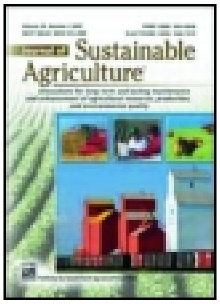

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Biointensive Sustainable Mini-Farming: II. Perspective, Principles, Techniques and History

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ABSTRACT. The purpose of this paper is to briefly describe the: principles for a more productive, resource-efficient and environmentally sound agriculture; the philosophical foundation for this kind of farming; the historical agricultural systems leading to Ecology Action's "Grow Biointensive" system: the French intensive, the Biodynamic, and Alan Chadwick's Biodynamic/French intensive approaches; and a description of Ecology Action's system. *[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

PRINCIPLES FOR A MORE PRODUCTIVE, RESOURCE-EFFICIENT, AND ENVIRONMENTALLY SOUND AGRICULTURE

A viable, strongly sustainable agriculture system will promote:

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- high productivity
- promotion of a healthy environment
- environmental stability and robustness
- resource-conservation
- flexibility
- a balanced sharing of farming power among local, regional and national levels, and
- a diverse and strong social fabric.

"GROW BIOINTENSIVE" SUSTAINABLE MINI-FARMING–PHILOSOPHICAL FOUNDATION

One of the most important aspects of this method's potential is that its *maximization of yields and minimization of resource consumption combined with a significant enhancement in soil fertility need not be fully developed in order to produce a major difference locally and globally*. At *intermediate* yield levels, that can be realized with a moderate increase in skill and soil fertility; combined with an improved understanding of diet involving a focus on the amount of caloric yield per unit of area for different crops: *approximately twice the people in the world might be fed while using one-half, or less, the water, purchased nutrients (in organic form), and energy per pound of food produced when compared with conventional mechanized chemical, or organic, agricultural practices*. In addition, this level of productivity might enable up to one-half the world's arable land to be left in wild to preserve essential plant and animal genetic diversity.

"Grow Biointensive" Sustainable Mini-Farming practices and an understanding of which crops provide a high level of caloric and/or carbon productivity per unit of area per unit of time can make it possible to grow a vegan diet for one person for all year on as little as 371 square meters (4,000 square feet) at reasonably obtainable *intermediate-level* yields (Diet Citations: Ecology Action, 1984-1997: estimate based on Ecology Action Diet Design practices growing key diet crops combined with the growing of compost crops for sustainable soil fertility). Since many of the world's people currently have only enough rainfall to satisfactorily raise food on an area this size (based on an article in: World Monitor, 1993) *and since, by the year 2014, ninety percent of the world's people (those in developing countries) are expected to have an average of only 836 square meters (9,000 square feet) of arable land upon which to raise their food,* this potential agricultural effectiveness could become very important (UN

FAO Yearbook–Production: Based on probable world farmable area projection from 1977 to 2014 combined with an anticipated 2014 world population level of approximately 6.7 billion people and a developing nations population of about 6.0 billion). It is even more important when one realizes that *conventional mechanized chemical and organic agricultural techniques* currently require:

- about 650 square meters of farmable soil (7,000 square feet) to raise a *vegan diet* that contains no animal products [this 1998 level is based on 1998 seed stock use and chemical fertilizer applications estimated from yields in: USDA Yearbook–1998. A *post fossil fuel era* estimate might be approximately three times as much, or 1,950 square meters (21,000 square feet), due to reductions in yield resulting from reduced chemical nitrogen fertilizer inputs],
- 1,393 to 2,787 square meters (15,000 to 30,000 square feet) to raise an *average U.S. diet* with an average amount of meat, milk, eggs and cheese [this 1998 level is based on 1998 seed stock use and chemical fertilizer applications estimated from yields in USDA Yearbook–1998. A *post fossil fuel era* estimate might be 4,180 to 8,561 square meters (45,000 to 90,000 square feet)], and
- approximately 3,623 to 5,852 square meters (39,000 to 63,000 square feet) to raise a *diet high in animal products* [this 1998 level is based on 1998 seed stock use and chemical fertilizer applications estimated from yields in: USDA Yearbook–1998. A *post fossil fuel era* estimate might be approximately 12,541 to 17,558 square meters (135,000 to 189,000 square feet)].

Thus, by 2014, with the current agricultural methods and diets, only 41% of the global population might be sustained nutritively [based on probable world farmable area projection from 1977 to 2014 (UN-FAO Yearbook–Production, 1997) combined with an anticipated 2014 world population level of approximately 6.7 billion people]. So, in fact, the major ways in which the world is currently farming and eating will not provide sufficient nutrition for most of the world's people as early as 14 years from now, in 2014, unless some dramatic changes occur in the way food is raised and/or in the diets eaten.

