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FACULTY OF AGRICULTURAL SCIENCES & ALLIED INDUSTRIES

Lecture-2 IPM: Introduction, history, importance, concepts, principles and tools of IPM

INTRODUCTION

Integrated pest management (IPM), also known as **integrated pest control (IPC)** is a broad-based approach that integrates practices for economic control of pests. IPM aims to suppress pest populations below the economic injury level (EIL).

The UN's Food and Agriculture Organization defines IPM as "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 minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms." Entomologists and ecologists have urged the adoption of IPM pest control since the 1970s. IPM allows for safer pest control.

According to Merriam Webster IPM is "management of agricultural and horticultural pests that minimizes the use of chemicals and emphasizes natural and low-toxicity methods (such as the use of crop rotation and beneficial predatory insects)".

The introduction and spread of invasive species can also be managed with IPM by reducing risks while maximizing benefits and reducing costs.

Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment.

The IPM approach can be applied to both agricultural and non-agricultural settings, such as the home, garden, and workplace. IPM takes advantage of all appropriate pest management options including, but not limited to, the judicious use of pesticides. In contrast, *organic* food production applies many of the same concepts as IPM but limits the use of pesticides to those that are produced from natural sources, as opposed to synthetic chemicals.

HISTORY

- Michelbacher and Bacon (1952) coined the term "integrated control"
- Stern et al. (1959) defined integrated control as "applied pest control which combines and integrates biological and chemical control"
- Geier (1966) coined the term "pest management"
- Council on Environmental Quality (CEQ, 1972) gave the term "Integrated Pest Management"
- Food and Agricultural Organization (FAO, 1967) defined IPM as "a pest management system, that, in the context of associated environment and population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains pest populations at levels below those causing economic injury"
- In 1989, IPM Task Force was established and in 1990. IPM Working Group (IPMWG) was constituted to strengthen implementation of IPM at international level.
- In 1997, Smith and Adkisson were awarded the World Food Prize for pioneering work on implementation of IPM.

Full history

History of Pest Management

• 2500 BC First records of insecticides; Sumerians used sulfur compounds to control insects and mites.

• 200 BC Romans advocated oil sprays for pest control.

• 300 AD First records of biological controls; Chinese used predatory ants in citrus orchards to control caterpillar and beetle pests.

• 1880 First commercial spraying machine.

• 1930 Introduction of synthetic organic compounds for plant pathogen control.

• 1940 First successful use of an entomopathogen; Milky Spore (*Bacillus popillae*) used to control Japanese beetle.

Supervised insect control –

Shortly after World War II, when synthetic insecticides became widely available, entomologists in California developed the concept of Supervised Control.

It is an alternative to calendar-based insecticide programs.

Supervised control was based on a sound knowledge of the ecology and analysis of projected trends in pest and natural-enemy populations.

Integrated control –

Supervised control formed much of the conceptual basis for "integrated control “that University of California entomologist articulated in the 1950s.

Integrated control sought to identify the best mix of chemical and biological controls for a given insect pest. The adage of "if a little works, a lot will work better “was the major premise for applying chemical to address pest problems on the farm and around the home.

Ecological Backlash –

As early as the 1950's, pesticide-induced problems such as pest resurgence, pest replacement,θ and pesticide resistance caused problems in agriculture.

Pest resurgence –

In 1959, scientists discovered that aphids could be better controlled byθ reducing the amount of pesticide used because the pesticides were killing aphid predators as well as the aphids themselves, causing large-scale pest resurgence (Stern, et al., 1959).

Pest Management –

The concept of 'pest management' was proposed in 1961 (Geier and Clark, 1961)

For the reduction of pest problems actions are selected after the life systems of the pests are understood and the ecological and economic consequences of these actions have been predicted, as accurately as possible, to be in the best interests of mankind.

Widespread pest resistance in 1950’s to DDT and other Pesticides

Environmental Awareness during the 1960s – new awareness of ecology and theθ environmental impact of pesticide pollution resulted from a public outcry about environmental contamination found in the air and foul water found in rivers and streams.

By 1962, when "Silent Spring" by Rachel Carson was published, serious concerns about the disadvantages of pesticide use were widely raised.

Rachel Carson and others suggested that pest control methods other than chemical pesticides should be used in order to protect wildlife, human health and the environment.

Public pressure led to government legislation restricting pesticide use in many countries resulting in ban of DDT and other pesticides.

Integrated Pest Management-

In 1967 the term IPM was introduced by R.F. Smith and R. van den Bosch.

The term IPM was formalized by the US National Academy of Sciences in 1969.

IPM was adopted as policy by various world governments during the 70's and 80's, including the USA (1972)

1970's-1980's IPM adapted for managing pests of landscape trees and shrubs in Urban Areas

In 1985 India declared IPM as official Ministerial Policy.

