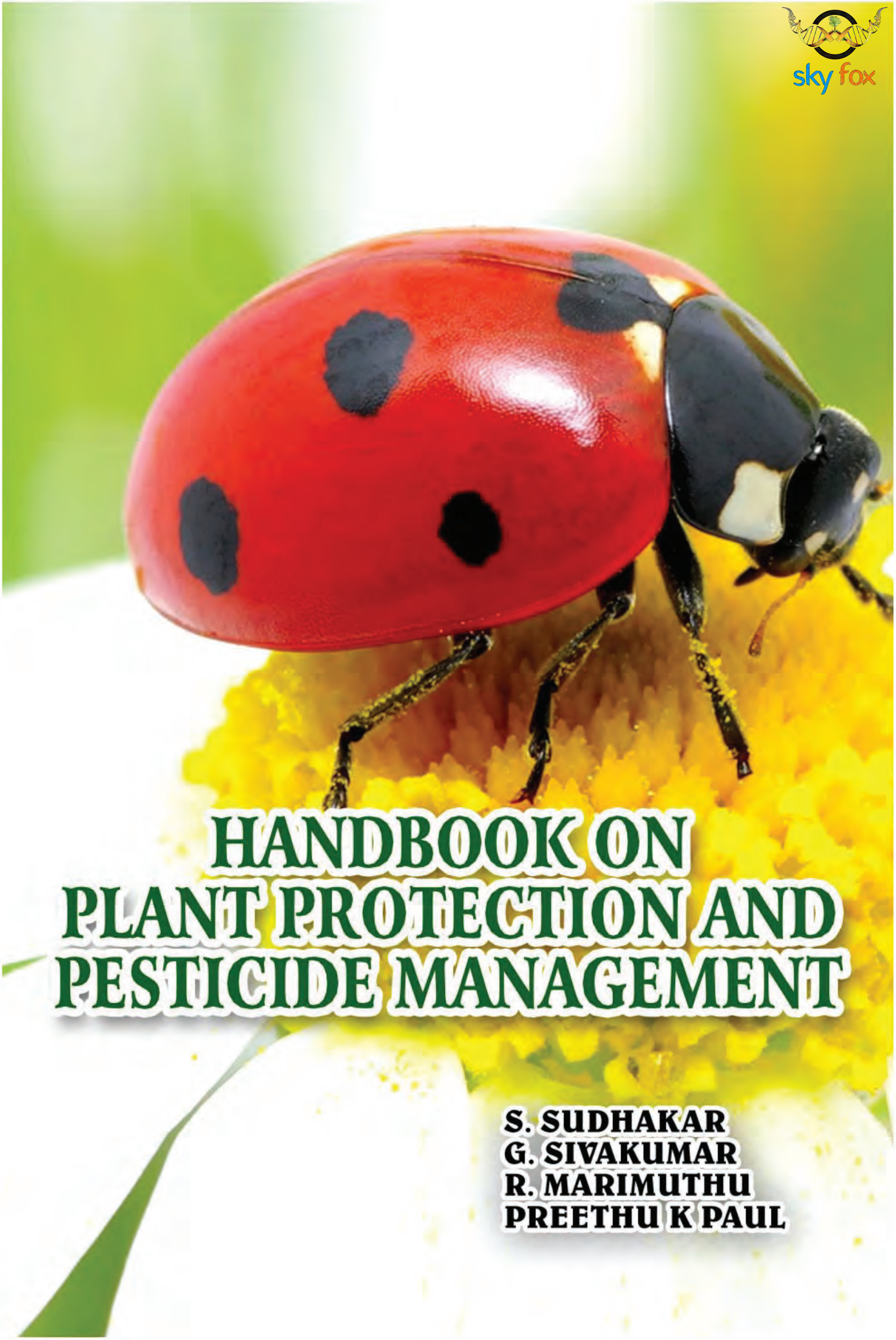

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HANDBOOK ON PLANT PROTECTION AND PESTICIDE MANAGEMENT

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Printed: April, 2022

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Published by:

Skyfox Publishing Group
Skyfox Press
#1789, Medical College
Road Thanjavur-613004
Tamil Nadu, India.
Phone: +918300123232
Email: skyfoxpublishing@gmail.com
skyfox@skyfox.org.in
Website: www.skyfox.co

Marketing Office
Skyfox Publishing Group
333 Cedar Street, PO Box
208002, New Haven,United States.
CT 06520-8002.Tel: 203.737.5603
Fax:203.785.7446
Email: skyfoxpublishing@gmail.com
skyfox@skyfox.org.in
Website: www.skyfox.co

Funded by: National Institute of Plant Health Management (NIPHM)
(An Organization of Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture, Govt. of India)

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ISBN: 978-93-90357-13-0
DOI: https://doi.org/10.22573/spg.024.978-93-90357-13-0/S/047
Price: ₹500

Printed at: Printech Offset Press,
Santhanpara, Idukki,
Kerala.

FOREWORD

This book deals with plant protection and pesticides management ideas for farmers, farm advisors, students and gardeners in mind.The manual is written for the pest management and for the official who is need of hours to learn the pesticides, pesticides formulation and thieir insect pest management. A pesticides application method continues to play a valuable role in many pest control operations; however, both the concepts and the procedures for controlling insects and other organisms are changing. With increased public concern over the adverse effects of pesticidal chemicals on human health and the environment, greater emphasis is being given to methods that can circumvent the use of these materials.

This book is highly acclaimed Handbook on Plant Protection and Pesticide Management is an in-depth, scientific sourcebook concerning use, properties, effects and regulation of pesticides. This book contains up-to-date information on a broad range of topics which establishes context of pesticide use and outlines how they are scientifically evaluated. Experts from a variety of disciplines contributed to this work. Some provide a fresh look at existing information and others look ahead at issues that are central to understanding pesticide use in modern integrated pest management.

The present work is a manual written, which gave a comprehensive account of the basic principles and practices of pesticides. Much of this information is valid and it has been retained, largely in its original form, with new information being added where appropriate and necessary. In the preparation of the manual, valuable help and guidance affored by colleagues throughout the world is gratefully acknowledged.

Reena Chacko
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Santhanpara
05/04/2022

PREFACE

Humans are constantly engaged in struggles against competitors and diseases. One way to gain an advantage in many of those ecological interactions is through the use of pesticides. These substances are used to protect crop plants, livestock, domestic animals and people from damage and diseases caused by microorganisms, fungi, insects, rodents and other "pests," and to defend crops from competition with unwanted but abundant "weeds".

It is important to understand that the use of words like "pest" and "weed" is highly contextual. In most situations, for example, white-tailed deer are valued for their wild beauty, and they provide economic and subsistence benefits through hunting. However, this animal may also be considered a pest when it feeds in a garden, agricultural field, or forestry plantation. The same is true, to some degree, of other species that are considered to be a pest or weed.

The Handbook on Plant Protection and Pesticide management is a comprehensive, reference guide to the properties, effects, and regulation of pesticides that provides the latest and most complete information .The handbook contains all the information that should be presented in the training course, together with some additional background information. The main target groups of the course are pesticide retailers and agricultural extension officers, although farmers could also be included. With the understanding of IPM provided by the course, participants should be able to understand the practical implementation of IPM in actual farm and crop situations.

Authors

CONTENTS

1. PESTICIDES AND INDIA AGRICULTURE

Globally more than half of the pesticides are utilized in Asia. India stands12th in pesticide use globall yand 3rdin Asia after China and Turkey. In present study, the data of different types of pesticides, pesticide use pattern and detailed pesticide consumption of the India and world were collected, organized and summarized. Around 70% of the total population is employed under agriculture sector which is the most important sector of Indian economy and pesticides and fertilizers are major integral part of modern agriculture. Commonly used pesticide includes insecticides, fungicides and herbicides for management of uncontrolled weeds and pests on agricultural sites. However in total pesticide consumption, insecticides occupies highest share in India. India share only1% of the global pesticide use. As per the data of FAO, India has utilized around 58160 tonnes of pesticide in 2018. Per hectare application rate of pesticide was only 0.31kg in 2017. While consumption in China, Japan and America was around 13.07, 11.76 and 3.57 kg ha^{-1} of pesticides respectively. So it is clear that India applies fewer amounts of pesticides in per hectare of crop land area, but uncontrolled and haphazard pesticide usage is responsible for the presence of high pesticide residues in both natural and physical environment. Bio-pesticides have proven to be the inest alternative to chemical pesticides for promoting a sustainable method of development in the agriculture sector, while also reducing pollution caused bychemical pesticides. Many biopesticides are now being developed in India and could be excellent alternatives tochemical pesticides. There are many eco-friendly plant based and microbial bio-pesticides available in the market. Bio-pesticides consumption is only 8% in India. For sustainable agricultural development and to protect environment from adverse effect of chemical pesticides, formulation and utilization of bio-pesticides should be prompted.

2. GENERAL OVERVIEW AND CLASSIFICATION OF PESTICIDES

Pesticides are chemical compounds that are used to kill pests, including insects, rodents, fungi and unwanted plants (weeds). Pesticides are mainly used for benefits like crops protection, preservation of food materials and prevention of vector borne diseases. They are also used in different field like agriculture, forestry, aquaculture, food industry, processing, transportation and storage of wood and other biological products.

1 Gross use of pesticides cause damage to public health and ecosystem. Incidence of poisoning, as reported, is 13- fold higher in developing countries than in highly industrialised nations, which consumes 85% of world's pesticide production. Most pesticide related poisoning in developing nations can be attributed to lack of training in their use, poor legislative control and carelessness in providing protection to the body during their application.

2 Pesticides have different distribution and persistence patterns in the environment, even if all of them are distributed in some way through air, soil and water.

3 Pesticides are classified on the basis of various criteria. Most commonly used criteria for classification of pesticides are its mode of entry, its chemical composition and target it kill. But giving importance to public health, World Health Organization (WHO) and Globally Harmonized System (GHS) classified pesticides according to their toxicity or hazardous effects. Without ignoring risk factors of pesticides, we must have to use it for better crop production & food preservation. But by using it judiciously with the help of different classification of pesticides, its gross use, exposure and toxic effects can be minimized.

3. CLASSIFICATION OF PESTICIDES

Pesticides are classified on the basis of various criteria such as toxicity (Hazardous effects), pest organism they kill and pesticide function, chemical composition, mode of entry, mode of action, how or when they work, formulations and sources of origin.

3.1.Classification of pesticides on the basis of toxicity

Toxicity of pesticide mainly depends on two factors namely dose and time. Hence, how much of the substance is involved (dose) and how often the exposure to the substance occurs (time) give rise to two different types of toxicity- acute and chronic toxicity.

Acute Toxicity- Acute toxicity refers to how poisonous a pesticide is to a human, animal or plant after a single short-term exposure. A pesticide with a high acute toxicity is deadly even when a very small amount is absorbed. Acute toxicity may be measured as acute oral toxicity, acute dermal toxicity and acute inhalation toxicity.

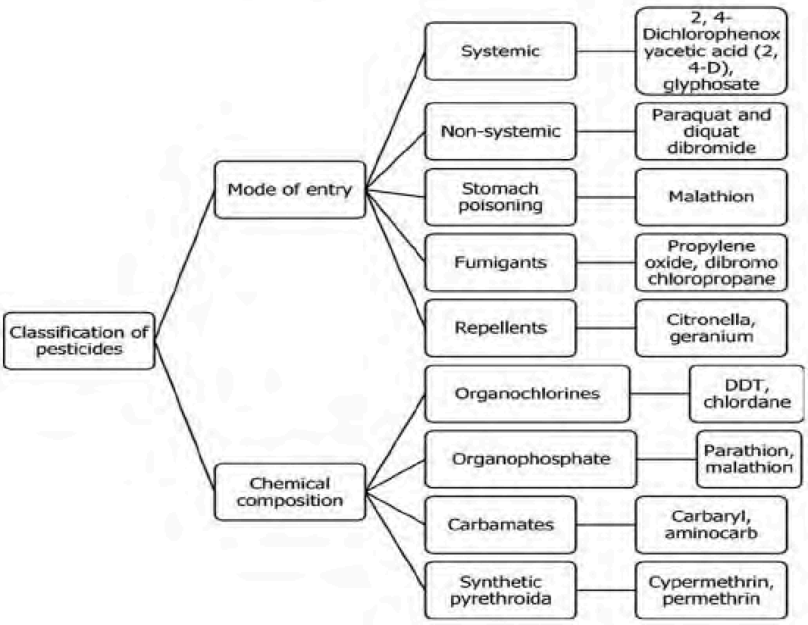
Chronic toxicity- Chronic toxicity is delayed poisonous effect from exposure to a pesticide. Chronic toxicity of pesticides concerns the general public as well as those working directly with pesticides because of potential exposure to pesticides on/in food products, water and the air. World Health Organization (WHO) has highlighted only acute toxicity for the classification of pesticides. According to WHO, pesticides are classified by acute oral and acute dermal toxicity using the estimated respective lethal dose LD50 (the pesticide dose that is required to kill half of the tested animals when entering the body by oral or dermal route). WHO recommended classification of 'Pesticides by Hazard' is shown in Table 1.

Table-1: Classification of pesticide based on their toxicity (under Insecticide Rule 1971)

Classification of the Insecticides	Oral LD_{50} mg/kg body weight of test animals	Dermal LD_{50} mg/kgbody weight of test animals	Colour Code on the label	Symbol
Extremely toxic	1-50	1-200	Bright red	
Highly toxic	51-500	201-2000	Bright yellow	
Moderately toxic	501-5000	2001-20000	Bright blue	
Slightly toxic	More than5000	More than 20000	Brightgreen	

3.2 Classification of Pesticides on the basis of Chemical Composition

This is the most common and useful method of classifying pesticide which is based on their chemical composition. Pesticides like insecticides, fungicides, herbicides and rodenticides are also classified on the basis of their chemical compositions as follows



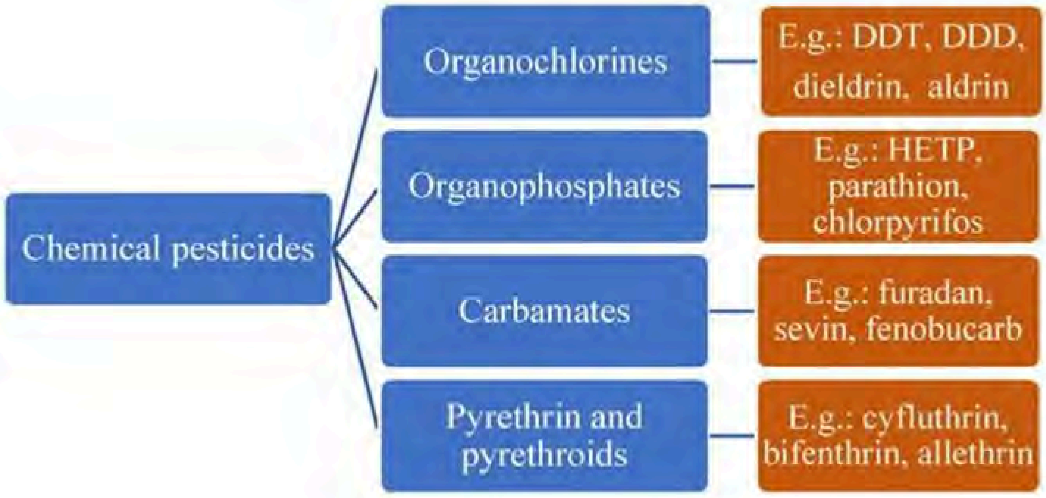
Insecticides: On the basis of chemical composition insecticides are classified as, Carbamates (Carbaryl), Organochlorine (Endosulfan), Organophosphorus (Monocrotophos), Pyrethroids (permethrin) Neonicotinoids (Imidacloprid), miscellaneous pesticides such as Spinosyns (Spinosad), Benzolureas (diflubenzuron), Antibiotics (abamectin), etc.

Fungicides: Fungicides are classified as aliphatic nitrogen fungicides (dodine), amide fungicides (carpropamid), aromatic fungicides (chlorothalonil), dicarboximide fungicides (famoxadone), dinitrophenol fungicides (dinocap) etc. Herbicides- The herbicides are anilide herbicides (flufenacet), phenoxyacetic herbicides (2, 4-D), quaternary ammonium herbicides (Paraquat), chlorotriazine herbicides (atrazine), sulfonylurea herbicides (chlorimuron), etc.

Rodenticides – They are classified as inorganic rodenticides (Zinc phosphide, Aluminium Phosphide), coumarin rodenticides (organic) (bromadiolone, coumatetralyl)

3.3 Classification based on Chemistry/Chemical structure

Based on the molecular structure of a compound, the pesticides are divided into two groups: organic and inorganic. The earliest chemical pesticides like Sulfur and lime were inorganic. Most of the modern pesticides are organic chemicals. Organic pesticides can be subdivided into two groups: the natural organics, and the synthetic organics which are further classified based on the chemical moiety attached to the carbon in to organo chlorines, carbamates, neo-nicotinoids etc. Eg: Chlorpyriphos, Dicofol, Fenvalerate, Thiamethoxam, Bifenthrin.

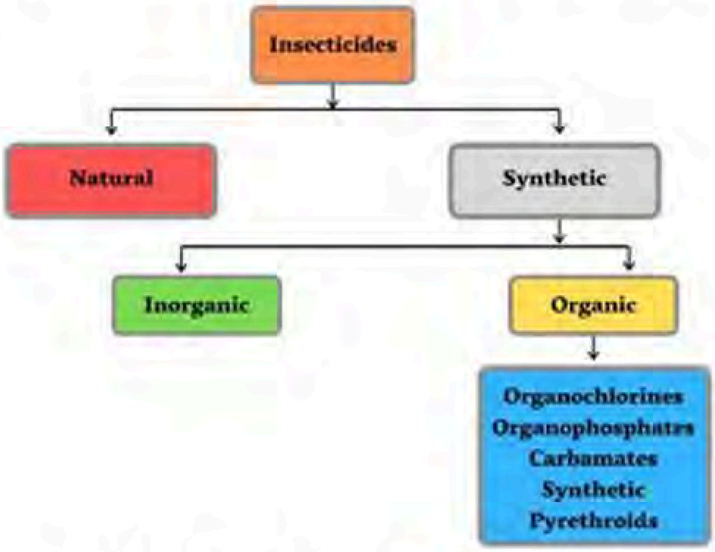


Classification of the chemical pesticides. DDT: dichlorodiphenyltrichloroethane; DDD: dichlorodiphenyldichloroethane; HETP: hexaethyl tetraphosphate.

3.3.1 . INSECTICIDES

INTRODUCTION

Based on the molecular structure of a compound, the pesticides are divided into two groups: organic and inorganic. The earliest chemical pesticides like Sulfur and lime are inorganic. Most of the modern pesticides are organic chemicals. Organic pesticides can be subdivided into two groups: the natural organics, and the synthetic organics.



1. **NATURAL ORGANICS**: The natural organic pesticides are derived from naturally occurring sources such as plants, microorganisms etc. and may be divided as Microbial bio-pesticides and Botanical Pesticide. Microbes used as bio-pesticides are basically bacteria (Antagonistic and Entomotoxic Bacteria), fungi (Antagonistic and Entomopathogenic Fungi) and viruses (Nuclear polyhydral virus and Baculovirus). Two major botanical pesticides are Azadirachtin and Pyrethrin.

1.1 Natural Pesticides

Natural pesticides are naturally occurring chemicals extracted from plants. Natural pesticide products are available as an alternative to synthetic chemical formulations but they are not necessarily less toxic to humans. Some deadly, fast-acting toxins and potent carcinogens occur naturally.

1.2 Mode of action

The mode of action or mechanism of action of pesticide is how the pesticide works. In other words, it is how the specific systems in the pest are affected by the pesticide. Mode of action refers to the specific biochemical interaction through which a pesticide produces its effect on the pest. Usually, the mode of action includes the specific enzyme, protein, or biological step affected. While most other classifications are the pests controlled, physical characteristics, or chemical composition, mode of action specifically refers to which biological process the pesticide interrupts .Knowing the mode of action is integral for scientists to improve the quality and sustainability of a product. To understand how pesticides work (their mode of action), it is necessary to understand how the pests' targeted systems normally function. It is also helpful to understand how human systems function in order to know similarities and differences between humans and the pests we try to control. It is also very important to understand the modes of action of the pesticides we use is to prevent the develop ment of pesticide resistance in the target pest(s).

1.3 Scope of Biopesticides

Efforts is been made to find biopesticides with novel mechanism of action and have no crossresistance with the old pesticides. Biopesti cides are a distinct group of pesticides which is different from conven tional pesticides. They are comprised of two major categories, which are the biochemical pest control agents (e.g., pheromones, hormones, natural plant growth regulators and enzymes) and the microbial pest control agents (e.g., microorganisms). Pesticides to be included in these categories must be naturally occurring, or if man synthesizes the chemical, and then it must be structurally safe and identical to a naturally occurring chemical. Minor differences between the stereo-chemical isomer ratios (found in the naturally occurring compound compared to the synthetic compound) will normally not rule out a chemical being classified as a biopesticides unless an isomer is found to have significantly different toxicological properties from those of another isomer.

Thus, the application of active toxic biopesticides agents as an alternative control strategy results in an urge to look for environment-friendly, biodegradable and easily available at affordable prices products for pests control.

1.3.1Uses of Biopesticides

Biopesticides give better control than conventional pesticides such as organochlorine, biopessticides are usually a narrow spectrum of activity; are cheaper, less toxic to workers or consumers; usually true to type, safer for the environment and for beneficial insects; and required for certified organic production surroundings. Biopesticides may be applied shortly before harvest without leaving excessive residues, are less persistence in the environment and have reduced risks to non-target organisms. They act very quickly in insect to stop feeding, they may not cause death for hours or days, but they often cause immediate paralysis or cessation of pests feeding. Most biopesticides insecticides may have low to moderate mammalian toxicity. In the field, their rapid degradation and action as stomach poisons make them more selective in some instances for plant-feeding pest insects and less harmful to beneficial insects. Many biopesticide are not toxic to plants, however, it is always best to test a new product on few plants first before applying on a large scale .

1.4 Various Types of Natural Pesticides

The major categories of biopesticides include botanicals, microbials, essential oil and minerals based, many of these come from plants themselves, insects, or naturally occurring minerals. Some of the more commonly used and effective natural pesticides are insect and mite growth regulators, *Bacillus thuringiensis* (Kurstaki), horticultural oils, insecticidal soaps, entomopathogenic nematodes and neem products. The advantage of using biological products is because they have less negative impact non-target organisms, including humans.

1.5 Microbial

This category include Fungi, bacteria, protozoans, algae, viruses, etc. which can be used to cause disease in an insect population. Several microbial have been genetically engineered to kill target insects more rapidly. These either introduce a disease to a certain insect population, produce a toxin or limit reproduction of insects. Milky spore is an example of this type of natural pesticide e.g. *Bacillus thuringiensis*

1.6 Mineral

Mineral based controls include sulfur and lime-sulfur. Both combination are sprayed as part of the control of common insect pests.

1.7 Botanical

Botanical pesticides are gotten from plants. Nicotine, Neem, Rotenone, anabasine, azadirachtin, ryania, essential oil, Sabadilla and Pyrethrins are all derived from other plants. Pyrethrins for instance, are from the chrysanthemum plant and are effective on flying insects and to flush out larvae and grubs. Chemicals extracted or derived from plants may be present and subsequently extracted from the plant material (a constitutive chemical). It may be activated in the plant as a response to insect activity (inducible chemicals). Some are chemically modified after extraction to enhance their insecticidal properties

1.8 Essential oil

Some plants also produce essential oils in specialized gland cells. Peppermint oil control of household pests such as cockroaches and ants. Clove oil inhibits soilborn fungal disease. Citrus oil control of flea, aphid and mites. Lavender oil is aninsect repellent like wise. Thyme oil, Rosemary oil and Cedar oil, are insect repellents

1.9 List of Natural Pesticide

Natural pesticides are naturally occurring chemicals extracted from plants use to kill or retard the growth of pests that damage or interfere with the growth of crops, shrubs, trees, timber and other vegetation desired by humans. These natural pesticides include: Rotenone, Nicotine, Neem, Ryania, Pyrethrins, Sabadilla, Fluoroacetate, Carboxin and *Bacillus thuringiensis*.

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1.10 Rotenone

Rotenone insecticides have been in use for centuries. Products containing rotenone are typically prepared from plant species of the genus Derris plant or Lonchocarpus (Leguminosae) with the majority from Cubé resin, a root extract of Lonchocarpus utilis and Lonchocarpus urucu . Although rotenone is the major constituent in Cubé resin and hence in rotenone products, the active ingredients deguelin, rotenone, and tephrosin are also present. Rotenone based products are approved for use as organic insecticides under many trade names and most are sold as blends containing both rotenone and pyrethrum extracts. Rotenone has been in use as a fish poison for more than 150 years . It is also highly toxic to fish and is often used to eradicate unwanted fish populations, for instance, minnows in lakes before introducing trout, or to eradicate salmon in rivers in order to get rid of Gyrodactilus salaries, an obligate fish parasite that is a big threat to the salmon population. Rotenone are derived from the roots of over 68 plant species and is very toxic to fish, pigs, and cool blooded animals. It is used to control leafeating caterpillars and beetles. Direct contact may cause skin and mucous membranes irritation. Rotenone is one of several isoflavonoids produced in the roots. Extraction of the root with organic solvents yields resins containing as much as 45% total rotenoids; studies indicate that the major constituents are rotenone (44%), and deguelin (22%) . Rotenone is commonly sold as dust containing 1 to 6% active ingredients for home and garden use, but liquid formulations used in organic agriculture can contain as much as 9% rotenone and 16% total rotenoids.

Rotenone is a mitochondrial poison, which blocks the electron transport chain and prevents energy production. As a pesticide, it is considered a stomach poison because it must be ingested to be effective. Pure rotenone is comparable to Dichloro-diphenyl-trichloro-ethane (DDT) and other synthetic pesticides in terms of its acute toxicity to mammals (rat oral LD50 is 132 mg kg−1), although it is much less toxic at the levels seen in formulated products. rbeen called into question because of: Controversial reports that acute exposure in rats produces brain lesions consistent with those observed in humans and animals with Parkinson's disease.

And the persistence of rotenone on food crops after treatment. A study of rotenone residues on olives conducted in Italy determined that the half-life of rotenone is 4 days, and at harvest residue levels were above the tolerance limit. Moreover, residues were concentrated in oil obtained from the olives. As an Agricultural pesticide, use of rotenone is limited to organic food production.

1.11. Rotenone mode of action

Rotenone is an important insecticide extracted from various leguminous plants. It inhibits the transfer of electrons from nicotine amide-adenine (NADH) to ubiquinone. Rotenone is a powerful inhibitor of cellular respiration, the process that converts nutrient compounds into energy at the cellular level . In insects rotenone exerts its toxic effects primarily on nerve and muscle cells, causing rapid cessation of feeding. Death occurs several hours to a few days after exposure. Rotenone is extremely toxic to fish, and is often used as a fish poison (piscicide) in water management programs.

Compound that disrupts energy metabolism has been identified from both natural and synthetic sources. Complex I is inhibited by rotenone which is derived from cube or derris root. Disruption of energy metabolism occurs in the mitochondria and usually takes the form of either an inhibition of the ETS, blockage of ATP synthesis. The ETS (complexes i-iv are macromolecular complexes that use high energy electrons to pump out hydrogen into the intermembrane space and to store this energy as a proton gradient, which is harnessed to synthesize ATP. Inhibition of ETS blocks indirectly the production of ATP and cause a decrease in oxygen consumption by the mitochondria. Rotenone inhibit complex I in the ETS and blockage at this site can reduce energy production and induce whole animal toxicity. The disruption energy metabolism and the subsequent loss of ATP results in a slowly developing toxicity, and the effects of all these compounds include inactivity, paralysis, and death shown.

1.12 Nicotine

Nicotine is an alkaloid obtained from the foliage of tobacco plants (Nicotiana tabacum) and related species, has a long history as an insecticide. Nicotine and two closely related alkaloids, nornicotine and anabasine, are synaptic poisons that mimic the neurotransmitter acetylcholine. As such, they cause symptoms of poisoning similar to those seen with organophosphate and carbamate insecticides. Owing to the extreme toxicity of pure nicotine to mammals (rat oral LD50 is 50 mg kg−1) and its rapid dermal absorption in humans, nicotine has seen declining use, primarily as a fumigant in greenhouses against soft-bodied pests. However, there remains some interest in preparing stable nicotine fatty acid soaps, presumably with reduced bioavailability and toxicity to humans . Nicotine is a Pale yellow to dark brown liquid which is highly toxic to warm-blooded animals. Nicotine is a fast-acting contact killer for soft bodies but does not kill most chewing insects. Nicotine is highly lipophilic and can pass through dermal tissues as well as the blood brain barrier.

1.13 Sabadilla

Sabadilla is a botanical pesticide obtained from the seeds of the South American lily Schoenocaulon officinale. In purity, the active principles, celandine-type alkaloids, are extremely toxic to mammals (rat oral LD50 is ca. 13 mg kg−1), but commercial preparations typically contain less than 1% active ingredient, providing a margin of safety. These alkaloids are remarkably similar to that of the pyrethrins, despite their lack of structural similarity. Sabadilla is used primarily by organic growers; in California about 100 kg is used annually, primarily on citrus crops and avocado

1.14 Ryania

Ryania Botanical insecticides are made from grounded stem of Ryana speciosa. Is highly toxic to the fruit moths, and citrus thrips. Another botanical in declining use is ryania, obtained by grinding the wood of the Caribbean shrub *Ryania speciosa* (Flacourtiaceae). The powdered wood contains < 1 % ryanodine, an alkaloid that interferes with calcium release in muscle tissue (National Research Council).

It is used to a limited extent by organic apple growers for control of the codling moth, *Cydia pomonella*. More information on sabadilla and ryania can be found in the two reviews .

1.15 Pyrethrum

Pyrethrum, also known as pyrethrins, is extracted from the seed of *Chrysanthemum cineraria folium* and has been used as an insecticide for over 100 years. Today these plants are grown primarily in Kenya. Pyrethrum is effective against a wide range of soft-bodied garden pests such as scales, whitefly, mealybugs, and thrips, but will not control mites. Pyrethrins are neurotoxins that attack an insect's nervous system and cause repeated and extended nerve firings. They may also have a repellant effect. Pyrethrins are easily broken down by stomach acids in mammals, so toxicity to humans and pets is very low. However, toxicity can occur when significantly more product is applied than specified on the label. Do not spray pyrethrins around ponds or other bodies of water, as they can kill fish. Pyrethrum is a broad-spectrum insecticide that is toxic to beneficial insects. Pyrethrum can paralyze susceptible insects upon exposure, but also degrades in sunlight within hours Pyrethrum is a daisy-like Chrysanthemum. In the tropics, pyrethrum is grown in mountain areas because it needs cool temperatures to develop its flowers. Pyrethrins is Very toxic to cool blooded animals, some peoples and cats. Very effective on most insects. It rapidly breaks down in sunlight, air and water.

Pyrethrins are insecticidal chemicals extracted from the dried pyrethrum flower. The flower heads are processed into a powder to make a dust. This dust can be used directly or infused into water to make a spray. Most of the world's pyrethrum crop is grown in Kenya. The term "pyrethrum" is the name for the crude flower dust itself, and the term "pyrethrins" refers to the six related insecticidal compounds that occur naturally in the crude material, the pyrethrum flowers. The flowers are ground to a powder and then extracted with hexane or a similar nonpolar solvent; removal of the solvent yields an orangecol-ored liquid that contains the active principles.

