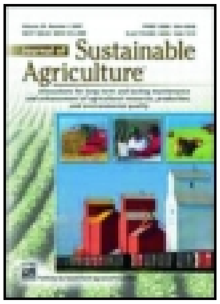

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Biointensive Sustainable Mini-Farming: I. The Challenge

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Biointensive Sustainable Mini-Farming: I. The Challenge

John C. Jeavons

ABSTRACT. The purpose of this paper is to: briefly describe current challenges in food production systems, land availability, water availability, genetic resources, human resources and per capita needs in light of an increasing global population; make a case for an alternative vision of effective, small-scale production (with a potential for long-term buildup of marginal soils) compared to conventional agriculture; and demonstrate that such a complementary, more decentralized system, where individual families take responsibility for what they grow and eat, may be productive, efficient, robust, flexible, resource-conserving, environmentally sound and strongly sustainable while encouraging and maintaining a higher degree of social and resource equity and stability for the people of this planet. *[Article copies available for a fee from The Haworth Document Delivery Service: 1-800-342-9678. E-mail address: <getinfo@haworthpressinc. com> Website: <http://www.HaworthPress.com> 2001 by The Haworth Press, Inc. All rights reserved.]*

KEYWORDS. Biointensive, small-scale, high-yielding, resource-conserving, organic

Population will increase rapidly, more rapidly than in former times, and 'ere long the most valuable of all arts will be the art of deriving a comfortable subsistence from the smallest area of soil.

–Abraham Lincoln, 1857

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THE CHALLENGES

To meet the challenges of increasing world population levels, many believe that a rough doubling of food production by 2050 is theoretically possible, but that the elements needed to accomplish it are not now available or in process. The United Nations in Agenda 21 reviewed the world's environmental, soil, and food situation and described goals for future food production through farming. These included: reducing chemical use, conserving and rehabilitating soil, improving farm productivity, conserving plant genetic resources, and developing effective organic farming techniques. The Asian Vegetable Research and Development Centre has observed that it will soon be essential to produce large amounts of calories from small areas through vegetable crops in order for there to be enough food for people.

THE BACKGROUND

This paper draws on Ecology Action's experience with *biologically intensive agriculture* for a 27-year period from 1972 through 1998. The specific form of farming being practiced has been named "Grow Biointensive" Sustainable Mini-Farming to distinguish it from other biointensive–biologically intensive–forms of agriculture that have appeared more recently and may use mechanical cultivation, pesticides and/or techniques not used by Ecology Action's approach. The "Grow Biointensive" method has been derived directly and indirectly from many similar practices developed independently in different parts of the world 1,000 to 4,000 years ago such as those in China, Greece, Bolivia, Peru, Mexico, Japan and more recently in France, Russia, Ireland and other parts of Europe (Biointensive History Citations, 1845 to 1991). One purpose is to describe the potential of this method as an applicable form of agriculture in today's world. (The method is described in detail in Part 2 of this series of articles.)

Ecology Action, a small non-profit organization located in California, has built on these forms of traditional agriculture, relearning techniques that are thousands of years old, discovering the scientific agronomic principles that underlie them, and developing written "how-to" materials for their replication in virtually all the global soils and climates where food is grown. The rediscovery of the principles involved in Grow Biointensive agriculture was facilitated by the work of Englishman Alan Chadwick, who brought similar food-raising practices to the University of California-Santa Cruz in 1967 (Bronson, 1970/1971). Ecology Action studied this work closely.

Many authorities have indicated the efficiencies of small-scale agriculture–some up to five times conventional agricultural yields. Globally, the small-scale experience has often demonstrated an "inverse relationship between farm size and productivity" (Wortman, 1976; Popenoe, 1982; Small-Scale Farming Citations, 1979 to 1998). Those making these evaluations have included representatives of the Rockefeller Foundation and the Institute for Tropical Agriculture.