PRINCIPLES

Basic principles of Integrated Pest Management:

1. **Prevention and Suppression**

"Prevention is better than cure" is the first general rule in any production system. Prevention can be considered as the creation of cropping systems inherently less likely to experience significant economic losses due to the presence of pests. Suppression, understood as the reduction of the incidence of pests or of the severity of their impact, complements prevention. This principle means that the aim is not to completely eliminate pests but to prevent any single one from becoming dominant or damaging in a cropping system.

Certain aspects of prevention dealing with the use of healthy and weed-free planting material and detection of pathogens in substrates deserve more attention, particularly in light of new technologies. Many pathogens associated with seed become the source of disease in the subsequent year. Weed seed contaminating harvest can become a major problem in the subsequent year. Certification of disease-free seed, seed potatoes, bulbs, cuttings, and new sorting technologies are very helpful in avoiding problems but it is important to apply measures.

Plant breeding for pest resistance is recognized as an important contributor to the development of prevention strategies. The use of pest-tolerant and resistant cultivars will help to decrease dependence on pesticides in arable crops.

Combinations of tactics and multi-pest approach

The combination of control tactics into management strategies generates more effective and sustainable results than single-tactic approaches. To create conditions that reduce the frequency and intensity of pest outbreaks, research and extension need to develop strategies integrating a range of methods. Plant genetic resistance can be exploited while addressing multiple pests, diversifying cropping systems in time and space, and integrating crop management practices and landscape effects within pest management.

Rotation

Spatial and temporal diversification is key to minimizing pest pressure and achieving effective prevention. In organic arable crop farming, crop rotation is the most effective agronomic alternative to synthetic pesticides (Fig. 4). In annual crops, the manipulation of crop sequence to break the life cycle of pests through rotation with crop species belonging to different families is a major lever to strengthen robustness of cropping and farming systems.

Crop management and ecology

Many crop management practices apparently unrelated to pest management actually have a significant impact on the vulnerability of cropping systems to pests. Fertilization is known to affect sap-sucking insects and mites, plant pathogenic fungi, and bacteria. Mechanical weeding can damage crop tissue and favor diseases. Crop residue management can affect the overwintering capacity of pests. Tillage systems often determine abundance and composition of weed communities and soil-borne diseases.

2. Consideration of Ecosystem :

Control of insect pest population is a function of the ecosystem itself by means of natural enemies and other factors. Knowledge of the role of the principle elements of the units is essential to an understanding of population phenomenon. The study of individuals is of prime importance, their biology behavior response to other members of the same species and to other organisms and to biotic factors in the environment. The study of individuals offers a potent method for this analysis of population change. The most effective system for controlling pests can be derived only after understanding the principles responsible for the population fluctuation in the ecosystem.

3. Pest Surveillance and Monitoring

Beyond prevention, moving away from a pesticide-based strategy implies monitoring harmful organisms at regular intervals or upon issue of local warnings. In an ideal world, all farmers would monitor pest populations and use forecasting systems prior to making a decision regarding control.

Pest Surveillance and forecasting are having a vital part in the integrated pest management. Surveillance or monitoring means constant observation of a subject i.e., a crop or pest, and recording the factors observed, compilation of information obtained and prediction of future events about pest population. Hence pest surveillance comprises of three basic components.

a. Determination of the level of incidence of the pest species.

b. Determination of what loss the incidence will cause.

c. Determination of economic benefits or other benefits the control will provide.

The above information would be immense use in determining the need for a pest control measure. Mere presence of a few numbers of pest species should not be the criterion for pesticide application and there should be sufficient justification. Surveillance can provide the necessary information to determine the feasibility of a pest control programme. It should be a tool that assists pest management specialists in determining the actual factors that are involved in a pest build up, so that the specialists can determine practices that will manage these factors and prevent the initial build up of a pest.

4. Decision based on monitoring and thresholds and Utilization of Economic Threshold Levels (ETL)

While it is true that sound intervention thresholds play an important role in IPM, they are, however, not always applicable, available, or sufficient. In many cases, thresholds have not been established for weeds. This is also the case for pathogens, particularly those that switch from a saprophytic to a pathogenic lifestyle depending on environmental events and climatic conditions.

In the past, many IPM programs have centered on threshold-based decisions. When decision-support systems are not in place or are not appropriate, however, the use of thresholds along with the concept of IPM are disregarded. It may be better in such cases to stress the importance of observation in general, of sound decision rules, and of the entire set of IPM principles.

The level of pest population is very important consideration for taking up control measures. Pest population must be maintained at levels below those causing economic injury. The economic threshold is the pest density at which control measures should be determined to prevent an increasing pest population from reaching economic injury level. The determination of these thresholds is a pre-requisite to the development of any pest management strategy.

