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Review Article

Challenges for farmer participation in integrated and organic production of agricultural tree crops

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Abstract

The effects of changes in cropping production technologies, systems and input and output markets on smallholders growing tree crops for export, and the consequences on pest management strategies, including augmentative and conservation biological control, are discussed in the context of pest and crop management research, technology development and farmer training. Evolving approaches in extension methodology are described, and the new knowledge and skills that changing markets require of farmers are identified. The limitations of conventional technology development and transfer methods, by both public and private sector commodity organizations and companies dealing with tree crop agroexports, are described. Case studies of some innovative experiences in farmer participatory training and research in different tree crops (cocoa, coffee, nuts and tea) and countries (Colombia, Costa Rica, Nicaragua, USA and Vietnam) are presented, and how far these are able to help farmers improve their pest and crop management practices and adapt to rapidly changing markets is discussed. Finally, suggestions are made for making tree cash cropping more beneficial in economic, social and environmental terms for smallholders and an outline of the training, institutional and policy needs for integrating tree crops into robust and flexible livelihood strategies.

Introduction

The last decade has witnessed a major rethinking in the principles and organization of agricultural policy and rural development in general. Accumulated evidence from the field has made donors and policy-makers question the value of conventional approaches to research, development and extension in improving the welfare of farming communities, especially those in marginal, resource-poor and diverse agroecosystems (e.g. SDC, 1999). In agricultural extension theory, the underlying concepts of the Technology of Transfer model are under increasing attack and the model's dominant application in practice via the Training & Visit system is widely discredited, even by its main funder, the World Bank (Röling & de Jong, 1998). The new focus lies in active participation (as opposed to summary consultation) of farmers in problem diagnosis in their specific arable, agroforestry or livestock systems, followed by planning, testing and evaluation of farming practice options and strategies in collaboration with research and extension agencies in both public and private sectors. The 'farmer first' ethos in rural development policy and practice called for in the 1980s (Chambers *et al.*, 1989) is now becoming incorporated within agricultural institutions in many developing countries.

At the same time, farmers growing cash crops, for export markets in particular, have been faced with rapid and profound changes in production technologies, processing and purchasing systems and market requirements as a result of agroindustrialization. As global agribusiness undergoes major restructuring, vertical integration and concentration, crop production systems are also changing with respect to the provision of farm inputs, the relationships between trading enterprises and individual farmers, and the type of produce demanded, as well as the technologies promoted and marketing mechanisms (Reardon & Barrett, 2000). All continents have witnessed an expansion in the practice of contract farming of high value horticulture (fresh fruit, vegetables and ornamentals) and of many perennial crops, including traditional agroexports produced by smallholders in developing countries such as oil palm, cocoa, coffee, tea and rubber. Contract farming can provide substantial income for smallholders but raises many concerns about its social and environmental impact, as well as its sustainability in economic terms (Baumann, 2000). Further challenges for farmers growing for export to Northern markets are the proliferation of environmental and ethical codes of practice among supermarket retailers and increasingly stringent requirements under international phytosanitary standards and the recent European Union (EU) legislation on Maximum Residue Levels (MRLs) for pesticides (Chan & King, 2000).

What do these changes in cropping production technologies, systems, and input and output markets mean for farmers trying to make a living from export agriculture and what might the consequences be for their pest management strategies, including the augmentative use of biological control agents and the conservation of natural enemies? This paper attempts to assess some of these issues for agricultural tree crops in the context of pest and crop management research, technology development and farmer training. It starts by looking in more detail at evolving approaches in extension methodology and the new knowledge and skills that changing markets require of farmers, followed by a description of some of the limitations of conventional technology development and transfer methods by both public and private sector commodity organizations and companies dealing with tree crop agroexports. It then reviews some innovative experiences in farmer participatory training and research in different tree crops and countries and assesses how far these are able to help farmers improve their pest and crop management practices and adapt to rapidly changing markets. Finally, there are some suggestions for making tree cash cropping more beneficial in economic, social and environmental terms for smallholders and an outline of the training, institutional and policy needs for integrating tree crops into robust and flexible livelihood strategies.

The farmer-first ethos and development of participatory approaches

Farmer participatory approaches to training and research are employed increasingly by a range of agricultural development institutions, in order to empower farmers as active subjects in the process of making crop production more sustainable, replacing their conventional role as passive recipients of information and inputs. Learning, as a process of knowledge construction and interpretation by individuals interacting with their ecological and cultural environment, is replacing the earlier extension theory of pouring doses of relevant facts and messages into the 'empty' vessels of 'ignorant/backward' farmers (Pretty & Chambers, 1994). Ter Weel & van der Wulp (1999) provide an excellent review of these research and training issues in relation to integrated pest management (IPM) and outline the benefits of participatory IPM for food security, farmer wellbeing and rural development.

Encouraging experiences in crop and livestock management are building up through farmer-first programmes in Asia, Latin America and Africa using innovative approaches including Local Agricultural Research Committees (CIALs), *Campesino a Campesino* (Farmer to Farmer), Farmer Field Schools (FFS) and others, based on common principles of discovery-learning, group experimentation, reflection and decision-making. For instance, CIAL farmer members in Latin America are conducting location-specific research on agronomic and natural resource management problems in key food security crops of maize, beans and potato, with an emphasis on appropriate varieties and management practices (Braun *et al.*, 2000). In the area of soil fertility and conservation, discovery-learning and group study tools are used in Zimbabwe and Australia to help farmers understand soil biophysics and the causes and effects of erosion (Pretty, 1995; Hagmann *et al*., 1997). Kenmore (1997) outlines the philosophy and potential of participatory IPM via FFS while a summary of FFS concepts and activities for improved decision-making by Asian vegetable farmers is given in Vos (1998), which emphasizes the need for integrated crop management (ICM).

