CropLife INTERNATIONAL

Representing the Plant Science Industry

IPM

Integrated Pest Management

Integrated Pest Management

The way forward for the plant science industry

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CropLife declaration of plant science industry policy on Integrated Pest Management

CropLife member companies and associations support the aims of sustainable agriculture: to produce sufficient affordable food and fibre, economically and in an environmentally and socially sensitive manner, maintaining the natural resource base for future generations.

We are committed to Integrated Pest Management* (IPM) as defined by the FAO International Code of Conduct on the Distribution and Use of Pesticides, as an economically viable, environmentally sound and socially acceptable approach to crop protection.

It is the mission of the CropLife member companies and associations to provide customers with safe and effective technologies to protect against adverse effects caused by weeds, diseases and pests.

We enable and encourage the implementation of IPM by developing and selling appropriate products, techniques and services.

We cooperate with partners to develop and test IPM strategies and programmes, as well as providing education and training on the sustainable use of our products.

We measure and communicate progress within our industry on the adoption of the principles and values of this declaration.

* **Integrated Pest Management (IPM)** means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimise risks to human health and the environment. IPM emphasises the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.

THE PRINCIPLES AND BENEFITS OF IPM

Increasing quality, yields and sustainability

Sustainable agriculture is a key element of sustainable development and essential to the future well being of the planet. Sustainability aims to achieve adequate safe and healthy food production, improved livelihoods of food producers and the preservation of non-renewable resources. Integrated Crop Management* (ICM), and Integrated Pest Management (IPM), to which CropLife International members from the plant science industry are committed, are the strategies best suited to preserve our environment and natural resource base in the long term.

This brochure illustrates the principles of IPM and ways in which the plant science industry supports its wider adoption. It is intended for use by CropLife members and other stakeholders in support of their development and implementation of IPM strategies and programmes.

The demands of a growing world population for food and fibre require world agriculture to produce higher yields from less cultivated land. Feeding future populations with today's crop yields is not viable; it would require drastic expansion of planted acreage. In many parts of the world additional land is unavailable. In others, expansion of the cropped area would be environmentally and socially unacceptable. Increasing yields from existing land requires continuous improvement of agricultural technologies including those in crop protection to minimise losses before and after harvesting.

* ICM is a farming system that meets the requirements of long-term sustainability. It is a whole-farm strategy which involves managing crops profitably, with respect for the environment, in ways which suit local soil, climatic and economic conditions. It safeguards the farm's natural assets in the long term. It includes practices that avoid waste, enhance energy efficiency and minimise pollution. ICM is not a rigidly defined form of crop production but is a dynamic system which adapts and makes sensible use of the latest research, technology, advice and experience.

Population growth

Year	World population (billion)	Arable land & permanent crops (billion ha)	Farmland per person (ha)
1950	2,5	1,3	0,5
1975	4,0	1,4	0,4
2000	6,0	1,5	0,3
2020	7,5	1,5	0,2

Source: United Nations. 1999. World Population Prospects, the 1998 revision.

More people means less land per person for food and fibre production.

The challenge is to do this without harming the environment and the resource base for future generations of farmers and consumers. IPM is an important strategy which is a relevant aspect of sustainable agriculture.

Less land per person requires more high yielding agriculture to meet necessary demands for food and fibre. To be sustainable, this must be achieved within the framework of IPM.

IPM policies and objectives are being adopted increasingly in developed and developing countries. IPM implementation is most advanced in Europe and North America, and is expanding in Asia, Latin America and Africa. The goal is to achieve long-term sustainable systems of crop protection and production. The plant science industry recognises and supports this objective.

CropLife International invites member companies and associations to consider ways in which they can integrate the principles of IPM into their policies, business strategies and conduct.

What is IPM?

The plant science industry supports IPM as defined by the FAO International Code of Conduct on the Distribution and Use of Pesticides:

Integrated Pest Management (IPM) means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimise risks to human health and the environment. IPM emphasises the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.

For farmers and pest control operators, IPM is the best combination of cultural, biological and chemical measures that provides the most cost effective, environmentally sound and socially acceptable method of managing diseases, insects, weeds and other pests according to local conditions.

IPM takes into account all relevant control tactics and methods available locally, evaluating their potential cost effectiveness. It does not, however, consist of any absolute or rigid criteria. Implementation of IPM lies with the farmers, who will adopt those elements of IPM which are seen to be practical and add value to their activities.

IPM allows farmers and others to control diseases, insects, weeds and other pests in a cost-effective, environmentally sound and socially acceptable way.

IPM should also include the utilisation of appropriate varieties of crops and biological control agents, including those enhanced by biotechnology.

Therefore, an elementary principle of effective IPM is to develop strategies taking into account all relevant control tactics, and methods available locally. The successful user of IPM will evaluate the potential cost effectiveness of each alternative as well as the whole control strategy.

This recognises that implementation of IPM ultimately rests with the farmer and others trying to control pests. They will adopt and exploit those elements of IPM which are seen to be practical and add value to their activities when available.

IPM's place in sustainable development

IPM is the crop protection system which best meets the requirements of sustainable development and sustainable agriculture. IPM is a component of Integrated Crop Management (ICM). ICM has been developed as a farming system to meet the requirements of long-term sustainability. It is a whole-farm strategy which involves managing crops profitably, with respect for the environment, in ways which suit local soil, climatic and economic conditions. It safeguards the farm's natural assets in the long term. It includes practices that avoid waste, enhance energy efficiency and minimise pollution. ICM is not a rigidly defined form of crop production but is a dynamic system which adapts and makes sensible use of the latest research, technology, advice and experience.

