UNIT 13 INTEGRATED DISEASE, PEST AND WEED MANAGEMENT

Structure

13.1 INTRODUCTION

In the previous unit, you have studied about eco-friendly strategies for Integrated Resource Management and also about Integrated Farming Systems. Another area that needs intervention from this stand point is that of integrated pest control. South Asian countries face significant crop losses every year due to pests. For example, in India, annual crop losses due to pests have been estimated at around Rs.200, 000 million per year. Therefore, eco-friendly management of these pests is an important aspect of sustainable crop production.

In this unit you will study about various pest control measures with special focus on **Integrated Pest Management (IPM)**. You will learn about the concept and goals of IPM and its components. We also present some case studies for effective implementation of IPM.

Objectives

After studying this unit, you should be able to:

- list some common pests of agricultural importance;
- explain the concept and goals of IPM;
- describe the pest control techniques adopted traditionally and in the Green Revolution era; and
- discuss the components of IPM, and analyse the major issues involved in the implementation of IPM.

13.2 WHAT IS INTEGRATED PEST MANAGEMENT?

The standard dictionaries define pest as *'a troublesome or destructive person, animal or thing'*. The term "pest" comes from the Latin word, "*Pestis*" meaning plague or a widespread disease

The concept of Integrated Pest Management (IPM) was originally mooted in the 1960s to bring about a compromise between chemical control and biological control of agricultural pests. Now the scope of IPM has widened to embrace not only chemical and biological control but also other means of control to keep the pest populations below economic injury level.

In Fig. 13.1, we show some important agricultural pests. Other than these, some common animals that cause damage to crops and plants include birds, squirrels, rats, whiteflies, termites, mantis, locusts, earwigs, butterflies, etc.

The term pest is anthropocentric (anthropos: man), and is defined differently by diverse segments of the human population. There are no pests in an ecological sense. In the absence of humans, all organisms are just part of an ecosystem.

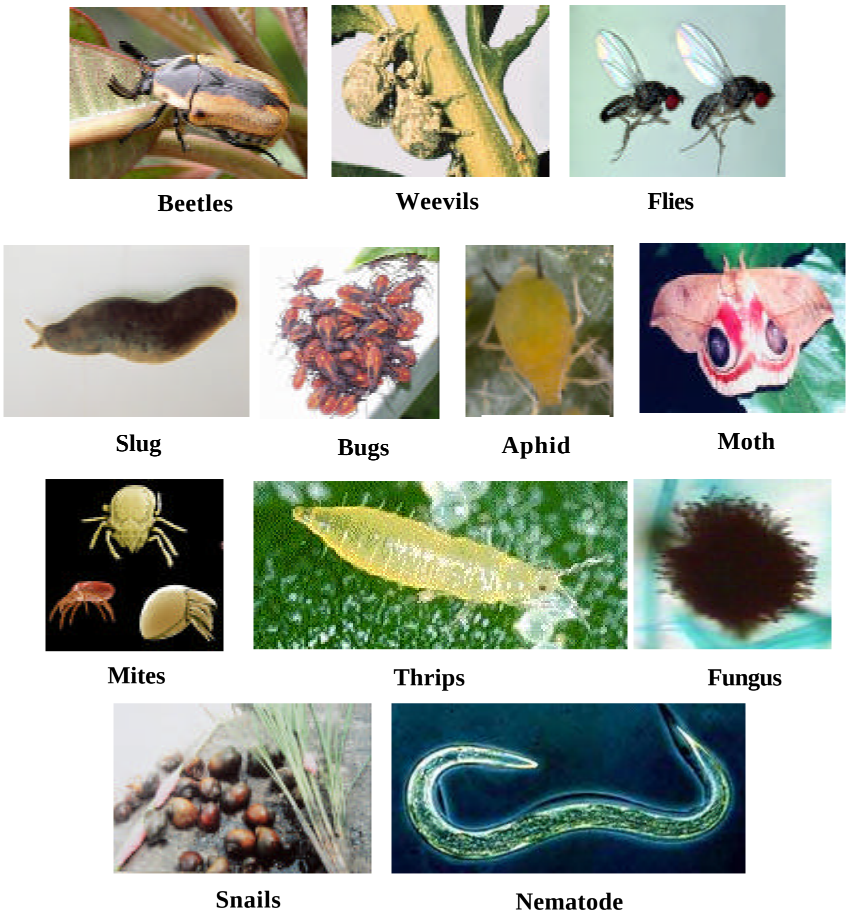

Fig.13.1: Some important agricultural pests

Let us now discuss the concept of IPM.

13.2.1 The Concept of IPM

The use of pesticides to control crop damage by pests(see Fig. 13.2) resulted in significant adverse impact on environment and food safety as you have been studying in this programme. IPM arose as a response to the need for eco-friendly management of pests. It requires a detailed understanding of pest biology and ecology, including interaction at the community and ecosystem levels.

Integrated Pest Management (IPM) may be defined as **"a comprehensive approach to pest control that uses combined means to reduce the status of pests to tolerable levels while maintaining a quality environment".**

Thus, the concept of integrated pest management contains ***three*** basic elements:

- Maintaining insect populations below levels that cause economic damage,
- The use of multiple tactics to manage insect populations, and
- The conservation of environmental quality.

