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Two Steps Back, One Step Forward:

Cuba's National Policy for Alternative Agriculture

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This Gatekeeper Series is produced by the International Institute for Environment and Development to highlight key topics in the field of sustainable agriculture. Each paper reviews a selected issue of contemporary importance and draws preliminary conclusions of relevance to development activities. References are provided to important sources and background material.

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TWO STEPS BACK, ONE STEP FORWARD: CUBA'S NATIONAL POLICY FOR ALTERNATIVE AGRICULTURE

Peter Rosset and Medea Benjamin

Introduction

In November 1992, a delegation[1] travelled to Cuba to report on changes that had taken place in Cuban agriculture since the 1990 collapse of its trading relations with the socialist bloc. Word had filtered out that Cuba was in the process of a national switch to local-input and organic farming because of a cessation of imports of agrochemicals. This paper summarises the delegation's findings[2].

The Crisis and the Emergence of a New Agricultural Model

During the past 30 years Cuba achieved a more rapid modernisation than most other developing countries. In the 1980s it ranked first in the contribution of industry to its economy and had a more mechanised agricultural sector than any other Latin American country. It has high marks for per capita GNP, good life expectancy, and high numbers of women in higher education. It was ranked first in Latin America for the availability of doctors, low infant mortality, housing, secondary school enrolment, and attendance by the population at cultural events.

These achievements were made possible by a combination of the government's commitment to social equity and the fact that Cuba received far more favourable terms of trade for its exports than did other developing nations in the region. During the 1980s the average price for sugar exports that Cuba received from the Soviet Union was 5.4 times higher than the world price (Pastor, 1992). Cuba also was able to obtain Soviet petroleum in return, part of which was re-exported to earn convertible currency. The resulting focus on sugar production contributed to a pattern of food dependency with 57% of the total calories consumed coming from imports (Pastor, 1992).

The agricultural sector was highly dependent on imports. In the late 1980s, 48 % of fertilisers and 82% of pesticides were imported (Deere, 1992). Data on the import coefficients of these inputs reveals even stronger dependency (Pastor, 1992). Thus the overall import coefficient for all fertiliser used in Cuba was actually 94% (Table 1). Balanced animal feeds were largely based on maize and other cereals, the bulk of which were imported. While Cuba's climate does permit the cultivation of maize, it has not been pursued extensively by the government (Deere, 1992).

Table 1: Import coefficients for agricultural products in Cuba, 1989
(Percent of value added contributed by imports of final product and/or imported inputs used in its production)

Category	*Import Coefficient (%)*
Foodstuffs	
Cereals	100
Beans	90
Rice	49
Raw Materials	
Fertiliser	94
Herbicide	98
Animal feedstocks	97

Source : Pastor 1992

Table 2: Comparison of selected Cuban imports in 1989 and 1992

Item	*1989 Imports*	*1992 Imports*	*% Change*
Petroleum	13,000,000 t	6,100,000 t	-53
Fertiliser	1,300,000 t	300,000 t	-77
Pesticides	US $80,000,000	<US $30,000,000	at least -62.5
Animal feeds	1,600,000 t	475,000 t	-70
Powdered milk	36,000 t	36,000 t	0

Source: Lage, Carlos. Interview on Cuban television, November 6, 1992. Reprinted in Granta

When trade relations with the Soviet Union crumbled in 1990, agriculture faced an immediate crisis. The 53% reduction in oil imports shown in Table 2 has not only affected fuel availability for the economy, but also reduced to zero the foreign exchange that Cuba used to obtain from the re-export of petroleum. Imports of wheat and other grains for human consumption have dropped by more than 50% (Deere, 1992), while other foodstuffs, with the exception of powdered milk, have declined even more. Cuban agriculture has also been faced with a drop of more than 80% in the availability of fertilisers and pesticides.

Suddenly, a country with a highly modernised agricultural sector found itself almost without chemical inputs, and with sharply reduced access to fuel and irrigation. Average daily caloric and protein intake by the Cuban population may have fallen by as much as 30% from the levels of the 1980s.

Changing Production and Consumption Patterns

At the time of the revolution, the diet of the Cuban people, as in the rest of Latin America, depended on what social class they belonged to. A goal of the revolution was to guarantee an adequate diet for everyone. This meant not only a diet that was nutritionally adequate but also socially acceptable, aimed at replicating the diet of the pre-revolution rich. Unfortunately, this culturally acceptable diet is one that is both unhealthy (high-calorie, high-fat, high cholesterol, low-fibre) and expensive, as much of the food and the materials to produce it must be imported. Stemming this reliance on imported goods means changing consumption and production patterns.

The nutritional goals set by the Cuban government in terms of calories and proteins have been very ambitious. With target values set consistently higher than UN standards, the national nutrition campaigns met with high rates of success up until the Special Period. While for 30 years Cuba was the only country in Latin America that had eliminated hunger, today's severe crisis is reversing this remarkable achievement. Malnutrition has been reported among children between 6–12 months old, and many pregnant women are found to be anaemic.

Beef production has plummeted and red meat is now rarely available. There are also problems with the supply of milk and other dairy products. Chicken and egg productions, like beef and dairy, are all heavily dependent on imported animal feeds. During this time when the lack of animal protein is causing discontent among the population, pig production has become a government priority as an easier source of animal protein.

Cuts in imported wheat from Russia have reduced the bread ration to one roll per person per day. At the same time, breads and pastas are more and more being replaced by traditional starchy crops, the *viandas*, which grow well under Cuba's soil and climatic conditions and are popular with the Cuban population. The state is now taking *viandas* seriously, and increasing their production is a top priority rather than the secondary status they had before. The government is trying to get people to substitute *viandas* and vegetables for wheat and rice, and to substitute vegetable for animal protein.

The Cuban government is in a stronger position than most governments to alter consumption patterns, because it controls the food supply through the ration system and it controls the media for educational campaigns. But this has always been a very delicate political issue (Benjamin et al. 1987). For example, any effort by the government to encourage people to eat less meat for health reasons could have been viewed as an excuse to disguise supply problems.

In short the lack of sufficient food is now the people's main complaint. For many years Cuba will be paying dearly for past external dependencies. To address this, the government launched an ambitious National Food Programme in 1989, which was conceived of before the collapse of Soviet trade relations. The main focus of this food programme was to increase quickly the production of *viandas* and vegetables, and to make the area around Havana as self-sufficient as possible.