An additional aspect of Grow Biointensive techniques is their potential for a dramatic reduction in water consumption per pound of food produced, compared with conventional agricultural practices. Biointensive may use water as much as three to eight times more effectively per pound of food produced when compared with conventional agriculture: for grain and seed crops as little as 33% of the water may be used per pound of food produced; for vegetables as little as 12% depending on the soil type, climate, water availability and the crops grown. An actual example of this effectiveness can be found in Machakos, Kenya, an area where there is reportedly "not enough water" to grow citrus. Morris Makiti, one of the teachers first trained in Biointensive in that country, applied what he learned by sprouting seeds from grapefruit he bought at the local village market. He then created an orchard of 1,000 thriving trees grown with Biointensive practices (Ecology Action, 1996).

A FEW HISTORICAL NOTES

China

Four thousand years ago the Chinese were using a biologically intensive, "miniaturized" form of agriculture (Buchanan, 1970). The Chinese grew food with this approach and maintained soil fertility for thousands of years without depleting the soil significantly. As recently as 1890 this way of farming enabled them to grow all the food for one person on about 538 to 668 square meters (5,800 to 7,200 square feet), including animal products used at that time (developed from: King, 1972).

Biosphere II

Despite all its challenges, the people in Biosphere II, using techniques based in part on those rediscovered by Ecology Action, were able to raise about 83% of their low-calorie diet during a two-year period within a "closed system" on approximately 274 square meters (2,957 square feet) per person (Marino, 1998). This experience indirectly demonstrated that a complete year's diet for just one person could be raised on the equivalent of 330 square meters (3,562 square feet)– less than the Chinese in 1890. In contrast, conventional agriculture in the United States requires approximately 2,787 square meters (30,000 square feet) to produce an average diet–while bringing in inputs from other areas and soils in order to make even this possible (this is based on 1998 seed stock use and chemical fertilizer applications estimated from yields in: USDA Yearbook–1998).

In contrast with Biosphere II and conventional United States agriculture, about 1,486 square meters (16,000 square feet) in the year 2000 will be required to raise all the food for one person given actual agricultural practices being used and actual diets being eaten in developing countries in 1998 [based on probable projection from 1977 to 2000 (UN-FAO–Production, data for years 1977 through 1997)].

THE HISTORICAL AGRICULTURAL SYSTEMS LEADING TO ECOLOGY ACTION'S GROW BIOINTENSIVE SYSTEM

The French Intensive Approach

French intensive techniques were developed in the 1600's, 1700's and 1800's outside Paris. Crops were grown on a 45-centimeter (18-inch) depth of usually composted horse manure, a fertilizer which was readily available at the time. The crops were grown so close to each other that when the plants were mature their leaves would barely touch. The close spacing provided a mini-climate and a living mulch which reduced weed growth and helped hold moisture in the soil. During the winter, glass jars were placed over seedlings to give them an early start. The gardeners grew up to nine plantings and harvests each year and could even grow melon plants during the winter (Biointensive Citations, 1658-1972).

The Biodynamic Approach

Biodynamic techniques were developed by Rudolf Steiner, an Austrian genius, philosopher and educator, in the early 1920's. Noting a decline in the nutritive value and yields of crops in Europe, Steiner traced the cause to the use of the newly introduced synthetic, chemical fertilizers and pesticides. An increase was soon noticed in the number of crops affected by disease and insect problems. These fertilizers were not deemed to be complete nutrient systems for the plants, but single, physical nutrients in a readily available, soluble salt form. Steiner believed that the fertilizers caused chemical changes in the soil which damaged its structure, killed beneficial microbiotic soil life and greatly reduced the soil's ability to make nutrients already in the air and soil available to plants.

Steiner recommended returning to the more gentle, diverse, holistic and balanced diet of organic fertilizers as a cure for the challenges brought on by synthetic, chemical fertilization. He also initiated a movement to scientifically explore the relationships–both beneficial and detrimental–which plants have with each other.

Biodynamics emphasized raised growing areas which mimic the advantages of plant growth in landslides. Two thousand years ago, the Greeks noticed that plant life thrives in landslides. The loose soil allows air, moisture, warmth, nutrients and roots to more optimally penetrate the soil. The large curved surface area between the two edges of the landslide provides more surface area for the penetration and interaction of the natural elements than a flat surface. Biodynamics developed the use of homeopathic herbal preparations for the optimum development and maintenance of soil health and the proper production of nourishing compost. It also utilized the forces of the planets and stars to optimize planting processes (Biodynamic Farming Citations, 1938-1988).