Integrated means that all appropriate methods and tactics from many scientific disciplines are combined into a systematic approach for optimising pest control and plant protection.

Pest includes all insects, mites, nematodes, plant pathogens, weeds and vertebrates which adversely affect crop quality and yield.

Management refers to the attempt to control pest populations in a planned, systematic way by keeping their numbers or damage within acceptable levels.

(a) (b) (c)

Fig.13.2: Damage to crops due to pests. a) Seeded lauki damaged by rats; b) nematode attack on lady's finger; c) broccoli damaged by birds

IPM implies an integration of approaches and methods into amanagement system, which takes into consideration the ecology and the environment and all relevant interactions that pest management practices may have upon the environment in which one or more pest problems may exist. When IPM principles are applied to a given pest problem, it is generally assumed that environmental impact and economic risks have been minimized. Since IPM considers all applicable methods, it is also assumed that emphasis on chemical methods may be reduced when effective non-chemical alternative methods are available. We can sum up this concept as follows.

The IPM Concept

IPM integrates the management of all pests. It is an ecologically based holistic approach that can be applied to any ecosystem.

- IPM integrates
  - management of multiple pests (insects, weeds, disease pathogens, nematodes, vertebrates, etc.)
  - pest management tactics on an area-wise basis (many pest control situations are better handled on a large-scale or regional basis).
- IPM reduces pests to tolerable levels but does not emphasize pest eradication or elimination.
- IPM incorporates economic sustainability as well as environmental and social concerns.

13.2.2 Goals

The goals of IPM are:

- Improved pest control and increased crop yield,
- Pesticide management,
- Economical crop protection,
- Reduction of Environmental Contamination.

Let us elaborate these further.

- **Improved Pest Control:** IPM aims to provide more effective pest control to maintain crop quality and yield. By implementing alternatives to strict dependence on pesticides, IPM makes use of a balanced approach. It relies, for example, on cultural practices, natural enemies (parasites or pathogens) of pests and host plant resistance as well as chemicals. By reducing the use of pesticides, IPM emphasizes on biological control and the conservation of natural enemies already occurring in the field.

- **Pesticide Management:** Whereas the use of pesticides is not altogether done away with, IPM aims at a more efficient and sensible approach to pesticides, thus increasing their effectiveness and useful life span, decreasing possible adverse effects, ensuring a more rational use and minimizing pesticide resistance problems. Pest resurgence and secondary pest out breaks (often caused by elimination of natural enemies with pesticides) are minimized.

- **Economical Crop Protection:** IPM aims to control pest populations more economically. For example, simply by treating crops as needed, instead of merely by the calendar, IPM reduces crop protection costs by reducing the amount of pesticide used and the number of applications.

- **Reduction of Environmental Contamination:** IPM's social goal is to better safeguard farm workers' safety, people's health, plant life and the environment from possible harmful side effects associated with pesticides. It aims to ensure food safety through reduction of pesticide residue in food products, and decrease the contamination of soil, surface water, ground water and air though. Practices that maintain environmental quality can conserve natural enemies and beneficial pests that may help lower the pest status of target insects. In this approach, the pollinators, wild life and endangered species are also protected from potential hazards of pest control.

While there is general agreement about the multiple goals of IPM, different people prioritise them according to their background, interests, and local needs. Thus, farmers, researchers, agricultural input suppliers, environmental activists, and the public may have different legitimate viewpoints on the relative importance of a particular goal.

Extension personnel working in the implementation of IPM programmes usually rank IPM goals as follows:

1. reduced costs;
2. reduced risk of output loss;
3. reduced chemical use;
4. improved environment; and
5. improved on-farm health and safety.

For agricultural suppliers, the most important IPM goal is profitability, followed by increased options based on increased information, reliability and company reputation, and environmental safety.

For crop and pest management experts, the most important goals could be increased options and benefits followed by profitability, reduced chemical use, and reliability.

The relative importance of the goals of IPM is likely to change, depending on local need, from the early emphasis on farm-level profitability to the current emphasis on reduction of pesticide use. People are currently focusing on the harmful effects of the use of pesticides as a social goal.

The goals of IPM are quite in tune with sustainable agriculture and a brief discussion on this point here will not be out of order.

Sustainable Agriculture and IPM

You know that sustainable agriculture is a food production system which is ecologically, economically, and socially viable, in short term as well as in long term. It

- yields plentiful, high-quality food and other agricultural products,
- promotes the health of the environment without depleting or damaging natural resources (such as soil, water, wildlife, fossil fuels, or the germplasm base),
- supports a broad base and diversity of farms and the health of rural communities.

All these goals are compatible with the goals of IPM for the following reasons.

IPM has had a traditional "low input" approach. From the beginning of what may be called the "IPM era" the judicious use of pesticides was emphasized. This is underlined in the economic threshold concept wherein pesticides are not applied unless pest levels are high enough to potentially reduce profits. Thus, IPM programmes have reduced costs yet preserved crop quality and yield.

IPM is founded on systems approach which requires that all crop management practices be carefully evaluated with respect to its impact on the system and utilized, modified or rejected based upon its influence upon the entire system. This well founded philosophy of pest management coincides and supports the stated objectives of sustainable agriculture.