Most farmer participatory approaches in training and, especially, research have focussed on food crops for household and/or local market consumption grown by resource-poor farmers in risky, diverse and marginalized agroecosystems. FFS have also been run, however, in export cash crops, notably cotton in Pakistan, India and Zimbabwe (CABI *Bioscience*, 2000) and in high value vegetable production for national markets throughout Asia and in Ghana, Kenya, Peru, Bolivia and Ecuador. Annual crops have tended to predominate in FFS programmes because rice, vegetables and cotton systems have been specific targets for farmer training in agroecological concepts since they are frequently plagued by pesticide misuse, pest resistance and elimination of natural enemies. Additionally, annual crops can produce good results from observation, experimentation and useful lessons via intensive training within one season. There are only a few examples of FFS development in perennial tree crops (coffee, tea, coconut and plantain) to date, of which tea is described later in this paper. Curricular content for tree crops often concentrates much more on soil health and crop husbandry than pest and disease management, for example the banana/plantain FFS in Zanzibar worked on selection of good planting material and varieties, spacing, sucker hygiene, soil fertilization, mulching, weeding and de-suckering, with pest management limited to physical control of black Sigatoka disease (*Mycosphaerella fijiensis* Morelet) and Panama disease (*Fusarium oxysporum* f. sp. *cubense* (E. F. Smith) Snyder & Hansen and banana weevil (*Cosmopolites sordidus* Germar; Col., Curculionidae) only in affected areas. Agroecosystem analysis exercises were therefore redirected from insect pests to disease observation, plant and soil health (Bruin & Meerman, 2001).

This is not to say that FFS and similar discovery-learning approaches are unsuitable methodologies for farmer training or technology development in perennials. Indeed, perennial agroecosystems lend themselves well to observation of natural enemy and pest dynamics and will often support a much more diverse and abundant insect fauna. There are, of course, logistical difficulties in running the same kind of intensive season-long training for perennials as is common in FFS programmes for short-cycle crops, especially the duration for which farmers' and facilitators' participation and commitment is required. Nevertheless, these problems can usually be overcome by adapting curricula, exercises and session timing to suit a particular cropping system and its demands on farmers' time. Visible learning points can be obtained within less than an annual cycle too: participants in a pilot coffee FFS in Kenya, for example, were able to observe differences in natural enemy levels, tree health and yield potential between IPM, 'no spray' and chemical application plots within a few weeks of setting up the treatments (Nyambo *et al*., 1997).

Far more serious obstacles to initiating farmer participatory training and/or research in tree crops, particularly for export, lie, however, in the attitudinal, operational and institutional characteristics of the commodity boards or individual companies through which farmers sell their produce. These obstacles are discussed in the next section, but first I shall draw attention to the new types of knowledge and skills tree crop farmers may need in order to grow and sell in rapidly changing global markets.

Change in market requirements

Many commentators have noted the importance for farmers, especially smallholders and family farmers, of developing new management skills and a more business-minded farming enterprise if they are to remain competitive under globalizing agroexport trade (e.g. Blowfield *et al*., 1999; Hellin & Higman, 2001). Urquhart (1999) provides an illuminating IPM example from the citrus sector in South Africa, where citrus growers are starting to adopt IPM, mainly for economic reasons, in order to keep in business as chemical control costs increase. The shift to IPM is also in response to the recently deregulated export market, which enables national exporters to differentiate between IPM and conventional produce. Fewer export markets now accept non-IPM fruit and there is a current competitive advantage with higher prices for IPM produce, which provides incentives for farmers to change practices. However, IPM production requires more intensive management, better management skills and much more time in administration, and many farmers are unwilling to take on these extra burdens. This market trend may lead to drastic changes in farm ownership: one estimate in part of the Western Cape is that 30% farms could change hands if their owners fail to adopt IPM. Urquhart suggests that these farms will be taken over by people who want to manage, monitor and make their own decisions.

Of particular relevance for farmers' capability to meet market requirements are quality issues surrounding pesticide use and especially the residues it may leave, as well as physico-chemical, microbiological and organoleptic properties of the harvested crop and any on-farm processing (e.g. preliminary fermentation of cocoa beans) and, of course, cosmetic appearance. These requirements are not necessarily new, but many are becoming much stricter and with the privatization of many former commodity boards under structural adjustment programmes, the onus of compliance and risk of loss has been pushed back to farmers in some cases. Thrupp *et al.* (1995) documented the problems faced by growers of sugarsnap peas and other export vegetables in Central America regarding pest management, the development of pesticide resistance and subsequent high levels of pesticide residues, leading to frequent shipment rejections at US customs for residue level infringement. For certain commodities, microbial contamination and the presence of specific fungal toxins that are highly toxic to humans may be a barrier to entry to Northern markets, for instance, ochratoxin A in coffee beans. Ochratoxin prevention is critical at the drying and secondary processing stages of coffee beans but preventative measures to avoid mould growth during picking and primary on-farm processing are also important and farmers may need to adapt their practices to incorporate these (Paterson *et al*., 2001).

The EU legislation on MRLs (Maximum Residue Levels) will effectively reduce to zero the permissible levels for hundreds of active ingredients over the next few years and MRLs have already been set at the Limit of Determination (i.e. analytical zero) for 102 of these for particular tropical, sub-tropical and off-season fruit and vegetables in 2000 (Chan & King, 2000). These restrictions will pose serious challenges for exporters of tropical fruit and vegetables and, in turn, for the farmers who supply them, unless they can switch quickly to less persistent products or non-chemical methods of pest and disease control. Residue compliance may affect not just fresh produce but also processed foods and beverage crops; for example, residues of the organochlorine pesticide lindane, widely used for mirid (*Distantiella theobroma* (Distant) and *Sahlbergella singularis* Haglund; Het., Miridae) control in West African cocoa, will have to be eliminated in 2002 from cocoa butter in chocolate sold in the EU (Buffin *et al*., 2002). What are the cocoa growers, most of whom are cash-strapped smallholders, going to substitute for cheap and persistent lindane and, more critically, how are they going to learn how to shift to new pest control methods for mirids?

The Good Agricultural Practice (GAP) production protocols of the European Retailers' Association, EUREP, which are currently being introduced for fresh fruit and vegetables among their suppliers, have enormous implications for current crop and pest management practice and advice and EUREP acknowledges that growers in developing countries will need special assistance to achieve the desired levels in food safety and sustainable production. Under its section on Crop Protection, for example, the protocol requires growers to protect crops with the appropriate minimum pesticide input and to apply recognized IPM techniques on a preventative basis, wherever possible (EUREPGAP, 2001). Another important compliance criterion is that any pesticides which are banned in the EU must not be used on crops destined for export to the EU, a major challenge for tree crop growers in the tropics, where organophosphate and carbamate insecticides, many of which are no longer approved for EU use, are the cheapest and most readily available products.

