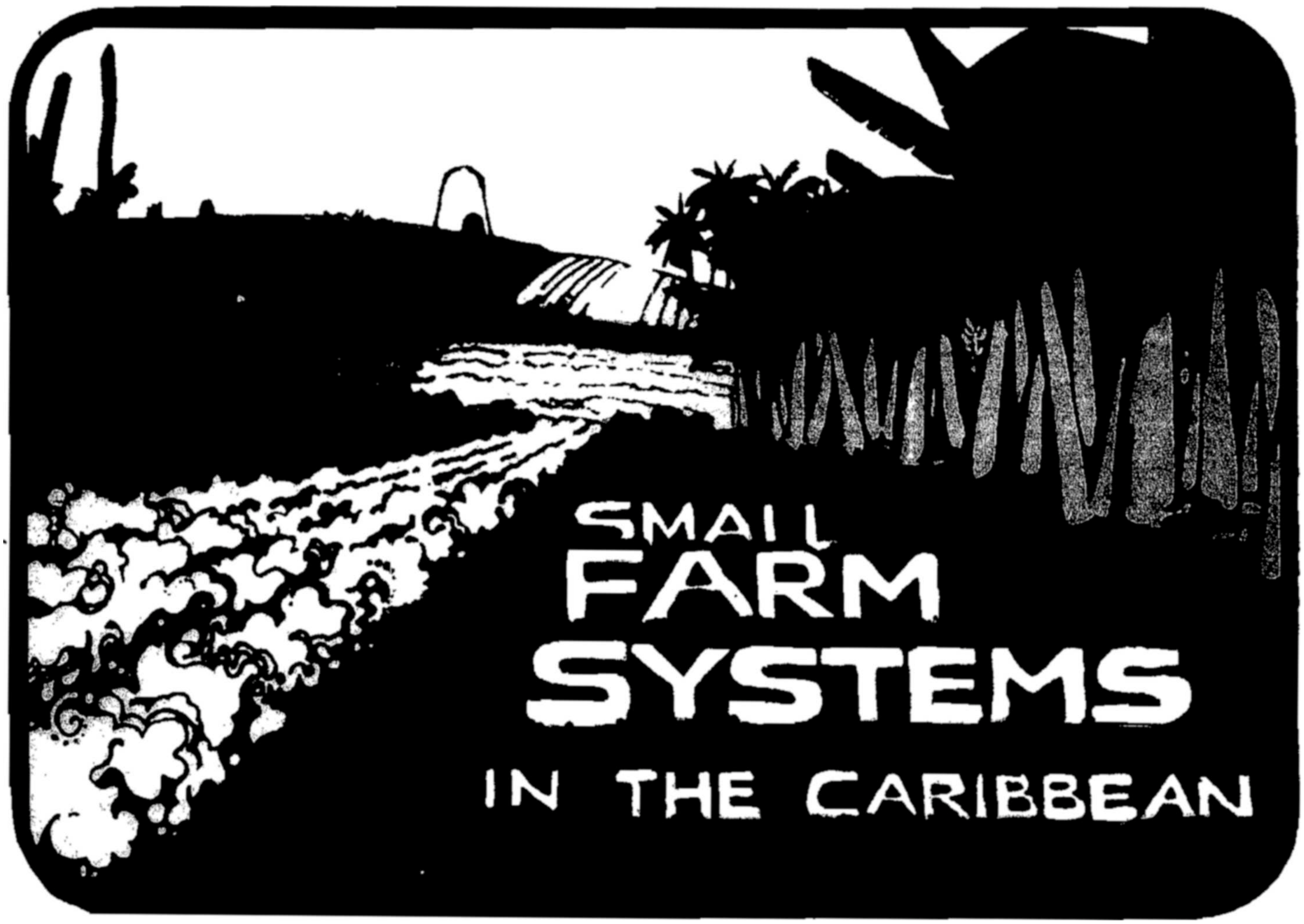
CARIBBEAN FOOD CROPS SOCIETY

Sociedad Caribeña de Cultivos Alimenticios
Association Caraîbe des Plantes Alimentaires

Vol. XX

PROCEEDINGS

OF THE 20th ANNUAL MEETING – ST. CROIX, U.S. VIRGIN ISLANDS – OCTOBER 21-26, 1984



Published by
THE EASTERN CARIBBEAN CENTER, COLLEGE OF THE VIRGIN ISLANDS *and* THE CARIBBEAN FOOD CROPS SOCIETY

Is it Possible to Find a Third Way Between "Green Revolution" and Traditional Systems of Agriculture?

