Session 10

Integrated Weed/Pest/Pathogen Management: Implications for Wildlife, Education and Training

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THE IMPLICATIONS OF INTEGRATED CROP PROTECTION APPROACHES FOR EDUCATION AND TRAINING

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ABSTRACT

Integrated crop protection represents an approach to the control of weeds, pathogens and invertebrate pests that places the emphasis on the crop and cropping system rather than the individual disciplines that still dominate approaches to pest management. Broadly the challenge of integrated crop protection is two-fold: to synthesise available knowledge from a range of sources (agronomy, crop ecology, pest disciplines, control technologies, socio-economics) in order to achieve tactical, strategic or policy goals (which may be economic, environmental or health-related); and to identify key processes and interactions that require further analysis and research. This paper deals with the first of these challenges and considers how training and educational courses can best be geared for the intending practitioner (consultant, extension worker, researcher), the industry (seed, agrochemical and biotechnology companies) and policy-makers. Examples of present curricula at Wageningen Agricultural University (undergraduate, M.Sc. and short advanced courses) and developments involving linkages between Universities of the North and South will be outlined. Examples will be given from both Europe and tropical countries of where some progress has been made towards integrated crop protection and where training and education has been a key factor in its adoption. As with integrated pest management (IPM) there is a danger that integrated crop protection becomes an arcane excercise for academic researchers, aid donors, and environmentalists that bears little relationship with the concerns, realities and vocabulary of the farmer. Ultimately the success of integrated crop protection as a key component of sustainable crop production will depend not on ideology or idealised argument, but on implementatation in practice. That is the challenge for education and training.

INTRODUCTION

Crop protection plays a key role in the practice of agriculture throughout the world, across a wide range of farming systems and socio-economic circumstances, and across all agro-ecological zones. There are virtually no circumstances in which consideration need not be given to the crop losses caused by weeds, pests and pathogens. A key issue in the current debate on sustainable agriculture is the extent to which crop protection is part of the problem or can contribute to evolving solutions. It is important to keep in mind the different rates of adoption of new agricultural practices in the developed (mostly temperate) and less developed (mostly tropical) countries; and that the key concepts and practice of sustainability should not be predicated solely on the perhaps myopic view of developed intensive agriculture, which is arguably looking to step back from its current position rather than move forward in a sustainable way to a more productive agriculture - the concern of the developing countries. This paper aims to outline the concept of integrated crop protection, examine its historical roots in integrated pest management, consider the types of educational and training courses that are currently available and their adequacy, briefly review the role of integrated crop protection in sustainable agriculture and finally posit the kinds of new courses that will be required to service these trends.

IPM AND CROP PROTECTION

For several decades now, integrated pest management (IPM), has been promoted as the key approach to crop protection. One major aid donor regards IPM as 'the concept of the future for achieving environmentally compatible agriculture' (Deutsche Gesellschaft für Technische Zusammenarbeit, 1992) and includes IPM as a major theme in all agricultural projects, including those involving training. Other reports are more circumspect, noting that there has been insufficient implementation to demonstrate adequately the effectiveness of IPM as a component of sustainable agriculture (National Research Council, 1992). One problem with evaluating IPM is that, despite several formal definitions, the term continues to have different meanings to different individuals with different agendas, as noted perhaps acidly by Geissbühler (1981) in reviewing the agrochemical industry's approach to IPM, which has long purported to take a serious approach (Sechser, 1981). Any approach to IPM must of course take into account the practices and views of the agricultural industry in its widest sense. The food retail industry has major interests in crop protection practices involving agrochemicals and IPM can be seen as a 'half way' house between conventional agricultural methods, using pesticides, and organic production (Spiegel, 1992).