Substituting Local for Imported Technology

While the National Food Plan called for more emphasis on foodstuffs to make up for the import deficit, the country also needs to maintain or increase export crop levels to avoid exacerbating the foreign exchange crisis. These two goals must be pursued virtually without chemical inputs, and with far less tractor power and irrigation than before. It is a formidable task.

Fortunately, Cuba was not totally unprepared to face the situation. It had invested much in education, and therefore had a cadre of scientists and researchers who could come forward with innovative ideas. In the early 1980s, Cuba's leaders had decided that technological expertise was going to be the world's most valuable commodity in the future, especially with the growth of high-tech, information-intensive industries. Accordingly, they invested the equivalent of an estimated US $12 billion in the 1980s in developing human capital and infrastructure in biotechnology, health sciences, computer hardware and software, and robotics. The long-term plan was to change Cuba's role in the world economy to that of purveyor of high technology, scientific consulting and quality health services, rather than providing of raw commodities and light industry.

At the same time, younger scientists, influenced by the international ecology movement, developed a critique of modern agriculture (Levins, 1991) and reoriented their research. They criticised the Cuban model of agricultural development for its dependence on foreign inputs and its contribution to environmental degradation. In 1982 official research policy began to respond. Nevertheless, the researchers complained that their approach was not taken seriously enough to be implemented on a broad scale, and they expressed frustration at ministry officials who favoured pesticide imports.

While neither the expensive scientific investments in advanced technology nor the research into agricultural alternatives by young scientists had paid great dividends by 1989 (Pastor, 1992), they provided Cuba with crucial resources that are now being mobilised to face the agriculture challenge in the 1990s. It is very well positioned for this transition; with only 2% of the population of Latin America, it has almost 11% of the scientists (UNESCO, various).

The Classical versus the Alternative Model

Critiques of conventional input-intensive agriculture (cf. Altieri, 1987; National Research Council, 1989; Soule and Piper, 1992; Carroll et al., 1990), would be very comfortable with what is now the basis for Cuban policy. This policy counterposes what is called the ‘Alternative Model’ with the ‘Classical Model’ of agricultural production (Table 3).

The Alternative Model promotes crop diversity rather than monoculture, organic fertilisers and biofertilisers instead of chemical ones, and biological control and biopesticides instead of synthetic pesticides. Animal traction is substituted for tractors, and reliance on irrigation is reduced by planting to take advantage of seasonal rainfall patterns. Local communities are to be more intimately involved in the production process, hopefully slowing the exodus

Table 3: "Strategy for the development of specific projects: most relevant considerations to keep in mind." *(Translation of Ministry of Agriculture chart circulated to planning staff)*

Classical Model

- External dependence of:
  - the country on other countries
  - provinces on the country
  - localities on the province & the country
- Cutting edge technology
  - imported raw materials for animal feed
  - widespread utilisation of chemical pesticides and fertilisers
  - utilisation of modern irrigation systems
  - consumption of fuel and lubricants
- Tight relationship between bank credit and production; high interest rates
- Priority given to mechanisation as a production technology
- Introduction of new crops at the expense of autochthonous crops and production systems
- Search for efficiency through intensification and mechanisation
- Real possibility of investing in production and commercialisation
- Accelerated rural exodus
- Satisfying ever-increasing needs has serious ecological or environmental consequences, such as soil erosion, salinisation, waterlogging etc.

Alternative Model

- Maximum advantage taken of:
  - the land
  - human resources of the zone or locality
  - broad community participation
  - cutting edge technology, but appropriate to the zone where it is used
  - organic fertilisers and crop rotation
  - biological control of pests
  - biological cycles and seasonality of crops and animals
  - natural energy sources (hydro, wind, solar, slopes, biomass, etc)
  - animal traction
  - rational use of pastures and forage for both grazing and feedlots, search for locally supplied animal nutrition
- Diversification of crops and autochthonous production systems based on accumulated knowledge
- Introduction of scientific practices that correspond to the particulars of each zone; new varieties of crops and animals, planting densities, seed treatments, post-harvest storage etc.
- Preservation of the environment and the ecosystem
- Systematic training (management, nutritional, technical)
- Systematic technical assistance
- Promote cooperation among producers, within and between communities
- Obstacles to overcome:
  - difficulties in the commercialisation of agricultural products because of the number of intermediaries
  - control over the market
  - poverty among peasantry
  - distances to markets and urban centers (lack of sufficient roads and means of transport)
  - illiteracy

to the cities. Because a significant amount of foodstuffs is produced by the Cuban private sector individual, peasant farmers and cooperative members, as opposed to state farms, the Alternative Model and the National Food Programme focus heavily on promoting those activities.

The Alternative Model is similar to other proposals for low external input agriculture with one difference. The difference is that in Cuba the Alternative Model has become official government policy, while elsewhere there are only isolated individual examples and widespread implementation remains a dream.

The vast majority of Cuban agricultural scientists and Agriculture Ministry officials who met the delegation agreed that the Classical Model was a model imposed from outside, and expressed resentment toward Soviet and other socialist bloc advisors. They are also self-critical for having had a colonised mentality. They believe that, while the conventional model might be appropriate for Europe where expensive inputs are produced within each nation, for a country like Cuba it makes little sense because of the extreme dependency and external vulnerability that it promotes. The consensus position seems to be that this is a change that is long overdue, and the Special Period provides the only pretext and the motivation.

Resource-Conserving Technologies

Conversion is the term commonly used to denote the fairly lengthy process of restoring soil fertility and natural pest controls in a farm that has previously made conventional use of chemical fertilisers and pesticides, both of which degrade the natural productive capacity of the soil over time. Empirical evidence from dozens of studies has shown that it generally takes from some years for a farmer switching to organic to equal the levels of productivity and profitability obtained in the final years of conventional production. After this, organic production often becomes more profitable than the earlier system, as the costs of inputs is reduced and in some cases organic produce fetches a higher price. During this transition period, however, the farmer must take positive steps to build up soil structure and organic matter, and establish pest natural enemies and ground covers.

