of increased mechanization, new technologies, increased chemical and fertilizer use, and specialization. Government policies have also favored this shift toward maximizing production.

The industrialization of agriculture and the development of synthetic chemicals and fertilizers allowed farmers to increase yields and reduce risks. These increased yields resulted in lower per-unit costs (Brumfield, 1996). Although increased yields are a benefit to both producers and consumers, several disadvantages have resulted from the use of agricultural chemicals. As farmers increased rates and frequency of application of chemicals, target insects have developed resistance to particular chemicals, and some pest populations have increased dramatically (National Research Council, 1986; Office of Technology Assessment, 1995). Other unintended costs of industrial agriculture include topsoil depletion, groundwater contamination (U.S. General Accounting Office, 1991), damage to wildlife (Lichtenberg, 1992), decline in the number of family farms, erosion of rural community economies (Feenstra et al., 1996), applicator health risks (Lichtenberg, 1992), and concerns about chemical residues in foods (Hanson et al., 1990; Lichtenberg, 1992).

In the late 1970s and early 1980s, environmental concerns spurred authors such as Hodges (1978, 1982) to endorse organic agriculture as an alternative to pesticide-based agriculture. In the popular press, authors such as Rachel Carson (1962), and later, Wendell Berry (1981, 1984, 1986) criticized the widespread use of agricultural chemicals, the industrialization of agriculture, and the sociological impacts of post-World War II agricultural methods. Many people began to believe that the price we pay for food does not reflect all the costs of production (Ikerd, 1990, 1996). By the 1980s, a host of systems including low input agriculture, alternative agriculture, integrated pest management, integrated crop management, biodynamic agriculture, agroecology, regenerative agriculture, and organic agriculture were proposed as alternatives

to conventional agriculture. Ultimately, sustainable agriculture became the term used in policy areas related to questions of the environment and resource conservation and the term organic was used in the marketplace as a label to differentiate among agricultural commodities (Klonsky and Tourte, 1998). Ecolabelling has gained widespread acceptance in Western Europe, and initiatives have begun in Virginia and New York in the United States. Eco-labels are used to differentiate products that are produced using sustainable production practices such as IPM and low-input agriculture (Estes et al., 1999).

The organic movement emphasized the relationship between agriculture and resource conservation by emphasizing the limited use of nonrenewable resources. Regulation of agricultural methods that focus on natural systems and ecological processes is difficult to accomplish because these methods often are conceptual and open to interpretation. Thus regulation of organic production became a list of acceptable and unacceptable inputs (Klonsky and Tourte, 1998), with most states having certification programs for organically certified products. Certification assures consumers that the product was produced using organic methods and assures producers that the term organic is not used unscrupulously (Lohr, 1998). To avoid farming by neglect or the overuse of organic chemicals, the Organic Foods Production Act of 1990 requires farm plans.

Sustainable agriculture is a new paradigm in which farmers and consumers recognize unintended side effects are likely through some production practices. Scaller's 1988 article in *Agricultural Outlook* compared alternative and conventional agriculture and explained the increased public attention paid to alternative agriculture. He listed factors that would affect the adoption of alternative agriculture: commodity and input prices, farm and environmental policies, infrastructure and markets, transition, and research and education. With initial appropriation in 1987, Low Input Sustainable Agriculture (LISA) was USDA's research and education grants program. The 1990 Farm Bill expanded the program and subsequently renamed it the Sustainable Agriculture Research and Education (SARE) program. The 1990 Farm Bill defined the term sus-

tainable agriculture to mean an integrated system of plant and animal production practices having a site-specific application that will over the long term: satisfy human food and fiber needs; enhance environmental quality and the natural resource base upon which the agricultural economy depends; make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls; sustain the economic viability of farm operations; and enhance the quality of life for farmers and society as a whole (Government Printing Office, 1990).

Economists have proposed various approaches to paying for unintended costs of chemical based agriculture. Lichtenberg (1992) proposed three alternatives to regulation: liability, information, and taxes. Lichtenberg concluded that liability already was being used for pesticide regulation for poor product performance. However, it becomes a poor policy instrument when environmental damage or health and safety issues are concerned, and it is costly. He concluded that information would be most effective in the area of farm worker safety. Taxes tend to influence application rates on a continuous basis, but cannot alter timing of applications. Abler (1992) favored market-based solutions to unintended side effects of chemical agriculture. People can refuse to work with pesticides that they view as unsafe, farmers can refuse to buy unsafe pesticides, and consumers can refuse to buy produce they perceive as unsafe. Farmers would use safer chemicals, and competition would force reductions in per unit prices, which would be passed along to consumers. Harper (1992) argued that in developing policy tools to account for unintended negative side effects of pesticide use, both individual risks and aggregate health risks should be taken into account. She stated that both benefits and risks of pesticides are overestimated. She also proposed developing models that take into account technological change and economic adoption if and when pesticides are no longer freely available or acceptable to consumers. It appears that a combination of policy tools is likely to be used.

