Principles of Agriculture For The Humid Tropics

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The odyssey of my colleagues and I started in 1982, the day Conrado Zavala, a Honduran villager, sheepishly showed us his experiment. Skeptical about the value of the organic matter we had recommended, he had piled a huge quantity of compost into several rows of his maize field. The last two rows he left as a control untilled and unfertilized. There, before our eyes, stood a field of 2 ½ m maize, with a last row less than 40 cm tall. That was the day we began to realize the incredible degree to which organic matter can restore soils.

Little by little, work in a dozen countries has convinced us that the vast majority of soils can be made highly fertile. How? By using our first principle: **maximize organic matter production**.

Conrado's particular approach, however, was anti-economic. The cost of using compost on basic grains exceeds the benefit. But intercropped green manure/cover crops (gm/cc's) can produce from 50 to 140 T/Ha (green weight) of organic matter with very little work: no transporting of material and no cutting up or layering or turning over of compost heaps. In fact, sometimes, because of the gm/cc's control of weeds, net labor costs decrease. And soil quality often improves visibly each year.

Then, as often happens, we found we were far from the first to employ intercropped gm/cc's. Gradually, between 1985 and 1992, we learned that villager farmers from Veracruz State in Mexico through Guatemala, El Salvador, and Honduras were intercropping velvetbeans (Mucuna pruriens), cowpeas (Vigna spp.) and jackbeans (Canavalia ensiformis) with their maize and sorghum.

To our amazement, these systems, virtually all of them in the supposedly infertile humid tropics, allow farmers to plant maize every year for decades, with productivity increasing over time up to 4 T/Ha.[(1)] In other words, these farmers have found an answer to slash-and-burn agriculture. Migratory agriculture is most frequently motivated by decreasing fertility, increased weed problems, or both. In the Mesoamerican gm/cc systems, nitrogen fixation and biomass recycling maintain soil fertility. Mulches of crop residues and fast-growing gm/cc's drastically reduce the weed problem. We had learned a second principle: **keep the soil covered**.

Gm/cc mulches provide a whole series of additional benefits. They protect the soil from irradiation and the heat of the tropical sun, thereby also reducing burn out of organic matter. They save a tremendous amount of work; farmers can sow into the

plant residue rather than tilling the soil. They keep the excess nitrogen from acidifying the upper soil horizons.[2] And they largely prevent soil erosion, even on slopes of 40%.

In the meantime, we had been reading Fukuoka's book, The One-Straw Revolution.[3] However, his recommendation of zero tillage failed to convince us. After all, most of the traditional agriculture in Latin America uses zero tillage, yet is far from productive.

In mid-1993, I visited the work of EPAGRI in southern Brazil. Having visited over 160 agricultural development programs through the years, I found this largely unpublicized effort to be the finest of its size I had seen in Latin America. Literally tens of thousands of animal traction farmers were producing harvests approaching those in the USA–with gm/cc's and zero tillage.[4]

Valdemar de Freitas, EPAGRI's manager, showed us that the secret to achieving zero tillage is applying massive amounts of organic matter to the soil. Brazilian farmers, after some four years of applying gm/cc's to the soil, are able to quit ploughing. The advantages, in terms of better soil structure, reduced soil compaction, higher fertility, and decreased cost, are impressive. Interestingly, farmers often use nonleguminous gm/cc's to increase biomass in order to quit ploughing sooner. That is, they spend scarce income on chemical nitrogen fertilizer for three or four years in order to achieve zero tillage sooner.

The Brazilians' discovery explains why the zero tillage gm/cc systems of northern Honduras–and Fukuoka's–produce so well, while many traditional zero tillage systems do not. Thus we added a third principle: use **zero tillage**.