Alan Chadwick and the Biodynamic/French Intensive Method

During the 1960's, Alan Chadwick, an Englishman, combined biodynamic and French intensive techniques into the "biodynamic/French intensive method." Chadwick prepared the soil 60 centimeters (24 inches) deep through the process of "double-digging," used less compost than the French, depended much less on manure, used few homeopathic solutions, utilized some plant relationships and planted by the phases of the moon. The United States was first exposed to the combination when Chadwick brought the method to the four-acre organic Student Garden at the University of California's Santa Cruz campus in 1967. Chadwick, a horticultural genius, had been gardening for half a century and was also an avid dramatist and artist. The site he developed at Santa Cruz was on the side of a hill with a poor, clayey soil. By hand, Chadwick and his apprentices created a good soil and a veritable "Garden of Eden" within several years (Bronson, 1970/1971).

ECOLOGY ACTION'S GROW BIOINTENSIVE SUSTAINABLE MINI-FARMING APPROACH

Chadwick noted that his method produced up to four times the yield per unit of area and used only half the water per pound of food produced when compared with commercial agriculture, but he had collected no data about these and other aspects of his method. He taught by the apprentice system through a series of lectures and practical work in the field and did not believe in teaching by the written word. He prepared the soil differently for most crops, one example of which is Scarlet Runner Beans which required twelve different layers of soil and amendments throughout the 24-inch-deep growing area (Cuthbertson, 1978). Ecology Action made Chadwick's method more accessible and accountable by initiating a program of research, data collection, and documentation in reports and how-to publications. It also developed a system in which the growing areas for all crops are prepared the same way. This latter simplification has enabled more people to easily become involved in this form of food-growing. In addition, Ecology Action emphasized the growing of compost crops on a "closed-system" basis for the development and maintenance of sustainable soil fertility. Ecology Action's program of international networking and technical assistance is facilitating the adoption of the Grow Biointensive method globally.

THE EVOLUTION OF FARMING RESEARCH PERFORMED AT THE STANFORD UNIVERSITY INDUSTRIAL PARK AND WILLITS, CALIFORNIA, SITES

In January of 1972, Ecology Action, then located in Palo Alto, California, initiated its Biointensive Sustainable Mini-Farming Program. It began to collect food and biomass yield and resource consumption data on a wide spectrum of crops including vegetable, grain, fruit, nut, berry and fiber crops. The program's purpose was to determine how one could grow all one's soil fertility, diet, income, clothing, housing and other agricultural needs in the smallest area in a sustainable and globally equitable manner while preserving genetic diversity. The biologically intensive practices involved were ones which millennia before had been successfully utilized in agriculture. Many of these practices, when used properly, had proven sustainable for hundreds and even thousands of years.

Potential "economies of small scale" in this system include up to:

- a 200 to 400 percent (or greater) increase in caloric production per unit of area,
- a 67 to 88 percent reduction in water consumption per unit of production,
- the potential of a 100 percent (or greater) increase in soil fertility in a few years in C-horizon and many depleted soils–while production increases and resource use is reduced (derived from: Maher, 1983),

- a 50 to 100 percent reduction in the amount of purchased organic fertilizer required per unit of production,
- a 99 percent reduction in the amount of energy used per unit of production,
- a 100 percent (or greater) increase in income per unit of area.

In an area as small as 9.3 square meters (100 square feet) with good soil, planning and choice of crops, all the *vegetables and soft fruits* needed for a whole year by one person can be grown in a six-month growing season. In addition, combined with a better understanding of how to maximize the production of nutrition per unit of area, "Grow Biointensive" practices may sustainably grow *a complete diet* for one person for all year in as little as forty 9.3-square-meter (100-square-foot) growing areas for a total of 371 square meters (4,000 square feet) of growing surface. When the right mixture of crops is selected, a good income may also be grown sustainably on as little as forty 9.3-square-meter (100-square-foot) growing areas and sometimes significantly less (Economic Mini-Farming Citations, 1983-1991).

THE "GROW BIOINTENSIVE" METHOD

The following elements, properly combined in the Grow Biointensive approach, can achieve these effective and synergistic results:

1. *Deep soil preparation* develops *good soil structure* to a depth of 60 cm (24 inches). The soil is alive with a combination of macro- and microorganisms, humus, minerals and water and air. The microorganisms need air to breathe. With this approach the soil thrives to a greater depth which gives the plant roots a more optimal feeding area. Once a good soil structure is established, only a surface cultivation of 5 cm (2 inches) may be required. In soils with good structure, double-digging is not needed to maintain significant yields and may even deplete the quality of the structure.