In their efforts to implement the Alternative Model, Cubans are attempting the largest scale conversion from conventional modern agriculture to organic or alternative farming in history. Whether this will be sufficiently successful to allow the present Cuban economic and political system to survive its present crisis is an open question (Pastor, 1992; Preeg, 1993). Yet Cuba clearly offers a unique opportunity for agricultural scientists everywhere to study the process of large-scale conversion.

Management of Insect Pests, Plant Diseases and Weeds

One of the keys to the Alternative Model is to find ways to reduce chemicals used for management of plant diseases, insect pests, and weeds. This process began during the

1980s, but took on more urgency during the Special Period. By 1982 Cuba was shifting toward an integrated pest management (IPM) paradigm, the integrated use of a variety of alternative pest, disease and weed control tactics, in order to reduce reliance on chemical pesticides.

Although Cuba's tradition of biological control dates back to the 1930s, more formal national research programme on biological control did not begin until the 1970s. In 1985, after many years of research, those efforts were transformed into a major campaign and biological control began to replace pesticides as the conceptual basis for pest management (Rego et al., 1986). These efforts did achieve a reduction in pesticide use but in 1991, Cuba was still importing $80 million in pesticides per year. With the Special Period, these imports were reduced to $30 million (MINAGRI figures). By the end of 1991, an estimated 56% of Cuban crop land was treated with biological controls, representing a savings, after costs, of US $15.6 million per year (MINAGRI figures). Twenty years of research in biological control and other alternatives had prepared Cuba for one of the most ambitious enterprises in integrated pest management in history.

The plant protection system of the Ministry of Agriculture consists of the National Service of Plant Protection, the Institute of Plant Protection, the Central Research Laboratory, 14 regional laboratories, more than 60 plant protection territorial stations distributed throughout the country, 27 frontier posts with diagnostic laboratories, and 218 Centres for the Reproduction of Entomophages and Entomopathogens (CREEs). In addition, there are other agencies specialised in a variety of crops that conduct research in plant protection. Research on and use of chemical pesticides still continues, but to a limited degree.

Pest and Disease Monitoring

Cuba has in place a unique pest and disease monitoring system. To prevent pesticide resistance from developing, each local research centre in Cuba maintains small plots of that area's important crops. As soon as resistance is detected in a pest or pathogen, the pesticide in question is temporarily retired and replaced with a range of other control measures. This cuts on costs and time needed to develop alternative measures. Because of these tactics, for example, Cuba is the only country in the world still able to use the systemic fungicide Ridomil® against tobacco blue mould.

Today more than 90% of Cuban agriculture uses some kind of pest and disease monitoring. However, the monitor system has not been modified for use with biological control techniques. A farm is warned of the possibility of a pest or pathogen outbreak, due to climatic conditions for example, but the means of controlling the outbreak depends largely on what is available in that area. The disease and pest loss data is also not in a computer database and does not appear to have been well exploited for epidemiological modelling. This is unfortunate as it represents a unique long-term data set on tropical organisms. It was also difficult to determine how successful the monitoring system has been as the data do not cover all diseases and are not fully analysed.

Entomophages are insects that eat or parasitise other insects, and thus can be released to achieve biological control of pests. The longest running biological control programme in Cuba involves the parasitic fly Lixophaga diatraeae (Tachinidae). Since 1968 it has been reared and released in a massive programme, which now covers 100 % of the area under sugarcane seed production, as well as a substantial part of the areas under general sugarcane production. Entomopathogens are diseases of insects (bacteria, fungi and viruses) which offer the possibility of non-toxic pest control. It is in their production and use that Cuba has a substantial lead over most countries in the world. Research and development efforts in Cuba have led to techniques for the production, harvesting, formulation, application, and quality control of numerous bacteria and fungi. Quality control and monitoring are carried out by three mechanisms: standardising field dose rates; direct tests of pathogen virulence; and monitoring field effectiveness by collection and observation of exposed pests.

The most interesting aspect of contemporary insect pest management efforts in Cuba may well be the CREEs, where decentralised, artesanal production of biocontrol agents takes place. Although few had been built before the beginning of the economic crisis, by the end of 1992, 218 CREEs provided services to state, cooperative, and private farm operations. The centres produce entomopathogens for the crops grown in each area. They are maintained and operated by local technicians. In one CREE four technicians with college degrees, four mid-level technicians, and seven high school graduates were employed, all children of members of the cooperative where it was located. They explained the cooperative received a ten-year loan from the bank to construct and equip the small Centre with laboratory rooms and about 20 small fermentation tanks. The Centre provides its products free of charge to the cooperative, while selling enough to neighbouring farmers, state farms and cooperatives to break even.

Besides CREEs, Cuba has a network of over 30 brewers yeast factories which use large scale fermentation technology. These normally function for only four days per month making yeast, but are now being converted to use the idle days to mass produce biopesticides on an industrial scale. Thus there will be a commercial product with high standards of quality control for the state farms and large coops that produce for export, while the network of CREEs will continue producing a lower priced product for local use.

Cuban scientists are actively involved in several other lines of research in developing alternatives to conventional insecticides. The research areas include work on parasitic nematodes and plant derived pesticides, screening a large number of plants for insecticidal, fungicidal, bactericidal, and herbicidal qualities. Applied work on the cultivation and production of two species of plants with known insecticidal qualities, neem and Melia, has been initiated.

Based on an old practice of peasant farmers, Cuban researchers studied and further developed an elaborate and unique system of biological control of Cylas formicarius, the sweet potato weevil, using the predatory ant Pheidole megacephala. The management system includes the establishment of reservoir areas where the ant is naturally abundant. This method has provided close to 99% control of the sweet potato borer in the Pinar del Rio Province, with lower production costs and higher yields per hectare (Castifieiras et al. 1982). So successful has the method been that MINAGRI prohibited the use of any chemical insecticide in sweet potato fields where this method is being employed. Where applications of pesticides for other pests are necessary, special permission is required from the Ministry.

Management of Plant Diseases

The emphasis in disease management is on methods of diagnosis and disease reduction in major crops. Until recently, disease diagnoses could not be performed at local research centres because the tests did not exist. Now the National Animal and Plant Health Centre has adapted techniques from Cuban veterinary and human health research for use in diagnosis of plant bacteria and viruses. Cuba now produces and exports cheap serological test kits for detecting plant pathogens of worldwide importance.