Organic food sales are only 1% to 1.5% of retail food sales (Rateman, 1997). Organic production methods are used on less than 1% of farms and

1% of farmland engaged in U.S. vegetable production (Klonsky and Tourte, 1998). However, the emergence of organic agriculture represents a much larger impact on the paradigm shift from industrial agriculture to a new more sustainable agriculture (Darling, 1991). The principles of sustainable agriculture are increasingly being incorporated into conventional agriculture. Integrated crop management, an ecologically based approach to crop production that includes management practices such as minimum tillage, nutrient balancing, and integrated pest management (IPM), has been widely adapted by producers. Many farmers rotate crops, apply fertilizers in bands, mulch, stake and use other practices that reduce their dependence on synthetic chemicals to produce high quality crops. After four decades of chemically dependant agricultural research, land grant universities are now doing research on sustainable agriculture, and chemical companies are introducing pesticides, fungicides, and herbicides which are less toxic and more environmentally benign (Darling, 1991). Producers are finding that diversified farms are less economically and environmentally risky (Cacek and Langner, 1986). Growing a large number of crops spreads the economic and production risks and makes the farm less susceptible to changes in supply and demand for a specific crop (Harwood et al., 1999). Farm bills since 1985 have included funding for research and extension programs that develop more sustainable systems. As farmers become more aware of the long-run costs of over dependence on petrochemicals and fertilizers, and consumers continue to push for a safer environment and safer food, both regulations and the marketplace will encourage farmers to adopt more sustainable systems.

The organic movement not only changed production, but also has had impacts on marketing. For example, Community Supported Agriculture (CSA) is a partnership-marketing venture between organic farmers and consumers. CSAs represent a shift from the individualism of traditional agriculture to a community approach to producing food; they also represent a channel through which organic produce can be distributed. CSAs depend on a direct link between local producers and the local community. The CSA

sells individual shares in the farm before the planting season, thus giving the CSA an infusion of equity to purchase inputs without having to finance the operation through credit. In turn, the shareholders receive bags of produce from the CSA throughout the growing season. CSAs often include consumers in the decision-making processes of what produce to grow, how to market, and whether labor as well as financial support is required by shareholders. Purchasing produce from a CSA requires more of a consumer's time than buying from a supermarket. This concept began in Japan in the 1960s where it was called "teikei," which means "putting the farmer's face on food" (Van En et al., 1999). The idea traveled to Europe and was introduced to the U.S. in 1985 by Jan VanderTuin at Indian Line Farm in Great Barrington, Massachusetts (Sabih and Baker, 2000). Today, there are over 1,000 CSAs in the US and Canada, mostly near urban areas. CSAs shift some of the production, market, and financial risk from producers to consumers. A study by Sabih and Baker (2000) showed that CSAs gave farmers a bigger share of returns and give consumers lower costs than conventional agriculture. Farmers were able to realize substantially more income than with traditional techniques. The savings that consumers realized on groceries yielded a return of 39%, which was higher than alternative investment opportunities.

Sustainable agriculture must be economically viable if it is to be adopted by producers. Many producers are concerned that while switching to organic or ICM methods would be more environmentally sustainable, it could be unprofitable and risky (Williams, 1990). Very few studies have been conducted which compare the economics of sustainable production systems to conventional ones. Studies relating to sustainable agricultural practices often contain no economic analysis (Gleason et al., 1992; Temple, 1991) or they focus only on one crop (Baldwin, 1991; King, 1991). A 1997 Cornell study (Pritts and Kovach, 1997), compared break-even prices for conventional and organic strawberries (*Fragaria × ananassa* Duchesne). The labor for weed control was twice as high in the organic system, and the yields were 30% to 70% lower. Break even prices were 34%

higher for organic strawberries than for conventional strawberries. A study comparing fresh produce prices over a 15-month period in North Carolina found, on average, about a 25% price premium for certified organic produce (Estes et al., 1999).