IPM recognizes the importance of protecting the environment. Consideration for off-site effects, non-target organisms, pesticide resistance, destruction of beneficial organisms, and other negative aspects of pesticide use are avoided in pest management programs to the extent possible.

Thus, IPM provides practical support for sustainable agriculture. A sustainable agriculture system requires flexible pest management programmes which allow farmers to test various components and utilize tactics which prove useful. IPM programmes have developed this flexibility through the years and are able to help farmers devise individualized plans.

The specific practical contributions IPM can make to sustainable agriculture are

- proven scouting procedures and economic thresholds for a wide array of crops and pests;
- crop management considerations when designing pest management programmes;
- practical experience on designing and operating on-farm tests and demonstrations.

13.2.3 Future Scope of IPM

The future of IPM promises to be an exciting and challenging era with tremendous scope for advancement in technology. The technological era with Internet capabilities provides tremendous opportunities to access information quickly, but it also presents challenges in reaching masses appropriately. We now briefly discuss the future scope of IPM from different perspectives.

Research, Development and Extension

Technological research and development is expected to revolutionise the IPM strategies. Although IPM concepts have already proven themselves, much research needs to be done, e.g., to determine the economic thresholds for many crops. Technologies are available only for few pests/crops, e.g., sugarcane, rice, cotton, vegetables etc. The IPM techniques, which have been successfully employed, are mainly the use of resistant varieties and bio-agents/bio-pesticides and these have been so far demonstrated on a limited scale; the user confidence in these approaches is still rather low. Effective IPM programmes could reduce substantially the expenditure on pesticides and ensure a better, safer environment.

Computer programs are required to integrate the vast material and data needed for simulation, prediction and control of pest populations. Technologies to develop non-human or automated scouting equipment need to be researched. Weather and geographic data need to be taken into account. On the whole, a massive boost to research and development efforts on IPM is required, which implies availability of trained manpower at all levels.

There is a lot of scope in the services sector, setting up of bio-control labs to make available bio-control agents, pesticide/bio-pesticide application services and maintenance of plant protection equipment.

Policy Environment

Most of the plant protection techniques used in IPM are not yet very attractive to private entrepreneurs and farmers in South Asian countries do not have easy access to IPM methods. There is a need for appropriate policies to promote more widespread adoption of IPM and requisite financial support to take up these activities on a large scale.

Legal aspects also need to be explored so that in the ultimate analysis, IPM becomes more efficient and economical. For example, stricter regulations concerning pesticide use on farm need to be implemented.

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Socio-economic Considerations

IPM is considered knowledge intensive and requires much more understanding of the agro-ecology which inhibits farmers from readily adopting them. Despite the great appreciation of IPM approach, the adoption of IPM at the field level is generally poor in most developing countries, barring in rice especially in selected South-East Asian countries. The usual implementation tactics have been to give instructions to farmers to follow certain recommendations. This was attributed to component approach, which viewed IPM as an integration of tactics. However, this approach did not empower farmers.

More participatory approaches for adoption of IPM should be encouraged to expand the scope of IPM in the future. The Farmer Field School (FFS) approach (see Sec. 13.5) made a significant impact on improving farmers' overall skills in IPM.

Future improvement of the FFS should involve the following:

- Upgrading and encouraging further technical studies,
- Focusing more on processes rather than results,
- Developing steps to encourage farmers to continue experimenting after FFS,
- Working with interested national researchers who are committed to ecological IPM.

Training by voluntary or non-governmental organizations has also been found effective in imparting knowledge and skills to the farmers. Active participation of greater number of NGOs would help considerably in popularizing the eco-friendly IPM practices among farmers.

Society's concern for the safety of food supply and preservation of endangered wildlife will direct major changes in the future of IPM. IPM must be viewed as a sound investment for preserving or protecting natural resources. IPM's future will depend upon how communication flows between the scientific community, the public and decision makers.

Certification of crops raised according to IPM or some other ecology-based standards may give growers a marketing advantage as public concerns about health and environmental safety have increased.

By using labels and other active marketing strategies (newspapers, brochures etc.), awareness and acceptance of IPM by consumers is enhanced because it will have positive consequences for human health.

These "eco-labels," as they are known, are becoming more popular, with over a dozen brands now in existence. They may provide for a more certain market and perhaps a price premium to help farmers offset any costs associated with implementing sustainable farming practices.

So far, we have discussed the concept, goals and future scope of IPM. You may like to ascertain whether you have grasped the concepts discussed so far.

SAQ 1

a) Outline the concept of IPM.
b) In your opinion, how should the goals of IPM be ranked? Give reasons for your answer.

We now turn our attention to the pest control techniques and see how these have evolved from the past to the present IPM era. This will also give you an idea of the need for IPM.

13.3 FROM TRADITIONAL PEST CONTROL TO THE IPM ERA

Three distinct phases can be identified in the evolution of pest control: The traditional era, the era of pesticides and the IPM era.

Traditional Approaches in Pest Control

Traditional approaches like crop rotation, field sanitation, deep ploughing, flooding, collection and destruction of damaged or infested plants etc. were among the oldest methods employed by humans to minimize the damage caused by pests. This was accompanied by the use of plant products from *neem*, chrysanthemum, rotenone, tobacco and several other lesser known plants in different parts of the world and a number of synthetic inorganic insecticides containing copper, arsenic, mercury etc. The focus of pest control shifted from traditional control practices to chemical control in the late 1930s.

