November 2000

Can Organic Farming “Feed the World”?

Christos Vasilikiotis, Ph.D.

University of California, Berkeley
ESPM-Division of Insect Biology
201 Wellman-3112
Berkeley, CA 94720-3112
christos@uclink4.berkeley.edu

The legacy of Industrial Agriculture

With the world population passing the 6 billion mark last October, the debate over our ability to sustain a fast growing population is heating up. Biotechnology advocates in particular are becoming very vocal in their claim that there is no alternative to using genetically modified crops in agriculture if “we want to feed the world”. Actually, that quote might be true. It depends what they mean by "we." It's true if the "we can feed the world" refers to the agribusiness industry, which has brought the world to the brink of food disaster and is looking for a way out. Biotech just may be their desperation move. "We'll starve without biotech," is the title of an opinion piece by Martina McGloughlin, Director of the Biotechnology program at the University of California, Davis. Could be. Modern industrial agricultural – which forms the foundation for biotech – ranks as such a dismal failure that even Monsanto holds them up as the evil alternative.

"The commercial industrial technologies that are used in agriculture today to feed the world... are not inherently sustainable," Monsanto CEO Robert Shapiro told the Greenpeace Business Conference recently. "They have not worked well to promote either self-sufficiency or food security in developing countries." Feeding the world sustainably "is out of the question with current agricultural practice," Shapiro told the Society of Environmental Journalists in 1995. "Loss of topsoil, of salinity of soil as a result of irrigation, and ultimate reliance on petrochemicals ... are, obviously, not renewable. That clearly isn't sustainable."

Shapiro is referring to the 30-year-old "Green Revolution" which has featured an industrial farming system that biotech would build on: the breeding of new crop varieties that could effectively use massive inputs of chemical fertilizers, and the use of toxic pesticides. As Shapiro has hinted, it has led to some severe environmental consequences, including loss of topsoil, decrease in soil fertility, surface and ground water contamination, and loss of genetic diversity.

Do we really need to embark upon another risky technological fix to solve the mistakes of a previous one? Instead, we should be looking for solutions that are based on ecological and biological principles and have significantly fewer environmental costs. There is such an alternative that has been pioneered by organic farmers. In contrast to the industrial/monoculture approach advocated by the biotech industry, organic agriculture is described by the United Nations Food & Agriculture Organization (FAO) as "a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity."

Despite the lack of support from government and university extension services in the US, consumer demand for organic products is driving the organic movement ahead at a 20% annual rate of market growth, primarily with the help of an increasing consumer demand for organic products. The amount of certified organic agricultural land increased from 914,800 acres in 1995 to 1.5 million in 1997, a jump of more than 60% in just two years.

Not surprisingly, agribusiness conglomerates and their supporters dismiss organic farming, claiming it produces yields too low to feed a growing world population. Dennis Avery, an economist at the Hudson Institute – funded by Monsanto, Du Pont, Dow, and Novartis among others – had this to say in a recent ABC News' 20/20 broadcast. "If overnight all our food supply were suddenly organic, to feed today's population we'd have plowed down half of the world's land area not under ice to get organic food … because organic farmers waste so much land. They have to because they lose so much of their crop to weeds and insects." In fact, as a number of studies attest, organic farming methods can produce higher yields than conventional methods. Moreover, a worldwide conversion to organic has the potential to increase food production levels -- not to mention reversing the degradation of agricultural soils and increase soil fertility and health.

Comparisons of organic and conventional chemical farming systems

A survey of recent studies comparing the productivity of organic practices to conventional agriculture provides an excellent example of the wide range of benefits we can expect from a conversion to sustainable agricultural methods. The results clearly show that organic farming accomplishes many of the FAO's sustainability aims, as well as showing promise in increasing food production ability.

- Sustainable Agriculture Farming Systems project (SFAS) at UC, Davis.

An ongoing long-term comparison study, SFAS is an interdisciplinary project that compares conventional farming systems with alternative production systems that promote sustainable agriculture.