These are three esters of chrysanthemic acid and three esters of pyrethric acid. Among the six esters, those incorporating the alcohol pyrethrolone, namely pyrethrins I and II, are the most abundant and account for most of the pesticidal activity. Technical grade pyrethrum, the resin used in formulating commercial pesticides, typically contains from 20 to 25% pyrethrins

1.16 Neem Products (Azadirachtin)

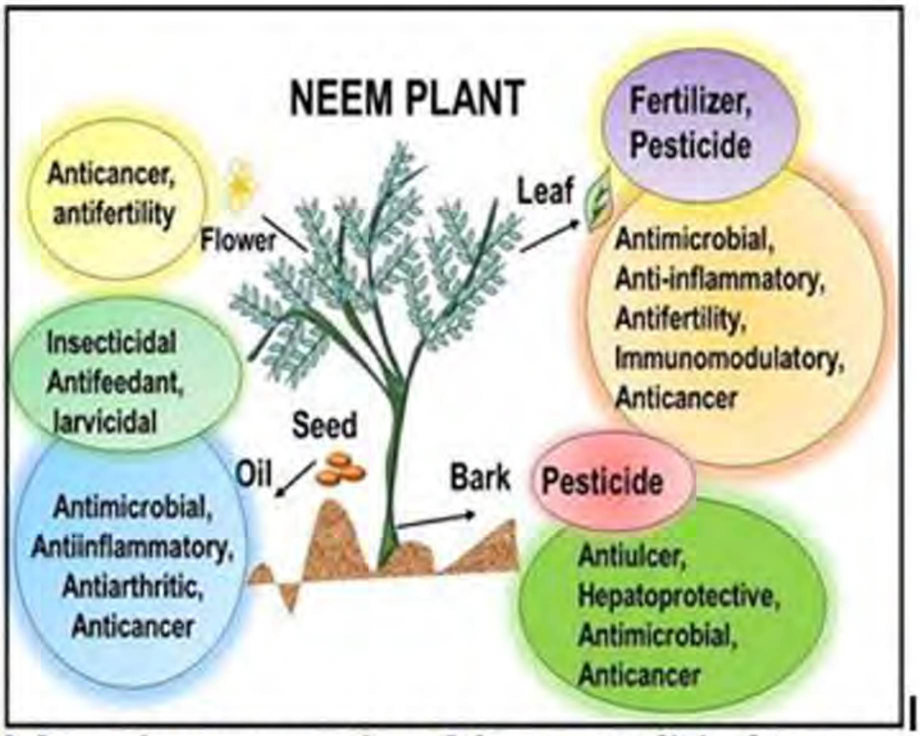
Neem is derived from the neem tree (*Azadiracta indica*) of arid tropical regions, contains several insecticidal compounds. Neem (*Azadiracta indica*) belonging to the Meliaceae family has emerged as a highly potent biopesticide. The main active ingredients is azadiractin, which both deters and kills many species of caterpillars, thrips and whitefly. Both seeds and leaves can be used to prepare the neem solution. Neem seeds contain a higher amount of neem oil. The leaves of neem are available all year compared to the seed. A neem solution loses its effectiveness within about 8 hours after preparation, and when exposed to direct sunlight. It is most effective to apply neem in the evening, directly after preparation, under humid conditions or when the plants and insects are damp. High neem concentration can cause burning of plant leaves. Also, natural enemies can be affected by neem applications.

Seeds from neem tree comprise 40% of oil with azadirachtin as the major active ingredient responsible for the insecticidal activity of neem Neem oil contains more than a dozen azadirachtin analogs, but the major contributor to the insecticidal activity is azadirachtin. Further, the seed cake obtained during the processing of neem oil is a vital natural fertilizer used in common agricultural practices. Neem leaves have been employed for centuries against the stored grain pests due to its repellent properties. Collectively, all parts of neem plant are known to exhibit by-products that inherently impart an internal chemical defense making neem free from the pest attack, which can also be exploited to develop an efficient pest control strategy. Further, the functional ingredients of neem, exhibit, and therapeutic significance as neem oil, bark, leaves and their purified biochemicals are documented to have anticancer and antimicrobial properties.

Neem leaf extract possesses anti-inflammatory properties, while the neem oil acts as an antifertility agent. This unique attribute of neem makes it an ideal bio-pesticide agent, as it does not cause non-specific toxicity to mammals. Neem oil, obtained by cold-pressing seeds, can be effective against soft-bodied insects and mites but is also useful in the management of phytopathogens. Apart from the physical effects of neem oil on pests and fungi, disulfides in the oil likely contribute to the bioactivity of this material. More highly valued than neem oil are medium- polarity extracts of the seed residue after removal of the oil, as these extracts contain the complex triterpene azadirachtin. Neem seeds actually contain more than a dozen azadirachtin analogues, but the major form is azadirachtin and the remaining minor analogues likely contribute little to overall efficacy of the extract. Seed extracts include considerable quantities of other triterpenoids, notably salannin, nimbin, and derivatives thereof. The role of these other natural substances has been controversial, but most evidence points to azadirachtin as the most important active principle. Neem seeds typically contain 0.2–0.6% azadirachtin by weight, so solvent partitions or other chemical processes are required to concentrate this active ingredient to level 10–50% seen in the technical grade material used to produce their products.

Neem insecticides are effective against many caterpillars, flies, whitefly, and scales, and are somewhat effective against aphids. Neem may not show signs of efficacy for 3–8 days, and it can degrade within 3–5 days. Multiple applications are generally needed to obtain good management of the targeted pests. Neem is regarded as nontoxic to vertebrate animals and has been shown to minimally affect many beneficial insects such as bees, spiders, and ladybugs. Well known as a potent insect antifeedant, azadiractin. A appears to work by blocking the synthesis and release of molting hormones (ecdysteroids) from the prothoracic gland. Many neem/azadirachtin based products are approved for use as organic insecticides. An added advantage of neem oil-based products is their ability to control fungal infections as well as a wide variety of both insect and mite pathogens

The seeds from the Indian neem tree, Azadirachta indica, are the source of two types of neem-derived botanical insecticides; neem oil and medium polarity extracts. Neem seeds contain more numerous azadirachtin analogues, but the major form is azadirachtin A and the remaining minor analogues likely contribute little to overall efficacy of the extracts.



Schematic representation of the agromedicinal tree

1.17 *Bacillus thuringiensis* (B.t.)

This is probably the most common microbial 'active ingredient'. This organism is incorporated into several products, most of which are used to control caterpillar pests. Specific strains of B.T. have been selected for their ability to control mosquitos, black flies and other organisms. For example, B. t. strains 'kurstaki', 'berliner' and 'aizawai' are used for controlling larvae of many Lepidoptera pests, while *B.T. 'tenebrionis'* is used against larvae of Colorado potato beetle, and B.T. 'israelensis' is used to control mosquito larvae. Be sure that the product chosen is labelled to control the pest the growers are targeting. Additionally, while some crops have been modified to express the insecticidal protein produced by *B. thuringiensis* these genetically altered plants are not considered.

1.18 Fluoroacetate

Fluoroacetate is produced by many plants in Australia and South Africa and has an important function as a natural pesticide for the plants. It is highly toxic to rodents and other mammals. In certain parts of Australia, where such plants are abundant, opossums have become resistant to fluoroacetic acid.

1.19 Carboxin

Carboxin is a systemic pesticide is taken up by the organism it protects and may kill sucking aphids or the growing fungal hyphae. The older of course, detrimental to the organism. The nervous system is sensitive to these changes because glutamic acid is an important transmitter called glutaminergic synapses, and calcium is a very important Ises. Furthermore, the halt of aerobic energy production is very harmful. Carboxin is a systemic pesticide is taken up by the organism it protects and may kill sucking aphids or the growing fungal hyphae. The older fungicides are active only as a coating on the surface of the plants and do not growing mycelia inside the plant tissue.

1.20 Microbial Insecticides:

Different species and strains and Bacillus bacteria are known to affect different groups of insect pests, primarily due to differences in endotoxin receptor sites on the gut wall. The lethal component is crystals of δ-endotoxin. *Bacillus thuringiensis var. kurstaki* (Dipel, Javelin)is effective against caterpillars of moths and butterflies

Various Microbial insecticides that are available in India are as follows:

S.No	Name of the Microbialbiopesticide	Available as
1.	*Trichodermaviridae*	Antagonistic fungi for the control of*Rhizoctonia, Sclerotium and Fusarium Spp.* etc
2.	*Trichodermaharzianum*	
3.	*Ampelomycesquisqualis*	
4.	*Pseudomonasflourescens*	Antagonistic bacteria for the controlof*Rhizoctonia, Sclerotium and Fusarium Spp.*etc
5.	*Metarhizium anisopliae*	Entomopathogenic fungi for the control of caterpillars such as *Helicoverpa, Spodoptera spp.* etc.
6.	*Beauveria bassiana*	
7.	*Verticillium lecanii*	
8.	*Bacillus spericus*	Entomotoxic Bacteria for variouscaterpillars of Lepidoptera and mosquito larvae
9.	*Bacillus thringiensis var. kurstaki*	
10.	*Bacillus thringiensis var. galleriae*	
11.	*Bacillus thringiensis var. sphericus*	
12.	NPV of *Helicoverpa armigera*	Baculoviruses for the control of caterpillars of Lepidoptera
13.	NPV of *Spodoptera litura*	

1.21 Advantages of using Biopesticides compared to Chemical Pesticides

Biological pesticides, also known as biopesticides, biological controls or biocontrols, are an organism used to manage pests or diseases and is most notably used in agriculture. Biopesticides are typically natural predators, parasitoids, fungi or nematodes which feed on a target pest, and use natural relationships in the food chain. Growers who use biologicals see the following benefits.

Effect on non-target species Biological control products typically target a narrow range of pests or diseases while non-target organisms, such as birds, bees, fish, humans and beneficial soil organisms, remain unaffected.

Pollution Since biological controls are naturally occurring organisms, at the end of their life they completely biodegrade and leave no harmful residues on the crop or in the environment. This feature helps promote the safety and wellbeing of people who work on farms and the environment.

Cost Biological control, as a part of IPM, works to achieve sustainable management of pests and diseases, keeping the pressure well below economically damaging levels. Pests and diseases do not develop resistance to biological controls. Since the rate of application will only change with pest or disease pressure, farmers can accurately predict input costs.

Pest resistance Records have shown that pests tend to become resistance to conventional pesticides thus proving that it is not a long term solution, something that never happens with the use of organic pesticides.

Market As the ordinary consumer became aware of the dangers posed by synthetic chemicals, demand for farm products that have undergone organic treatments rose. This makes the use of these chemicals a potential risk as there's a glaring. possibility of incurring huge losses due to the consumer shunning your product.

3.3. 2. Synthetic Organic Pesticides are produced artificially by chemical synthesis. This group comprises most "modern" pesticides and subdivided into following groups:

i. Organochlorine Pesticides
ii. Organophosphate Pesticides
iii. Carbamates
iv. Synthetic-pyrethroid
v. New Group of Insecticides
vi. New Insecticides from Microorganisms

3.2..1 Chlorinated Hydrocarbon

These chemicals are often considered to belong to the group of organochlorine pesticides. These pesticides were commonly used in the past but many have been removed from the market due to their persistence.They are hard to break down in the natural environment and their prolonged use in large quantities lead to environmental pollution and accumulation in mammals, resulting in cumulative poisoning or damage. Termed as Persistent Organic Pollutants (POPs), most of the organochlorine pesticides are banned.

Chemical group	Compounds
Dichlorodiphenylethanes	DDT, Methoxychlor
Hexachlorocyclohexane	Lindane
Cyclodienes	Aldrin, Dieldrin, Endrin, Chlordane, Heptachlor
Chlordecone	Mirex

3.2.2 Organophosphorus Insecticides

Organophosphorous compounds can kill by contact, systemic or fumigant action or a combination of the three. They affect the nervous system by disrupting an enzyme that regulates acetylcholine, a neurotransmitter. Being a nerve poison they can cause acute toxic reactions in humans.

Based on the chemical structures op's are classified as the following groups

S. No.	Type	Pesticides
1	Pyrophosphatesand related compounds	TEPP, Schradan
2	Phosphates	Chlorfenvinphos,Mevinphos, Dichlorvos, Monocrotophos, Tetrachlorvinphos
3	Thiophosphates	Chlorpyriphos, Diazinon, EPN, Ethyl parathion, feniitrothion, Fenthion, Methyl parathion, Primiphosmethyl, Triazophos
4	Dithiophosphates	Dimethoate, Aazinphos-methyl, Malathion, Phorate
5	Phosphonates	Terbufos, Trichorfon
6	Phosphoramidates	Acephate, Tebophos, Methamidophos

3.2.3 Carbamates

They have systemic and contact in action. They are nerve poison and inhibit acetyl cholinesterase activity at synapse or nerve junctions. They act similar to organophosphorus compounds except for the reversible nature of toxicity. Example: Carbofuran, Propoxur etc.

2.4 Pyrethroids

Pyrethrum is found in the flowers of plants belonging to the family Compositae and the genus Chrysanthemum sp. The pyrethrum compounds found in pyrethrum flowers consist of six esters which are the combinations of three different alcohols (pyrethrolone, jasmolone and cinerolone) with two different acids (chrysanthemic acid and pyrethric acid). Pyrethrums are highly unstable in the presence of light, moisture, and air. The pyrethrins are contact insecticides and have almost no stomach poison action because they are so readily hydrolyzed to nontoxic products. Their primary action is on the insect central nervous system, as shown by the fact that they produce such rapid paralysis. Synthetic pyrethroids (SPs) are synthetic analogs and derivatives of the original pyrethrins and include a variety group of about 1,000 insecticides. Though they are analogs of pyrethrins, their production has involved extensive chemical modifications which make them highly toxic and less degradable in the environment. Due to complex chemical structure, the pyrethroids are composed of two, four or eight isomers, and their commercially products may contain a mixture of these various isomers. For increasing the efficiency of the insecticides, the pyrethroids are formulated with compounds like piperonylbutoxide, piperonyl sulfoxide and sesamex, which act as synergists. Pyrethroids are broad spectrum insecticides, effective against a wide range of insect pests of the sucking complex such as aphids, jassids, whiteflies as well as chewing pests such as borers and leaf feeders. Prior to harvest, they are sprayed over edible products to control pests, as grain protectants, veterinary pests and household insecticides.

2.5 NEW GROUP OF INSECTICIDES:

Mankind has a history of using crop protection products from non-selective, naturally occurring compounds to highly specific synthetic and biological materials for assured food production and protection of environment since long time. Researchers are going on to develop safer molecules which could undergo photo-degradation, microbial degradation as well as chemical degradation l eaving very less amount of residues in the environment. Accordingly, many conventional pesticides have been replaced by newer insecticides which are more selective than conventional insecticides. The prime motto for these developments is to give protection to the crops along with safety to the natural enemies of different pests as a whole safety to environment.

1.Neo-Nicotinoids: They are synthetic a nalogues of nicotine. These neo-nicotinoids are further classified into three groups namely:

a) Chloronicotinyl compounds: Examples are Imidacloprid and Acetamiprid Imidacloprid: It is the first commercial insecticide of this group which inhibits nicotinic acetylcholine by binding with nicotinic acetylcholine receptor (nAChR). Imidacloprid has good xylem mobility and formulated for use as seed treatment, soil and foliar application and it is found effective against sucking pests (aphids, leaf hoppers, plant hoppers, white flies and thrips). In India manyformulations of Imidacloprid are registered viz., Imidacloprid 17.8% SL (Confidor), and 70% WS (Gaucho) as seed treatment. Acetamiprid: The mode of action is same as imidacloprid and it is a broadspectrum insecticide used for control of pests of vegetables, fruit trees, tea etc. It is found effective against sucking insect pests of cotton and formulated as Acetamiprid 20% SP and available in Indian market as Pride, Thiacloprid: It affects transmission of nerve impulse. Thiacloprid is also available with trade name Calypso.

b) Thionicotinyl group compounds e.g. Thiomethoxam Thiamethoxam is a broad spectrum insecticide acting against stem borers, hoppers, jassids, whiteflies, aphids, mosquito bug, psyllids and used in crops viz., rice, cotton, wheat, mustard, okra, mango, potato, tea and citrus etc. It can be used both for seed and foliar treatment. The formulations developed are 25% WG (foliar spray), 70% WS (Seed treatment). It is commercially available in market as Actara, Cruiser etc.

c) Furanicotinyl group compounds e.g. Dinotefuran Dinotefuran is third generation nicotinyl group of insecticides acting against sucking pests like hoppers, jassids and aphids of different crops. It is highly systemic compound. Commercially available formulation is Dinotefuran 20% SG in the name of Osheen and Token.

d) Pyridincarboxamides e.g Flonicamid Flonicamid has systemic as well as translaminar activity which gives long term control. Flonicamid rapidly inhabits the feeding behavior of aphids. Excellent activity against major species of aphids. It offers good persistence gives long time protection from the pest. It is also moderately effective against whiteflies, plant hoppers, plant bugs and mealy bugs of cotton, potato vegetables and fruit crops. It is available with the brand name Ulala with flonicamid 50% WG in the market.

2.Phenyl Pyrazoles The insecticide of this group is Fipronil. It is having systemic compound with contact and stomach activity. Fipronil blocks the gammaaminobutyric acid (GABA) regulated chloride channel in neurons,thus antagonizing the "calming" effect of GABA. It is found effective against stem borer, gall midge, DBM, thrips, shoe borers, root borer and can be used in crops viz., sugarcane, cruciferous crops cotton and rice. In India the formulations registered are 5% SC and 0.3% GR. It is popular with the farmers under the brand name as Regent .

3.Pyridine azomethines

The insecticide of this group is "Pymetrozine" and it has no direct toxicity against insects but it blocks stylet penetration of sucking insects which may cause immediate cessation of feeding after exposure to this insecticide. It found to effective against sucking pests (whiteflies, hoppers and aphids) and can be applied both as foliar and soil application. The commercial products of pymetrozine available in USA market are Chess, Fulfill.

4.Oxadiazine Group: The insecticide of this group "Indoxacarb" which inhibits the flow of sodium ions into nerve cell in insects that cause paralysis and death and enters into the insect body in two ways like through ingestion of treated foliage and also penetrates through insect cuticle used to control for variety of lepidoptera pests, specially against american boll worm, Helicoverpa armigera and diamond back moth (DBM) , Plutellla xylostella. The formulation available is 14.5% SC and recently indoxacarb 15.8% EC is registered with different isomers and found to be more effective against cotton bollworms, DBM, & pod borer complex. It is sold under trade name as Avaunt® and Avanut EC.

5.Halogenated Pyrroles:

The insecticide of this group is Chlorfenapyr. It is first and only member of this unique chemical group, acts by disrupting the proton gradient across mitochondrial membrane and prevent mitochondria from producing ATPs. It is found effective against DBM in cabbage and cauliflower and also against mites in chilli and commercially available as Intrepid® (Chlorfenapyr 10% SC).

6.Thiazolidine Group:

The insecticide of this group is Hexythiazox. Hexythiazox is an acaricide of this group. It affects growth and development of mites and used for control of red spider and yellow mites in tea and chilli, and available as hexythiazox 5.45% EC in the market with trade name as Maiden.

7.Thiourea Derivatives:

The insecticide of this group is Diafenthiuron. The mode of action of this insecticide is inhibition of oxidative phosphorylation i.e specifically they inhibit ATP synthase. They are found to be effective against sucking insects (whiteflies, aphids, jassids, thrips), mites and capsule borer. It is available in Indian market as Diafenthiuron 50% WP as Pegasus or Polo.

8.Sulfite Ester Group:

Propargite an acaricide belongs to this group. It kills mites through inhibition of oxidative phosphorylation i.e this compound act as disruptors of ATP formation. It is highly effective against phytophagous mites viz., red spider mite, pink mite, purple mite, scarlet mite in tea, yellow mite in chilli and European red mite & two spotted mite in apple and available in liquid formulation as 57% EC in market as Omite.

9.Diamide Group :

Flubendiamide and Chlorantraniliprole are two insecticides of this group.Flubendiamide a novel class of insecticide having a unique chemical structure used against broad spectrum of lepidopterous insects Ryanodine receptors are intracellular Ca2+ channels specialized for the rapid and massive release of Ca2+ from intra cellular stores, which is an essential step in the muscle contraction process. It has been recently registered in India under different formulations such as 20% WG registered trade name as Takumi & 39. 35% SC with registered trade name as Fame which act on insect pests of rice (stem borer, leaf folder) and cotton (*H. armigera* and spotted bollworm) The other new class of chemistry of this group is Chlorantraniliprole, to be specific it belongs to anthranilidin diamides controlling almost all economically important Lepidoptera and other species. It has high larvicial potency and long lasting activity with new mode of action and safe to non target insects (parasitoids, predators and pollinators). It is also used to control insects which are found resistant to other insecticides and fits into IPM programs. It binds to insect ryanodine receptors in muscle cells causing the channe l to open and release Ca^{2+} ions from internal stores into cytoplasm and because of depletion of calcium it causes paralysis and death. It is registered in India in 2009 and available in different formulations as 18.5% SC and 0.4% GR and targets stem borer, leaf folder (Rice), DBM (Cabbage), *H. armigera, S. litura, Earias spp* (Cotton), Termites, early shoot bore, top borer in sugarcane and yellow stem borer, leaf folder in rice, respectively. It is marketed as Coragen and Ferterra.

10.Ouinazoline Group: Acaricide.

Fenazaquin belongs to quinazoline group. It inhibits mitochondrial electron transport chain by binding with complex I at co-enzymes site Q. In India, it is registered as Fenazaquin 10% EC and sold as Magister which proved to be effective against mites in tea and chilli.

11.Tetronic Acid Derivatives Spiromesifen

This acarcide cum insecticide belongs to tetronic acid derivatives. It blocks the fat synthesis which ultimately causes the target pest to dry out and die i.e. the active ingredient is a lipid biosynthesis inhibitor that prevents insects from maintaining a necessary water balance.

12.Insect Growth Regulators

A. Benzoyl Urea The insecticides of this group are Novaluron and Lufenuron. Novaluron is new Insect Growth Regulator. It is powerful toxicant for controlling lepidopteran larvae. It acts by both ingestion as well as contact. It has got translaminar effect. It is quiet safe for beneficial insects and beneficial insects and natural parasites and predators. It is available with the name of Rimon and Signa in the market. B. Thiadiazines This is Chitin s ynthesis inhibitor. It prevents proper formation of exoskeleton after molting. It is effective against homoperean insects such as hoppers, Jassids and white fly. In the market Buprofezin active ingredient available with trade name Applaud.

13.Carbazate Acaricide: It is selective acaricide that controls spider mite. These compounds are neuroactive but it's exact mode of action is unclear. It paralyses the mites suggesting that it may act on nervous system of mites. In the market it is available by trade name Bifenazate with Trade name Floramite.

14.Pyridazinones Acaricide : This class of acaricide is very effective against red spider mites and two spotted mites. It inhabits mitochondrial electron transport. It affects respiratory chain also. In the market it is available with active in gradient Fenpyroximate with trade name Mitigate

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2.6 NEW INSECTICIDES FROM MICROORGANISMS

Avermectins: These are 16 members macrocyclic lactones natural product isolated from soil microorganism mycelia of Streptomyces avermitilis. These compound are closely related to milbemycins. Series of closely related macro cyclic lacton derivatives produced as fermentation metabolites of Streptomyces avermitilis. It inhibits signal transmission at the neuromuscular junction. Upon stimulation releases the inhibitory neurotransmitter Gamma-Amino Butyric Acid (GABA) from the pre-synaptic nerve terminals and by potentiating its binding at the post-synaptic receptors. Abamectin (Vertimec, Avid, Agrimec) is commercially used against sucking pests, dipterans, psyllidae, leaf miners and phytophagous mites. Ivermectin, a semi synthetic derivative of abamectin used to control parasites of cattle. Emamectin benzoate is also a semi synthetic derivative of avermectin which is highly effective against lepidopteran pests with the trade name of Proclaim.

Spinosyns: Spinosad is the first active ingredient proposed for a new class of insect control products, the Naturalytes. Spinosad is derived from the metabolites of t he naturally occurring bacteria, Saccharopolyspora spinosa.. This formulation contained a mixture of two of the most active metabolites, Spinosyns A and Spinosyn D. The name spinosad is derived by combining the species name spinosa, with the two metabolites, available in formulations as 45% SC and targets stem borer, leaf folder (Rice), DBM (Cabbage), *H. armigera, S. litura, Earias spp* (Cotton), Termites, early shoot borer, top borer in sugarcane and yellow stem borer, leaf folder in rice, respectively. It is marketed as Tracer

3 . FUNGICIDES

3.1 Introduction

Fungicides are chemicals which are used to prevent, cure eradicate the fungi. They are used mainly to control of disease during crop establishment. Increase productivity of crop (photosynthesis) and/or reduce blemishes, maintain yield and/or market value and to improve storage life and quality of harvested plants /grain / produce.

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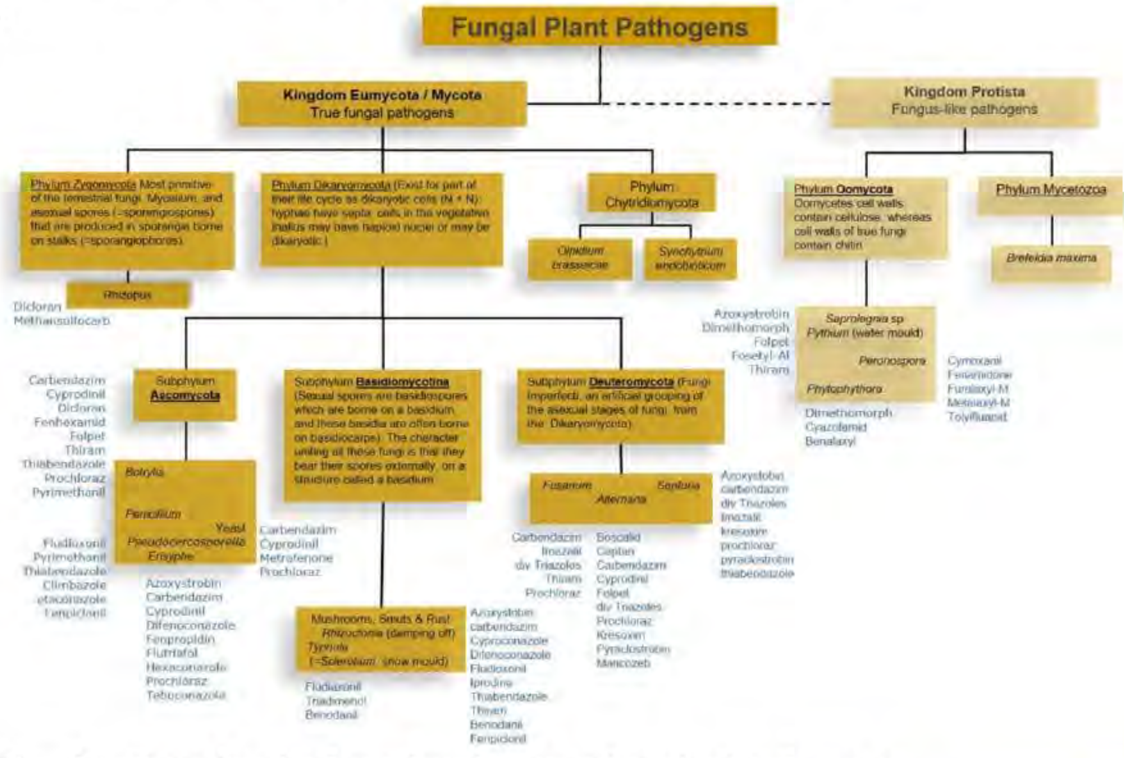


Classification of major fungal and oomycetes plant pathogens.

There are several ways to classify fungicides

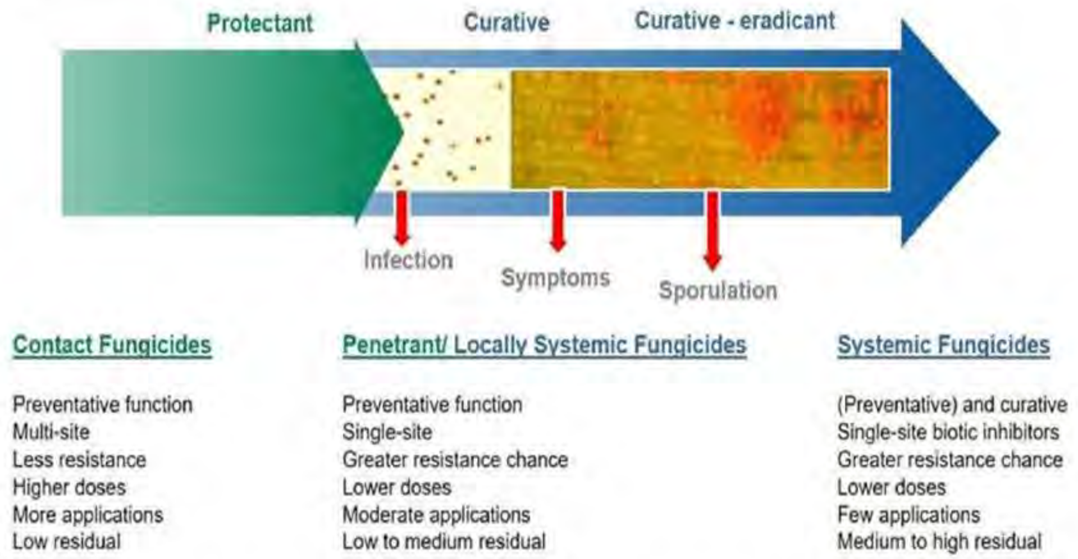
3.2 Based on the time of application

Based on time of applications, fungicides are called as preventive, curative, eradicant and inhibitive fungicides. A Preventative fungicide must be present on plant surface before the pathogen and repeated applications are required to protect new growth. Where As a curative fungicide can protect crop even when the pathogen is present (postinfection, pre-symptom kick-back activity) and arrest the disease spreading. Eradicant fungicides are applied for post- symptomatic activity and Inhibitive fungicides prevent spore germination or sporulation.

3.3 Based on their movement

Fungicides are also called Contact and systemic based on their movement in the plant system. Contact fungicides are immobile and must come in direct contact with the pathogen. Systemic fungicides are mobile and can move within plant.

Based on the spectrum of disease control fungicides are called Non-specific, or Broad Spectrum (fungicide affects pathogen in multiple ways) or Specific or Narrow Spectrum fungicides(targets a specific metabolic site in pathogen or against critical enzyme or protein).



Application timing for contact (protectant) versus systemic (curative) fungicides.

3.4 Based on Use

Foliar-Applied Fungicides

Foliar fungicides are used to manage fungal disease organisms that infect the aboveground portions of plants. The majority of these fungicides protect foliage from infection; therefore, these fungicides should be on the foliage before fungal spores germinate.

The decision to apply foliar fungicides to a specific field only should be made after considering current and future weather conditions, disease development, potential yield of the crop, and the cost benefit ratio with use of the fungicides. Some plant surfaces have a waxy or hairy coating causing some fungicides to collect in large droplets that run off the plant surface, thus reducing fungicide coverage. Using a wetting agent such as spreader- stickers (surfactants) will improve coverage.

3.5 Seed Treatment Fungicides

Fungicidal seed treatment helps protect seed from soil-borne or seedborne fungi that cause rotting, damping off, seedling blight, or a combination. When seeds germinate under favorable soil conditions, there is less danger of seed and s eedling attack from soil-borne pathogens unless seed is of poor quality. Treatment of seed with a protectant fungicide may help with stand establishment when seeds are germinating under unfavorable conditions, such as cold wet weather, or when seed is of poor quality. Seed may be treated commercially or on the farm.

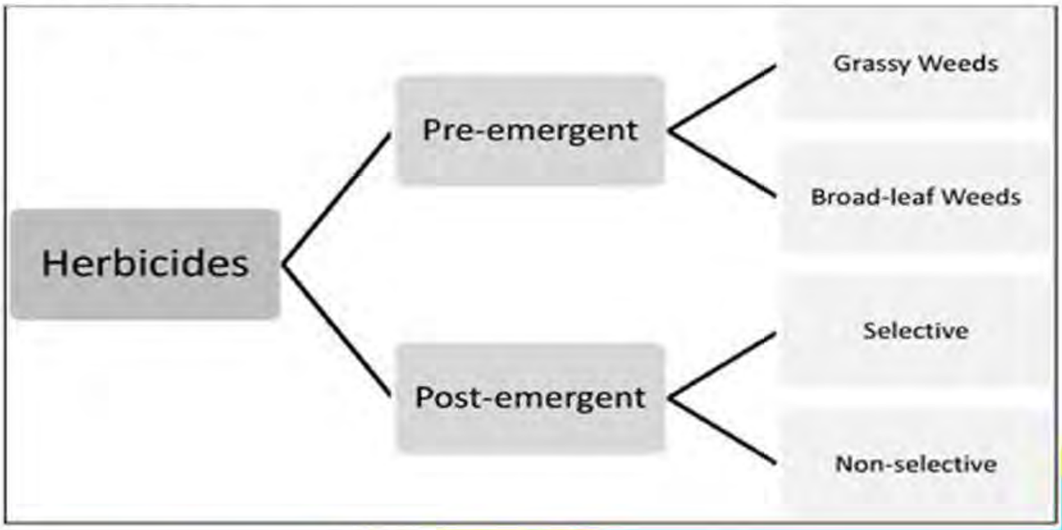
Based on Chemistry fungicides are classified as Copper compounds(Copper sulphate, Copper Oxychloride), Sulphur Compounds (Sulphur, Lime sulphur) Pthalimides (Captan),Dithio carbamates (Mancozeb, Zineb, Thiram), Benzimadazole(Carbendazim), Organo Phosphorus fungicides(Edifenphos, Fosetyl Al), Conazoles(Hexaconazole), Imidazoles,Oxazoles and Strobilurins (Azoxystrobin, Fenamidone, Fenoxazone), Pyrimidines (Thifluzamide), Dithiolane Fungicide (Isoprothiolane) and Antibiotic fungicides (Kasugamycin, Streptomycin, Validamycin)

Group	Fungicide	Controlling pathogen
Imidazole and its derivatives	Glyodin,Fenoparil Prochloraz, Imazalil	*Ascomycetes spp.* Basidiomycetes, *Helminthosporiumsp,Fusarum* , *Septoria* spp
Benzimidazole derivatives and precursors	Carbendazim,Benomyl Cypendazole,thiophanatemethyl	*Erysiphe, Septoriu*and *Fusarium* sp. *Deuferomycete*
Triazoles	Fluotrimazole, Triadimefon Triadimenol, Bibertanol Diclobutrazol, Triazbutil	Powdery mildew and Rust *Ustilagonuda, U. tritici, U. maydis Venturia*sp.

