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Designing Integrated Pest Management for Sustainable and Productive Futures

MICHEL P. PIMBERT

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Michel P. Pimbert was Principal Entomologist in the Legumes Program of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru P.O. 502 324, A.P., India. This is a modified version of a paper presented at the Asian Farming Systems Research and Extension Symposium on "Sustainable Farming Systems in 21st Century Asia," 19-22 November, 1990, Bangkok, Thailand. He is now coordinator of the Biodiversity Program of the World Wide Fund for Nature and Natural Resources (WWF) in Switzerland.

DESIGNING INTEGRATED PEST MANAGEMENT FOR SUSTAINABLE AND PRODUCTIVE FUTURES

Michel P. Pimbert

Introduction

Pests have plagued agriculture ever since people began domesticating plants and animals. Over the centuries, farmers have developed a wide range of methods to combat these pests, but with varying degrees of success. In the 20th century, however, the introduction of commercial pesticides revolutionised pest control. These modern pesticides have helped to control and reduce crop and livestock losses to a remarkable degree.

The use of these pesticides has, however, created some of today's major environmental and health problems: reduction in the abundance and diversity of wildlife, human health hazards associated with acute or chronic exposure to dangerous products in the workplace, and contaminated air, food and water (Conway and Pretty, 1991; Gips, 1987; Pimbert, 1985). Most of the social costs are unevenly distributed within and between countries. For example, about half of all pesticide poisonings of people, and 80% of pesticide related deaths, are thought to occur in developing countries, even though this is where only 15-20% of pesticides are consumed.

The self-defeating nature of the chemical control strategy that dominates today's crop and livestock protection efforts has also become more apparent in recent years. Repeated applications of synthetic pesticides have selected pesticide resistant pests worldwide, and there are now at least 450 species of insects and mites, 100 species of plant pathogens, 48 species of weeds resistant to one or more products. In addition, the deaths of natural enemies has allowed previously harmless organisms to reach pest status. The impression is that more and more pesticides have to be used to achieve less and less.

For these reasons, crop protection specialists are increasingly being asked to develop pest control methods that are more compatible with the goals of a sustainable, productive, stable and equitable agriculture. To meet these aims, research must seek to integrate a range of complementary pest control methods in a mutually enhancing fashion, namely as Integrated Pest Management (IPM). IPM focuses on five control areas:

- cultural pest controls: the manipulation of sowing and harvest dates to minimise damage, intercropping, vegetation management to enhance natural con processes, and crop rotations;
- host plant resistance: the breeding of crop varieties that are less susceptible to pests (insects, diseases, nematodes, parasitic weeds, and so on);

- biological control: the conservation of natural enemies, manipulation/augmenting of natural enemy populations, and the introduction of exotic organisms;
- the wise and judicious use of pesticides: chemical, microbial, botanical icides used along with information on economic thresholds;
- legal control: the enforcement of measures and policies that range from quarantine to ated land and water management practices. This approach to pest management must involve area-wide operations that include many rural households that are enacted for the common good of both farmers and society at large.

But amongst users and promoters of IPM, such as researchers, donors, policy makers, pesticide companies, and extension staff, there are significant differences in emphasis and approaches. Some of the more fundamental differences are briefly discussed here clearly to identify IPM approaches that reflect and reinforce the goals of sustainable and equitable production systems. There will be a need to focus on structural changes in agroecosystems, give greater importance to self-sustaining control methods, and draw on the local stocks of knowledge useful for pest management.

IPM : Systemic Adjustment or Structural Change?

The scope and content of various approaches to pest management are compared in Table 1. The alternatives to the single goal, high intervention, industrial model of pest control broadly fall into two styles:

- curative ecological solutions that seek for more efficiency in the use of pesticides and product substitution (e.g. biocontrol agents for pesticides) within a farming landscape that remains essentially unchanged in structure and function. This is the most commonly held perception of the role and scope of IPM today.
- preventive ecological pest management that seeks to redesign farming landscapes by injecting appropriate levels of biological diversity and by maximising beneficial functional connections.

