C. B. HUFFAKER, A. P. GUTIERREZ
Division of Biological Control
Department of Entomological Sciences
University of California
Berkeley

Organizational problems in integrated pest management (*).

1. Problems with pesticides

The huge and increasing human population will continue to require huge and increasing production of food and fiber. Of course, these supplies must be protected from pests; production must be increased in areas of shortage. But in addition, efforts need to be made to greatly slow the growth of human populations and the increasing demands for food and fiber. Otherwise we will be locked in a spiral of ever-increasing need (Ehrlich and Ehrlich, 1970) and the associated pollution, not only from the human activity, but also from the chemicals used to protect the crops from pests, and to enhance the growth of genetically narrow crop plants. The importance of this protection and the worldwide concern in the use of pesticides means that we must learn to control pests in ways that are economical, long-lasting and of minimal, or no, harm to the environment, the public, or to domestic and wild animals and plants. We must also be cognizant of the fact that modern agriculture is petroleum-based, that far greater energy is put into production than is retrieved, and that the fertility of the soil and the soil itself is disappearing at an alarming rate: a situation that cannot continue indefinitely ([1]).

Prior to the early 1970's, first insect control and then plant disease, nematode and more recently weed control came to be mostly chemical

---

(*) Lettura presentata al seminario tenuto presso l'Istituto di Entomologia « Guido Grandi » dell'Università di Bologna il 9 ottobre 1985.

([1]) This point was made vigorously by several speakers at the recent University of California-sponsored Symposium on the Sustainability of California Agriculture held at Sacramento, California.

control in the economically advanced countries. A prior era of controlling insects using biological control, cultural methods and minimal chemicals, used with respect to the ecological conditions of pest occurrences, had been replaced by a nearly sole reliance on pesticides. For a while, good results were provided, but soon many agricultural systems reached the « crisis phase of pest control »: the triple curses of pesticide resistance, pest resurgence and secondary pest induction became commonplace (van den Bosch, 1978). This situation arose where chemicals used for certain pests were overused and because essential natural enemies were destroyed, causing resurgence or creating pests that were formerly largely innocuous. Some few pesticides (arsenic and heavy metals) were even concentrated in the soils to an extent toxic to growth of the same or other crops (e.g., Brown and Jones, 1975). Many cases led to development of pesticide resistance, a problem that became intense and widespread in insects. Natural enemies were affected by the chemicals in both direct and less obvious, indirect ways (Table 1). Moreover, some pesticides are known to increase pest fecundity, or lead to the rise of a competitively suppressed pest (especially weeds) to pest status (« pest trading » — Bottrell, 1979).

TABLE 1. — THE KINDS OF DISRUPTIVE INFLUENCES OF PESTICIDES ON INSECT POPULATIONS

A. Adverse effects on natural enemies
   1. Direct toxic effects
   2. Indirect effects
      a. Severe reduction of the pests serving as hosts or prey
      b. Direct or indirect reduction of alternate hosts or prey
      c. Reduction of species supplying subsidiary foods (e.g., honeydew)
      d. Direct poisoning of subsidiary foods

B. Stimulation of pest reproduction

C. Development of resistance

D. Combined effects of A, B, and C

E. Rise of competitively suppressed species through reduction of superior competitors

F. Destruction of pollinators

The problems of pest management were further complicated by the independent pursuit of goals by the various research disciplines that impinge on pest control, and by the imperative of individual researchers to go their own way to control a given pest, without much regard for the consequences of their remedies for other pests or for long-term values in producing the crop. There was also an intensive effort to develop crop varieties producing maximum yields, with little regard to the effects of such breeding programs on the natural control of insects and other pests. Thus, the Green Revolution produced plants that had been stripped of much of their ability to compensate for pest damage; they required chemical protection from pests that became increasingly resistant to the chemicals used to control them, often leading to a situation where pest control costs became a major problem for the survival of the agricultural system (Smith, 1972; Pathak, 1970; Kenmore, 1980).

2. Return to an ecological approach

In the early 1950's and 1960's, efforts were made in the U.S.A. and elsewhere (e.g., FAO, 1984) to turn this situation around and to develop again a more ecologically oriented pest control. This effort became what is known as integrated control, now also called integrated pest management. Hunter and Coad (1923) had developed rudiments of IPM for cotton in Arkansas in the 1920's, but the work failed to attract attention outside of that area. Integrated control was developed and more fully accepted as a result of the work of A. D. Pickett and colleagues in Nova Scotia and by A. E. Michelbacher in California in the late 1940's and early 1950's. It soon became apparent that many of our pest problems did not have simple solutions, especially when new ecological, economic and even social-political consraints were introduced that required more comprehensive analyses than those possible from small research teams with meager resources. The development of computer-based technology and systems analysis (see Getz and Gutierrez, 1982) enabled scienists to deal with often-conflicting and complex factors inherent to integrated pest (and even crop) management (see Huffaker, 1980 for an overview). With the encouragement of the United States government in 1972, a large-scale multi-institutional project (i.e., the Huffaker/Smith/Adkisson Project) was developed in the U.S.A. that is still in being. This paper deals with some of the organizational and inherent problems such a program encounters in its development and conduct. The root problems are the necessity of dealing with the whole of the ecosystem and with people who, often as not, have a decisive and individualistic bent not easily molded to cooperative research.