Since 1989, the cost of fungicides has become prohibitive. Fungicides are used only for foliar diseases of potato, *Alternaria* leaf blights of onion and garlic, and some sugarcane diseases, while alternatives are stressed for other pathogens. For example, a major disease of banana, which kills the leaves and reduces fruit yield, is monitored carefully. Affected leaves are removed, and mineral oil sprayed which appears to inhibit infection.

A relatively new research direction in Cuba is the biological control of plant diseases using microbial antagonists. In a short period, Cuba has advanced further than other countries toward large-scale implementation of this sort of biological control.

One of the main obstacles to be overcome in biocontrol research is the lack of taxonomic knowledge of the fungi involved. Although Cuban researchers try to use native strains of fungi in biological control, identification is sometimes a problem, due to the lack of reference books and the equipment needed for modern taxonomy. Another obstacle is the need for strict quality control. Uncontaminated inoculum must be tested periodically for vigour and virulence. The methods of application of biocontrol agents must be more precise than with pesticides. Finally, screening biocontrol agents is a time-consuming process, and evaluations in the lab to find antagonists effective in the field is difficult.

Each biocontrol agent must pass safety regulations based on those of the USA and of the European Union. It has to be observed and tested for efficacy at a quarantine lab and to undergo toxicological testing in order to be registered for use. More work needs to be done on post-harvest use of biocontrol agents, and integrating biocontrol with soil improvement research.

Nematicides are expensive and, in Cuba's experience, not very effective. The soil flora in continuously cropped fields appears to deactivate nematicides. At first, research was oriented towards cultural control measures, such as planting in nematode-free seedbeds, reducing populations of weed hosts, and using crop rotation and tillage practices detrimental to nematodes. Future work will include searching for local strains of fungi antagonistic to nematodes, experimenting with different methods of mass production, and researching the use of *Pasteuria penetrans*, a bacterium that is an obligate parasite of nematodes.

The final type of plant disease control employed in Cuba is biotechnology[3] produced seedlings of bananas, plantains and timber species. To avoid diseases being passed on from parent plant to the cuttings or seeds, tiny seedlings are produced in test tubes by culturing tissue from healthy growing tips or meristems. Though tissue culture is used in many countries, Cuba is perhaps the most advanced Latin American country in this field.

Weed Management

Weed management in Cuba before the Special Period had been mostly dependent on the use of agrochemicals. Since 1989 an effort has been made to rediscover the traditional methods used by *campesinos*, which were lost as herbicide dependency grew. Research focused on four major areas:

- a monitoring technique which can predict weed pressures and community composition a year in advance;
- systems of rotations based upon a prediction model based on the monitoring;
- very selective use of herbicides in combination with the above methods; and
- tillage methods, including design of new farm implements.

Cubans are using their monitoring systems on about 16 state-owned farms across the country. The techniques combine into a mathematical model data such as the previous years' weed species and densities; a determination of the seed bank and seed viability; the type of crop to be planted and how well it will compete with those weeds; the effectiveness of herbicides on those weeds; and how similar the growth habit of the weeds is to the desired crop. With these data, the scientists have been able to determine with a very high degree of accuracy what the weed problems will be and devise suitable responses with cropping calendars.

Crop selection can prohibit weed growth. For example, maize can be used in rotation with beans because it can shade out lower growing weeds. A maize rotation may be used together with a selective herbicide to kill broadleaf weeds which could not be used in a bean crop. For severe weed problems, a crop with a very dense cover such as sweet potato is planted, which smothers virtually all weeds.

Cultivation and soil preparation are planned based on the weed community while attempting to minimise the number of passes in a field. Rototillers are rarely used; with the focus more on discs, rotating discs, and the 'multi-plough'. This was designed by Cuban engineers to open the sub-soil without turning it, thereby not exposing more seed to germination. It essentially lifts and drops the soil, breaking weeds from their roots.

Soil Management

Soil management practices in Cuba prior to the Special Period seem to have been like those of most other countries engaged in industrialised agriculture. Practices were production-oriented and based on high-energy inputs, and treated the soil as just another agricultural input. Little was done to protect the soils from erosion, loss of fertility, salinisation, and other forms of degradation.

This is no longer the case. There is now great concern for implementing a sound and effective soil management programme that includes minimum tillage, rational use of fertilisers, the use of soil amendments, crop rotations and crop covers. Increasing the dosages of fertilisers and pesticides to compensate for soil degradation is no longer an option.

As a first step toward implementing an effective soil management programme, Cuban researchers launched an ambitious project to reclassify, evaluate, and map the country's soils in great detail (at scales of 1:250,000 and 1:25,000), and to interpret the maps for sustainable management. With nearly 66% of the agricultural lands having soils with low or very low potential, the concentration of soil fertility building efforts on these poorer lands could pay relatively large dividends.

Due to excessive cultivation and heavy use of fertilisers and pesticides most of Cuba's agricultural soils suffer from the depletion of organic matter, with resulting loss of fertility. Since 1989, efforts to maintain and improve soil fertility have been based primarily on organic amendments and biofertilisers. Crushed zeolite rock, mined locally in a number of places, is used as a part of this programme. Composting of crop residues is now also common. They are also working on the collection, processing, and utilisation of urban garbage.

Cubans have greatly expanded the use of green manures, mostly inoculated legumes in crop rotation combinations. Through crop rotations and other management practices, they aim to raise yields and achieve sustainable production. Green manures include velvet beans, cowpeas, soybeans, sorghum, and Sesbania. One interesting and effective way for reclaiming eroded lands is by filling gullies with soil and organic matter removed from lowlands and carted up by wagons pulled by either animals or tractors. This is essentially a revival of a very old practice which some small farmers had never stopped using.

A key component is to reduce or even eliminate tillage to prevent erosion. By 1992, tillage operations had been reduced from a national average of 10 to 12 per season to only three to five (MINAGRI figures). As tillage does help in weed control, Cuba is trying to achieve minimum tillage with alternative weed management technologies such as crop rotations.