Whilst some of the defining characteristics listed in Table 1 are, to some extent, common to both "alternatives" to the industrial or green revolution model (e.g. mixed strategies of pest control, diversification), others are fundamentally different (e.g. overall goals, boundary conditions and research goals and modes) (Table 1). These divergences primarily relate to human values and are important because they highlight the ideological framework that IPM practitioners consciously or unconsciously adopt in their work. Human values and subjective elements enter the theory and practice of IPM by:

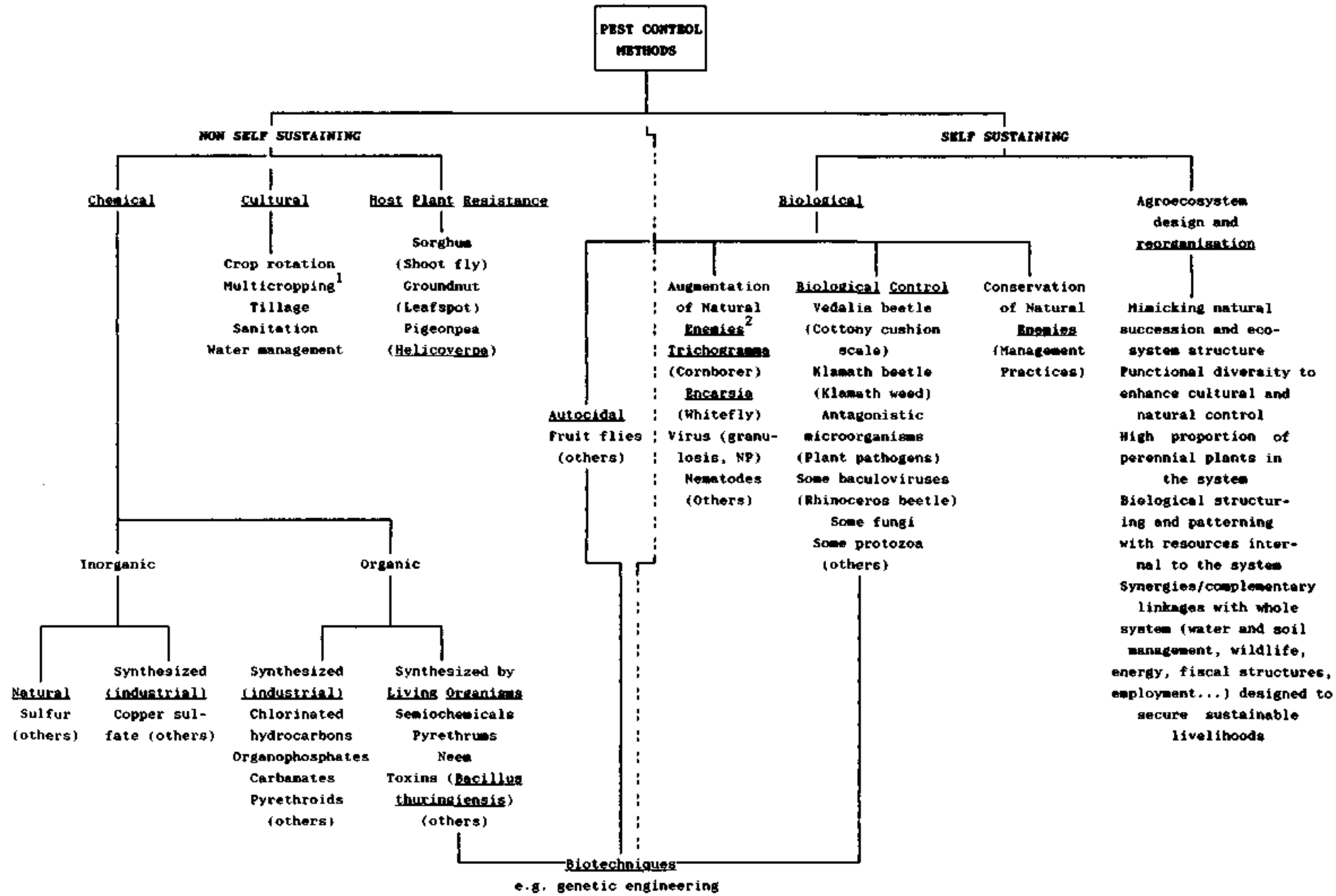
- defining what to think about and how to think about it;
- informing the choice of a research problem and the way it is tackled;
- setting limits on the thinking and imagination of scientists, policy-makers, and donors;

and thus partly determine the ultimate nature of pest control technologies.

Table 1 : Approaches to pest management

	Industrial and Green Revolution	**Present IPM (systemic adjustments)**	**Sustainable Agriculture (structural changes)**
Goal	Eliminate or reduce pest species	Reduce costs of production	Multiple economic, ecological and social goals
Target	Single pest	Several pests around a crop and their predators	Fauna and flora of a cultivated area and linkages with non-cultivated ecologies
Signal for Intervention	Calendar date or presence of pest	Economic Threshold	Multiple criteria
Principal method	Pesticide	Prevention by plant breeding and crop timing, careful monitoring, product substitution, insecticide resistance management and multiple interventions	Agroecosystem design to minimize pest outbreaks and mixed strategies including group action on an area-wide basis to complement pest controls aimed at individual households
Diversity	Low	Low to medium	High
Spatial scale	Single farm	Single farm or small region defined by pest	Bio-geographic regions
Time scale	Immediate	Single Season	Long-term steady-state oscillatory dynamics
Boundary Conditions	Everything as is: crops, cropping system, land tenure, microeconomic decision rules, social organisation	Major crops, land tenure, and decision rules. Economy treated as given but subject to some intervention via price supports and subsidies	
Research goal	Improved pesticides	More kinds of interventions	Minimize need for intervention
Research mode	Transfer of Technology (TOT)	TOT Mode	Complementarity between TOT and Farmer First Mode (FF)