Initially there is little doubt that the impetus for IPM came from the foresight of the scientific community who were able to influence and persuade funding bodies that change in crop protection practices was required. Paradoxically in evaluation of IPM programmes the criteria used and the conclusions drawn, tend to emphasise the economic considerations (Thompson et al., 1980; Linder et al., 1983; Trumble & Alvarado-Rodriguez, 1993) rather than the concerns of the early proponents, which were largely related to technical efficiency or environmental concerns, and the reduction in pesticide use. Increased revenue to farmers and growers is seen as an important perhaps necessary condition for the successful implementation of IPM. In the developing countries where the impetus for IPM programmes comes more from external aid donors rather than from intrinsic economic imperatives there has equally been concern over the lack of implementation of IPM research (NRI, 1992a, b), despite the success of some programmes (Matthews, 1991) in reducing pesticide usage on specific crops such as cotton. Croft's (1981) prediction - that possibilities for reducing the amounts of pesticides applied, when adjustments between reductions in active ingredient and increases in area treated are made, will be few - has broadly been correct. The influence of policy, however, on reducing pesticide usage in various countries, notable Scandinavia and The Netherlands, has been reviewed by Pettersson (1992, 1994). In The Netherlands the government launched a Multy-Year Crop Protection Plan in 1990, in order to halve the use of pesticides by the year 2000, curtail pesticide emissions to the environment, and implement stricter requirements for pesticide registration. As well as providing legislation, research funding and farmer incentives, the plan has included special extension and education programmes as policy instruments.

INTEGRATED CROP PROTECTION AND PRODUCTION ECOLOGY

One problem with IPM is the contrast presented between research and implementation. Is there such a thing as IPM research rather than research on its component disciplines, e.g. nematology (Roberts, 1993), or is the whole essence of IPM in implementation and farming practice? Certainly much of the research, and the conventional outputs of research such as scientific publications, remain solidly discipline (effectively pest taxa)-based. Also, it is clear that the very term IPM may tend to consolidate this trend. In practice farmers do not manage pests, they protect crops (and the investments made in producing them) by whatever means they have at their disposal. This suggests that a subtle change in emphasis to integrated crop protection is called for, in which the emphasis shifts to the crop and the cropping system - not as a change to hide a failed concept but as a more realistic approach that bears a closer relationship with agricultural practice, offers new research opportunities, and identifies needs for education and training. In fact this approach, often stemming from plant pathology (the least taxonomically-oriented of the traditional plant protection disciplines), has been espoused on several occasions (Wiese, 1982; Teng, 1987; Pfender, 1989). Of course traditional accounts of pest management in specific crops continue to be published (e.g. Grayson et al., 1990) but accounts which focus more on the crop or cropping system, or broader policy issues, have been made (Rola & Pingall, 1993).

A logical and consistent approach to the place of crop protection in sustainable agriculture has been proposed by production ecologists at Wageningen (Rabbinge et al., 1994). As well as defining issues at different hierarchical levels, often according to policy, strategy and tactics (Conway, 1984), crop growth and production are considered under categories that are successively growth defining, growth limiting, and growth reducing. Within this schema crop protection lies firmly in the growth reducing area. This analysis clarifies many of the concepts discussed previously by Wiese (1982) and provides a strong conceptual framework for the place of crop protection in sustainable agriculture (Chadwick, 1993). This context for integrated crop protection then sets an agenda for alleviating constraints caused by the whole range of biotic (also abiotic) factors. As well as helping to define a research agenda for integrated crop protection, there are also clear implications for the role of education and training in the implementation of such research and the practice of integrated crop protection. In considering education and training it is important to recognise the full range of beneficiaries, including the farmers, practitioners and the agricultural industry in its widest sense. It is also important to recognise there are differing views of education and training, that impinge particularly on extension, depending on the view taken of whether the 'Technology transfer' or 'Farmer participation' model is more appropriate. An extreme parody, but nevertheless present in accounts of the virtues of traditional farming (Thurston, 1990), is that it is the researcher or professional who has most to learn from the farmer. This contrast has been most sharply posed in developing countries and aid programmes but is by no means absent in the developed world.