IPM in the context of ICM and sustainable development

IFAD/Franco Mattioli

BASIC COMPONENTS OF AN IPM STRATEGY

Prevention, observation, intervention

IPM requires competence in three areas: prevention, observation and intervention. The first includes a range of practical strategies that can be rationalised to suit local conditions. Observation links monitoring with decision-making, often together with "expert systems". Intervention involves a range of physical, biological and chemical methods optimally employed to preserve the economic value of the crop with minimal effects on the environment.

PREVENTION

Many aspects of farm and crop management are designed to limit or prevent initial outbreaks of pests, weeds and disease infestations. Practical strategies, many already familiar in agriculture, can be combined and optimised to design IPM programmes. The goal is preventing pest populations from building up to economically damaging levels.

Location

Growing crops in appropriate locations where they are suited to climate, soil and topography provides the crop with optimal growing conditions from the start.

Crop rotation

Growing different crops in rotation helps reduce the build-up of certain pests, especially those in the soil, such as nematodes, root feeding insects and fungal pathogens. Rotations can also reduce weed problems and increase the range of weed control methods that can be used.

Cropping pattern

Planting of similar host crops alongside each other can substantially increase weed, disease or pest pressure, and should be avoided if possible.

Crop variety selection

Choice of crop variety has always been a cornerstone of Integrated Pest Management, especially the growing of disease and pest resistant varieties. These varieties may reduce the need for other crop protection measures.
Progress in genetic engineering increases the opportunity to develop new pest and disease resistant plants and herbicide tolerant crops, providing greater choice for farmers. Management is needed to delay or prevent the development of resistance.

Crop husbandry and hygiene

Mechanical, physical and cultural crop protection methods are important in promoting good crop development, and in preventing or minimising weed, disease and pest infestation. For example, traditional mould board ploughing turns the soil and buries crop residue and weeds before the seed bed is prepared for the next crop. But the process has led to increased erosion as well as loss of soil moisture and organic material, so it should be used only when necessary. It is desirable to combine it with other conservation techniques such as the use of contour ploughing and ridging. In many countries, there has been a trend towards reduced ploughing using herbicide technology. This has led to the practice of direct drilling in Europe and no till in the USA. As a result, soil erosion problems have been greatly reduced.
Good crop hygiene is also important in reducing the build-up and carry-over of pest populations from one crop to another. Methods are often labour intensive (e.g. removal and destruction of crop residue), but may provide an essential way of reducing the survival of some pests into the next season (e.g. in cotton, the carry-over of pink bollworm from one crop to another can be reduced by removing and destroying cotton trash).

Irrigation

Supply of water to the crop is essential to increasing and maintaining plant health and can greatly influence pest incidence and impact. Flooding of

some crops, particularly lowland rice, is important in checking weeds. However, flood irrigation can also adversely affect the survival of some soil-inhabiting beneficial organisms. In vegetables this can be lessened by growing the crop on ridges or raised beds, and should be taken into account in designing IPM programmes.


IFAD/Franco Mattioli

Natural habitat management and biodiversity conservation

Protection of natural habitats within the farm environment is recognised as a means of conserving biodiversity, including many of the natural enemies of pests. Careful management of farm land margins, as well as growing trees or hedges, are particularly important because they not only provide habitat, cover and refuge for beneficial insects and other animals (e.g. in rice paddies, field levees provide important refuges for predatory spiders which help control several important rice pests; and for snakes which help control rats), but also contribute to the conservation of flora and fauna.

Inter-cropping

Traditionally, some farmers may sow different crops in alternate rows, or undersow a crop (e.g. maize) with a legume (e.g. beans) to help improve soil fertility and reduce weeds. Such systems can be labour intensive and difficult to mechanise, but can help reduce pest pressures in individual crops.

Harvesting and storage

Carry-over of weed seeds and pathogens can be reduced by appropriate harvesting, seed cleaning and storage methods.

Tillage

Weed control by manual or mechanical soil disturbance is an age-old and often effective component of an IPM strategy. Tilling can complement other methods, such as the use of pre-emergent herbicides when rainfall is untimely or insufficient. In sequence with post-emergence herbicides, tilling can be very effective when continuous germination of weeds poses a challenge. However, tilling can be labour and energy intensive, and, like ploughing (above), can pose threats to soil quality and erosion. Often, application of an appropriate herbicide may be the wiser option.

Plant nutrition

Different soil types contain varying amounts of nutrients. At harvest-time, nutrients are removed with the harvested crop from the soil. In order to maintain or improve soil fertility, these nutrients have to be replaced via mineral and organic fertilisers. Plant nutrition management provides the necessary nutrients for each soil, at the right time and in the correct amounts in order to maintain soil fertility and avoidance of erosion.

Crop monitoring or observation is a key step in deciding if, when and how to intervene. Many indirect prevention measures have a cumulative effect – for example, host plant resistance and crop rotation and conservation of natural enemies, all help to reduce pest pressure, but are often not sufficient on their own to eliminate the need for some form of intervention.

OBSERVATION

The aim of observation is to determine IF, WHEN and WHAT action should be taken to maximise crop production and optimise quality at harvesting. This involves crop monitoring and decision support systems to interpret the data. Decision tools, or "expert systems" range from pegboards to computers, trained local experts to remote sensing technologies.