From these examples, it is clear that the business of producing tree crops, particularly for export markets, has become much more complicated than in the past, requiring farmers to have a better understanding of not only agronomic factors and up-to-date price information but, increasingly, of processing, marketing, importer and consumer requirements and changing international trading systems. This observation is equally relevant for smallholder farmers in developing countries as for farmers in the North attempting to survive impending reductions in price support and other forms of protectionism. In the UK, a recent policy review of farming and food in England highlights the urgent need for farmers to become more business-oriented, planning well and understanding market needs, in order to add value to their produce in the face of fierce international competition (Policy Commission on the Future of Farming and Food, 2002). The authors concluded that supply chain analyses are essential for salvaging farmers' profitability because market messages are getting lost before they reach producers, and recommend the establishment of a permanent Food Chain Centre to bring all the relevant stakeholders together. Similarly, an analysis of the structure, linkages and coordination of evolving global commodity chains has been recommended for developing countries to upgrade the production and processing of commodities, including tree crops (Gibbon, 2000). At field level, this implies a much more detailed appreciation of commodity chain function and power structures by farmers, extensionists, the private sector, donors and policymakers.

Technology Development and Transfer in Tree Crop Commodity Organizations

The achievements of many commodity organizations in delivering substantial benefits for their farmer members should be acknowledged, for example the notable success of Colombia's Coffee Growers' Federation, FEDERCAFE, in raising farmer and village living standards in the coffee zones, compared to other coffee-producing countries (Bentley & Baker, 2000). Nevertheless, there have also been major shortcomings in production and marketing activities, organizational structure and ethos and operational relations with individual farmers. This section discusses some of the organizational and methodological issues prevalent in agricultural tree crop production, whether via commodity organizations or contracting companies, and how these relate to effective technology development and transfer. Table 1 lists some of the constraints on effective implementation of IPM, compiled mainly from the author's experience with coffee and cocoa research and extension systems in Latin America, Africa, and Asia working on control of key pests and diseases. However, many of the constraints are common to other tree cropping systems and organizations and may lead to similar negative effects on other aspects of crop management and productivity. Examples of certain constraints are discussed further below.

Organizational aspects

Agricultural tree crops differ quite widely with respect to the kind of organizational structure available for their development, production and marketing. Traditional tropical agroexport crops such as tea, coffee, cocoa, rubber and oil palm usually enjoyed substantial government and donor support in developing countries, often via state-monopolized specific commodity boards which covered research, extension, purchasing, primary processing, quality control and export. Under structural adjustment and trade liberalization measures, most of these commodity boards have been, or are in the process of being, privatized or dismantled. Ghana's Cocoa Board, for

Table 1 Constraints to effective IPM implementation in coffee and cocoa production.

Constraint	Effect on farmers, extension or research
Organizational	
Dismantling/deregulation of state-run commodity boards	Close relationship and mutual interlocking between farmers and boards disrupted
Bureaucracy and slowness to adapt to changing markets and policies	Lack of farmer confidence in extension and/or marketing
Concentration on monocropping of tree crop	Lack of holistic agroecological and livelihoods perspective among researchers, decision-makers
Research & Development	
'Orphan crop' syndrome	Inadequate information sharing, duplication of research effort
Research agenda doesn't address smallholder needs	Disengagement of smallholders, poor adoption of research results
Focus on optimal zones and resources	Disengagement of smallholders or disadvantaged groups (women), poor adoption of research results
'Lab-to-field' ethos and unidirectional flow of information	Valuable insights, experience and judgements of farmers ignored or lost
Poor linkages with extension and other IPM stakeholders	Poor adoption of research results, ignorance of innovative methods from other cropping systems, lack of synergy
Overemphasis on technical *c.f.* socioeconomic aspects of crop and pest management	Key adoption constraints missed, farmers' production needs and concerns ignored
No active experimentation with farmers	Slow or ineffective diffusion and adoption, technology improvement process weakened
Extension and advice	
Outdated, top-down extension methods	Ineffective communication of useful information, poor attendance/participation by farmers
Extensionists under-resourced and undervalued	Weak extension impact, low morale, failure to deal with critical pest management issues
Blanket recommendations for all farm types and sizes	Poor adoption by smallholders, farmer disengagement, poor returns on research investment
Technical detail at expense of agroecological understanding	Farmers cannot adapt important principles to changing circumstances
Negligible use of group discussion and farmer-farmer training	Farmers' experience under-utilized, little multiplication effect by farmers
Lack of systems approach to IPM	Key socioeconomic issues ignored, lack of basic cost:benefit and feasibility analyses of IPM options

example, is slowly being part-privatized and its 1315 cocoa extension staff will be reduced in number or transferred to work as general extension staff to advise on all crops in the Ministry of Food & Agriculture (Gerken *et al*., 2000).

Whilst there were numerous, serious shortcomings of state commodity boards (inefficiency, mismanagement, unfair practices and pricing policy towards farmers, etc.), most did provide crucial support to individual farmers and farmer groups, particularly in agrochemical input supply, planting material, agronomic advice and quality control of harvested produce. Since liberalization, commentators have observed a noticeable decline in the yield and/or quality of several tree crop products in specific countries as the private sector took over these services or left farmers to fend for themselves. Coffee yields in Tanzania dropped from averages of 250 kg/ha to 200 kg/ha, for example, following liberalization in 1994/5, attributed to the reduced use of fertilizers and pesticides, while cashew export production has been affected by increased powdery mildew problems as farmers are no longer supplied with sulphur-based fungicides (Shepherd & Farolfi, 1999). Deregulation of commodity purchasing has disrupted the close relationship between farmers and commodity boards, which may have important knock-on effects on IPM attempts. In India, extension staff from the Coffee Board in 1998 complained bitterly about the deregulated market which they saw as contributing to the spread of pests and diseases, especially coffee berry borer (*Hypothenemus hampei* Ferrari; Col., Scolytidae) (CBB) as coffee quality and interzonal transport was no longer strictly monitored and controlled. Farmers selling CBB-damaged beans were not penalized by lower prices, thus reducing motivation for community-wide action to control the pest (L. V. Ananda Rao & B. V. Mohan Das, pers. comm.).

In other tree crops, including those grown more for local or regional markets, such as citrus, stone and other fruits, nuts, spices, etc., farmers have rarely benefited from exclusive government support via commodity boards, although crop-specific growers' associations may have been established to promote marketing and improve production methods and access to useful germplasm. Certain countries, however, (e.g. South Africa, Israel, Chile) have invested substantially in tree crops where these constitute an important export for the national economy and employment and some governments may actively help the grower sector to access new markets. Chile, the largest fruit exporter among developing countries, has begun to respond to domestic and international concerns about the high levels of pesticide use on its orchards with some support from its state export agency. Chilean organic exports rose from 25 t in 1992 to over 1000 t in 1995, including dried organic apple, and public and private sector organizations are now working on pest management and quality control constraints for organic fresh apples and cherries (Robins & Roberts, 1997).