The study examines four farming systems that differ in crop rotation design and material input use: a 2-year and a 4-year rotation conventional system, an organic and a low-input system.

Results from the first 8 years of the project show that the organic and low-input systems had yields comparable to the conventional systems in all crops which were tested - tomato, safflower, corn and bean, and in some instances yielding higher than conventional systems (Clark, 1999a). Tomato yields in the organic system were lower in the first three years, but reached the levels of the conventional tomatoes in the subsequent years and had a higher yield during the last year of the experiment (80 t/ha in the organic compared to 68 t/ha in the conventional in 1996). Corn production in the organic system had a higher variability than conventional systems, with lower yields in some years and higher in others.

Both organic and low-input systems resulted in increases in the organic carbon content of the soil and larger pools of stored nutrients, each of which are critical for long-term fertility maintenance (Clark, 1998). The most important limiting factor in the organic system appeared to be nitrogen availability (Clark 1999b). The organic system relied mainly on cover crops and composted poultry manure for fertilization. One possible explanation for a lower availability in the organic system, is that high carbon inputs associated with nitrogen to build soil organic matter, thus reducing nitrogen availability for the organic crops. During the latter 2 years of the experiment, soil organic matter levels appeared to be stabilized resulting in more nitrogen availability. This was in agreement with the higher yields of organic crops that were observed during those last two years. The organic systems were found to be more profitable in both corn and tomato among the 4-year rotations mainly due to the higher price premiums (Clark, 1999b).

- Farming Systems Trial at the Rodale Institute – Soybean study.

Initiated in 1981, the Farming Systems Trial compares intensive soybean and maize production under a conventional and two organic management farming systems.

The first organic cropping system simulates a traditional integrated farming system. Leguminous cover crops are fed to cattle and the resulting manure is applied to the fields as the main source of nitrogen. In the second organic system, the leguminous cover crops were incorporated in to the soil as the source for nitrogen before corn or soybean planting.

Corn yields were comparable in all three cropping systems (less than 1% difference) (Drinkwater, 1998). However, a comparison of soil characteristics during a 15-year period found that soil fertility was enhanced in the organic systems, while it decreased considerably in the conventional system. Nitrogen content and organic matter levels in the soil increased markedly in the manure–fertilized organic system and declined in the conventional system. Moreover, the conventional system had the highest environmental impact, where 60% more nitrate was leached into the groundwater over a 5 year period than in the organic systems (Drinkwater, 1998).

Soybean production systems were also highly productive, achieving 40 bushels/acre. In 1999 however, during one of the worst droughts on record, yields of organic soybeans were 30 bushels /acre, compared to only 16 bushels/acre from conventionally- grown soybeans (Rodale Institute, 1999). “Our trials show that improving the quality of the soil through organic practices can mean the difference between a harvest or hardship in times of drought” writes Jeff Moyer, farm manager at The Rodale Institute in Kutztown, Pennsylvania (Rodale Institute, 1999). He continues, “over time, organic practices encourage the soil to hold on to moisture more efficiently than conventionally managed soil.” The higher content of organic matter also makes organic soil less compact so that root systems can penetrate more deeply to find moisture. These results highlight the importance of organic farming methods and their potential to avert future crop failures both in the US and in the rest of the world.

- Broadbalk experiment at the Rothamsted Experimental Station, UK

One of the longest running agricultural trials on record (more than 150 years) is the Broadbalk experiment at the Rothamsted Experimental Station in the United Kingdom. The trials compare a manure based fertilizer farming system (but not certified organic) to a synthetic chemical fertilizer farming system. Wheat yields are shown to be on average slightly higher in the organically fertilized plots (3.45 tones/hectare) than the plots receiving chemical fertilizers (3.40 tones/hectare). More importantly though, soil fertility, measured as soil organic matter and nitrogen levels, increased by 120% over 150 years in the organic plots, compared with only 20% increase in chemically fertilized plots (Jenkinson, 1994).

