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Shattering Myths: Can sustainable agriculture feed the world?

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For years, critics and proponents alike have worried that the related methods of organic, low-input, low- or no-pesticide, integrated, small-scale, and sustainable production may address environmental concerns, but cannot produce sufficient food to sustain the large and growing human population.

Such skepticism was understandable—the so-called Green Revolution of the 1940s, 50s, and 60s had been credited with averting widespread hunger crises by drastically increasing agricultural production, while the downsides of its technological advancements only began to enter the popular consciousness in the years after Rachel Carson's *Silent Spring* in 1962. Questioning the source of the cornucopia that provided plenty to people throughout the world seemed downright ungracious and backward. How could we be critical of the Green Revolution when it had staved off so much hunger?

Now, years later, with the benefit of both hindsight and the insights available to us in works from *Silent Spring* to *World Hunger: Twelve Myths* to *The Omnivore's Dilemma*, evaluations of the social and environmental costs of the Green Revolution—and the fact that hunger is still pervasive—have led many to question the Green Revolution's claims. Sustainable alternatives are receiving greater attention. Organic agriculture is fast on the rise, and the call to buy local, buy seasonal, and buy fair are growing louder. But the question of whether or not such alternatives can provide enough food for a growing human population is still open. Or is it? A recent study by a research team at the University of Michigan addresses just this question.

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Smashing the myth that sustainable organics cannot produce enough food

The important question of whether or not sustainable agricultural methods can produce enough food is still a stumbling block for its advocates 40 years after the heady days of the Green Revolution. Can we risk spending scarce resources on an unproven system of production? Indeed, the focus on sustainable and organic agriculture has been portrayed by some, such as geographer Vaclav Smil and the conservative Hudson Institute's Dennis and Alex Avery as a "liberal fetish" that would bring hunger and ruin to millions in the global south if it were allowed to go forward.

Such concerns would be valid if sustainable methods were as unproven or unproductive as often portrayed. However, besides the thousands of years of small-scale and family agriculture that developed and field-tested



Food First interns Caiti Hachmyer and Trisa Chakrabarti in Food First's organic garden.

the antecedents of many modern sustainable practices, the past 40 years have not been spent idly by those who question the now-conventional industrial agricultural methods. A significant amount of scientific literature has compared “conventional” and “sustainable” agriculture. Nonetheless, what were originally valid and important doubts among some scientists about sustainable agriculture, have since turned into a “New Myth” that ignores this accumulated scientific work. That is, the idea that yields from sustainable agriculture are insufficient to feed the human population is almost regarded as “common knowledge.” Skepticism is a vital and healthy part of science and public debate, but it must be moderated by even-handed evaluations of available information. So what does the available information on organic agriculture say? Are organic yields sufficient to feed us?

Organic agriculture and the global food supply

2 A study in the June 2007 issue of the *Journal Renewable Agriculture and Food Systems* looked to answer this question. What do we know now about agricultural production from sustainable methods? Can we say with any confidence that it could provide enough food for a global population? Looking at 293 examples comparing alternative and conventional agriculture from 91 studies, a group of University of Michigan researchers were able to demonstrate that current scientific knowledge simply does not support the idea that a switch to organic and sustainable agriculture would drastically lower food production and lead to hunger. Instead, we found that current knowledge implies that, even under conservative estimates, organic agriculture could provide almost as much food on average at a global level as is produced today (2,641 as opposed to 2,786 kilocalories/person/day after losses). In what these University of Michigan researchers considered a more “realistic” estimation, organic agriculture could actually

increase global food production by as much as 50% (to 4,381 kilocalories/person/day).

The University of Michigan study synthesized as much of the current scientific literature on the subject as possible, gathering 160 cases comparing production from sustainable/organic methods to conventional production and 133 cases comparing sustainable/organic production to local low-intensity methods (i.e., subsistence farming or other non-industrialized practices). For the purposes of our study, we used the term “organic” to refer to practices that fall under the related categories of agroecological, sustainable, or ecological agriculture rather than to a specific certification system. “Organic” practices generally utilize natural (non-synthetic) nutrient sources and nutrient-cycling processes, exclude or rarely use synthetic pesticides, and sustain or regenerate soil quality. Examples of such practices include cover crops (which are often used as “green manure”), animal manure, compost, crop rotation, intercropping, and biological pest control.