C. M. Messiaen
INRA - Domaine Duclos
97170 Petit-Bourg, Guadeloupe

Traditional systems of agriculture still feed millions of people in tropical countries. There is probably a superior limit to their yield potentials, especially in over-populated situations. However, many things can be learned about the biological mechanisms which explain their productivity, and perhaps it is possible to imagine ameliorated systems in which productivity would be ameliorated by minimal inputs of chemieal aid, and adequate plant breeding.

"Biological agriculture," as it is known to Europeans, or "organic farming," seems to be a new, although less and less marginal orientation for industrial countries. On the contrary, millions of small farmers in tropical areas are still working in a "biological" way, without chemical fertilizers or pesticides. These traditional methods still dominate food production in Haiti, where they have been thoroughly investigated by the "Madian-Salagnac" team, founded by MMrs Brochet, Cavalier and De Reynal (French technical cooperation). In French West Indies, such methods were used 30 years ago to produce food crops: root and tubers, plantains, pulses and various vegetables. Some old farmers still work in this way; younger ones use chemical fertilizers, pesticides and weed killers on industrial crops (sugarcane, bananas).

Ten or 20 years ago we were all sure that a "green revolution," using high yielding cultivars and fertilizers, would be successful everywhere for food crops and for industrial crops. French agronomists worked with the same orientation, even though they spoke less of the "green revolution."

We now wonder, as energy and nitrogen become more and more expensive, if we will be able to apply the "green revolution" to the whole tropical world. Would it not be better to understand the biological mechanisms by which soil fertility was preserved and epiphtotics restricted in traditional systems, and to try to ameliorate and stimulate them, rather than sweep them away by application of large amounts of fertilizers and pesticides? On the contrary, would it be wise to decline the use of any chemical help, being unconscientious of the productivity limits of exclusively biological systems, especially in overpopulated countries?

Yield Limitations of Traditional Systems

First, let us observe that these systems may operate in two different ways:

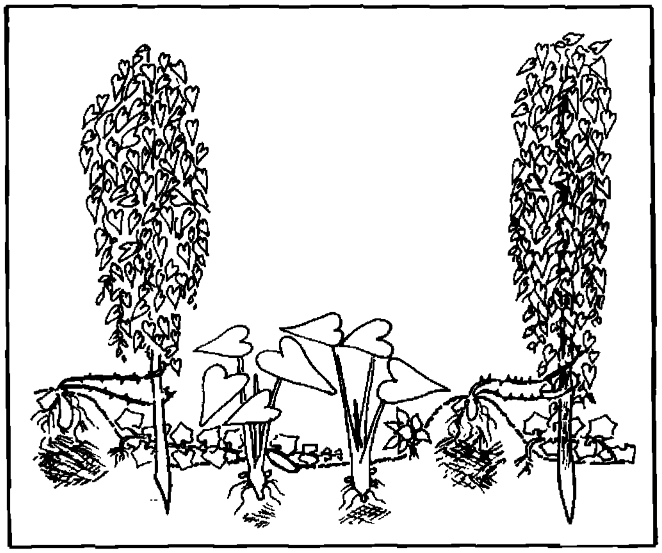
1. Partial cultivation of the arable land allows crop production and soil fertility restoration by nitrogen fixation, organic matter accumulation, and subsoil mineral absorption by deep roots to occur on different plots. Restorer plots either are in rotation with cultivated plots (shifting cultivation), or, vegetable or animal wastes are transferred from them to cultivated plots. European "biological agriculture" systems work in this way, since they use large amounts of composts or algae taken from outside.
2. Total cultivation of the arable land occurs when population density becomes so high that there are no more fallows. Cultivated plants alone, with their associated microflora, must assume the two functions: food production, and soil fertility preservation.

We shall try to choose some more or less typical examples of this situation:

a. The traditional "Bulu" rice grown in Java (*Oryza sativa* var. *javanica*), is associated with an aquatic nitrogen-fixing microflora (blue-green algae, *Beijerinckia* etc...), which yields 3.6t/ha with two crops/yr and permanent rains.
b. The associated culture of maize, sorghum and pigeon pea in the south peninsula of Haiti, gives 2.3t/ha of cereals + peas for nine months when rains arrive in the good season. Here we can attribute nitrogen fixation to the *Cajanus* tree, which produces 1t leaflets and 0.3t peas/ha although the intervention of *Azospirillum* assicated with maize and sorghum roots might not be excluded (Fig. 1).
c. Vegetable and tuber gardens in volcanic Guadeloupe, associate yams, tannia with shorter-cycle crops like beans or cucumbers, with pigeon pea borders. First estimations of yields from these gardens indicate 8t tubers/yr + 2 or 3t vegetables, and approximately 2.5t dry matter (Fig. 2).
d. Wheat fields in Europe before fertilizer use, or today in the plots without fertilizer at the Grignon Agriculture School in France yielded 1.2t/ha for an 8-month cycle.