- Organic grain and soybean production in the Midwestern United States

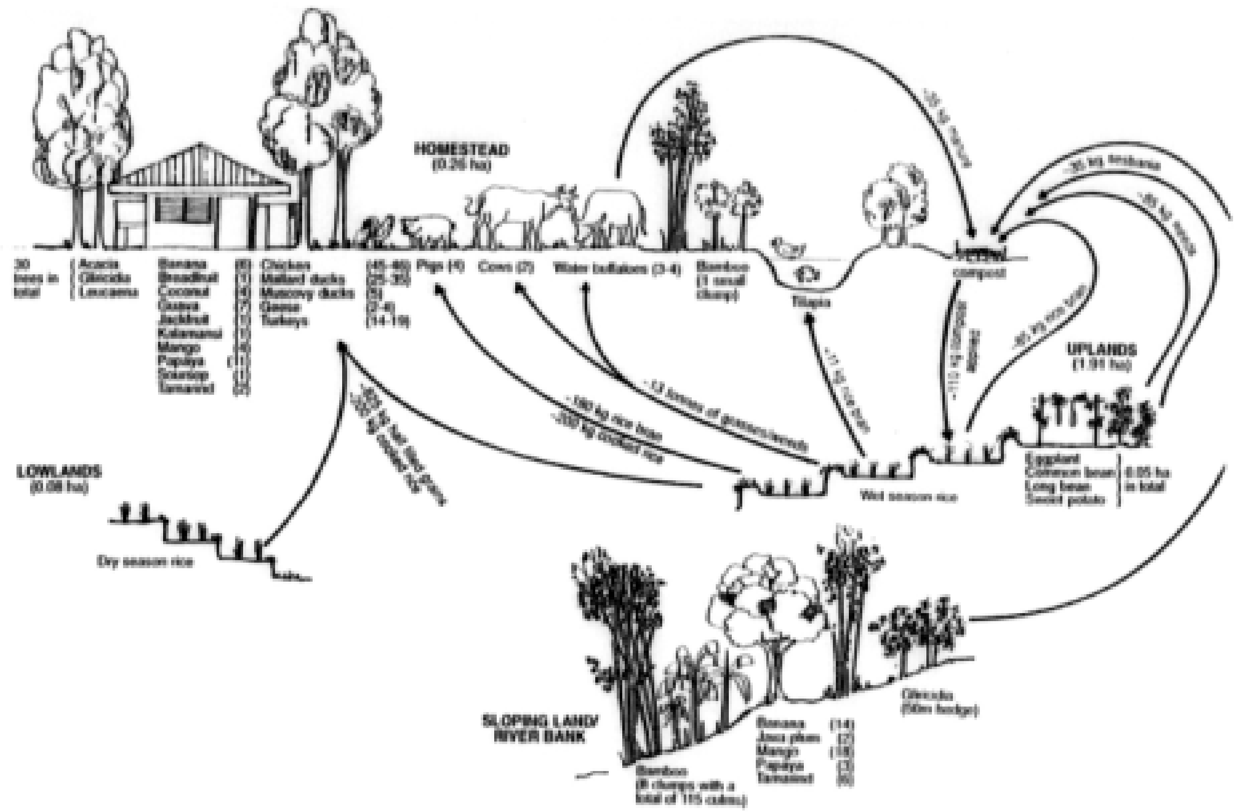
A comprehensive review of a large number of comparison studies of grain and soybean production conduct by six Midwestern universities since 1978 found that in all of these studies organic production was equivalent to, and in many cases better than, conventional (Welsh, 1999). Organic systems had higher yields than conventional systems which featured continuous crop production (no rotations) and equal or lower yields in conventional systems that included crop rotations. In the drier climates such as the Great Plains, organic systems had higher yields, as they tend to be better during droughts than conventional systems. In one such study in South Dakota for the period 1986-1992, the average yields of soybeans were 29.6 bushels/acre and 28.6 bushels/acre in the organic and conventional systems respectively. In the same study, average spring wheat yields were 41.5 bushels/acre and 39.5 bushels/acre in the organic and conventional systems respectively.