3. Scope of the problem — Integrated Pest Management (IPM) or Agroecosystem Management (AM)?

At the outset, one must determine the desirable bounds of the effort. By definition, integrated pest management means the utilization of a complex of measures to reduce or control pest problems in a manner compatible with economic needs and public health and environmental concerns (an ecological orientation). Agroecosystem management would also have as goals features other than just the pests—e.g., soil and water resources and collateral benefits of the whole system to the farmer (e.g., wood, pigs or fowl) and the community (Altieri, 1983). Analysis of agroecosystem-level problems are clearly much greater than those for IPM systems, and are at present likely to be beyond the levels of both our understanding and our ability to analyse the system, except in a descriptive way.

4. Technical and non-technical constraints

As noted by Beirne (1970), Corbet (1970), Corbet and Smith (1976) and Geier (1970), non-entomological constraints may dominate the decision of whether to undertake a project or the approach to be used. For example, an eradication attempt may be decreed by government, disposing of IPM unless the effort fails and is abandoned. This has been the case for the boll weevil which recently invaded south central Brazil. The original intent was to eradicate it, but now IPM solutions are being investigated. Biological constraints can also exist. For example, existence of an especially difficult pest that requires a severe chemical treatment schedule greatly lessens the possibilities for fully utilizing IPM for the crop or system concerned. In other situations, several such pests on the same crop, or frequent tillage, complicate possibilities of biological control. Indigenous pests are not so likely to be controlled by imported, exotic natural enemies (but there are examples of such).

5. Deciding on the scope and precise goal

5.1 Containment Strategy, Eradication or Prevention (Quarantine)?

Containment of the pests, not eradication or prevention, is by definition the operational *strategy* of pest management (Huffaker and Smith, 1980), and the methods used to accomplish this containment below economic densities are the *tactis*. In IPM, chemicals are to be avoided when possible, or used at a minimum level so as to avoid their adverse ecologically disruptive and health effects. For IPM to be acceptable, the control strategy has to return a profit to the producer but without causing unacceptable social costs external to the operation. An ideal IPM system, or ideally an AM system, would reduce the costs by reducing the use of pesticides, water, fertilizer and other inputs (e.g., Adkisson, 1984) and proportionally reduce or eliminate the abuses to the public health and the environment.

5.2 Maximum Yields or Optimizing Long-Term Benefits?

Maximizing yields was the primary objective of the era of unilateral use of pesticides, as it was also of Green Revolution programs, as both relied mainly upon pesticides alone to control the pests. Maximal original yields could not be maintained in either case because of the consequences of the pesticide disturbances (above). Also, if chemical control is overly costly, though it produce maximum yields, the cost-benefit ratio could dictate agains its use and demand a less costly pest control that optimizes costs/benefits over a period of time, or even year by year (see Bottrell, 1979), but this is not always the case. The pink bollworm in the desert valleys of California is a case in point; the farmer will not adopt IPM strategies because he thinks they may lower profits. In this case, early termination of the cotton crop would effectively solve the pink bollworm problem, but lower yields would result. However, the net long-run average revenues might be greater using short-season cotton (Riverside), but in a short-run profit maximizing system the farmer remembers that profits were greater during some previous year and thinks such profits are the norm, not the exception, and will not consider short-season cotton. This has led to adoption of control practices based upon the insecticidal "cocktails", where various chemicals are applied weekly in various combinations to control this pest. The failure of the chemical control strategy in pink bollworm control in this area is documented by the fact that cotton acreage has been reduced from 100,000 acres to 20,000 in 1984 because control costs became too great, and the effectiveness of the pesticides dropped precipitously due to resistance and the emergence of new pests. Similar problems can arise through plant breeding programs, as was so dramatically demonstrated during the southern U. S. corn blight outbreak in 1970. This problem resulted from the « single » focus on maximum yield and the consequent extreme narrowing of the genetic base, with the loss of genetic resistance—in this case to the corn blight organism (Smith, 1972).

5.3 Insects Alone, or All Pests? or Total Farm Benefits?

Early efforts in the U.S.A. national IPM project (Huffaker, Ed., 1980) concentrated on insect pests because there was a lack of interest and acceptance in an overall program by plant pathologists, nematologists, and weed scientists. This has now improved considerably, and many of the state projects are led by scientists in these disciplines; this has been especially fruitful in Texas where the project director is also Deputy Chancellor of the coordinating university and can encourage scientist participation. As a minimum, an IPM effort should embrace each major class of pests and, where possible, should include other farm practices that impinge upon crop production and ultimate farm income.

5.4 Focus: the Crop, the Pests, the Farmer, or Society's Benefit?

In existing U.S.A. IPM programs, there has evolved, desirably, a focus on the crop, and with focus on the pests secondary and assessed in terms of effects on the crop. Assessment in an AM mode should desirably look at the farmer's total benefits in a free enterprise or individualistic operation. All too often in such systems, the focus is profit maximization, while societal benefits are cast to a distant second priority. Society benefits may often be addressed in a collective governmental operation, but again governmental interest may also short-run maximization, and the IPM problems are simply magnified. Thus, strange as it may seem, farmer and government often appear to equate maximum yields with maximum gain. Furthermore, in a free market economy there is little obvious incentive for individual farmers to delay the buildup of resistance, decrease environmental pollution, enhance biological control, or avoid creating an environment where quick profits, or risk and uncertainty factors, cause farmers to spray as insurance measures (Regev, 1984). These factors are termed « negative common property resources », and the situation described above leads to an « addiction to pesticides ». Hardin (1968) describes this bio-economic conflict as « the tragedy of the commons », and, in the extreme, he would appear to question the ability of complete free enterprise, since the incentives are lacking for its members to adopt socially responsible strategies.