2. The soil is fed with appropriate amounts of *compost*–the major source of food for microbes. An amount of cured compost the size of a teaspoon can contain up to 6 billion microbial life forms. This is more life forms than there are people on the Earth. In one raised growing bed there are unimaginably more life forms than this. Many of these microbes have the capacity to fix nitrogen in the soil, and others produce antibiotics in the

soil which help keep plants healthy. The humus in compost also "traps three to five times more nutrients, water, and air than other soil matter does" (Brown et al., State of the World, 1998, p. 102).

3. *Organic fertilizers* on the approved list of the California Certified Organic Farmers, such as alfalfa meal, oyster shell flour, kelp meal and zinc chelate, are used if needed.

4. *Close spacing* is utilized for the plants in the growing area. The plants are placed in offset, or hexagonal, spacing so their leaves touch, or barely touch, when they are mature. Nature has a desire to grow plants close together rather than in rows. That is why so many weeds grow in between the rows in conventional agricultural practices. Nature abhors a void or desert and as much as possible fills it with living plants. For the greater part of history, much of humankind has grown plants close together. In this way the plants provide a *living mulch* which preserves precious moisture in the soil. The plants also like the stimulation of growing together. The umbrella provided by the plants creates a *carbon dioxide envelope* underneath the leaves as well as a *humidity envelope*. The crops breathe in this extra carbon dioxide which increases their productivity, and the humidity provides a more optimal environment for the soil microbes. All these factors produce healthier plants.

5. *Companion planting/plant symbiosis* relationships are used to advantage. Different crops have special affinities for each other. Some prefer to be close–others distant–just as in human relationships. Green beans and strawberries are reported to do better when they are grown together rather than separately. For the best-tasting bibb lettuce, Alan Chadwick suggested growing one spinach plant with each four bibb lettuce plants. Wheat may benefit by a ratio of one chamomile plant to 200 wheat plants. Grain crops have key rotation relationships as well (Companion Planting Citations, 1936-1985).

6. The use of *open-pollinated seeds*. With Grow Biointensive techniques, Green Revolution-type yields can be obtained with normal open-pollinated seeds which have been selected over the decades and centuries because of their advantage. Special hybrids are not needed for excellent results. In this way a wide spectrum of varieties can be grown with success while more of the world's genetic diversity is preserved actively in the field.

7. *Carbon farming–Soil fertility* is facilitated when approximately 60% of the growing area is planted in *dual-purpose* seed and grain crops. These key crops produce a large amount of carbonaceous material per unit of area, which is used to build compost for improving and maintaining the

soil ecosystem's microbial life. These crops also produce a significant amount of calories. Corn, wheat, amaranth, millet, sorghum and oats are some of the crops that make this possible. Growing compost materials on the farm will be important in the future, since large amounts of organic matter and nutrients are currently being "mined" from other soils and sent away to improve other farms. Instead we need to be producing more organic matter and retaining more nutrients on a "closed-system" basis. One survey asked organic farmers, " 'Approximately what percentage of your soil fertility inputs come from on-farm and off-farm sources?' (This question, of course, allows for tremendous leniency in the perception of the farmer.) The 945 respondents, as a group, generated 58% of their soil fertility inputs on-farm, and 38% came from off-farm. Two additional follow-up questions asked whether on-farm livestock were part of the fertility regime (43% said yes; 47% keep no livestock), and what off-farm soil fertility inputs were most important to them: manures came in first at 331 responses, composts came in second at 179 responses" (Organic Farming Research Foundation, 1995). In the future the "mining" of other soil in order to improve a farm will need to be kept to a minimum if world-wide sustainable soil fertility is to be maintained.

8. *Calorie farming*–The production of sufficient calories efficiently in a small area is facilitated when special root crops are planted in 30% of the growing area. These crops include potatoes, sweet potatoes, salsify, burdock, garlic and parsnips and produce a large amount of calories for the human diet per unit of area.

9. Grow Biointensive farming involves a *whole system*. It is important to use all of its elements together or the soil may be depleted rather than improved. For example, the production of high yields without replenishing the soil with nutrients and organic matter will ultimately result in lower yields and a depleted soil. Also, close spacing does not generally work well with shallow soil preparation unless good soil structure 60 centimeters (24 inches) deep has already been established.

The Questions

The questions are: Given the perspective, principles, techniques and history of Grow Biointensive Sustainable Mini-Farming, what has been its performance under different conditions, what is its future potential and what research needs to occur?

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