The cases used came predominantly from peer-reviewed, published scientific literature, though a minority came from what scientists call “Grey Literature”—conference proceedings, technical reports, and results from a well-known agricultural research station posted online. Such sources are considered “Grey” as they may be generated by reputable scientists and institutions, but have not necessarily undergone formal peer review by other scientists unconnected to the specific research project. The team statistically tested whether or not results would significantly differ if only the peer-reviewed works were used.

The University of Michigan team grouped the 293 examples into 10 general food categories covering the major plant and animal components of human diets (i.e. grains, meats and offals, fruits, etc.), and determined the average ratio of yield from organic production to yield from convention-

al/low-intensity production in each category. Averaging the yield ratios from different studies within a food category reduces the effects of unusually high or low yield ratios from individual studies. Certain products were omitted as they didn’t compose a significant source of calories or nutrients (i.e. spices and stimulants), and although data were reported for “seafood and other aquatic products,” a yield ratio was not constructed since most of these foods are currently harvested from the wild.

Once we had determined yield ratios, we used food production data from the United Nations’ Food and Agriculture Organization (FAO) from 2001—the most recent data available when we began our analysis—and calculated the amount of food theoretically available in each category on a caloric basis if all agriculture were organically produced. Data from the FAO, based on on-farm production, was aggregated at the national level and adjusted for exports, imports, stocks, and losses to feed, seed and waste.

Compiling the data for the world, for “developed” countries and for “developing” countries (following the FAO classifications for nations), we found large differences in yield ratios between the developed and developing countries. From our food production estimate based on the 10 food categories and 160 cases in developed countries, we found that organic production could theoretically generate an amount of food equal to 92% of the current caloric availability (or a yield ratio of 0.92). This ratio is close to that found in a 1990 study by Gerald Stanhill of Israel’s Agricultural Research Organization. However, looking at the 133 examples from the developing world, our team estimated food production equivalent to an overall yield ratio of 1.80—that is, 180% of current production in the developing world on a caloric basis.

From these regional results, researchers at the University of Michigan then constructed two models, a “conserva-

tive case” and a “realistic case.” The “conservative case” applied the yield ratios of organic production to conventional production from the developed countries to worldwide agricultural production (production in both the developed and developing countries). As the yield ratios in the ten food categories were generally lower in the developed countries, applying them worldwide means that slightly fewer calories would be produced under a fully organic global system: 2,641 kcal/person/day instead of 2,786 kcal. However, this number is still above the suggested intake for healthy adults of 2200 to 2500 kcal/person/day, so even under this conservative estimate there would be sufficient food production for the current population. However, under more realistic assumptions—that a switch to organic agriculture would mean the relatively lower developed world yield ratios would apply to production in the developed world and the relatively higher developing world yield ratios would apply to production in the developing world—the result was an astounding 4,381 kcal/person/day, a caloric availability more than sufficient for today’s population. Indeed, it would be more than enough to support an estimated population peak of around 10-11 billion people by the year 2100.

As with any scientific work, there are caveats. The study isn’t a precise prediction for any specific crop or region, but rather an indicator of potential performance of organic relative to conventional and the current low-intensity agriculture practiced in much of the developing world. By necessity, an average ratio isn’t predictive of specific cases. Critics often seize upon this and a similar point—that the best comparison of the different methods would be an optimized organic system versus an optimized conventional one. Such an argument misses the point. There is not an agreed-upon one way to optimize a given system, and even if there were, different local

conditions would require different methods of optimization. Beyond this, no real system can ever fully meet all of the theoretical requirements for optimum performance. The Michigan study, by drawing from a wide base of data, reflects the best current understanding of how the two systems compare across a variety of circumstances. Indeed, one could argue that Green Revolution technologies have advanced rapidly largely as a result of decades of public and private research funding which dwarfs the modest resources devoted to organic research in the same time period. It therefore does not stretch imagination to think that the potential of organic agriculture hasn’t yet been as fully realized as that of Green Revolution methods.