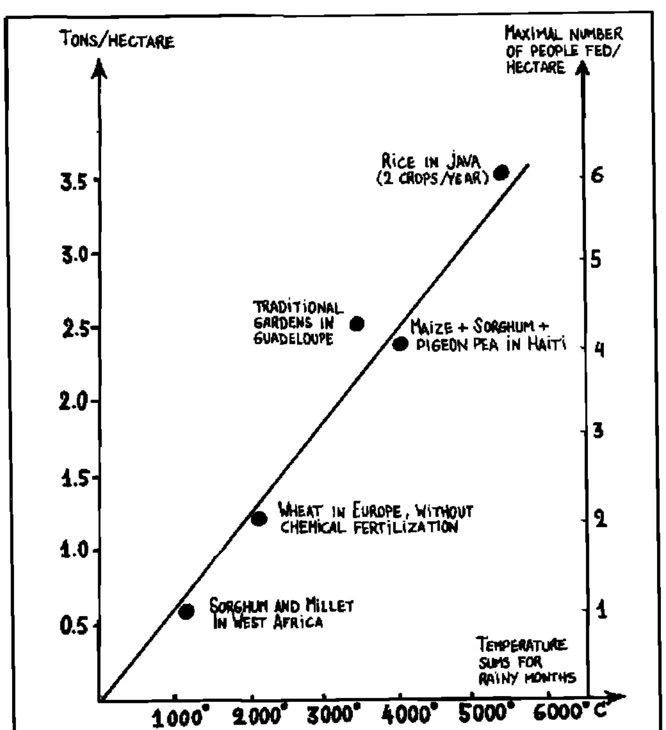
FIG. 1: Associated culture of maize, pigeon pea and sorghym in Haitian lowlands, as seen in July.

FIG. 2: Example of a traditional garden in Guadeloupe, associating long-cycle crops (*rotundada* yams, tannia) and short cycle vegetables (beans, cucumbers).



e. *Sorghum* or *Pennisetum* yields are stabilized in West Africa during the third or fourth crop after fallow at the relatively low level of 0.6t/ha with three months of rain. If we choose a temperature threshold of 10°C for rice, 14° for yams and tannia, 12° for *Sorghum* and *Pennisetum* in Africa, 11° for the complex association in Haiti and 0°C for wheat in Europe, and if we try to correlate the temperature sums (5760° for Java, 4050° in Haiti, 3600° for Guadeloupe, 2160° for wheat in Europe, 1260° for African cereals), we obtain a surprising linear regression which perhaps expresses the yield limit of traditional systems, especially when all of the arable land is cultivated (Fig. 3).

FIG. 3: Regression curve associating temperature sums during rainy months and yields obtained under the conditions of traditional agriculture.



Still more approximated computations lead us to consider that a temperature sum of 1000°/ha is needed to feed one person in such a system. Traditional systems, therefore, will be saturated with one person/ha in the dry parts of West Africa, two in Europe (36 million Frenchmen for 18,000,000 cultivated ha during the XIXth century), four in Haiti (they are now five), six in Java, etc.

In the most densely crowded countries of the world, especially in the West Indies, traditional systems are beginning to be inadequate for food auto-efficiency.

Is it possible, learning from traditional agriculture, to elaborate higher yielding systems by stimulation of biological mechanisms?

Let us try to compare the general characteristics of traditional systems, to the general orientation of tropical modern agronomy:

