For: B Sc IV Semester Biotechnology

What is IPM?

According to the Food and Agriculture Organization (FAO) of the United Nations*, IPM means considering all available pest control techniques and other measures that discourage the development of pest populations, while minimizing risks to human health and the environment.

For farmers, IPM is the best combination of cultural, biological and chemical measures to manage diseases, insects, weeds and other pests. It takes into account all relevant control tactics and methods that are locally available, evaluating their potential cost-effectiveness. IPM does not, however, consist of any absolute or rigid criteria. It is a flexible system that makes good use of local resources and the latest research, technology, knowledge and experience.

Ultimately, IPM is a site-specific strategy for managing pests in the most cost-effective, environmentally sound and socially acceptable way. Implementation of IPM lies with farmers, who adopt practices they view as practical and valuable to their activities.

Why is IPM Important?

The demands of a growing world population for food and fiber require farmers to produce more crops on existing farmland. To increase these yields requires continuous improvement of agricultural technologies to minimize crop losses. The challenge is to do this while protecting the environment.

IPM is a big part of the solution. Increasingly it is being adopted in both developed and developing countries for long-term, sustainable agriculture that achieves adequate, safe and quality food production, improves farmer livelihoods and conserves non-renewable resources.

been used to control several important pests (e.g., caterpillar pests in vegetables, vineyards and orchards). With modern biotechnology, crops like corn and cotton can now express the insect toxin produced by this natural control agent, delivering it more effectively.

Finally, the development and availability of insect sex pheromones and other behavior-modifying chemicals offer farmers the possibility of:

- **Selective trapping techniques to monitor the movement of pests or changes in their populations during the season**
- **"Lure and kill" strategies to attract the pest to insecticide deposits and reduce the need for overall crop spraying**
- **Mating disruption that slows population build-up to delay or reduce the need for control treatments**

Biotechnology also has considerable potential to contribute to IPM. One focus of research has been on mass production of micro-organisms that cause disease in insect pests and weeds or compete with plant disease-causing organisms. The second and most rapidly expanding area of biotechnology for pest control has been the development of crop varieties resistant to pests and diseases and/or tolerant to herbicides. These varieties incorporate insect or disease resistance within the plant for accurate and timely delivery of an active ingredient.

CHEMICAL CONTROL

Chemical crop protection products (pesticides) are biologically active chemicals that control a range of insect and vertebrate pests, diseases and weeds. They are often the most cost-effective way of controlling infestations as part of an IPM strategy. Today's crop protection products are the result of more than 50 years of research, development and field experience around the world by the plant science industry.

Before crop protection products are released in the market, they are thoroughly tested for their safety, usefulness and effectiveness. When sold, they are labeled with explicit use instructions.

To get the most out of these products, they must be applied correctly. Responsible use and good handling practices limit potential pesticide residues in crops and the environment as well as help avoid pest resurgence and resistance.

Improved application techniques and equipment, such as reduced drift nozzles and spot spraying, help farmers protect untreated refuges (e.g., hedgerows and field margins) and natural habitats for wildlife and pest enemies. The timing of treatment (season and time of day) as well as the types of products used are also critical factors.

Monitoring

Observing crops determines if, when and what action should be taken to maximize crop production and quality. Decision-making tools range from pegboards to computers and trained local experts to remote-sensing technologies. Getting real-time information on what is happening in the field is ideal.

Management of any crop requires routine inspections to assess how well plants are growing and what actions need to be taken from seeding to harvest. Walking through a field involves scouting for pests and distinguishing them from non-pests and beneficial insects. Tools like pheromone traps, diagnostics and forecasting systems can assist with such monitoring in a timely and accurate way.

IPM often requires collaborative decisions within a specific geography to provide effective control of pests. Some of these decisions need to be taken by national governments in relation to quarantine regulations and legislation, provision and training of advisory services and strategies for control of highly mobile pests like locusts. Geographic information systems and remote-sensing techniques can also assist in area-wide management.

Intervention

Reducing economically damaging pests to acceptable levels may involve cultural, physical, biological and chemical control measures individually or in combination. Costs, benefits, timing, labor force and equipment as well as economic, environmental and social impacts all have to be taken into consideration.

CULTURAL AND PHYSICAL METHODS

These techniques, such as weed control by tractor cultivation or disease control by removing infected plant debris, should be assessed for their impact on plant roots and yields as well as their requirements for labor and energy. Also, the possibility of integrating cultural techniques with the careful use of crop protection products should be explored. For example, instead of replacing manual weeding entirely with herbicides, hoeing may be used in conjunction with them.

BIOLOGICAL CONTROL

Research on nature's own methods of pest control is yielding new products and methods that can be used in IPM programs. Many of these require similar technical expertise as crop protection products in relation to formulation, field application and resistance management.

These controls include introducing beneficial insects or predators; applying micro-organisms such as viruses, fungi and bacteria; and using pheromones to lure, trap and kill or interfere with insects' mating habits.

Using beneficial insects to control pests works best when crops are grown in controlled environments like greenhouses and plastic tunnels. There are cases when control techniques with living organisms are successful in open field conditions, such as using predatory mites against spider mites. However, biological control products are usually only efficient at low pest intensities and other interventions are often required.