Only limited attempts have been made to analyze the economics of whole farm sustainable systems (Dhillon and Paladino, 1981; Goldstein and Young, 1987; Lockertz, 1989). Studies such as that of Buttel et al. (1986) began to compare organic and conventional agriculture in ways that assessed not only the bottom line in terms of profits, but also in terms of the effects on the sustainability of family farms. Ray et al., (1992) reviewed previous research into alternative agricultural practices and discussed some of the limitations of research. They found the studies to be constrained by lack of reliable cost and return data. Fox et al. (1991) reviewed the literature published between 1975 and 1989 on the economics of alternative agricultural systems. All the studies used budgeting or linear programming, and much of the data was based on only 1 or 2 years. They found no general pattern about the relative profitability of alternative or conventional systems.

In a review of several farm-level studies comparing sustainable and conventional cropping systems, Lee (1992) found that net returns and yields per acre tended to be lower for sustainable cropping systems, but net returns could be comparable under certain conditions. Smolik et al. (1995) found an alternative row cropping system to be more profitable than a ridge and till system in South Dakota. Madden and O'Connell (1990) found that many farmers who adopted sustainable methods experienced a slight decrease in gross returns, but an increase in net returns. Dobbs et al. (1991) found that in side by side comparison of a conventional and alternative grain farm, costs, gross returns, and net returns were higher and labor requirements were lower on the conventional farm than the alternative farm with no price premiums. Price premiums for organic products could have reduced or eliminated the difference in net returns. Later studies by Dobbs (1994) found organic farms to be competitive with conventional and reduced tillage farms. In another study Dobbs (1994) found profitability to be crop dependent.

Conventional systems were more profitable than organic or near-organic systems in corn-soybean areas, and organic and near-organic were economically competitive in wheat areas.

The University of California at Davis began a research project to study conventional, low input, and organic farming systems. This research consisted of 2- to 5-year field studies to develop cost and return studies for over 125 crops. The budgets included a wide range of fruits and vegetables and are available on line as well as in printed form. (Klonsky and Tourte, 2000; Klonsky, personal communication). Organic price premiums ranging from 7% to 125% existed for all organic crops in the project. The organic system relied on price premiums for economic viability, except for beans (*Phaseolus vulgaris* L.), which were profitable even without the price premium. With price premiums, the organic system had the highest net returns, but without price premiums, it showed an average net loss. On average, the low input system outperformed the organic system without price premiums, but had higher costs, lower gross returns, and lower net returns than the conventional system. In general, the low input system showed potential to decrease the costs of chemical inputs and to maintain gross returns in comparison to the conventional system, but this varied with some crops. Yields of low input tomatoes (*Lycopersicon esculentum* Mill.) were similar to yields of conventional beans, but yields of low input corn (*Zea mays* L.) and beans were higher than with conventional production. Organic premiums appear to be required for profitability. With price premiums, the organic system was the most profitable.

In longer-term studies, sustainable systems seem to fare better than conventional systems, depending on the assumptions and how costs are calculated. Hanson et al. (1995) compared a conventional and organic rotational system in an on-going farming systems trial at the Rodale Institute Research Center in Kutztown, Pa. They constructed budgets for three 5-year time periods. During the two later time periods, the yields of organic corn and soybeans (*Glycine max*. L. Merr.) were comparable to yields in conventional systems. However, the organic systems produced higher-value crops less frequently, and required more fam-

ily labor and management. If the value of family labor and management and the initial cost of investing in soil capital were ignored, organic rotations were more profitable than conventional ones, but if those costs are included, the conventional system was more profitable. The organic system was adjusted as more information was learned about sustainable systems. Hanson et al. (1990) found that the sustainable system was more profitable on average after the initial 5-year transitional period. In a study comparing tomatoes produced using conventional, IPM, and organic systems by Brumfield et al. (1995), the yields were lower under an organic system. However, because of an organic price premium of 30%, net returns per unit were higher under the organic system. The costs per acre were highest in the organic system, and the system changed as more information was learned about organic systems. The net returns per acre were highest for the IPM system. These results seem to indicate that costs will decline as organic systems are developed.

The principles of sustainable agriculture are increasingly being incorporated into conventional agriculture. Producers must be convinced that sustainable systems are profitable before they will adopt them. Differences in costs and returns of conventional, organic, and sustainable production systems vary with crop and assumptions made. In general, organic systems rely on price premiums for economic viability. If producers are going to adopt more sustainable systems, more research is needed to develop systems and reduce costs of organic and ICM systems. Methods that include the true costs of production, including family labor and unintended negative side effects, need to be developed. Policy tools that can account for these costs include regulations, liability, information, taxes, risk-benefit models, and market-based solutions.

Literature cited

Abler, D.G. 1992. Issues in pesticide policy: Discussion. N.E. J. Agr. Resource Econ. 19(2):93-92.