4. HERBICIDES

4.1 Introduction

Herbicide is a pesticide used to kill unwanted plants.Selective herbicides kill certain targets while leaving the desired crop relatively unharmed. Some of these act by interfering with the growth of the weed and are often based on plant hormones. Some plants produce natural herbicides, such as the genus Juglans (walnuts). Chemical weed control in agriculture began in the 1880s. Herbicides can be classified in different ways: by chemical name, by chemical characteristics of the compound, by toxicity, or by mode of action. There are two major categories of herbicides classified by mode of action: contact herbicides and translocated herbicides.Contact herbicides affect only the part of the plant that they touch. Absorption through foliage is minimal. The application, therefore, must be made in sufficient quantity to cover the foliage thoroughly. Examples of contact herbicides are diclofop, dinoseb, diquat, and paraquat. Unlike contact herbicides, systemic herbicides can be translocated to other parts of the plant.



4.2 Herbicides are also classified based on the mode of action

Herbicides are classified on the mode of action as Photosynthesis Inhibitor, Cell Membrane Disrupters, Amino acid inhibitors, Plant growth regulator (PGR), Lipid biosynthesis inhibitor, Pigment inhibitor, Seedling growth inhibitor

1.Photosynthesis Inhibitor: Block the light reactions of photosynthesis. Herbicide binding of the protein sites blocks the flow of electrons normally initiated when chlorophyll absorbs solar energy. Yellowing (chlorosis) of leaf tissue followed by death (necrosis) of the tissue. Example: Atrazine

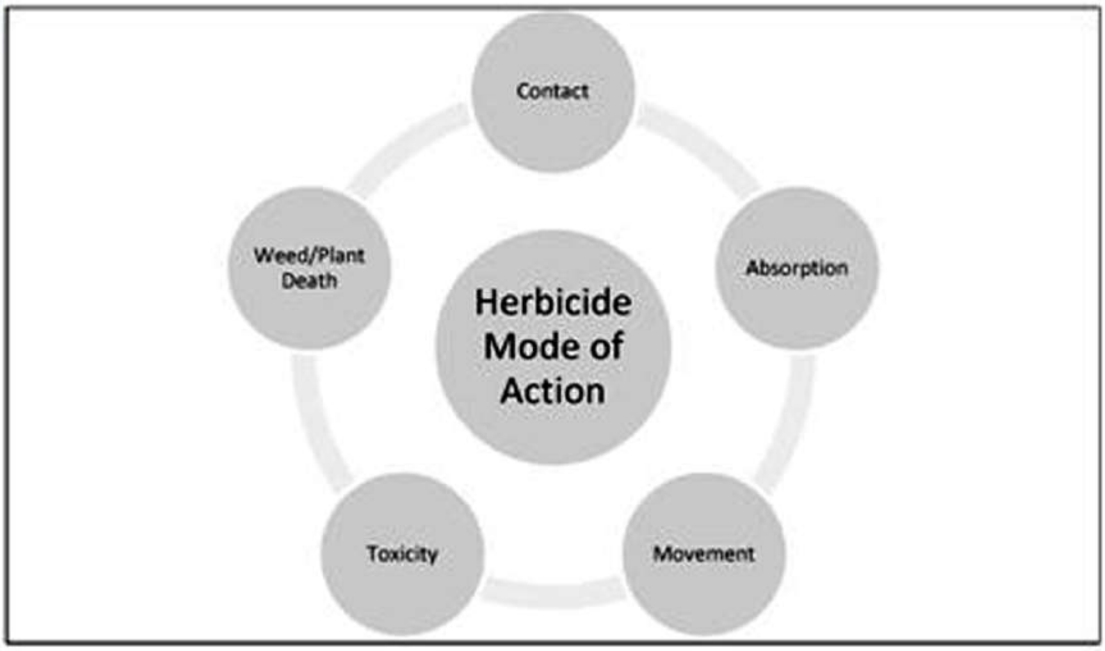
2. Cell Membrane Disrupters: Rapid disruption of cell membranes. Prevent translocation to other region of the plant. Rapid browning (necrosis) of plant tissue. Example: Paraquat

3. Amino acid inhibitors:Prevent synthesis of certain amino acids produced by plants. Symptoms include yellowing of new growth and death of treated plants in days to weeks.These are relatively nonselective compounds, control annual grasses, annual broad leaves etc. Example: Glyphosate

4. Lipid biosynthesis inhibitor: Prevents formation of fatty acids, essential for production of lipids. Aryloxyphenoxypropionic herbicides inhibit Acetyl-Coenzyme A Carboxylase (ACCase), an enzyme responsible for the first step in fatty acidbiosynthesis. Symptoms include chlorosis followed by necrosis of newest leaf tissue.Example: Clodinafop-propargyl

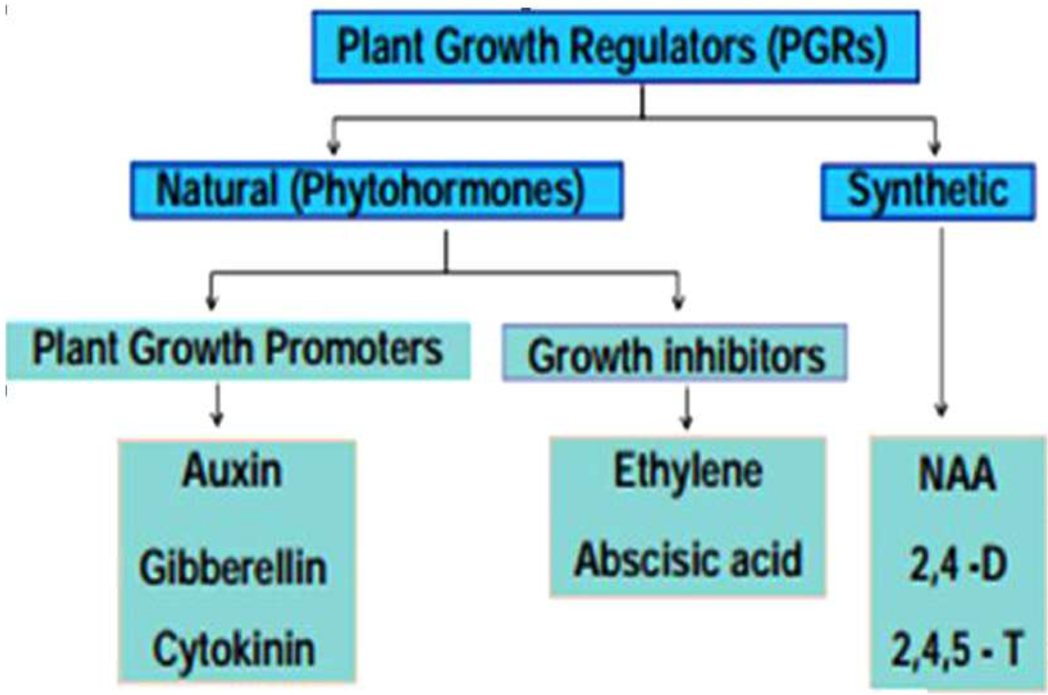
5. Pigment inhibitor:Inhibitors of carotenoid biosynthesis. Prevent the production of compounds that protect the plant from chlorophyll destruction. Plant tissue turns white.Example: Clomazone

6. Seedling growth inhibitor: Interrupt new plant growth and development. Grass shoots are short and thick and may appear red or purple in colour. Example: Butachlor



5. PLANT GROWTH REGULATOR (PGR)

The PGRs can be broadly divided into two groups based on their function in a living plant body.



Plant growth promoters

PGRs which are involved in growth promoting activities, such as cell division, cell enlargement, pattern formation, flowering, fruiting and seed formation are called plant growth promoters. e. g., auxins, gibberellins and cytokinins.

Growth retardants or Inhibitors

PGRs of the other group play an important role in plant responses to wounds and stresses of biotic and abiotic origin and are called as Growth retardants or Inhibitors. They are also involved in various growth inhibiting activities such as dormancy and abscission. Eg: Abscisic acid & ethylene.

There are five major types of Plat Growth Regulators (i) Auxins (ii) Cytokinins (iii) Gibberellins (iv). Ethylene (v) Abscisic acid

5.1. Auxin

These plant hormones are specially concerned with cell enlargement or the growth of the shoots. An auxin may, thus, be defined as "an organic substance which promotes growth along the longitudinal axis.

Physiological function of Auxins

Cell Elongation

Cell elongation occurs in the presence of auxins and it is proportional to the concentration of auxins. Cell elongation occurs in almost all parts of the plant such as petiole midrib, lateral veins and leaves. Auxin based herbicides have greater effect on dicots than on monocots due to larger surface area in dicots which will cause more absorbtion of herbicide by plants (Example: 2,4-D)

Root Initiation in stem cuttings

The auxins most commonly employed for this purpose are IAA, NAA, 2,4-D, naphthalene acetamide (NAd) etc. Auxin-induced rooting helps propagation of certain plants by cuttings.

Apical Dominance

If the apical bud is intact on the plant, the growth of the lateral buds remains suppressed. Upon removal of the apical bud, the lateral bud nearest the apical bud establishes its dominance over the remaining buds, causing them to become in active again. This inhibitory effect of a terminal bud upon the development of the lateral buds is called apical dominance and produces a cone-shaped plant.

Delay (or inhibition) of abscission of leaves

The abscission of leaves can be delayed or inhibited by the application of auxins on the surface of the lamina or on the cut surface of a debladed petiole

5.2. Gibberellins

A Japanese scientist Kurosawa found that the rice seedlings infected by the fungus Gibberella fujikuroi grow taller and turned very thin and pale. An active substance was isolated from the infected seedlings and named as Gibberellin. These are diterpenoids, with a gibbane ring structure. They have the ability to elongate the stem of green seedlings especially certain dwarf and rosette types

Biosynthesis of gibberellins in plants: They are produced in the shoot apex primarily in the leaf primordial (leaf bud) and root system. GA translocates easily in the plant in both directions.

Functions of Gibberellins

a) Stimulate stem growth through cell elongation and cell division.

b) Involved in overcoming dormancy in seeds and buds.

c) It causes internodes to stretch in relation to light intensity.

Used commercially in stimulating seed germination & seedling growth

a. Stimulate development of flowers. Delayed ripening Flowering Malting

b. Increasing fruit size of seedless (Parthenocarpy) in grape

c. Delay Senesence: Increase photosynthesis and proteins synthesis and thereby decrease abscission

d. Increase cambial growth and differentiation

e. Break dormancy and promote leaf expansion.

Mechanism of action: It acts by inducing activity of enzymes during early stages of seed germination. It also induces the synthesis of α – amylase & other hydrolytic enzymes during germination of monocot seeds and mobilizes seed storage reserves during germination.

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5.3. Cytokinins:

Cytokinins are first isolated from Coconut milk. Miller &Skoog and their co-workers isolated the growth factor responsible for cellular division from a DNA preparation calling it as cytokinins in (1950). These are synthesized in root apex, endosperm of seeds, young fruits where cell division takes place. eg: Zeatin.

Functions of Cytokinins:

a. Cytokinins promote cell division (Cytokinesis)

b. Contribute to cell elongation in leaves

c. Stimulate cell differentiation in combination with auxins

High cytokinin and low auxin content promote shoot initiation in root, and the reverse will induce root formation. Optimum level of both will induce callus formation. Cytokinins delay senescence (senescence refers to the ageing of the leaves which is associated with the loss of chlorophyll and the breakdown of proteins) in leaves

5.4 Ethylene

Ethylene gas is the byproduct of gas combustion and that this gas could affect plant growth. This same gas was naturally produced by plants and it caused faster ripening of many fruits. Ethylene is a gaseous hormone and it produce throughout the plant. Large amounts are released into the air by roots, the shoot apical meristem, nodes, senescing flowers and ripening fruits.

Functions of Ethylene in Plants

a. Inhibits root and shoot initiation by blocking the transport of auxins from apical meristems and controls stem elongation.

b. Stimulates leaf curling (epinasty)

c. Stimulates fruit ripening Because of this activity, ethylene is known as ripening hormone.

d. Promotes flowering in Mango, pineapple and some ornamentals.

e. Hastens leaf abscission and falling down of leaves due to formation of abscission layer.

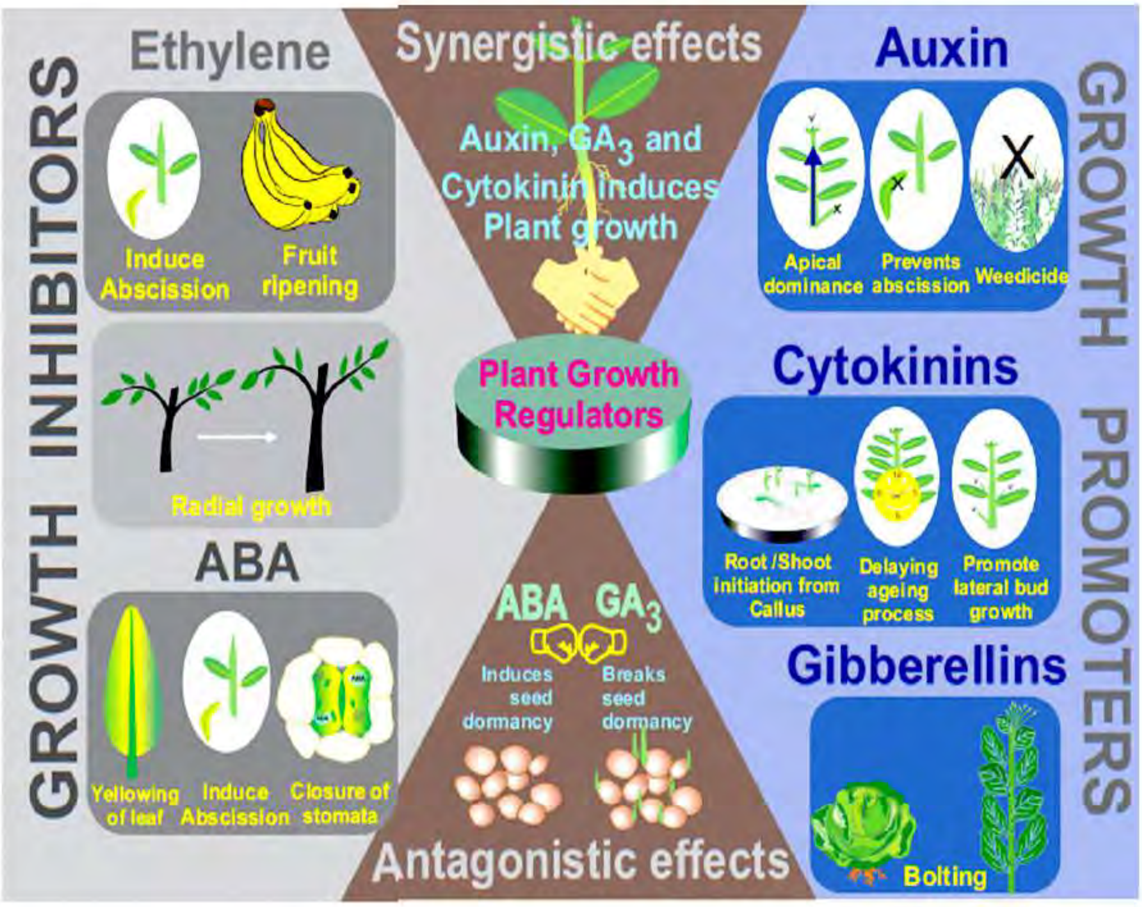
f. Determines sex expression in monoecious plants, plants that produce both male and female flowers on the same plant. Application of ethylene causes more female flowers in cucurbits.

5.5. Abscisic Acid (ABA)

The plants also do possess a few substances which inhibit growth. They retard such processes as seed germination, root and stem elongation and bud opening. As a matter of fact, the growth inhibitors act as chemical check upon plants preventing the seeds from germinating and the buds from opening under unfavourable conditions.

Physiological Role in Plants

a) Closure of Stomata: During drought, leaves synthesize large amounts of ABA which causes stomata to close. Thus, ABA acts as a messenger and enables plants to conserve



water during drought

b) Delays seed dormancy: Applying ABA delays seed germination. It controls bud dormancy, counteracts the effects of other hormones. It inhibits cell growth that is promoted by IAA. It inhibits amylase production that is induced by Gibberellins thus delaying seed germination. It induces chlorosis and senescence unlike cytokinins that promote rejuvenation of leaves and delay senescence.

6. OTHER PESTICIDES

6.1 Acaricides

Acaricides are pesticides meant for controlling harmful species of mites Phytophagous mites feed on the liquid content of plant cells, thus disrupting the physiology of a host plant and causing various damages to plant tissues and organs, while some of the species can also act as vectors of plant viruses.

a) First Generation Acaricides: Bridged diphenyls (bromopropylate, chloropropylate, chlorobenzilate, chlorfenethol, dicofol, tetradifon), the first specific acaricides, established themselves on the market in the 1950s.

b) Second Generation Acaricides: During the 1960s and early 1970s, the second generation of specificacaricides emerged, the most important of which were propargite, organotins (cyhexatin, fenbutatin-oxide) and formamidines (amitraz, chlordimeform).

c) Specific acaricides of third generation: represented by mite growth inhibitors. eg: Hexythiazox.

6.2 Nematicides

Nematicides are the compounds used to control nematodes. Nematodes are soil dwelling worm like organisms which affcect the root system of the plant and decrese and vigour and production. Nematicidal activity of synthetic chemicals started with the use of carbon disulfide, and chloropicrin as soil fumigants. New generation of nematicides were introduced with carbamates organophosphates and avermectinswhich served as contact nematicides, devoid of fumigant activity. Examples of major groups nematicides are given below:

Group	Nematicide	Mode of effectiveness
Organophosphates	Ethoprop	Nonsystemic insecticide/nematicide
	Fenamiphos,	Systemic in action
	Cadsafous	Burrowing nematode, *Radopholussimilis, Rotylenchulusreniformis*
	Fosthiazate	lesion nematode *Pratylenchuspenetrans* on potato and root knot nematodes (*Meloidogyne* spp.) on tobaccoand *Meloidogyne arenaria* on peanut
	Triazophos	*Meloidogyne sp., Rotylenchulusreniformis*
Carbamates	Carbofuran	Systemic nematicide
	Oxamyl	*Pratylenchuspenetrans*
Avermectin	Abamectin	*Contact& stomach pesticide aginst root knot nematode*

6.3. Rodenticides:

Pesticides meant for killing rodents are called rodenticides. Rodenticides can be acute toxins or anticoagulants. Their modes of action are described below:

5.3. 1. Inorganic Rodenticides

Compounds such as Zinc phosphide, Magnesium phosphide and aluminium phosphide are classified under inorganic pesticides. Among them zincphosphide can be purchased commercially and is commonly used in rodent control.

These toxins are very lethal

ingestion leads to death of an animal within a few hours. When zincphosphide is ingested, it reacts with stomach acids and causes poisonous phosphine gas to be released. This leads to nausea, vomiting, pulmonary edema, and eventual death.

5.3. 2. Anticoagulant Rodenticides

Another group of rodenticide compounds are the anticoagulants. Death from these compounds results from internal bleeding and can take from 1 - 10 days after the initial poisoning. The first anticoagulant r odenticides (warfarin, diphacinone, andchlorophacinone), that came out in the late 1940's, were slow acting. These are called first generation compounds.Their inherent toxicity is lower than acute toxins and an antidote (vitamin K1) is available in the event of accidental

Newer anticoagulants, (brodifacumandbromadiolone) that came into use in the 1970's, have enough active ingredient to cause death in a single feeding. There are two classes of anticoagulant rodenticides, the coumarinsand the indandiones. Both types act by depressing the hepatic vitamin K dependent synthesis of substances essential to blood clotting. Thepermeability of capillaries is increased throughout the body, predisposing the animal towidespread internal hemorrhage.

7. CLASSIFICATION OF PESTICIDES ON THE BASIS OF HOW OR WHEN THEY WORK

Pesticides can also be classified according to how or when they work

Contact Pesticides – These pesticides control a pest as a result of contact. Insects are kill when sprayed directly or when they crawl across surfaces treated with a residual contact insecticide.

Systemic pesticides – Pesticides which are absorbed by plants or animals and move untreated tissues. Systemic insecticides or fungicides move throughout treated plants and kill certain insects or fungi.

Foliar Pesticides – These are applied to plants leaves, stems and branches.

Soil applied Pesticides - These are applied to soil. Some of these are taken up by roots and trans- located inside the plant.

Fumigants – Chemicals that are applied as toxic gas or as a solid or liquid which forms a toxic gas and it will penetrate cracks and crevices of structures or soil.

Pre-plant herbicides- These are applied to soil before seedling or transplanting.

Pre-emergent herbicides- These are applied to s oil after planting but before emergence of crop or weed.

Post-emergent herbicides- These are applied after crop or weed has emerged.

Selective Pesticides – They will only control certain pests.

Non-selective (or broad- spectrum) pesticides – They will control a wide range of pests.

Suffocating pesticides- They clog the breathing system of insects and may affects eggs.

Residual pesticides – They do not break down quickly and may control pests for long time.

Non-residual pesticides – They are quickly made inactive after application and do not affect future crops or pests

8. CLASSIFICATION BASED ON TYPE OF PESTICIDE FORMULATIONS

Pesticide formulations are the mixtures of technical grade pesticides with inert diluents and auxiliary chemicals. Pesticide formulations can be divided into three main types: solids, liquids and gases. Some formulations come ready to use while others must be mixed before use

I. Pesticide Application
A. Pesticide Formulations

1. Types of Pesticide Formulations

1.1 Introduction:

According to FAO (1986), the definition of pesticide formulation can be given as "Pesticide product offered for sale. It generally comprises active ingredient(s), adjuvant(s) and other formulants combined to render the product useful and effective for the purpose claimed".

Most of the modern pesticides are synthetic organic chemicals, which are manufactured on large scale in chemical industries. Such chemicals in concentrated form are called 'technical grade pesticides'. Purity of technical grade pesticides may be between 70 to 100 %. These possess different physical consistencies such as solid, pasty mass, waxy viscous liquids and liquids. Many of these chemicals are insoluble in water. Hence, as such these chemicals can't be directly used in the field. Processing of technical grade pesticide by any method to improvise its properties such as storage, handling, application, effectiveness and safety is called formulating the pesticide

Characteristics of Technical Grade Pesticides

a) High purity hence, very low quantity of chemical need to be sprayed over large surface area which is very difficult and cannot be uniform.

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b) Solids or liquids or thick viscous pasty materials because of which spraying or broadcasting them is very difficult over the large area.
c) Low water solubility: This makes their application in the field very difficult.
d) Toxic to mammals in varying degree: Technical grade chemicals are extremely to highly toxic which will be fatal to the operator, farm labor besides causing environmental hazard.
e) Low selectivity: All the pesticides do not have inherent property to adhere and translocate in the plant system.
f) Low storage Stability: Some of the compounds do not possess storage stability unless stabilizers are added.

Most of the technical pesticides are formulated before use, by mixing with a.i.(s) with inert material(s) and/or other need based adjuvants/auxiliaries, to obtain a product which is effective, easy to handle and apply, possesses satisfactory shelf life and devoid of any undesirable side effects. The key objectives of formulating a technical pesticide are to provide required dosage, cover, mass and momentum of the pesticide product.

Advantages of Pesticide Formulations over technical grade Pesticides:

a) Easy handling and application:

The novel pesticides are highly active that small quantity will suffice. Thus dosages of these chemicals may range from 0.025 kg to 0.5 kg of a.i/ha. If such small quantities have to be applied uniformly over large area, then it is a bit difficult because of the physical inconsistency of technical grade pesticides. As the technical grade pesticide is diluted, the volume of the finished product (pesticide formulation) increases for the same dose. Hence, it becomes easier to apply over large area. Example: It is easier to distribute uniformly 17 kg of 3% granular formulation to distribute than 0.5 kg technical grade pesticide.

b) To facilitate dilution at field level:

Because of low or no solubility of technical grade pesticides it will not be possible for the farmer to dissolve it in water. However, addition of certain auxiliary chemicals will enable the formulations for dilution with water and uniform application due to increased spray volume

c) To reduce Toxic Hazards:

Toxic hazards of technical grade pesticides are reduced by diluting them through formulating it.

d) To improve efficacy of the pesticide:

In order to be very effective the pesticide should possess good adhesion and absorption characteristics. Further, it should give good coverage and be stable in the field. All these desirable characters can be imparted by adding suitable auxiliary chemicals

e) To achieve selectivity:

It is possible to change the composition of formulation by altering the auxiliary chemicals. By such manipulations it is possible to impart selectivity.

f) Economics:

The benefit in terms of the output or control of pest by using the pesticide formulation is many fold higher compared to technical grade pesticides because of uniform spreading and other characteristics. By diluting with cheaper diluents the finished product becomes cheaper. Basically there are solid, liquid, gas and gel/paste formulations, each of which can be further divided in to various sub classes of formulations on the basis of their physico chemical properties. In general, pesticide formulations exist in the form of solid or liquid, irrespective of the physical state of the a.i. (solid or liquid). The choice of the form of pesticide formulation depends on:

i. purpose of pesticide use
ii. manner in which the control is to be affected
iii. mode of application
iv. physico-chemical properties of the a.i.
v. weather conditions of application
vi. economic considerations
vii. ready availability of formulation auxiliaries

On the basis of type of application, two kinds of products are available:

a) Concentrated formulations: They must be mixed with water, or some other carrier, before being applied. They are very economical when treating large areas but it may be hard to measure amounts needed for small areas. Also, the handling, mixing, need for specialized spray equipment, and clean-up time may make the use of concentrates inconvenient. Example: emulsifiable concentrate, suspension concentrate etc.

b) Ready-to-Use formulations: They may be more appropriate for small areas. They contain small amounts of active ingredient (often 1% or less a.i. per unit volume). Some contain petroleum-based solvents; others are water-based. RTU formulations are already diluted and may be sold in containers that serve as applicators. Example: granules, aerosol, baits etc.

Types of Pesticide Formulations:

Solid formulations:

Formulations whose physical aggregate condition is solid are known as solid formulations. In these formulations the a.i. is present in/on the surface of a solid carrier. Some of the majorly used solid formulations are enlisted below.

a. Dustable powder or Dust (DP): Dusts are manufactured by the sorption of an active ingredient onto a finely-ground, solid inert such as talc, clay, or chalk. They are relatively easy to use because no mixing is required and the application equipment. Dusts can provide excellent coverage, but the small particle size that allows for this advantage also creates an inhalation and drift hazard. In general, dust formulations are no longer used in large scale outdoor situations due to their high drift potential. However, dusts are still applied as spot treatments for insect and disease control outdoors.

b. Granule (GR) and Pellet (PT):

The manufacture of granular formulations is similar to that of dusts except that the active ingredient is sorbed onto larger and heavier particles. The inert solid may be clay, sand, or ground plant materials. A granule is defined by size: granule-sized products will pass through a 4-mesh

(number of wires per inch) sieve and be retained on an 80-mesh sieve. Granules are applied dry and usually are intended for soil applications where they have the advantage of weight to carry them through foliage to the ground below. The primary drawbacks of granules are their bulk, the problems they present in handling, and the difficulty inherent in achieving a uniform application with this type of product. Granules also may have to be incorporated into the soil to work, and they are sometimes attractive to non-target organisms such as birds.

Pellets are very similar to granules, but their manufacture is different. The active ingredient is combined with inert materials to form slurry (a thick liquid mixture). This slurry is then extruded under pressure through a die and cut at desired lengths to produce a particle that is relatively uniform in size and shape. Pellets are typically used in spot applications. Pelleted formulations provide a high degree of safety to the applicator. They do have the potential to roll on steep or frozen slopes and thereby harm no target vegetation or contaminate surface water.

Wettable powder (WP): Pesticide in dry form with surfactant, often mixed or coated on a fine solid carrier for dispersion in water to form a suspension which is called as wettable powder formulation. Wettable powders are finely divided solids, typically mineral clays, to which an active ingredient is sorbed. The particles do not dissolve in water. They settle out quickly unless constantly agitated to keep them suspended. WPs contain 5-95% active ingredient by weight (usually 50% or more). This formulation is diluted with water and applied as a liquid spray. Upon dilution, a suspension is formed in the spray tank. Wettable powders contain wetting and dispersing agents as part of the formulation. They provide an ideal way to apply an active ingredient in spray form that is not readily soluble in water. Wettable powders tend to pose a lower dermal hazard in comparison to liquid formulations, and they do not burn vegetation as readily as many oil-based formulations. This formulation does present an inhalation hazard to the applicator during mixing and loading because of the powdery nature of the

d. Water dispersible granule (WG or WDG)

Dry flowables or water dispersible granules, as they are sometimes called are manufactured in the same way as wettable powders except that the powder is aggregated into granular particles. They are diluted with water and applied in a spray exactly as if they were a wettable powder. Dry flowables, as would be expected, form a suspension in the spray tank; they have basically the same advantages and disadvantages as wettable powders, with several important exceptions. During the mixing and loading process, dry flowables pour more easily from the container and, because of their larger particle size, reduce inhalation hazard to the applicator. The percentage of a.i. in the formulation is high, often as much as 90% by weight.

e. Water soluble powder (SP): This kind of powder formulations is to be applied as a true solution of active ingredient after dissolution in water. These comprise of either a water soluble a. i. alone or formulated with water soluble auxiliaries. Such formulations offer one of the easiest and the cheapest modes of pesticide application. Some water soluble herbicides like salts of acid herbicides can be conveniently formulated in this form.

f. Baits (B) Formulation: A bait formulation is an active ingredient mixed with food or another attractive substance. The bait either attracts the pests or is placed where the pests will find it. Pests are killed by eating the bait that contains the pesticide. The amount of active ingredient in most bait formulations is quite low, usually less than 5 %. Baits are used inside buildings to control ants, roaches, flies, other insects, and rodents. Outdoors, they sometimes are used to control snails, slugs, and insects such as ants and termites. Their main use is for control of vertebrate pests such as rodents, other mammals, and birds.

Pastes, Gels, and Other Injectable Baits: Pastes and gels are mainly used i n the pest-control industry for ants and cockroaches. Insecticides formulated as paste s and gels are used in cockroach control. They are designed to be injected or placed inside small cracks and crevices of building elements where insects tend to hide or travel. Two basic types of tools are used to apply pastes and gels—syringes and bait guns. The applicator forces the bait out of the tip of the device by applying pressure to a plunger or trigger.

Liquid formulations:

The physical state of liquid formulations is liquid when they are being marketed irrespective of the physical state of the a.i. Most of the commercially available liquid formulations are either organic solvent based or water based. Some widely popular liquid formulations are listed below.

a. Emulsifiable concentrate (EC)

EC is a clear liquid homogeneous formulation of active ingredient(s) which form emulsion after dilution with water. It is a solution of a.i. and surfactant in water immiscible solvent(s), which on addition of water forms usually an oil in water emulsion (spontaneously or with agitation). Emulsifying agents are added to this type of formulations to hol the oil and water layers together by which upon addition to water a white milky emulsion is formed. The concentration of a.i. depends on its potency and attainable solubility in the solvent system. Emulsifiable concentrates, widely ranging in a.i. strength (2.5 to over 50%) are commercially available. They are the most popular and extensively used formulations

b. Suspension concentrate (SC): Liquid flowable or suspension concentrate is the designation for a stable suspension of active ingredient(s) in an aqueous continuous phase, intended for dilution with water before use. A SC formulation contains finely divided solid particles in a liquid dispersing medium, usually water. The proportion of the solid usually ranges from 5 to 60% which may be a single a.i. or a mixture of several active ingredients with or without a carrier. They are becoming much more important because of increasing solvent costs and environmental restrictions on pesticide auxiliary materials. This formulation disperses spontaneously when poured in water having good suspension stability.