(Modified from Levins 1986)



Notes

1 Some forms are self-sustaining

2 Partially self-sustaining

Figure 1. Methods for crop protection with some specific examples

The Relative Importance Given to Self-Sustaining Control Methods

The methods used for plant protection are either self-sustaining or require periodic human and/ or capital input (Figure 1). Under this definition, all forms of chemical and most cultural controls are non-self sustaining and, whilst some forms of biological control require periodic inputs, most are self-sustaining. Most methods that emphasize agroecosystem design and reorganisation based on renewable, farm derived resources, are self-sustaining (Figure 1).

IPM is premised on the idea that a mix of strategies should be deployed to contain pest damage within acceptable limits. However, whenever IPM practitioners fully internalise the sustainability concept in their minds, self- sustaining methods tend to be consciously chosen and preferentially built into pest management schemes. Examples of biological pest control methods deployed in the context of re-designed agroecosystems are shown in Table 2. Figure 2 shows a multifunctional design primarily fuelled by solar energy in which the feeding activities of chicken help suppress weeds and some insect pests. In this instance, pest management is a function of carefully designed biological restructuring of the landscape that closes nutrient cycles by integrating poultry and vegetable production along with grain and tree crops.

If the shift to self-sustaining pest control methods based on structural changes is to occur, then it will be necessary for institutions greatly to broaden their knowledge bases. Whilst the industrial pesticide approach depends mainly on the disciplines of taxonomy and toxicology, cultural and biological methods add on population biology, behaviour, ecological genetics, agroclimatology and micro-economics. Future self-sustaining designs that minimize the need for pest control interventions will require more understanding of complex ecological systems and bio-social wholes. Moreover, the move towards system design to minimize pest outbreaks calls for the decompartmentalisation of knowledge and decision making as IPM becomes more broadly coordinated with land and water management, conservation of biodiversity, public health protection and socio-economic development.

The Stocks of Knowledge Used by IPM Practitioners

IPM practitioners may rely on four separate stocks of knowledge, of which two are as yet embryonic in their development.

The first is derived from the Western positivist and mechanistic science and technology. The industrial model of pest control is firmly rooted in this tradition and much present day IPM that seeks systemic adjustments derives its tools of intervention and legitimacy from this stock of knowledge. One example is the crops genetically engineered to resist insects and viral diseases that are introduced as quick fixes for increasingly complex pest control problems. These new genetically manipulated organisms are being developed to fit into conventional agriculture's industrialised monocultures. Like chemical pesticides, they further accentuate farmers' dependence on new products from corporations that have recently moved into the genetic supply industry.

Table 2. Examples of pest control relying on diversity and renewable, farm derived, resources.