With the decline in state-run commodity boards, trends in tree crop production and marketing have tended to shift towards contract farming (by the private or public sector) and smaller, site-specific projects managed by NGOs with farmer groups. Donor funding from international lending banks and bilateral development assistance has been important for both types of support. Contract farming refers to a system where a central processing or exporting unit purchases the harvests of independent farmers, with the terms of purchase arranged in advance by contract. The contracting company may also provide credit, agricultural inputs and agronomic and pest management advice. Baumann (2000) gives a good overview of different types of contract farming in agricultural tree crops, with case studies in five traditional tropical agroexports. Both Ghana and Côte d'Ivoire, for example, have substantial contract farming of oil palm by smallholders, as does Malaysia, whose smallholders produce 30-300% higher yields on their small plots compared with large-scale plantation productivity. NGO-driven projects usually aim to improve smallholder productivity and profitability by strengthening the management and marketing skills of growers and their associations or co-operatives, but may involve farmer training and agronomic support too, as in the case of Bolivia's successful cocoa growers co-operative El Ceibo (Bebbington, 1996).

A further trend is related to the increasing vertical integration of production, processing and retailing operations in global agri-business and, especially, the supply sourcing arrangements of the large supermarkets. In African export horticulture, as supermarkets have come to dominate retailing of fresh fruit and vegetables, smallholder production is now on the decline in some commodities as buyers look to improve product quality, reliability and traceability, in response to retail demand and residues and hygiene legislation, which they believe can best be met by concentrating on a few, large-scale suppliers and growers (Dolan *et al*., 1999). A new phenomenon arising from the quality and productivity concerns of the food and retail industry is the emergence of partnerships between the public sector and particular private sector companies in crop production projects, such as the Sustainable Cocoa Programme of chocolate manufacturers Mars plc with Germany's overseas development agency, GTZ (Gesellschaft für Technische Zusammenarbeit), in Côte d'Ivoire (Koehler, 2000).

Extension and research methodologies

All agricultural tree crops suffer from the 'orphan crop' syndrome – there is no international research centre dedicated to them (unlike the major food staple crops of rice, potato, wheat, legumes, etc.) or significant and well-coordinated donor research support and investment, despite their importance in providing livelihoods for millions of poor smallholders and agricultural workers in developing countries. Research and development in a particular crop is often competitive and secretive between key producer countries and between agribusiness players, with insufficient sharing of information, lessons and much duplication of research effort.

Research and technology usually takes place without any meaningful participation of farmers, particularly smallholders, in any stage of the R&D cycle apart from some field evaluation of research-derived technologies. There are, of course, difficulties with the timescale of research in perennials, particularly on germplasm improvement for pest and disease resistance, while some aspects of pest dynamics and control options may be hard to grasp even via intensive participatory training. For example, researchers working on cocoa pod borer (*Conopomorpha cramerella* Snellen; Lep., Gracillariidae) (CPB) problems in Indonesia faced the challenge of analysing the complexity of biophysical and socioeconomic factors which influence CPB control and of developing and demonstrating sustainable production strategies. A critical issue was that the interactions of certain factors in CPB management were too complex for farmers to understand or assess themselves within a short time span; for instance, measuring weekly or average percentage of pods infested by CPB gave unreliable or misleading information (Mumford *et al*., 2001).

In terms of R&D (research and development) and extension approaches, tree crop production organizations have been characterized as favouring a rigid and hierarchical structure and strict division of labour (Goldthorpe, 1995, quoted in Baumann, 2000), certainly true of most commodity boards. Contract farming also leans towards prescriptive approaches and top-down communication flows, with crops grown to strict specifications linked to grade and quality standards. Indeed, the popularity of contract farming among policymakers and lenders is partly due to its potential for transfer technology to smallholders. One problem is that R&D and advisory systems based on formal, conventional approaches to technology development and transfer can lead to the neglect of valuable farmers' experience, traditional practice and insights. Baumann points out that the effectiveness of technology transfer in contract farming projects has been mixed, however, and it may fail to transfer knowledge on how to manage the crop as part of an integrated farming system.

Another issue is the generation of unrealistic or uneconomic extension messages, which fail to take a holistic, farmer-centred perspective on tree cropping within their farming enterprises and livelihoods. A particular difficulty has been over the inclusion of food intercrops. Oil palm contract farmers in West Africa were forbidden to grow food crops for household consumption, causing predictable frustration among smallholders, especially when commodity prices fell (Baumann, 2000), while for many years the Kenya Coffee Board prohibited farmers from uprooting coffee bushes or intercropping between the rows. The Coffee Research Foundation is slowly addressing the issue of intercropping (Njoroge & Kememia, 1995), which is widely practised by farmers anxious to improve their income and food security, but there is little information on which short-term crops can be grown successfully with coffee, and when, where and how. Furthermore, the rigid research-extension hierarchy and bureaucratic procedures are unable to translate useful preliminary research results quickly into practical information for farmers (J. Kememia, pers. comm.). In the case of FEDERCAFE research and extension in Colombia, the scale of the 'recommendation domain' has been a contentious issue in relation to the applicability of centrally-generated messages for smallholders. In 1997, coffee extensionists were recommending that all growers renew 20% of their coffee trees each year, to maximize productivity, often by establishing new varieties. For smallholders, this would mean sacrificing 20% of their cash income each year and not surprisingly, few smallholders were able or prepared to do so (Williamson, 1997).

The 'lab-to-field' ethos found in some organizations militates against making use of farmers' experience and implies that solutions to problems will only be generated by formal research, irrespective of whether the problems are largely technical or socioeconomic. Development of transgenic *Bt* (*Bacillus thuringiensis* Berliner) coffee against CBB, for instance, is more attractive as a research option for many scientists and policymakers than is the investment in extension required to get farmers to understand the need for regular removal of berries from infested fields. In theory, research linkages with extension should be very close in specific commodity organizations, compared to the situation in general agricultural extension services, but in practice this is rarely so. Only an estimated 2% of FEDERCAFE extension staff had met coffee researchers in the field, for example, and of the 20% who had been involved in field trials, their role was limited to farmer selection and follow-up tasks (Uribe, 1996).