5.5 Enforceability—Governmental or Free Society Aspects

An IPM program is assisted materially if producers are subsidized (for society's good), encouraged or decreed to follow practices determined to be essential. Implementation programs will often require either voluntary participation or some form of regulatory enforcement. For example, Israel enforces practices consistent with IPM in citrus production (Harpaz and Rosen, 1971) and Texas requires crop residue destruction in IPM of cotton insects (Adkisson, 1984). Tax incentives can also be used if the value is clear. In an analysis of the alfalfa/Egytian alfalfa weevil system in California, Regev et al. (1976) proposed that increasing penalties be levied for increasing pesticide use to force implementation of more desirable policies. In Sweden, a tax is put on pesticide use and the revenues are used to fund research to find alternative solutions; hence, as research finds solutions to replace pesticides, the revenues needed to fund the research decrease. In theory, this seems a reasonable way of problem solving. Again, such solutions add still more dimensions to the IPM or AM problem.

6. Financial support

Rengionwide projects require broad-based support, such as that received by the Huffaker/Smith/Adkisson projects from each of the participating states and from NSF, EPA and USDA. Such a program had to develop policies and machinery for handling funds from diverse sources and channeling them into the project in a flexible way. This effort can be contrasted to the individualistic IPM implementation efforts in California, which in the past were often funded by the growers and focused on quick, not comprehensive, solutions. Often as not, grower perception of the IPM problem guided whatever research was done. The practice of paying private, certified pest control consultants on a per-acre fee basis in widespread in California, but the results can be mixed because of poor quality-control of advisor qualifications.

Project organizers need to consider the political and « sovereignty » considerations in seeking funds and in the management of the project. Each state, research institution, department head and dean may want to exercise control, and if they are successful it can be a death-knell to a coordinated effort. Arrangements need to be made to circumvent this with, say, the granting agency, as was done in the University of California Statewide IPM project where control language was written into the grant by the state legislature. Sometimes growers' organizations, or industries, will add some support for specific aspects but, as exists in the University of California system, such provision of funds for research should be in a manner so as not to compromise the objectivity of the research.

7. Problems of coordination

A project like the grant-supported U.S.A. programs (above) faces major problems in the coordination of the 600 plus scientists in the different crop production specialties: forestry, entomology, plant pathology, weed science, ecology, economics, systems analysis, mathematics and extension specialists in the eighteen participating university experiment stations, each with one or more within-state substations. The National Science Foundation, the Environmental Protection Agency and the U.S.D.A. provided funding, as did each state via support for

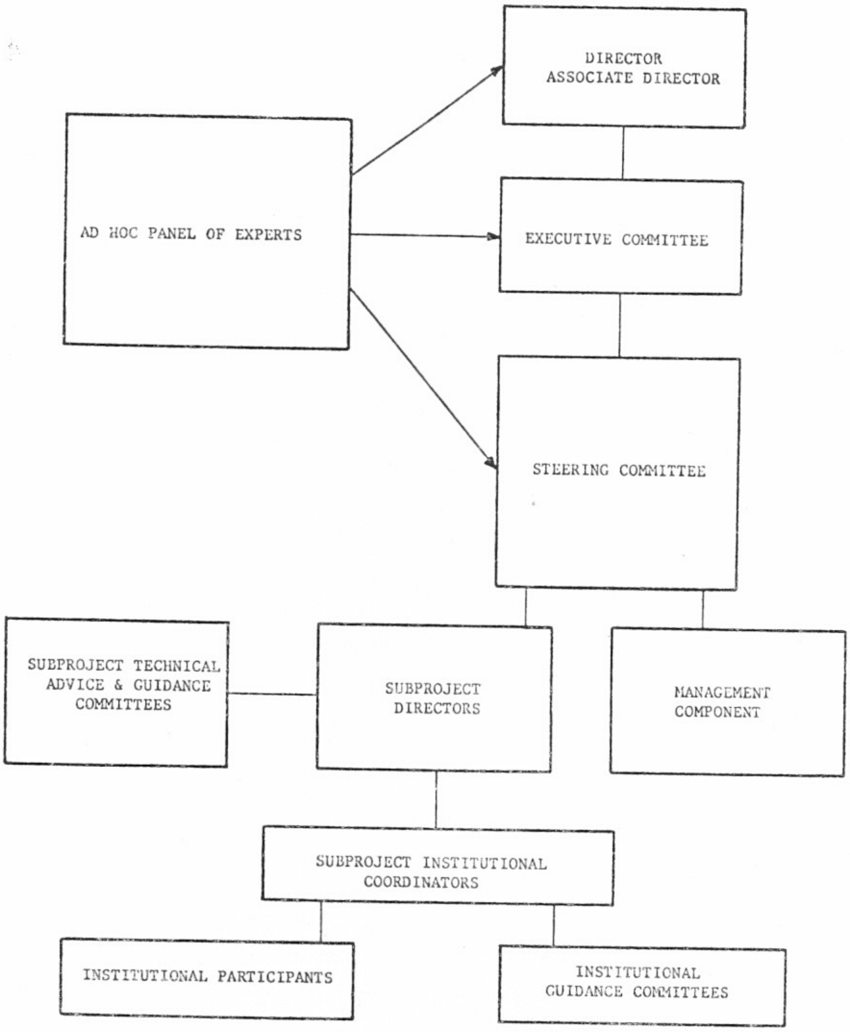

Fig. I
Administrative structure of an IPM project.