Nitrogen: The Limiting Factor

Another frequent claim by critics of organic agriculture is that organic agriculture is bad for the environment and biological conservation because it requires more land. This requirement, they say, is because of its lower yields and its use of green manure—nutrients from cover crops planted in between food crop rotations and then incorporated into the soil.

University of Manitoba geographer Vaclav Smil has prominently maintained that a cropping system using only residue and manure recycling, rotations of cereals with legumes and planting of green manures cannot provide sufficient Nitrogen (N) for global food production to meet humans’ dietary needs. This point is used to justify the assertion that because additional land will be needed to generate green manure and other organic N sources, organic agriculture will require more land than conventional practices and therefore be damaging to conservation. This important point was tested in the Michigan study, in which we evaluated the N availability generated solely by green manure as opposed to N

from synthetic sources. Based on 77 studies—33 for temperate regions and 44 for tropical regions—we found that current data would predict an average N availability from green manure of 102.8 kg N/ha. How much is that? Assuming that green manures could be planted on the current agricultural land base in between food crops, during winter fallow, or as a relay crop (and excluding land already planted under similar crops, such as soybeans and other legumes), we calculated that 140 million Mg of N could be fixed by green manures each year. In comparison, the global use of synthetic N fertilizers in 2001 was 82 million Mg, or 58 million Mg less than our estimated production from green manures.

These results imply that, in principle, no additional land is required to obtain enough useful N to replace the current use of synthetic N fertilizers. Besides, other organically-acceptable sources of N including intercropping, alley cropping with leguminous trees, reintegration of livestock and annual crops, and inoculation of soil with free-living N fixers were not included in our analysis. In other words, similar to the findings around yields from organic production, our estimate is a conservative one and there may be significant potential in such alternative N sources that could be realized if research resources were devoted to them on the scale of the effort that has supported the Green Revolution.

What does the future hold?

Though the results from our study show that the most dramatic concerns of ruin and starvation predicted by organic opponents are contradicted by current knowledge, there is clearly much work yet to be done. For example, the typically different crop rotation systems used in organic and conventional production significantly complicated the calculation of relative yields and made any “across the board” yield adjustment for rotation systems unrealistic. When

comparing, say, a three or four-year rotation schedule in an organic system growing corn with legumes to a conventional system where corn is planted every other year, the time-yield adjustment for this system would not apply to other, alternate rotation patterns. Further experimental comparisons and demonstrations are therefore needed to adequately address production differences from organic and conventional rotation systems. Nevertheless, adjustments for specific cases in our study showed that while total calories produced did drop in organic rotation systems, the amount of food produced was still sufficient.

Other directions for future research also include exciting lines of inquiry in agroecology, from fertility generated by certain forms of crop/microbe "cooperation" to the benefits of urban agriculture, and the possibilities of agroforestry systems and companion planting. It is also

worth noting that although a significant scientific literature shows that organic agriculture is, on the whole, better for conservation and the environment, further work is needed to understand how to go beyond local strategies to coherent national and international policies and incentives.

Yet the concerns listed here should not obscure two vitally important points: a) the Michigan study shows that (notwithstanding future research) the answer to whether organic agriculture can provide enough food for the world is an unambiguous yes, and b) the problems of hunger and food security in the world are not presently associated with not enough food, but with poverty and the lack of ability to acquire food. Whether sufficient food is produced organically or conventionally, the problems of fair distribution and acknowledgment of the right

to food will still need to be resolved, and no amount of food production alone will change the political system that leaves those without money to live without sufficient food.

Critics and proponents of organic agriculture alike can agree that there are serious problems in a food system that produces more than sufficient calories worldwide, but still has 840 million people who cannot acquire enough food for their basic needs. Though the discussion regarding organic agriculture is certainly not over, if it is to address world hunger, it cannot avoid food sovereignty: people's right to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, no matter how much is produced. This implies the democratization of our food systems—not their further industrialization.

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