Ingrained institutional attitudes, procedures and behaviour can make commodity organizations slow and unwilling to address farmers' concerns and realities. A few years ago Ghana's Cocobod acted swiftly to prevent a group of cocoa farmers from trying to sell organic cocoa, arguing that by stopping pesticide use the farmers could aggravate mirid bug and black pod disease (caused by *Phytophthora* spp.) incidence in affected zones. However, there has been a recent softening in attitudes and the Cocoa Research Institute of Ghana, CRIG, is now field trialling organic methods, with the use of neem (*Azadirachta indica* Juss; Meliaceae) seed extract for mirids (Buffin *et al*., 2002). Under falling coffee prices and rising input costs, Kenyan smallholders can no longer afford the complete fungicide application regime for controlling coffee leaf rust *Hemeleia vastatrix* Berk. & Br. They end up applying only half the recommended dosage and frequency and there is some evidence that this kills off microbial antagonists but fails to kill the disease pathogen (J. Kememia, pers. comm.). A change in recommended advice might be to explain that if a farmer cannot afford the full protection, the next best option is not to spray at all but make maximum use of existing natural control.

While most other cropping systems now acknowledge the need for farmer participatory research and training based on closer and more equitable dialogue between farmers, extensionists and researchers, agricultural tree crop organizations have lagged woefully behind, as opposed to those working in forestry and agroforestry, some of which have been pioneering innovative methods since the 1980s. A 10-year programme of participatory agroforestry action research with Bangladeshi rice farmers placed variants of 'best available technology' into the hands of interested men and women farmers, who contributed their understanding of the details of land use, essential to the successful development of technological improvement. By 1997, 300,000 participating households had planted over eight million trees with 80% survival and fruit, timber and fuelwood seedlings were being produced commercially by 2000 village-based nurseries, along with rigorous research results replicated over 25,000 ha ((Hocking *et al*., 1998). Examples of numerous action research and community participation initiatives in forest farming are given in a special issue of the LEISA Newsletter, (Reijntjes *et al*., 2000).

The use of farmer participatory methods is just beginning in some agricultural tree crops by some commodity organizations. Research on the role of shade (neighbour) trees in cocoa production systems in Ecuador (Boa *et al*., 2000; Bentley *et al*., in press) stressed the direct economic value of such trees to farmers ahead of their ecological role. Dialogue and joint research with extension and local technical officers show considerable promise for providing new insights into tree health, as outlined in the approach used in Bolivia (Boa *et al*., 2001). Van Mele & Cuc (2000) discuss the importance of drawing on the experiences of those Vietnamese fruit growers who use little or no pesticide in their citrus orchards and rely instead on natural control, especially active conservation and husbandry of weaver ants *Oecophylla smaragdina* F. (Hym., Formicidae) for insect pest control. They suggest that these farmers' experiences be shared via farmer-to-farmer training and in mass media tools.

The next section describes some innovative methods in farmer participation, which attempt to tackle some of the constraints on effective pest and crop management implementation discussed above.

Innovative Methods of Farmer Training and Research in Tree Crops

Organic coffee production, Colombia

The Colombian Organic Coffeegrowers Association (ACOC) was set up in 1990 to meet the needs of smallholders in marginal coffee zones who were in serious credit difficulties and suffered food insecurity. An organic focus was provided by agronomists from a local NGO and farmer-to-farmer training encouraged with support from them and local municipal extension staff. As of 1997, ACOC had 19 member families and milled, packed and sold its own brand of organic coffee for the local market. ACOC provided training and individual advice to families wishing to become members and certified members' organic coffee. The training was based around on-farm workshops and demonstrations and each new family was assigned an experienced ACOC farmer as mentor during their first few years. Organic production practices were tested and adapted from various sources, including formal research, CBB (coffee berry borer) IPM advice and farmers' knowledge, and also from biodynamic and other schools of thought. ACOC's principle was, however, in line with discovery-learning in that they stressed that "each farm is a world of its own" and each farmer has to find out what works best for her/his situation.

Despite growing coffee at low altitude, ACOC farmers managed to reduce CBB incidence significantly by cultural and biological methods. One farmer adapted a production strategy based on the logic of FEDERCAFE recommendations to renew 20% of coffee bushes annually but, recognizing that this was economically impossible for smallholders, he maintained his bushes for 10 years with good organic fertilization but using a wider spacing to facilitate berry removal on the older trees. His coffee was shaded and mulched and *Beauveria bassiana* (Bals.) Vuill. incidence on CBB was high under these conditions. He succeeded in reducing CBB levels from 5% to 0.8 % in 4 years by these methods, combined with fortnightly berry removal and destruction of bored berries (Williamson, 1997).

Through their family and food security emphasis, ACOC succeeded also in motivating young people in coffee production, a major achievement in a country where many children of farmers leave for the city and where coffee is increasingly grown by an aged population.

Biologically Integrated Orchard Systems, USA

The Biologically Integrated Orchard Systems (BIOS) programme began in 1993 when almond and walnut growers in California approached IPM researchers via a local NGO, the Community Alliance with Family Farmers, for help in reducing agrochemical inputs on their farms (Schafer, 1998). By 1998 there were over 100 growers enrolled in projects and the programme brought together university researchers, pest control advisors, independent crop consultants, agricultural suppliers and governmental staff from agriculture and natural resource management agencies. Local management teams of these stakeholders met monthly to plan and review on-farm research projects in conjunction with local farmers who signed up to take part in the scheme. To enrol, farmers agreed to: reduce pesticide use, especially of most toxic classes; dedicate 6-12 ha of their land to implement or study BIOS practices; collect and share information and data from the orchards; meet with the management team and attend field days and group meetings.

Research and development of biologically-based systems included the use of biological pest management, pheromones and trapping, cultural practices, cover crops and soil and water management. By 1996, impact assessment of 53 BIOS growers showed that the percentage using organophosphate compounds had dropped from around 32% to under 10% whilst biological control users increased from 4% to 40%. Average synthetic nitrogen inputs had decreased by 42%. BIOS stakeholders attributed the field impact and growth of the programme to the following factors: building on farmers' experience; integrating scientific and practical knowledge; teamwork and effective coordination which encourage participation; and flexibility in programme management, both at project and farm level. Whilst action research was carried out on individual farms, farmers evaluated results together with other stakeholders and implementation was promoted via specific training and demonstration days, educational material, and advice 'hotlines' and 'buddy systems' for supporting BIOS members. Equally important was the institutional and policy support gained from agricultural development agencies and state organizations and the innovative multi-institutional partnerships developed (Thrupp, 1996).