a) Insect pests

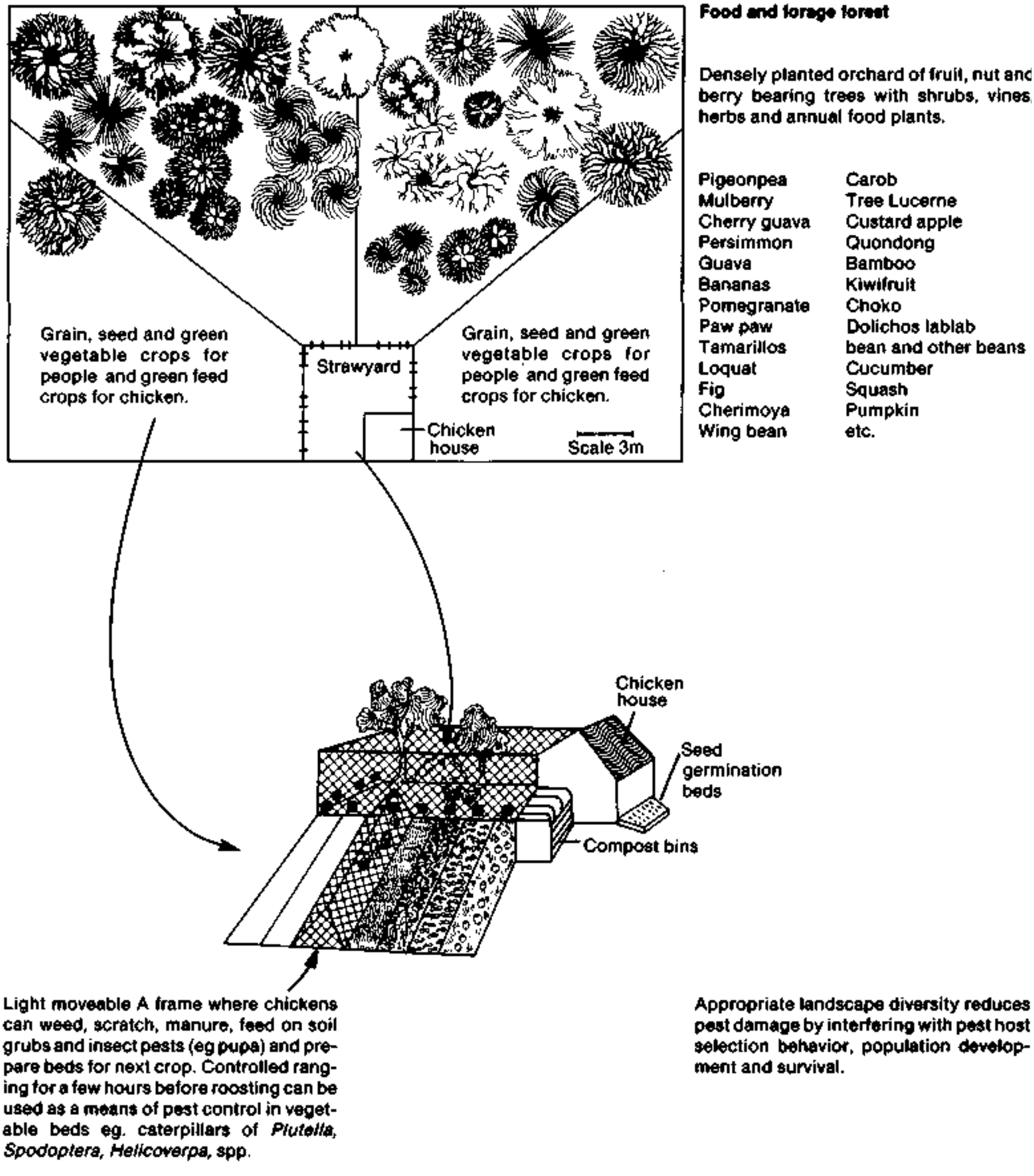
Cropping system	Pest(s) regulated	Factor(s) involved
Chickpea and coriander	*Helicoverpa armigera*	Increase in natural enemy activity
Cotton intercropped with sesame	*Helicoverpa* spp.	Increase of beneficial insects and trap cropping
Tomato and tobacco intercropped with cabbage	Flea beetles *(Phyllotreta cruciferae)*	Feeding inhibition by odours from non-host plants
Mungbeans and natural weed complex	Beanfly *(Ophiomyia phaseoli)*	Alteration of colonisation background
Soybean and weeds *(Cassia* spp)	*Nezara viridula, Anticarsia gemmatalis*	Increased abundance of predators
Cassava varietal mixtures	Whiteflies	Interference with host selection behaviour
Cabbage/and natural weed complex	Aphids *(Brevicoryne brassicae)*	Alteration of colonisation background and increase of predators

b) Soil borne diseases

Crops and pest	**Soil amendment**
Pea root rot	Crucifer tissues
Banana wilt	Sugarcane residue
Coriander wilt	Oil cakes

The second are traditional, empirical, experimental, and operational stocks of knowledge that have been nurtured by rural people to secure their livelihoods within the constraints of a wide variety of environments. Farmers have traditionally developed several strategies to cope with undesirable organisms. Mixtures of various crop species and varieties minimise risks of crop losses by insect pests and disease. Complex crop canopies and overplanting can effectively suppress weed growth and reduce the need for weed control. Other control practices include: planting in times of low pest potential, the use of resistant varieties, the use of botanical insecticides or repellents, cultural practices to enhance natural enemy activity, and mulching to minimise pest interference. Many of these traditional pest control

Figure 2. Designed agroecosystem for pest management



methods and their underlying ecological rationale provide useful tools and ideas for contemporary IPM research (Altieri, 1987).

The third is knowledge that might arise from the interaction and complementarities between the western positivist and traditional stocks. The detailed intimate knowledge that farmers have of their local agroecologies can be usefully combined with the more widely applicable scientific knowledge that comes from research centres. In the context of a sustainable agriculture this may be indeed necessary: the more gentle, self- renewing IPM technologies are especially site specific. Potentially fertile interactions between traditional pest control knowledge and modern science would be encouraged if:

- IPM practitioners rejected the arrogant dismissal of non-scientific knowledge without adopting the naive, uncritical, view that rural people always know best;
- Farmers met scientists on terms of equality; that farmers were persuaded they have something to teach and became involved in key decisions relating to IPM research and extension;
- Innovative methodologies were used to actively involve farmers in observation, experimentation and adaptation of general IPM principles to local conditions (see below).