After decades of research, Dr. Robert Netting cites numerous examples of this effectiveness in such diverse regions, cultures and climates as Nigeria, Mexico, Switzerland and Asia. The groups studied by Netting have demonstrated how smallholder family households employ simple tools, intensive labor, detailed knowledge of the local environment, and skillful management and organization to produce their own food and surplus crops for trade or market. He discovered that land tenure by individual family households provided farmers with the incentive to carefully conserve and sustain resources, and that long-term agricultural and social stability was a product of this smaller, more local control of land and labor. This approach contrasts to large-scale, energy-expensive, mechanized, specialized, capital-intensive practices pursued by conventional agriculture (Netting, 1993). More recently, small-scale farming has made an important difference in Russia. In 1997 fifty percent of Russia's agricultural production "was on household plots of less than an acre each. These represented some 14 million acres, or 3 percent of all [Russian] farmland" (Matloff, 1998).

Catalyzing long-term Grow Biointensive agricultural research, development and educational programs has been a goal of Ecology Action since 1972. Only recently have sufficient data been collected and evaluated to call for an academic initiative. Grow Biointensive Sustainable Mini-Farming practices demonstrate *a potential of enabling people to double their food production regionally while using a fraction of the resources used by conventional practices per pound of food produced.* This experience of Ecology Action and others around the world is not meant to be exhaustive or totally definitive. Instead it illustrates a key *pattern* with a capacity for significantly increased yields, combined with significantly reduced resource consumption. As a result, these practices seem to be worthy of serious long-term statistical evaluation by the agricultural academic community, so that the importance of their applications to soil fertility, food production and resource conservation may be determined in relation to a planet with a diminishing per capita soil, water, fertilizer and energy base.

The study of Biointensive practices has revealed several *biologically intensive economies of small-scale*. How many people have experienced plants growing in widely spaced rows in nature? In contrast, a *densely woven, living blanket of biodiversity* can be observed if natural systems are encouraged. When natural systems are mimicked in organic Grow Biointensive farming practices, yields up to Green Revolution-type high productivity may be obtained with normal open-pollinated seeds while just a fraction of the water, nutrient and energy resources are consumed per pound of food produced. If the techniques are utilized in their entirety, the fertility of the soil can be *built* and *maintained* at the same time. Grow Biointensive practices, when used properly, have the capacity to build the soil in terms of humified carbon in the upper one to one-and-one-half inches of the soil–one key measure of soil-building–up to 60 times faster than occurs in Nature–at a time when conventional practices in the U.S. are depleting the soil about 18 times faster than happens naturally (Maher, 1983; Ecology Action, 1996).

Agricultural systems based on natural systems can offer greater long-term economy and also can possess a *stronger level of sustainability*. Current conventional agricultural systems, in contrast, have depleted and are continuing to significantly deplete regional environments, and demonstrate *less strong levels of sustainability*. As a result, their initially naturally based soil systems are not responding well. It has been observed that the economic consequence to agriculture from these soil system losses is major, and that a *basic correction* of the problems involved would be much less expensive than trying to minimize them by balancing out their negative effects with technological solutions.

A PERSPECTIVE AND A PROJECTION OF FUTURE CONDITIONS

Soil

Normally it takes 500 years for nature to build 1 inch of topsoil. To grow good crops agriculturally, 6 inches of topsoil are required. Therefore, approximately 3,000 years are needed to build up a reasonable agricultural soil. In contrast, the 5,454 kilograms (12,000 pounds) per acre of soil being lost due to wind and water erosion in the U.S. is an annual average loss of 0.09 centimeter (0.0356 inch–approximately 1/28th of an inch) of soil over 0.4 hectare (1 acre). Since only 1/500th of an inch of topsoil is being built up naturally as an annual average in the U.S., the soil depletion rate each year occurs approximately 18 times faster than the soil is formed in nature. In developing nations, soil is being depleted up to 36 times faster than it is being formed in nature; and, in China, 54 times faster (derived from: Soil Conservation Service, 1994). It is essential to find a way to reverse these losses to our soil base.