Action research in tea IPM, Vietnam

The Vietnamese National IPM Programme began IPM training and development activities with the Bac Thai provincial Plant Protection Sub-Department in 1993, principally through the setting up of FFS. The NGO CIDSE (Coopération Internationale pour le Développement et la Solidarité) had been active in farmer support in the province for over a decade and became involved first in rice FFS training. CIDSE trainers and farmers then requested that the FFS approach be developed for tea IPM since many smallholders relied on tea as a valuable cash crop and pesticide use was high, with an average of 17 applications per yearly cycle. Methamidophos made up 82% of pesticide applications in a 1994 survey, mainly because farmers believed it acted as growth promoter and stimulated new tea shoots after plucking. CIDSE started the tea IPM programme with a multi-stakeholder workshop to discuss tea production problems, including high external inputs, and to develop a plan for training and action research (FAO, 1997).

IPM strategies for smallholder tea in Vietnam were poorly developed so the project began with field studies by farmers on the economic and ecological aspects, as identified and discussed in five farming communes. Stakeholders included the extension and plant protection staff, CIDSE and the national tea research institute. Study groups of 3-10 farmers were facilitated by extension staff, with technical support from the research agencies, and they chose to investigate green manures, irrigation methods, fertilization and plucking regimes and shade trees, as well as the usual FFS comparison plots. A key feature for research was also to compare the effects of commercial plant growth stimulants with methamidophos. The groups met weekly to carry out tea agroecosystem analyses, collect data and decide on management practices under the different comparisons.

Based on the results from 2 years' of farmer participatory field studies, tea FFS groups for training and further research were set up in 1996, using extension staff and farmers from the field study groups as facilitators. The tea IPM programme was very useful for providing researchers with a strong farmer view of technologies currently recommended and for helping farmers to make decisions regarding pesticide reduction and alternatives. The studies and FFS training helped farmers understand that pesticides themselves are not plant stimulants and the fertilization research led to farmers halving synthetic fertilizer foliar application and switching to manuring where feasible. The programme also showed that farmers can become trainers too: as one farmer commented, "two years of doing action research is the same as graduating from a technical college".

Experimenting with cocoa and banana crop and disease management, Costa Rica

The Talamanca Small Farmers' Association (APPTA) organizes over 1500 members producing cocoa and bananas, of which around two-thirds are certified for organic cocoa. APPTA started specific training activities in sustainable cocoa production in 1998 in ten indigenous BriBri communities, working with groups of 6-12 farmers and employing the farmer exchange and training methodology known in Latin America as *Campesino a Campesino*. The emphasis was on farmer experimentation, experience sharing and integration of practices such as green manuring, terraces for soil conservation and botanical and mineral-based methods of pest control and fertilization. A critical issue for APPTA was that many of their members and other farmers in the communities work part or full-time off farm for much of the year to make ends meet, as their income from cocoa has plummeted in recent years. This loss in revenue was partly due to chronically low global prices but also to serious yield loss from frosty pod disease (*Moniliophthora roreri* (Cif.) H. C. Evans *et al.*) which can cut yields by 90% in severe cases. To aggravate the situation, many cocoa groves were poorly maintained and farmers did not have the time or motivation to invest in replacing unproductive trees as they had to find paid jobs in town. Lengthy time out for training and crop renovation was, therefore, a direct cost which many cocoa farmers could not afford.

APPTA decided to utilize the strong tradition amongst BriBri people of communal workdays, whereby a group will work together on one member's land, in rotation, in return for some alcoholic drink. APPTA instead provided a good lunch to compensate farmers for losing a day's wage. The cocoa renovation programme emphasized good shade management and sanitary pruning, both labour-intensive tasks, on 200 ha of members' land. The benefits were provided to both APPTA members and non-members who took part, and APPTA observed some spontaneous diffusion of renovation practices among farmers outside the programme. Removal of diseased pods is also time-consuming, especially the first round, and farmers tended to leave infected pods on the ground rather than burying or burning them. APPTA staff and some farmers were able to confirm improvements in harvestable pods when sanitary removal was done regularly to destroy the fungal inoculum (Luis Rodriguez, pers. comm.).

APPTA staff were keen to experiment with effective microorganisms (EM) for fertilizing seedlings and mature banana and cocoa trees, as an alternative to labour-intensive production of organic fertilizer and for a certain level of antagonistic action against plant pathogens. While traditional composting and other bulk organic fertilization was technically feasible, transport was problematic and there were time constraints with farmers' paid employment, hence the interest in augmentative microbiological techniques. Some staff experimented quite successfully with 'home-grown' EM mixtures collected via baiting of useful bacterial isolates from the forest and found these more effective than imported commercial EM formulations. APPTA members tried these out for themselves on 100 ha and noticed increased vigour in the bananas, no increase in black Sigatoka disease and suspected a reduced incidence of frosty pod in cocoa. However, no quantitative data were taken and no controls were included in their experimentation.

In order to test APPTA's hypotheses, participatory trials, jointly managed by collaborating farmers, APPTA technical staff and scientists of the CABI – CATIE (Centro Agronómico Tropical de Investigación y Enseñanza) – USDA (US Department of Agriculture) cocoa pathology project, were initiated in 1999. Preliminary results showed that, in fact, diseases were unaffected by EM application but a fertilizer effect might be confirmed by observations over longer periods of time, which APPTA could research independently. Additionally, antagonistic fungi are being tested in participatory trials against cocoa diseases (Ulrike Krauss, pers. comm.). This example shows the value of close collaboration between farmers' associations and researchers, along with commercial buyers (in this case the US-based Organic Commodities Project) in technology development and evaluation on-farm and under realistic production scenarios. Useful technologies can be more quickly screened and improved and less promising ones eliminated by combining resources and expertise from formal science and farmers' experience.

Promoting mycoinsecticides with coffee farmers, Nicaragua

The long-standing IPM and Agroforestry Program managed by CATIE with Nicaraguan farmers, extensionists, researchers and NGOs since the late 1980s has energetically promoted the use of biocontrol, including microbial control for several pests. The Program developed a participatory training methodology similar to the FFS approach, based around crop and pest phenology, and also initiated technology development with smallholders in vegetables, grains and legumes, coffee and plantain. In coffee, some of their work on integrated weed management is summarized in Staver *et al*. (1995), while they have also looked at gender issues in coffee management, such as women's reluctance to use manual control and preference for herbicides where they can afford this.

