Indigenous and modern app

Prevailing economic policies in Latin America encourage the production of export and/or commercial crops, primarily in large-scale monocultures. Pesticide expenditures in the Latin American region increased from US$1.0 billion in 1980 to US$2.7 billion in 1990. The major recipients of pesticides were large-scale production systems producing sugar cane, cotton, maize, soya beans, rice, citrus and tomatoes, especially in Brazil, Colombia, Argentina and Mexico. Predictably, the emphasis of the chemical-intensive agricultural export model has intensified ecologically-based crisis conditions and has led to serious environmental and health consequences (Belloti et al., 1990).

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Despite the above trends, there are several documented cases of alternative pest management approaches scattered throughout the region that have resulted in sustainable crop production. These are both traditional crop protection practices (indigenous IPM systems) developed by indigenous farmers using traditional knowledge and local resources, and modern IPM systems developed by innovative researchers involved in the search for more sustainable methods of food production.

Despite many scientific advances, it is still arguable whether ecological principles have actually had an impact on the practice of modern IPM. In many cases, modern IPM has come to mean Intelligent Pesticide Management, which aims at scouting crops to monitor pest densities in order to take action (usually insecticide application) when they threaten economic viability (the economic threshold (ET)). As long as the simplified structure of monocultures is maintained, pest problems will continue because the process of ecological simplification has been set in motion. The IPM projects described below are, however, a step in the right direction as they emphasise the withdrawal of pesticides, allowing beneficial fauna to recover and a more desirable level of biodiversity to re-establish itself within agro-ecosystems.

Peru

In the mid-1950s, as cotton production reached a peak in the Canete Valley, organochlorinated insecticides were in intensive use. Several pests had already developed resistence to these pesticides, and heavier dosages and more frequent applications became necessary. Six new species of secondary pests made their appearance and cotton yields fell sharply.

A number of changes in pest control practices were introduced in response to this crisis including the banning of synthetic organic pesticide use, the reintroduction of beneficial insects, crop diversification schemes, planting of early maturing varieties and the destruction of cotton crop residue. Pest problems declined dramatically, and pest control costs were substantially reduced (Hansen, 1987).

Nicaragua

In Nicaragua, cotton also exhibited the classic pesticide 'treadmill' pattern observed earlier in Peru. After a successful production phase in which cotton yields peaked in 1964-1965, pesticide-induced ecological disruptions made themselves felt: insecticide-resistant pests, secondary pests and the elimination of natural enemies. Average yields fell by 15-30% because of insect damage, despite 28 insecticide applications per season. In 1971, a programme started by UN-FAO began to yield information on, amongst other things, economic thresholds, the seasons when natural enemies were most abundant, and cotton phenology. This helped researchers to identify the best time for planting cotton and the conditions that gave the best growth environment to the plant, allowing it to escape boll weevil and boll worm attack. Later, a 'trap cropping' system was developed. This consisted of planting small cotton plots at the beginning and end of the growing seasons to attract and concentrate weevils. Once trapped, they were then killed off by selective insecticides (Swezey et al., 1986).

Costa Rica

Another case of insecticide-induced ecological disruption comes from the Pacific coastal plains. In 1954, over 12,000 hectares of United Fruit Company banana plantations were treated with an aerial application of dieldrin granules against banana weevil and rust thrips. This killed off many natural enemies and led to the appearance of other pests which had previously been of minor significance. An outbreak of banana stalk borer, Castiomera humbolti was countered by more pesticide spraying. By 1958, in spite of increasing pesticide use, there was an unprecedented outbreak of pests, with even six major Lepidopteran pests including Ceramidia moth, owleye and the West Indian bag worm that had not previously been a problem. In 1973, the oil crisis prompted United Fruit entomologists to stop all insecticide sprays in the entire Golfito banana division. Insect pests fell to below a level where they were a threat to profitability within one to three generations (a period of several months) with little or no fruit loss. Within two years, virtually all of the former pest species had almost disappeared from the plantations. Indeed, pests like Ceramidia and the owleyes were rarely seen. There were occasional small outbreaks of larvae of the West Indian bag worm, but their numbers did not threaten the economic threshold. The same was true of the banana weevil. Stopping pesticide sprays allowed natural enemies to move in from the surrounding jungle, colonise the area, become more abundant and thus re-exert a natural control over many of the pest populations (Stephens, 1984).

Brazil

By 1970, total soya bean production had reached 2,278 x 106 tons, especially in the states of Parana and Rio Grande do Sul, cov-

Table 1. Selected examples of multiple cropping systems that effectively prevent insect-pest outbreaks in Latin America (after Altieri, 1994).

Multiple cropping System	Pest(s) regulated	Factor(s) involved	Country
Cassava intercropped with cowpeas	Whiteflies *Aleurotrachelus socialis* and *Trialeurodes variabilis*	Changes in plant vigour and increased abundance of natural enemies	Colombia
Corn intercropped with beans	Leafhoppers (*Empoasca kraemeri*), leaf beetle (*Diabrotica balteata*) and fall armyworm (*Spodoptera frugiperda*)	Increase in beneficial insects and interference with colonisation	Colombia
Corn intercropped with beans	Corn leafhopper (*Dalbulus maidis*)	Interference with leafhopper movement	Nicaragua
Cucumbers intercropped with maize and broccoli	Flea beetles (*Acalymma vitata*)	?	Costa Rica
Corn-bean-squash	Caterpillar (*Diaphania hyalinata*)	Enhanced parasitisation	Mexico
Corn-beans	Stalk borer (*Diatraea lineolata*)	?	Nicaragua

oaches to IPM in Latin America

ering an area of about 5.5 x 106 has. As soya bean acreage increased, so did the number of insect pests. In 1974, Brazil adopted an IPM programme that relied primarily on monitoring pest damage, establishing economic thresholds and the application of specific insecticides. This IPM programme was so successful that between 1974 and 1982 insecticide applications fell by 80-90%. In the 1980s, the programme was expanded to include the use of Nuclear Polyhedrosis Virus against the velvetbean caterpillar. This virus is host specific and it can be readily mass-produced by farmers themselves. They collect sick larvae that, when macerated and filtered, can be applied in a water solution (Campanhola et al., 1995).