Given the projected increases in population in the coming decades, the amount of cropland per person is expected to decrease as urban sprawl overtakes land previously used for agricultural production and as the rural areas lose their fertility (Gardner, 1996, pp. 12-19). *Food security* is an increasing concern in countries everywhere and with reason. *By the year 2014 there may be an average reduction in farmable soil to as little as 836 square meters (9,000 square feet) per person*–down from 2,787 square meters (30,000 square feet) in 1977 and 2,043 square meters (22,000 square feet) in 1988–for the 90% of the world's people expected to be living in developing countries, and some of this soil will be needed to preserve key non-farm genetic diversity. (This is based on a probable world per-person farmable area projection from 1977 to 2014 derived from the data in *UN-FAO Yearbook–Production* for the years 1977 through 1996 and extended by a conservative progression through 2014 combined with a conservative world population level for 2014 of approximately 6.7 billion people and a developing nations population of approximately 6.0 billion–about 90 percent of the world population.)

In contrast, a Master's of Science thesis at the University of California, Berkeley in 1983 indicated that Biointensive practices (as performed by Ecology Action on Syntex Corporation land at the Stanford University Industrial Park) built up the humified carbon level in the upper 1 to 1.5 inches of the soil, which began as only 'C'-horizon material, to a level in about 8 years that would have taken nature alone 500 years to accomplish. Therefore, this thesis indicated that Biointensive techniques may have the potential to build soil up to 60 times faster than it can be developed by nature alone. If utilized, this technique may make possible not only the maintenance of sustainable soil fertility, but also the reclamation of deteriorated and marginal lands (Maher, 1983).

Grow Biointensive agricultural practices, *fully and properly* used, can produce a greatly increased level of nutrition per unit of area, thus leaving fragile ecosystems uncultivated and protecting genetic plant and animal diversity in the wild. These practices can accomplish this in part by utilizing: (1) a combination of certain varieties of grains in 60% of the growing area, that produce high levels of carbonaceous dry matter per unit of area for compost in addition to a significant amount of calories for diet; (2) special root crops in 30% of the growing area, such as potatoes, sweet potatoes, salsify, burdock, garlic, and parsnips, that produce large amounts of calories per unit of area; and (3) salad/ salsa/stew sauce-type vegetable crops in 10% of the growing area for additional vitamins and minerals.

". . . worldwide, prime farmland is rare. The FAO estimates that only 11 percent of the world's soil can be farmed without being irrigated, drained, or otherwise improved" (Markwart, 1999). "With soil erosion exceeding soil formation in many areas, parts of the Earth are slowly being drained of their inherent fertility" (Brown et al., State of the World, 1998). "Approximately 30% of the world's arable crop land has been abandoned because of severe soil erosion in the last 40 years . . ." (Rural Advancement Foundation International, 1997). "Mechanical cultivation and the production of continuous row crops have resulted in soil loss through erosion, large decreases in soil organic matter content, and a concomitant release of organic carbon as carbon dioxide to the atmosphere" (Houghton et al., 1983). "Where the topsoil has been entirely removed, or where it has been severely eroded, crop yields are from 20 to 65% lower than on non-eroded soils." (See also: Soil Conservation Service, 1994; Barrow, 1991; Parr et al., 1992; Pimentel et al., 1995; Ribaudo, 1989; Doran, 1996; Karlen et al., 1992, p. 49.)

Population

Currently, about 213,699 people net are added to the global population daily (United Nations, 1998). As a result, the planet in one sense "needs" at least 19,853 more hectares (34,341 acres) of farmable land daily (752 square meters or 7,000 square feet/person) to produce just a vegan diet, given conventional U.S. agricultural practices (see also: Brown and Kane, 1994; Cohen, 1995; Pearce, 1998; Mossat, 1996). This underscores the continuing need for family planning initiatives to maintain population levels within available farmable soil levels.