EDUCATION AND TRAINING IN INTEGRATED CROP PROTECTION

Under this heading can be included all formal instruction ranging from short courses on aspects of crop protection, undergraduate and M.Sc. courses in crop protection or its component disciplines/technologies, to research training for Ph.D. degrees, especially where the latter includes formal course work. In practice emphasis will be placed upon the first two types of course and to illustrate the issues involved reference will be made to courses held at or run by the Wageningen Agricultural University. This paper is not an inventory of such courses, but rather considers the types of issues that determine the courses that exist or are likely to develop in the future. Any viewpoint expressed is solely that of the author.

The WAU is uniquely placed at the heart of agricultural research and training in The Netherlands. The Crop Protection Departments of the University (Phytopathology, Entomology, Nematology and Virology), the Research Institute for Plant Protection (IPO-DLO) and the Plant Protection Service (PD), collaborate extensively, and with the International Agricultural Centre (IAC) form the Wageningen Crop Protection Centre (WCPC) for developing countries. The IAC, together with other research/training institutes in the Netherlands, hosts an International Course on Integrated Pest Management for 15 weeks each year. The course is now in its 24th year. The programme for the course is summarised in Table 1.

TABLE 1. International Course on Integrated Pest Management, Programme, 1995

Subject	% course content
Introduction in Plant Production & Protection	5
Mycology	6
Bacteriology	3
Entomology	8
Virology	6
Nematology	8
Weed Science	8
Development of IPM	20
Pesticide Management	10
Presentation Techniques	5
IPM Extension	3
Case study Development of IPM	4
Library	14

Although much of the course is developed to subject matters based on pest taxa (40%) the remainder is allocated to generic topics, including IPM development, pesticide management, extension, and cropping system case studies. The participants in the course include researchers, practitioners, lecturers and private sector representatives. Refresher courses for alumni are regularly held in different regions, e.g. Latin America and S.E. Asia, and in general every effort is made to engender a sense of continuing involvement. A rather different short course is an International Postgraduate Course on 'Modern Crop Protection: Developments and Prospectives' (Zadoks, 1993). This is an intensive 1-week course which broadly addresses three topics: (1) Crop Protection Chemicals; (2) Biotechnology in Crop Protection; and (3) Integrated and Biological Control. In some cases again, however, these topics are sub-divided along conventional taxonomic lines, and presented by discipline specialists.

The Master's degree at Wageningen is generally for overseas students whether from Europe or the tropics. Crop Protection features in several Master's courses, e.g. in Ecological Agriculture, and is a major component of a Masters Course in Crop Science, with specialisation in crop breeding, crop production, crop protection and protected cultivation. Crop protection features in each of these specialisations. Dutch students normally graduate with the Ir. degree, broadly of the same level. As well as traditional courses offered by the individual Departments there is a wide range of courses available which are interdisciplinary in nature and address crop protection issues (Table 2).

TABLE 2. Range of courses in crop protection available in undergraduate curricula at Wageningen Agricultural University

Level	Course
Introductory	Orientation on crop protection Crop protection
Intermediate	Disease and pest development Phytopharmacy Analysis of a problem in crop protection Crop protection and society Biotechnology in crop protection Plant protection in the tropics Excursions (Netherlands and foreign country) Simulation and systems management in crop protection
Advanced	Crop loss Integrated control: plant diseases : insects Research training Practical training

A more recent development has arised with NATURA (a Network of European Agricultural (Tropical and Subtropical Oriented) Universities and Scientific Complexes Related with Agricultural Development) founded in October 1988. A major initiative within NATURA has been the European Community Training Programme for Agricultural Universities in the South (which carries the acronym NECTAR). The aim of NECTAR through cooperation between NATURA members and Southern Universities is to establish and implement new courses and curricula in eight thematic fields, within agricultural development. The complete list of thematic fields in given in Table 3. These courses/curricula may be restricted to short courses or form the basis for M.Sc. curricula. One of the thematic fields is Sustainable Crop Protection which is co-ordinated by Wageningen Agricultural University. Five modules are planned within this thematic field: biological control, integrated pest management, decision tools for crop protection, recent developments in epidemiology, and weed management. Other than in the last module a purely pest taxonomic approach has been avoided and in all modules crops and cropping systems relevant to the southern partners are stressed. About six European Universities have been involved thus far in curriculum development for sustainable crop protection, which it is planned will finish in 1997. Implementation of the curricula is currently being discussed with the Universities of Zimbabwe, Harare, Cotonou, and Benin. A weakness of the early curricula development was the lack of involvement of Southern Universities in the early planning; this has subsequently been addressed.