The final stock is knowledge which might come from the significant demand in many countries (developed and developing) for a simpler, more humane, ecological lifestyle. Some emergent features of this class of knowledge are: holistic understanding, non-compartmentalised and inclusive of other stocks of knowledge, lateral and transdisciplinary thinking, consciously life affirmative and participatory. Despite occasional lapses into sentimentality and some errors of detail, the conceptual initiatives of these critical movements offer much to the theory and practice of IPM and sustainable agriculture. One example that merits close study in this context is permaculture, a philosophy and practice of whole system design that seeks to supply human needs (food, energy, shelter...) while retaining the self-sustaining features of unmodified ecological systems (Mollison, 1988).

As we shift from the industrial model of pest control to more sustainable pest management approaches, the third and fourth knowledge stocks will assume greater importance.

Research for IPM

The three approaches to pest management (Table 1) can be further differentiated on the basis of their research modes i.e. the way IPM research is decided, carried out, evaluated and how its products are extended to farmers.

The transfer of technology model (TOT) of agricultural research is typical of both the industrial formula for pest control and of IPM construed as a systemic adjustment to the sustainability crisis. In the TOT model, all the key research decisions are made by scientists who experiment on research stations or under controlled, simplified conditions in farmers' fields. The resulting IPM technology, such as pest resistant varieties, economic threshold data, and recommendations on cultural practices is then handed over to the extension services for transfer to farmers.

It has been claimed that industrial and green revolution agricultures have been well served by this model of agricultural research. The physical and economic conditions on research stations have, after all, been similar to those of resource rich environments. The simplifying tendencies of reductionist science have also meshed well with the ecological and social simplicity of standardised, specialised farming systems (Chambers and Ghildyal, 1985). As a result, production gains per unit area of land have been spectacular. For example, the introduction of DDT and organophosphates in New Zealand to control soil pests in pastures led to a doubling of the stocking rate of sheep 30 years ago. But the growing list of social and environmental costs of capital and energy intensive interventions has drawn further criticism to this high technology model of agriculture, which is not of pesticides alone, but of the package of which it is part.

Moreover, the TOT model of pest management research has had limited successes in the context of complex, risk-prone, diverse environments where the majority of the world's rural people live today. Along with many other agricultural technologies developed within the TOT framework, failure rates have been and remain high: the research priorities often turn out to be wrong, the IPM packages are rejected, the pest control technologies do not fit, are non-sustainable or inequitable because of an emphasis on purchased inputs in resource-poor contexts. Examples include:

- pest management research based on scientists' perceptions of pest problems on research stations rather than on data derived from reliable pest surveys and farmers' rankings of pests in order of importance;
- farmers' non adoption of improved high yielding, pest resistant crop varieties on account of their poor taste or cooking qualities;
- recommended weed control operations that create new insect pest control problems by destroying the wild plants that key natural enemies rely on for food and shelter within the farming system;
- insecticide resistance management strategies based on rotations of different chemicals are being introduced in response to field failures or to avoid the gradual build up of insecticide resistance in major pests. But many low to middle income farmers are unable to afford some of the more selective products recommended in these schemes.

This crisis of the TOT model has led some IPM practitioners to explore new approaches that hinge on farmer participation. These Farmer First (FF) approaches reverse parts of the TOT model (Chambers et al. 1989):

- rather than blame farmers' ignorance or farm level constraints for the non-adoption of IPM technology, a reversal of explanation points to deficiencies in the technology and the very processes that generated it;
- a reversal of learning has IPM researchers and extension workers learning with and from farmers;
- roles and locations are also reversed, with farmers and farms central instead of research stations, laboratories, scientists and abstract theories. Analysis, choice and

experimentation are conducted by and with farmers themselves, with IPM researchers and extensionists in a facilitating and support role.

To combine effectively the theoretical insights and technical power of western science with indigenous knowledge on pests and their control, both FF and TOT approaches are needed in IPM research seeking sustainable pest management (Table 1). This more inclusive research paradigm is still largely in its formative stages. It recognises that both scientists and farmers have limitations and strengths, and so the challenge is to forge active complementarities between these social actors and fully express their comparative advantages in generating sustainable IPM.