Under its promotion of microbial control, the Program supported researchers at local universities to develop mycoinsecticides based on indigenous isolates of *Beauveria bassiana* and *Metarhizium anisopliae* (Metsch.) Sorok. and helped evaluate their effectiveness with farmers' associations and several NGOs working in sustainable agriculture. The Union of Agricultural Cooperatives (UCA) Miraflor was one of the first farmer groups to collaborate with CATIE staff on testing preliminary *Beauveria* formulations and application methods, first on cabbage for diamondback moth (*Plutella xylostella* (L.); Lep., Plutellidae) control and then on coffee. An assessment of the Program's work in mycoinsecticides in 1999 revealed that its strategy of training farmers on the effective use of microbial control, in conjunction with its distribution via NGOs and farmers' organizations, had been instrumental in generating farmer demand for mycoinsecticides (Williamson & Ali, 2000). Conventional farmers did not use biocontrol agents mainly because they did not understand the concept and there was little simple information on biocontrol compared to the intensive propaganda by agrochemical distributors and many government extension agents. In contrast, the Program's training of farmers and extension staff in mycoinsecticide use revolved around the principles of: understanding basic biology and behaviour of insect pests and beneficial microorganisms; on-farm testing of mycoinsecticides and joint evaluation of impact and costs; and integration of mycoinsecticides into an IPM or organic cropping system.

Trained farmers were well aware of the differences in mode of action between chemical and biological products and how to get the best results with mycoinsecticides, by not spraying under high temperature and UV light conditions, for example, and not applying in knapsacks used for fungicides. Research and extension stakeholders agreed that it was essential to build direct links to biopesticide sales through training and important to support inter-institutional collaboration with universities and farmers' organizations. Demand for *B. bassiana* has now outstripped the limited supply capacity, particularly for CBB control from the growing number of organic coffee farmers. The UCA Miraflor has been producing small quantities of *B. bassiana* on a simple rice substrate system, for its own members, and aims to scale up to commercial sales. The two agricultural universities produce larger volumes under semi-industrial methods but are constrained from expanding further by lack of facilities and start-up capital, indicating that the bottlenecks in achieving wider usage of mycoinsecticides are not related so much to technical aspects or farmer demand, but to policy conviction and financial support (Williamson & Ali, 2000).

Suggestions for Improving Farmer Participation for Sustainable Tree Crop R&D

The examples given in the last section sketch out some encouraging learning tools, methods and novel partnerships for farmer participatory training and research in a variety of tree crops. Many are very small-scale or at the early stages of development or evaluation. It will be important to assess the impact of such experiences in terms of not only outputs (knowledge acquired, changes in farming practice and farm income) but also process (learning and decision making processes, training and action research methodologies, institutional and policy changes). There are three key elements in empowering farmer decision-making and participatory technology development, based on the FFS experiences:

- agroecological literacy (the principles of integrated pest and crop management)
- appropriate learning methodologies (the tools and group dynamics of discovery-learning activities)
- ensuring a supportive environment (inter-institutional collaboration and pressure for policy and process change)

These elements are applicable to other farmer participatory approaches. In the case of agricultural tree crops, agroecology needs to be studied in close relation to crop phenology and within a farming systems context, with emphasis on soil and water management, shade trees and other crops, nutrient cycling and improved biodiversity. Other commentators have stressed the relevance of participatory IPM training and research methods to extension challenges for any complex issue, highlighting the success factors of: active farmer participation as clients, rather than beneficiaries; confident and skilful extension staff; specific inclusion of disadvantaged farmer groups, such as women; and a more equitable balance and closer dialogue between farmers, extensionists and research (Schmidt *et al*., 1997). The use of participatory methods has been cited as one of the success factors in the Ophir contract farming project in West Sumatra, a joint collaboration between the Indonesian and German governments, which has helped smallholders produce much higher yields of oil palm and rubber than on professionally managed large-estates, as well as improving farm family welfare (Peters, 1999).

Appropriate learning methodologies are equally applicable to researchers and decision-makers (and not just farmers and extensionists), in order to redirect research agendas to better meet farmers' needs and key constraints. A recent study of factors affecting uptake and adoption of crop protection research in banana-based cropping systems in Uganda describes methods used to help researchers gain a better understanding of the reasons behind farmers' practice, their sources of information and their responses to research-derived recommendations. Banana farmers reported 46 different reasons for what they did in their fields, of which a mere eight were intended to control diseases, pests or weeds, the others relating to food security, soil fertility, fuelwood and livestock production goals (Lamboll *et al*., 2000).

It is also essential to look at socioeconomic factors, at local and macro level, particularly in the context of the globalization of commodity trading. Smallholders need to be able to access up-to-date information on prices so as to make appropriate management decisions, whether they are producing for niche markets in organic, fair trade or environment-friendly produce or selling to conventional export or national markets. Farmer-centred, socioeconomic methodologies such as participatory budgeting (Dorward *et al.*, 1998) would be valuable in helping farmers and facilitators visualize and assess existing and potential scenarios at the farm level with changing farming practices or market factors. With the exception of the BIOS Program, the examples above focus on smallholder production but participatory training and research principles may also be adapted and used with larger farms and with farm managers. Australia has been leading much of this work, for example with soil nitrogen workshops for action research with wheat farmers in Queensland (Visser *et al.*, 1998) and multi-stakeholder Problem Specification and Planning Workshops for IPM in tomato and weed management (Norton *et al.*, 1999). CATIE's IPM Program in Nicaragua has also worked with large-scale coffee plantations, via discovery-learning training of pest observers, foremen and production managers, and achieved significant reductions in CBB infestation from 6-10% to less than 1%, via biological and cultural controls methods, with improved yield and parchment quality (Morales & Guharay, 1998).

Whilst researchers have concentrated on solving specific technical production constraints, methods for combining technical options into cost-effective and flexible production strategies appropriate for individual farm contexts are poorly understood and rarely studied. Modelling is a useful tool for exploring strategies and scenarios 'on paper' but action research with farmers and other stakeholders provides the best means of testing and refining production strategies in the real world and of motivating farmers to try out new farming practices. Frameworks for sustainable rural livelihoods offer a new opportunity to analyse the complexity of farmer options, with a focus on poverty alleviation, improved food security, reduced vulnerability of farm systems and sustainable use of natural resources (DFID, 1998). They recognize that rural households develop coping strategies based on multiple sources of income and inputs and that sustainable livelihoods must be able to withstand external shocks and adapt to trends in biophysical and socioeconomic factors. By studying the different capital assets (natural, physical, social, human and financial) which growers of tree crops have access to, practitioners of sustainable crop production can work with farmers and other stakeholders to strengthen these assets and to work out flexible farm production strategies.

These holistic frameworks specifically include institutional structures, processes and the broader cultural context and how these influence farmers' use of and access to resources and capital assets. Rather than technical aspects, it is this wider set of influences which currently constrains sustainable production of tree crops and which needs to be considered in any programme aiming to achieve field impact. A good example of the crucial importance of institutional

Box 1. Suggestions for improving training and farmer participation in tree crop R&D.