Crop monitoring

Management of any crop requires routine inspections to assess how well plants are growing and what actions need to be taken on cultivations, fertiliser use, weed, insect, other pest and disease control, as well as when to harvest. Monitoring for pests is an important part of the need to "walk" through a crop. There is a need to be able to distinguish between pest, non-pest and beneficial species. Various tools, such as pheromone traps, diagnostics and forecasting systems are available to assist pest monitoring, minimise the time required, and achieve acceptable accuracy in determining changes in pest infestation.

Decision support systems

Farmers need assistance in interpreting pest monitoring data. Simple "expert systems" can be designed and made available to farmers in a range of ways, including simple pegboards or charts, special booklets, radio and television programmes or more advanced aids such as prediction models and computer-based systems. Development and provision of up-to-date information is a key factor enabling farmers to implement IPM programmes.

Area-wide management

IPM often requires collaborative decisions within a national or more localised area to provide effective control of pests. Some of these decisions need to be taken centrally by governments in relation to:

- quarantine regulations and legislation
- provision and training of advisory services
- strategies for control of highly mobile pests (e.g. locusts)

Geographical Information Systems (GIS) and remote sensing techniques can also assist in implementation of area-wide management.

INTERVENTION

Reducing the effects of economically damaging pests, weeds and diseases to acceptable levels may involve mechanical, biological, chemical and biotechnological control measures applied individually or in combination. Costs, benefits, timing, available labour force, machines/tools and control agents, as well as economical, environmental and social effects all have to be taken into consideration.

Cultural and physical control

A number of cultural and physical techniques continue to be used in agriculture (e.g. weed control by manual methods or tractor cultivation; disease control by removing infected plant debris). Before including such methods in IPM recommendations, their impact on yields (e.g. through root disturbance) and their requirements for labour inputs and energy consumption need to be assessed. Recommendations must be practical. Also, the possibility of integrating appropriate cultural techniques with judicious use of plant protection products should be explored (e.g. instead of replacing manual weeding entirely by herbicides, it may be better to use band treatments to control weeds close to the crop plants, but continue to hoe the central part of the inter-row space).

Biological control

Research on nature's own methods of pest control is yielding new useful products and methods which can be integrated into IPM programmes. However, most biological control techniques (e.g. using beneficial insects, mites, nematodes) work best when crops are grown in controlled environments (e.g. glasshouses and plastic tunnels) to ensure consistent results. There are cases when control techniques with living organisms are successful in open field conditions (e.g. predatory mites against spider mites). However, biological products are generally too often unreliable or not efficient enough in the field to be commercially used on their own. Nevertheless, there is an increasing interest in using other biological products (e.g. viruses, fungi and bacteria). These require similar technical expertise as chemical agents in relation to formulation, field application and resistance management.

Biological control includes introducing beneficial insects or predators, applying biological products such as viruses, fungi and bacteria and using pheromones to trap, lure and kill, or interfere with insects' mating habits.

Classical biological control (i.e. the introduction of a predator or parasite to control a particular pest species) and inundative control (i.e. repeated mass release of a control agent) programmes do not necessarily remove the need for other interventions. Combining biological and chemical control is achieved through selection of the appropriate chemical active ingredient or formulation type, or separating their use over time. Likewise, judicious use of biotechnology derived crops, for example those providing insect resistance, should be considered.

Micro-organisms such as bacteria, fungi or viruses, have been mass produced to control some pests. The most common and successful is Bacillus thuringiensis (Bt), a naturally occurring bacterium, which has been used to control several important pests (e.g. mosquitoes and caterpillar pests in vegetables, vineyards and orchards). The insect spectrum of activity is narrow compared with most synthetic chemicals, and this is useful in IPM strategies. Gene technology has produced plants that express this natural control agent, delivering it more effectively to the pest.

IFAD/Anwar Hossain

Development and availability of pheromones offer interesting new possibilities for the farmer:

- selective trapping techniques to monitor the movement of pests or changes in populations during the season
- use in "lure and kill" strategies to attract the pest to localised insecticide deposits and reduce the need for overall crop spraying
- mating disruption to delay or reduce the need for control treatments

Chemical control

A very wide range of chemical products is available. These represent the results of some fifty years of research, development and field experience around the world by the plant science industry. With current knowledge, the use of chemical control agents represents in many situations the most important and widespread means of achieving reliable and cost-effective reduction of pests (disease, insect, weed and rodent) infestations. In addition, herbicide tolerant varieties have expanded the range of options available to the farmer. It is essential to reduce unnecessary user exposure to plant science products, improve standards of work practice and hygiene, limit residues in the environment and harvested crops, and avoid potential problems of pest resurgence and pesticide resistance. The industry promotes a full life-cycle approach throughout development, handling and use of their products. Judicious application of chemical products to minimise the risk of adverse effects is integral to the principles of IPM.

Local recommendations for IPM will vary depending on the farming system, crops being grown and climatic conditions. Whether of synthetic or natural origin, plant science products will remain indispensable components of IPM in agriculture systems on a worldwide scale. Their use in Integrated Crop Management systems must be based on the principles of IPM.

To make full use of naturally occurring beneficials, great care is needed to maintain untreated refuges (e.g. hedgerows, field margins, or "natural wildlife island" habitats). Improved application techniques of chemical controls (e.g. improved targeting, reduced drift, spot spraying) offer some way of reducing exposure of beneficials. The main requirement is to ensure that the timing of treatment (during day and season) as well as specificity of product used, reduce adverse effects on beneficials as far as possible.

