Agroecology: Transitioning Organic Agriculture beyond input substitution

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Organic farming is a production system whose objective is to sustain agricultural productivity by avoiding or largely excluding synthetic fertilizers and pesticides. The original philosophy that guided organic farming emphasized the use of resources found on or near the farm. These internal/local resources include solar or wind energy, biological pest controls, and biologically fixed nitrogen and other nutrients released from organic matter or from soil reserves. The idea was to rely heavily on the use of crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients, and to regulate insect pests, weeds, and diseases. Original adherents to the movement were typical small and/or family farmers, growing diverse enterprises for the local markets, who saw farming as a way of community life closely linked to the rhythms of nature.

Thanks to the pioneering efforts of these farmers and the advocacy work of many organic agriculture promoters, organic farming is now widespread throughout the world and is growing rapidly. Today there are about 23 million hectares of land under organic management, of which 10,6 million has and 3.2 million ha are in Australia and Argentina respectively, mostly devoted to extensive grazing land. More then 4 million hectares are under certified organic farming in Europe. In Italy alone there are about 56,000 organic farms occupying 1.2 million hectares. In Germany alone there are about 8,000 organic farms occupying about 2 percent of the total arable land. In Italy organic farms number around 18,000 and in Austria about 20,000 organic farms account for 10 percent of total agricultural output. In Latin America, organic farming accounts for 0.5% of the total agricultural land, about 4.7 million hectares. In North America about 1.5 million hectares are certified organic (45,000 organic farms) occupying 0.25 % of the total agricultural landin . In the USA the organic acreage doubled between l992 and l997 and in 1999 the retail organic produce industry generated US$ 6 billion in profit. In California organic foods are one of the fastest-growing segments of the agricultural economy, with retail sales growing at 20-25 percent per year for the past six years. But are these new organic farmers and associated industry following the original precepts of the pioneers? Or is organic farming being incorporated into the systems of intensified production, finance, management and distribution typical of conventional agriculture? Is organic agriculture replicating the conventional model that it so fiercely opposed?

Realities working against organic farming

There is no question that demands for organic food is increasing, but seems confined to the rich and especially to populations of the industrialized world. As Third World countries enter the organic market, production is mostly for export and thus contributing very little to the food security of poor nations. As organic products are increasingly traded as international commodities, their distribution is slowly being taken over by the same multinational corporations that dominate conventional agriculture. Locally owned natural food stores and organic brands are becoming consolidated into national/ international chains.

It is possible that some of the above problems could have been minimized if the organic movement have not disregarded three important factors that now have come back to haunt them:

The size of farms to be certified: By not limiting the maximum amount of land that a particular farmer or company could certify as organic, it has allowed big corporations to join the fad, displacing small organic farmers. In California, over half the value of organic production was represented by 2% of the growers who grossed over US$ 500,000 each; growers grossing $10,000 or less comprised 75 % of all growers and only 5 % of the sales.

The consolidation of multiple farms, packing plants, and regional hubs under a single corporation requires the adoption of conventional big business practices. This system is excellent for consolidating wealth and power at the apex of a pyramid, but it is antithetical to the goals of community and local control that were part of the original inspiration of the organic movement.

Inappropriate certification standards: The movement was quick to develop rules that sought to standardize practices that inevitably vary by farm or region. The high variability of ecological processes and their interactions with heterogeneous social, cultural, political, and economic factors generate local organic systems that are unique. When the heterogeneity of these systems is considered, the inappropriateness of standardized technological recipes or blueprints becomes obvious. Many guidelines proved unworkable for some farmers for technical reasons. Some farmers were offended at being told to alter their on-site proven methods, especially when they saw only higher costs as a result. Such standardization process proved particularly culturally and economically inappropriate to small farmers in the developing world whose farming rationale is rooted in biodiversity and traditional knowledge. In fact, many people in the south perceive organic standards as an imposition and as a form of protectionism from the north.

Ironically, organic standards are now under threat, and as organic standards erode, a false perception of organic integrity will be created through advertising and political control of regulatory agencies as is already happening in the USA. As a consequence, many farmers are opting out, and together with consumers, many are creating their own standards and certification procedures as well as more locally-centred marketing strategies.