Water

Water Scarcity and Population

By 2050, the average person in the world is expected to have only 25% of the fresh water that was available in 1950 (Meadows, 1999). ". . . Per capita water supplies worldwide are a third lower now than in 1970 due to the 1.8 billion people added to the planet since then . . . The projected increase in the world's population is resulting in a greater urban demand for water" (Postel, 1996, p. 28). Therefore, agricultural production will be forced to use water more efficiently. Organic agricultural systems including Biointensive practices are both more water-efficient and more "drought-proof." A 15-year study recently completed by the Rodale Institute has demonstrated such a resilience (Drinkwater et al., 1998).

"The UN's 1994 medium population projection suggests that by the middle of the coming century, [under] the low projection . . . the proportion [of the world's population] would be 44 percent, or 3.5 billion people living in 51 water-short countries out of a total world population of 7.9 billion. Clearly, the extent of water shortages will depend to a large degree on which trajectory world population follows" (Engleman and LeRoy, 1994, p. 8). "Worldwide, agriculture accounts for about 65 percent of all the water removed from rivers, lakes, and aquifers for human activities, compared with 22 percent for industries and 7 percent for households and municipalities . . ." (Postel, 1996, p. 13).

Natural Rainfall vs. Irrigation

". . . Today, 84 percent of the world's cropland is watered only by rain, while 16 percent benefits from the greater control afforded by farmers applying water" (Postel, 1996, p. 49). "As per capita fresh water supplies plummet in many nations, formidable forces constrain future irrigation projects, and thus any accompanying gains in yield" (Brown et al., 1998, Vital Signs, p. 42).

Global Warming

". . . An international group of scientists has concluded that a 1 to 2 degree Celsius [1.8-3.6 degrees Fahrenheit) warming along with a 10 percent decrease in precipitation–well within the realm of possibility in some areas–could reduce annual runoff by 40-70 percent. Such a drop would have staggering economic environmental consequences on regions already short of water–forcing land out of irrigation, reducing hydroelectric power production, wiping out many species, and greatly constraining urban growth and the quality of life" (Postel, 1996, p. 88).

Meeting Water Demands and Growing Sufficient Food

". . . within the next 25 years, providing sufficient water to meet projected food needs on a sustainable basis will be extremely difficult. . . . food production from both fisheries and pastured livestock is already reaching its limits, so that nearly all of the additional food needed by 2025 will need to be produced on croplands. . . . when degradation of currently utilized croplands is taken into account, the potential for significantly expanding total cropland area is low. Therefore, the necessary annual increase in agricultural productivity of at least two percent per year must come *almost entirely* from increased productivity *per unit area* for plant crops. . . . Water supply is a key factor for determining plant crop productivity per unit area. Doing more with less is the first and easiest step along the path toward water security. By using water more efficiently, we in effect create a new source of supply" (Williams, 1998).

Energy

"Human influence on the planet has increased faster than the human population. For example, while the human population more than quadrupled from 1860 to 1991, human use of inanimate energy increased from . . . 1 billion megawatt hours/year . . . to 93 billion . . ." (Cohen, 1995). Oil availability is expected to peak at about 2005 and natural gas at about 2020 (Oil and Gas Journal Special, 1997). Current estimates of practically available fossil fuel reserves project crude oil to be depleted within 35 years (Flavin and Lenssen, 1990; Campbell and Laherrere, 1998). Fossil fuels will become more scarce in the future, making fuel, artificial plant nutrients, and crop protectants for agricultural use much more expensive. *Without these inputs, the area needed to produce an annual diet for one person by U.S. current conventional commercial agricultural practices might conservatively be estimated to increase as much as threefold, due to productivity decreases resulting from a reduction in availability of inexpensive nitrogen fertilizer inputs*–from a current range of approximately 1,612 to 3,901 square meters (15,000 to 42,000 square feet) to as much as 4,836 to 11,705 square meters (45,000 to 126,000 square feet) in the future (developed in part from: Watt, 1974, pp. 39-40).