C. Emulsion concentrate (EW):

It is a stable emulsion of active ingredient(s) in an aqueous phase, intended for dilution with water before use. The active ingredient is normally a liquid and forms the dispersed oil phase, but it is also possible to emulsify a solid or liquid active ingredient dissolved in a water immiscible solvent. The solvents, whenever used, are added in very small amount. Thus, the emulsion concentrates are more economic in view of the ever rising solvent costs, reduced operator hazard and phyto-toxicity. In EW, pesticidal a.i. in organic liquid is dispersed as fine globules in continuous water phase. The globules may take the size ranging from macro (500-1000 µ) to micro (3-10 µ).

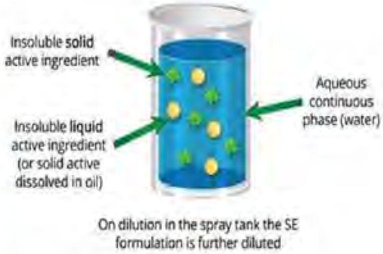
d. Soluble Liquid (SL):

It is a clear to opalescent liquid which is to be applied as a solution of the active ingredient(s) after diluting in water. It comprises the solution of the a.i. in suitable solvent(s), along with other necessary formulants. The SL formulation is free from any visible suspended matter and sediment, to be applied as a true solution of a.i. in water. The number of pesticides that can be formulated in this simple way is limited due to solubility and/or hydrolytic stability. Some acid herbicides and plant growth promoter hormones are being formulated in SL formulation.

e. Micro-emulsion (ME):

A micro-emulsion is a mixture of water, water insoluble and water soluble components forming a visually homogeneous, transparent liquid. One or more active ingredients may be present in either the aqueous phase, the non-aqueous phase, or in both phases. Micro-emulsions will disperse into water to form either conventional emulsions or dilute micro-emulsions.

f. Suspo-emulsion (SE): An aqueous suspo-emulsion is a mixture of water-insoluble active ingredients dispersed in an aqueous solution, where one(or more) of the active ingredients is in suspension form and one (or more) of the active ingredients is in emulsion form. The formulation is intended for dilution into water prior to spray application. Mixtures of active ingredients are often used to provide a broader spectrum of pest control. Formulating the active ingredients together eliminates the need for tank mixing (which can lead to incompatibilities). Like other aqueous liquid formulations, suspo-emulsions are easy to handle and measure, dust free, non-flammable and offer good miscibility with water.



g. Aerosol (AE): An aerosol is a suspension of solid or liquid particles with a diameter less than 50 μ, in air or gas. This is a self-contained sprayable
product in which the propellant force is supplied by a liquefied gas. The spray of aerosols (mist formation) constitutes their most important character. The mist is formed when an aerosol is discharged and the propellant changes from liquid to gas at the atmospheric pressure. An aerosol is just not any specific product, but the whole package comprising of container with a valve, a liquefied gas propellant, solvent, a.i. and other auxiliaries packaged under pressure. This kind of formulation is widely used for household pest control and application in cracks and crevices.

All the formulations will contain some inert materials/filler materials as diluent. The pesticide is mixed with the diluent to a desired level and then added some adjuvants to bring about the desired physico chemical properties and stabilizers to the product besides some colouring dye. The following are some of the diluents used in different formulations.

S.No.	Type of formulation	Preferred diluent
1.	Emulsifiable concentrate	Aromax, xylene, solvent CIX
2.	Soluble liquids	Isopropyl alcohol,
3.	Water dispersible powders	China clay
4.	Granules	Bentonite, coarse sand
5.	Dusting powders	Soap stone, talc

The adjuvants are usually a class of chemicals known as surface active agents which are available as anionic, cationic, nonionic, Amphotylic and water insoluble. The concentration of these surface active agents usually present in the range of 5% to 20 % Depending on the function they perform these are called as wetting agents, spreading agents, dispersing agents and emulsifiers. In solid formulations, stabilizers are used to enhance the stability of the active ingredient or to enhance the shelf life of the product. Some of the chemicals which are used as stabilisersare, glycols, urea, hexa methyl tetra amine. In almost all the formulations, Epichlorohydrin is used as stabiliser.

Apart from the stabilisers, some miscellaneous substances also are used in certain formulations to enhance their shelf life. Rosin added to granular formulations for coating the granules, Carboxy Methyl Cellulase (CMC) as viscosity modifier and to improve the stability of suspension, Calcium Silicate, Zinc Oxide as anticaking agents in dusting powder and WP formulations are some the miscellaneous chemicals that are added to various formulations.

Formulations for Seed Treatment:

The concept of seed treatment involve use and application of biological and chemical agents that control or contain primary soil and seed borne infestation of insects and diseases which affect crop productivity and crop production. The benefits of seed treatment include increased germination, uniform seedling emergence, protection of seeds or seedlings from early season diseases and insect pests improving crop emergence and its growth. Seed treatment complexity ranges from a basic dressing to coating and pelleting.

Seed dressing: This is the most common method of seed treatment. The seed is dressed with either a dry formulation or wet treated with a slurry or liquid formulation. Dressings can be applied at both farm and industries. Low cost earthen pots can be used for mixing pesticides with seed or seed can be spread on a polythene sheet and required quantity of chemical can be sprinkled on seed lot and mixed mechanically by the farmers. It is a first protection treatment; basic and the cheapest way to fight with pathogens in the soil and relocated with seeds.

Seed coating: A special binder is used with a formulation to enhance adherence to the seed. Coating requires advanced treatment technology, by the industry.

Seed pelleting: The most sophisticated Seed Treatment Technology, resulting in changing physical shape of a seed to enhance pelletibility and handling. Pelleting requires specialized application machinery and techniques and is the most expensive application.

Most of theSeed treatment pesticides are formulated as Dust (D), Wettable powder (WP),Water Dispersible Granules (WDG/WG), Emulsifier Concentrates (EC), Flowable concentrate for seed treatment (FS)

Seed Treatment Components: Active ingredients, Inert diluents, Dye, Colorants, Solvents - some may be phytotoxic, eg. Xylene, Stickers, Wetting agents, Emulsifiers, Film coating.

Seed Treatment Campaign for promoting 100 percent Seed Treatment Practices among Farmers initiated by Ministry of Agriculture, Department of Agriculture Cooperation and Farmers Welfare, Directorate of Plant Protection, Quarantine and Storage plays an important role in protecting the seeds and seedlings from seed and soil borne diseases and insect pests affecting crop emergence and its growth.

This campaign is expected to ensure that no seeds of major crops be sown without seed treatment by the farmers. Seed distribution/selling agencies should not sell the seeds without treatment. Campaign coordination and monitoring committees are to be constituted at State/ District/Block level by the Commissioners /Directors of the State Agriculture Departments to gear up the efforts by various agencies involved in the programme

4. Approved Uses and Compatibility of Pesticides

Introduction

It has been a practice among our farming community to mix pesticide formulation, with another pesticide formulation or micronutrients, or fertilizers and spray such tank mixture in the field. This is done for simultaneous control of different pests that maybe present in the field, to reduce the dose of one chemical on account of synergistic effects of other ingredients of mixture, to save on labour cost, time, water and to reduce the wear and tear of spray equipment.

But this type of unscientific practices can lead to catastrophic results as such tank mixtures may not be compatible and can lead to many problems like

a) The very purpose of pest control is not achieved due to decrease in the bio efficacy (or toxicity).
b) The spray fluid is non-homogenous, breaks or settles down resulting in erratic/inadequate or no spray of pesticide.
c) This leads to pest developing resistance to such chemicals.
d) The toxicity may increase enormously which becomes hazardous to the farmer as well as the non-target organisms.
e) It ultimately leads to environmental contamination of the pesticide.
f) It may cause phyto-toxicity
g) The farmer will be at great loss of his investment as well as yield.

There fore, it is essential that the scientific principles, merits and demerits of the tank mixtures be made to known to every field/ extension workers

Compatibility of Pesticides

Compatibility may be defined as ability of two or more chemicals to exist together in one medium in perfect harmony and the ideal requirements for calling a mixture to be compatible are as follows:

a) Physical compatibility
b) Chemical compatibility
c) Physico-chemical compatibility
d) Absence of phyto- toxicity
e) Absence of increase in toxicity to non-target organism.
f) No reduction in bio efficacy

The compatibility of pesticides is effected by various factors such as difference in composition of products mixed, sequence of mixing, degree of agitation, quality of water used in mixing

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a.i. in organic liquid is dispersed as fine globules in continuous water phase. The globules may take the size ranging from macro (500-1000 μ) to micro (3-10 μ).

d. Soluble Liquid (SL):

It is a clear to opalescent liquid which is to be applied as a solution of the active ingredient(s) after diluting in water. It comprises the solution of the a.i. in suitable solvent(s), along with other necessary formulants. The SL formulation is free from any visible suspended matter and sediment, to be applied as a true solution of a.i. in water. The number of pesticides that can be formulated in this simple way is limited due to solubility and/or hydrolytic stability. Some acid herbicides and plant growth promoter hormones are being formulated in SL formulation.

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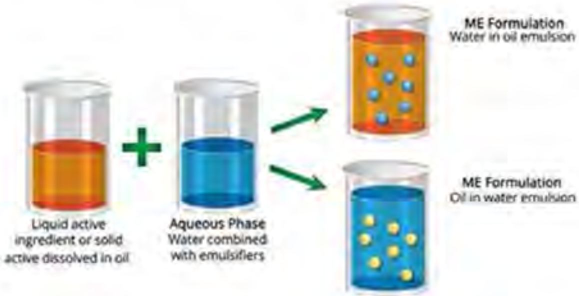

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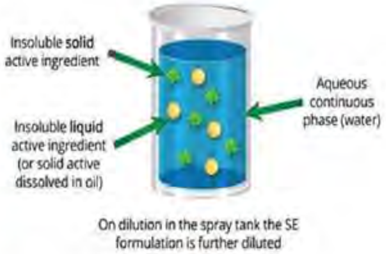

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4.	Granules	Bentonite, coarse sand
5.	Dusting powders	Soap stone, talc

The adjuvants are usually a class of chemicals known as surface active agents which are available as anionic, cationic, nonionic, Amphotylic and water insoluble. The concentration of these surface active agents usually present in the range of 5% to 20 % Depending on the function they perform these are called as wetting agents, spreading agents, dispersing agents and emulsifiers. In solid formulations, stabilizers are used to enhance the stability of the active ingredient or to enhance the shelf life of the product. Some of the chemicals which are used as stabilisersare, glycols, urea, hexa methyl tetra amine. In almost all the formulations, Epichlorohydrin is used as stabiliser.

Apart from the stabilisers, some miscellaneous substances also are used in certain formulations to enhance their shelf life. Rosin added to granular formulations for coating the granules, Carboxy Methyl Cellulase (CMC) as viscosity modifier and to improve the stability of suspension, Calcium Silicate, Zinc Oxide as anticaking agents in dusting powder and WP formulations are some the miscellaneous chemicals that are added to various formulations.

Formulations for Seed Treatment:

The concept of seed treatment involve use and application of biological and chemical agents that control or contain primary soil and seed borne infestation of insects and diseases which affect crop productivity and crop production. The benefits of seed treatment include increased germination, uniform seedling emergence, protection of seeds or seedlings from early season diseases and insect pests improving crop emergence and its growth. Seed treatment complexity ranges from a basic dressing to coating and pelleting.

Seed dressing: This is the most common method of seed treatment. The seed is dressed with either a dry formulation or wet treated with a slurry or liquid formulation. Dressings can be applied at both farm and industries. Low cost earthen pots can be used for mixing pesticides with seed or seed can be spread on a polythene sheet and required quantity of chemical can be sprinkled on seed lot and mixed mechanically by the farmers. It is a first protection treatment; basic and the cheapest way to fight with pathogens in the soil and relocated with seeds.

Seed coating: A special binder is used with a formulation to enhance adherence to the seed. Coating requires advanced treatment technology, by the industry.

Seed pelleting: The most sophisticated Seed Treatment Technology, resulting in changing physical shape of a seed to enhance pelletibility and handling. Pelleting requires specialized application machinery and techniques and is the most expensive application.

Most of theSeed treatment pesticides are formulated as Dust (D), Wettable powder (WP),Water Dispersible Granules (WDG/WG), Emulsifier Concentrates (EC), Flowable concentrate for seed treatment (FS)

Seed Treatment Components: Active ingredients, Inert diluents, Dye, Colorants, Solvents - some may be phytotoxic, eg. Xylene, Stickers, Wetting agents, Emulsifiers, Film coating.

Seed Treatment Campaign for promoting 100 percent Seed Treatment Practices among Farmers initiated by Ministry of Agriculture, Department of Agriculture Cooperation and Farmers Welfare, Directorate of Plant Protection, Quarantine and Storage plays an important role in protecting the seeds and seedlings from seed and soil borne diseases and insect pests affecting crop emergence and its growth.

This campaign is expected to ensure that no seeds of major crops be sown without seed treatment by the farmers. Seed distribution/selling agencies should not sell the seeds without treatment. Campaign coordination and monitoring committees are to be constituted at State/ District/Block level by the Commissioners /Directors of the State Agriculture Departments to gear up the efforts by various agencies involved in the programme.

4. Approved Uses and Compatibility of Pesticides

Introduction

It has been a practice among our farming community to mix pesticide formulation, with another pesticide formulation or micronutrients, or fertilizers and spray such tank mixture in the field. This is done for simultaneous control of different pests that maybe present in the field, to reduce the dose of one chemical on account of synergistic effects of other ingredients of mixture, to save on labour cost, time, water and to reduce the wear and tear of spray equipment.

But this type of unscientific practices can lead to catastrophic results as such tank mixtures may not be compatible and can lead to many problems like

a) The very purpose of pest control is not achieved due to decrease in the bio efficacy (or toxicity).
b) The spray fluid is non-homogenous, breaks or settles down resulting in erratic/inadequate or no spray of pesticide.
c) This leads to pest developing resistance to such chemicals.
d) The toxicity may increase enormously which becomes hazardous to the farmer as well as the non-target organisms.
e) It ultimately leads to environmental contamination of the pesticide.
f) It may cause phyto-toxicity
g) The farmer will be at great loss of his investment as well as yield.

There fore, it is essential that the scientific principles, merits and demerits of the tank mixtures be made to known to every field/ extension workers

Compatibility of Pesticides

Compatibility may be defined as ability of two or more chemicals to exist together in one medium in perfect harmony and the ideal requirements for calling a mixture to be compatible are as follows:

a) Physical compatibility
b) Chemical compatibility
c) Physico-chemical compatibility
d) Absence of phyto- toxicity
e) Absence of increase in toxicity to non-target organism.
f) No reduction in bio efficacy

The compatibility of pesticides is effected by various factors such as difference in composition of products mixed, sequence of mixing, degree of agitation, quality of water used in mixing

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and preparing the spray fluid, spraying equipment and its design, temperature, crop and its variety, quality of different components of the mixture and their concentrations.

As there are many variable factors that affect the compatibility of pesticide formulations, it is difficult to suggest which pesticides with what other chemical or substance or what concentration can be compatible as a guide, the mixing of pesticide formulations with any other as a tank mix at the field level should be discouraged and the farmers may be advised to use only those pre mixed/combination pesticides which have been approved by the CIBRC and are available in the market.

5. Pesticides Act, Rules and Regulations

1. Introduction to Insecticide Act, 1968 and Insecticide Rules, 1971

1.1. Introduction

The Insecticide Act-1968 has come in to existence in India as act of 46 of 1968, Dt. 2-9-1968. The enactment of act took place on the basis of recommendation of Inter-ministerial Committee, headed by DR. M.S. THACKER on "the Kerala & Madras Food-poisoning Cases Enquiry Commission's report" under Justice J.C. Shah, then a sitting judge of Bombay High court. Dr M.S. THACKER committee recommended Short-term and Long-term measures on the basis of the enquiry commission's report which were accepted and the enactment of the Insecticide Act took place.

The constitution of Kerala & Madras Food-poisoning Cases Enquiry Commission under Justice J.C. Shah took place due to the accidents occurred in April & May, 1958 , in Kerala(by Folidol contamination) & Tamil Nadu, causing Food Poison due to which many people died and suffered due to the their toxic effects

The Government has enacted the Insecticide Act 1968 on the basis of long term measures to regulate import, manufacture, sale, transport, distribution and use of pesticides with a view to prevent risk to human beings, animals and for matters connected therewith.

1.3 Salient Features of the Insecticide Act, 1968

The Salient features of the Bill of are Establishment of CIB and RC Licensing of persons, Establishment of CIL, Prohibition of import, manufacture, sale, etc., Regulation of transport and storage of insecticides so as to prevent cases of accidental contamination of food. Provision of t aking immediate action by way of prohibition of sale, distribution and use of any insecticide if it involved risk to human beings and vertebrate animals.

The IA-1968 act comprises of 38 Sections in it dealing various aspects of the pesticides in its life cycle and the act is executed following the 46 rules provided in the Insecticide Rules 1971 and the Insecticides (Price, Stock Display and Submission of Reports) Order - 1986 . The rules are being amended from time to time to suit and improve so as to serve the nation and farmers in particular and the following are the amendments existing to the Insecticide Rules 1971.

As per the Act The Central Insecticides Board (CIB) is the Apex Advisory Body, which is headed by Director General, Health services, and advises the Central & State Governments on technical matters relating to Risk to human beings or animals involved in the use of insecticides and measures necessary to prevent such risk; and manufacture, sale, storage, transport and distribution of insecticides with a view to ensure safety to human beings and animals.

The Technical Executive Body under the act is Registration Committee which is Headed by Agricultural Commissioner, Govt. of India . The Registration Committee Registers insecticides after scrutinizing their formulae and verifying claims, made by applicants with regard to their efficacy and safety to human beings and animals; and other functions as assigned by or under the Act.

The Registration of the insecticides is done under the Act in different categories depending on the purpose and type operations intended by the applicant. They are three Types of registration provisional [9(3B)], regular [9(3)] and repeat [9(4)] registration of pesticides.

The registration committee ensures the efficacy and safety of the products registered on scrutiny of the data submitted by the registrants through its panel of experts for chemistry,bio- efficacy / residuesToxicity, Packing & Packaging. It also ensures infrastructural facilities for manufacture, stock, distribution, sale and Commercial Pest Control Operations.

The CIB & RC periodically reviews the pesticide usage and its effects and considers the feed back from the general public, scientific community and research bodies and through the media and satisfy through its own technical expert committees and take necessary steps to impose prohibition on certain pesticides pertaining to Import, Manufacture, Sale, Stock or exhibit for sale, Distribution, Transport and Use or Caused to be used as it deemed fit for the reasons of Public Safety.

1. Insecticides Banned (MIU)	:28
2. InsecticidesFormulations banned except Export	:02
3. Insecticide Formulations banned (MIU)	:04
4. Withdrawn	:08
5. Refused Registration	:18
6. Restricted for Use	:13

The Act envisages for the regulation of Quality of Insecticides being marketed and available for use in the country. Both the Sate and Central Governments play a major role in the enforcement of the Act and the important functionaries are The licensing officers, Insecticide Inspectors (Drawl of samples) and Insecticide Analysts (Analysis of samples). There are various sections and rules which deal with and to explain the manner to proceed.

6 Pesticides Management Bill 2008

The National Policy for Farmers brought out in 2007 states that "the development, introduction and diffusion of environmentally safe and effective pesticides will be given priority" while "suitable quality control, safety evaluation and other regulatory system would be strengthened". The policy highlights the need for "incorporating the use of chemical pesticides in an Integrated Pest Management System". The policy also states that " the sale of spurious and sub-standard pesticides would be prevented and bio-pesticides would be promoted". Various Parliamentary Committees recommended stringent and deterrent punishment for manufacturers/sellers of spurious insecticides and the necessity of fixing of maximum residue limits for registration of pesticides.

Pesticide Management Bill 2008 Rajya Sabha (Bill No. XLVIII of 2008)was introduced in the 214 Session of the Rajya Sabha in 2008 (September 30) after 40 years of the existence of the Insecticides Act. The Bill is expected to regulate the import, manufacture, export, sale, transport, distribution, quality and use of pesticides with a view to:(i) control pests; (ii) ensure availability of quality pesticides;(iii) allow its use only after assessing its efficacy and safety;(iv) minimize the contamination of agricultural commodities by pesticide residues; (v) create awareness among users regarding safe and judicious use of pesticides, and to take necessary measures to continue, restrict or prohibit the use of pesticides on reassessment with a view to prevent its risk on human beings, animals or environment, and for matters connected therewith or i ncidental thereto. It consists of 8 Chapters and 54 clauses(Appendix III)

6.1 Salient features

Salient features of the Pesticides Management Bill include :

1. Improving the quality of pesticides available to Indian farmers and introduce new, safe and efficacious pesticides
2. More effective regulation of import, manufacture, export, sale, transport, distribution and use of pesticides, to prevent risk to human beings, animals, or the environment,
3. Detailed categorization of offences and punishments for greater deterrence to violators.
4. De-licensing of retail sale of household insecticides, and
5. Timely disposal of time-barred pesticides in an environmentally safe manner.

The Pesticide Management Bill, 2008 defines the pesticides as substandard or spurious or misbranded pesticides.

6.2 Misbranded Pesticide under Pesticide Bill, 2008:

A pesticide shall be deemed to be misbranded

a. if its label contains any statement, design or graphic representation relating thereto which is false or misleading in any material particular, or if its package is otherwise deceptive in respect of its contents; or

b. if its label does not contain a warning or caution which may be necessary and sufficient, if complied with to prevent risk to human beings or animals;

c. if any word, statement or other information required by or under this Act to appear on the label not displayed thereon such conspicuous manner as the other words, statements, design or graphic matter have been displayed on the label and such terms as to render it likely to be read and understood by any ordinary individual under customary conditions of purchase and use; or

d. if it is not packed or labelled as required by or under this Act, or

e. if the label contains any reference to registration other than the registration number; or

f. if the date of manufacture and date of expiry printed on its label is at variance with the shelf life as approved by the registration committee.

Substandard Pesticide under Pesticide Bill, 2008:

A pesticide shall be deemed to be substandard-

if it does not conform to the active ingredient test approved for it by the Registration Committee and its active ingredient is within five per cent of the nominal value when applied beyond the upper and lower limits prescribed for conforming to the test. Provided that no tolerance limit shall apply in case of pesticides, which are registered on minimum purity basis; or

f. if the date of manufacture and date of expiry printed on its label is at variance with the shelf life as approved by the registration committee.

Substandard Pesticide under Pesticide Bill, 2008:
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if it does not conform to the active ingredient test approved for it by the Registration Committee and its active ingredient is within five per cent of the nominal value when applied beyond the upper and lower limits prescribed for conforming to the test. Provided that no tolerance limit shall apply in case of pesticides, which are registered on minimum purity basis; or

a) if it does not conform to other tests specified or approved for it by the Registration Committee while granting registration;

A pesticide shall be deemed to be spurious-

a) if it is not registered or licensed in the manner required by or under this Act; or

b) if on test or analysis it shows active ingredient higher or lower even beyond the limits prescribed under clause (v); or

c) if it is an imitation of, or is sold under the name of, another pesticide; or

d) if the container bears the name of the person or company purporting to be the manufacturer of the pesticide, which is either fictitious or does not exist; or

e) if the chemical composition as approved by the Registration Committee is not adhered to or is modified or changed by adding or substituting any ingredient or substance; or

f) if it has outlived its shelf-life, as evident by the date of manufacture and the date of expiry as printed on its label, approved by the Registration Committee and displayed for sale, distribution, use or caused to be used or not disposed of as per provision under section 52; or

g) if its import, manufacture, use or sale is prohibited and it is found to be imported, manufactured, stocked, distributed, transported, sold or exhibited for sale, caused to be used;

7. Registration of Pesticides and License Procedures

Introduction:

Registration of pesticides as defined under Section 3 (e) of the Act. It states that any person desiring to import or manufacture any pesticide is required to apply to the Registration Committee appointed under Section 5 of the Act for registration of such pesticide as provided for under Section 9 of the Act.

Section 5 (5) of the Act states that Registration Committee shall regulate its own procedure and the conduct of business to be transacted by it. Section 5 (1) empowers the Committee to register the pesticides after scrutinizing the formulae and verifying claims by the importer or the manufacturer as regards the efficacy and safety to human beings and animals. It also allows the Committee to carry out any other function which the Act stipulates. If in the course of its function, it spells out the manner of scrutinizing the chemical formulae or assessing efficacy or safety, then it can be taken as competent to lay down condition in the manner which clause 5 provides.

7.1 Registration Types:

First type of registration of pesticides is under section 9 (3). The Statutory Committee is required to evaluate various parameters related to the use and application of the product or pesticide and on being satisfied that the pesticide to which the application relates conforms to the claim made by the importer or the manufacturer regarding the efficacy and its safety to human beings and animals, and the same can be registered by the said Committee

The Second type of registration of pesticide is Provisional Registration under Section 9 (3B) of the Act. The provision has been made in respect of pesticides being introduced in India for the first time. Section 9 (3B) provides for provisional registration of imported pesticides for a period of two years. However, this sub-section is applicable only to the biopesticides and is no longer applicable to conventional chemical pesticides as per directives from the Department of Agriculture and Cooperation, Ministry of Agriculture.

Third type of registration contemplated under Section 9 Sub section (4) of the Act is when a pesticide is already registered under Section 9 (3) of the Act. Section 9 (4) provides that in case when pesticide is registered on an application, any person desiring to import or manufacture the pesticide or engaged in the business of import or manufacturing the pesticide shall make an application for registration. This type of registration of pesticides under Section 9 (4) is known commonly as "Me too Registration".

7.2 Ensuring Efficacy and Safety

The registration committee ensures the efficacy and safety of the products registered on scrutiny of the data submitted by the registrants through its panel of experts on the following before issuing the registration.

a) Chemistry
b) Bio-efficacy / Residues
c) Toxicity
d) Packing & Packaging

The CIBRC periodically reviews the pesticide usage and its effects and considers the feedback from the general public, scientific community and research bodies and through the media and satisfy through its own technical expert committees and take necessary steps to impose prohibition on certain pesticides pertaining to Import, Manufacture, Sale, Stock or exhibit for sale, Distribution, Transport and Use or Caused to be used as it deemed fit for the reasons of safety to human beings, animals and for matters connected therewith.

The Act envisages for the regulation of Quality of Insecticides being marketed and available for use in the country. Both the Sate and Central Governments play a major role in the enforcement of the Act. The important functionaries are licensing officers, Insecticide Inspectors (Drawl of samples) and Insecticide Analysts (Analysis of samples). There are various sections and rules which deal with and to explain the manner to proceed.

7.3 Licensing

State Governments notify the Licensing officers. Any person desiring to manufacture or to sell, stock or exhibit for sale or distribute any insecticide or to take commercial pest control operations may make an application to the licensing officer. Application for grant of license to manufacture shall be made in Form II

7.4 License for Pest Control Operators (Rule 10 (3a))

a) who desires to undertake pest control operations, with the use of Aluminum Phosphide, Methyl bromide etc., Application for the Grant of License to Stock and Use Restricted Insecticides for Commercial Pest Control Operations should be made in Form II (Annexure 5)
b) License is valid for 5 years. It should be renewed before the expiry for a period of another 5 years

Qualification

Pest Control Operations:
a) A graduate in Agriculture or in science with chemistry as subject with a certificate of minimum15 days training.

b) For undertaking fumigation, the pest control operators shall have to obtain special permission for the Plant Protection Adviser to the Govt. of India.

The applicant along with application for grant of License to undertake operation or sell, stock exhibit for sale or distribute insecticides, file certificate from principal (appendix of Form II).The principal should clearly give particulars of their reg. no., license number, authorized persons and type of formulations. The licensing officer shall conduct inspection of infrastructure, premises, stocks and records at least once in every two years

7.5 Prohibition against sale or storage of pesticides at certain Places (Rule 10 (C)

No Person shall manufacture, store or expose for sale or permit the sale or expose for sale or permit the sale or storage of any insecticide in the same building where articles consumable by human bings or animals are manufactured, stored or exposed for sale. Nothing contained in this rule will apply to the retail sales of household insecticides, provided the household insecticides have been registered as such and are packed and labeled in accordance with these rules. A license granted by endorsement for commercial pest control operations under 10 (3)- A shall be renewable along with main license.A license for retail selling of household insecticides shall be issued for a period of ten calendar years.

2.4. Packing of Insecticides (Rule 16 &17)

No person shall stock or exhibit for sale or distribute any insecticide unless it is packed and labeled in accordance with provision of Insecticide Rule 1971 as per Rule 16.

Every package containing an insecticide shall be a type approved by the registration committee and a container sample in which the product is proposed to be packed either shall accompany the application for registration or shall be supplied to the registration committee separately. (Rule 17, Insecticide rules)

3. Insecticide Inspector

Introduction:

The Insecticide Inspector is an important and active functionary in the field under the Insecticide Act 1968. The sampling of pesticide samples under the Insecticide Act is done by the Insecticide Inspector, to ascertain the conformity of samples to certain standards approved by the CIBRC while registering the products and to those laid down specifications as approved in the Bureau of Indian Standard specifications.

The Insecticide Inspectors are appointed under section 20 of the Insecticide Act, by the Central Government or a State Government, by notification in the Official Gazette, in such number as it thinks fit and possessing such technical and other qualifications as may be prescribed to be Insecticides Inspectors for such area as may be specified in the notification:

8.1 Powers of Insecticide Inspectors

Powers of Insecticide Inspector are defined under section 21 of the act. An Insecticide Inspector shall have power-

a) to enter and search, at all reasonable times and with such assistance, if any, as he considers necessary, any premises in which he has reason to believe that an offence under this Act or the rules made there under has been or is being or is about to be committed, or for the purpose of satisfying himself that the provisions of this Act or the rules made there under or the conditions of any certificate of registration or license issued there under are being complied with;

b) to require the production of, and to inspect, examine and make copies of, or take extracts from, registers, records or other documents kept by a manufacturer, distributor, carrier, dealer or any other person in pursuance of the provisions of this Act or the rules made there under and seize the same, if he has reason to believe that all or any of them may furnish evidence of the commission of an offence punishable under this Act or the rules made there under;

c) to make such examination and inquiry as he thinks fit in order to ascertain whether the provisions of this Act or the rules made there under are being complied with and for the purpose stop any vehicle;

d) to stop the distribution, sale or use of an insecticide which he has reason to believe is being distributed, sold or used in contravention of the provisions of this Act or the rules made there under, for a specified period not exceeding twenty days, or unless the alleged contravention is such that the defect may be removed by the possessor of the insecticide, seize the stock of such insecticide;

e) to take samples of any insecticide and send such samples for analysis to the Insecticide Analyst for test in the prescribed manner; and

f) to exercise such other powers as may necessary for carrying out the purposes of this Act or the rules made there under.

3.2 Duties of Insecticides Inspector

The Insecticides Inspector shall have the following duties under section 27 of the Insecticide Rules 1971, namely:

a) to inspect not less than three times in a year all establishments selling insecticides within the area of his jurisdiction;

b) to satisfy himself that the conditions of licence are being complied with;

c) to procure and send for test and analysis, samples of insecticides which he has reason to suspect are being sold, stocked or accepted for sale in contravention of the provisions of the Act or rules made there under;

d) to investigate any complaint in writing which may be made to him;
e) to institute prosecution in respect of breaches of the Act and the rules made there under;
f) to maintain a record of all inspections made and action taken by him in the performance of his duties including the taking of samples and seizure of stocks and to submit copies of such record to the licensing officer;
g) to make such inquiries and inspections as may be necessary to detect the sale and use of insecticides in contravention of the Act.

The provisions of the Code of Criminal Procedure, 1973 (2 of 1974), shall, as far as may be, apply to any search or seizure under this Act as they apply to any search or seizure made under the authority of a warrant issued under section 94 of the said code.An Insecticide Inspector may exercise the powers of a police officer under section 42 of the code of Criminal Procedure, 1973 (2 of 1974), for the purpose of ascertaining the true name and residence of the person from whom a sample is taken or insecticide is seized.

The act has also provision to notify Insecticide Inspector for special purpose as mentioned here; any person who does not possess the required qualifications may also be appointed as Insecticide Inspector for the purposes of search and seizure operations as and when necessary for enforcement of the Act.
The Insecticide Inspectors during the inspection of dealer shops shall verify the following aspects:
1. Display stock and price list.
2. Display of license in prominent place.
3. Proper maintenance of stock registers, bill books and other records.
4. Product wise, batch wise, stocking.
5. Physical verification of the stock with book balance.
6. Purchase invoices with source of supply approved in principal certificates.
7. Date expired stock are kept separately with label "date expired ".
8. Pesticide storage facilities to satisfy himself whether the pesticides are stored in good conditions, well-constructed structure, well ventilated, environmentally safe, fire-proof, theft-proof and childproof. And also to ascertain sufficient care is taken to avoid cross contamination and pesticides are stored with proper label.
9. The inventory in the stores/godown is also verified.