When comparing the profitability of farming systems, the study found that organic cropping systems were always more profitable than the most common conventional cropping systems if the higher premiums that organic crops enjoy were factored in. When the higher premiums were not factored in, the organic systems were still more productive and profitable in three of the six studies. This was attributed to lower production costs and the ability of organic systems to outperform conventional in drier areas, or during drier periods.

The author of the report remarked: “What is most surprising is how well the organic systems performed despite the minimal amount of research that traditional agricultural research institutions have devoted to them.” (Welsh, 1999).

- Comparison of conventional and organic farms in California.

Lastly, a study which compared ecological characteristics and productivity of 20 commercial farms in the Central Valley of California gives us a better understanding of how a conversion to organic would fare in a commercial farm setting.
The farms compared had a fresh market tomato production. Tomato yields were shown to be quite similar in organic and conventional farms (Drinkwater, 1995). Insect pest damage was also comparable in both cases of organic and conventional farms. However, significant differences were found in soil health indicators such as nitrogen mineralization potential and microbial abundance and diversity which were higher in the organic farms. Nitrogen mineralization potential was three times greater in organic compared to conventional fields. The organic fields also had 28% more organic carbon. The increased soil health in the organic farms resulted in considerably lower disease incidence. Severity of the most prevalent disease in the study, tomato corky root disease, was found to be significantly lower in the organic farms (Drinkwater, 1995).



Can we afford *not* to go Organic?

From the studies mentioned above and from an increasing body of case studies, it is becoming evident that organic farming does not result in neither catastrophic crop losses due to pests nor in dramatically reduced yields as many critics from agribusiness and in academia would have us believe. A report from UC Davis predicted a 36% reduction in tomato yields in California if conventional insecticides and fungicides were eliminated (Agricultural Issues Center 1988).

On the contrary, organic farming systems have proven that they can prevent crop loss to pests without any synthetic pesticides. They are able to maintain high yields, comparable to conventional agriculture without any of the associated external costs to society. Furthermore, organic and agroecological farming methods continually increase soil fertility and prevent loss of topsoil to erosion, while conventional methods have the opposite effect. In the end, only a conversion to organic farming will allow us to maintain and even increase current crop yields.

The ability of organic agriculture to produce comparable yields is particularly significant, considering that limited research has been conducted in land-grant universities to optimize cultural practices or select for suitable crop genetic traits in organic farming systems. It is becoming imperative that we move away from organic versus conventional systems comparisons, to research into ways of improving organic farming methods.

One of the criticisms of organic agriculture has been that there is not enough nitrogen available naturally, therefore only chemical fertilizers can provide adequate supplies to sustain current yields. This is clearly not the case as shown by both the Rothamsted and Rodale experiments, where manure-based systems can provide enough nitrogen not only to sustain high crop yields but also to build up the nitrogen storage in the soil. Animal manure is not in short supply by any means. EPA estimates indicate that US livestock operations generate one billion tons of manure per year; most of this is not utilized in agriculture, instead it leaches nitrogen and phosphorus into our waterways, thus threatening wetlands and river systems and in many cases drinking water supplies. Organic agriculture, and especially small diversified farms, could allow us to once again couple livestock production to crop production, thus cycling this valuable byproduct back into the soil and eliminating costly environmental degradation.

Another argument that critics are making is that organic food is more expensive, therefore, low-income families and people in the third world would not be able to afford it. While it is true that organic food has a price premium, this price difference is the result of higher demand for organic products, and does not necessarily reflect a higher cost of production. According to the Wallace Institute report mentioned earlier, organic production of grains and soybeans in the mid-west was more profitable than conventional in at least half the cases studied, even without factoring the higher prices that organic soybeans bring in the market (sometimes more than twice as much as conventional soybeans). There are still situations though in which organic systems appear to depend on price premiums to remain profitable, such as the case of high-value tomato crops in California. The higher cost of production that was found in the SFAS project is attributed mainly to the increased labor requirements for weed control in organic systems.