TECHNOLOGIES AND SERVICES REQUIRED FOR IPM

Working together for sustainable productivity

Successful IPM must be based on farmers' needs, concerns and circumstances. A wide range of products and services are required by farmers in order to adopt IPM, calling for close interaction between them, the scientists and the experts developing IPM technologies. Farmers themselves are often the best judges of what is the most appropriate technology for their needs but the farmer's options may be limited due to government intervention. Targetted, judicious and appropriate use of technologies protect and enhance the environment and contributes to sustainable production.

Product research and development

- Searching for and developing chemical, natural, biological and biotechnology products which widen the range of technologies available for IPM programmes.
- Investigating methodologies for incorporating new and existing products into IPM strategies.
- Developing decision-making tools such as diagnostics and forecasting systems.

Field application

Development and testing of farmer-oriented whole season crop programmes which may include:

- crop calendar and critical stages for pest control
- pest (disease, insect, weed) complexes
- identification of appropriate prevention, observation and intervention measures
- application techniques
- weather patterns

Economic or action thresholds replace routine calendar schedules by only treating when infestation levels may cause economic damage. Constant monitoring of pest populations, the stage of the crop and other biological and economic factors all play a role in setting threshold levels.

Economic or action thresholds

- To develop and test appropriate economic or action thresholds, it is important to monitor infestation levels in a crop and only treat those which cause economic damage. The economic or action thresholds may change depending on the stage of crop development. On the other hand a range of biological and economic factors can influence threshold levels. It is important that thresholds are defined in a simple and understandable way so that farmers can adopt them in practice without undue difficulty. Much work still needs to be done to develop accurate thresholds for the wide range of crops, pests and environments that farmers have to deal with on a daily basis.

Sampling methods

- Farmers need simple methods for quickly determining whether a pest population in a crop is likely to cause economic damage. Guidance and support is needed to establish the effectiveness of different sampling procedures and related decision criteria.
- There are many ways in which local knowledge can be used to help develop practical methods acceptable to farmers. In some regions, it may be possible to develop local computerised databases to assist in making decisions on an area-wide basis.

Conserving beneficials

- The impact of crop protection products on important beneficial insects and other species needs to be monitored as a basis for developing appropriate IPM strategies.
- Conserving natural enemies of pests is recognised as an important part of IPM programmes. This should take account of the natural regulation of pest populations and their dynamics. So, in addition to assessing the effect of a crop protection product or biotechnology derived crop on the pest, the impact on important natural enemies also needs to be considered. Reductions in the amount of product used through IPM practice may reduce the exposure of natural enemies and lessen the risk of pest resurgence. Maintaining minimum pest and non-pest populations for natural enemies to feed on may be essential for their survival. Such an approach requires a more fundamental understanding of the impact of different control strategies on the population dynamics of the pest/natural enemy system.
- Research should also assess the importance of weeds and other local plants that may encourage survival of beneficial species at field edges.

Novel products and techniques

- The continued search for novel modes of action of chemical and new biotechnology products will widen the range of IPM strategies and practices available to farmers and others managing pests economically and sustainably.

Technologies and services include the development and use of chemical, natural, biological and biotechnology products for pest control, possibly computer-aided sampling and decision-making, applying different methods and improving farm equipment. Farmer-orientated programmes are essential to put these into practice.

Resistance management

An important consideration when using crop protection products is to prevent and manage the emergence of pests, weeds and diseases resistant to agrochemicals. IPM offers a combination of tools, which reduce the risk that resistance will develop in pest populations: monitoring the development of populations of pests and applying treatments when the economic threshold is exceeded and implementing strategies such as alternating or mixing compatible crop protection products with different modes of action.

- A grower should utilise all tools available to avoid development of resistance. These tools include chemical and biological insecticides but also any agronomic practices that would reduce insect populations, such as crop rotation or reducing crop residues at the end of the season. The industry can provide the information, but the grower must make the final decision.

Biotechnology

Biotechnology has considerable potential to contribute to sustainable biological elements of IPM. One focus of biotechnology research has been on improving natural enemies of pests as pest control agents. This has focused principally on pathogens of insect pests and their use as formulated biological pesticides. The second and most rapidly expanding area of biotechnology for pest control has been the development of crop varieties resistant to pests and diseases, or tolerant to herbicides, through genetic engineering.

Improved application methods

Targetted and timely application of products is an essential element of efficient pest control. This requires the use of appropriate and well maintained equipment as well as a knowledge of the pest. Many pests can survive under the “umbrella” of leaves which collect the spray because farmers hold the nozzle above the crop. In excessively high volume applications, the spray often completely wets the top leaves and then drips over the outer canopy to the soil. This wasted spray can have serious adverse effects on soil-dwelling natural enemies, especially spiders and ants. When farmers see pests surviving, they will often spray some crops as frequently as twice a week, instead of investing in better equipment, or changing their

spraying practices. Even simple changes (e.g. by directing the nozzle or lance to spray more where the pest is located, on the undersides of leaves or control of pressure at the nozzle) can improve spray coverage and give better control of a pest.

Even simple changes, such as directing the spray to the undersides of leaves where the pest is located, can give better control of a pest.

Many farmers spray late or alter the dose because of difficulties in obtaining sufficient water to spray, especially in semi-arid and arid areas. However, there are reduced volume techniques available that allow farmers to treat more quickly when the pest population reaches the economic threshold. In other situations, granule application is more appropriate as the product can be localised, for example in the root of a crop or in the "funnel" of maize plants. Seed dressing, particularly with a systemic product that is transported throughout the plant, offers another solution to inefficient application, and also minimises impacts on non-target organisms. There is therefore a need to support changes in application efficiency rather than accept that farmers will only use the equipment currently on sale in the marketplace.