The Insecticide Inspector shall issue stop sales under rule 30 and give notices under Section 21(1)(d) in Form-V(A) after establishing a reasonable cause for taking such action if necessary.

The stop sale notices can be served,

a) If the dealer has purchased stocks from source other than those mentioned in the principal certificates.
b) If he failed to maintain proper accounts , stock registers etc., to show proper stocks and batch numbers etc.
c) If t here is reasonable suspicion that he may be selling certain products which are spurious/substandard or which are not purchased from authorized and declared sources.
d) If the packing is defective in respect of labeling, sealing etc.
e) If storage conditions are not proper.
f) When there are complaints from farmers or any other agency.

8.2 Drawal of Pesticide Samples:

After completion of the above, he shall draw the samples of pesticides as per the stipulated sampling procedures either f rom small packs or big packs. He is empowered to draw any sample(s) whichever he has reason to suspect or may be on routine random check of the displayed, kept for sale or stocked pesticides in the godowns. The samples shall be drawn and dispatched to the laboratories to check the Label claims, Adulterants, Field Effectiveness under Section 24(2) of Insecticide Rules 1971

The Insecticide Inspector shall intimate such purpose in writing in Form-V (C) to the person from whom the samples are drawn under Section 22(5) of I . Act 1968 and the dealer or person from whom samples are drawn is offered to put their seal and signature on the sealed packs of the pesticides drawn besides acknowledging the receipt of intimation in form No. V(C)

The Inspector shall issue a receipt under Section 22(3) of Insecticide Act 1968 for t he samples drawn stating that the fair price of such samples shall be tendered if the samples after test or analysis are not found to be misbranded. Once the test reports are arrived, the payment of fair price or otherwise will be decided

The Insecticide Inspector draws three samples and one sample is given to the person from whom the sample is drawn and the second one is sent forthwith to the Insecticide Analyst. The 3rd sample is to be produced in the court of law in case of dispute, for referee analysis in the Central Insecticide Laboratory (CIL), which is a referee laboratory.

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In case of a pesticide declared misbranded the Insecticide Inspector will send the test result in Form-IV to the person from whom the sample was drawn and simultaneously serve a copy of the same to the distributor / manufacturer immediately. The Insecticide Inspector while serving the misbranding result in Form-IV shall seize the misbranded stocks, records and he shall tender a receipt there for in Form-V(B) by taking the signature / seal of the dealer under panchanama (witnesses).

After the analytical result from CIL arrives and tallies with the State PTL results, the Insecticide Inspector will proceed for prosecution as per the procedure laid down in the Insecticide act 1968 and Cr PC.

8.3 Confiscation

Where any person has been convicted under this Act for contravening any of the provisions of this Act or of the rules made thereunder, the stock of the insecticide(s) in respect of which the contravention has been made shall be liable to confiscation.

Without prejudice to the provisions contained in sub-section (1), where the Court is satisfied on the application of an Insecticide Inspector or otherwise and after such inquiry as may be necessary, that the insecticide is a misbranded insecticide, such insecticide shall be liable to confiscation.

No prosecution, suit or other proceedings shall be against the Government or any officer of the Government, or the board, the registration committee or any committee of the board, for anything in good faith done or intended to be done under this Act under Section 35 of Insecticide Act, 1968.

7.2 Ensuring Efficacy and Safety

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a) Chemistry
b) Bio-efficacy / Residues
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The Insecticide Inspector is an important and active functionary in the field under the Insecticide Act 1968. The sampling of pesticide samples under the Insecticide Act is done by the Insecticide Inspector, to ascertain the conformity of samples to certain standards approved by the CIBRC while registering the products and to those laid down specifications as approved in the Bureau of Indian Standard specifications.

The Insecticide Inspectors are appointed under section 20 of the Insecticide Act, by the Central Government or a State Government, by notification in the Official Gazette, in such number as it thinks fit and possessing such technical and other qualifications as may be prescribed to be Insecticides Inspectors for such area as may be specified in the notification:

8.1 Powers of Insecticide Inspectors

Powers of Insecticide Inspector are defined under section 21 of the act. An Insecticide Inspector shall have power-

a) to enter and search, at all reasonable times and with such assistance, if any, as he considers necessary, any premises in which he has reason to believe that an offence under this Act or the rules made there under has been or is being or is about to be committed, or for the purpose of satisfying himself that the provisions of this Act or the rules made there under or the conditions of any certificate of registration or license issued there under are being complied with;

b) to require the production of, and to inspect, examine and make copies of, or take extracts from, registers, records or other documents kept by a manufacturer, distributor, carrier, dealer or any other person in pursuance of the provisions of this Act or the rules made there under and seize the same, if he has reason to believe that all or any of them may furnish evidence of the commission of an offence punishable under this Act or the rules made there under;

c) to make such examination and inquiry as he thinks fit in order to ascertain whether the provisions of this Act or the rules made there under are being complied with and for the purpose stop any vehicle;

d) to stop the distribution, sale or use of an insecticide which he has reason to believe is being distributed, sold or used in contravention of the provisions of this Act or the rules made there under, for a specified period not exceeding twenty days, or unless the alleged contravention is such that the defect may be removed by the possessor of the insecticide, seize the stock of such insecticide;

e) to take samples of any insecticide and send such samples for analysis to the Insecticide Analyst for test in the prescribed manner; and

f) to exercise such other powers as may necessary for carrying out the purposes of this Act or the rules made there under.

3.2 Duties of Insecticides Inspector

The Insecticides Inspector shall have the following duties under section 27 of the Insecticide Rules 1971, namely:

a) to inspect not less than three times in a year all establishments selling insecticides within the area of his jurisdiction;

b) to satisfy himself that the conditions of licence are being complied with;

c) to procure and send for test and analysis, samples of insecticides which he has reason to suspect are being sold, stocked or accepted for sale in contravention of the provisions of the Act or rules made there under;

d) to investigate any complaint in writing which may be made to him;
e) to institute prosecution in respect of breaches of the Act and the rules made there under;
f) to maintain a record of all inspections made and action taken by him in the performance of his duties including the taking of samples and seizure of stocks and to submit copies of such record to the licensing officer;
g) to make such inquiries and inspections as may be necessary to detect the sale and use of insecticides in contravention of the Act.

The provisions of the Code of Criminal Procedure, 1973 (2 of 1974), shall, as far as may be, apply to any search or seizure under this Act as they apply to any search or seizure made under the authority of a warrant issued under section 94 of the said code.An Insecticide Inspector may exercise the powers of a police officer under section 42 of the code of Criminal Procedure, 1973 (2 of 1974), for the purpose of ascertaining the true name and residence of the person from whom a sample is taken or insecticide is seized.

The act has also provision to notify Insecticide Inspector for special purpose as mentioned here; any person who does not possess the required qualifications may also be appointed as Insecticide Inspector for the purposes of search and seizure operations as and when necessary for enforcement of the Act.
The Insecticide Inspectors during the inspection of dealer shops shall verify the following aspects:
1. Display stock and price list.
2. Display of license in prominent place.
3. Proper maintenance of stock registers, bill books and other records.
4. Product wise, batch wise, stocking.
5. Physical verification of the stock with book balance.
6. Purchase invoices with source of supply approved in principal certificates.
7. Date expired stock are kept separately with label “date expired “.
8. Pesticide storage facilities to satisfy himself whether the pesticides are stored in good conditions, well-constructed structure, well ventilated, environmentally safe, fire-proof, theft-proof and childproof. And also to ascertain sufficient care is taken to avoid cross contamination and pesticides are stored with proper label.
9. The inventory in the stores/godown is also verified.

The Insecticide Inspector shall issue stop sales under rule 30 and give notices under Section 21(1)(d) in Form-V(A) after establishing a reasonable cause for taking such action if necessary.

The stop sale notices can be served,

a) If the dealer has purchased stocks from source other than those mentioned in the principal certificates.

b) If he failed to maintain proper accounts , stock registers etc., to show proper stocks and batch numbers etc.

c) If t here is reasonable suspicion that he may be selling certain products which are spurious/substandard or which are not purchased from authorized and declared sources.

d) If the packing is defective in respect of labeling, sealing etc.

e) If storage conditions are not proper.

f) When there are complaints from farmers or any other agency.

8.2 Drawal of Pesticide Samples:

After completion of the above, he shall draw the samples of pesticides as per the stipulated sampling procedures either f rom small packs or big packs. He is empowered to draw any sample(s) whichever he has reason to suspect or may be on routine random check of the displayed, kept for sale or stocked pesticides in the godowns. The samples shall be drawn and dispatched to the laboratories to check the Label claims, Adulterants, Field Effectiveness under Section 24(2) of Insecticide Rules 1971

The Insecticide Inspector shall intimate such purpose in writing in Form-V (C) to the person from whom the samples are drawn under Section 22(5) of I . Act 1968 and the dealer or person from whom samples are drawn is offered to put their seal and signature on the sealed packs of the pesticides drawn besides acknowledging the receipt of intimation in form No. V(C)

The Inspector shall issue a receipt under Section 22(3) of Insecticide Act 1968 for t he samples drawn stating that the fair price of such samples shall be tendered if the samples after test or analysis are not found to be misbranded. Once the test reports are arrived, the payment of fair price or otherwise will be decided

The Insecticide Inspector draws three samples and one sample is given to the person from whom the sample is drawn and the second one is sent forthwith to the Insecticide Analyst. The 3rd sample is to be produced in the court of law in case of dispute, for referee analysis in the Central Insecticide Laboratory (CIL), which is a referee laboratory.

The 3rd sample is to be produced in the court of law in case of dispute, for referee analysis in the Central Insecticide Laboratory (CIL), which is a referee laboratory.

In case of a pesticide declared misbranded the Insecticide Inspector will send the test result in Form-IV to the person from whom the sample was drawn and simultaneously serve a copy of the same to the distributor / manufacturer immediately. The Insecticide Inspector while serving the misbranding result in Form-IV shall seize the misbranded stocks, records and he shall tender a receipt there for in Form-V(B) by taking the signature / seal of the dealer under panchanama (witnesses).

After the analytical result from CIL arrives and tallies with the State PTL results, the Insecticide Inspector will proceed for prosecution as per the procedure laid down in the Insecticide act 1968 and Cr PC.

8.3 Confiscation

Where any person has been convicted under this Act for contravening any of the provisions of this Act or of the rules made thereunder, the stock of the insecticide(s) in respect of which the contravention has been made shall be liable to confiscation.

Without prejudice to the provisions contained in sub-section (1), where the Court is satisfied on the application of an Insecticide Inspector or otherwise and after such inquiry as may be necessary, that the insecticide is a misbranded insecticide, such insecticide shall be liable to confiscation.

No prosecution, suit or other proceedings shall be against the Government or any officer of the Government, or the board, the registration committee or any committee of the board, for anything in good faith done or intended to be done under this Act under Section 35 of Insecticide Act, 1968.

4. Insecticide Analyst

4.1 Introduction:

Quality control is defined as various steps undertaken to ensure the conformity of samples to certain standards or specifications. The three important aspects of quality control are

a) Standard specifications: The specifications for sample analysis will be given by Bureau of Indian Standards. The manufacturer at the time of registration has to submit the method of analysis which will be scrutinized by BIS, with the help of various public and private organizations for the suitability of method and finally release the specification for that pesticide. Until the specification comes from BIS, the method submitted by the manufacturer can be used for the analysis of sample which is called as Registration committee approved method.

b) Sampling procedures: Sampling is a very important aspect of quality control. Samples are drawn by Insecticide Inspectors appointed by central and state governments from the retail out lets as well as manufacturing units. The drawn samples are sent to various state Pesticide Testing Laboratories to check the quality of the pesticide. Sample drawn should be homogeneous and representative of the entire lot or consignment. Section 21 and 22 of the insecticide act provides procedures for drawl of samples. Preference for drawl of sample should be given in the order of priority. Sample should be sent along with form XX and form XXI to the insecticide analyst.

c) Analysis of samples: The Central Government or a State Government by notification in the Official Gazette, appoint persons possessing technical and other qualifications as Insecticide Analysts, who has no financial interest in the manufacture, import or sale of any insecticide.

9.2 Qualifications of Insecticide Analyst:

Insecticide Analyst is the key authority for ensuring the quality of insecticides by testing the samples under the provisions of IA, 1968. Appointment of insecticide analyst is done under Sec 19 of IA, 1968. A person shall be eligible for appointment as an insecticide analyst under the Act only if he possesses the following qualifications, namely:

a) A graduate in Agriculture or a graduate in Science with Chemistry as special subject; and

b) adequate training in analyzing insecticides in a recognized laboratory.

Powers of Insecticides Analyst (Rule 22 of Insecticide Rule, 1971)

The Insecticides Analyst shall have the power to call for such information of particulars or do anything as may be necessary for the proper examination of the samples sent to him either from the Insecticide Inspector or the person whom the sample was obtained. Further the duties of the Insecticides Analyst also have been defined as furnished hereunder

9.3 Duties of Insecticides Analyst (Rule 23 of Insecticide Rule, 1971)

a) The Insecticides Analyst shall analyze or cause to be analyzed or test or cause to be tested such samples of insecticides as may be sent to him by the Insecticide Inspector under the provisions of the Act and shall furnish report or results of such tests or analysis.

b) An insecticides analyst shall, from time to time, forward to the State Government reports giving the result of analytical work and investigation with a view to their publication at the discretion of the government.

9.4 Procedure on receipt of sample (Rule 24 of Insecticide Rule,1971)

a) On receipt of a package from an Insecticide Inspector containing a sample for test or analysis, the Insecticides Analyst shall compare the seals on the packet with the specimen impression received separately and shall note the condition of the seals on the packet.

b) In making the test or analysis of insecticides, it shall be sufficient if the insecticides analyst follows those specifications and the months of examination of samples as approved by the Registration Committee.

c) After the test or analysis has been carried out under sub-rule (2), the Insecticides Analyst shall forthwith supply to the Insecticides Inspector a report in triplicate in Form XVII (Annexure 3) of the result of test or analysis.

The analyst registers all those samples in the sample register in a chronological order and issues a laboratory code. The analysis will be taken up on priority based on the history of the sample, such as near expiry date and /or under stop sale/seizure of the stock.

9.5 Parameters to be Tested:

The analyst must analyze the samples for all the parameters as per the requirement of the respective BIS specification such as active ingredient and other Physico chemical Parameters. The tolerance limit for the following nominal content of the active ingredient is furnished as

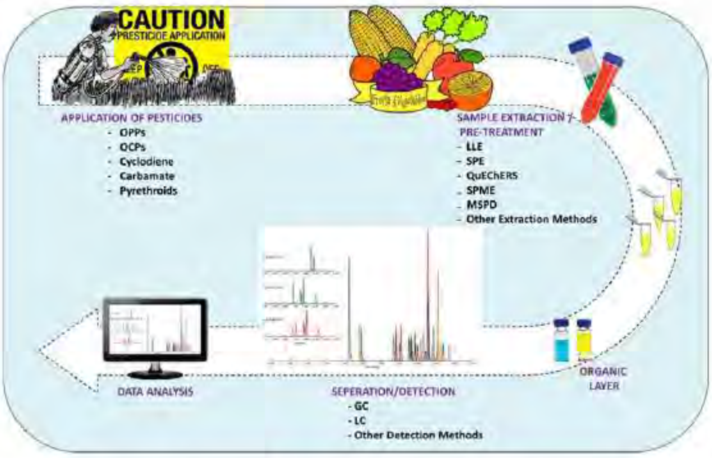
Nominal Content of A.I.	Tolerance Limit (%)	Example	Range
Up to 9	-5 to + 10	5%	4.75 to 5.5
10 to 49	-5 to +5	30	28.5 to 31.5
50 and above	-3 to +5	50	48.5 to 52.5

9.6 Other Physico chemical Parameters

Sl.No. Parameter Application for

1. Acidity / Alkalinity All samples
2. Suspensibility WP, SC, WDG
3. Wettability WP
4. Emulsion stability EC
5. Flash point EC / SL
6. Cold test EC / SL
7. Attrition test Coated Gr
8. Water run off test Coated Gr
9. Bulk density DP
10. Particle size DP / WP / Gr

The Analyst shall follow any techniques as of conventional analysis / titrimetric analysis and/or instrumental analysis and must follow only the referee method as test protocol. The analyst must reconfirm the analytical results before reporting the same and maintain all the records of receipt of samples and analysis undertaken along with the chromatograms in case of chromatographic analysis. The analysis and reporting is done with in the stipulated 30 daytime [Under Rule 24 (1)] from the receipt of the sample in the laboratory. A sample can be declared Misbranded if the sample fails in any one of the parameters such as active ingredient and / or physico-chemical parameters.



10 Organizations Involved in Quality Control:

Analytical report shall be conclusive evidence till adduced by aggrieved under Sec 24 (4). And CIL report shall be conclusive evidence.Various Organizations such as industry, GOI and Bureau of Indian Standard are involved in quality control.

10.1. Industry

It is the industry which develops and manufactures the pesticides also develops analytical methodology and drafts the required specifications for approval, besides supply of reference standards / technical grade chemicals for undertaking the analysis and cooperate with BIS in framing specifications and are the members of FAD1.

10.2. Government of India

CIBRC which registers pesticides under, The Insecticide Act 1968& The Insecticide Rules 1971 takes care of the "Quality control" aspects included in the act Established CIL (Under Section 16 of IA, 1968), two Regional Pesticide Testing Laboratories (Kanpur &Chandigarh) and 68 SPTLs all over India.Established Training Institute/facilities (NIPHM).

3. Bureau of Indian Standards (BIS)

Headed by Plant Protection Adviser to the Govt. of India, frames specifications for pesticides and issues the 'mark of certification' to the manufacturers

11.Misbranded crop protection products

An insecticide shall be deemed to be misbranded

a. if its label contains any statement, design or graphic representation relating thereto which is false or misleading in any material particular, or if its package is otherwise deceptive in respect of its contents; or

b. if it is an imitation of, or is sold under the name of, another insecticide; or

c. if its label does not contain a warning or caution which may be necessary and sufficient, if complied with to prevent risk to human beings or animals;

d. if any word, statement or other information required by or under this Act to appear on the label not displayed thereon such conspicuous manner as the other words, statements, design or graphic matter have been displayed on the label and such terms as to render it likely to be read and understood by any ordinary individual under customary conditions of purchase and use; or

e. if it is not packed or labelled as required by or under this Act, or

f. if it is not registered in the manner required by or under this Act; or

g. if the label contains any reference to registration other than the registration number; or

h. if the insecticide has a toxicity which is higher than the level prescribe or is mixed or packed with any substance so as to alter its nature or quality or contains any substance which is not include in the registration;

12. Report of Analyst and Follow up action:

Analytical report should be served to the dealer imediately without delay.Accused Within 28 days of receiving the report can appeal for reanalysis of sample. The cost for reanalysis shall be paid by the accused.If the results of both are in agreement prosecution must be launched without delay by taking permission of the competent authority. The imsecticide inspector should serve the analytical report to the dealer immediately. If contested within 28 days, send referee samples to CIL through Court of Law.

The Insecticide Inspector while depositing the referee sample in the court should impress upon them that according to section 24(4) of Insecticide Act 1968 the report of analysis should be delivered within a period of (30) days by the Central Insecticide Lab. The Central Insecticide Lab result shall be conclusive evidence.

. The District Licensing Authority i.e., Joint Director of Agriculture concerned should issue Show Cause Notice to the person under Section 14 of Insecticide Act 1968. In case of misbrands the provision of Section 24(3) of Insecticide Act for reanalysis at Central Insecticide Lab to be indicated in Show Cause Notice.

If State Pesticide Testing Laboratory (SPTL) & Central Insecticide Laboratory (CIL) result tally launch prosecution, immediate after receipt of Central Insecticide Lab report, it has to be sent to the Commissionerate of Agriculture duly attested by the Joint Director of Agriculture concerned.

A detail charge sheet must be filed in the court of law, if the sample is misbranded in Central Insecticide Lab. In case the person not contested for the Central Insecticide Lab should be taken to launch prosecution in the court duly obtaining the orders of Jt. Director / District Collector.

13. Importance of Packaging and labelling

Package means a box, bottle, casket, case, sack, wrapper, or other material in which an insecticide or it's formulation is packed. Package of pesticide should be leak proof and exhibit good design. Packaging can be described as a coordinated system of preparing goods for transport, warehousing, sale and end use. Packaging contains, protects, and preserves the contents packed in it. Packaging extends the life span of products by its protective action.

13.1 Objectives of Packaging and labelling:

Physical protection – The objects enclosed in the package may require protection from, among other things, mechanical shock, vibration, electrostatic discharge, compression, temperature, etc.

Barrier protection – A barrier from oxygen, water vapour, dust, etc., is often required. Keeping the contents clean]and safe for the intended shelf life is a primary function.

Information transmission – Packages and labels communicate information regarding how to use, transport, recycle, or dispose of the package or product for better efficacy and safety.

Marketing – The packaging and labels can be used by marketers to encourage potential buyers to purchase the product.

Security – Packaging can play an important role in reducing the security risks of shipment. Packages can be made with improved tamper resistance to deter tampering.

Convenience – Packages can have features that add convenience in distribution, handling, stacking, display, sale, opening, reclosing, use, dispensing, reuse, recycling, and ease of disposal.

13.2 Packaging types

1. Packaging may be looked at as being of several different types. It is sometimes convenient to categorize packages by layer or function: "primary", "secondary", etc. Primary packaging is the material that first envelops the product and holds it. This usually is the smallest unit of distribution or use and is the package which is in direct contact with the contents.

2. Secondary packaging is outside the primary packaging, perhaps used to group primary packages together.

3. Tertiary packaging is used for bulk handling, warehouse storage and transport shipping.

The packaging material must be tamper resistant, statutorily approved, non-reactive, and nontoxic and should protect the contents from environment.

As per the Rule 16 of IA,1968, No person shall stock or exhibit for sale or distribute any insecticide unless it is packed and labelled in accordance with provision of Insecticide Rule 1971 as per Rule 16.

Every package containing an insecticide shall be a type approved by the registration committee and a container sample in which the product is proposed to be packed either shall accompany the application for registration or shall be supplied to the registration committee separately. (Rule 17, Insecticide rules)

13.3 Leaflet Information:

The packing of every insecticide shall include a leaflet containing the following details, namely;

a. The plant disease, insects and noxious animals or weeds for which the insecticide is to be applied, the adequate direction concerning the manner in which the insecticide is to be used at the time of application;

b. particulars regarding chemicals harmful to human beings, animals and wild life, warning and cautionary statements including the symptoms of poisoning suitable and adequate safety measures and emergency first-aid treatment where necessary;

c. cautions regarding storage and application of insecticides with suitable warnings relating to inflammable, explosive or other substance harmful to the skin;

d. instructions concerning the decontamination or safe disposal of used containers;

e. a statement showing the antidote for the poison shall be included in the leaflet and the label;

f. if the insecticide is irritating to the skin, nose, throat or eyes, a statement shall be included to that effect.

g. Common name of the insecticide as adopted by the International Standards Organisation and where such a name has not yet been adopted such other name as may be approved by the Registration Committee.

13.4 Manner of labelling

The following particulars shall be either printed or written in indelible ink on the label of the innermost container of any insecticide and on the outer most covering in which the container is packed:

i. Name of the manufacturer

ii. Name of insecticide

iii. Registration number of the insecticide.

iv. Kind and name of active and other ingredients and percentage of each

iii. Net content of volume.

iv. Batch number.

v. Expiry date, i.e. up to the date the insecticide shall retain its efficiency and safety.

vi. Antidote statement.

6. Role and Responsibilities of Pesticide Dealer under IA, 1968

Introduction:

Farm input suppliers highly influence the decision taken by farmer for the selection of farm inputs for increasing the crop production or to control pest or disease damage on crop. Similarly, the pesticide dealer relies on the farmer for success of his shop. A farmer chooses a retailer who offers quality products with best price and gives best advice in term of product selection and pest control. It is the duty of the pesticide dealer to maintain his out let in a proper manner, following all the rules and regulations as required under the Insecticide Act, 1968 and Insecticide Rules 1971.

Qualification for dealer for Pesticide Sale or Distribution (Rule 10 of IR, 1971)

A person who wants to sell, stock or distribute pesticides for commercial purpose shall make an application to the licensing authority in Form II (Annexure V) along with the prescribed fee. The person shall possess or employ a person possessing following qualification

a) A graduate degree in agricultural sciences or biochemistry or biotechnology or life sciences or science with chemistry or botany or zoology form recognized university or institute or

b) One year diploma in agriculture or horticulture or related subjects from any govt. recognized university or institute with course contents on plant protection and pesticide management.

A person possessing a valid license without the prescribed qualification as on date are given
a period of three years to comply with the given qualifications.

Responsibilities of Pesticide Dealer:

The duties and responsibilities of a pesticide dealer/ distributor can be summarized as follows.

1. Maintaining the shop in a clean, well ventilated manner
2. Segregating the stocks product wise, batch wise and stacking them in a organized manner.
3. Displaying the license in a prominent place in the shop/ godown.
4. Display of price list of the stocks product wise.

5. Separating the date expired products and leaked products from the regular stocks and labelling them as “expired products” and maintain the register for date expired products (Annexure V, Appendix A of Form II, IR,1971)

6. Timely disposal of expired products to the manufacturer or distributor for proper disposal through incineration

7. Maintenance of stock registers product wise (as per the Annexure V, Appendix B of Form-II, IR, 1971) bill books and registers.

8. Selling the products that are procured from the manufacturer as stated on principal certificate (Annexure V, Appendix to Form II IR, 1971).

9. Renewal of licenses when required before the due date of renewal (Distribution of household pesticides)

10. Duly Submitting the monthly returns to the licensing officer as per the formats (Annexure V , Appendix D2 of Form II, IR 1971)

11. Extending Co-operation and support to the Insecticide Inspector while drawl of pesticide samples.

12. Not to sell any counterfeit or misbranded samples. Not to deface the labels or erase the inscription on the labels of pesticide products.

13. Updating the knowledge on the usage of products and on any amendments to the act, or ban or restrictions imposed on the usage of certain products

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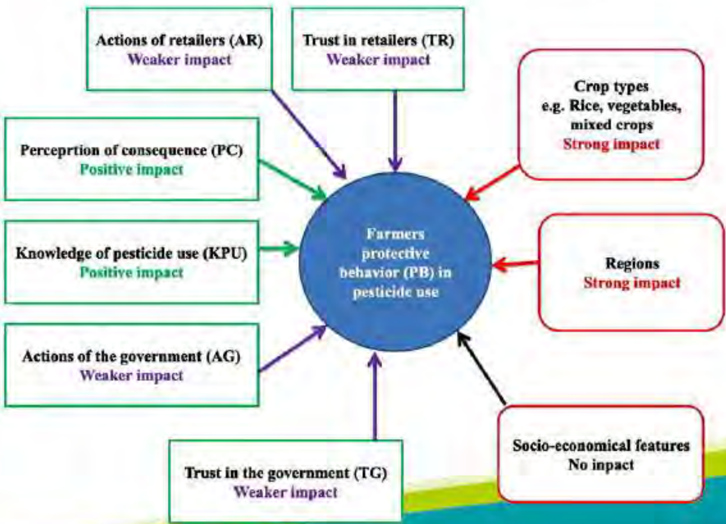
14. Honesty and establishing trust when dealing with farmers by selling genuine products with clearly marked prices.



16. INTEGRATED PEST MANAGEMENT: CONCEPTS AND STRATEGIES

The basic concepts of integrated pest management (IPM) to aid in management decision-making.
As an introduction to IPM, the intended audience of this article includes new farmers, consultants, and all those involved in pest management. It can be used in conjunction with specific pest management recommendations to make well-informed decisions that utilize the principles of IPM.

IPM is a process of holistic evaluation and implementation of pest management strategies in food production systems, landscapes, and urban environments. The goal of IPM is not to eradicate pests entirely but to maintain population levels below economically relevant levels. Effective implementation of IPM programs can reduce costs of management to growers as well as the impact of management on the ecosystem by minimizing the use of pesticides.

The concept of integrated control was introduced in the mainstream in 1959, based on the recognition of problems caused by heavy reliance on chemical control measures. Since then, the use of IPM has varied wildly based on geographic location and the cropping systems.2-6 This article discusses the strategies, concepts, and benefits of IPM that apply to the management of pests in crop production, landscapes, and urban settings.

16.1 Basics of IPM

The principal component of IPM is use of multiple control tactics to manage pests while reducing costs for producers and/or minimizing the use of pesticides in some cases. Some of the available tools in integrated management are discussed below. In many cases, multiple control measures can be used to r educe pest numbers below an economic level or prevent them from ever reaching those levels. An important component of IPM is that it does not preclude the use of pesticides, but rather encourages the use of alternate control tactics combined with periodic sampling to minimize the need to use pesticides. IPM can be used to manage a single pest or a group of pests in a single crop, an ecosystem, or an entire production community.

16.2 Levels of Integration in IPM

The level of integration that a production system can achieve is often dependent on the scale of production . The higher levels of IPM integration require systematic change on a community-wide basis. As IPM is adopted into more s ustainable agricultural practices, the following levels of integration have been proposed to classify degrees of integration:

• Level 1 integration: Individual pest species or species complexes.

• Level 2 integration: Community of pest species (insects, pathogens, weeds)

• Level 3 integration: Ecosystem (crop and non-crop host plants and other components)

• Level 4 integration: Farming community (including social and economic components)

The levels of integration in IPM are intended to allow producers to consider the extent to which integrated management is implemented. True integrated management takes into consideration a vast range of biotic and abiotic factors; however, IPM can be practiced at varying levels.

16.3 Types of Control

• Cultural control involves the use of farm management strategies and resistant plant varieties to minimize the i mpact of certain pests. Examples include rotating corn production with other crops to prevent corn rootworm from completing its life cycle, using landscape varieties resistant to disease, or sanitation to prevent household pest pressure.

• Biological control focuses on protecting beneficial species in the field as well as introducing beneficial species in some cases to reduce densities of target pests. Examples include reducing broad-spectrum pesticide use to promote populations of beneficial predators in the field or landscapes or introducing lady beetles to greenhouses to control aphid populations.

• Mechanical control is any physical measure taken to trap pest species, e xclude them from the area, or eliminate them. Examples include using a grease band on fruit trees to prevent wingless female moths from laying eggs on developing trees in spring, using trap crops to exclude pests from cultivated fields, or discing weeds to eliminate them.

• **Chemical control** is typically a last resort in integrated management systems but can still be used in the context of IPM. The goal of chemical control is to use products that specifically target a pest (as/when possible) while also reducing the number of sprays by using periodic sampling and action thresholds. An example includes using pesticides that specifically target lepidopteran pests (i.e., spinosad, B.t.) with minimal impact on natural enemies.

• **Behavioral control** often involves the use of chemicals but does not involve directly killing the pest species. It is the alteration of pest behavior such as mating, aggregation, or host identification via the use of pheromones and semiochemicals. Pheromones are intraspecific chemical cues used by insects, and semiochemicals are more broadly defined as chemicals that convey signals from one organism to another. Both can be synthetically produced and used to alter the behavior of pest species. An example includes introducing mating disruption pheromones to reduce populations of pest species in the field.

16.4 Economic Injury Levels and Economic Thresholds

Two of the most important concepts in making integrated management decisions are the economic injury level (EIL) and economic threshold (ET). The EIL is defined as the lowest acceptable pest density that results in economic damage and is specific to individual pest species and crops. 1,9 The amount of damage caused at the EIL causes profit loss equal to the cost of management. The ET is set below the EIL and is the point at which management is implemented to prevent the pest density from reaching the EIL.1,9 EILs and ETs are set by conducting research on the relationship between specific pest densities, yield losses related to crop damage from pests, and the cost of management

16.5 Steps in Developing an IPM Program

Below are some typical steps in implementing an IPM program:

1. Identify pests: Identifying pests is a critical step in developing managing strategies. In many cases, a single pest is of primary concern; however, many pests can be managed in similar ways (for instance, several stink bug species cause similar damage to fruiting structures of crops and can be managed as a species complex). Identifying all the pests that require management can promote the use of strategies that are effective in preventing a range of pests.

2. Determine acceptable injury level (EIL and ET): Research-based economic injury levels and economic thresholds are available for many major pests and can be found in crop production and management guides.

3. Monitor pest population levels: Achieved/accomplished through trapping or scouting of managed areas. Degree day models are predictive tools involving simple calculations using high and low daily temperatures to determine when pest species may be emerging and can sometimes help to optimize the timing of sampling efforts.