Social standards: most certification protocols did not include social criteria. For this reason, today in California, it is possible to buy organic produce that may be environmentally produced, but at the expense of the exploitation of farm-workers. There are no major differences in living conditions, labor practices or pay for a farm-worker working in an organic *versus* a conventional farm operation. Might this be a reason why for example, in California, the United Farmworkers have not wholeheartedly endorsed organic farming? There is no question that organic agriculture must be both ecologically and socially sustainable. For this to happen, organic techniques must be embedded in a social organization that furthers the underlying values of ecological sustainability. Ignoring the complex social issues surrounding commercial and export-oriented organic agriculture is to undermine the original agrarian vision of organic farming.

Input substitution

Structurally and functionally speaking, large-scale commercial organic farms do not differ substantially from conventional farms . The most important difference is that organic farmers avoid the use of chemical fertilizers and pesticides in their farming operations, while conventional farmers may use them extensively. However, a large number of organic farmers do use modern machinery and commercial crop varieties and adopt monocultures. Due to their inherent low levels of functional biodiversity, these simplified systems lack natural regulatory mechanisms and therefore are highly dependent on external (organic/biological) inputs to subsidize functions of pest control and soil fertility. Adopting such practices and leaving the monoculture intact does little to move towards a more productive redesign of farming systems. Farmers following this regime are trapped in an input substitution process that keeps them dependent on suppliers (many of a corporate nature) of a variety of organic inputs, some of questionable effectiveness and environmental soundness. Clearly, as it stands today, “input substitution” has lost its “pro-sustainability” potential. It is precisely the heavy use of these inputs that has been the target of organic farming detractors (the biotech industry) who accuse organic farmers of promoting insect resistance due to continual use of Bt sprays, of contaminating soil and water with copper sulphate and eliminating beneficial insects with rothenone and other non selective botanical insecticides.

It is important however to emphasize that only a minority of organic farmers follow the input substitution model, but these are the ones that control large tracts of land and amass much capital. Most small and medium size farmers still feature legume-based rotations, use of compost and a series of diversified cropping systems such as cover crops or strip cropping, including crop-livestock mixtures. Research shows that these systems exhibit acceptable yields, conserve energy, and protect the soil while inducing minimal environmental impact. A recent study in Washington State revealed that organic apple orchards gave similar apple yields than conventional and integrated orchards. Moreover, the organic system ranked first in environmental and economic sustainability as this system exhibited higher profitability, greater energy efficiency and lower negative environmental impact. Despite the benefits, such farming systems can still improve if guided by agroecological principles.

Agroecological conversion

The monoculture nature of organic farms can be transcended by adopting diversification schemes that feature optimal crop/animal assemblages which encourage synergisms. So the agroecosystem may foster its own soil fertility, natural pest regulation and crop productivity through maximizing nutrient recycling, organic matter accumulation, biological control of pests and constancy of production.

Promotion of biodiversity within agricultural systems is the cornerstone strategy of the system-redesign, as research has demonstrated that:

- Higher diversity (genetic, taxonomic, structural, resource) within the cropping system leads to higher diversity in associated biota.
- Increased biodiversity leads to more effective pest control and pollination.
- Increased biodiversity leads to tighter nutrient cycling.
- Increased biodiversity minimizes risks and stabilizes productivity

Using agroecological principles to improve farm performance can be implemented through various techniques and strategies. Each of these will have different effects on productivity, stability and resiliency within the farming system, depending on local opportunities, resource constraints, and, in most cases, on the market. The ultimate goal of agroecological design is to integrate components so that overall biological efficiency is improved, biodiversity is preserved, and agroecosystem productivity and its self-sustaining capacity are maintained.

The key challenge for the 21st century organic farmers is to translate ecological principles into practical alternative systems to suit the specific needs of farming communities in different ecoregions of the world. There are already numerous examples, according to researchers at the University of Essex who examined 208 agroecological projects implemented in the developing world, about 9 million farming households covering about 29 million hectares have adopted sustainable agricultural systems. A major strategy followed by these farmers was to restore agricultural diversity by following key agroecological guidelines. Some examples are given below.

Increase species diversity through intercropping.