participating scientists and technicians and the support facilities. All of these funds had to be integrated in a manner so that the individual donor could identify the progress attributable to his funds, yet showing the fruits of the combined effort. The organizational scheme is shown in Figure 1, but it is noted here that such structures mean little if the administrators are not clear-minded and scientifically competent, and the scientists involved are of limited capabilities or lack true interest.

The scientific effort also had to be unified, and crop growth analysis (modelling) became a coordinating focus for guiding the research (see

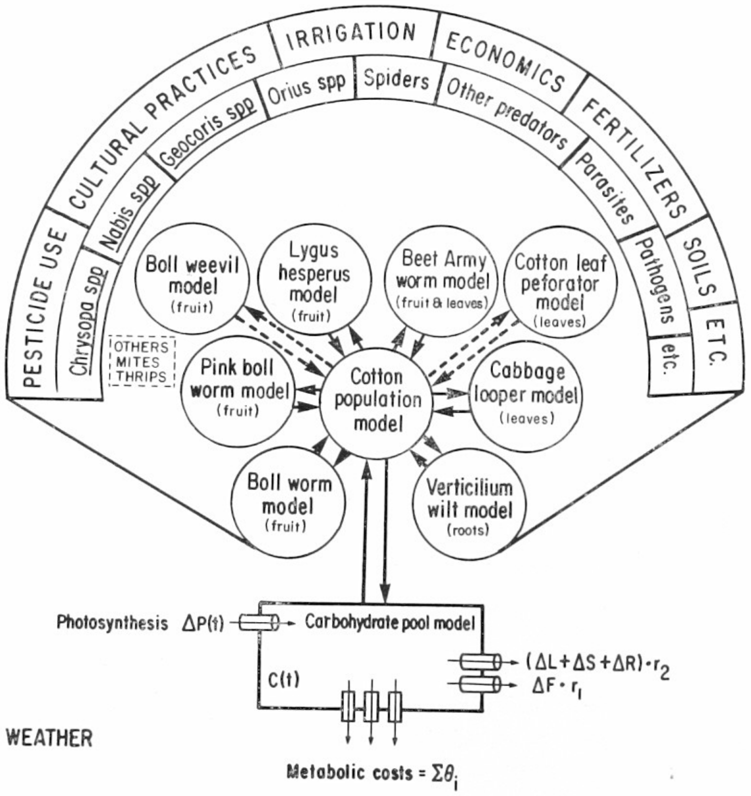

FIG. II

Format of an IPM model for cotton, centered on the crop itself. (After Gutierrez et al., 1980, in Huffaker, ed., 1980).

Fig. 2). Pest probems could then be evaluated in terms of their *effects* on plant growth and development and higher trophic levels, and also on the economic consequences that should be superimposed (Gutierrez and Wang, 1984). A major problem was that grass roots (biology) researchers did not want to turn their own data over to a modeller who might « hog the show » in a publication. Yet neither the economist nor the modeller could work without the data. We encouraged the earliest possible publication of each grass roots data set by its securer and also the inclusion of these researchers as co-authors in resulting general systems analysis papers. Also encouraged was the development of modelling expertise by biologists; a scheme that worked quite well in California and Florida.

Basic researchers, tactics researchers, and model verification and implementation workers need to understand the work of the others and the necessity to furnish information as quickly as feasible to the others requiring it. The power to curtail funds for technicians, equipment and the work itself to a bald recalcitrant, achieved the necessary « cooperation » in some cases. « People problems » can indeed be real impediments, often the major ones.

8. Policy guidelines and phases of project development

Project directors and subdirectors, with inputs from the advisory structure, must decide upon policy guidelines and the steps or phases to be followed. We present here the specific, detailed objectives relating to the various tactics and informational inputs employed in the overall strategy of pest containment. These are:

1. The significant biological, ecological, physical and economic processes affecting the growth of the crops and the population dynamics of the pests and their natural enemies, as well as their interactions, must be identified.
2. Better methods of collecting, handling, and interpreting relevant biological, meteorological and crop production data to investigate the above relationships need to be developed.
3. Systems analysis in the general and specific senses, including modelling as a central unifying and research-guiding tool in the pursuit of the main goal and its subsidiary goals, must be adopted.
4. Development of models of the crop production and pest systems, integrating these with economic analysis (impact, etc.), and conducting pilot tests for the crop system must be accomplished.
5. Alternative tactics, especially cultural, biological, and host resistance factors which are ecologically compatible and which can be expected to reduce the use of broad-spectrum biocides and lessen the adverse effects of their use must be developed. From several perspectives, this phase of the process is greatly facilitated by using systems analysis methods to help evaluate optimal strategies. Often the solution will show that only constrained solutions are possible.