Increasingly, farmers are being encouraged to participate in the evaluation of pest resistant varieties and improved genetic material (Ashby et al., 1987; Maurya et al., 1988; Pimbert, 1991) as well as in pest surveys (Figure 3). These provide examples of IPM research in which scientists, extensionists and farmers are more equal partners in agricultural research and development. In these examples, scientists have clear advantages at two levels of organisation:

- micro level e.g. Accurate identification techniques for causal agents of diseases; taxonomic skills needed to identify pests and natural enemies (for biological control); instrumentation and expertise needed to understand cellular, physiological and behavioural processes;
- macro level e.g. Satellite remote sensing to spot biotic stresses and environmental factors that promote pest outbreaks; computer assisted geographic information systems (GIS) to integrate information on temporal and spatial variations in environment-pest-host interactions; worldwide electronic communication networks and data banks that make extensive searches for literature and pest resistant germplasm possible.

But the collective knowledge that farmers and rural people have of their watersheds and agroecosystems gives them distinctive advantages at the mesolevel - where the pest control interventions are ultimately aimed at. This is, after all, the social and ecological context in which farmers experiment, adapt and innovate.

The suite of Participatory Rural Appraisal (PRA) methods used to learn by and with farmers in the pest survey example (Figure 3) include transect and time line analysis, diagrams, mapping and analytical games. Semi-structured group interviews and several ranking techniques are used in farmer evaluations of improved pest resistant genotypes in the field trials needed to identify stable and acceptable sources of host plant resistance for heterogeneous and risk prone environments (e.g. pair-wise and direct matrix ranking; Pimbert, 1991). Thus PRA methods allowed farmers to compare pest-resistant pigeonpea varieties bred by ICRISAT with their own evaluation criteria. High quality information was generated during group interviews in which Indian farmers ranked various pigeonpea varieties using piles of tamarind seeds (1 seed for very good, 2 for good, and 3 for less good). The matrix indicating their preferences in reproduced in Figure 4.

Figure 3.

Survey to map the severity and extent of insect pest damage in pigeonpea/sorghum growing areas

Definition of agroecological zones and use of geographical grid to structure systematic sampling in core production areas

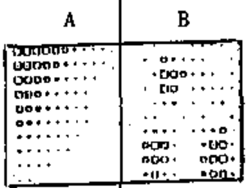
Formal Pest Survey

Agroecosystem analysis

Identification of insect pests and natural enemies, scoring for pest damage in farmer's fields.

Statistical analysis and generation of biotic stress maps.

Overlays showing intensity and distribution of pest damage fed into Geographic Information System (GIS).



Informal Survey, participatory rural appraisal (PRA)

Diagnosis of pest problems _via_ semi - structured interviews with farmers (women, men). PRA techniques used to elicit information on relative importance of pests (past and present), their importance in household economies and uses of crops in livelihood systems. (e.g. proportion of pigeonpea harvest used as green vegetable).

PRA results organised for GIS acquisition

Geographic Information System

GIS

Integration with agroclimatic, edaphic, socio - economic data that are regularly updated along with pest survey data.

Uses :

- Fine tuning sorghum, pigeonpea breeding programs to meet requirements of productivity, equity, stability and sustainability
- Insights into ecology of insect pests and rationalisation of IPM research.

Figure 4

Matrix ranking: farmers' pigeonpea preferences.
Medak District, Andhra Pradesh, India

	Local	Improved ICPL 84060	Improved ICPL 332
Leaf production	ooo	o	oo
Flower production	ooo	o	oo
Pod production	ooo	oo	o
Pod filling	ooo	o	oo
Pest resistance	ooo	oo	o
Seed yield	ooo	oo	o
Taste	oo	o	ooo
Wood production and quality	ooo	o	oo
Market price	o	oo	ooo
Storability	o	o	o
If only one variety available:	o	o	ooo[1]

1. Rejected because of poor taste.

ICPL 332, an officially released variety in Andhra Pradesh, was decisively rejected by women farmers because of its bitter taste. Based on their own criteria of evaluation, farmers selected three other improved pest resistant pigeonpeas, all non-released varieties (Pimbert, 1991). They also made helpful suggestions concerning new lines of pest management research which have since demonstrated the pest control value of mixing different pigeonpea varieties in the same field. This is an example of the more general risk minimising features of crop variety mixtures in marginal environments selected by farmers (Jiggins, 1990).

A rich repertoire of PRA methods (see McCracken et al, 1988; RRA Notes, 1988-1991) thus allows farmers' knowledge and values to become embodied in IPM research and its products.