Era of Pesticides (1939-1975)

The era of chemical pesticides, started with the discovery of insecticidal properties of DDT in 1939. Then came a number of other insecticides, which played a major role in pest management by successfully controlling the pests and increasing crop production. The success of high yielding varieties that ushered in the "**Green revolution**" was partially due to the crop protection umbrella of pesticides. Pesticides consumption increased all over the world from a few hundred tons in the 1950s to hundreds of thousand tons in recent years, a large fraction of which is used in agricultural sector.

For example, the consumption of pesticides in India increased from 434 tons in 1954 to more than 90,000 tons in recent years. Still, the average use of pesticides in India is about 500 grams per hectare against about 1.5 to 3 kg per in USA and 10 to 12 kg per hectare in Japan.

Although chemicals have been extremely beneficial in crop protection, an almost total dependence on pesticides resulted in unintended and unforeseen problems such as:

- Environmental contamination,
- Pest resistance,
- Improper use of chemical pesticides,
- Secondary pest outbreaks,
- Natural enemies targeted,
- Resurgence of original pest population due to ecological imbalance, and
- Energy crisis and escalated pesticide costs.

Since pesticide use began to be legally restricted due to the above-said possible adverse effects on people and on the environment, and since some pesticides became less effective for the variety of reasons listed above, a more comprehensive, ecologically based approach to crop protection was clearly called for.

Era of Integrated Pest Management (IPM)

The Agenda 21 of the United Nations Conference on Environment and Development (UNCED) at Rio de Janeiro in June 1992 approved and accepted IPM as an approach to reduce the use of pesticides in agriculture. In view of the global concern and the benefits of IPM programme, developing countries are also adopting IPM as the main strategy of plant protection in the overall agricultural production programmes. Although chemical pesticides continue to play an important role in the IPM program, these products are used selectively and judiciously and the dependence on pesticides as the exclusive tool for pest control is getting reduced.

Effective IPM consists of the following approaches:

- **Exclusion:** This seeks to prevent pests from entering or establishing in areas currently not infested, thus stopping problems before they arise.

- **Suppression:** This refers to the attempt to reduce pest populations below the level at which they would be economically damaging, so that they are no longer a problem. This includes temporary limitations of localized pest out breaks on an emergency basis.

- **Eradication:** It strives to eliminate entirely certain pests whose presence, however minimal, cannot be tolerated.
- **Plant resistance:** It stresses the effort to develop healthy, vigorous strains that will be resistant to certain pests.
- **Management of within-field populations:** This occurs at the within-field spatial scale on a continuing basis because the pest is well established in an area.
- **Area-wide pest management:** For some pests, management must be extended to the regional level to achieve population regulation, especially for many viral diseases and for some mobile insects. This strategy is referred to as **area wide pest management**, and requires the cooperation of people throughout the range of the pest.

In order to implement these approaches, the following steps are often taken:

- **Pest surveillance and monitoring**: The identification of key pests and beneficial organisms is a necessary first step. In addition, biological, physical and environmental factors which affect these organisms need to be ascertained. This involves the systematic collection of pest and crop data from the field (pest distribution, growth stage, population, crop stage, etc.). The information is used, in the short term, to make predictions about pest populations. It is also used to make immediate pest management decisions to reduce or avoid economic crop loss.

  In the long term, field scouting and monitoring is important in evaluating the success or failure of pest management programmes and for making sound decisions in the future. Monitoring helps in pinpointing early outbreaks and the progress of infestation. It also enables decisions to be made on control strategy and the efficiency of the treatment. The application of suitable control strategy at the right time results in its efficient use and reduces the frequency of treatment.
- **A prediction of loss and risks** involved is made by setting an economic threshold. Pests are controlled only when the pest population threatens acceptable levels of quality and yield and then remedial action is taken. The level at which the pest population or its damage endangers quality and yield is often called the **economic threshold**. The economic threshold is set by predicting potential loss and risks at a given population density. This estimation takes into account weather data, state of crop development, markets, risk benefit, costs and kinds of control available.
- **An action decision must be made**. In some cases pesticide application will be necessary to reduce the crop threat, while in other cases, a decision will be made to wait and rely on closer monitoring.
- **Evaluation and follow-up** must occur throughout all stages in order to make corrections, assess levels of success and to project future possibilities for improvement.

In this section you have studied about the evolution of pest control techniques and approaches from the past to the present. You may like to stop for a while and review what you have learnt.

SAQ 2

a) Explain in you own words why the need for IPM arose.
b) Outline the major approaches to pest control followed in the IPM era.

13.4 COMPONENTS OF IPM

So far we have discussed the concept of IPM, and the approaches to IPM. You may like to know: What are the pest management practices followed in IPM? Preventive cultural control, mechanical control, chemical control, biological control, pest modelling and remote sensing, and legislative control are the major components of IPM and we now discuss these briefly.

13.4.1 Preventive /Cultural Control Methods

You have learnt in the previous section that prior to the advent of the chemical era, people relied on cultural control. It is one of the major control methods in IPM; it involves the use of practices which make the environment less favourable for the survival, growth, reproduction or dispersal of pest species. It is also called **ecological control**. A number of cultural control techniques are currently practiced in pest management and here we describe a few of the most common and potentially useful ones.