Training methods and materials

- ✔ Actively involve those farmers who already use integrated management techniques, or who are experimenting with control options, in training and on-farm research activities.
- ✔ Coordinate the design and production of training and educational materials with inputs from researchers, extensionists, farmers and educationalists working as a team, and target materials better to specific farming contexts.
- ✔ Develop discovery-learning exercises for key pest and crop management problems and test these out with farmers on a pilot scale. Exercises should help farmers understand key agroecological and biophysical processes and improve their decision-making skills.
- ✔ Develop (with farmers) more user-friendly and farming system-specific sampling and recording methods for key production problems needing regular monitoring, likewise for easily measurable indicators of progress.
- ✔ Develop a programme for systematic and participatory monitoring and evaluation of the impact and effectiveness of training activities (including expertise in socioeconomics and communications).

Building inter-institutional partnerships and networking

- ✔ Set up a provincial and/or national Farmer Participatory Working Group to coordinate farmer-centred training and action research activities, evaluation and dissemination.
- ✔ Create an informal space for dialogue and networking between interested individuals in research, extension, farmers' groups, NGOs and relevant policy-makers and private companies, with the aim of improving communication, feedback and collaboration.
- ✔ Publish and disseminate useful data, experiences and lessons from work in progress, via non-academic channels, including websites, newsletters, local authorities, farmers' associations, marketplaces and the mass media.

Promoting action research

- ✔ Develop a strategy for farmer participatory research to explore technical and socioeconomic feasibility and cost/benefit of various ICM options under different farm contexts, within a systems perspective.
- ✔ Evaluate and disseminate relevant experiences in action research in other crops and programmes elsewhere.
- ✔ Involve extension, NGO staff, small farmer representatives and public and private sector research in setting research agendas and improve linkages between these groups and with supply chain stakeholders.

learning comes from the experience of researchers working with the Vijaya Association of Fruit & Vegetable Growers in India to help improve the quality of their mangoes in order to access more lucrative export markets (Hall *et al*., 2001). The rigid demarcation between pre- and post-harvest crop management and the tendency to treat fruit quality problems as purely technical constraints to be solved by technical fixes (controlled atmosphere facilities, etc.) resulted in continued problems with their export shipments, especially from anthracnose and stem end rot (*Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc.), which developed during storage and transport. It gradually became obvious that long-lasting solutions would need to address on-farm disease management, harvesting and packing processes, as well as sea-shipment, in an integrated fashion under a total-systems perspective, which included farmer and packhouse training, communication and feedback along the production chain and better accountability of public research services contracted to provide technical advice.

Box 1 provides suggestions for improving farmer participation in R&D and more effective training in sustainable methods for agricultural tree cropping, compiled with respect to coffee and cocoa but relevant to other commodities and the range of organizational structures which produce and market these.

Particular challenges for pest and disease management, sustainable production methods, farmer training and institutional capacity-building in agricultural tree crops are posed by the increasingly stringent food safety and quality requirements in conventional markets, but also the rapid expansion of organic markets. In Brazil, for example, where the number of organic enterprises has leapt from 700 in 1977 to over 12,000 in 2001, there are now 14 different national and international certification bodies operating with Brazilian growers, and public sector research and education is starting to work on organic systems. Amongst tree crops, Brazil now produces organic coffee, cocoa, orange and other citrus fruits, mango, papaya, passion fruit, coconut, cashew and oil palm for domestic and export markets (Prata Neves *et al*., 2001). The high cost of certification is a major issue for farmers, while some farmers' associations are keen to build social and ethical standards into product marketing. These issues will require inter-institutional collaboration, information-sharing and innovative thinking, as will perhaps the key disease management constraint looming on the horizon for thousands of certified organic farmers worldwide: the reduction of copper-based fungicides to a maximum of 8kg/ha after 2002 under organic production standards (IFOAM, 2002), with probable prohibition of copper under EU organic regulation in the very near future (Soil Association, 2001).

Finally, from a development and poverty alleviation perspective (for Southern and Northern farmers alike), it is critical to examine how far participatory training and research methods and, indeed, ecologically-based production systems can deliver sustainable benefits for farmers and society, unless the serious obstacles in today's vertically integrated and hyper-concentrated agribusiness and retailing sector are tackled. There is indisputable evidence that organic farming systems can produce huge environmental, social and economic benefits for farmers and rural communities and reduce the cost of agricultural externalities born by taxpayers, governments and society. A recent study of conventional, integrated and organic apple production in Washington State, USA, demonstrated that the organic system produced not only better soil quality and fewer negative environmental impacts, as might be expected, but also sweeter apples, higher profitability and greater energy efficiency. The organic orchards studied employed *Bt* sprays and pheromone mating disruption techniques for codling moth, while conventional and integrated growers relied mainly on pesticides (Reganold *et al*., 2001). Despite growing evidence of this kind, nonetheless, the purchasing decisions and product selection of the large supermarket chains can act as a powerful brake on the promotion of more sustainable crop production methods. Pesticide Action Network Germany also compared conventional, IPM and organic apple production in the Hamburg region and found, in fact, that there was little significant pesticide reduction in IPM, compared with conventional production. They concluded that for significant pesticide reduction to take place, i.e. via a major shift to organics, there would need to be considerable changes in consumer and supermarket preferences (PAN Germany, 2001). They found that cv. Golden Delicious is very susceptible to scab (*Venturia inaequalis* (Penz.) Penz. & Sacc.) in cold, humid climates while a local German variety, cv. Finkenwerder Prinz, showed high scab resistance and yielded well without any fungicide application, while maintaining good cosmetic appearance. These apples were tasty and acceptable to consumers but the stumbling block was that German supermarkets were unwilling to offer these to their customers as they did not 'fit' the image of apples with shiny, red skins. European decision-makers who set quality and appearance standards for food regulation, including fresh fruit, also have a strong influence on which varieties are grown and hence the type of production system (Lars Neumeister, pers. comm.).

The concluding message from this review of trends and challenges for farmer participatory training and research in agricultural tree crops is that biocontrol and IPM researchers and extensionists need to locate their specific pest or disease management work in a much broader and holistic production context, which includes all aspects of cropping practices, as well as post-harvest management and processing. They must develop a better understanding of the institutional and organizational linkages and tensions operating along the supply chain from producer to consumer and update themselves regularly on the changes in market requirements and procedures for their specific crops, with careful attention to the implications these hold for training and technology adaptation. Working within a broader production system and livelihoods framework is fast becoming a prerequisite for those who aim to promote ecologically-based tree cropping which is economically, environmentally and socially sustainable.

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