Baldwin, F.L. 1991. Developing and extending minimum input strategies for weed control in agronomic and horticultural crops. Univ. Ark. Coop. Ext. Sustainable Agr. Res. Educ. Rpt. LS88-11.

Berry, W. 1981. The gift of the good land. North Point Press, San Francisco, Calif.

Berry, W. 1984. The agricultural crisis as a crisis of culture, p. 219-225 In: G.K. Douglas (ed.). Agricultural sustainability in a changing world order. Westview Press, Boulder, Colo.

Berry, W. 1986. The unsettling of America: Culture and agriculture. Sierra Club Books, San Francisco, Calif.

Brumfield, R.G., F.E. Adelaja, and S. Reiners. 1995. Economic analysis of three tomato production systems. Acta Hort. 340:255-260.

Brumfield, R.G. 1996. Sustainable horticulture: An overview. HortTechnology 6(4):352-354.

Buttel, F.H., G.W. Gillespie, Jr., R. Janke, B. Caldwell, and M. Sarrantonio. 1986. Reduced-input agricultural systems: Rational and prospects. Amer. J. Alternative Agr. 1(2):58-64.

Cacek, T. and L.L. Langner. 1986. The economic implications of organic farming. Amer. J. Alternative Agr. 1(1):25-29.

Carson, R. 1962. Silent spring. Houghton Mifflin, Boston.

Darling, D.R. 1991. Research and education in the western region, p. 158-160. In: National Research Council. Board on Agriculture (eds.). Sustainable agriculture research and education in the field: A proceedings. Natl. Acad. Press, Wash., D.C.

Dhillon, P.S. and B.A. Paladino. 1981. Characteristics of organic vegetable farms in New Jersey with estimated costs and returns for selected organic crops. Cook College—Rutgers the State Univ. N.J. Agr. Expt. Sta. Publ. 381.

Dobbs, T.L. 1994. Organic, conventional, and reduced till farming systems: Profitability in the Northern Great Plains. Choices, 2nd Quarter. p. 31-32.

Dobbs, T.L., J.D. Smolik, and C. Mends. 1991. On-farm research comparing conventional and low-input sustainable agriculture systems in the northern Great Plains, p. 250-265. In: National Research Council Board on Agriculture (eds.). Sustainable Agriculture research and education in the field: A proceedings. Natl. Acad. Press, Wash., D.C.

Estes, E.A., T. Kleese, L. Lauffer, D. Treadwell, and R. Burton. 1999. An overview of the North Carolina organic industry. ARE Rpt. 17, N.C. Agr. Res. Serv., N.C. State Univ., Raleigh.

Feenstra, G., C. Ingels, and D. Campbell. with contributions from D. Chaney, M. R. George, E. Bradford, the staff and advisory committees of the Univ. Calif. Sustainable