Bacteria, fungi, nematodes or viruses have also been mass produced to control some pests. The most common and successful is *Bacillus thuringiensis (Bt)*, a naturally occurring bacterium, which has

SOIL MANAGEMENT

Mechanical, physical and cultural crop protection methods prevent or minimize pests as well as reduce their build-up and carryover from one crop to another. For example, traditional ploughing ("tillage") turns the soil and buries crop residue and weeds before the seed bed is prepared for the next crop.

However, tillage has led to increased erosion as well as loss of soil moisture and organic material. In many countries, there has been a trend towards reducing tillage and using herbicide-tolerant biotech crops. This has led to increased practice of direct drilling in Europe and no-till in the United States and Canada. As a result, soil erosion problems have been greatly reduced.

WATER MANAGEMENT

Supplying water to crops is essential to plant health but it can greatly influence pest incidence and impact. Irrigation may be required, especially in dry areas or with crops that require a lot of moisture. But while flood irrigating some crops, such as lowland rice, can control weeds, it is wasteful of water and can adversely affect beneficial soil organisms. Methods to combat these risks and conserve water include drip irrigation or growing crops on ridges or raised beds.

OPTIMIZING PLANT NUTRITION

Different soil types contain varying amounts of nutrients. At harvest, nutrients are removed with a crop from the soil. In order to maintain or improve soil fertility, these nutrients have to be replaced with mineral and/or organic fertilizers. These products must be applied at the right time in the correct amounts to optimize soil health. New plant varieties with more efficient uptake of nutrients should be considered.

HARVESTING AND STORAGE

Carryover of weed seeds and disease-causing organisms can be reduced with good harvesting, seed cleaning and storage methods.

PRESERVING BIODIVERSITY

Protecting natural habitats near farmland is the best way to conserve biodiversity, including many natural pest enemies. Careful management of farmland edges, including trees and hedges, is important for wildlife habitats, providing cover and refuge for beneficial insects and animals (e.g., field bunds in rice paddies provide refuge for predatory spiders that help control several insects).

CROP LOCATION

Growing crops in locations where they are best suited to climate, soil and topography provides them with optimal conditions from the start. Appropriate land preparation builds on these conditions.

VARIETY SELECTION

Choosing beneficial crop varieties, such as those with disease and pest resistance, has always been a cornerstone of IPM. These varieties can be derived from traditional cross-breeding or modern biotechnology: pest-resistant and herbicide-tolerant varieties, for example, may reduce the need for other crop protection measures. Biotech crops can also facilitate reduced or no-till practices, helping to maintain soil health and prevent erosion.

STRATEGIC PLANTING AND CROP ROTATION

Planting similar crops alongside each other can substantially increase pests and should be avoided if possible.

Traditionally, some farmers sow different crops in alternate rows or undersow a crop like maize with a legume such as cowpea to help improve soil fertility and reduce weeds. Such systems can help reduce pests.

Prevention

Many aspects of crop management are designed to prevent initial outbreaks of insects, diseases or weeds. Practical strategies (outlined below) can be combined and optimized for an IPM program. The goal is to prevent pest populations from building up to economically damaging levels.

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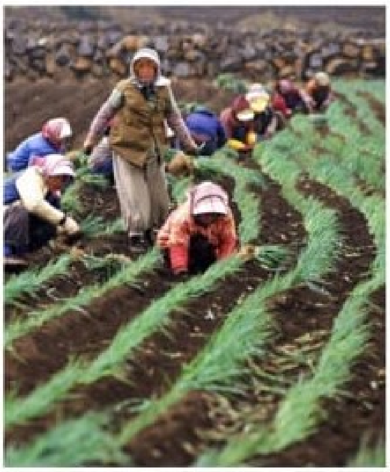

Growing different crops in rotation also helps reduce the build-up of pests, especially those in the soil such as root-feeding insects and fungi. Rotations can reduce weed problems and increase the range of weed control methods that can be used.

Benefits of IPM

IPM provides multiple benefits for society and the environment.
It is vital for the long-term future of the plant science industry.

- Improved crop profitability due to better pest control measures and appropriate use of crop protection products
- Stable, reliable and quality crop yields
- Decreased severity of pest infestations
- Reduced potential for problems of pest resistance or resurgence
- Increased consumer confidence in the safety and quality of food and fiber products

Crop protection companies that integrate IPM principles into marketing and customer support for their products also stand to benefit from:

- Sustained market share and access
- Less risk of restrictions or deregistration
- New opportunities for established and novel products, techniques and services
- Longer product lifecycles
- Decreased resistance of pests to crop protection products and biotech plants
- Increased public confidence in, and credibility of, the crop protection industry

IPM Components

IPM requires competence in three areas: prevention, monitoring and intervention.

PREVENTION

Prevent the build-up of pests

Includes a range of practical strategies that suit local conditions.

MONITORING

Monitor crops for both pests and natural control mechanisms

Involves scouting for pests (insects, diseases and weeds) to determine if, when and how intervention should occur.

INTERVENTION

Intervene when control measures are needed

Involves physical, biological and chemical methods to preserve the economic value of crops with minimal effects on the environment.