Due to the petroleum shortage, animal traction is replacing tractor use on a wide scale. Animal traction cuts down on soil erosion and is feasible during the rainy season when tractors would bog down in the mud. The down side, of course, is that it is very labour intensive. Other low impact strategies in field preparation are also being implemented. For example, in rice cultivation, a system where large new dikes had to be rebuilt annually by heavy equipment is being redesigned to prevent annual machine use.

Besides crop rotation and reduced tillage, the effects of salinisation and acidity are also being addressed. As Cuba is a long and narrow island, there is severe salt stress on about 800,000 hectares of farmland. To provide organic matter under conditions of salt stress, many rice farmers are now using Sesbania in their rotations, and other salt-tolerant plants are being studied. Although Cuba claims to have arrested further salinisation throughout the country, very little progress has yet been made in actually rehabilitating the saline soils. Also, little progress had been made by 1990 in draining water-logged agricultural soils.

Fertilisers

Since 1989, fertiliser availability has plummeted by 80% and alternatives are being sought to obtain plant nutrients from local organic sources. One factor that has mitigated the effects of this dramatic decline is the years of research that had already been carried out on biofertilisers. Cuba has responded with a biofertiliser programme that by 1992 was making up 30% of the deficit (MINAGRI figures). Recycled organic waste along with other biofertilisers like nitrogen fixing bacteria and earthworm humus, quarried minerals, and peat, have helped close the gap. The starting point for developing the low-input fertiliser strategy is to determine, for each combination of crop and soil, the minimum quantity of plant nutrients needed to produce the crop. They have already obtained results of fertility trials for all major crops.

Biofertilisers

The Institute for Research in Soil and Fertilisers (IRSF) laboratory in Havana produces enough *Rhizobium* inoculum for the whole nation, providing up to 80% of the nitrogen required by leguminous crops. More unique to Cuba than Rhizobium inoculant is the commercial use of the free-living nitrogen-fixer *Azotobacter*. By 1991 the IRSF was producing 5 million litres of liquid *Azotobacter* which is applied to leaves or to the soil. The use of *Azotobacter* has provided 40–50 % of the nitrogen needs of non-leguminous plants (MINAGRI figures). Also due to other benefits of *Azotobacter* Cuban scientists claim they have achieved a 30–40 % increase in yield for maize, cassava, rice and other vegetables. A second area unique to Cuba has been the widespread use of bacteria of the genus *Bacillus* to promote the solubilisation of phosphorus from Oxisols and Ultisol soils.

The Institute for Research in Ecology and Taxonomy is studying *Vesicular Arbuscular Mycorrhizae* (VAM), fungi that penetrate roots and help with uptake of phosphorus and other nutrients, as a way of increasing plant uptake of mineral nutrients. Fifty-three species of VAM in Cuba have been identified and will be introduced nationwide for coffee plantations. The Cuban government planned to produce 18 tonnes of VAM material for commercial purposes in 1993.

Crop Rotations and Intercropping

To increase the amount of available nutrients to plants, Cuban scientists have been using several combinations of crops with grasses and legumes. One rotation system consists of planting rice for two or three years followed by *Sesbania*. This legume is able to incorporate up to 60 tonnes of green manure in 45 days, providing up to 75% of the nitrogen needed by the next rice crop. *Sesbania* is used due to its tolerance to high levels of soil salinity. Sorghum is being used in tobacco as a green manure. Other legumes, like beans, are being used in crop rotations and as green manures.

Although intercropping has been a traditional practice for Cuban small farmers, almost no intercropping systems were used in commercial-scale production during the years of modernisation. In the Alternative Model intercropping has received new attention. Three general areas in which the technique is either being used in production or under strong consideration for development are: soybeans and common beans intercropped with sugarcane, green manure crops interplanted with several crops, and combinations in conjunction with the new weed management system. However, intercropping is not yet widely implemented.

Perhaps the most significant development in the technique has been interplanting soybeans with sugarcane. Before 1989 a substantial portion of animal feed had come from imported soybeans and maize. Technical experts claim that the technique not only helped make up for losses in imported soybeans (a 30% shortfall), but also helped reduce the nitrogen fertiliser use in sugarcane.

With approximately 45% of the cultivable land in Cuba experiencing erosion problems, a major thrust has also been crop rotations to maintain crop cover all year around. Many legumes were chosen as rotation crops and are now increasingly being intercropped. The emphasis appears to be shifting to crop succession rather than rotation.

Earthworm Humus

Cuba's vermi-composting programme started in 1986 with two small boxes of redworms, *Eisenia foetida* and *Lumbricus rubellus*. Today there are 172 vermicompost centres that in 1992 made 93,000 tonnes of worm humus. Cuban scientists have been able to develop a full technology for the production of humus from earthworms, also known as vermi-composting or vermiculture. By using California Red hybrids they have been able to provide 2% of soil nitrogen with each application of 4 tonnes/ha of earthworm humus (MINAGRI figures). The humus that is produced in vermicomposting provides binding sites for plant nutrients, improves soil permeability, helps control diseases that attack plants, and stimulates plant growth. Cuban researchers have found that nitrogen concentrations are higher in the vermicompost than static compost piles. For instance, four tonnes of vermicompost can replace 40 tonnes of cow manure per hectare of tobacco and in one test plot, has resulted in a 36% improvement in yield (MINAGRI figures).

A 40 kg bag of Cuban worm humus can sell for as much as US $80–100 on the international market, though humus production has not reached levels that permit significant exports. Income generating schemes have focused on joint production ventures and the sale of technical assistance for start-up vermiculture programmes outside Cuba. Five experimental stations located in different parts of the country have responsibility for training new worm growers in their regions. Information is exchanged among worm growers at an annual national conference on vermicomposting and vermiculture. National television programmes and newspaper articles are used to help educate farmers, school children, and the general public about vermicomposting. However, home worm composting is not yet commonly practised and commercial vermicompost is not available for home use.

Waste Recycling

As part of Cuba's transition to low input agriculture, resource recovery and recycling programmes are being implemented on a countrywide scale. Cuban scientists are converting waste products into animal food, energy, and fertiliser. Organic by-products from sugarcane processing, cattle ranches, sheep ranches, poultry and pig farms, coffee harvests, garbage and crop residue, crops and foodstuffs are being collected and processed into biofertilisers. Processing methods include vermiculture/vermicomposting, static pile (aerobic) composting, anaerobic digesters and mechanised, on-site recycling of industrial waste. In addition to the impressive vermiculture programme previously discussed, several recycling programmes stand out as examples of innovative solutions to production and pollution problems.