Each of these objectives presents its own problems in execution. Theoretically, the best coordination is achieved if all the researchers and staff are salaried by the Project, but in our case this was not possible. Staff salaries came with their positions in their universities, and each person also had other obligations of their positions. In the beginning, progress was slow but with the real possibility of a successful outcome on a grand scale, and with insights gained by the biologists from cooperative efforts with systems analysts using crop growth analysis as the catalyst and focus, reasonably cooperative efforts were secured.

We also present here the steps, or phases, in the execution of an IPM project in depth. The basic steps (adapted from guidelines of F. R. Lawson and associates, U.S.D.A., Columbia, Missouri) for developing the program were followed. The steps outlined below were not followed specifically by each of the crop subprojects, but all features were dealt with by most of them:

1. Separate the real pests from those induced by insecticides in the different regions involved.
2. Establish realistic economic injury levels and thresholds for the real pests with appropriate attention to the hidden costs of controls.
3. Separate the real pests into those causing intolerable losses (i.e., key pests) and those causing only light or sporadic damage controllable by occasional or limited use of pesticides.
4. Identify the key factors controlling, or of great potential value for controlling (e.g., a key resistant variety, natural enemy, or a cultural measure), populations of the key pests and measure their effects.
5. Design and test control systems based upon these guidelines in each of the areas where the key pests and/or factors are different.
6. Modify control systems according to time and area conditions and new inputs as the program develops.

9. Setting priorities for key efforts

Project directors, subdirectors and advisory staff must also determine the priorities for the different components of the program. Arrival at a consensus in philosophy and basic goals will ease the problems of setting priorities so as not to estrange valuable participants who, understandably, have strong ideas about work they wish to be emphasized. Key areas for high priority are, without ranking here: 1) tactics research (basic and applied), 2) monitoring for pest presence and damage, for natural enemy effectiveness, and of weather factors, 3) economic analyses, including economic thresholds, 4) model building and verification testing, and 5) implementation and education.

Each of these areas poses problems. The tactics research is of very high priority because you must have effective methods to integrate in any integrated control program. But conditions are always changing, including the economic threshold, disturbances from weather, the cost effectiveness of monitoring, and the results of natural enemy action;

hence, tactics developed must remain tentative as others will need to be developed later. Strickland (1970) cautioned about introducing changes without evaluating their effects in the system. Simulation modelling can be used to test the potential consequences of a given factor or tactic over a very wide range of intensities under prescribed conditions—something that would be cost-prohibitive experimentally in the field. Counter-intuitive consequences may be exposed by such analyses (Watt, 1970). Even high costs of monitoring in research, to establish a necessary understanding of the system, must be borne. Often, only a few key factors are exposed as dominant (Watt, 1970), and when the program goes operational monitoring can be cost-effectively limited to them. The question of economic threshold is not an easy one in a dynamic system, and few realistic ones have emerged. Economic analyses are often delayed until an understanding of the system has been achieved and the appropriate systems models developed. These models become the benefit functions in the economic analyses.

10. Decision-making and implementation

10.1 General, Direct, and Supportive Research

Decisions on implementation should be based on sound knowledge of the system, including consequences of the tactics used and natural factors, monitoring (in most cases), economic thresholds or analysis, and the acceptability and cost-effectiveness of the program to the producer, with due regard for environmental, social or other externalities. Such inputs will be based on both direct tactics research and supportive research to establish how the whole system works. Biological control, crop resistance, and cultural manipulation, the latter to bring to bear extremes of physical conditions on the pest, or to favor natural enemies, are the central features. Traditional chemical controls are more and more coming into question regarding their overall long-term consequences for society. They should be used sparingly and only when truly needed, for this reason, and also because this seems to be the only way we can prolong their useful life because of the potential for pesticide-resistance development (Huffaker and Smith, 1980; Bottrell, 1979; Glass, et al., 1975).

Glass et al. (1975) noted:

« The growing of a crop and the management of its pests are ecological endeavors. There are strong biological and ecological interactions among the various basic factors affecting: crop productivity (plant variety, soil type, fertility, water supply, temperature, wind, sunlight, etc.), the potential for damage by pests of the crop, the potential of the pests' natural enemies to circumvent such damage and the various practices used by man to control the pests. Because of these interactions, often involving strong compensations, the end results of various actions are difficult to predict. There is a great need to characterize, both quantitatively and qualitatively, the population dynamics and mobility of our major crop pest, the damage they cause and the various interactions among the many factors mentioned above.

Far too little attention has been given the *crop* and the means by which it produces its particular item(s) of yield. We must know the effects on yield of various environmental and agronomic factors, as well as of pests and the various pest control tactics, whether these operate alone or in a combination. Moreover, the level of acceptability of the cost of controlling a pest is dependent upon the market outlook. Thus, economic relationships must receive attention ».

Huffaker and Smith (1980) noted in this connection:
« Establishing economic thresholds and real need to use an insecticide, or to intervene in any way, is of foremost importance. This is the number one priority. The economic threshold, however, is not a fixed level, but a dynamic concept, the density level satisfying the concept depending upon a variety of circumstances which may vary markedly with the location and as the season progresses. We need to determine the relationships of various levels of economic damage to the size and stage of development of the crop and of each major pest species, for the complex of pest species, and the probability of alleviation by natural enemies or by the crop's own capacity to compensate for pest damage at a particular time ».