The use of genetic engineering to incorporate pest resistance within the plant achieves both accurate and timely delivery of the active ingredient.

Season-long IPM crop programmes

- Research to determine the most suitable crop protection products, appropriate local dosage and timing recommendations during the crop season, needs close collaboration amongst scientists, as well as farmers, developing IPM in a particular farming area. Instead of recommending a number of separate products against individual pest species, IPM may require a programme designed for a crop in a given area. The aim is to have season-long recommendations including products that complement other IPM tactics and provide a means of resistance management.

Pre-testing IPM methods and programmes

As a prerequisite to developing an appropriate control programme it is important to understand farmers' perceptions of the pest problems and current practices of pest control. Socio-economic research is needed to assess the acceptability and applicability of IPM recommendations. Agriculture is a dynamic process so IPM recommendations must be flexible enough to adjust to changes in the environment, cropping patterns and market forces. It is important to understand the wider socio-economic effects of IPM programmes and the components they use. For example, the use of herbicides is sometimes seen as contributing to problems of urban migration. On the other hand, manual weeding is time consuming and labour intensive, and not always possible to perform at the right time. This is an important problem since yields of some crops suffer due to late weeding and root damage.

IFAD/Franco Mattioli

THE ROLE OF THE PLANT SCIENCE INDUSTRY IN DEVELOPING IPM STRATEGIES

Providing thoughtful, informed advice and access to technology

Farmers remain the primary decision-makers in IPM programmes. Individually or collectively they have to decide how to manage all the insects, weeds, diseases and other pests that may cause sufficient crop damage to result in economic losses if no action is taken. The role of the plant science industry is to provide access to a wide range of appropriate technologies, services and products and as much information as possible on their characteristics, costs, specificities and optimal strategies for their use within IPM principles.

A range of technologies can be considered for use in IPM programmes; sensible choice requires good knowledge and expertise being available to farmers and their advisors.

The extent of economic losses can vary significantly between seasons, depending on weather conditions and other factors. Since the severity of pest infestations varies, it is generally far better to monitor pest populations or the damage they cause before deciding to use a crop protection product when a certain threshold has been reached. This threshold is usually called the "economic threshold". It is defined as the pest population level that causes losses greater than the cost of controlling the pest.

One difficulty with the use of economic thresholds as a decision tool is that they depend on the value of the crop and the income from the sale of crops can change rapidly, especially for some horticultural crops which depend on supply and demand conditions in local markets. The threshold is also dependent on the pest pressure and the stage of crop development at which it occurs. The latter is important because many crops can compensate for some damage, at least during part of their cycle of crop growth. The growing of resistant varieties can reduce the severity of some pests on the crop, but there is still a need to monitor pest populations and check the need for additional intervention based on economic thresholds.

Available technologies for an IPM strategy

1. Variety selection The correct choice of variety suitable for location and climate, and also, where appropriate, resistant to pests or tolerant to herbicides, is one of the first decisions a farmer needs to make. A large number of conventional varieties are available to the farmer and the choice is increasing through developments in genetic engineering.

2. Chemicals In developing an appropriate strategy of chemical control in IPM programmes, it is essential to review the known product characteristics and costs of products which are locally available; then select those products which provide the most cost-effective treatment with minimal undesirable side effects and which together provide an effective resistance management strategy. Careful advice on the most appropriate crop protection product to use in an IPM programme is needed. Some chemicals have a broad spectrum of activity, while others are only active against a few pest species. Selective compounds are less likely to affect natural enemies and other non-target organisms, but are often more expensive and not so widely available. When they are available, it is important to determine whether fewer applications of a more selective but more expensive compound are actually more cost-effective than a cheaper broad-spectrum compound which requires more applications.

In some circumstances, early prophylactic chemical treatment may be used to reduce the number of later season sprays. A good example of this is the use of a seed treatment, which may be essential to protect young seedlings during a critical period of crop establishment.

Most commercially available products have a broad spectrum of activity. When reviewing the choice of such compounds in IPM programmes it is important to distinguish between intrinsic toxicity and bio-availability. The intrinsic toxicity of some broad spectrum compounds against natural enemies can be misleading. Under some field conditions “behavioural selectivity” can occur which limits their “bio-availability” against non-target organisms. For example:

- Where pesticides are highly systemic within the plant, localised treatments may keep contact between the active ingredient and non-plant eating organisms to a minimum.
- Compounds with translaminar penetration of leaves combined with fast degradation on the leaf surface can also be “selective”.
- Products with short persistance or bio-availability can also be “selective” even though there could be an initial impact on beneficials.

- If care is taken in terms of dose applied as well as timing and placement of the application (e.g. seed treatment) then the exposure of non-target organisms can be reduced.

3. Biocontrol agents Mass release of pest predators or parasites or application of microbial pesticides may be an effective option in some environments. However, they rarely remove the need for additional control measures.

Review the range of product dose suitable for IPM in relation to local pest conditions and the agricultural ecology.

Practical considerations

It is very likely that a combination of different approaches will be used in most situations. In any IPM system the possible side effects of all the crop protection interventions used should be taken into account. For example, while insecticides as a group are ranked as the most toxic against arthropod natural enemies, some fungicides and herbicides are also rated as harmful.

It is important to recognise that populations of beneficial species can recover quite quickly, even when broad spectrum products are used, particularly if they are easily degradable, by migration and recolonisation of sprayed areas from refuge areas at field margins. Systematic adoption of action thresholds prevent unnecessary applications and enhances the beneficial fauna. Wherever feasible, such considerations should be taken into account when recommending which products to use.