TABLE 3. Thematic fields for curriculum development supported by the NECTAR programme

Theme	Co-ordinating University
Food and nutrition sciences	Royal Veterinary and Agricultural University, Copenhagen
Sustainable crop protection	Wageningen Agricultural University
Biomolecular sciences in sustainable agriculture	Athens Agricultural University
Rural environment and development interventions	Universidade de Tras os Montes e Alto Douro, Vila Real
Agricultural economics and policy reforms	Hohenheim Universität & Université Catholique de Louvain
Agricultural economics and rural development	University of Reading
Development operations, preparation and follow up	Agropolis, Montpellier
Water	Universita degli studi di Firenze

THE IMPORTANCE OF TRAINING AND EDUCATION FOR IMPLEMENTATION OF INTEGRATED PEST MANAGEMENT AND CROP PROTECTION

In the early fervour for integrated pest management approaches there was little attention given to requirements for formal training and education. Pimentel (1982) for example fails to mention these elements as being a constraint to IPM or its implementation. The report by the Natural Research Council (1992), under 'educational constraints', only places emphasis on inadequate extension, lack of trained personnel to interface between researchers and the farmer, and the general lack of information about IPM. Education and training must involve more than this, even if the technology transfer model of implementation is accepted. Linder et al. (1983) in their economic evaluation of an IPM programme, while recognising the need for continuing education, state little more than the efforts of the extension services to educate the farmer have been positive, and certainly provide no evidence to support this view.

At a recent BCPC symposium, several speakers addressed the issue of training especially for developing countries (Cox, 1994; Croxton, 1994; Ledru et al., 1995; Marshed-Kharusy, 1994), although the perception of training ranges from the technology transfer model to one in which it is the scientists and planners who actually need the training, not the farmers. In what may be the largest exercise in IPM adoption, on rice in

S.E. Asia, the very concept and contrast of the 'trainers' and the 'trainees' is considered as something to be avoided. Participants learn to obtain personal ownership of the knowledge that will help them to improve their crop protection practices (Chapter discussions in Chadwick, 1993).

Training in the safe use of pesticides might be considered desirable whatever the views on use of pesticides *per se*, but in some ways such training can be seen as effectively part of a pesticide subsidy which most aid donors now exclude from funding. The corollary of this is that where storage and disposal of previously-supplied agrochemicals presents a major hazard then there is a direct responsibility of the donor to provide assistance, especially through appropriate training (Cox, 1994).

In 1978 several chapters of the Proceedings of the IXth International Plant Protection Congress (Kommedahl, 1979) were devoted to education and training in Plant Protection; this trend continued at the XIIIth Congress in 1995 at The Hague, with major sessions held on the transfer of knowledge in crop protection (Anon., 1995), especially in relation to institutional constraints and the use of computer models in education and extension. The latter topic will be discussed at the end of this paper.

ROLE OF CROP PROTECTION IN SUSTAINABLE AGRICULTURE

A whole body of literature is now burgeoning on sustainable agriculture, which includes much of relevance for the development of integrated crop protection. It is only possible to do justice to a few of the issues within the confines of this paper. Much of the debate on sustainable agriculture concerns the need to conduct on-farm research as opposed to the perceived artificiality of the experimental station (Anderson, 1992). An added bonus is the involvement of the farmer in the design, implementation and dissemination of research. By definition, such research must include the interdisciplinarity lacking in IPM programmes (Pimentel, 1982). It should be recognised, however, that 'agro-ecosystems' approaches do not necessarily involve on-farm research, especially those where a regional network of sites is involved (Peterson et al., 1993). Nevertheless if research on integrated crop protection as a component of sustainable agriculture is increasingly to be done on-farm, with an increased participation of farmers, then changes in the way researchers are trained will be inevitable. Although it has been argued that sustainable agriculture must derive from applied ecology (Thomas & Kevan, 1993) it would be a delusion to believe that the issues relating to sustainability are entirely scientific (Levin, 1993). This is a particularly apposite point in relation to crop protection with a wide range of lobby and pressure groups competing with the supposed objective data provided by the scientific community. On the other hand the scientific community must better appreciate its limitations in determining policy and decision making (Miller, 1993) and accept that agricultural and environmental questions are, at this level, trans-science. It is simply no longer acceptable to train crop protection practitioners who can deal only with hard facts and cannot cope with the wider rationale and arguments relating to crop protection; these cannot, with profit, be dismissed.