Relatively newer components, such as genetic improvement, use of semiochemicals, or additions of nutritional supplements regarding natural enemies may find a place. So also for growth regulators and attractants and repellents. Pheromones may be used in monitoring, or in a « trap-out » research fashion, as has shown some promise in bark beetle control research (Waters, et al., 1985). More selective pesticides and more selective ways to use them are greatly needed. Methods of application are being improved in some cases to achieve this. We need more information in nearly every case on the side-effects of pesticides on other organisms in the system and external to it. These data come only with great effort and over a period of time.

10.2 Modelling, Implementation and Testing

It has already been noted that because of the complexity (with unpredictable interactions) of pest-crop systems or agroecosystems, modelling is often crucial or central in arriving at decisions on what to do, particularly in testing for complex consequences (above). Yet, the insights gained, for example through the work on cotton in California, may make it unnecessary to use modelling, or extensive monitoring, beyond the research stage. Chemical controls, except for spider mites and occasionally for lygus bugs, are generally not needed in San Joaquin Valley cotton. Natural enemies now keep the lepidopterous pests under control. In the Sacramento Valley, on the other hand, integrated control in almonds centers around biological control of spider mites by a predatory mite (pesticide resistant form released if not adequately present) and monitoring is used generally (Drs. Barry Wilk and Cliff Kitayama, personal communication).

In the process of deciding on research emphasis, modelling may be used and field testing of the model(s) may result in altering the model and thus an eventual field operational program.

An implementation system should be widely tested on limited areas before it is recommended to extension people or to growers. There should be extensive interplay between the research and decision-making leaders and farmer education outlets, including extension, farm magazines and television. Education of farmers in the cost-effectiveness and other values (to them and society) of the program should be a major item, as it has been relative to IPM for cotton in Texas (Adkisson, 1984).

Governments may legislate or decree adoption of IPM in some cases (above). However, as in California, legislatures may get ahead of the researchers and technologists and decree a broad unrealistic adoption of IPM, usually, however, with a hedging phrase, « whenever feasible ». Extension-guided or grower-determined programs may also go beyond the practical. Such exuberance can harm the long-term potential of IPM. On the other hand, researchers, extension workers and growers in Arkansas have worked together so closely using model-guided, short-term prediction that treatments with insecticides to control *Heliothis* in cotton have been reduced from about 10 down to 1 or 2 (Phillips and Nicholson, 1979).

11. Promise, obstacles and conclusions

IPM is not used extensively in the U.S.A. For many crops, little has been done to establish a solid IPM research base, although cotton, alfalfa, apples, and soybeans are among the exceptions. These are widely using IPM (acc. Adkisson, 1984). Yet more research is needed for these crops, but especially for many other crops for which little has been done (Bottrell, 1979; Glass, 1975). Lack of understanding of IPM at all levels is a real impediment. For example, banks making crop loans often require following a « spray schedule », even though IPM may be less costly and more efficient. The U. S. Food and Drug

Administration uses regulations against insects and insect parts in food which encourage chemcial treatments and discourage IPM (Bottrell, 1979).

Huffaker and Smith (1980) commented on this topic and the essence is extracted here:

Pest control in the United States will now go backward or forward, depending upon whether or not government at all levels, pest control scientists, and private industry will accept and implement the possibilities inherent in IPM. This must include changes in the way programs are funded, how they are organized and managed, and how funds are allocated to different areas of research and implementation, and communication of the benefits to the farmer, consumer, government officials, and other levels of society.

There are perhaps three areas that stand out in importance in preventing a much broader, effective, socially conscious pest control. The first is that the chemical industry has dominated the scene, resulting in a general departure from the older, ecologically based methods of pest control. An army of insecticide salesmen has replaced traditional dependence of the farmer upon his university for advice on pest control. There seems to be no way this can be corrected unless the government, by law, removes the conflict of interest inherent in an industry representative selling both insecticides and the advice to use them.

The second need is that the method of funding and managing IPM programs must allow some changes. Existing funding, through small individual grants, or through the U.S.D.A., which (as with ARS) either fails to bring in a broad-based input from university researchers, or when it does so (as with CSRS) funds are filtered down through Experiment Station Directors, Deans, Department Heads, and by « formula funding ». The money getting to researchers is usually a little here and a little there. It is nearly impossible to fund a major cropbelt-wide, coordinated IPM program with the strength needed for success.

Thirdly, the management and priorities must be revamped. At present, the management is automatically subject to the cross-currents, opposing views, parochialisms and personal interests of the above- named administrators in the universities usually involved in such coordinated programs. A program of considerable scope and depth requires a strong centralized management largely independent of domination by these administrators.

Cosmetic appearance is stressed by marketing concerns and this can work against IPM although no health hazard or reduced food value is involved (Pimentel et al., 1977; Bottrell, 1979). Few farmer organizations advocate IPM or recognize the bias in a pesticide salesman also selling advice to use pesticides. An exception is the Texas Pest Management Association (Bottrell, 1979). But, currently, many universities are offering courses or specialized degrees in IPM, and this should improve the situation in the U.S., as seems to be occurring in other world regions as well.