It is also possible to physically limit the impact of broad spectrum products. Part of a crop area can sometimes be left untreated to allow natural enemies to survive and recolonise the treated areas. Another example is band treatment of fruit tree stems to prevent certain pests climbing into the upper canopy, or to restrict movement of predators so that beneficial insects can survive in fruit tree canopies. Selective treatment with a non-persistent pesticide can also limit overall impact on beneficial populations.

- **Look after beneficial insects.**
- **Do not spray flowering crops when bees are busy pollinating.**
- **Do not spray field margins with insecticides and avoid drift onto hedgerows.**
- **Where practical, use selective insecticides.**

Sustainable use

Every product should be used according to the label recommendations. These are designed to provide reliable control under average field conditions and cover the legal responsibility of the supplier. They also provide instructions on how to handle and apply the product. Recommendations on the appropriate storage, transport and disposal of unused products and empty containers are also available and should be strictly followed. The industry actively promotes this through its life-cycle approach to product stewardship. Ideally, the minimum effective dose of a product should be employed against a particular pest to provide adequate control.

IFAD/Lou Dematteis

IPM IMPLEMENTATION

Many links in the chain

The global plant science industry has a major role to play in the widespread adoption of IPM by farmers and other users of crop protection and pest control products. This requires mutual support and collaboration with government and non-government organisations (NGOs), and also international research-based companies, international, national and local associations, distributors, dealers and retailers and of course, farmers themselves.

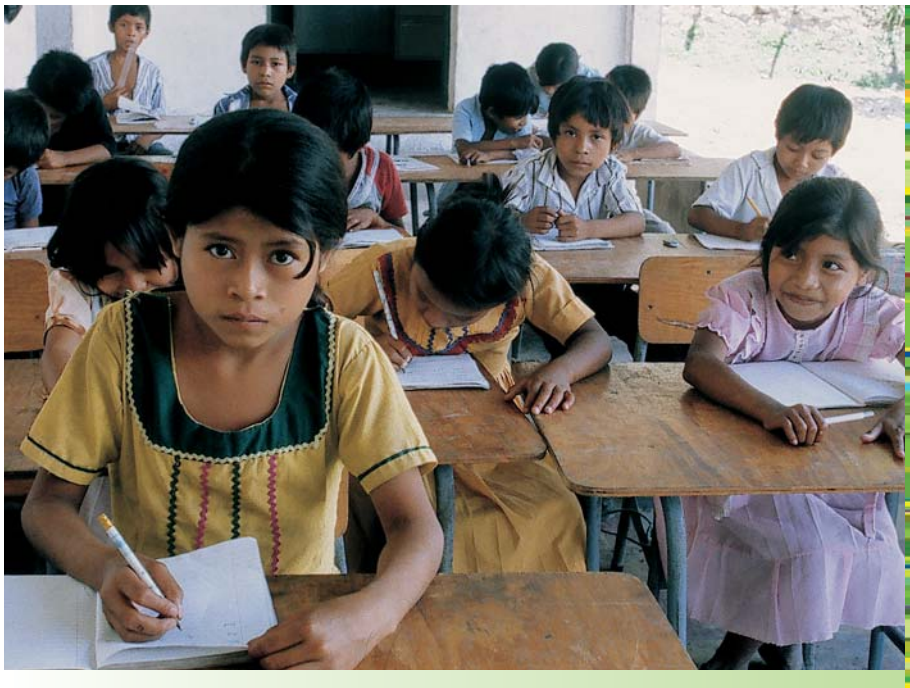
The range of skills in the plant science industry (e.g. technical, research, product development, marketing, education and training), its experience, resources, products and infrastructure are all relevant to the goal of transforming IPM into a reality in the hands of farmers and others trying to manage pests sustainably.

Education and training

This is a vital part of IPM implementation. There are many links in the chain, from scientists developing IPM to farmers and pest control operators practising it. Appropriate education and training are likely to be required at each step. Some **key components** include:

- Training of technical and teaching staff, who may be the key people for taking the IPM message to advisory and sales staff. Also, broadening the training to those concerned with marketing of crop protection and biotechnology products, so that they are well informed about IPM. It is important to ensure that the promotion of products complements the implementation of IPM programmes.

- Training of government, private extension staff, distributors and retailers is an important link with a direct influence on individual farmers. They need to be able to provide practical advice to farmers about appropriate local IPM programmes and practices.
- Development of education and training programmes for farmers. Practical ways of reaching smallholder farmers as well as large-scale plantations, estates and professional pest control operators need to be identified (e.g. farmer field schools, mass media like TV or radio, newsletters, direct mail, videos, colour charts to help pest recognition, simple pegboards to count pests and make the use of economic and action thresholds easier, traps for pest population sampling).
- In the longer term, it would help maintain IPM implementation if the next generation of farmers were trained in IPM principles and technologies at school. Much of the training information prepared for farmers could be adapted for schools.



Training of farmers and their families is an essential element in ensuring the implementation of IPM over the long term. Much of the training information prepared for farmers could be adapted for schools.

Education and training needs to enable farmers and others trying to manage pests properly, that IPM is relevant to their local circumstances and that it will bring them benefits. It should provide the means for farmers to better understand the population dynamics of pests and beneficial organisms in their crops and the impact of any control actions they undertake. A range of knowledge and practical skills are required by farmers to adopt and implement IPM. These include:

- Recognition of pests, beneficials and their uses.
- How to keep initial infestation pressure low using every farm management opportunity (e.g. optimised cropping system and sowing dates).
- How to select the most suitable cultivars to grow.
- How to assess the importance of different pest populations and crop damage, as a low pest population may not cause economic damage.