- Agriculture Research and Education Program (SAREP). 1996. What is sustainable agriculture? 16 July 2000. <<http://www.penpages.psu.edu/penpages/reference/12101/121011083.HTML>>.
- Fox, G., A. Weersink, G. Sarwar, S. Duff, and B. Deen. 1991. Comparative economics of alternative agricultural production systems. *N.E. J. Agr. Resource Econ.* 20:124-142.
- Gleason, M.L., S.E. Taylor, H.G. Taber, and M.L. Hockmuth. 1992. Timing of fungicide sprays on processing tomatoes. *Fungicide Nematicide Tests* 47:144.
- Goldstein, W. A. and D. L. Young. 1987. Agronomic and economic comparison of conventional and a low-input cropping system in the Palouse. *Amer. J. Alternative Agr.* 2:51-56.
- Government Printing Office. 1990. Food, Agriculture, Conservation, and Trade Act of 1990 (FACTA), Public Law 101-624, Title XVI, Subtitle A, Section 1603. Govt. Printing Office, NAL KF1692.A31, Wash., D.C.
- Hanson, J.C.E. Lichtenberg, and S.E. Peters. 1995. Organic versus conventional grain production in the mid-Atlantic: An economic and farming system overview. Dept. Agr. Resource Econ., Univ. Md., College Park, Working Paper 95-22.
- Hanson, J.C., D.M. Johnson, S.E. Peters, and R.R. Janke. 1990. The profitability of sustainable agriculture on a representative grain farm in the mid-Atlantic region, 1981-89. *N.E. J. Agr. Resource Econ.* 19(2):90-98.
- Harper, C.R. 1992. Issues in pesticide policy: Discussion. *Northeastern J. Agr. Resource Econ.* 19(2): 96-97.
- Harwood, J., R. Heifneer, K. Coble, J. Perry, and A. Somwaru. 1999. Managing Risk in farming: Concepts, research, and analysis. USDA Econ. Res. Ser. Market and Trade Econ. Div. Agr. Economic Rpt. 774.
- Hodges, R.D. 1978. The case for biological agriculture. *Ecologist Quarterly*, summer: 122-143.
- Hodges, R.D. 1982. Agriculture and horticulture: the need for a more biological approach. *Bio. Agr. Hort.* 1(1):1-13.
- Ikerd, J.E. 1990. Agriculture's search for sustainability and profitability. *J. Soil Water Conservation* 45(1):18-23.
- Ikerd, J.E. 1996. Sustaining the profitability of agriculture. Paper presented at the American Agricultural Economics Association Extension Pre-conference: The Economist's Role in Agricultural Sustainability Paradigm, San Antonio, Texas, 27 July 1996. 14 July 2000. <<http://www.ssu.missouri.edu/faculty/JIkerd/papers/aae-sasa.htm>>.
- King, L. 1991. A comparison of cropping systems managed conventionally or with reduced chemical input. North Carolina State University. Sustainable Agr. Res. Edu. Rpt. LS88-9.
- Klonsky, K. and L. Tourte. 2000. Cost and return studies. Univ. Calif., Davis, Dept of Agr. Resource Economics, Davis. 19 July 2000. <http://www.aes.ucdavis.edu/ex/departments/Dep_agri_&_res_ec.htm>.
- Klonsky, K. and L. Tourte. 1998. Organic agricultural production in the United States: Debates and directions. *Amer. J. Agr. Econ.* 80(5):1119-1124.
- Lohr, L. 1998. Implications of organic certification for market structure and trade. *Amer. J. Agr. Econ.* 80(5): 1125-1129.
- Lee, L.K. 1992. A perspective on the economic impacts of reducing agricultural chemical use. *Amer. J. Alternative Agr.* 7:82-88.
- Lichtenberg, E. 1992. Alternative approaches to pesticide regulation. *Northeastern J. Agr. Resource Econ.* 19(2): 83-92.
- Lockertz, W. 1989. Comparative local economic benefits of conventional alternative cropping systems. *Amer. J. Alternative Agr.* 4:75-83.
- Madden, J.P. and P.F. O'Connell. 1990. LISA some early results. *J. Soil Water Conservation* 45(1):61-64.
- National Research Council. 1986. Pesticide resistance: Strategies and tactics for management. National Academy Press, Wash., DC.
- Office of Technology Assessment. 1995. Biologically based technologies for pest control. Office Technol. Assessment, Wash., D.C.
- Pritts, M. and J. Kovach. 1997. Organic strawberry production systems. 18 July 2000. <<http://www.fvs.cornell.edu/Faculty/php/MarvinPritts/organic.html>>.
- Rateman, K. 1997. Market overview '96: Contradictions propel industry growth. *Natural Food Merchandiser.* 28(1):26-30.
- Ray, D.E., B.C. English, R.L. White, R.M. Pendergrass, and M.G. Bhat. 1992. Economic impacts of sustainability on southern agriculture. In: L.A. Johnson (ed.). Enhancing the environmental quality of the Tennessee Valley region through alternative farming practices. Univ. Tenn. Ext. Bul. EC1022-750-9/92.
- Sabih, S. F. and L.B.B. Baker. 2000. Alternative financing in agriculture: A case for the CSA method. *Acta Hort.* 524:141-148.
- Scaller, N. 1988. Alternative agriculture gains attention. *Agricultural Outlook* 1988. USDA, Wash., D.C.
- Smolik, J.D., T.L. Dobbs, and D.H. Ricker. 1995. The relative sustainability of alternative, conventional, and reduced-till farming systems. *Amer. J. Alternative Agr.* 10(1):25-35.
- Temple, S. 1991. A comparison of conventional, low input and organic farming—The transition phase and long term viability. Univ. Calif. Sustainable Agr. Res. Edu. Rpt. LS89-18.
- U.S. Department of Agriculture, 2000. Census of Agriculture. National Agricultural Statistics Service. 14 July 2000. <<http://www.nass.usda.gov/census/>>.
- U.S. General Accounting Office. 1991. Pesticides: EPA could do more to minimize groundwater contamination GAO/RCED-91-75. U.S. Govt. Printing Office, Wash., D.C.
- Van En, R., L. Manes, and C. Roth. 1999. What is community supported agriculture and how does it work? 16 July 2000. <<http://www.umass.edu/umext/csa/about.html>>.
- Williams, J.R. 1990. Social traps and incentives: Implications for low-input, sustainable agriculture. *J. Soil Water Conservation* 45(1):28-30.