4. Evaluate management options : Determine all available control methods for the pest or groups of pests. Prevention or exclusion of target pests is often the first line of defense, then biological or chemical control can be used if pest levels still reach economic levels.

5. Develop and implement an IPM program: Pest exclusion or prevention should be used whenever possible, for all previously identified pests. These strategies must be used prophylactically. If populations still reach previously determined threshold levels, implement one or more of all the other available control strategies. Chemical management should be supplemental and used if all other strategies fail. Chemical applications should be made at the determined acceptable level of injury or ET.

6. Monitor management effectiveness: Continue to monitor pest population levels after control implementation. This is a critical portion in IPM as it can inform the use of additional management strategies.

7. Evaluate the program: Evaluate the effectiveness of each step in the IPM implementation proces s to determine strengths and shortcomings for future management.

Benefits and Limitations of IPM

The main benefits of integrated management are a potential decrease in management costs, reduction in the use of pesticides, and adoption of more sustainable management practices by minimizing reliance on chemical control alone. The use of multiple control tactics can minimize selection pressure from reliance on pesticides only, which can slow or prevent the development of pesticide resistance. In areas of high IPM adoption such as California, there is documented reduction in pesticide residues on products as well as in surface waters.

A decrease in pesticide residue is attributed to an overall decrease in use, but also to the use of newer pesticides that do not persist as long in the environment. Integrated chemical management ideally narrows the spectrum of activity to a specific pest or group of pests and can increase populations of natural enemies. Protecting natural enemies ultimately can keep target pest numbers below action thresholds and reduce the overall number of chemical applications. IPM adoption has been associated with a net increase in returns and yields in many cases.6,11,12 For instance, IPM adoption in tomato production resulted in net profits \$123-\$234/ac higher than in conventional production, while simultaneously reducing the overall use of pesticide.

Unfortunately, in some cases, pesticide usage increased, or overall pesticide cost in IPM programs increased.6 Reasons for these increases may, in part, occur because growers using IPM monitor fields more frequently and therefore, may spray more than growers using a timed spray regime. Also, the increase in pesticide cost could result from the use of newer, more expensive pesticides that have a lesser impact on the environment but come at a higher cost for producers. Reliance on an affordable broad-spectrum pesticide such as a pyrethroid insecticide can sometimes be cheaper than implementing an IPM program. One of the main limitations of IPM is that the ability to implement multiple strategies and the effectiveness of those strategies varies between geographic regions and crops produced. Although there is variation, IPM can be implemented to some extent in all cases. Individual growers have to assess their needs and make management decisions based on the evaluation of IPM tactics used. This process can ultimately cost producers time and money, which can be a limitation for producers in under-researched areas and cropping systems in particular.

General IPM principles can be applied in under-researched areas by applying basic strategies from similar pests or crops which promote natural enemies and minimize the use of broad-spectrum pesticides. The effectiveness of IPM is dependent on continued research on the ever-changing population of pests across all types of production systems, but more importantly, the dissemination of that research to producers who use it. Promotion of IPM will improve the rate of adoption across communities and, over time, increase the benefits to producers and decrease the environmental impact of the management of pests in crop production, landscapes, and urban settings.

19.3 Pest surveillance

Pest surveillance can be done using the light traps, pheromone traps, food traps, attractants, pitfall traps (for soil insects), field scouting etc.

Pest surveillance is usually done in two methods; fixed plot and row-plot surveillance. • Based on the surveillance, using various techniques, pest forecasting is done.

19.4 Forecasting

Forecasting is the process of making statements about events whose actual outcomes (typically) have not yet been observed. A common place example might be estimation of the expected value for some variable of interest at some specified future date. Prediction is a similar, but more general term. Both might refer to formal statistical methods employing time series, cross-sectional or longitudinal data, or alternatively to less formal judgmental methods. Pest forecasting is based on the models developed using the previous data points and many organizations are involved in forecasting of pest incidences and also forewarning about the pest outbreaks.

Pest Forecasting is the systematic monitoring of pest population, dispersion and dynamics in different crop growth phases using models prepared based on the previous data, to forewarn the farmers to take-up timely crop protection measures needed. Advance knowledge of probable pest infestation (out breaks) in a crop would be very useful not only to plan the cropping pattern (to minimize the pest damage) but also to get the best advantage of pest management programs.

Pest Forecast will help and guide us with insect timing and biology to eliminate blanket applications of pesticide, reduce pesticide amounts, and achieve quality results. Online pest forecasting data is developed by both public and private sectors. (eg.: http://www.pestforecast.com).

Crop plant diseases and insect pests predict is the foundation of integrated control in advance, the important prerequisite of a bumper harvest as a result of effective control. However, such predict is

17 AGRO ECOSYSTEM ANALYSIS (AESA) :

AESA is an approach which can be gainfully employed by extension functionaries and farmers to analyse field situations with regard to pests, defenders, soil conditions, plant health, the influence of climatic factors and their interrelationship for growing healthy crop. Such a critical analysis of the field situations will help in situations will help in taking appropriate decision on management practices.

A. The basic components of AESA are:

i. Plants health at different stages. Monitor symptoms of diseases and nematodes.
ii. Built-in-compensation abilities of the plants.
iii. Pest and defender population dynamics.
iv. Soil conditions.
v. Climatic factors.
vi. Farmers past experience.

B. The methodology of AESA is as under:

Field Observations:

i. Enter the field at least 5 ft. away from the bund. Select a site with a dimension of 1 sq mt. randomly.
ii. Record the visual obervation in following sequence:
a. Flying insects (both pests & defenders)
b. Close observation on pests and defenders which remain on the plants.
c. Observe pests like borer, BPH etc. and defenders like cooccinellid, chrysopa, ground beetle/rove beetle and earwigs etc, by scrapping the soil surface around the plants. d. Record disease and its intensity.
e. Record insects damage and disease incidence in percentage.
iii. Record parameters like number of leaves, plant height and reproductive parts of the selected plants for makingobservation in the following weeks. Observe nematode damage symptoms.
iv. Record the types of weeds, their size and population density in relation to crop plant.
v. Record soil conditions
viz flooded, wet or dry.

vi. Observe rodent live burrows.

vii. Record the climatic factors viz sunny, partially sunny, cloudy, rainy etc. for the preceding week.

C. Drawing :

First draw the plant at the centre on a chart. Then draw pests on left side and defender on the right side. Indicate the soil condition, weed population, rodent damage etc. Give natural colours to all the drawing, for instance, draw healthy plant with green colour, diseased plant/leaves with yellow colour. While drawing the pests and the defenders on the chart care should be taken to draw them at appropriate part of the plant, where they are seen at the time of observation. The common name of pest and alongwith diagram. The weather factor should bereflected in the chart by drawing the diagram of sun just above the plant if the attribute is sunny. If cloudy, the clouds may be drawn in place of sun. In case of partially sunny, the diagram of sun may be half masked with clouds.

D. Group Discussion and Decision making:

The observations recorded in the previous and current charts should be discussed among the farmers by raising questions relating to change in pest and defender population in relation to crop stages, soil condition, weather factors such as rainy, cloudy or sunny etc. The group may evolve a strategy based upon weekly AESA, ETL and corresponding change in P.D. ratio and take judicious decision for specific post management practices.

E. Strategy for decision making:

Some of the defenders like lady beetles, groundnut beetles, rove beetles, wasps play useful role in arriving at P.D. ratio.

F. AESA by Extension Functionaries:

The extension functionaries during their regular visit to the village mobilize the farmers, conduct AESA and critically analyse the various factors such as the pest population vis-a-vis defender population andtheir role in natural suppression of the pest, the influence of per prevailing weather condition/soil conditions on the likely build-up of defender/pest population. They may also take the decision based on the AESA which IPM components like release of defenders application of need formulations/ safe pesticides are to be used for specific pest situation. Such an exercise may be repeated by the extension functionaries during every visit to the village and motivate the farmers to adopt AESA in their fields.

G. AESA by Farmers :

After a brief exposure during IPM demonstrations/ field trainings, farmers can practice AESA in their own field. Whenever trained farmers are available their experiences could be utilized in training their fellow farmers in their own villages. Thus a large group of farmers could be made proficiently competent in undertaking weekly AESA thereby empowering themselves in decision making on any specific pest situations. Farmers-to-farmers training approach will go a long way in practicing IPM on a large area on sustainable basis.

H. Pest Monitoring Through Pheromones/ Light Traps etc.

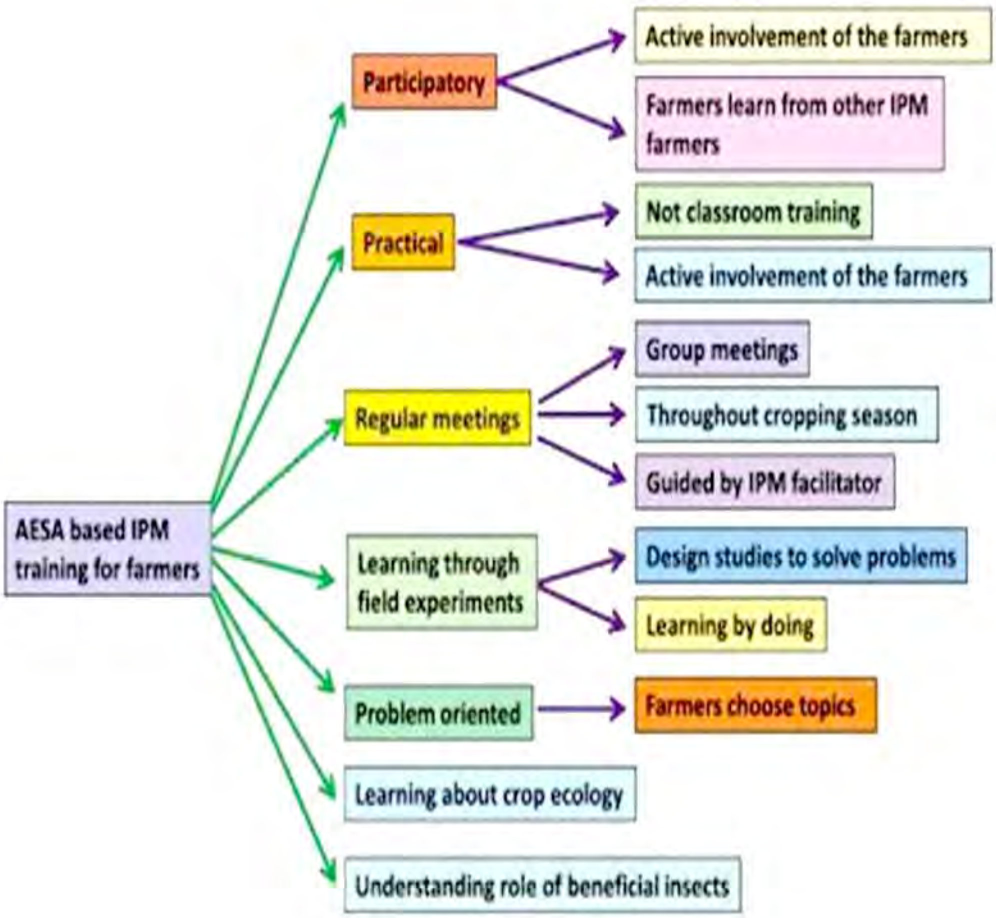
Certain pests required positioning of various kinds of traps like pheromones, light trap to monitor the initial pest build up. Therefore, the State Department of Agriculture is to initiate action for positioning of different kinds of traps at strategic locations at village level as per the following details.

1. Pheromone trap – 8 traps per ha. may be used to monitor stem borer moth population in Summer rice initiate in February to April (Boro & Early Ahu) trapping should be done from February to April and in Winter rice –(Sali rice), it should be done from July to September lures should be replaced at 10 days intervals.

2. Light trap - Chinsurah light trap or any other light trap with 200 watts mercury lamps can be operated for two hours in the evening to observe photo tropic insect pests. Traps should be placed away from other light sources.

3. Sweep-nets-water pans – Besides visual observations sweep-nets and water pans may also be used to assess the population of insect pests and bio-control agents.(In paddy crop) and mechanical collection and identification in vegetable crops.

I. Economic Threshold Level (ETL) The Economic threshold level (ETL) is an attempt to improve decision making practices by using partial economic analysis on the impact of the control practice such as spraying a pesticide. At the ETL,the benefit of spraying a pesticide. At the ETL, the benefit of spraying is equal to the losses caused by the insects in the field. The farmers are advised to take appropriate control measures when the incidence crosses ETL. The ETL for some of the major pests are listed below: Pest Economic Threshold Level Tomato fruit borer One egg/one larve/one damaged fruit per plant Whitefly 4 adults/leaf (as a sucking pest) Root-knot reniform Nematode 1-2 larvae/g soil .



19 PEST SURVEILLANCE-DEFINITION-IMPORTANCE IN IPM

Surveillance is the monitoring of the behavior, activities, or other changing information, usually of people, insects, and pathogens. It most usually refers to observation of individuals or groups by government organizations, but disease surveillance, for example, is monitoring the progress of a disease in a community.

The word surveillance comes from the French word for "watching over". • Pest Surveillance is the systematic monitoring of pest population, dispersion, and dynamics in different crop growth phases to forewarn the farmers to take up timely required crop protection measures. • Pest Surveillance is the constant watch on population dynamics of pest, its incidence and damage on each crop at fixed intervals, to fore-warn farmers to take-up timely crop protection measures. • Regular monitoring of the pest will aid in decision making of pest management practices, and this can be achieved through pest surveillance. • Pest surveillance can be done using the light traps, pheromone traps, food traps, attractants, pitfall traps (for soil insects), field scouting etc.

19.1 Importance and advantages of Pest Surveillance

1. Useful for pest forecasting
2. Help to plan cropping pattern
3. Help to plan pest management programmes
4. Aids in developing models, and to find-out the Thumb Rule Models.
5. Help in application of insecticides (stage, dose, type etc.)
6. Helps in maintaining stability of Agroecosystem.

19.2 Components required for Pest Surveillance:

1. Identification of the Pest
2. Distribution pattern, and prevalence of the Pest
3. Severity of Pest
4. Levels of incidence of the pest
5. Losses due to pest incidence
6. Population dynamics
7. Weather parameters
8. Data on Natural enemies

19.3 Pest surveillance

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Pest surveillance is usually done in two methods; fixed plot and row-plot surveillance. • Based on the surveillance, using various techniques, pest forecasting is done.

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Forecasting is the process of making statements about events whose actual outcomes (typically) have not yet been observed. A common place example might be estimation of the expected value for some variable of interest at some specified future date. Prediction is a similar, but more general term. Both might refer to formal statistical methods employing time series, cross-sectional or longitudinal data, or alternatively to less formal judgmental methods.

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Pest Forecast will help and guide us with insect timing and biology to eliminate blanket applications of pesticide, reduce pesticide amounts, and achieve quality results. Online pest forecasting data is developed by both public and private sectors. (eg.: http://www.pestforecast.com).

Crop plant diseases and insect pests predict is the foundation of integrated control in advance, the important prerequisite of a bumper harvest as a result of effective control. However, such predict is affected not only by the characteristic of insect pests but also the restriction of the meteorological factor. Traditional forecasting methods, including data set fitting, regression and approximation theory and so on, are based on the data analysis and model construction manually. Now the new concept is GP (Genetic Programming) which has the characteristic of self-organization, self-learning and self adaptation, to get the mathematics model from history data of insect pests for forecasting system.

Forecasting pest incidence often requires systematically recorded specific field data in an elaborate manner over considerable period of time which can be easily retrieved and analyzed.

Insect Forecasting is useful in the following ways:

- ✔ To predict the forth-coming infestation level of the pest, which knowledge is essential in justifying use of control measures mainly insecticidal applications.
- ✔ To find-out the critical stage at which the applications of insecticides would afford maximum protection.
- ✔ To assess the level of population and damage by pest during different growth stages of crops.
- ✔ To study the influence of weather and seasonal parameters on pest.
- ✔ To fix-up hot-spots, endemic and epidemic areas of the pest.
- ✔ To fore-warn farmers to make decisions in timing of control measures.

Many diseases, insects, and weeds affect field crops every year. However, depending on weather conditions, the severity is very variable from year to year and very often control strategies are applied without considering this variability. With increasing concerns about production costs, food safety, and protection of the environment, appropriate timing of pesticide applications is required. For this purpose, economic thresholds should be understood thoroughly before the forecasting is propagated.

19.5 The forecasting of pest infestation must be related to the economic threshold levels of the pest, and can be done through:

1. Population studies: These studies should be carried-out several years using appropriate sampling methods to find out the seasonal range, the population variability and geographic distribution.

The seasonal counts should be related to the climatic and topographical data.

2. Studies on the pest's life history: The possible number of generations along with fecundity and the behavior of different larval instars under controlled conditions (either in insectary or laboratory) and field conditions can be related to range of environmental factors.

3. Field studies of the effects of climate on the pest and its environment:

Climatic factors usually influence pest numbers either directly or indirectly. Systematic occurrence of insect pests and diseases in many places would contribute to evolving an effective pest forecasting module. For example, the spread of pest is largely influenced by wind currents. A nationwide pest observatory work over entire country is essential to note the systematic occurrence of insect pests in many places, and this would contribute to an effective pest forecasting service. The pest forecasting is based on monitoring of different weather parameters over a long period of time. Temperature, Relative humidity, and rainfall are the most commonly used weather parameters fo r insect pest forecasting, where the changes in these factors influence the type of pest as well as number of pests, followed by their extent of infestation. For example, increase in rainfall increases the incidence of c otton bollworm Helicoverpa armigera, castor r ed hairy caterpillar Amsacta albistriga, tobacco caterpillar Spodoptera litura and leaf spot diseases. Increase in temperature would lead to increase in the populations of sucking pests, mites and leaf minors. Areas where ' critical' infestations are likely to occur can also be forecast for some pests. The principal factors may be biotic, topographic or climatic. Combinations of temperature, rainfall, atmospheric humidity are most important.

4. Prediction from the empirical data on the pests of previous season:

The pest population is forecasted based on the counts/occurrence of pest in the previous season. But this can be successful in case of static or regular pests. In the case of many others, the numbers of the pest in the early part of the cropping season will give an indication as to the extent of it likely multiplication with the progress of that season.

During 1941, a nationwide pest forecasting system was established in Japan. Locust warning station in India was established in 1939. The "Locust Control and Research" is one of the divisions of the Directorate of Plant Protection, Quarantine and Storage, being implemented through an Organization known as Locust Warning Organization (LWO) established in 1939, to monitor, forewarn and control of Desert Locust (an international pest) with its 10 Circle Offices located at Bikaner, Jaisalmer, Barmer, Palanpur, Bhuj, Jalore, Phalodi, Nagaur, Suratgarh and Churu with its field Headquarters at Jodhpur and a Central Headquarter Faridabad. Besides, there is one Field Station for Investigations on Locusts (FSIL) situated at Bikaner. To strengthen the locust monitoring and forecasting, a Remote Sensing Laboratory has also been set up to prepare vegetation maps based on satellite imageries for locust forecasting.

20 INSECT PESTS

• Pest is defined as insect or other organisms that cause any damage to crops, stored produce or animal.

• Pest is an organism that causes damage resulting in economic loss to a plant or animal. It can also be said that pest is a living organism that thrives at the expense of other living organism.

• The expression of "Pest" is used very broadly to insects, other invertebrates like nematodes, mites, snails and slugs, etc., and vertebrates like rats, birds, jackals, etc., that cause damage to crops, stored products and animals. • An insect reaches the status of a pest when its number increases and inflicts significance damage.

• Pest that cause less than 5% loss in yield, are said to be negligible.

• Pest that cause 5-10% loss in yield, are minor pests.

• Pest that cause more than 10% loss in yield, are major pests.

Different categories of insect pests

Regular pests: Occur most frequently (regularly) in a crop and has close association with particular crop. Eg: Chilli Thrips, Brinjal Shoot & Fruit borer, Sugar Cane Borers.

Occasional Pests: The pest has close association with a particular crop. They occur occasionally. Eg: Rice Case Worm, Paddy Flea Beetle.

Seasonal Pests: Occur mostly during a particular part of the year, usually the incidence is governed by climatic conditions. Eg: Red Hairy Cater Pillar on Ground Nut during April-May, Rice Grass Hopper (*Oxya nitidula*) during June-July.

Persistent Pests: Occur on a crop persistently. Eg: Scales and Mealy Bugs, Cockroaches.

Sporadic Pests: Occasionally causing serious damage. Eg: Paddy leaf roller (*Chephalocrocis medinalis*), Sucking pests on Sorghum (aphids and shoot bug). Spodoptera litura on Cotton.

Epidemic Pests: Epidemic, means abundance, outbreaks (sudden increase in large numbers) of a pest in a given area at given time.

Endemic Pests: (Endemic, mean belonging, or native to, prevalent in a particular area). Endemic means a pest occurs continuously and with predictable regularity in a specific area or population. Native pest or pests permanantlay established in an area. Eg: Citrus black fly, endemic to Nagpur area, Black headed caterpillar (*Opisina arenosella*) of Coconut is endemic in Coastal Tracts of Kerala, Paddy Gall Midge, *Orseolia oryzae* in Warangal tracts of AP.

Exotice Pests: Non-Native or Non-Indeginous Pests not known to occur in the state or country.

21. MAJOR PESTS AND DISEASES OF CROPS: IDENTIFICATION AND THEIR MANAGEMENT

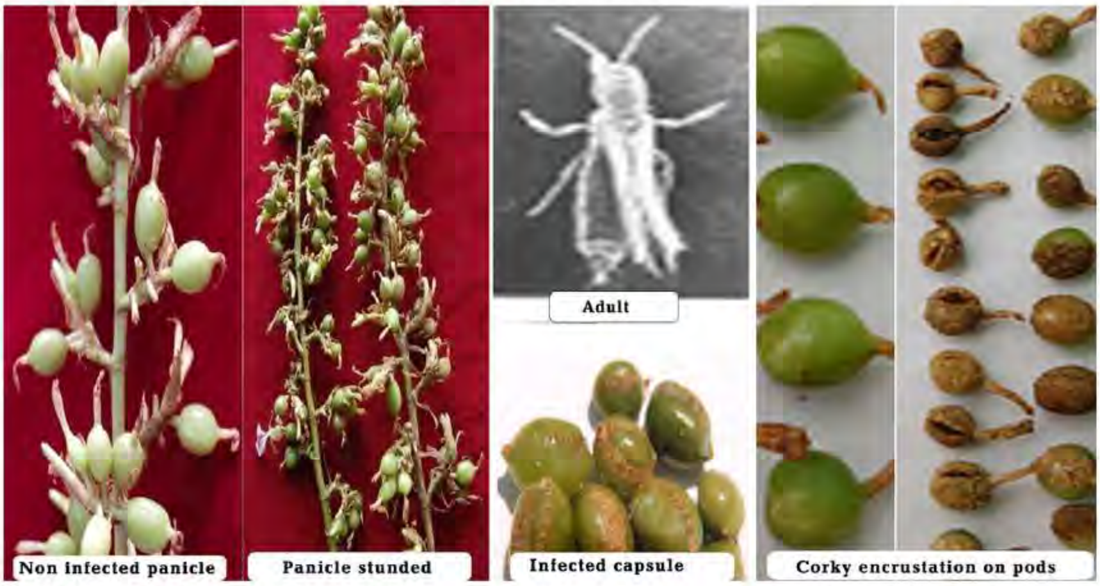
1.MAJOR PEST AND DISEASE IN SPICES:

1.1 MAJOR PEST OF SMALL CARDAMOM:

1. Thrips: *Sciothrips cardamom*

Life cycle:Damage symptoms: Panicles become stunted, Shedding of flowers and immature capsules thus reducing the total number of capsules formed, Infestation causes formation of corky encrustations on capsule resulting in their malformed and shriveled condition and Such pods lack their fine aroma and the seeds within are also poorly developed.

INSECT PEST SMALL CARDAMOM THRIPS



Management:

Cultural control: Removal of dry drooping leaves as well as dry leaf sheath (trashing) during January February. Destruction of collateral host plants. Detrashing and weeding reduce thrips infestation.

Biological control: Release *Chrysoperla zastrowi sillemi* 2 larvae/plant in early stage of the plant and 4 larvae/plant in latestage.

Chemical control: Spray quinalphos 25% EC @ 240-480 ml in 200-400 l of water/acre or phenthoate 50% EC • @ 200 ml in 200-

400 l of water/acre or diafenthiuron 50% WP @ 320 g in 400 l of water.

2. Shoot, panicle and capsule borer: *Dichocrocis (Conogethes) punctiferalis*

Biology:

Egg: Eggs are pink, oval, fl at and laid singly or in groups on the tender part of the plant

Larva: Long, pale greenish with a pinkish colour dorsally, head and pro-thoracic shield brown in colour and body covered with minute hairs.

Pupa: Pupation takes place in lose silken cocoon in larval tunnel.

Adult: Medium sized moth (22-24mm); the wings are pale yellowish with black spots on the wings.

Damage symptoms

Early stage of the larva bores the unopened leaf buds and feeds on the leaf tissue. They also bore the panicles leading to drying up of the portion from the affected spot and Feed on immature capsules and the young seeds inside rendering the capsules empty.

Late stage larvae bore the pseudostem and feed on the central core of the stem resulting in drying of the terminal leaf and thus produce characteristic 'dead heart' symptom. Oozing out of frass material at the point of tunnelling is the indication for the presence of larva inside the plant parts. The incidence of this pest is noticed throughout the year but they occur in enormous number in four periods, December-January, March-April, May-June and September-October and their abundance synchronizes with the panicle production, fruit formation and new tiller production.

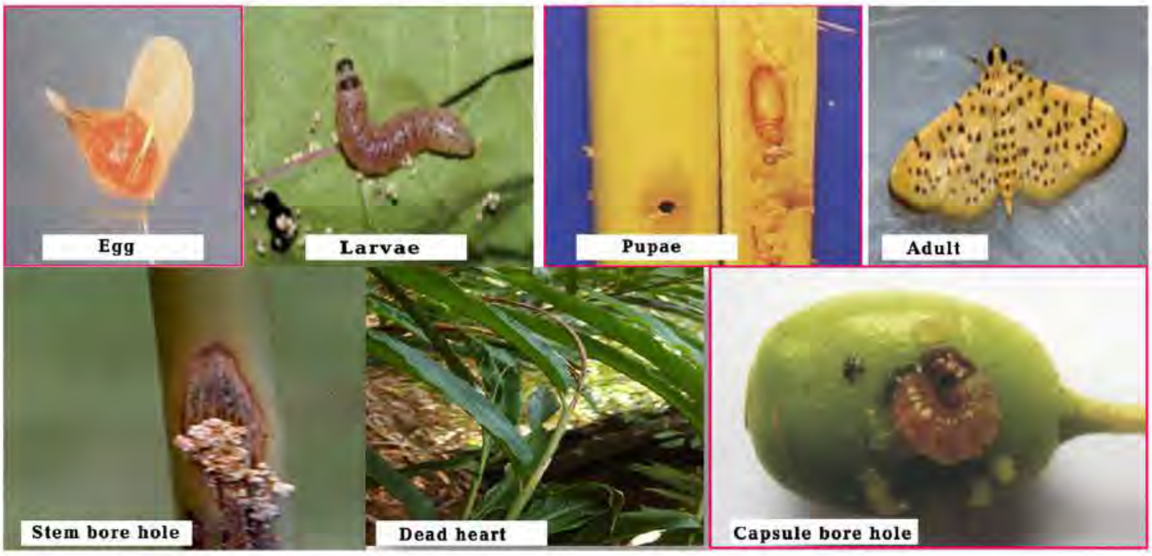
Management:

Cultural control: Castor seeds 0.4-0.8 Kg/acre may be sown as trap crop in open areas/ boundary. Rogueing and destruction of infested tillers during September-October.

Mechanical control Castor inflorescence with capsules infested by shoots and capsule may be collected and destroyed. Use of pheromones in the monitoring of the pest and therefore correct timing of application of bio-rationals shall be recommended.

Biological control: Application of Bacillus thuringiensis when early-instar larvae are found in capsule or panicle or unopened lead buds i.e., within 20 days of adult moth emergence.

CROP INSECT PEST
SMALL CARDAMOM
Shoot /Panicle/ Capsule borer
Dichocrocis punctiferalis



3. Early capsule borer:

Biology:

Egg: Eggs are spherical, greenish white l aid on the panicled flower.
Larva: Larvae are fl at, trowel shaped covered with dense hairs covering all over the body.
Pupa: Small and brownish in colour and pupates in the debris near the panicle.
Adult: The wings of moth are bluish with metallic lustier on the upper surface and bordered with a white thin line and black shade
Damage symptoms: Caterpillars bore and feed on the inflorescence, flower buds, flowers and capsules.
Affected capsules become empty with a big circular hole, turn yellowish – brown which decay and drop off in the rainy season.

Management:

Mechanical control: Clipping the inflorescence/flower parts of alternate hosts viz., *Alpinia speciosa, A.mutica, Amomum ghaticum*, A. pterocarpum, Curcuma heilyherrensis, Hedydium arium during offseason (December to May).
Chemical control: Spray of Diafenthiuron 50% WP @ 320 g in 400 l of water/acre.

A. pterocarpum, Curcuma heilyherrensis, Hedydium ceranarium during offseason (December to May).

Chemical control: Spray of Diafenthiuron 50% WP @ 320 g in 400 l of water/acre

4. Cardamom Root grub: *Basilepta fulvicorne*

Biology:

Among the three species *B. fulvicorne* is found to cause more damage in cardamom tracts.

Egg: Eggs are pale yellow in colour.

Grub: Grubs are short, stout, 'C' shaped, pale white in colour.

Adult: Beetles are shiny, metallic blue, bluish green, greenish brown or brown in colour.

Damage symptoms: The grubs feed on the roots in the form of irregular scraping. In advanced stages entire root system is found damaged resulting in drying and rotting depending on the season of attack. In the severely infested plants, leaves turn yellow and dry.

CROP INSECT PEST
SMALL CARDAMOM
ROOT GRUB
Basilepta fulvicornis

Management:

Cultural control: Avoid planting of jack, mango, fig etc. as shade trees as these trees are alternate hosts of the pest. Mulching of plant base with leaves of wild Helianthus sp. to prevent egg laying of adult beetles. Earthling up and detrashing. Irrigation @15–20 l per plant reduces root grub population.

Mechanical control: Set up light trap @ 1/acre.

Biological control: Local strain of EPN (*Heterorhabditis indica*) application @ 1,00,000 nematodes (IJS) / plant.

5. Cardamom whitefly: *Dialeurodes cardamom*

Biology:

Egg: Eggs are cylindrical, pale yellow in colour when freshly laid and gradually turn brown.

Nymph: Nymphs are elliptical and pale green in colour. There are four nymphal stages.

Adult: Adults are small soft bodied insect, about 2 mm long and having two pairs of white wings. The life cycle is completed within two-three week.

Damage symptoms: Damage to the plant is caused by the depletion of sap from leaves. In severe infestation the leaves turn yellow and the vigour and growth of the plant get considerably reduced. The nymphs secrete sticky honeydew, which drops on to loweleaves. On these, black sooty mould develops, which interrupts photosynthesis of the leaves.

Management:

Biological control: Release of *Chrysoperla zastrowi sillemi* @ 2 larvae/plant in early stage of the plant and 4 larvae/plant in later stage. Spraying of neem oil @ 50 ml with soap solution in 500 ml in 100 l of water (lower surface of leaf)

6. Shoot fly: *Formosina flavipes*

Biology: Egg: Eggs are cigar shaped and white colour and are laid in between leaf sheath and pseudostem on the whorl.

Damage symptoms: Larvae feed on the growing shoot of the young cardamom suckers. Emerging maggots (larvae) enter the pseudostem reach down the base by feeding the core tissue resulting in drying of the terminal leaf. Infestation is more on plants in open **area;** the pest activity starts during November and is at its peak in March-April.

Management:

Remove the affected shoots at ground level and destroy them.
Spray dimethoate or quinalphos (0.05% each).

7. Cardamom aphid:*Pentalonia nigronervosa f.caladii*

Biology:

Nymph: Nymphs are dark in colour. Adult: Adults are brown in colour and has black veined wings. They reproduce by viviparous and parthenogenetically Life cycle: Damage symptoms: Both nymphs and adults suck up plant sap. Colonies of aphids are seen under concealed conditions inside leaf s heaths of the older pseudostems.

Natural enemies of aphid: Parasitoids: *Aphidius spp., Aphelinus spp.* etc Predators: Ladybird beetle, lacewing, spiders, hover fl y etc.