Sugarcane production is virtually organic in Cuba, which is not new. What is new is the maximum utilisation of cane and cane processing by-products to produce energy, fertiliser, animal food supplements, and irrigation water. Waste water from 152 sugarcane processing plants is used to irrigate cane fields. Filter press cake, a processing by-product that is high in phosphorus, potassium, and calcium, is used as fertiliser. And bagasse, a dry pulp, is used as animal feed and biomass for energy production.

In the 1950s, large-scale swine production did not exist in Cuba. Today, 14 farms with approximately 2000 pigs at each installation complement small, private pig farm production. There is a concerted effort among institutions to promote pork as the principal source of protein in Cuban households and provide sufficient quantities to meet those needs. The recycling goal at the large pig farms is zero waste discharge, where liquid and solid waste is treated and used for a series of applications, including vermicompost, energy (biogas), and feed supplement. Recycling at the state pig farms includes a focus on processing food scraps from work places, restaurants, and schools for pig feed supplement. Since 1989, 1,200,000 tonnes of supplementary animal food was produced from garbage, equal to 70,000 ha of soy cultivation or 200,000 ha of maize.

Other initiatives includ growing water hyacinths in processed waste water from pig farms for use as protein rich animal food supplement, producing energy from swine excrement using biogas plants to meet on-site energy needs, and using processed slaughterhouse waste as protein supplement in feed. Alternative, supplemental feeds have helped alleviate a 30 % feed supplement deficit that has resulted from the unavailability of maize and soy imports.

In 1990, in response to the severe shortages of imported animal feed, Cuba began to experiment with a new system of cattle management called Voisin Rational Pasture Management (also called rotational or rational grazing). The basic technique involves using movable electric fencing to confine cattle to small pasture areas, where their manure fertilises the forage plants. The enclosures are moved around the fields on a tight schedule. Environmental pollution is reduced as fewer pesticides and fertilisers are used to produce feed, and manure is distributed to benefit pasture plants and soil rather than concentrated where it can become a pollution problem.

Voisin Pasture Management has been implemented on a wide scale since May 1991. Today over 300,000 hectares (450 units of 600–700 ha each) are under the Voisin system. However, researchers at the Cuban Animal Institute admit they have much more research to do before they can call their Voisin programme a success. Details on pasture ecology, pasture nutrition, paddock layout and fencing, feed planning, economics, recovery periods, stock rate, and forage allowances are presently unavailable. Furthermore, competing demands for cattle manure are already evident. Vermiculture operators want manure as a primary source for their compost systems while Voisin pasture managers want to keep it on their fields.

Reforestation

A key component of soil management involves care of Cuba's forests. Trees cover more of the island now than in 1959, something few countries in the world can boast. Pre-revolution policies and practices had left only 17% forest cover. Perhaps the most important cause of deforestation was for the development of sugarcane plantations during the 17th, 18th and 19th centuries. Forests were rased to plant sugarcane, and much firewood was needed for the process of sugar manufacturing.

Starting in the 1970s, a programme for the development of community nurseries or *viveros populares* was created nationwide. The objective was to collect seed, raise seedlings in the community nurseries and plant them in the countryside. Under the name of *Plan Manati*, the Cuban government has continued the reforestation of degraded areas and the reclamation of areas affected by mining activities. The plan consists in providing plastic bags and seeds to interested people, who later on will use them for the reforestation of degraded areas. In 1989–1990, over 200,000 hectares were reforested. In terms of total forested area, in 1990 two million hectares were forested, 1.7 million of them natural forests and 332,000 hectares of plantations. Today 18% of Cuba is covered with forests – a net increase since 1959. Elsewhere in Latin America, deforestation is occurring.

Mobilising Labour

Under the Classical Model, extensive mechanisation in agriculture had occurred, largely due to high degree of urbanisation of the Cuban population. This created the conditions for a labour crisis in the Special Period. Much of the extant mechanised activities had to be curtailed due to a shortfall in petroleum resources, thus requiring a reversion to animal traction. Exacerbating this, the new low-input sustainable techniques required significant additional amounts of manual labour, to which Cuba has responded in several ways.

Throughout the countryside temporary labour camps have been built to house urban workers who volunteer their labour for anywhere from two weeks to two years while keeping their normal salaries. Short-term workers leave their jobs or their studies for 15 days at a time to volunteer in the countryside, living in dormitories at the agricultural camps. In the first year of these two-week mobilisations, some 146,000 residents of Havana participated (MINAGRI figures).

The two-year volunteers are organised in work brigades called *contingentes*, where they work long hours but receive higher pay and above-average living conditions. To convince workers to stay on after their two-year stints are up, the government is building attractive agricultural communities near state farms, with good housing, medical facilities, sports and recreation facilities. In fact, the only new housing being built in Cuba during the Special Period is in these agricultural communities.

Incentives to volunteer for both the short-term and long-term stints seem to be largely moral, although some material incentives either creep into the system or are actively being experimented with (see above). An experimental way to encourage workers to stay on the land has been to maintain the same workforce on the same piece of land over the entire agricultural cycle. Previously, work teams on large centrally managed farms might plant one plot and never return to it. They might weed and harvest plots that other teams had planted. The goal now is to re-create a more traditional relationship of the producer with the land. State farms are being broken up into smaller management units and work crews are given responsibility for a given piece of land. Furthermore, a bonus system is being established in which the base pay is augmented according to the production (quantity and quality) on that parcel, thus adding another material incentive to the system. Workers interviewed at Las Marias said these bonuses had doubled their pay in the last year. They also claimed that yields had doubled since the system had been implemented. Cuba is presently testing this system in the plantain and citrus sectors, according to MINAGRI officials.

Another approach to the increased labour demands makes agricultural work mandatory for young men completing their military service. A voluntary female component is also included in this plan. The hope is that many of these young people will find rural life attractive enough to make a permanent move to the countryside once their duty is up.