In Africa, scientists developed an intercropping system using two kinds of crops that are planted together with maize: a plant that repels borers (the push) and another that attracts (pulls) them. The push-pull system has been tested on over 450 farms in two districts of Kenya and has now been released for uptake by the national extension systems in East Africa. Participating farmers in the breadbasket of Trans Nzoia are reporting a 15-20% increase in maize yield. In the semi-arid Suba district plagued by both stemborers and striga, a substantial increase in milk yield has occurred in the last four years, with farmers now being able to support grade cows on the fodder produced. When farmers plant maize, napier and desmodium together, a return of US$ 2.30 for every dollar invested is made, as compared to only $1.40 obtained by planting maize as a monocrop. Two of the most useful trap crops that pull in the borers' natural enemies are napier grass (*Pennisetum purpureum*) and Sudan grass (*Sorghum vulgare sudanese*), both important fodder plants; these are planted in a border around the maize. Two excellent borer-repelling crops which are planted between the rows of maize are molasses grass (*Melinis minutifolia*), which also repels ticks, and the leguminous silverleaf (*Desmodium*). This plant can also suppress the parasitic weed *Striga* by a factor of 40 compared to maize monocrops; its N-fixing ability increases soil fertility; and it is an excellent forage. As an added bonus, sale of *Desmodium* seed is proving to be a new income-generating opportunity for women in the project areas.

Using flowers and other vegetation in annual cropping systems to enhance habitat for natural enemies.

Several researchers have introduced flowering plants as strips within crops as a way to enhance the availability of pollen and nectar, necessary for optimal reproduction, fecundity and longevity of many natural enemies of pests. *Phacelia tanacetifolia* strips have been used in wheat, sugar beets and cabbage, leading to enhanced abundance of aphid-eating predators especially syrphid flies, and reduced aphid populations. In England, researchers created "beetle banks" sown with perennial grasses such as *Dactylis glomerata* and *Holcus lanatus* in an attempt to provide suitable over-wintering habitat within fields for aphid predators. When these banks run parallel with the crop rows, great enhancement of predators (up to 1500 beetles per square meter) can be achieved in only two years.

Diversifying perennial systems with agroforestry designs including the use of cover crops in vineyards and orchards

In such systems, the presence of a flowering undergrowth enhances the biological control of a series of insect pests. The beneficial role of *Phacelia flowers* to enhance parasitism of key pests in apple orchards was well demonstrated by Russian and Canadian researchers more than 30 years ago. In Californian organic vineyards, the incorporation of flowering summer cover crops (buckwheat and sunflower) leads to enhanced populations of natural enemies, which in turn reduced the numbers of leafhoppers and thrips.

Increasing genetic diversity through variety mixtures, multilines and use of local germplasm and varieties exhibiting horizontal resistance

Researchers working with farmers in ten townships in Yumman, China, covering an area of 5350 hectares, encouraged farmers to switch from rice monocultures to planting variety mixtures of local rice with hybrids. This enhanced genetic diversity reduced blast incidence by 94% and increased total yields by 89%. By the end of two years, it was concluded that fungicides were no longer required.

Intensifying use of green manures for regenerating soil fertility and soil conservation

In Central America, about 45,000 families using velvet bean tripled maize yields while conserving and regenerating soil in steep hillsides. In southern Brazil, no less than 50 thousand farmers use a mixture of cover crops that provide a thick mulch, allowing grain production under no-till conditions but without dependence on herbicides.

Enhancing landscape diversity with biological corridors, vegetationally diverse crop-field boundaries or by creating a mosaic of agroecosystems and maintaining areas of natural or secondary vegetation as part of the agroecosystem matrix

Several entomologists have concluded that the abundance and diversity of predators and parasite within a field are closely related to the nature of the vegetation in the field margins. There is wide acceptance of the importance of field margins as reservoirs of the natural enemies of crop pests. Many studies have demonstrated increased abundance of natural enemies and more effective biological control where crops are bordered by wild vegetation that natural enemies colonize. Parasitism of the armyworm, *Pseudaletia unipunctata*, was significantly higher in maize fields embedded in a complex landscape than in maize fields surrounded by simpler habitats. In a two year study, researchers found higher parasitism of *Ostrinia nubilalis* larvae by the parasitoid *Eriborus terebrans* in edges of maize fields adjacent to wooded areas, than in field interiors. Similarly, in Germany, parasitism of rape pollen beetle was about 50% at the edge of the fields, dropping significantly to 20% at the center of the fields.