Management:

Removal of Colocasia and other hosts in the vicinity of cardamom plantation is recommended. Remove partly dried and decayed pseudostems which harbour the colonies of aphids to reduce aphid population and Foliar spraying with dimethoate 2 ml/lit at an interval of 2 weeks in November and April gives adequate control.

8. Red spider mites:

Damage symptoms: Affected leaves become reddish brown and bronzy, Severe i nfestation larvae silken webbing on the leaves, Leaves wither and dry and Flower and fruit formation affected.

Favourable conditions:

Warm weather conditions are favourable for multiplication.

9. Root-knot nematode:

Biology: Most species of plant parasitic nematodes have a relatively simple life cycle consisting of the egg, four larval stages and the adult male and female. They are microscopic in size.

Development of the first stage larvae occurs within the egg where the first moult occurs. Second stage larvae hatch from eggs to find and infect plant roots or in some cases foliar tissues. Under suitable environmental conditions, the eggs hatch and new larvae emerge to complete the life cycle within 4 to 8 weeks depending on temperature. Nematode development is generally most rapid within an optimal soil temperature range of 70 to 80°F.

Damage symptoms: Root knot nematode, infest cardamom roots. • Common symptoms of attack are narrowing of leaves, thickening of veins, reduction of internodes length and consequent appearance of rosette leaves. • Roots branch heavily and galls appear on them. Plant growth becomes highly stunted

Survival and spread: Primary: Egg masses in infected plant debris and soil or collateral and other hosts such as Solanaceous, Malvaceous and Leguminaceous plants act as sources of inoculum Secondary: Autonomous second stage juveniles that may also be water dispersed.

CROP-INSECT PEST
SMALL CARDAMOM
TINGID BUG
Stephanitis typicus

Management:

Provide adequate shade in the plantation

Spraying of Dimethoate 30EC@1.5 ml /L would effectively manage the pest.

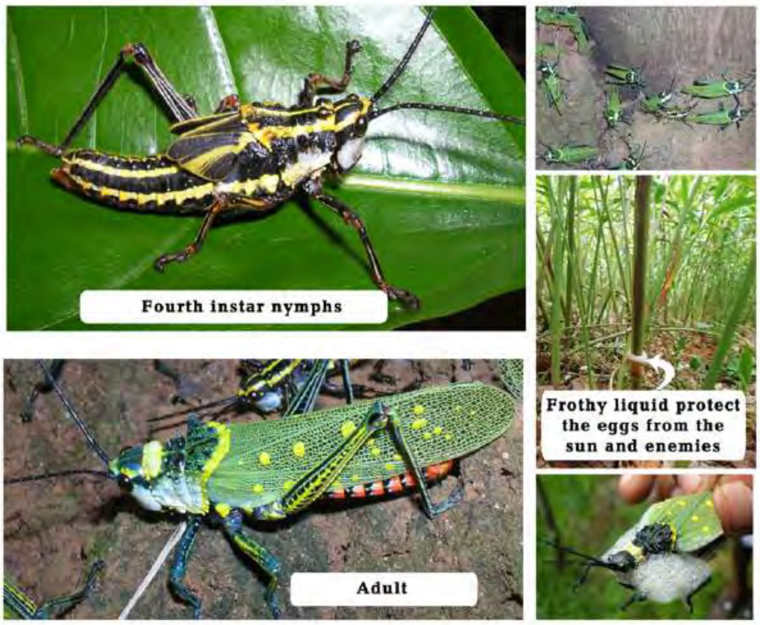
11. Scales : *Saisseteia coffeae*

Provide adequate shade in the plantation

Spraying of Dimethoate 30EC@1.5 ml /L would effectively manage the pest.

CROP INSECT PEST SMALL CARDAMOM-SCAELS

CROP INSECT PEST
SMALL CARDAMOM
LOCUST
Locusta migratoria




Roots infected by mealy bug


Large number of mealy bugs colonise in the roots

Small cardamom Root mealy bugs


Microscop view of mealy bugs


Stem yellowing

IMPORTANT NATURAL ENEMIES OF SMALL CARDAMOM INSECT PESTS

PREDATORS

1.2 MAJOR DISEASE OF SMALL CARDAMOM:

1. Capsule rot/azhukal disease: *Phytophthora parasiticacar. nicotianae/ Phytophthora palmivora*

Disease symptoms:

The disease appears during the rainy season. On the infected leaves, water soaked lesions appear first followed by rotting and shredding of leaves along the veins. The infected capsules become dull greenish brown and decay. This emits a foul smell and subsequently shed. Infection spreads to the panicles and tillers resulting in their decay

Survival and spread: The disease spreads through soil, water and wind.

Favourable conditions: Continuous rain fall and high relative humidity.

Biological control: Trichoderma harzianum 0.50% WS @ 100 g/plant (soil treatment): Apply 100 g product/plant along with neem cake (0.5 Kg/plant) and 5 Kg FYM/plant Follow the common cultural, mechanical and biological practices

Chemical control: Spray/drench the soil with fosetyl-AL 80%WP @ 900-12000 g in 300-400 l of water/acre

2. Clump rot or rhizome rot: *Pythium vexans, Fusarium oxysporum, Rhizoctonia solani, Phytophthora*

Disease symptoms:

Decay of the tillers starting from the collar region and toppling of tillers. Affected tillers can be pulled out with little force and the discoloration of the basal portion of clump can be seen. Early symptoms on leaves appear as pale yellow colour, partial of leaf margins and withering. Rotting or decay starts at the collar region and it spreads to rhizomes and roots and in severe cases, the collar region breaks off and the seedling .

DAMPING OFF (RHIZOME ROOT) -PYTHIUM

Rotting or decay starts at the coller region and rhizomes/roots

Survival and spread

Below 24° C for few days are ideal for infection and development of disease.

Favourable conditions

High humidity, high soil moisture, cloudiness and low temperatures.

Chemical control

Spray/drench the soil with copper oxy chloride @ 1 g in 300-400 l of water/acre

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Fusarium disease


3. Chenthal disease/capsule brown spot:

Colletotrichum gloeosporioides

Disease symptoms: Initially the symptoms appear as small water soaked rectangular lesions onthe leaves which, later elongate to form parallelly arranged streaks and turn to yellowishbrown to orange red in colour. • The central portions become necrotic.

Survival and spread:

The disease intensity is found to be severe in open areas where shade in inadequate • The disease which appears during mid- monsoon, becomes severe during late monsoon periods.

Favourable conditions:

Intermittent rains and prevalence of misty conditions

Management:

Removal and destruction of affected leaves

Three sprays with carbendazim 0.1% (or) Mancozab 0.2% (or) copper oxychloride 0.25% at 30 days interval

4. Leaf blotch disease:

Disease symptoms: The disease is characterized by the appearance of large blotches of irregularlesions with alternating shades of light and dark brown necrotic leaves. This is mainlyobserved on mature leaves. Later, on the underside of these blotches, the fungal mycelium and spores develop as grey brown masses

Survival and spread:

During monsoon season very active and dry weather conditions infection is restricted

Favourable conditions:

High rainfall and humidity

5.'Katte disease' (mosaic or marble disease)

Disease symptoms

The first visible symptom appears on the youngest leaf of the affected tiller as spindle shaped slender chlorotic flecks measuring 2-5 mm in length.

Later these flecks develop into pale green discontinuous stripes. The stripes run parallel to the vein from the midrib to leaf margin. All the subsequently emerging new leaves show characteristic mosaic symptoms with chlorotic and green stripes. As the leaf matures, the mosaic symptoms are more or less masked.

Disease is systemic in nature and it gradually spreads to all the tillers in a clump.

Younger plants express symptoms earlier than grown up clumps. Infected clumps are stunted and smaller in size with a few slender tillers and shorter panicles.

Katte infected plants continue to survive for many years and serve as sources of inoculum.

If the plants are infected in the seedling stage or the same year of planting the loss will be total. In bearing clumps, the loss will be upto 68% in three years after infection (the loss will be even more at later stages).

Survival and spread

It spreads through aphid vector *Pentalonia caladii*.

6. Cardamom necrosis/nilgiri necrosis

Disease symptoms

Young leaves exhibit whitish to yellowish continuous or broken streaks proceeding from the midrib to the leaf margins and later turn reddish brown. Often leaf shredding is noticed.

The affected plants are stunted and fail to bear the panicles and capsules.

Survival and spread

The disease spreads mainly through infected planting material.

7. Cardamom vein clearing or Kokke kandu

Disease symptoms

Its characteristic symptom "hook- like tiller" it is locally called as "Kokke Kandu".

The characteristic symptoms are continuous or discontinuous intraveinal clearing, stunting, rosetting, loosening of leaf sheath, shredding of leaves and clear mottling on stem.

Clear light green patches with three shallow grooves are seen on the immature capsules.

Cracking of fruits and partial sterility of seeds are other associated symptoms.

Survival and spread

Transmitted through cardamom aphid, *P. caladii* in a semi persistent manner.

Primary: Alate viruliferous vectors and infected plant materials.
Secondary: Alate forms of aphid

2. MAJOR PEST AND DISEASE BLACK PEPPER:

2.1 MAJOR PEST OF BLACK PEPPER

1. Black pepper Pollu beetle: *Longitarsus nigripennis*

Biology

Egg: Eggs are laid on the berries and lays 1-2 eggs in each hole, egg period 5-8 days.

Grub: Grub period 30-32 days.

Pupa: Pupation occurs in soil in a depth of 5.0 - 7.5 cm. Pupal period 6-7 days. Life cycle completed in 40 - 50 days. Four overlapping generations in a year.

Adult: Adult is a bluish yellow shining flea beetles.

Pollu beetle in Black pepper

Damage symptoms

The pollu beetle is a serious in black pepper plantations in the plains and at lower altitudes.

The adults feed on tender shoots, spikes and berries.

The infested shoots and spikes turn black and drop.

The grub on emergence bore into the berries, feed on the internal contents and make them hollow.

The infested berries turn yellow initially and then black and crumble when pressed.

The pest population is more severe in shaded areas.

During the period from January to April the adults do not breed but remain in the field feeding on older leaves.

Mangement:

Regulation of shade in the plantation reduces the population of the pest in the field.

Tilling the soil at the base of the vines at regular intervals

Spraying quinalphos (0.05% each) during June/July and September/October or quinalphos (0.05% each) during July and Neemgold (0.6%) (neem-based insecticide) during August, September.

2. Top shoot borer; *Laspeyresia hemidoxa*

Biology

Egg: Eggs are small colourless.

Larva: Larva grayish green, 12-14 mm long, larval period 10 -15 days. Pupates inside shoots.

Pupa: Pupal period 8 – 10 days.

Adult: Adult moth is tiny, forewing black with distal half red, hind wing greyish. Life cycle completed in a month.

Damage symptoms

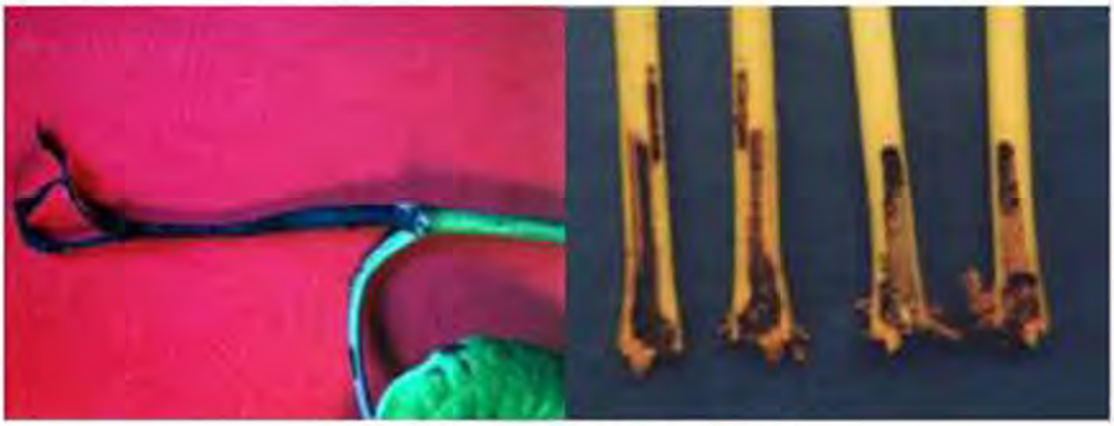
The adult is a fine moth with basal half of the forewing black and distal half orange red.

The top shoot borer is found more in younger plantations.

The caterpillars of the moth bore into tender shoots which turn black and dry up.

When successive new shoots are attacked, the growth of the vine is affected.

The pest infestation is higher during July-November when numerous new shoots are available on the vines



Management:

Cultural control: Regulation of shade in the plantation reduces the population of the pest in the field.

Biological control: Spraying Neemgold (0.6 per cent) (neem-based insecticide) during August, September and October is effective for the management of the pest. The underside of leaves (where adults are generally seen) and spikes are to be sprayed thoroughly.

Chemical control:

Spray quinalphos (0.05% each) on tender terminal shoots; repeat spraying at monthly intervals (during July - October) to protect emerging new shoots

3. Leaf gall thrips-*Liothrips karnyi*

Biology

Egg: Eggs are laid in single within the marginal leaf folds or on the leaf surface, egg period6-8 days.

Nymph: Nymphs whitish and sluggish, nymphal period 9-13 days

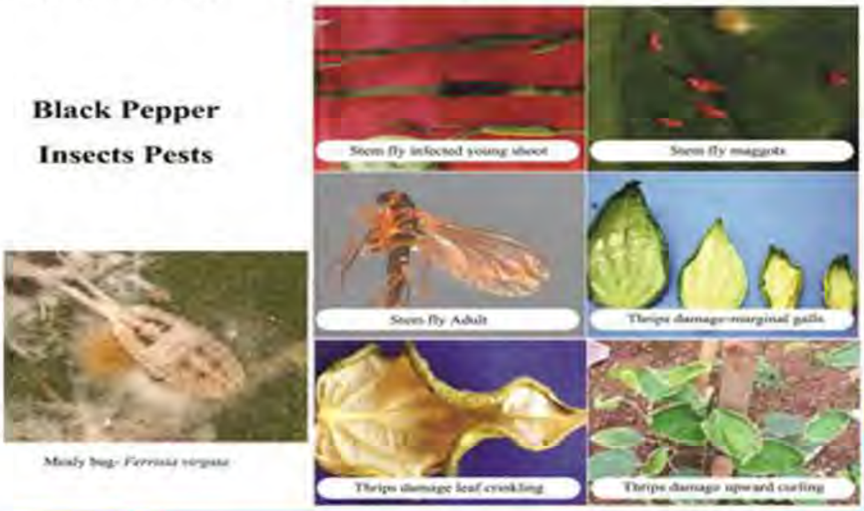
Pupa: Pupal period, 2 to 3 days

Adult: Adults with heavily fringed wings. Adult longevity is 7-9 days.

Damage symptoms

Infestation by leaf gall thrips is more serious at higher altitudes, especially in younger vines and also in the nurseries.

The feeding of thrips on tender leaves causes the leaf margins to curl down and inwards resulting in the formation of marginal leaf galls. The infested leaves become thick, malformed and crinkledLife stages of the insect can be seen within the gall.In severe cases of infestation, the growth of young vines is affected



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Management:

Spray dimethoate (0.05%) during emergence of new flushesin young vines in the field and cuttings in the nursery.

4. Scale insect

Biology:

Scales have unusual life cycles.

The eggs are laid underneath the waxy covering and hatch over a period of one to three weeks.

The newly hatched scales (called crawlers) move about over the plant until they locate succulent new growth.

They insert their piercing-sucking mouthparts into the plant and begin feeding. Female scales lose their legs and antennae during the first molt.

They moult a second time before reaching maturity and do not pupate.

The cast skins (exuviae) are incorporated in the scale cover.Male scales go through two additional molts and pupate underneath thewax. Adult males are tiny two-winged, gnat-like insects without mouthparts.

BLACK PEPPER -SCALES

Damage symptoms

Scale insects appear as encrustations on stems, leaves and berries They feed on plant sap resulting in yellowing and drying of infested portions of the vines.

Management:

Clip off and destroy severely infested branches

Spray dimethoate @ 0.1% (Roger 30 EC).

Repeat spraying after three weeks.

Spray Verticillium lecanii formulation 20 g /l or 5ml/l.

Control against scale should be initiated during early stages of infestation.

5. Mealy bugs: *Planococcus sp*

Biology

Egg: These eggs are yellowish to orange in colour

Nymph: The first instar nymphs are also called as crawlers, which are mobile. The total nymphal period is 19 days for male and 21 days for female. The male nymph forms a cottony cocoon in which the pupal stage is found mainly in the winter season

Adult: The adult female mealybugs are pinkish white and sparsely covered with white wax. The male and female mealybugs are similar in early stages.

The female passes through three nymphal instars while male passes through four nymphal instars.

The adult male has a pair of wings and a pair of halters. Males are very rare and female mealybugs are commonly found causing the damage in the field.

Mealybug completes the life cycle in about 30 days. Without mating, they are known to reproduce partheno-genetically throughout year.

Damage symptoms

Large number of mealy bugs colonise the roots of the vine As a result of sap sucking, the plant turns yellow, leaves and branches dry and drop

Many of the vines infested by root mealy bugs are also likely to be infected with Phytophthora and nematodes

Management:

Drench stems and roots with Chlorpyriphos 20 EC 3ml/L. Repeat drenching after 60 days if infestation persists. Adequate precaution has to be taken to ensure that the insecticide solution reaches the root zone of the vines.

6. Berry gall midge: *Cecidomyia malabarensis*

The midge lays its eggs where the berry attaches to the spike. Eggs are also laid on the tender stalks and shoots. The full grown maggots fall to the ground and pupate in soil.

Damage symptoms:

Due to the presence of the larvae inside the berries, they appear larger in size .Such galled berries do not develop.Shoot galls are formed as a result of midge infestation on tender stalks

Manageement:

Application of neem cake to the base of the plant and incorporation will help to kill the pupae.Spary 2% neem oil garlic emulsion.

7. Root-knot nematode

Biology

Most species of plant parasitic nematodes have a relatively simple life cycle consisting of the egg, four larval stages and the adult male and female.

Development of the first stage larvae occurs within the egg where the first molt occurs. Second stage larvae hatch from eggs to find and infect plant roots or in some cases foliar tissues.

Under suitable environmental conditions, the eggs hatch and new larvae emerge to complete the life cycle within 4 to 8 weeks depending on temperature.

Nematode development is generally most rapid within an optimal soil temperature range of 70 to 80°F

Damage symptoms

Infected plants in patches in the field

Formation of galls on host root system is the primary symptom

Roots branch profusely starting from the gall tissue causing a 'beard root' symptom

Infected roots become knobby and knotty

In severely infected plants the root system is reduced and the rootlets are almost completely absent. The roots are seriously hampered in their function of uptake and transport of water and nutrients

Plants wilt during the hot part of day, especially under dry conditions and are often stunted

Nematode infection predisposes plants to fungal and bacterial root pathogens

Survival and spread

Primary: Egg masses in infected plant debris and soil or collateral and other hosts like Solonaceous, Malvaceous and Leguminaceous plants act as sources of inoculums.

Secondary: Autonomous second stage juveniles that may also be water dispersed.

Favourable conditions

Loamy light soils.

Management:

Use nematode free rooted cuttings raised in potting mixture sterilized by soil solarisation.

Remove and destroy severely affected vines which are beyond recovery.

Apply neem cake @ one kg/vine.

Incorporate it by raking the soil lightly without causing damage to the root system.

In order to control the secondary infection by pathogen drench the basin with 1 % Bordeaux mixture or 0.4% Copper oxy chloride. Apply talc based formulation of Bacillus macerans @ 10 g/vine at the time of planting or just before monsoon in established plantations. Drench the basin with Paecilomyces lilacinus @ 20 g/l.Intercrop with Marigold and incorporate the crop residue.

8. Burrowing nematode

Biology

Burrowing nematode is an endoparasitic migratory nematode, meaning it completes its life cycle within root tissue.

Adults and juveniles are vermiform in shape. Adults are sexually dimorphic. The male has a poorly developed stylet, a knob-like head, and a sharp, curved spicule enclosed in a sac.

The male is 500 to 600 µm in length, while the female is about 550 to 880 µm long. The female has a well-developed stylet. Both male and female have long, tapered tails with rounded or indented ends. The nematode completes its life cycle in about 21 days at 25°C. Females and juveniles feed inside roots, especially near the tips. Males with their weak stylets do not feed. Females lay two to six eggs per day. The nematode causes a disease condition called toppling or blackhead disease in plants

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Management:

Use nematode free rooted cuttings raised in potting mixture sterilized by soil solarisation.

Remove and destroy severely affected vines which are beyond recovery.

Apply neem cake @ one kg/vine.

Incorporate it by raking the soil lightly without causing damage to the root system.

In order to control the secondary infection by pathogen drench the basin with 1 % Bordeaux mixture or 0.4% Copper oxy chloride. Apply talc based formulation of Bacillus macerans @ 10 g/vine at the time of planting or just before monsoon in established plantations. Drench the basin with *Paecilomyces lilacinus* @ 20 g/l.Intercrop with Marigold and incorporate the crop residue.

9. Erythrina Gall Wasp :*Quadrastichus erythrinae*

Symptoms

This is an alien species, which got introduced in 2004-05.Female wasp (Image1) thrusts eggs into tender tissues of shoots using ovipositor. Apodous creamy white larvae develop individually in chambers of tissues. Proliferation of tissues in the attacked region results in gall formation.Infested leaves fail to attain normal size and shrivel with thick galls on them . Galled leaves and tender branches finally dry up.Young plants die and dry up after some time. Mature plants become severely stunted, malformed and present a lean appearance .The thornless jack *(E. lithosperma)* is affected severely comparedto the local one *(E. indica)*.

Management:

Being an introduced pest, sustainable control is possible only by introducing natural enemies from the centre of its origin Lop the affected branches and burn to reduce the inoculum.Systemic granular insecticides like Carbofuran @ 50 g per standard can be tried but care has to be taken to see that there is no residue in black pepper berries. Ensure adequate moisture in the soil at the time of application.Trail pepper on alternate standards such as Matti (Ailanthusmalabaricum),Gliricidia(Gliricidiamaculata),Jack

(Artocarpus heterophyllus), Moringa, Karayam (Garuga pinnata) and Pathiri (Stereospermum suaveolens), Silver oak (Grevillea robusta) Payyani (Orthoxylum indicum), Agathi (Sesbania grandiflora).

2.2. MAJOR DISEASE OF BLACK PEPPER:

1.Foot rot /quick wilt disease

Disease symptoms

One or more black spots appear on the leaves which have a characteristic fine fibre like projections at the advancing margins which rapidly enlarge and cause defoliation.

The tender leaves and succulent shoot tips of freshly emerging runner shoots trailing on the soil turn black when infected. The disease spreads to the entire vine, from these infected runner shoots and leaves, during intermittent showers due to rain splash.

If the main stem at the ground level or the collar is damaged, the entire vine wilts followed by shedding of leaves and spikes with or without black spots. The branches break up at nodes and the entire vine collapses within a month.

If the damage is confined to the feeder roots, the expression of symptoms is delayed till the cessation of rain and the vine starts showing declining symptoms such as yellowing, wilting, defoliation and drying up of a part of the vine.

Survival and spread

Fungus survives in disease plant debris as well as soil. These vines may recover after the rains and survive for more than two seasons till the root infection culminates in collar rot and death of the vine.

Favourable conditions

Rainy season during October-November onwards favour the development of disease

.

Black Pepper Disease
Foot rot / Quick Wilt
Phytopthora capsici

Collar rot

2.Pollu disease /anthracnose

Disease symptoms

It can be distinguished from the pollu (hollow berry) caused by the beetle by the presence of characteristic cracks on the infected berries.

The disease appears towards the end of the monsoon.

The affected berries show brown sunken patches during early stages and their further development is affected.

In later stages, the discolouration gradually increases and the berries show the characteristic cross splitting.

Finally, the berries turn black and dry. The fungus also causes angular to irregular brownish lesions with a chlorotic halo on the leaves.

Survival and spread

The primary infection by sowing infected seeds and secondary by wind.

Favourable conditions

Rain and high humidity are responsible for the development of disease.

3.Slow decline /slow wilt

Disease symptoms

Foliar yellowing, defoliation and die-back are the aerial symptoms of this disease. The affected vines exhibit varying degrees of root degeneration due to infestation by plant parasitic nematodes.

The diseased vines exhibit foliar yellowing from October onwards coinciding with depletion of soil moisture. With the onset of south west monsoon during May/June, some of the affected vines recover and put forth fresh foliage.

The symptoms reappear in subsequent seasons after the cessation of the monsoon and the diseased vines gradually lose their vigour and productivity. The affected vines show varying degrees of feeder root loss and the expression of symptoms on the aerial parts occur after a considerable portion of the feeder roots are lost. The root system of diseased vines show varying degrees of necrosis and presence of root galls due to infestation by plant parasitic nematodes such as Radopholus similis and Meloidogyne incognita leading to rotting of feeder roots. The damage to feeder roots is caused by these nematodes and P. capsici either independently or together in combination.

Survival and spread

Fungus survives in disease plant debris.

Cysts and egg masses in infected plant debris and soil or collateral and other hosts like Solonaceous, Malvaceous and Leguminaceous plants act as sources of inoculums.

Autonomous second stage juveniles that may also be water dispersed.

Favourable conditions

Rainy seasons and loamy light soils favours the development of disease.

4.Stunt disease

Disease symptoms

This disease which is caused by viruses is noticed in parts of Kannur, Kasargod, Kozhikode, Wayanad and Idukki Districts of Kerala and Kodagu, Hassan and Uthara Kannada districts of Karnataka.

The vines exhibit shortening of internodes to varying degrees.

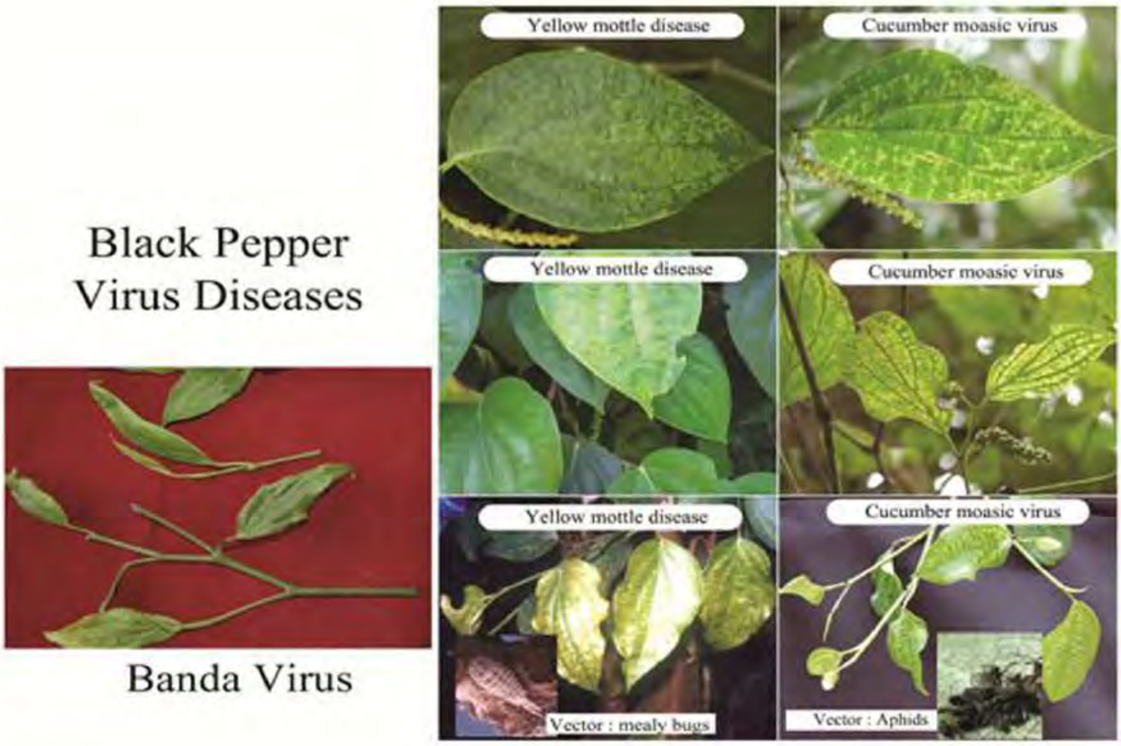
The leaves become small and narrow with varying degrees of deformation and appear leathery, puckered and crinkled.

Chlorotic spots and streaks also appear on the leaves occasionally. The yield of the affected vines decreases gradually.

Two viruses namely Cucumber Mosaic Virus and a Badna virus are associated with the disease.

Transmission and favorable conditions:

The major means of spread of the virus is through the use of infected stem cuttings. The disease can also be transmitted through insects like aphids and mealy bugs.



5.Phyllody disease

Disease symptoms

This disease which is caused by Phytoplasma is noticed in parts of Wayanad and Kozhikode districts of Kerala.

The affected vines exhibit varying stages of malformation of spikes. Some of the floral buds are transformed into narrow leaf like structures. Such malformed spikes show leafy structures instead of floral buds, exhibiting Phyllody symptoms. In advanced stages, the leaves become small and chlorotic, and the internodes are also shortened. The affected fruiting laterals give a witches broom appearance. Severely affected vines become unproductive.In severely affected vines the entire spike is converted into small branches which appear chlorotic and the vines decline rapidly.

The infected vine becomes unproductive within two to three years Transmission and favourable conditions The infected vines are to be destroyed to prevent the further spread of the disease.Phytoplasma disease is spread by leaf hoppers and plant hoppers besides spread by vegetative propagation through cuttings, storage tubers, rhizomes or bulbs.

6.Basal wilt

Symptoms

Grayish lesions appear on stems and leaves.

On the leaves white mycelium are seen at the advancing edges of the lesions.

The mycelial threads later girdle the stem resulting in drooping of leaves beyond the point of infection and in advanced stages the rooted cuttings dry up.

Small whitish to cream coloured grain like sclerotial bodies appear on the mature lesions.

Survival and spread

Disease is soil born and pathogen survives in soil which is the source of primary infection.

Favourable conditions

The disease is mainly noticed in nurseries during June- September and is caused by *Sclerotium rolfsii.*

7.Leaf rot and blight

Symptoms

Greyish sunken spots and mycelial threads appear on the leaves and the infected leaves are attached to one another with the mycelial threads.

Leaf spots caused by *Colletotrichum sp*. are characterized by yellow halo surrounding the necrotic spots.

On stems, the infection occurs as dark brown lesions which spread both upwards and downwards . The new f lushes subtending the points of infection gradually droop and dry up.

Survival and spread

Disease is soil born and pathogen survives in soil which is the source of primary infection.

Favourable conditions

The disease is caused by *Rhizoctonia solani Kühn* and is often serious in nurseries during April- May when warm humid conditions prevail. The fungus infects both leaves and stems.

Nutmeg *(Myristica fragrans Houtt.)*

Very few insects have been recorded on nutmeg in the field in India; however, a few species of scale insects infest seedlings in the nursery and sometimes young plants in the field.

Scale insects

Among the scale insects infesting nutmeg, the black scale (Saissetia nigra Nietn.) and white scale (Pseudaulacaspis cockerelli (Cooley) (Hemiptera: Diaspididae) are important.

Damage

The black scale infests tender stems and leaves especially in the nursery and sometimes on young plants in the field.

The scales are seen clustered together and are black, oval and dome shaped. They feed on plant sap and severe infestations cause the shoots to wilt and the plants present a sickly appearance.

The white scale is greyish white, flat and shaped like a fish scale and measures about 2.25 x 1.5 mm in size.

The white scale occurs clustered together on the lower surface of leaves especially in nursery seedlings. The pest infestation results in yellow streaks and spots on affected leaves and in severe infestations the leaves wilt.

Management

Spraying of dimethoate (0.05%) is recommended for the management of scale insects.

Leaf spot and shot hole: *Colletotrichum gloeosporioides*

Symptoms:

Sunken spots surrounded by a yellow halo are the initial symptoms.

Subsequently the central portion of the necrotic region drops off resulting in shot hole symptoms.

Dieback symptoms are also observed in some of the mature branches.

On young seedlings drying of the leaves and subsequent defoliation are seen.

Management:

The disease can be controlled by spraying 1% Bordeaux mixture two or three times during rainy season.

Fruit rot: *Colletotrichum gloeosporioides and Botryodiplodia theobromae*

Symptoms:

This is caused by Colletotrichum gloeosporioides and Botryodiplodia theobromae.

Water soaked lesions are seen on the fruits, the tissues of which become discoloured and disintegrated.

Premature splitting of the pericarp and rotting of mace and seed are the main symptoms of the disease.