It seems that this impressively large mobilisation of the workforce has been accomplished largely through the double vehicle of material incentives (ensuring that at least the material conditions of one's normal job would be realised) coupled with moral incentives ("in a time of crisis your country needs you to work in the field"), with a seemingly large component attributable to the latter. According to officials, these temporary measures are meeting current special labour requirements. But there are serious questions about quality of work, and about the cost in transportation, housing, food, etc, especially for the short-term volunteers. While the two-year volunteers are a better solution, it remains to be seen if these long-term volunteers will continue to come forward in sufficient numbers.

Community Gardens

Another way that labour has been mobilised to help grow food is through a programme to promote urban gardens. Before the Special Period, Cuban cities were dependent on the rural areas for their food, as a result of a lack of agricultural land near cities, cultural urban biases, and urban opportunities for career advancement away from agriculture. This agricultural dependence on the rural areas necessitated an intricate refrigeration, transportation, storage, and distribution system, which required petroleum at all of its stages. The Special Period has had an extremely detrimental effect on the availability of petroleum, causing a severe reduction in food supply in the cities. This effect has been most strongly felt in Havana, where about one-fifth of Cuba's population resides.

Urban gardens can do much to reduce the pressures of the national food shortage. Localised production alleviates the problems of transportation and post-harvest storage. Small-scale production relies on human resources, as opposed to heavy machinery and other energy-taxing inputs. With the Cuban diet quite low in vitamins and minerals, produce from urban gardens can help alleviate these deficiencies. The crop diversification common to small-scale gardening also greatly reduces vulnerability to plant diseases and pests. Finally, individuals are empowered as they work to resolve their problems of food availability, instead of looking to the state or the black market to supply their needs.

Urban gardens take on three basic levels of organisation in Cuba: individual and family gardens on private land, organised groups of neighbours gardening on public land, and institutionally organised gardens. The produce from individual or family gardens is for personal consumption, with all production inputs provided by the gardeners themselves. Gardens organised by private groups on public land are informally structured by those involved. Land is obtained through the government body *Poder Popular*, or through mass organisations such as the Federation of Cuban Women or block committees. The third type of garden is organised by an institution, such as a school, workplace or mass organisation. Decisions concerning what is planted, work scheduling, and responsibilities are made jointly by the group. The produce from the gardens is used to provide food for the institution's cafeteria or distributed to local day care centres, rehabilitation centres, hospitals, etc. Sometimes the produce is taken home to feed participants and their families.

Knowledge about agriculture is not uncommon in the Cuban population, even among the urban dwellers, as the Cuban revolution has tried to keep people connected to agricultural work and the production of food. This goal stems from a fundamental philosophy of José Marti, Cuba's national hero, that everyone should know what is involved in the production of the goods that they consume. For example, agricultural work is part of many school programmes. Furthermore, knowledge regarding small-scale low-input gardening is presently being spread through a television show being aired twice a week. This method of mass extension via television is crucial during the Special Period, as paper shortages prevent mass printing of informational material.

Urban gardening has become very prevalent throughout Havana city, as well as in other areas of the country. Unfortunately, it is impossible to calculate the importance of urban gardens in terms of production. Due to budget cutbacks no government office maintains such statistics.

Generating and Using Appropriate Knowledge

New systems of farm production and readjustments of rural-urban living patterns are at the heart of Cuba's short-term quest of a new model for food production. Of equal importance, however, especially for the long-term, is Cuba's recognition that a substantially revised knowledge base is needed if adequate yields are to be achieved and maintained. Since 1989, Cuba has fully accepted the policy to promote a new science of agriculture and has moved substantially to implement this policy in research station, the extension services, and with farm producers.

The political priorities are aimed at maintaining its production levels of export crops with vastly lowered inputs, most of which will be made in Cuba, rather than imported. What is remarkable about Cuba's new research directions is the heavy emphasis on understanding and exploiting the subtle yet powerful abilities of biological organisms to perform many of the tasks previously done by synthetic chemicals. Such chemicals typically have little subtlety of biological knowledge incorporated in their design. Biologically-based or -derived fertilisers and biological control of pests, as described earlier, are at the heart of this new quest.

It is worth remembering that the movement toward the new research programmes predated 1989, but administrative and political leadership within the government was decidedly not interested at the time and scientists' analyses and proposals fell on deaf ears. After 1989, low-input agricultural scientists suddenly found themselves high on political and administrative agendas, with top priority for funding. The future prosperity and even security of Cuba is seen by all to depend on them. As a result administrative and political leaders and environmentally concerned scientists have embraced their newly found common interests with enthusiasm.

While the enthusiasm for research to support the new model is unmistakable, the Cubans are still essentially working with the old organisational structure of agricultural research. Most institutes are heavily oriented to single commodities (e.g., tobacco, sugar, rice, pork). Sugar is the main agricultural crop, yet it is located in a different ministry from the rest of agriculture. Bureaucratic divisions seem to exist between research programmes that deal with biological phenomena that will not be confined to the organisational charts of Ministers.

Also, one particular crop, beans, does not have a high priority identification within the Ministry of Agriculture's research institutes. Instead, research on beans is buried within INIVIT,[4] which has a broad mandate in the starchy roots (cassava, sweet potatoes, and taro), starchy fruits (plantains and bananas) and vegetables of various sorts. Given the importance of beans as a source of high quality protein, it does not seem to be matched by a corresponding prominence in the research bureaucracies. There is also little research on maize, a potential food crop that is not a part of the contemporary Cuban diet. Nevertheless, Cubans did consume maize historically and imports large quantities of maize for animal feed. Given the suitability of Cuba's climates and soils for maize and beans, and the potential benefits of them, the invisibility of these two plants within the research institutes is puzzling.

Local Knowledge and Popular Participation

A pivotal component of the Cuban research shift toward sustainable agriculture is an exploration of the knowledge base of Cuba's farmers. The Ministry of Agriculture is, therefore, explicitly emphasising an increase in the degree of local participation in decision-making and in developing agricultural systems adapted to the local agroecological conditions.

At the community level, the Ministry has encouraged the recovery of former land use practices such as animal traction, intercropping, biological pest control techniques, crop rotations, agro-pastoral and agro-forestry systems. Farmers are also being asked to participate in the selection and dissemination of cultivated plants. The replacement of tractors by animal traction in the food crops sector is well under way, and is being promoted as a prototype for other forms of local knowledge that can facilitate the shift to a low-input sustainable system of agricultural production.