In this approach the advantages of scientists (micro and macro levels) are effectively combined with the strengths of indigenous knowledge and experimentation when farmers are empowered by modifying conventional roles and activities as follows:

Farmer activities	New roles for IPM practitioners
1. Diagnosis and analysis	Catalysts and advisers
2. Choice	Searchers and suppliers
3. Experiment	Supporters and consultants
4. Evaluation, farmer to farmer extension of pest control technology	Facilitators and removers of legal and administrative obstacles

This decentralised approach makes it uniquely suited for generating diverse, knowledge rich IPM systems that echo the sustainability and balance of the surrounding natural world. Moreover, its high level of participation also satisfies the equity criterion: it allows farmers to make their own demands on their national research organisations and introduces some measure of accountability and democratic control over agricultural research and extension.

It has been argued elsewhere that this research mode is particularly appropriate for complex, diverse, risk-prone farming environments (Farrington and Martin, 1988; Chambers et al., 1989; Richards, 1989). However, creative interactions between FF/TOT and plural stocks of knowledge are equally relevant for the development of sustainable pest management in well endowed environments that have been standardised and simplified by capital intensive agriculture. After all, restructuring industrial and green revolution technologies for sustainability, productivity, stability and equity will call for research paradigms that emphasize and support:

- the maximum use of production inputs that are internal to the system e.g., incorporating indigenous knowledge on pest controls in IPM design, enhancing local natural control processes via vegetation management;
- the development (or redevelopment) of germplasm well adapted to local conditions and pest problems (as opposed to germplasm with "broad adaptability");
- the selective use of diversity in time and space, both at the genetic and agroecological levels;
- the wise and judicious use of insecticides and an economics which does not leave out social and environmental costs ("externalities") when defining threshold levels;
- site specificity and a process that enhances the adaptability of farmers by widening their choices;
- complex interactions and linkages between crops, weeds, livestock, grasses, trees, insects and fish (within and between cultivated and wild ecologies);
- indigenous experimentation and multi-simultaneous sequential innovations largely based on the use of renewable resources derived from farms and their surroundings;
- a frame of reference and set of concepts that allows us to visualize IPM programs centered more on pest management than pesticide management (or any other single "magic bullet" tactic). This calls for the integration of orically distinct fields of crop and pest management, the end of disciplinary myopia and a more holistic appreciation of the potential role of functional diversity, patterning, and complementarity in IPM;

- collective decision making and community participation in implementing area wide pest management schemes needed to complement pest controls used by individual farming families. Many cultural pest controls against some of the more intractable migratory insect pests that feed on many crops and wild plants require a high degree of inter-farm cooperation and group action, both within and across watersheds, to realize their full potential, e.g. soil and water conservation practices, synchronous sowing and harvesting at optimum time, wide-spread use of pest resistant varieties;
- a more open partnership with farmers that involves them in the conception, implementation and evaluation of IPM tools. This participatory process should help stimulate the acquisition and use of technological information by farmers. This is critical because IPM in the context of a more sustainable agriculture requires more management time, substituting thoughtful observation and information for capital and resource intensive external inputs;
- complementarities between food production and other development sectors (energy, housing, water...) organised to secure sustainable livelihoods.

An Agenda for Change

Appropriate incentives, infrastructure, institutions and attitudes are required to focus mainstream pest management on designs that suppress pests while achieving maximum yield and quality without jeopardising the environment and public health.

Changes Within IPM Science and Extension

1. Broadening the scientific method.

In a review of the existing scientific barriers to sustainable food production MacRae et al (1989) have shown how logical positivist and reductionist methods limit our understanding of complex biological systems.

The conventional process of scientific enquiry could be broadened by adopting the more inclusive IPM research paradigms described here. There is a need to lay more emphasis on synthesis and complementarities between plural stocks of knowledge and research modes (see above). Reductionist methods and quantification would have their place in holistic explorations of pest management. However, approaches that seek useful information without requiring exact precision in the description of events should be regarded as equally valid ways of knowing (e.g. experiential approaches like phenomenology).

2. A well rounded education for IPM practitioners.

Training people in sustainable pest management is a key strategy for its implementation. IPM practitioners need to be cognizant with the various crises that undermine the natural and social basis of agriculture and should understand how these crises compound each other. They must be able to describe the principles of ecology and their application to agriculture and pest management; researchers should be able to recognise and conceptually integrate the technical, psycho-social and moral aspects of a problem; they must understand the historical evolution of their science as well as the underlying philosophy and the operational principles of new paradigms that can be used (eg. FF modes and PRA methods). However, education and training programs should not only seek to expand the world view and scientific competence of IPM practitioners. They should also instil attitudes and values that psychologists associate with cooperative, life affirmative modes of existence: nurturing "being" life orientations rather than the more having, domineering, exploitative character structures that seek security in absolute control (Fromm, 1978). This is important because IPM science and technology are not value free. Like all other human constructs, they bear the imprint of scientists' life orientations as well as the dominant values, priorities and character structure of the societies in which they are developed and used.