- How to monitor for resistance.
- Product knowledge – pests controlled, effects on beneficials.
- How to select which crop protection products to use; with emphasis on efficacy to the target pest, user and environmental safety, specificity on the target pest, and resistance management strategy.
- How to decide when to apply a crop protection product.
- Where crop protection products are needed; and if treatments can be localised.
- What equipment is needed to apply the product.
- How to calibrate equipment.
- What safety precautions are needed for applicators, others and the environment.

IPM implementation is often required on an area-wide basis. Much of the success of a programme will depend on educating all those involved in an area to accept the same overall policy. This applies particularly to the non-chemical aspects, such as synchronous sowing and uprooting dates when recommended as part of an IPM programme. Use of pheromones, especially in mating disruption programmes, must also cover extensive areas for success. Some aspects of a pesticide policy require an area-wide adoption (e.g. resistance strategies need to be used over a large area, although there is freedom for companies to compete with services and products with the same mode of action or common resistance mechanism within a region).

Multi-stakeholder partnership

The last decade has seen an increase in partnerships and alliances among various stakeholders, including the public and private sectors. At first sight, the private sector and the public sector would appear to have little in common.

• **Private sector**	• **Public sector**
profit-driven	non-profit
highly competitive	non-competitive
return on investment	socio-economic investment
shareholder capital	social and human capital

LITTLE IN COMMON?

The private sector is profit-driven and highly competitive, concentrating on return on investment and based on shareholder capital. The public sector is non-profit and non-competitive, concentrating on socio-economic investment and based on social and human capital.

There is a common ground, however. Public-sector institutions promote an environment in which the economy thrives by fostering human development, social cohesion and good governance, i.e., factors for sustainable development. The private sector increasingly acknowledges that without social infrastructure, education, health, access to clean water and arable land, no stable political and enabling environment can be guaranteed, and this, in turn, affects the private sector "bottom line". There is a recognition of the need to address the "triple bottom line" – social, environmental and economic factors – if the goals of sustainable development and sustainable business are to be realised. The public sector is coming to realise that the private sector is a driving force behind growth and that it should not be overlooked when poverty alleviation initiatives are being formulated.

A more lasting impact could be achieved if poverty was addressed by building on each partner´s competencies and comparative advantages and by creating long-term relationships through the expansion of successful partnerships in both scope and geographic coverage.

Technology transfer and capacity building

Long-term and sustainable adoption of IPM by farmers will only occur if the information and knowledge of the principles and technology that underly the strategy are made available to them. A sense of "ownership" for that strategy by the farmers as well as local governmental and non-governmental organisations is also key. An essential element towards achieving this is providing access to information and training that can enhance the capacity of these groups to implement the strategies effectively and further develop and adapt them to local conditions. The industry is actively engaged in training and capacity building programmes across the world which provide the knowledge required to apply IPM practically and use the range of products available effectively.

OR COMMON GROUND?

The public sector fosters human development, social infrastructure, education, health, access to clean water and arable land, and stable governance – all essential for sustainable development. The corporate sector can provide a driving force for growth, alleviating poverty and promoting sustainable agriculture through programmes such as IPM.

QUESTIONS AND ANSWERS

Summary

What is IPM?

IPM is a site-specific strategy for managing insect, weed, disease and other pests in the most cost effective, environmentally sound and socially acceptable way. This means IPM is not a rigidly defined form of crop protection, but a dynamic system that adapts and makes sensible use of local resources and the latest research, technology, advice and experience. Below are some questions and answers to help illustrate further aspects of IPM.

Who supports IPM?

- Widespread implementation of IPM is supported by consumer and environmental groups, food chains, major donors, aid agencies and non-governmental organisations in agricultural development, the FAO, as well as national governments and the plant science industry itself.
- Adoption of IPM is an important part of sustainable agriculture. This is endorsed by the FAO World Food Summit (Objective 3.1) and the Rio Environmental Conference (Agenda 21). It forms part of the FAO International Code of Conduct on the Distribution and Use of Pesticides.
- Adoption of IPM is growing fast in developed and developing countries, motivated by the desire to achieve long-term sustainable systems of crop protection and production, at national and international level.
- IPM is becoming incorporated into regulatory policies and strategies of governments, donor and development agencies. Legislation is increasingly being used to support integration of IPM into farming practice in developed and developing countries.

Why is IPM important for the plant science industry?

- IPM is central to sustainable agriculture and the long-term viability of farming is integral to the long-term viability of the industry, society and the environment.
- Adoption of IPM will increase public confidence in the appropriate use of crop protection products.
- Widespread adoption of IPM will not be accomplished without support from the global plant science industry.
- The plant science industry has always responded quickly to the needs of its customers and should be pro-active in meeting their future needs.

How is IPM likely to help farmers and other customers?

- Improved consumer confidence in the quality of food and fibre products.
- Improved crop profitability where currently available pest control measures and crop protection products are inappropriately used.
- Stable, reliable and quality yields.
- Reduced severity of pest infestations.
- Reduced potential for problems of pest resistance.
- Secure agricultural environment for future generations.

How does the plant science industry support IPM?

Much of the research, development, technology transfer, education and training undertaken by the plant science industry, already supports implementation of IPM. However, more can be done to research and develop IPM technologies and promote their transfer into practice. The plant science industry can play a key role in this.

Here are some examples of what individual crop protection companies are doing:

General

- Integrating IPM awareness and principles into business plans and product development strategies where feasible.
- Developing IPM skills and understanding.