The agricultural policy objectives have required a major reorganisation in the structure and flow of agricultural research and extension in Cuba. Moving away from capital- and energy-intensive technologies requires new relationships between scientists, extension agents, and farmers. The previous role of scientists as generators of innovative technological packages and extension agents as conduits of their delivery to farmers is clearly changing in favour of a partnership between the three in the development and dissemination of new approaches.

Towards this objective, the Ministry of Agriculture currently sponsors farmer-to-farmer and farmer-to-extensionist/scientist workshops in the provinces. Farmers from different regions facing similar problems are brought together to: make locally adapted or developed technologies known to a broader audience; facilitate farmer knowledge of techniques and practices successfully used in other regions with similar crop complexes; and promote scientific research and development of promising low-input innovations.

Cuban scientists have become increasingly dependent on farmer innovation and experimentation for research directions that complement their efforts to develop promising organic farming practices. Two types of innovation are being made: technologies recovered or developed at the local level that have widespread applicability, which extension agents and scientists disseminate over a broader region; and low-input technologies used in other countries, which are promoted for local experimentation and adaptation. One example where local knowledge from farmers proved the catalyst for technology generation is in the biological control programme of the sweet potato weevil. Some Cuban farmers began experimenting with collecting colonies of ants in banana orchards and transferring them to sweet potatoes. Cuban researchers investigated and refined the locally developed technique, which was subsequently disseminated by the Ministry of Agriculture to other regions.

The renewed emphasis on germplasm banks during the Special Period illustrates another area in which local knowledge and community participation is being incorporated into Cuba's research. While founded over ten years ago, germplasm reservoirs for national research are receiving greater emphasis today. The Instituto Nacional de Investigaciones Fundamentales de la Agricultura Tropical (INIFAT) is sponsoring a national programme for the popular collection of crop varieties to halt the widespread genetic erosion. Also, emphasis on labour-displacing mechanised agriculture resulted in the steady out-migration to cities of farmers with knowledge of local varieties. As these dramatic changes have occurred in less than one generation, considerable hope is being placed on the prospect for rescuing funds of local knowledge that might otherwise have vanished. Farmers are encouraged by INIFAT to collect currently utilised and promising varieties of food crops for evaluation and germplasm conservation.

Despite the progress that has been made, in terms of rescuing the knowledge of local farmers and promoting more participatory research, Cuba lags behind the NGO movement elsewhere (see for example Chambers el al., 1990; and Altieri and Hecht, 1990). Yet, if one considers that in these other countries NGOs must fill the vacuum left by disinterested governments, then the active role of MINAGRI in promoting change in Cuba is all the more impressive.

The Cuban Experiment

It took the crisis of the Special Period to force changes in Cuban agriculture. The economic crisis wrought by the collapse of trading relations with the socialist bloc represents two steps back for the Cuban people as it has caused much suffering and scarcity. The hope is that the rise of the Alternative Model for agriculture will truly come to represent a big step forward.

Cuban officials repeatedly said, "*The United States claimed we were a satellite of the Soviets, yet our planet has disappeared and we're still here* ". However, it will not be easy for Cuba to survive the present situation with its society intact. Since the delegation visited in November, 1992, two severe storms have devastated Cuban agriculture. In March 1993 half of the food crops were destroyed just before they were to be harvested. Another storm then hit while sugarcane was being transported from the fields to the mills, causing such severe losses that Cuba had to default on major delivery commitments for the first time ever.

In the rest of the world, an alternative model of agriculture exists only in theory. If the Cuban people have been shown to be anything during the past three decades it is audacious. Today, in the midst of the most severe crisis in their history, they are making a bold attempt to change the rules of the game. Though it is impossible to say if they will ultimately be successful, what they have already achieved under conditions of adversity is impressive. Daughters and sons of peasant farmers are producing cutting-edge biotechnology, literally on the farm, and supplying their parents and neighbours with organic substitutes for toxic pesticides and chemical fertilisers.

The Cuban experiment is the largest attempt at conversion from conventional agriculture to organic or semi-organic farming in human history. Other nations will be able to learn from Cuban successes as well as from Cuban errors. This national experiment, which is so potentially important for many, requires support to continue.

Notes

1. Members of the International Scientific Delegation were: Peter Rosset (Delegation Leader), Nanda Herman, Larry Burkman, Judith Carney, Orville Coil, Carl Davidson, Jeffrey Dlott, Paul Gersper, Jeanne Haught, Juan Martinez, John McConkey, Julio Monterrey, Cesar Morales, Catherine Murphy, Laura Orlando, Ivette Perfecto, John Perkins, Carmen Rodriguez-Barbosa, Jeff Schatz, Nina Shishkoff and John Vandermeer.

2. All major agricultural research centres located in the capital were visited, as were the major agricultural universities, the office of the Food and Agriculture Organisation (FAO) of the United Nations, a local non-governmental organisation (NGO), and various urban gardens and private homes. In the countryside state farms, cooperatives and individual private farms, research stations, and other agricultural facilities were visited. Extensive interviews were held with government officials, farmers, farm workers, farm administrators, researchers and extension agents, professors, the representative of the FAO in Cuba, and dozens of ordinary people.

3. The only genetic engineering in relation to agriculture used in Cuba appears to be in the development of diagnostic kits for plant viruses, a technique in common use elsewhere.

4. INIVIT: Instituto de Investigaciones de Viandas Tropicales; Cuban research institute with responsibilities for sweet potatoes, taro, plantains and cassava.

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The Sustainable Agriculture and Rural Livelihoods Programme

The Sustainable Agriculture and Rural Livelihoods Programme of IIED promotes and supports the development of socially and environmentally aware agriculture through policy research, training and capacity strengthening, networking and information dissemination, and advisory services.

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The Programme supports the exchange of field experiences through a range of formal and informal publications, including *PLA Notes* (*Notes on Participatory Learning and Action - formerly RRA Notes*), the *IIED Participatory Methodology Series*, the *Working Paper Series*, and the *Gatekeeper Series*. It receives funding from the Swedish International Development Cooperation Agency, the British Department for International Development, the Danish Ministry of Foreign Affairs, the Swiss Agency for Development and Cooperation, and other diverse sources.

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