Atmospheric Carbon Dioxide, Global Warming and Climate

Carbon dioxide is one of the major gases responsible for the Greenhouse Effect. Some carbon dioxide in the atmosphere is normal, but currently in our atmosphere there is an excess of approximately 65 metric gigatons (gigaton = G ton = 1 billion tons) [update] of carbon in the form of carbon dioxide, largely from the burning of carbon-based fossil fuels, deforestation, and insustainable farming practices (Volk, 1994, p. 48). This excess atmospheric carbon dioxide has been shown to be responsible for at least one-half of the Greenhouse Effect, the long-term effects of which are difficult to prove but which will probably increase or decrease regional temperatures, sea levels, and/or snow and ice coverage around the world, depending on the conditions and premises involved, to extremes non-optimal to most living beings and ecosystems.

"Soil organic matter . . . is the major global storage reservoir for carbon" (Rural Advancement Foundation International, 1997, p. 81). Grow Biointensive Sustainable Mini-Farming and other approaches such as sustainable agroforestry may be able to remove all excess Greenhouse Effect-causing atmospheric carbon dioxide developed since 1976 and expected to be developed through 2016 while producing more food and conserving resources. This could be made possible by the increased amount of carbon tied up in increased crop plant populations per unit of area and the increased organic matter levels in the soil. An increased number of trees on the planet would assist greatly (Ecology Action, 1999). "Stabilizing the climate will ultimately require reducing global carbon dioxide emissions by 60 to 80 percent" (Flavin and Lenssen, 1990, p. 7).

Climate change models predict greater severity and frequency of extreme weather events in the future (Karl et al., 1996). Should an average increase in temperature of 5 degrees Celsius (9 degrees Fahrenheit) occur, some scientists believe the result could be a reduction of up to 50% in U.S. food production. In the first eight months of 1998, the average world temperature was 0.4 degrees Celsius (0.7 degrees Fahrenheit) warmer than in 1997 (Flavin, 1998). Changes in climate will require agricultural production systems to be environmentally robust. At the core of environmental robustness is diversity. Grow Biointensive agricultural practices encourage both plant and soil microbe diversity.

FARMING: CONVENTIONAL AND BIOINTENSIVE

The Production and Environmental Record of Conventional Agriculture

"Conventional agricultural practices, producing a larger amount of food for the world's people than ever before, have been seen as the 'most efficient in history.' At the same time, however, the environmental degradation of soil, water, nutrient and energy resources has occurred at an unparalleled rate. Globally, grain production began to level off in the 1990s as increased chemical fertilizer inputs ceased to produce increased yields. The point of diminishing returns has been reached" (Brown and Kane, 1994).

Small-Scale

Approximately 85% of U.S. farmers obtain yields slightly less than the U.S. average, 14.5% produce yields about twice the U.S. average and about 0.5% obtain yields up to four times this average. Grow Biointensive farmers, with an average buildup in skill and soil fertility and without high water, fertilizer and energy inputs, may produce about two times the U.S. average–thereby being in the upper 15th percentile of farmers (Ecology Action, 1975-1976).

Transportation

The average piece of food consumed in the U.S. travels approximately 1,400 miles. "Americans once fed themselves–with a few exceptions. . . . Today, one-third of all fresh fruit and 12 percent of all vegetables consumed in the United States come from other countries. Even staples, like tomatoes (31.4 percent), come from abroad. And the numbers keep growing. Imports are up more than 50 percent since 1990" (Hoyle and Flatley, 1998). The utilization of Grow Biointensive production efficiencies on "greenbelt" farms in and near cities holds significant potential in an increasingly urbanized world. This kind of more-local food growing would mean fresher food available to large numbers of people and greatly reduced transportation costs. In addition, local Community-Supported Agriculture (CSA) farms could produce freshly grown complete diet packages for retail sale to nearby neighborhoods with almost no transportation expenses.