Research and development

- Developing IPM-compatible crop protection products including chemicals, semio-chemicals to modify pest behaviour, biotechnology and biological control products.
- Supporting screening programmes to monitor the effects on natural enemies in target crops, and environmental fate.
- Developing practical IPM crop programmes and pest control strategies.
- Developing effective decision-making systems (e.g. diagnostic tools and pest population forecasting systems).
- Product research, including reduction of drift, run-off and leaching into ground water, safer and more effective formulations, seed treatment, improved packaging and disposal.

Training and education

- Develop appropriate programmes and media for in-house IPM training for management, marketing, sales, technical and other relevant staff.
- Support and promote practical IPM training programmes for distributors, dealers, farmers, advisory services, agricultural schools, school children.

Marketing and sales

- Include IPM information and recommendations on product labels, technical literature and other educational materials.
- Establish IPM demonstration sites and farms.
- Integrate marketing and sales performance incentives with "IPM performance".

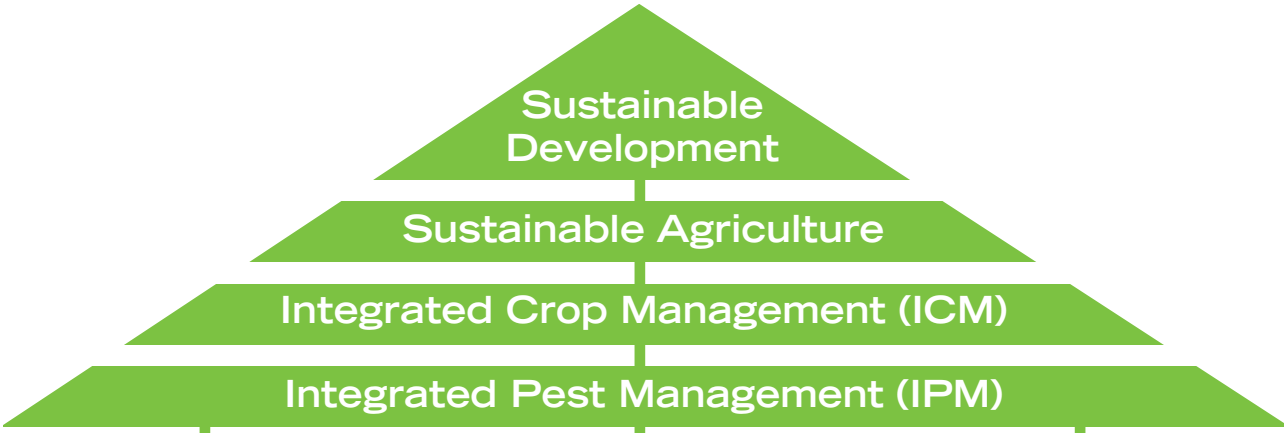
Cooperation with other organisations promoting IPM

- Participate in local IPM projects supported by FAO, World Bank, other development banks, donor agencies, NGOs and other organisations, bringing in industry's expertise and competence (e.g. training in responsible use of crop protection products, application techniques, product knowledge, control thresholds).

What are the benefits of IPM for the plant science industry?

Innovative crop protection companies, which integrate IPM principles into their marketing and customer support services for products, stand to benefit from:

- Sustained market share and access, and less risk of restrictions or deregistration.
- New opportunities for established and novel products, techniques and services.
- Longer product life cycles.
- Decrease in resistance of pests, diseases and weeds to chemical control.
- Increase public confidence and credibility.
- It's the right thing to do!



Basic Components

Prevention
- Location
- Crop rotation
- Cropping pattern
- Seed selection
- Crop husbandry and hygiene
- Fertilisation
- Irrigation
- Habitat management
- Inter-cropping
- Harvesting and storage
- Tillage practice

Observation
- Crop monitoring
- Decision support systems
- Area-wide management

Intervention
- Cultural and physical control
- Biological control
- Chemical control

Technologies and services

Research and Development
- Low-dose products
- Selective action
- IPM positioning of broad spectrum products
- Safety to people and the environment
- Resistance management
- Need directed optimum use recommendations
- Application technology
- Biopesticides

Crop variety selection
- Improved varieties with disease and pest resistance through genetic engineering and traditional breeding

Disease control
- Fungicide technology
- Diagnostics

Insect control
- Insecticide technology
- Pheromones
- New modes of action
- Band treatment

Weed control
- Herbicide technology
- Band treatment
- Weed control in conservation areas

Erosion control
- Conservation tillage techniques: direct drilling, no-till, minimum tillage
- Cover crop management

IPM Implementation

Education and training
- Staff including company, government, distributors and retailers
- Universities, colleges and schools
- Users: plantations, food processing companies, commercial growers and smallholders
- Topics include: pest and beneficial recognition, appropriate IPM strategies, product knowledge, product safety

Multi-stakeholder partnerships
- Corporate sector
- Public sector
- Scientific community

Technology transfer and capacity building
- Farmers
- Government research and extension
- Non-government organisations
- Industry

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CropLife International is the global federation representing the plant science industry.
It supports a network of nearly 100 regional and national associations and their member companies worldwide, led by companies such as BASF, Bayer CropScience, Dow AgroSciences, DuPont, FMC, Monsanto, Sumitomo and Syngenta.

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Publisher: CropLife International
Responsible: CropLife International IPM Project Team
Editorial address: BASF AG Eva Erisgen, Agricultural Center Limburgerhof,
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Layout: Artwork, Munich