Lastly, we would note that the public is becoming increasingly concerned with the hazards posed by pesticides (and other chemicals) in the environment. As a result, many people would now prefer lowered standards in produce cosmetic appearance, and even infestation, rather than pesticide contamination. If this trend continues, it could force a lessening of the market standards regarding insects. The trend could have profound influence on our ability to develop sound and sustainable IPM practices.

SUMMARY

The realities of worldwide chemical pollution of land and water necessitate intensive efforts to reduce such effects. Pest control is one of the areas requiring drastic changes. Human birth control is of course paramount; otherwise, increased demands for food and fiber will defeat all other efforts. The crop protection specialist's efforts must be to reduce use of polluting pesticides to a minimum. There must be a return to an earlier era when pest ecology was the clue to non-chemical solutions. The arrival of computer-based technologies has helped to assess complex situations and alternative solutions. Solutions are sought through integraetd pest management (IPM). There are the opposing concepts of maximum yield vs long-term optimization. There is the question of containment strategy versus eradication or prevention. Economic and societal restraints pose difficulties for IPM systems even when technically possible. There is the question of insects alone, or all pests, or total farm benefits. Should the focus be on the crop, the pests, the farmer's benefit, or society's benefits? Enforceability in free societies will be different from in authoritarian societies. Problems of financing and coordination will also differ under these two forms of society. Guidelines and phases of technical project development are logically centered on the crop or the farm, usually, but a large-scale focus is sometimes required. The research and decision-making will involve ecological, economic and societal values. All of these areas are discussed.

I problemi organizzativi della gestione integrata dei fitofarmaci dannosi

RIASSUNTO

L'inquinamento chimico del terreno e delle acque è oramai in tutto il mondo una realtà e, quindi, occorre fare ogni sforzo per eliminarne le conseguenze. La lotta contro i fitofagi dannosi è uno dei campi che richiedono drastici cambiamenti. Certamente il controllo delle nascite è dominante nella specie umana; in caso contrario le crescenti richieste di alimenti e di fibre renderanno vano ogni ulteriore sforzo. Il lavoro degli specialisti in protezione delle piante deve avere lo scopo di ridurre al minimo l'impiego degli antiparassitari inquinanti.

Dobbiamo ritornare ad un passato quando l'ecologia dei fitofagi era il mezzo per

giungere a soluzioni che non richiedevano l'impiego di mezzi chimici. L'avvento di tecnologie basate sul calcolatore elettronico ci ha permesso di valutare situazioni complesse e soluzioni alternative. La ricerca di tali soluzioni avviene mediante la gestione integrata dei fitofagi dannosi (Integrated Post Management-IPM). Il concetto di produzione massima e quello del raggiungimento a lunga scadenza di una condizione ottimale sono in contrasto tra loro. Si presenta il problema di una strategia di contenimento o prevenzione, invece dell'eradicazione. Limitazioni di ordine economico e sociale oppongono difficoltà ai sistemi IPM, anche quando questi sarebbero tecnicamente possibili; sorge anche la questione se prendere in considerazione solo gli insetti, o tutti i fitofagi dannosi, o il profitto globale dell'agricoltore. L'attenzione dovrebbe concentrarsi sulla coltura, sui fitofagi, sul profitto dell'agricoltore o sui vantaggi derivanti alla società? Nelle società libere le possibilità di applicazione di questi principi saranno diverse da quelle offerte dai regimi totalitari.
In queste due forme di società differiranno anche i problemi concernenti il finanziamento e la coordinazione. In genere le direttive e le fasi di sviluppo di un programma tecnico si concentrano logicamente o sulla coltura o sull'azienda agricola, anche se talora si presenta la necessità di un centro d'interesse di più vasta portata. Le ricerche e le decisioni da prendere coinvolgono valori ecologici, economici e sociali. Tutti questi settori saranno oggetto di discussione.

LITERATURE CITED

ADKISSON, P. L. 1984. — Biological control as a component of integrated pest management. - In P. S. Adkisson and Shijun Ma (Editors) *The Proceedings of the Chinese Academy of Sciences-United States National Academy of Sciences Joint Symposium on Biological Control of Insects.* Science Press, Beijng, China, pp. 1-8.

ADKISSON, P. L. 1986. — Integrated pest management. - *Bull. Entomol. Soc. Amer.*, (32) 3: 136-141.

ALTIERI, M. A. 1983. — Agroecology: The Scientific Basis of Alternative Agriculture. - Division of Biological Control, University of California, Berkeley. 173 pp.

BEIRNE, B. P. 1970. — The practical feasibility of pest management systems. - In R. L. Rabb and E. F. Guthrie (Editors), *Concepts of Pest Management*, North Carolina State University, Raleigh, pp. 158-169.

BOTTRELL, D. R. 1979. — Integrated Pest Management. - President's Council on Environmental Quality, U.S. Government Printing Office, Washington D.C., 120 pp.

BROWN, J. C., and JONES, W. E. 1975. — Heavy metal toxicity in plants. I. A crisis in embryo. - *Commun. Soil Sci. Plant Anal.*, 6: 421-438.