Sanitation involves the removal or destruction of breeding, refuge, and over-wintering sites of pests. Control of annual weeds, especially before seedling stage not only reduces weed pressure, but also reduces crop pests and diseases that shelter in, or feed on them. Seeds are treated with pesticides, hot water or solar energy to control pests and diseases. Seeds, manure and irrigation water free of weed seeds, pests and diseases, are used. Sanitation also involves the removal of the whole plant infected with pest or diseases and destruction of weeds.

Crop rotation is effective for pests that have a narrow host range and dispersal capacity and cannot survive for long periods of time (i.e., one or two seasons) without crop or favoured host contact. This includes all plant pathogens, nematodes, insects and a number of weeds. This technique is economical and important in the control of many nematode problems. Crop rotation also provides the opportunity for using a wider range of herbicides for controlling weeds. Strip farming, intercropping and multi-cropping have also shown reduction in pest problems.

Tillage timing and its type can markedly influence the soil environment and affect the survival of insect pests or their natural enemies. Tillage practices can kill pests by mechanical injury, starvation, desiccation and exposure. For example, deep ploughing immediately after harvest destroys insect pests and seeds of various weeds by exposing them to their natural enemies like birds and to the action of sun and wind.

Mulches help to retain moisture in the soil and can impact insect populations.

Fig.13.3: Plastic mulching in field

Kairomones are chemicals produced by a member of one species that have a beneficial effect on the recipient member of another species.

Trap cropping is a technique of growing crops that attract insects and other organisms so that the target crop escapes pest attack. The attractiveness of trap crops may be enhanced by use of insect pheromones, plant kairomones or insect food supplements.

Irrigation management can be used for pest control purposes. Small pests such as aphids are easily washed off plants by overhead irrigation, and soil insects may be killed by the pressure of swelling soil particles in saturated soils.

Sowing and harvesting schedules can be altered to control pests. Sowing period can be suitably advanced or delayed to avoid the egg-laying period of the pest or to allow the plants to reach an age where they are resistant by the time the pest appears. Short duration varieties of the crop may be sown or harvesting may be done without any delay after the crops mature. Early harvesting may also remove pests (especially cereal pests in the straw and grains) from the field before they can emerge and perpetuate the population in the area.

Transplanting ensures that plants cross the stage of growth which is susceptible to diseases of germinating seeds. The transplanted crop is much larger/older than germinating weeds and thus has a competitive advantage in comparison of the direct sown crop.

13.4.2 Mechanical Control

The reduction or suppression of insect populations by means of manual devices is referred to as mechanical control.

The main mechanical methods are:

- **Collection** and **destruction** of pests, which includes handpicking.
- **Mechanical exclusion** consists of the use of devices like door and window screens, digging trenches, and row covers to physically prevent insects from reaching crops and agricultural produce.
- **Trapping and suction devices** are used for collecting insect pests. Other than insect control, traps also provide valuable information for estimating pest intensity/crop loss assessment, monitoring initial infestation and periodicity of pest activities. Various types of traps used are light traps, air suction traps, pheromone traps, rat traps, etc. (Fig. 13.4a).

(a)

(b)

Fig.13.4: a) Rat caught in a live trap; b) pruning of infested material

- **Mowing/interculturing** is used to limit weed growth without killing the plants.
- **Dredging**, i.e., physical removal of soil and plant material is very useful particularly for aquatic weed control.

- **Clipping pruning**, **flaming** and **burning** of infested shoots and floral parts are useful against many pests (Fig. 13.4b).

Temperature, sound, controlled atmospheres and radiations are employed as important methods of physical control. Stored grain insects are controlled by physical methods effectively.

13.4.3 Chemical Control

Under certain circumstances like heavy incidence or pest epidemics, the use of pesticides becomes unavoidable. Often pesticides are the only feasible means of control and provide convenient and economical protection from pests that would otherwise cause significant losses. However, injudicious, careless or excessive use of pesticides can result in poor control, crop damage and hazards to human and animal health and the environment. Pesticide resistance, pest resurgence and secondary pest outbreaks are the major problems created by prolonged use of pesticides. It is desirable that pesticides should be used only when needed. Different groups of available pesticides (including insecticides, fungicides, weedicides, rodenticides) may be used according to the demand of the situations.

13.4.4 Biological Control

The successful control of a pest species through the manipulation of another organism/natural enemy is called **biological control**. Insect pests may be preyed upon or parasitized by other insects. Most insect pests are attacked by bacterial, fungal or viral pathogens. Specific weeds may be controlled by insects with specialized feeding habits. Biological control offers a sustainable, ecologically sound and economically viable solution to the pest problems. The implementation of biological control methods has been categorized into three basic approaches, namely,

- classical,
- augmentation, and
- natural.

The classical approach of biological control is employed when a pest is not native to a given area, assuming that the biological organisms that regulate its population dynamics in its native environment are lacking. In this approach, farmers

- determine the pest's native home,
- locate beneficial organisms that naturally control the pest organism in its native area, and
- if feasible, import, multiply, release and establish the beneficial organisms in the problem area to facilitate biological regulation of the pest problem

If successful, the import and establishment of beneficial organisms results in a long term reduction of the pest problem and repeated release of the beneficial organisms is not required. The process of importing and releasing beneficial organism is complex, since many precautions need to be taken to prevent the introduction of organisms that may have adverse effects.