Equipping IPM practitioners with appropriate conceptual tools, attitudes and techniques for the 21st century therefore imply changes in the content of curricula and the way students are taught. Some of the desirable features of the pedagogical philosophy and associated techniques needed to generate productive and sustainable agricultural technologies are highlighted in Table 3.

Institutional and Policy Reforms

Decision makers and donors can play a key role in neutralising the counterproductivity of chemical intensive pest control by effecting the following changes in international and national policies.

3. The withdrawal of international financial support and national subsidies for pesticides.

The International Monetary Fund, World Bank and other development banks should discuss with borrowers the removal of subsidies that undermine the objectives of safe, equitable and sustainable pest management (Repetto 1985).

4. Adoption and enforcement of legislation regulating international pesticide trade.

Pesticides that have been banned in one country for public health and environmental reasons should not be exported without the prior informed consent of the importing country. Penalties should be applied to those who act irresponsibly.

Table 3. An educational process that serves the needs of a sustainable agriculture (Ison, 1990; MacRae et al., 1989; Spring 1975).

Enhancing students' learning autonomy and possibilities for self-actualisation and empowerment

- Emphasis on process; on access to knowledge/information; on how to ask questions, on "learning how to learn"; on open exploration.
- Students as co-instructors in courses, as designers of flexible, learner-centred curricula.
- Emphasis on rewarding disagreement/dissent rather than conformity/agreement.
- Personal feeling explored.
- Emphasis on intuitive guess work, analytic thinking, "open" divergent thinking, alternative possibilities.
- Teachers are facilitators, catalysts, consultants who encourage students to define their personal goals and act as allies to help students meet these goals.
- Students design their own evaluation systems with the aid of teachers.

A people and earth-centred learning system that values participation

- Classroom/learning space reflects interaction and exchange rather than one-way transmission and "a teacher centred" world.
- Emphasis on relationships as aids to learning; on the dynamics and inter-dependence of biological and man-made systems. Themes that can be vertically integrated are used to develop ideas and a sense of empathy for the living world that sustains human life.
- Emphasis on student participation in the actual ecological design and running of the school's life-support systems (food, energy, shelter...) - the design process and its products (eg.multistorey food gardens) are integrated in a genuinely cross-curricular praxis rooted in everyday life (eg. the pest control methods used in producing food for the school also help develop and link ideas on food quality, public health, soil and plant science, economics and ecology).

A problem determined learning system that emphasises context and history

- Emphasis on applying concepts or knowledge to real life problem situations (a pest management crisis, environmental/public health issues….).
- Assignments designed to approximate real-world experiences eg. role playing, event organising, writing articles for the popular media, political action projects, action research.
- Students spend time working directly in the agricultural milieu (farms, agro-industrial sector, government services).
- Emphasis on ability to engage in constructive intellectual and interpersonal conflict resolution in real problem situations.
- Rather than just accepting precise definitions, students are encouraged to study a new concept from different angles and in different contexts. Facts are always provided in a broad historical context.
- The systemic, rather than linear or sequential, approach is used to return to the subject several times but at different levels.

5. Increased funding for IPM research that reflects and reinforces the goals of sustainable agriculture.

Budgetary allocations for IPM research based on holistic explorations of agroecosystem design and management are still pitifully small in comparison with funds for pesticide management research. Governments should no longer provide financial support for R and D that are only of immediate benefit to agroindustrial corporations. The use of public money to fund biotechnology research that leads to patentable products (e.g. herbicide resistant crop varieties) should be discontinued. Powerful transnational companies are the most likely immediate beneficiaries of the monopoly control conferred by patent rights on life. These large firms can pay for biotechnology derived pest control technologies that are protected by the intellectual property rights currently being extended to plants, animals and microorganisms by the General Agreements on Tariffs and Trade (GATT) (Chakravarthi, 1990).

6. Reward systems

As scientists and extension staff do respond to rewards, these can be used to redirect IPM research. IPM practitioners who pioneer successful blends of FF and TOT research modes in national and international agricultural research systems need to be encouraged, supported and rewarded. Scientists and national extension personnel must be given the incentive and freedom to behave and work in new ways.

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Sustainable Agriculture and Rural Livelihoods Programme

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.

The Programme emphasises close collaboration and consultation with a wide range of institutions in the South. Collaborative research projects are aimed at identifying the constraints and potentials of the livelihood strategies of the Third World poor who are affected by ecological, economic and social change. These initiatives focus on the development and application of participatory approaches to research and development; resource conserving technologies and practices; collective approaches to resource management; the value of wild foods and resources; rural-urban interactions; and policies and institutions that work for sustainable agriculture.

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.

International Institute for Environment and Development
3 Endsleigh Street
London
WC1H 0DD

www.iied.org