CORBET, P. S. 1970. — Pest management: objectives and prospects on a global scale. - In R. L. Rabb and F. E. Guthrie (Editors), *Concepts of Pest Management*, North Carolina State University, Raleigh, pp. 191-204.

CORBET, P. S., and SMITH, R. F. 1976. — Integrated control: A realistic alternative to misuse of pesticides? - In C. B. Huffaker and P. S. Messenger (Editors), *Theory and Practice of Biological Control*, Academic Press, New York, pp. 661-682.

EHRLICH, P. R., and EHRLICH, A. H. 1979. — Population, Resources and Environment. - W. H. Freeman and Company, San Francisco.

FAO. 1984. — Report of the FAO Panel of Experts in IPM, FAO, Rome.

GEIER, P. W. 1970. — Temporary suppression, population management, or eradication: How and when to choose. - In R. L. Rabb and F. E. Guthrie (Editors), *Concepts of Pest Management*, North Carolina State University, Raleigh, pp. 170-189.

GETZ, W. M., and GUTIERREZ, A. P. 1982. — A perspective on systems analysis in crop production and insect pest management. - *Annu Rev Entomol.*, 27: 447-466.

GLASS, E. H. (Coordinator). 1975. — Integrated pest management: Rationale, potential, needs, and implementation. - *Entomol. Soc. Am. Special Publ.* 75-2, College Park, Maryland.

GUTIERREZ, A. P., and WANG, Y. H. 1984. — Models for managing the economic impact of pest populations in agricultural crops. - In C. B. Huffaker and R. L. Rabb, *Ecological Entomology*, John Wiley and Sons, New York, pp. 729-761.

HARDIN, G. 1968. — The tragedy of the commons. - *Science*, 162: 1243-1248.

HARPAZ, I., and ROSEN, D. 1971. — Development of integrated control programs for crop pests in Israel. - In C. B. Huffaker (Editor), *Biological Control*. Plenum Press, New York, pp. 458-468.

HUFFAKER, C. B. (Editor). 1980. — New Technology of Pest Control. - Wiley Interscience. New York, 500 pp.

HUFFAKER, C. B., and SMITH, R. F. 1980. — Rationale, organization, and development of a national integrated pest management project. - In C. B. Huffaker (Editor), Wiley Interscience, New York, pp. 1-24.

HUNTER, W. D., and COAD, B. R. 1923. — The boll weevil problem. - *USDA Farmers' Bull.* 1329, 30 pp.

KENMORE, P. E. 1980. — The ecology and outbreaks of a tropical insect pest of the Green Revolution, the rice brown planthopper, *Nilaparvata lugens* Stal. - Ph.D. Thesis. University of California, Berkeley.

PATHAK, M. D. 1970. — Genetics of plants in pest management. - In R. L. Rabb and F. E. Guthrie (Editors), *Concepts of Pest Management*. North Carolina State University, Raleigh, pp. 138-157.

PHILLIPS, J. R. 1980. — Community (cotton) pest management can defeat *Heliothis*. - *Meister. Cotton. International Edition*, Vol. 47, p. 60, 67, 108.

PIMENTEL, D., TERHUNE, E. C., DRITSCHILO, W., CALLAHAN, D., KINNER, N., NAFUS, D., PETERSON, R., ZAREK, N., MISITI, J. and HABER-SCHAIM, O. 1977. — Pesticides, insects in foods, and cosmetic standards. - *BioScience*, 27: 178-185.

REGEV, U., GUTIERREZ, A. P., and FEDER, G. 1976. — Pests as a common property resource: A case study of alfalfa weevil control. - *Am. J. Agric. Econ.*, 58: 186-197.

REGEV, U. 1984. — An economic analysis of man's addiction to pesticides. - In G. R. Conway (Editor), *Pest and Pathogen Control-Strategic, Tactical and Policy Models*. John Wiley and Sons, Chichester.

SMITH, R. F. 1972. — The impact of the Green Revolution on plant protection in tropical and subtropical areas. - *Bull. Entomol. Soc. Am.*, 10: 7-14.

STRICKLAND, A. H. 1970. — Economic principles of pest management. - In R. L. Rabb and F. E. Guthrie (Editors), *Concepts of Pest Management*, North Carolina State University, Raleigh, pp. 30-43.

VAN DEN BOSCH, R., 1978. — The Pesticide Conspiracy. - Doubleday, Garden City, New York, 226 pp.

WATERS, W. E., STARK, R. W., and WOOD, D. L. (Editors). 1985. — Integrated Pest Management in Pine-Bark-Beetle Ecosystems. - Wiley Interscience, New York, 256 pp.

WATT, K. E. F. 1970. — The systems point of view in pest management. - In R. L. Rabb and F. E. Guthrie (Editors), *Concepts of Pest Management*, North Carolina State University, Raleigh, pp. 71-79.

ERRATA CORRIGE

Boll. Ist. Entom. «Guido Grandi» Univ. Bologna, vol. 40, 1986:

HUFFAKER C.B., GUTIERREZ A.P. - Organizational problems in integrated pest management.

pag. 182, 32ª riga

ERRATA	CORRIGE
I problemi organizzativi della gestione integrata dei <u>fitofarmaci</u> dannosi.	I problemi organizzativi della gestione integrata dei <u>fitofagi</u> dannosi.