There is of course a danger that the development of ideas on sustainable agriculture will carry all the vices (and some virtues) of traditional disciplines. One danger is the development of a specialised vocabulary, often justified as necessary for precision, but in reality operating to distance the practitioner from his/her subject matter. The theory of IPM rapidly developed its own distinctive vocabulary far removed from the farmers perceptions of pest problems (Norton, 1980). How many farmers, for example, would recognise that 'Pest Management is a multistage decision process in a stochastic and observable system' (Schoemaker, 1981); or in the context of agricultural systems, that 'Sensitivity in systems shows a negative relationship with the degree of internal articulations among different farming activities' (Viglizzo, 1994). However useful such language may be for a small circle of initiates, it serves little purpose for the implementation and practice of integrated crop protection and sustainable agriculture. A severe challenge in education and training is how to avoid such jargon in getting over the key concepts and elements of integrated crop protection.

NEW REQUIREMENTS IN EDUCATION AND TRAINING

Other than the requirement for education and training in on-farm research, farmer participation, and possibly a better appreciation of trans-science issues (but in a systems context), undoubtedly an element that will increase in importance is the use of different types of models ranging from biophysical simulations to econometric analysis, and to expert systems and decision tools combining both formal and informal elements.

TABLE 4. Papers presented in a session on Use of Computer Models in Education and Extension, XIIIth International Plant Protection Congress, The Hague (Anon., 1995).

Paper title	Country affiliation
A global survey of computer users in agricultural extension	Israel
Communication technologies for information provision and advisory communication in Dutch agriculture	Netherlands
IPM training approach used in Vietnam	Vietnam
Information technology in support in NGO based extension and education in Ghana	Ghana
Information technology supporting capacity building for rice systems research in National Agricultural Research Centres in Asia	Netherlands
Targeting your software to your audience	USA
Genetic software tools for pest management	Australia
A decision support system for integrated crop management of greenhouse crops	Canada

The use of systems analysis and simulation modelling has a long history in IPM and crop protection and increasingly in its relation to sustainability (Rabbinge et al., 1989). Pest management models are increasingly being formulated as crop management models (Hearn & de Roza, 1985). Many models remain that are solely concerned with pest taxa (e.g. Gonzalez-Andujar & Fernandez-Quintanilla, 1993; Doyle, 1991; Duncan, 1991) or control practices (e.g. Gallant & Moore, 1993; Russell & Layton, 1992) and this can also apply to the less formal expert systems or decision models (Cook & Royle, 1984; Luo Yong & Zadoks, 1992; Rossing et al., 1994a, b; Shtienberg et al., 1990; Travis & Latin, 1991; Teng & Yong, 1993). Some decision-models are broader in scope within crop protection (Edwards-Jones, 1993) and in their place at farm level (Milham, 1994). The field of decision-making has developed rapidly since the early 1980's (Austin, 1982). At the XIIIth Interaction Plant Protection Congress held in The Hague in July 1995 a session was devoted to the use of computer models in education and extension. The list of presentations (Table 4) gives an indication of the wide range of applications that have been tested.

Not only will computer modelling be linked more closely to on-farm research, but increasingly much of the exposure to integrated crop protection will come through courses involving computer exercises rather than traditional experimentation. This may be anathema to some but, as in other areas of life, computer education has become inevitable in dealing with the full range of complexities inherent in agriculture in general, and crop protection in particular.

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