Colombia

During the late 1970s and early 1980s, it would have been considered usual to make some 20 to 30 pesticide applications in a tomato growing area covering about 2,000 hectares. An IPM programme in the Cauca Valley implemented in 1985 succeeded in reducing the number of pesticide applications to two or three. This saved over US$ 650 per hectare. Use of a microbial insecticide derived from *Bacillus thuringiensis* combined with the release of natural enemies such as *Trichogramma* spp., and the encouragement of natural populations of the parasite *Apanteles* spp., were particularly effective in reducing the major pest *Scrobipalpula absoluta*, a leaf miner/fruit borer (Belloti et al., 1990).

Chile

In 1972, populations of two aphid species (*Sitobium avenae* and *Metopolophium dirhodum*) were detected in cereal fields. Despite the presence of resident natural enemies, these aphids reached outbreak proportions. As a result, over 120,000 hectares of wheat were sprayed aerially with insecticides. In 1975, the aphids and the Barley Yellow Dwarf Virus they transmit were responsible for the loss of about 20% of national wheat production. In 1976, the Chilean government's agricultural research centre, in conjunction with the FAO, initiated a pest management programme. As part of the strategy, several aphidophagous insects and parasitoids were introduced against the aphids. Five species of predators were brought in from South Africa, Canada and Israel, and nine species of parasitoids of the families Aphidiidae and Aphelinidae came from Europe, California, Israel and Iran. In 1975, more than 300,000 Coccinellidae were mass-reared and released, and from 1976 to 1981 more than 4 x 106 parasitoids were distributed throughout the cereal areas of the country. Aphid populations were maintained below the threshold where they could inflict economic damage by the action of biological control agents (Zuñiga, 1986).

Cuba

Since trade relations with the socialist bloc collapsed in 1990, pesticide imports to the island have dropped by more than 60 percent. Because of this, the Cuban government adopted an IPM policy which focused on biological control in its search for techniques that would enable biologically sophisticated management of agro-ecosystems (Rosset and Benjamin, 1994). Key components of their strategy are the Centers for the Production of Entomophagae and Entomopathogens (CREEs), where the centralised, 'artesanal' production of biocontrol agents takes place. By the end of 1992, 218 CREEs had been built throughout Cuba and were providing services to the State, cooperatives, and individual farmers.

CREEs produce a number of entomopathogens (*Bacillus thuringiensis, Beauveria bassiana, Metarhizium anisopliae*, and *Verticillium lecanii*), as well as one or more species of *Trichogramma* wasps. Their production depends on what crops are being grown in the area.

The array of both proven and promising IPM technologies developed by innovative researchers and indigenous farmers offers considerable potential for reducing agrochemical use and improving agricultural sustainability. The challenge now is how to incorporate local knowledge and skills as well as innovative IPM research into the research agenda of national and international organisations. The other challenge is how to mobilise these organisations to help scale up the initiatives described here and make wider eco-regional impact possible. At the political level it is clear that a true reduction and/or elimination of pesticide use in the agro-export sector will require major political reforms that deal with the reasons why farmers turn to chemicals. These include government pesticide subsidies, corporate control of agricultural enterprises, research serving the needs of the private sector, and internationally set, unrealistic, cosmetic standards. ■

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Table 2. Selected examples of cropping systems in which the presence of weeds enhances the biological control of specific crop pests (after Altieri, 1994).

Cropping systems	Weed species	Pest(s) regulated	Factor(s) involved	Country
Beans	Goosegrass (*Eleusine indica*) and red sprangle-top (*Leptochloa filiformis*)	Leafhoppers (*Empoasca kraemeri*)	Chemical repellence or masking	Colombia
Brussels sprouts	Natural weed complex	Imported cabbage butterfly (*Pieris rapae*) and aphids (*Brevicoryne brassicae*)	Alteration of colonisation background and increase of predators	Chile
Corn	Natural weed complex	*Heliothis zea, Spodoptera frugiperda*	Enhancement of predators	Colombia
Corn	Natural weed complex	*Dalbulus maidis*	Interference with leafhopper movement	Nicaragua
Soybean	Broodleaf weeds and grasses	*Epilachna varivestis*	Enhancement of parasites	Mexico, Colombia
Soybean	*Cassia obtusifolia*	*Nezara viridula, Anticarsia gemmatalis*	Increased abundance of predators	Brazil
Soybean	*Crotalaria usaramoensis*	*Nezara viridula*	Enhancement of Tachinid parasite (*Trichopoda sp.*)	Brazil
Sweet potatoes	Morning glory *Ipomoea asarifolia*	Argus tortoise beetle (*Chelymorpha cassidea*)	Provision of alternate host for the parasite *Emersonella* sp.	Costa Rica
Vineyards	Natural weed complex	Grape mealy bug *Pseudococcus affinis*	Enhance natural enemies	Chile