Augmentation is the approach in which beneficial biological organisms are mass reared and released periodically to supplement the natural enemy complex to achieve reduction of a pest problem. This approach may be applied to pest populations that are either native to the area or of foreign origin. In general, augmentation may be considered when it is economic and feasible to rear, multiply, and release a natural enemy of a pest to the point that reduction of the pest problem is achieved. Successful augmentation efforts have been developed for greenhouse environments where altering the balance between a pest and its natural enemy is feasible.

Natural biological control is carried out through natural **predators**, **parasites** and **diseases**. If such forces are not in effect in nature, we would be overrun by pest populations. Populations of natural enemies can be enhanced by selective use of cultural practices or decimated by indiscriminate use of pesticides. In some cases, pesticides have been developed that effectively control a pest population without having a significant effect on beneficial species. For example, a new pesticide for control of alfalfa weevil could effectively kill weevils without harming beneficial parasitic wasps and pollinating bees.

An example of natural control includes the impact of predatory ground beetles on early pests of corn such as cutworms and armyworms. It is observed that the efficacy of a given soil insecticide to reduce cutworm damage may be related to the lack of toxicity of the compound to the ground beetles that prey upon cutworms. Spiders, birds, insects like lady bird, praying mantis, beetles, and several fungi, bacteria, viruses are important bio-control agents (see Fig.13.5).

(c) (d)

Fig.13.5: a) Predatory spider; (b) A praying mantis feeding on a moth; (c) Lady bird beetle predating on mealy bug; d) Predatory lady bird beetle larva feeding on the rose aphid

Bio pesticides (Pathogens)

Bio pesticides are defined as pesticides of biological origin including micro-organisms and natural products. The term bio pesticide or biological pesticide as defined by FAO, 1996 pertains to **"a generic term, not specially definable, but generally applied to a biological control agent, usually a pathogen, formulated and applied in a manner similar to a chemical pesticide, and normally used for the rapid**

reduction of a pest population for short term pest control". The bio pesticides are broadly classified into two groups:

- Microbial pesticides.
- Botanical pesticides.

Microbial pesticides are bio pesticide formulations containing bacteria, fungi, virus, protozoa or nematodes as pest control agents (Fig.13.6).

Fig.13.6: Castor semi looper larva attacked by a virus

The prospects of microbial control of agricultural pests seem to be very good. We present below some success stories of biological control in India. The work on biological control of crop pests in India commenced with the introduction of vedalia beetle, *Rodolia cardinalis* for the control of cottony cushion scale, *Icerya purchasi* and *Dactylopius opuntiae* for the control of prickly pear in the first quarter of the previous century. In recent years the successful biological control programmes in the country include sugarcane *Pyrilla, gram* caterpillar, water hyacinth, etc.

i) **Sugarcane *Pyrilla*:** The outbreak of this injurious pest was successfully controlled by the use of potential bio control agents like *Epincania melanoleuca* in Uttar Pradesh, Punjab and Haryana in 1985. This saved the loss to the tune of Rs.80.00 million in two years. This parasite has also been successfully introduced for sugarcane *Pyrilla* control in the State of West Bengal, Orissa, Gujarat, Maharashtra, Tamil Nadu, Karnataka and Kerala. During 1994, the severe incidence of sugarcane *Pyrilla* in Karnataka could be successfully controlled by release of *E. melanoleuca* from northern states and by augmentation of *Tetrastichus pyrillae*.

ii) ***Heliothis*:** Use of Nuclear Polyhedrosis Virus (NPV) against gram pod borer has given spectacular success in biological control of *Heliothis*, one of the dreaded pests of pulses, cotton, vegetables, oilseeds, etc., in Tamil Nadu, Karnataka, Gujarat and other States.

iii) **Water Hyacinth:** Two exotic weed control insects viz., *Neochetina eichhorniae* and *N. bruchi* have been successfully employed for the biological control of water hyacinth in the States of Karnataka and U.P.

iv) ***Salvinia* weed: *Cyrtobagus salviniae*** has successfully controlled the *salvinia* weed (water fern) in the water bodies in Kerala which has provided relief in navigation and irrigation.

v) ***Agrobacterium tumefaciens*:** Crown gall is a serious bacterial disease caused by the bacterium ***Agrobaterium tumefactiens*** Biological control of this pathogen was achieved by dipping bare-root transplants into a suspension of a non-pathogenic strain of the bacterium ***Agrobacterium radiobacter***.

Botanical pesticides are insecticides of plant origin extracted from seed, flower, leaves, stem and roots. Plants are rich sources of bioactive organic chemicals.

Neem, *Pyrethrum*, *rotenone* and *nicotine* are the four most important sources for botanical pesticides. The bioactivity of *neem* products has attracted the attention of scientists the world over. All parts of the *neem* tree (leaves, fruits, seed kernel) possess insecticidal activity but seed kernel is the most active one.

The potential for development of biological control for a wide range of pest problems is significant. However, development of successful biological control technologies often requires significant investments into research that may or may not readily produce satisfactory results. To date, biological control has not been a marketable product like chemical controls and research efforts into the field have been limited. Furthermore, implementation and evaluation of biological controls are often more complex than that of chemical methods.