Traditional Systems Characteristics	Supposed Advantages	Modern Tropical Agronomy Orientations
1. Maximal occupation of *space* by intercropping.	Better utilisation of light (light and shade plants) and of soil (superficial and deep rooted species.	Short cycle homogeneous crops, with rotations.
2. Maximal occupation of *time* by overlapping crops.	Avoid the "young plants on bare soil" situation, which is very susceptible to erosion and leaching (for 1 and 2, "multiline" effect for pests and diseases.	Short cycle homogeneous crops, with rotations.
3. Trees or shrubs present, especially leguminous trees.	Organic matter and fertilizing elements going down to soil with dead leaves.	No more use of "shade trees," even for coffee plantations.
4. Fertilization with organic matter or ashes exclusively, often localised into mounds or ridges.	Progressive solubility of nutrients, especially nitrogen, lesser stimulation of weeds between the cultivated plants.	Chemical fertilizers applied on the whole field.
5. Late, often photoperiodic cultivars, with a low "harvest index."	Maturation insurance during a favorable season, organic matter for soil, or forage during the dry season. Double functions of some plants: *Fertility maintenance* during the vegetative period, *Food production*, after anthesis.	Early, non-photoperiodic cultivars, with a good "harvest index."
6. Intraspecific heterogeneity.	Insurance for regular yields, "multiline" effect towards diseases and pests.	Morphologically homogeneous crops, even if they are "multilines" for resistance genes.

The yields of ttaditional sysrems, which are significanc and telatively regulat, test therefore on a numbet of mechanisms, some of them playing on opposite directions (like "maximal rime occupation" and "late cultivars"), perhaps with a better homeostatic tesult. All these mechanisms, and their relative impottance, ate not well known today, for example, nitrogen fixation by *Azospirillum* on ceteal roots, or endomycorhiza on cassava ot legumes. Most of them probably do not work with maximal efficiency:

1. For nutrients, especially on ferrallitic soils, recycling of vegetable by-ptoducts, even from deep-tooted plants, will not be enough to correct major or minor element deficiencies (phosphorus, molybdenum).
2. For cultivars, inter- and inrraspecific heterogeneity allow individual planrs, either resistant but low yielders, or higher yielders but susceptible, or even without any quality, to survive in the mixture.

There would be, therefore, good reason to elaborate ameliotated systems, taking advantage of what can be learned ftom scientific studies on the biological mechanisms operating in the traditional systems, without declining eirher a reasonable amount of chemical aid, or adapted plant breeding.

For this objective research we need to follow a number of paths.

1. Bettet knowledge of biological mechanisms of soil ferrility maintenance; evaluation of restitution by stems and leaves of annual plants or dead leaves of trees and shrubs; better knowledge of the systems of nitrogen fixation and soil and subsoil mineral exploiration other than rhe classical *Rhizobium* one (bacteria associated with cereal and grass toots, endomycorhizae);
3. A genetal policy of restriction of system losses: better use of vegetable and animal wastes, and ability to stimulate the system efficiency with minimal inputs of phosphoric acid, calcium, magnesium, porassium, etc.
4. Definition of a number of crop associarions or successions with ptoved reciprocal benefits, the partners of which could be introduced in planr breeding programs, either for their food productivity, or for their soil fertility restoration performances, or for both. Plant breeding is indeed a very efficienr system, which gives solutions ir was asked for, for example, "varieties rolerating and utilizing large amounts of chemical fertilizers." Other solutions can perhaps be obtained: varieites with wide adaptation, which would be the best both in medium-fertile and poor soils, varieties ameliorated both for yield and ferrility restorarion (perhaps for pigeon peas), or even plants bred only for soil fertility restoration.

Results in Coincidence with the Orientations Defined Above

The first result was obtained by the French cooperators in Haiti: it concerns a very simple traditional system, growing *Phaseolus vulgaris* beans in pure crop, but with varietal mixture, alternating with 9 or 21 months fallow. The use of a bean line, tolerant to powdery mildew and rust, and of a minimal 0-30-40 fertilization, obtained with wood ashes and superphosphate, allows the harvest of 1.5 r dry beans/ha in the place of 0.5.

For the French Wesr Indies, we begin to have in hand the varietal components of ameliorated creole gardens: for example, L. Degras' collection of *alata* yam clones toleranr to anrhracnose; lima bean lines which, although non-photoperiodic, are able to survive more than one year without pesticides or nitrogen; the besr cucumber lines of American catalogs, resistant to downy and powdery mildews; and, before long, the best sweer potato clones bred by Dr. F.W. Martin.

The best associations of such culrivars are still to be chosen, and a minimal fertilization scheme to be found. The srudy of rhe thermophilic microflora of composts in tropical conditions was begun this year by S. Pelrier. It is somewhat similar to the flora described in temperate countries, with Actinomycetes, *Bacillus* spp. and fungi. Some of these microorganisms seem to be antagonistic towards *Sclerotium rolfsii* and the tannia decline *Pythium*. There is also a possibility of colonizarion, at lower temperatures, by *Trichoderma* spp. on organic substrates in order to control *Sclerotium rolfsii*. The work has begun; general synthesis still remains to be made.