EPAGRI's investigation and dissemination of over 60 species of gm/cc partly to avoid diseases and insect pests, confirmed another, more widely known principle: **maintain biological diversity.**

The last principle was discovered by Martha Rosemeyer, a Cornell doctoral candidate working in Costa Rica. For several years, agronomists working with a low-cost, traditional, mulched-bean (Phaseolus vulgaris) system had been trying to solve a phosphorus deficiency problem. With highly acid (pH = 4.0 to 4.5) soils, virtually all the phosphorus applied became tied up almost instantly. Farmers' harvests averaged 500 kgs/Ha.[5]

Martha and a group of farmers tried broadcasting the phosphorus on top of the mulch. The results, since 58-2 confirmed in numerous additional experiments, were astounding. Bean yields rose to between 1.5 and 2.5 T/Ha.[6]

This phenomenon has not yet been validated with other crops. Yet it would help explain the success of Mesoamerica's gm/cc systems, and coincides with the fact that plants as diverse as maize, manioc, and tropical trees tend to develop a heavy mass of feeder roots immediately under thick mulches.[7] Furthermore, it makes simple sense: when soils are as hostile to plant growth as are the humid tropic's acid soils, feeding plants through a mulch would seem a much more promising alternative. The fifth principle is undoubtedly the most unconventional: **feed plants through the mulch.**

These five principles enjoy a nice synergy. For example, if we are going to feed our plants through a mulch, we certainly cannot plough our fields. Nevertheless, the most important relation between these principles is precisely the one that took us the longest to figure out: they describe quite well the way a humid tropical forest functions. That is, all we discovered in our 12-year odyssey is something we should have guessed all along. **In order for humid tropical agriculture to be both highly productive and sustainable, it must imitate the highly productive, millions-of-years-old humid tropical forest.**

Three months ago, I searched the computerized agricultural data system in the United States for information on the nutrient dynamics in mulches and the feeding of crops through a mulch. I found virtually nothing. The above principles mean we are going to have to develop agricultural systems totally different from those agronomists have tried, for so many years, to "transfer" from the temperate nations.

The possibilities are enormous. A study from northern Honduras shows that the gm/cc/maize system there is 30% more profitable than the high-input maize system nearby.[8] It may well be we are just beginning to fathom the full potential of low-input agriculture in the humid tropics.

NOTES:

1. Elio Duron, presentation made to CIDICCO's First Interchange of Ideas on the Role of Leguminous Plants in Today's Agriculture, Tegucigalpa, Honduras, April 1990
2. Bernard Triomphe, personal communication on the results of his doctoral dissertation research on the long-term effects of a Honduran gm/cc/maize system on tropical soils, 1994.
3. Masanobu Fukuoka, The One-Straw Revolution. An Introduction to Natural Farmers (Emmaus, Pennsylvania: Rodale Press, 1978).
4. Roland Bunch, "EPAGRI's Work in the State of Santa Catarina, Brazil: Major New Possibilities for Resource-Poor Farmers". Photocopied.
5. Martha Rosemeyer, "Yield, Nodulation and Mycorrhizal Establishment in Slash/Mulch vs. Row-cropped Beans," in H. David Thurston, et al., eds., Tapado. Slash/Mulch: How Farmers Use It and What Researchers Know About It (Ithaca, NY: CIIFAD and CATIE, cl994), pp. 169-178.
6. Kenneth Schlater, personal communication on the results of his doctoral dissertation research on the effects of applying phosphorus to the mulch of slash/mulched beans, 1995.
7. Rattan Lal, "Conservation Tillage for Sustainable Agriculture, Tropics vs. Temperate Environments," in N. C. Brady, ed., Advances in Agronomy, vol. 42 (San Diego, California: Academic Press, c1989), and P. M. Vitousek and R. L. Sanford, Jr., "Nutrient Cycling in Moist Tropical Forest," Annual Review of Ecological Systems vol. 17, 1986, pp. 137-167. Also, Bernard Triomphe, personal communication (see above).
8. Milton Flores and Nicolas Estrada "Estudio de Caso: La Utilizacion del Frijol Abono (Mucuna spp.) Como Alternativa Viable para el Sostenimiento Productivo de los Sistemas Agricolas del Litoral Atlantico," paper presented to the Center for Development Studies at the Free University of Amsterdam, 1992. Mimeographed.