Host plant resistance is an inheritable trait that enables the plant to inhibit the growth of insect population or to recover from injury caused by populations that were not inhibited to grow. Interaction between host plants and insects are spread over a wide range of intensity. Breeding insect-resistant varieties is an essential feature of host plant resistance for which development and standardization of screening techniques is an essential pre-requisite.

Transgenic plants are plants with a gene or genetic construct that has been introduced by molecular techniques for specific tasks. Genetic engineering may serve as a boon to pest management if exploited correctly. Bt cotton is a transgenic cotton in which a special type of protein called cry protein is produced by introducing a bacterial gene. Bt cotton is highly effective against cotton boll worms (Fig. 13.7).

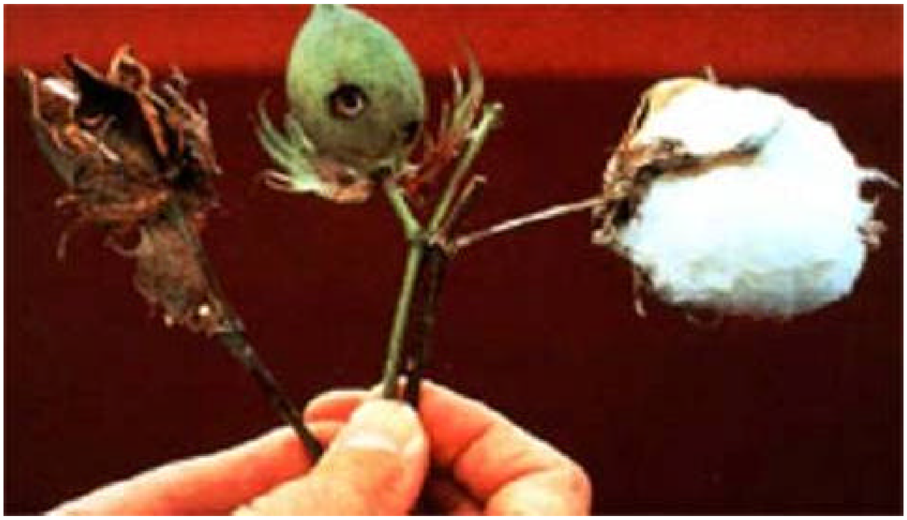

Fig.13.7: Insect infestation on Bt (right) and non-Bt (left) cotton (Source: envfor.nic.in/news/ aprjun02/aftcbci.html)

Examples of approved virus-resistant varieties include the following:

i) Cucumber mosaic virus, watermelon mosaic virus and zucchini yellow mosaic virus resistance has been available in squash varieties.

ii) Papaya rings pot virus resistance in papaya is one of the few examples of transgenic varieties.

iii) Potato leaf roll virus resistance has been available since 1998 and only in combination with insect resistance.

13.4.5 Pest Modelling and Remote Sensing

A simplified representation of a system is termed as a model. Agricultural systems are dynamic and continuous systems as these show gradual continuous changes. The models representing them are termed as dynamic continuous models, which are also known as crop growth simulation models. A crop growth simulation model coupled with pest damage mechanisms is called a **crop-pest model**. Simulation models can be used for the determination of economic injury levels of pests, pest risk analysis, pest forecasting and assessing effects of climate change on crop growth and productivity.

Observation of objects from a distance is called remote sensing. By remote sensing, pest incidence on plants is detected by change in the colour of leaves. In India, remote sensing has been used for locating favourable places for locust breeding in desert areas and assessing severity of white fly incidence in Andhra Pradesh.

13.4.6 Legislative Control

The pests introduced from outside have frequently been found to inflict greater damage than the indigenous ones. Legislation is required to:

a) Prevent the introduction of foreign pests, diseases and weeds.

b) Prevent the spread of already established pests, diseases and pests from one region to another within the country.

c) Motivate the farmers for the application of effective control measures to prevent damage by already established pests, diseases and weeds.

d) Prevent the adulteration, misbranding and mishandling of pesticides or other devices used for the control of pests and to determine their permissible residue tolerance in food stuffs.

e) Regulate the activities of people engaged in pest control operations and take precautions in the application of hazardous pesticides.

In India, at present two categories of regulatory measures are in operation for control of pests, diseases and weeds, viz.

i) legislative measures through plant quarantine, and
ii) legislative measures through State Agricultural Pests and Diseases Act.

You may now like to attempt an exercise on these concepts.

SAQ 3

a) List the major practices adopted in cultural and mechanical control of pests.
b) What do you understand by biological control? Why is it an important component of IPM?

13.5 IPM Initiatives

IPM has been implemented world wide and has been found to work well on many crops. Its principles are being applied to many other areas around the world. In this section, we describe some examples of successful implementation of IPM.

13.5.1 Community based IPM Approach– Farmer Field School

The training approach, which has been used to help farmers learn about IPM, is called the Farmer Field School (FFS). The concept of the farmer field school (FFS) as an extension activity was initially developed by FAO, validated by Indonesia and subsequently by India and other countries. FFS has given small farmers practical experience in agro-ecosystem analysis, providing the tools they need to practice IPM in their own fields. FFS also provides a natural starting point for farmer's innovation covering the whole range of issues relating to crop management and plant health. The success of FFS has opened up a new approach to the development of sustainable, small scale agricultural system. The approach places farmers at the centre of the IPM, empowering them as the key pest management decision maker.