Even these studies overestimate the relative costs of organic production. Federal commodity programs and subsidies are geared towards large-scale chemically intensive agriculture and artificially inflate figures for industrial agriculture. Furthermore, this type of economic comparison ignores external costs that conventional agriculture creates. The World Resources Institute, an environmental policy think tank, reports that when measured with traditional cost analysis methods the average farm shows an $80/acre profit. After accounting for all the external costs of soil loss, water contamination and environmental degradation caused by farming practices however, the average farm shows a $29/acre loss instead!

A number of European nations have started to factor these expenses into their agricultural support programs. In several European countries, such as Denmark and Sweden, farmers get government support during their conversion to organic and continue to receive support for environmental services that they provide to their communities, such as wildlife corridors and the elimination of toxic runoffs which contaminate underground water sources. These programs helped foster an almost 100-fold increase in organically farmed land in Europe, from 29,000 acres in 1986 to 2.4 million acres in 1996. Similar programs in the U.S. could help the conversion of more farms to organic methods. These price supports do not have to be subsidies, rather a compensation to organic farmers for each of the ecological and social services that they provide.

Despite claims from the biotech industry and academic researches, there is no indication that biotechnology will solve the shortcomings of industrial agriculture. Compared to the novel and untested crop systems that biotech corporations are pushing as the only solution to food security problems, organic farming has many advantages. The majority of genetically engineered crops currently in cultivation do not appear to show higher yields. For example, contrary to claims by Monsanto, a recent study by Dr. Charles Bendrook, the former director of the Board on Agriculture at the National Academy of Sciences, indicates that genetically engineered Roundup Ready soybeans do not increase yields (Bendrook, 1999). The report reviewed over 8,200 university trials in 1998 and found that Roundup Ready soybeans yielded 7-10% less than similar natural varieties. In addition, the same study found that farmers used 5-10 times more herbicide (Roundup) on Roundup Ready soybeans than on conventional ones. The only reason farmers seem to prefer Roundup Ready soybeans is because they simplify management of large chemically-intensive farms, by allowing them, for example, to spray larger doses of herbicides from planes on crops, engineered to be resistant to the particular herbicide. Applications of biotechnology continue the legacy of industrial agricultural with monocultures and high energy and chemical inputs.

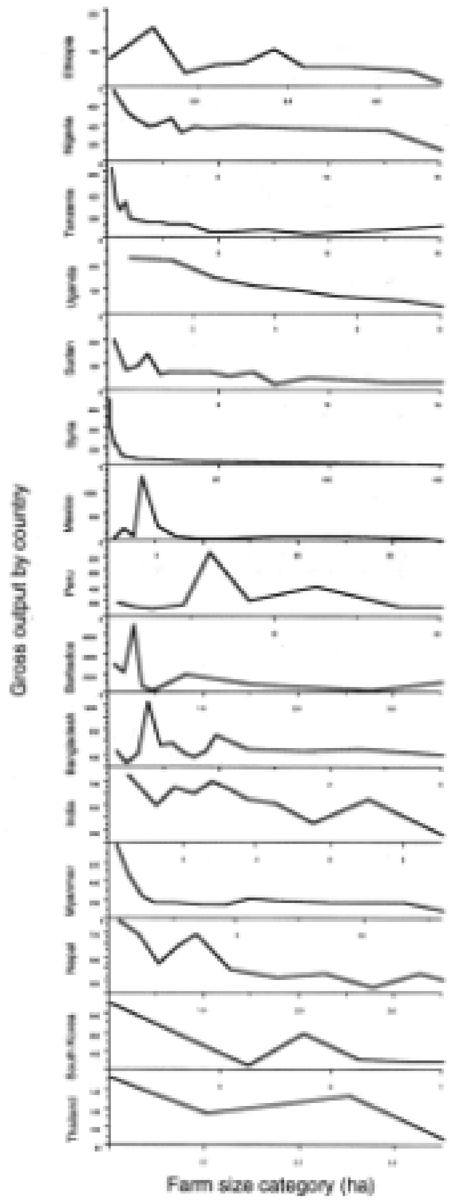


Figure 1: Total production per unit area versus farm size in 15 countries.