The decision-making process determining in season control measures based on the short-term pest situation could be extended to integrate more systemic factors for longer-term strategic design.

5. Application of minimum selective hazards :

Giving preference to non-chemical over chemical methods, if they provide satisfactory pest control, appears to be a sound and straightforward principle. The difficulty lies in the way "satisfactory pest control" is determined. The authors believe that the highest level of control attainable by chemical measures is often not sustainable, creates new pest problems, and is not a proper standard against which single non-chemical tactics are evaluated, rather, a satisfactory while sustainable level of pest management can be achieved via a broad IPM strategy that includes an array of protection methods. Separately, each alternative method, e.g., a biopesticide, may perform with lower and slower biocidal power and appear more costly than synthetic pesticides if externalities are not included. Collectively, however, alternative methods should generate synergies resulting in satisfactory pest management.

There is a wide range of non-chemical but direct pest control measures such as soil solarization or biological control, but their availability, efficacy, or pertinence varies considerably. Though various biotechnical methods have been developed, pheromone-based mating disruption is probably the most advanced and successful of such techniques.

The application of chemical measures to pest population has to be in such a manner that target pest populations are just kept below economic injury thresholds. By observation of this principle the development of resistant populations of pest is avoided or delayed, the possibility of resurgence of treated population is decreased, adverse effect on non target organism and amount of environmental contamination are reduced, and the cost of control is also lowered.

When insecticide treatments are deemed necessary special consideration should be given to
(1) Effectiveness of the insecticide against most vulnerable life stage of the pest
(2) Employing an insecticide that will cause least disturbance in the ecosystem.
(3) Applying the insecticide in such a way that it will restrict its distribution to the area where it is needed.

6. Pesticide selection

IPM seeks to reduce reliance on pesticides. When prevention and alternative control methods by themselves do no yield satisfactory results, however, selective pesticides are also used. In this situation, Principles 5, 6, and 7, which presuppose pesticide use, become relevant. Sound selection of pesticides to minimize unwanted health or environmental effects (including negative effects on pest regulation) is essential.

7. Reduced pesticide use

Reducing doses, application frequency, and resorting to partial application of pesticides contribute to the IPM goal of reducing or minimizing risks to human health and the environment. In fact, national pesticide plans have adopted reduced use as their overall quantitative time-bound goal. Expressing reduction in terms of volume used automatically generates a downward trend due to a switch to more potent products. Practitioners consider reducing dose rates as secondary to reducing reliance on pesticides; they acknowledge it as a tactic along the IPM continuum that can be judiciously combined with other ones: use of resistant cultivars, applying thresholds concerning disease intensity rather than frequency combined with advanced decision-support systems. One aspect to consider applying reduced doses is the potential influence on the risk of pesticide resistance developing in the pest population, which is the focus of the next principle.

Reduced pesticide use, in terms of frequency, spot spraying, or dose reduction is a recognized tactic along the IPM continuum that can be combined with other ones.

TOOLS OF IPM

The available techniques for controlling individual insect pests are conveniently categorized in increasing order of complexity as -

1. Cultural
2. Mechanical
3. Physical
4. Biological
5. Genetic
6. Regulatory
7. Chemical

1. Cultural methods or agronomic practices:

a. Use of resistant varieties
b. Crop rotation
c. Crop refuses destruction
d. Tillage of soil
e. Variation in time of planting or harvesting
f. Pruning or thinning and proper spacing
g. Judicious and balanced use of fertilizers
h. Crop sanitation
i. Water management
j. Planting of trap crops

2. Mechanical methods:

a. Hand destruction
b. Exclusion by barriers
c. Use of traps

3. Physical methods:

a. Application of heat

- Hot water treatment
- Exposing of infested grain to sun
- Super heating of empty store at 50 ^{0}C to kill hibernating stored grain pests.

b. Manipulation of moisture

- Reduction of moisture content of grains helps to prevent from the attack of stored grain pests.

c. Energy

- Light traps

4. Biological control:

a. Protection and encouragement of natural enemies
b. Introduction, artificial increase and colonization of specific parasitoids and predators.

- Conservation of natural enemies
- Parasites and Parasitoids
- Egg Parasitoids
- Larval Parasitoids
- Pupal Parasitoids

c. Propagation and dissemination of specific bacterial, viral, fungal and protozoan diseases.

5. Genetic methods: - Use of sterile male technique

6. Regulatory methods: - Plant quarantine

a. Foreign quarantine

b. Domestic quarantine

7. Chemical methods:

- Use of attractants
- Use of insecticides

- Use of repellants
- Use of growth inhibitors