Food Supplies

"Grain reserves averaged the equivalent of 81 days of global consumption between 1982 and 1993, but have fallen steadily since then, dropping to 48 days' worth in 1995" (Gardner, 1996. p. 12). Generally 60 days of grain food reserves are required to "fill the food pipeline," and politicians and food specialists worry when reserves fall below this level. In 1998 the reserves climbed to a 64-day supply with a projection of 62 days for 1999 (USDA, 1999), but it must also be kept in mind that *the world has consumed more grains than it has grown* for eight of the last 12 years (1987 through 1998), and population and environmental pressures are increasing the vulnerability of this situation [During 7 of the previous 12 years (1975 through 1986) and 8 of the 12 years before that (1963 through 1974) *the world produced more grain than it consumed*] (USDA, 1998).

Seeds

". . . Biotechnology has not produced any yield-raising technologies that will lead to quantum jumps in output, nor do many researchers expect it to. Donald Duvick, for many years the director of research at the Iowa-based Pioneer Hi-Bred International, one of the world's largest seed suppliers, makes this point all too clearly: 'No breakthroughs are in sight. Biotechnology, while essential to progress, will not produce sharp upward swings in yield potential except for isolated crops in certain situations' " (Brown and Kane, 1994, p. 25). The loss of the world's agricultural genetic base is not necessary. Globally endangered seed varieties are often preserved unknowingly in small farm pockets. Small farms (and gardens) are key locations for the preservation and acclimatization of seeds. New seed strains which are adapted to particular climates and soils and which are resistant to local pests and diseases can be developed in these locations. In addition, seed yields obtained with Grow Biointensive practices can be up to two to four times conventional yields per unit of area and can be grown in or near the area in which they are intended to be used.

Fertilizer and Nutrients

"The principal reason for the slower growth or stabilization of fertilizer use in many countries is that the amount being used is approaching the physiological capacity of crops to absorb nutrients" (Brown et al., 1998, p. 44). "As more and more countries turn to imported grain, the nutrient cycle is further disrupted. The United States, which exported close to 100 million tons of grain a year during the eighties, suffered a heavy loss of soil nutrients. The nutrients in the wheat from Kansas and the corn from Iowa were ending up in the sewage discharges of St. Petersburg, Cairo, Lagos, Caracas, and Tokyo" (Brown and Kane, 1994, p. 124).

". . . According to one calculation, it takes the equivalent of 53 million barrels of oil–worth more than $1 billion–to replace with fossil fuel-based fertilizers the amount of nutrients yearly discarded in U.S. sewage" (Postel, 1992, p. 127). "Most fertilizer inputs–whether chemical or organic–are nutrient substitutes for the nutrients harvested from the soil in the form of crops, eaten by people, and then flushed away into sewage systems. Rarely are these nutrients recycled properly into the soils from which they came. The human sewage from one person from all year, under certain cropping and recycling conditions, can contain most of the nutrients needed to grow a complete, balanced diet for one person for all year on a small-scale agricultural basis" (Beeby, 1995).

Since 1972, Ecology Action has generally added the same amount, or less, of purchased nutrients (in organic form) *per unit of area* in comparison with conventional agriculture. With Grow Biointensive's potential of two to four times the yield per unit of area, this means the potential of a *reduction* in the use of purchased fertilizer nutrients to one-half to one-quarter per pound of food produced, or less. The yield *per plant* in these intensively planted areas, which have an increased plant population per unit of area, can sometimes be equal to those in less-densely planted areas and sometimes even greater. This is different than in conventional intensively planted areas where the total yield per unit of area increases, but the yield per plant usually decreases.

The Question

The question for the global community at this point is: Are there any agricultural approaches that might meet all of these challenges in an environmentally sound, universally affordable and effective manner?

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