One way to introduce the beneficial biodiversity from surrounding landscapes into large-scale monocultures is by establishing vegetationally diverse corridors that allow the movement and distribution of useful arthropod biodiversity into the centre of monocultures. Researchers in California established a vegetation corridor that connected to a riparian forest and cut across a vineyard monoculture. The corridor allowed natural enemies emerging from the riparian forest to disperse over large areas of otherwise monoculture vineyard systems. The corridor provided a constant supply of alternative food for predators effectively decoupling predators from a strict dependence on grape herbivores and avoiding a delayed colonization of the vineyard. This complex of predators continuously circulated into the vineyard interstices, establishing trophic interactions that enriched natural enemies, which in turn led to lower numbers of leafhoppers and thrips on vines located up to 30-40 m from the corridor.

Moving ahead

A key agroecological strategy to move farms beyond organic is to exploit the complementarity and synergy that result from the various combinations of crops, trees, and animals in agroecosystems that feature spatial and temporal arrangements such as polycultures, agroforestry systems and crop-livestock mixtures. In real situations, the exploitation of these interactions involves farming system design and management and requires an understanding of the numerous relationships among soils, microorganisms, plants, insect herbivores, and natural enemies. But such modifications are not enough to achieve sustainability as it is clear that the livelihood of farmers and the food security of communities is a much more complex problem determined by economic, social and political factors. How can organic farmers produce enough food in ecologically, environmentally and socially sustainable ways without adopting a specialized industrial model of production and distribution? How can advocates of organic farming promote an agriculture that is local, small-scale and family operated, biologically and culturally diverse, humane, and socially just? Is it possible to replace the industrial agriculture model with a new vision of farming deeply rooted in the original precepts of organic agriculture?

Surely, technological or environmental intentions are not enough to disseminate a more agroecologically-based agriculture. There are many factors that constrain the implementation of sustainable agriculture initiatives. Major changes must be made in policies, institutions, markets and research and development agendas to make sure that agroecological alternatives are adopted, made equitably and broadly accessible, and multiplied so that their full benefit for sustainable food security can be realized. It must be recognized that major constraints to the spread of truly sustainable form of farming are the powerful economic and institutional interests that are trying to de-rail and control the organic industry and its regulations.

The evidence shows that throughout the world, there are many organic agricultural systems that are economically, environmentally and socially viable, and contribute positively to local livelihoods. But without appropriate policy and consumers support, they are likely to remain localized in extent. Therefore, a major challenge for the future entails promoting institutional and policy changes to realize the full potential of a truly organic approach. Necessary changes include the following.

- Increase public investments in agroecological research methods with active participation of organic farmers, thus replacing top-down transfer of standardized technology model with participatory technology development and farmer-centred research and extension, emphasizing principles rather than recipes or technological packages.

- ♦ Changes in policies to stop subsidies of conventional technologies and to provide support and incentives for agroecological approaches.
- ♦ Appropriate equitable market opportunities including fair market access and expand local farmers markets and CSAs (Community Supported Agriculture or subscription farming) with pricing systems accessible to all
- ♦ Create policies that intervene in the market by opening opportunities for local organic producers (i.e., ordinances that mandate all food served in school and university cafeterias should be organic)
- ♦ Democratize and provide flexibility to the certification process, encouraging emergence of solidarious (no-cost certification, based on mutual trust) locally adapted certification
- ♦ Include farm size and social-labour considerations in organic standards, and limit certification against operations that leave a large ecological footprint.

In summary, major changes must be made in policies, institutions, markets and research to scale-up organic agriculture. Existing subsidies and policy incentives for conventional chemical approaches must be dismantled. Corporate control over the food system, including the organic industry must also be challenged. The strengthening of local institutional capacity and widening access of farmers to support services that facilitate use of accessible technologies will be critical. Governments and international public organizations must encourage and support effective partnerships between NGOs, local universities, and farmer organizations in order to assist and empower organic farmers to achieve success. There is also need to increase rural incomes through local and equitable market opportunities emphasizing fair trade and other mechanisms that link farmers and consumers more directly. The ultimate challenge is to scale-up forms of organic agriculture that are socially equitable, economically viable and environmentally sound. For this to happen, the organic movement will have to engage in strategic alliances with peasant, consumer and labour groups around the world and with the anti-globalization movement. It also needs to secure political representation at local-regional and national levels so that the political will is present in municipal or state governments to implement and expand the goals of a truly sustainable organic agriculture.

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