Once this foundation has been laid, farmers are better able to act on their own initiatives, and to sharpen their observation, research and communicative skills. Thus the Farmer Field School sets in motion a longer-term process, in which opportunities are created for local leadership to emerge and for new, locally devised strategies to be tested.

Fig.13.8: Farmers in Ecuador learning about FFS (Source: www.ag.vt.edu/.../Ecuador/ bigimages/DSCN8781.jpg)

13.5.2 Examples from Around the World

IPM programmes for various crops are being successfully implemented in different countries. For example, since 1972, IPM programmes have been implemented in the USA for 16 crops (including cotton, corn, sorghum, soybean, alfalfa, citrus, apples and peanuts), on about one million acres. Many farmers in these programmes have reduced pesticide use and cost by 30-50% compared to conventional approaches. Some examples are: One cotton farmer reduced the number of pesticide applications from 27 to 17. Farmers in Texas (USA) reduced insecticide use on sorghum by 73%. New Jersey sweet corn growers cut insecticide usage by as much as 20% with no sacrifice in quality of this high value, low threshold crop. In 1975 Evaluation of 25 Integrated Pest Management Programs for Cotton, Peanuts, and Tobacco in the U.S. revealed that

- Crop yield actually increased in 72% of the programs.
- Pesticide use was decreased in 86% of the programs.
- Production costs decreased in 85% of the programs.
- Profit increased in 95% of the programs.

In Table 13.2, we summarise some more successful IPM initiatives in developing countries.

Table 13.2: Successful IPM initiatives in different countries for various crops

Crop	IPM Components	Pesticide reduction	Savings and other benefits
Rice (Indonesia)	Parasitoid conservation, plant resistance, need based pesticide use, pesticide subsidy abolished	50% number of applications from 4 (1986) to 0.8 (1991). Pesticide production decline by 75%	Subsidy abolition benefit of 67-100 million/yr. Net profit up by 12%.
Cotton (Egypt)	Pheromones for key pest scouting, pest thresholds used	70% reduction nationally, application from 8 to 2-4	35 million/yr reduction in import cost of pesticides
Sugarcane (Pakistan)	Release of parasitoids, avoiding post-harvest burning to conserve beneficials	Aerial application avoided, chemical application effectively removed	Net farmer income up by 9.15% per yr
Soybean (Brazil)	Scouting, natural enemies, need based pesticides especially NPV biopesticide	Reduction in annual applications from 12 to 9	Superior crop yield
Mango (Pakistan)	Shelters for predators, traps for fruit flies, reduced chemical treatment for hoppers	Pesticides eliminated for all pests except hoppers where application restricted to part of the tree. Application reduced from 5 to 1	14 fold reduction in cost of chemical control. Reduced outbreaks of scale insects
Cabbage (Taiwan)	Exotic parasitoids, timing of planting, need-based biopesticide	Spray frequency halved	Substantial reduction in cost.
Banna (Costa Rica)	Economic thresholds developed for moth pests. Fruit bagged for thrips control	Complete removal of pesticide use after several years	Removal of pesticide cost and environmental and health benefits

With this, we end our discussion on IPM and summarise the contents of this unit.

13.6 SUMMARY

- IPM may be defined as "**a comprehensive approach to pest control that uses combined means to reduce the status of pests of tolerable levels while maintaining a quality environment**".
- The **goals** of IPM are: Improved pest control and increased crop yield, Pesticide management, Economical crop protection, Reduction of Environmental Contamination.
- Effective IPM consists of **exclusion, suppression, eradication, plant resistance, management of within-field populations** and **area-wide pest management.**
- The various types of **pest control measures** that are integrated in pest management practices include physical, mechanical, cultural, behavioural, chemical, biological, genetic and legislative control methods.
  - Rotation of crops, trap crops, strip farming, intercropping and multi cropping mowing, tillage, transplanting, dredging and sanitation are important **cultural control** methods.
  - **Mechanical** methods bring about reduction or suppression of insect populations by means of manual devices, viz., hand picking, exclusion by screens and barriers, trapping and suction devices, use of hand-nets and bag-nets, clipping, pruning and crushing, beating and hooking, shaking or jarring, sieving and winnowing, and burning.
  - **Chemical control** in IPM involves judicious and minimum use of chemicals to manage pest populations.
  - Control of pests through natural enemies as encouraged and disseminated by man is called **biological control**. These organisms include fungi, bacteria, viruses, nematodes, protozoa, predators, parasites and pathogens (bio agents).
  - **Bio pesticides** are chemicals obtained from plant sources, which can kill pests. Bio pesticides are not readily available and they have shorter shelf life.
  - Breeding insect-resistant varieties is an essential feature of **host plant resistance** for which development and standardization of screening techniques is an essential pre-requisite.
  - **Pest modelling** and **remote sensing** and advancement in information technology will further add value to the approach towards IPM.

13.7 TERMINAL QUESTIONS

1. What are the common goals shared by IPM and sustainable agriculture?
2. Discuss the future scope of IPM.
3. What do you understand by pest surveillance and monitoring?
4. How can different components of IPM be integrated for its effective implementation? Give examples.
5. How can FFS play an important role in popularizing IPM?