Our current world food production is more than sufficient to provide an adequate diet to all humans, yet more than 840 million people are suffering from hunger. Hunger is a problem of poverty, distribution, and access to food. The question then, is not "how to feed the world", but rather, how can we develop sustainable farming methods that have the potential to help the world feed and sustain itself. Organic management practices promote soil health, water conservation and can reverse environmental degradation. The emphasis on small-scale family farms has the potential to revitalize rural areas and their economies. Counter to the widely held belief that industrial agriculture is more efficient and productive, small farms produce far more per acre than large farms. Industrial agriculture relies heavily on monocultures, the planting of a single crop throughout the farm, because they simplify management and allow the use of heavy machinery. Larger farms in the third world also tend to grow export luxury crops instead of providing staple foods to their growing population. Small farmers, especially in the Third World have integrated farming systems where they plant a variety of crops maximizing the use of their land. They are also more likely to have livestock on their farm, which provides a variety of animal products to the local economy and manure for improving soil fertility. In such farms, though the yield per acre of a single crop might be lower than a large farm, total production per acre of all the crops and various animal products is much higher than large conventional farms (Rosset, 1999). Figure 1 shows the relationship between total production per unit area to farm size in 15 countries. In all cases, the smaller farms are much more productive per unit area– 200 to 1000 percent higher – than larger ones (Rosset, 1999). Even in the United States, the smallest farms, those 27 acres or less, have more than ten times greater dollar output per acre than larger farms (US Agricultural Census, 1992). Conversion to small organic farms therefore, would lead to sizeable increases of food production worldwide. Only organic methods can help small family farms survive, increase farm productivity, repair decades of environmental damage and knit communities into smaller, more sustainable distribution networks – all leading to improved food security around the world.

References

1. Agricultural Issues Center, 1988. *Agricultural chemicals in California plant production: are there alternatives?* University of California, Davis, California, USA.

2. Bendrook, 1999. *Evidence of the Magnitude and Consequences of the Roundup Ready Soybean Yield Drag from University Based Varietal Trials in 1998*. Ag Biotech InfoNet Technical Paper: (http://www.biotech-info.net/RR_yield_drag_98.pdf)

3. Clark S., et al 1999a. *Crop-yield and economic comparisons of organic, low-input, and conventional farming systems in California's Sacramento Valley.* American Journal of Alternative Agriculture v. 14 (3) p. 109-121

4. Clark, M. S. et al 1998 *Changes in Soil Chemical Properties Resulting from Organic and Low-Input Farming Practices,* Agronomy Journal, v. 90 p. 662-671

5. Clark, M. S. et al 1999b. *Nitrogen, weeds and water as yield-limiting factors in conventional, low-input, and organic tomato systems*. Agriculture, Ecosystems and Environment v. 73 p. 257-270.

6. Drinkwater, L.E. et al, 1995. *Fundamental Differences between Conventional and Organic Tomato Agroecosystems in California.* Ecological Applications, v. 5 (4) p. 1098-1112

7. Drinkwater, L.E. et al, 1998. *Legume-based cropping systems have reduced carbon and nitrogen losses,* Nature, v. 396, 19.

8. Jenkinson, D. S. et al, 1994. In *Long-term experiments in Agricultural and Ecological Sciences* (eds Leigh, R. A & Johnston, A. E) p.117-138 (CAB Int. Wallingford, U.K. 1994).

9. Rosset, P. 1999. *The Multiple Functions and Benefits of Small Farm Agriculture,* Food First

10. US Agricultural Census, 1992.

11. Welsh, R. 1999. *The Economics of Organic Grain and Soybean Production in the Midwestern United States*, Henry A. Wallace Institute for Alternative Agriculture (http://www.hawiaa.org/pspr13.htm)

12. Rodale Institute, 1999. *100-Year Drought Is No Match for Organic Soybeans*, (http://www.rodaleinstitute.org/global/arch_home.html)