The internal tissues are found rotten. The fallen fruits become enveloped with the growth of the organism.

Management

The disease can be controlled by spraying 1% Bordeaux mixture

DISEASE OF NUTMEG

1. LEAF SPOT AND SHOT HOLE

Symptoms:

The initial symptoms of the disease appea r as sunken spots surrounded by a yellow halo.

Later, the central portion of the necrotic region drops off resulting in shot hole symptoms.

Die back symptoms are also observed in some of the matured branches.

On young seedlings, drying of the leaves and subsequent defoliation are observed.

Pathogen:

The disease is caused by Colletotrichum gloeosporioides (Penz.) Penz. & Sacc.

Pathogen , disease cycle and epidemiology have been described under Large Cardemom.

Sunken spots of leaves **Necrotic region** **Drying**

Management:

i) Collect and destroy the infected plant debris.
ii) Apply prophylactic sprays of Bordeaux mixture (5:5:50) and repeat 2 or 3 times at 14 days interval

2. THREAD BLIGHT

The disease manifests in two types:

a. White thread blight:

The first is a white thread blight wherein fine white hyphae aggregate to form fungal threads that traverse along the stem underneath the leaves in a fan shaped or irregular manner causing blight in the affected portion.

b. Horse hair blight:

The symptoms of this disease appear as fine black silky thread of the fungus form an irregular, loose network on the stems and leaves. These strands caused blight of leaves and stems.
However, these strands hold up the detached, dried leaves on the tree, giving the appearance of a bird's nest, when viewed from a distance.

Pathogen:

White thread blight is caused by Marasmius pulcherima while horse hair blight is caused by Marasmius equicrinus.

Disease cycle and epidemiology:

These fungi perennate as mycelium in dried up leaves.
These diseases are severe under heavy shade.

Management:

i) Follow phytosanitation and shade regulation practices.
ii) With the initiation of the disease spray the crop with Bordeaux mixture (5:5:50).

3. FRUIT ROT: *Colletotrichum gloeosporioides and Botryodiplodia theobromae*

Symptoms:

On immature fruits, the symptoms of the disease appear as splitting and rotting of fruits which ultimately drop prematurely.
In case of fruit rot, the infection starts from the pedicel as dark lesions

and gradually spreads to the fruits, causing brown discolouration of the rind resulting in the rotting.

In advanced stages, the mace also rots emitting a foul smell.

Pathogen:

The disease can be due to both physiological and pathological regions.

The fungi associated with this disease are Phytophthora spp. and Diplodia natalensis Pole-Evans.

Water soaked lesions and seed **Rotten fruit** **Rotting of mace**

Management:

i) Spray the crop with Bordeaux mixture (5:5:50) when the fruits are half mature.

Major inspect Pest of Clove

1. Major Pest of Clove:

1. Stem borer (*Sahyadrassus malabaricus Moore*)

(Lepidoptera : Hepialidae)

The stem borer is the most serious pest of clove in India and is generally seen in clove plantations grown near forest clearings. The pest has a wide host range and has been recorded on more than 40 species of woody plants and trees.

Damage

The larva of the stem borer girdles the stem of young clove trees at the basal region and bores downward into the root zone.The girdled region and the bore-hole are covered with frass consisting of coarse wood particles that are formed as a mat-like structure.The infested trees wilt and defoliate and succumb to the pest attack subsequently.

Biology

Egg: The eggs are laid on the weeds around the basins of clove trees.

Larva : Early instar larvae feed on the weed plants and the later instars migrate to the clove trees and bore into the stem. The larvae are creamy white with a black head and fully grown larvae measure about 90 mm in length. The dorsal sclerites of the thoracic and abdominal segments are brown.

Pupa: Pupation occurs within the larval tunnel.

Adult: The adult is a large sized moth with a wing span of about 110 mm with greyish-brown mottled forewings.

The base of clove trees is to be inspected regularly for symptoms of pest infestation.

In case the pest infestation is noticed on the stem, the mat-like frass has to be removed and quinalphos 0.1% sprayed around and injected into the bore hole.

Swabbing the basal region of th e main stem of young clove trees with carbaryl paste and keeping the basins of clove trees free of weeds are prophylactic measures for preventing the pest infestation.

2. Scale insects

A few species of scale insects infest clove seedlings in the nursery and sometimes young plants in the field. The scale insects generally seen on clove include wax scale *(Ceroplastes floridensis Com.)*, shield scale *(Pulvinaria psidii Mask.),* masked scale (Mycetaspis personata Com.) (Hemiptera: Diaspididae) and soft scale (Kilifia accuminata *(Sign.) (Hemiptera: Coccidae).*

Damage

Scale insects are generally seen clustered together on tender stems and lower surface of leaves.

Scale insects feed on plant sap and cause yellow spots on leaves, defoliation and wilting and drying of shoots.

Saissetia

Mycetaspis personata

Management

Spraying of dimethoate (0.05%) is recommended for the management of various species of scale insects.

4.DISEASE OF CLOVE

1.Seedling Wilt: *Cylindrocladium sp.*, *Fusarium sp.*, *Colletotrichum sp.*, Rhizoctonia sp., and Trichoderma sp

Symptom:

Seedling wilt is found mainly in nurseries and causes five to 40% death of seedlings. Leaves of affected seedlings loose natural lustre, tend to droop and ultimately die.

The root system and collar region of the seedling show varying degrees of, discolouration and decay.

Management:

Since the infected seedlings promote spread of the disease they are to be removed and destroyed and the nursery is drenched with Copper oxychloride 0.25 %.

2. Leaf rot: *Cylindrocladium quinquiseptatum*

Symptom:

It is noticed in the nurseries as well as in the main field both at young and mature stages.

Infection starts as dark spots at the leaf margin and spreads sometimes with no definite pattern.

Rotting may be in the whole leaf or at the tip resulting in defoliation.

Management

Seedling and young plants can be sprayed with systemic fungicides Carbendazim 0.1%.

Last Spot, Twig Blight and Flower Bud shedding: *Gloeosporium gleosporioides*

Symptom

Necrotic spots of variable size and shapes are noticed on the leaves. Severely affected leaves wither, droop down and dry up.In nursery seedlings die back symptoms are seen. Twigs are infected as the symptoms extend from the leaves through petioles. The affected branches stand without leaves or only with young leaves at tips. Flower buds are attacked by spreading infection from the twigs.

Shedding of flower buds occurs during periods of heavy and continuous rainfall.

Management

Spraying 0.25% Copper oxychloride at monthly interval reduces disease intensity, defoliation and flower bud shedding. Initial spray is given just prior to flower bud formation and continued till the harvest of buds.

5.Cinnamon *(Cinnamomum verum Bercht. et Pres)*

Over 35 species of insect pests infest cinnamon in India, among which cinnamon butterfly and leaf miner are important.

Major pests

1. Cinnamon butterfly (Papilio clytia L.) (Lepidoptera: Papilionidae)

The cinnamon butterfly is the most serious pest of cinnamon in the nursery and field being widely distributed in all cinnamon growing areas in India and is more serious during the monsoon seasonDamage The larvae of the cinnamon butterfly feed voraciously on tender and partly mature leaves.

In case of severe infestations, the entire plant is defoliated and only the midribs of leaves with portions of veins are left on the plant.

Young plants are often completely defoliated by the pest adversely affecting the growth of plants.

Biology

Egg: Adults lay eggs on tender leaves and they hatch in 3–4 days.

Larva: Newly hatched larvae are pale green with a pale yellow dorsal line and irregular white stripes. The larval stage comprising of five instars is completed in 11–17 days. Fully-grown larvae are dark brown and yellow with four rows of red spots on the sides and measure about 25 mm in length.

Pupa: Pupae and elongated and brownish-black and the pupal period last for 11–13 days.

Adult: Adults are large sized butterflies with a wingspan of about 90 mm and occur in two forms namely, clytia and dissimilis. The form clytia mimics Euploea sp. and has blackish brown wings with a series of arrowhead shaped white spots on the outer margins. The form dissimilis which is more common mimics Danais sp. and has black wings with elongated white spots and a series of marginal arrowhead shaped spots.

Management

Spraying quinalphos (0.05%) is recommended for the management of the cinnamom butterfly.

2. Leaf miner (*Conopomorpha civica Meyr.*)
(Lepidoptera: Gracillaridae)

The leaf miner infests tender leaves of cinnamon plants in the nursery and field and is more serious during the monsoon season.

Damage

The larvae of leaf miner feed on the tender tissues between the upper and lower epidermis of the leaf resulting in the formation of linear mines that end in blister-like patches.

Severely infested leaves become crinkled and malformed and later the mined areas dry up leading to the formation of large irregular holes on the leaves.

Biology

Larva: Larvae are pale creamy white and are generally seen at the centre of the mine. The larvae become pinkish red when fully grown measuring about 5 mm in length.

Pupa: Pupation generally occurs outside the larval mines on the leaf.

Adult: Adults are minute silvery grey moths with narrow fringed wings with a wing span of about 5 mm.

Management

Spraying quinalphos (0.05%) is recommended for the management of the leaf miner.

DISEASE OF VANILA:

1. Root rot: Fusarium sp., Sclerotium sp.

Symptoms

Browning of roots leading to rotting and decay.

Yellowing of leaves, stem and leaves becoming flaccid, shriveled and giving a drooping appearance.

Management

Cut and remove the affected roots, reduce mulch.

Soil drench and spray the plant with 0.2 % Copper oxychloride @ 2 or 3 litre per plant.

2. Stem rot: *Fusarium sp.*

Symptoms

Water soaked lesions giving stem a brown coloured appearance resulting in rotting of tissues, leaves turning yellowish and drying off.

Management

Cut and remove the affected portion

Spray 0.2% Carbendazim, repeat spray after one month.

2. Black rot *Phytophthora spp.*

Symptoms:

Water -soaked green to black rot of stems, leaves and/or pods; thin white mycelium may b e visible in infected tissues; disease usually begins at the apical part of the plant and spreads to leaves, stems and all other parts of the plant

Disease emergence favored by prolonged wet weather, poorly draining soil, excessive shading of plants, overcrowded plants and lack of weed control in the plantation

Mangement:

Spray 0.1% Carbendazim and 1 % Bordeaux mixture alternatively at weekly intervals

3. Shoot tip rot: *Fusarium, Sclerotium*

Symptoms

Decaying of shoot tip and leaves at the tip

Management

Spray 0.1% Carbendazim at 15 days interval.

4.Vanilla mosaic: Vanilla mosaic virus

Symptoms

Mosaic pattern or mottling on foliage and Stunting sterility and leaf distortion.

Management

Uproot and destroy the affected plant, Important Prophylactic Measures, Timely shade management

Avoid excess moisture, Allow free movement of air.

Avoid overcrowding of vines by keeping adequate spacing.

Avoid excessive mulching during rainy season and mulching with materials that are not easily decomposed.Avoid excessive manuring and use of fresh cow dung.

Apply recommended doses of bio agents like Trichoderma, Pseudomonas, Bacillus etc. Collect and destroy the parts of plants showing disease symptoms.

To prevent the chances of multiplication of these fungi and spread of these diseases, the following should be adhered to,Avoid excessive use of manure, mulch and irrigationCut and remove disease affected plant parts and burn them.

Do not use planting materials procured from infected gardens.Avoid close planting of vines and over crowding. Follow the recommended spacing.

Viral disease affected vines should be uprooted and burnt.Do not use implements, which have been used on disease- affected plants on healthy plants without thoroughly washing and cleaning them.

INSECT PESTS OF GINGER:

Disease of Ginger:

Soft rot or rhizome rot : *Pythium aphanidermatum/ P. vexans* / P. myriotylum

Symptoms

The infection starts at the collar region of the pseudostems and progresses upwards as well as downwards. The collar region of the affected pseudostem becomes water soaked and the rotting spreads to the rhizome resulting in soft rot.At a later stage root infection is also noticed.Foliar symptoms appear as light yellowing of the tips of lower leaves which gradually spreads to the leaf blades In early stages of the disease, the middle portion of the leaves remain green while the margins become yellow.

The yellowing spreads to all leaves of the plant from the lower region upwards and is followed by drooping, withering and drying of pseudostem.

Infected plants and rhizome

Rotting of rhizome

Cross section of rotten region

Management

Treatment of seed rhizomes with mancozeb 0.3% for 30 minutes before storage and once again before planting reduces the incidence of the disease.

Cultural practices such as selection of well drained soils for planting is important for managing the disease, since stagnation of water predisposes the plant to infection.

Seed rhizomes are to be selected from disease free gardens, since the disease is also seed borne.

Once the disease is located in the field, removal of affected clumps and drenching the affected and surrounding beds with mancozeb 0. 3% checks the spread of the disease.

Bacterial wilt: *Ralstonia solanacearum*

Symptoms

Water soaked spots appear at the collar region of the pseudostem and progresses upwards and downwards.

The first conspicuous symptom is mild drooping and curling of leaf margins of the lower leaves which spreads upwards

Yellowing starts from the lowermost leaves and gradually progresses to the upper leaves. In the advanced stage, the plants exhibit severe yellowing and wilting symptoms.

The vascular tissues of the affected pseudostems show dark streaks. The affected pseudostem and rhizome when pressed gently extrudes milky ooze from the vascular strands.

Bacterial streaming from diseased rhizome of ginger (ooze test)

Management

The cultural practices adopted for managing soft rot are also to be adopted for bacterial wilt.

The seed rhizomes may be treated with streptocycline 200ppm for 30 minutes and shade dried before planting.

Once the disease is noticed in the field all beds should be drenched with Bordeaux mixture 1% or copper oxychloride 0.2%.

Leaf spot : *Phyllosticta zingiberi*

Symptoms

The disease starts as water soaked spot and later turns as a white spot surrounded by dark brown margins and yellow halo. The lesions enlarge and adjacent lesions coalesce to form necrotic areas. The disease spreads through rain splashes during intermittent showers.

The incidence of the disease is severe in ginger grown under exposed conditions.

Management

The disease can be controlled by spraying Copper oxychloride 0. 25 % or Mancozeb 0.2%.

INSECT PESTS OF TURMERIC:

Diseases:

1. Leaf spot: *Colletotrichum capsici*

Symptoms

In affected leaves, elliptic or oblong spots with yellow halo are seen. The centre of spots are grayish white and then with numerous black dots in centre As the disease advances, the leaves dry up and give a scorched appearance.

Management

Field sanitation

Spray with Mancozeb 0.25% or copper oxy chloride 0.25% immediately after the appearance of symptom and at 15 days interval.

2. Leaf blotch: *Taphrina maculans*

Symptoms

The spots of 1-2mm diameter appear in more numbers, covering both sides of leaf.

The attacked leaf presents a reddish brown appearance instead of the normal green colour.

These spots coalesce to form irregular bigger patches.

Management:

Field sanitation

Spray with Mancozeb 0.25% or copper oxy chloride 0.25% immediately after the appearance of symptom and at 15 days interval.

3. Rhizome rot: *Pythium aphanidermatum*

Symptoms:

In infected plants, basal portion of the shoots appear watery and soft.

The root system is very much reduced

The leaves exhibit gradual drying along the margin

Infected rhizomes soft, rotted, color changes into different shades of brown

Management

Use disease free planting material

Providing good drainage facilities

Rhizome dip in copper oxy chloride or zineb (0.3%) for 30 minutes before planting

Soil drenching with copper oxy chloride (0.25%) in and around affected plants

Soil application of Pseudomonas fluorescens talc formulation (2.5 kg/ha)

9. INSECT PEST OF COCONUT

1.Rhinoceros beetle: *Oryctes rhinoceros*

Damage:

Coconut rhinoceros beetle adults damage palms by boring into the center of the crown, where they injure the young, growing tissues and feed on the exuded sap. As they bore into the crown, they cut through the developing leaves. When the leaves grow out and unfold, the damage appears as V-shaped cuts in the fronds or holes through the midrib

Management:

- Chop and burn decaying logs or break them up and destroy any rhinoceros beetles developing inside.
- Cut stumps as close to the soil surface as possible.
- Dead, standing coconuts should be felled, chopped, dried, and burned.
- Rhinoceros beetles do not usually lay eggs in potential breeding sites that are obscured by growing vegetation. Vines or ground covers can be planted or allowed to grow over logs or stumps that cannot be destroyed.
- Piles of dead leaves or grass can be composted, used for mulch, burned, or spread on the ground in a thin layer.
- Compost piles should be maintained properly. When turning compost piles or applying compost to plants, destroy any rhinoceros beetles found. It takes longer for rhinoceros beetle larvae to develop than it takes to make compost, so properly maintained compost should not serve as a source of rhinoceros beetles.
- A hooked wire can be used to extract and destroy rhinoceros beetle adults feeding in palm crowns.
- The fungus Metarhizium anisopliae or the Oryctes virus are used to control the rhinoceros beetle. More recently a chemical attractant, ethyl-4-methyloctanoate, has been used in traps to attract and kill the beetles. Both Metarhizium anisopliae and the Oryctes virus are present and helping to reduce rhinoceros beetle populations in India.

Red Palm Weevil: Rhynchophorus ferrugineus

Damage:

- The hole can be seen on the stem with chewed up fibres protruding out.
- Many times reddish brown liquid can be seen oozing out from the hole.
- The grubs cause damage inside the stem or crown by feeding on soft tissues and often cause severe damage especially when a large number of them bore into the soft, growing parts. In case of severe infestation the inside portion of trunk is completely eaten and become full of rotting fibres.
- In case of young palms the top withers while in older palms the top portion of trunk bends and ultimately breaks at the bend (wilting).
- Sometimes the gnawing sound produced by the feeding grubs inside will also be audible.
- In the advanced stage of infestation yellowing of the inner whorl of leaves occur. The crowns falls down or dry up later when palm is dead.

Holes on the stem

chewed up fibres

Identification of the Pest:

- Egg: Oval and creamy white in colour. Eggs laid in scooped out small cavities, wounds and other cut injuries on the trunk
- Grub: Light yellowish grub without legs. Stout, fleshy and apodous with a conical body bulged in middle and tapering towards the end
- Pupa: The full frown larva pupates inside the stem and fibrous cocoon made out of fibrous strands
- Adult: Reddish brown weevil has six dark spots on thorax. Male has conspicuous long snout has a tuft of hairs.

Pupae

Adult

Management:
Cultural Method:

• Remove and burn all wilting or damaged palms in coconut gardens to prevent further perpetuation of the pest.

• Avoid the cutting of green leaves. If needed, they should be cut about 120 cm away from the stem in order to prevent successful inward movement of the grubs through the cut end.
Chemical Method:

• In attacked palms, observe for the bore- holes and seal them except the top most one. Through the top most hole, pour 1% carbaryl (20gm/lt) or 0.2% trichlorphon @ one litre per palm using a funnel. Then plug this hole also. If needed repeat after one week.

• When the pest infestation is through the crown, clean the crown and slowly pour the insecticidal suspension. In case of entry of weevil through the trunk, the hole in trunk may be plugged with cement / tar. A slanting hole is made with the aid of an auger and the insecticide solution is poured with funnel.

• Fill the crown and the axils of top most three leaves with a mixture of fine sand and neem seed powder or neem seed kernel powder (2:1) once in three months to prevent the attack of rhinoceros beetle damage in which the red palm weevil lays eggs.

Trap Method:

Coconut log traps:

Setting up of attractant traps (mud pots) containing sugarcane molasses 2½ kg or toddy 2½ litres (or pineapple or sugarcane activated with yeast or molasses) + acetic acid 5 ml + yeast 5 g + longitudinally split tender coconut stem/logs of green petiole of leaves of 30 numbers in one acre to trap adult red palm weevils in large numbers. Incorporate any of the insecticide to each trap to kill the weevils trapped.

Pheromone lure with bucket

Trapped Red Palm Weevil

Pheremone trap

- Install pheromone trap @ one trap per ha
- Step 1: Specialized buckets with 3 of 4 holes are made, the bucket is wound with coconut fibre/ jute sack, so that the pests can enter.
- Step 2: The lure (Ferrolure +) is suspended inside the bucket and one lit of water is added along with 100g pineapple/ sugarcane, 2g yeast and 2g Carbaryl in the bucket.
- Step 3: The bait buckets are placed at sites in the farm, where infestation is seen most.
- Step 4: After a week the water is checked for the catch & re filled to prevent mosquitoes from breeding.

Coconut Eriophyid: Aceria guerreronis

Pest population occurs round the year but population maximum during June – Sep coinciding with the onset of monsoon.

Symptoms of Damage:

Yellow patches on leaves

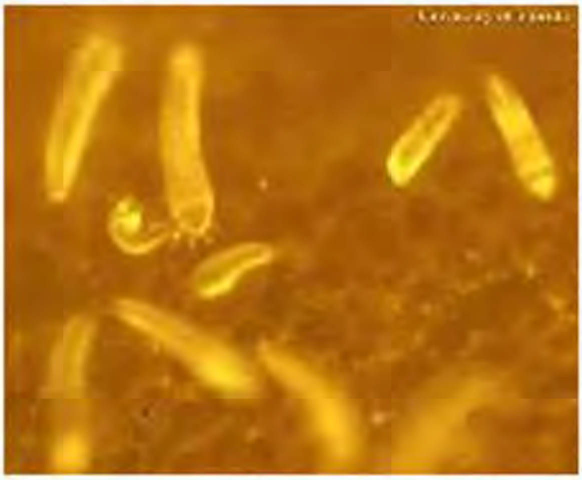
Oozing of the gummy exudation

Brown colour patches on nuts

V Shaped spindles

- The earliest symptom on 2-3 month old buttons is pale yellow triangular patches seen below the perianth.
- Later, these patches become brown. Severely affected buttons may fall. As the buttons grow, brown patches lead to black necrotic lesions with longitudinal fissures on the husk.
- Oozing of the gummy exudation from the affected surface of the nuts.
- Uneven growth results in distortion and stunting of nuts leading to reduction in copra yield. In severe cases, the nuts are malformed with cracks and hardened husk.

Identification of the Pest:



Colony of coconut mite

Eriophyid mite under microscope

• Mite are usually found under the bracts of fertilized female flowers and do not infest the unfertilized flowers.

• This mite is very minute in size measuring 200 – 250 micron in length and 36 – 52 micron in width with two pairs of legs.

• Nymph and Adult is pale in colour with elongate body and worm like appearance. The life cycle of this mite, which consists of egg, two larval instars and an adult stage, is completed in 7 -10 days.

Management:

Cultural Method:

• Collect and destroy all the fallen buttons of the affected palm.

• Grow intercrop (sun hemp, four crops/year) and shelter belt with casuarina all round the coconut garden to check further entry.

• Providing adequate irrigation.

• Apply urea 1.3 kg, super phosphate 2.0kg and muriate of potash @ 3.5 kg/palm/year. Increased quantity is recommended to increase the plant resistance to the mite.

• Soil application of micro nutrients like, Borax 50 g + gypsum 1. 0kg + Manganese sulphate 0.5 kg/palm/ year TNAU Micronutrient solution 200 ml/tree.

Chemical Method:

Spot application of ecofriendly Botanicals

• Round 1: Azadirachtin 1% (5 ml in one lit. of water)

• Round 2: Neem oil + Teepol (30 ml in one lit. of water)

• Triazophos 40 EC 5 ml/lit or monocrotophos 36 WSC @ 2 ml / lit or carbosulfan 25 EC 2 ml/ lit in alternation with neem azal 1% 5ml/lit as spot application

• Neem cake application @ 5 kg per palm per year

Preparation of neem oil + garlic emulsion (2%):

• To prepare 10 litres of 2% neem oil + garlic emulsion, 200 ml neem oil, 200 g garlic and 50 g ordinary bar soap are required. Slice the bar soap and dissolve in 500 ml lukewarm water. Grind 200 g of garlic and take the extract in 300 ml of water. Pour the 500 ml soap solution in 200 ml neem oil slowly and stir vigorously to get a good emulsion. Mix the garlic extract in the neem oil + soap emulsion. Dilute this 1 litre stock solution by adding 9 litres of water to get 10 litres of 2 % neem oil + garlic emulsion.

Method of Application

• The botanicals should be applied in the sequence indicated above at 45 days interval using a one litre hand sprayer. Rocker or Pedal sprayer can be used for spraying small trees.

• The spray should be applied at the crown region by a climber covering only the top six bunches during non rainy season.

Precautions and Safety Measures

• Spraying should be avoided during windy season to prevent contamination.

• At the time of spraying, protective mask and clothing should be used.

• Wash face and hands cleanly with soap after spraying.

Biological Method:

• Entomofungal pathogen Hirsutella thompsonii and Verticillium lecanii are reported to be promising in managing the mites.

• Both the pathogens are mass multiplied by a commercial firm and sold in the market.

• The earliest symptom on 2-3 month old buttons is pale yellow triangular patches seen below the perianth.

• Later, these patches become brown. Severely affected buttons may fall. As the buttons grow, brown patches lead to black necrotic lesions with longitudinal fissures on the husk.

• Oozing of the gummy exudation from the affected surface of the nuts.

• Uneven growth results in distortion and stunting of nuts leading to reduction in copra yield. In severe cases, the nuts are malformed with cracks and hardened husk.

BUD ROT: *Phytophthora palmivora*

Symptom:

• Palms of all age susceptible, but normally young palms are more susceptible, particularly during monsoon.

• In seedlings, the earlier symptom is the yellowing of one or two younger leaves. Basal tissues of the leaf rots quickly and can be easily pulled out from the crown.

• In the later stages the spindle withers and drops down.

• The tender leaf base and soft tissues of the crown rot into a slimy mass of decayed material emitting foul smell.

• Ultimately the entire crown falls down and the palm dies

• In adult palms, the first visible symptom is the colour change of the spear, which becomes pale and breaks at the base and hangs down. The rotting slowly progresses downwards, finally affecting the meristem and killing the palms. This is accompanied by drooping of successive leaves. Even then, nuts that are retained on the palm may grow to maturity.

Pale leaf | Leaf rot | Rooting of basal tissue | Drooping

Cultural method

- Provide adequate drainage in gardens.
- Adopt proper spacing and avoid over crowding in bud rot prone gardens.

Chemical method

- Remove all the affected tissue of the crown region and drenching the crown with Copper oxychloride 0.25%. Apply Bordeaux paste and protect it from rain till normal shoot emerges. (Dissolve 100 gm of copper sulphate and 100 gm of quick lime each in 500ml. water separately and mix to form 1 litre of Bordeaux paste).
- Spray 0.25% Copper oxychloride or 1 % Bordeaux mixture on the crown of the neighbouring palms as a prophylactic measure before the onset of monsoon. Palms that are sensitive (Dwarf palms) to copper containing fungicides can be protected by mancozeb. Small, perforated sachets containing 2 g of mancozeb may be tied to the top of leaf axil. When it rains, a small quantity of the fungicide is released from the sachets to the leaf base, thus protecting the palm.
- The infected tissues from the crown region should be removed and dressed with Bordeaux paste sprayed with 1% Bordeaux mixture as pre-monsoon spray (May and September).
- Spray with Copper oxychloride 0.25% after the onset of Monsoon.

LEAF BLIGHT (LB): *Lasiodiplodia theobromae*

Symptom:

- Leaf blight causes serious damage in seedlings, leaves and nuts of adult palms.
- Generally the adult leaves in the outer whorls are affected.

- The affected leaflets start drying from the tip downwards and exhibit a charred or burnt appearance.
- Dark grey to brown lesions with wavy to undulated margins appear from the apex of the nuts.
- The fungus entered in to the kernel through mesocarp, resulting in a decay of the endosperm.
- The affected nuts were desiccated, shrunken, deformed and dropped prematurely and resulting in nut yield loss up to 10 to 25%.
- The incidence was noticed throughout the year and maximum incidence was observed during summer months.
- Spores and the resting structures on the affected portion of the leaves served as inoculum for further spread through wind.


Drying of leaf tips


Burnt appearance


Infected kernel


Infected tree

Management:
Cultural method
- Remove and burn the severely affected leaves to avoid further spread.

Biological method
- Application of 200g Pseudomonas fluorescens along with 50 kg of FYM+ 5 kg of Neemcake/ palm/ year.

Chemical method
- Spray 1.0 per cent Bordeaux mixture or 0.25 percent Copper oxychloride (2 times at 45 days interval during summer months).
- Root feeding of Carbendazim 2 g or Hexaconazole/ Tridemorph 2 ml + 100 ml water (3 times at 3 months interval).

ROOT WILT (OR) KERALA WILT DISEASE: *Phytoplasma*
Symptom:
- Tapering of terminal portion of the trunk.
- Reduction of leaf size
- Abnormal bending or Ribbing of leaf lets termed as flaccidity.
- Flowering is delayed and also yield is considerably reduced.

• The characteristic symptom is the flaccidity of leaflets. This is the earliest visual symptom. In the beginning yellowing is restricted from the leaf tips to the middle of the leaves, necrosis of leaflets and deterioration and decay of root system are other salient features of the disease. The leaflets curve inwardly to produce ribbing so that the whole frond develops a cup like appearance. Abnormal shedding of buttons and immature nuts are also noticed.

Stephanitis typica

Proutista moesta

Management:

Cultural Method:

- Cut and remove disease advanced, uneconomical palms yielding less than 10 nuts per palm per year
- Grow green manure crops - cowpea, sunhemp (Crotalaria juncea), Mimosa invisa, Calapagonium mucanoides, Pueraria phaseoloides etc. may be sown in coconut basins during April-May and incorporated during September-October.
- Irrigate coconut palms with at least 250 litre water in a week.
- Adopt suitable inter/mixed cropping in coconut gardens.
- Provide adequate drainage facilities.

Biological method:

- In addition to the above, apply 50 kg FYM or green manure and 5 kg of neem cake / palm / year.
- Growing green manure crops like sunn hemp, sesbania, cowpea and calapagonium in the coconut basin and their incorporation in situ is beneficial as the practice reduces the intensity of the root (wilt) and increases the nut yield. The ideal green manure crops for the sandy and alluvial soils are cowpea and sesbania, respectively.

Chemical Method:

• Apply fertilizers for coconut palms in average management at the rate of 1.3 kg urea, 2.00 kg super phosphate and 3.5 kg potash (MOP) / palm / year in the form of urea, rock phosphate and muriate of potash, respectively.

• Magnesium may be supplied @ 500 g MgO per palm per year
• To manage the insect vectors, treat the top tow leaf axils with insecticide preparation. This can be prepared by mixing phorate 10 G with 200 g sand or powdered neem cake 250 g. Mix equal quantity of sand place around the base of the spindle.

LEAF ROT DISEASE: *Colletotrichum gloeosporioides, Exserohilum rostratum and Fusarium spp.*
Symptom:

• The first symptom is the appearance of water-soaked brown lesions in the spear leaves of root-wilt affected palms.

• Gradually these spots enlarge and coalesce resulting in extensive rotting.

• As the leaf unfurls the rotten portions of the lamina dry and get blown off in wind, giving a "fan" shape to the leaves.

• Sometimes, the symptom becomes very acute and the spear fails to unfurl.


aked brown leisons


Extensive rotting of leaves


Fan shaped appe

Management:

Physical method

• Remove the rotten portions from the spear and the two adjacent leaves.

Chemical method

• Pour fungicide solution of Hexaconazole - 2ml or Mancozeb - 3g in 300ml water per palm to the base of spindle leaf. 2-3 rounds of spraying are sufficient in case of mild infection.

• Spray the crowns and leaves with 1% Bordeaux mixture or 0.5% copper oxychloride formulations or 0.4% mancozeb in January, April-May and September. While spraying, care has to be taken to spray the spindle leaf.

10.INSECT PEST OF COFFEE

White stem borer: *Xylotrechus quadripes* Symptoms of attack and nature of damageLarvae enter into the hardwood and make the tunnels may extend even into the roots.Tunnels - tly filed with the excreta of the grubs. Infested plants show visible ridges around the stem. Yellowing and wilting of leaves.Young plants (7 to 8 years old) attacked by the borer may die in a year

White stem borers destroying a coffee plant

White stem borers adult

Identification of the pest

• Adult - slender, long beetle (2.5 cm).

• Forewings are black with white bands.

• Males are generally smaller than females.

• Head Shows distinctly raised black Ridges and the Hind Leg Femur extends beyond the apex of the Elytra

• In the Female,the Black Ridges on the Head are not much conspicuous and the hind leg Femur does not extend beyond the apex of the Elytra

Management

• Maintain optimum shade on the estates.

• Trace the infested plants - flight periods (i.e, during March and September)

• Every year - looking for ridges on the main stem and thick primaries.

• Collars prune the infested plants, uproot and burn the affected parts.

• Remove the loose scaly bark of the main stem and thick primaries using coir glove or coconut husk – kill the eggs

• Scrubbing during flight periods - kills the eggs and grubs present in the bark region.

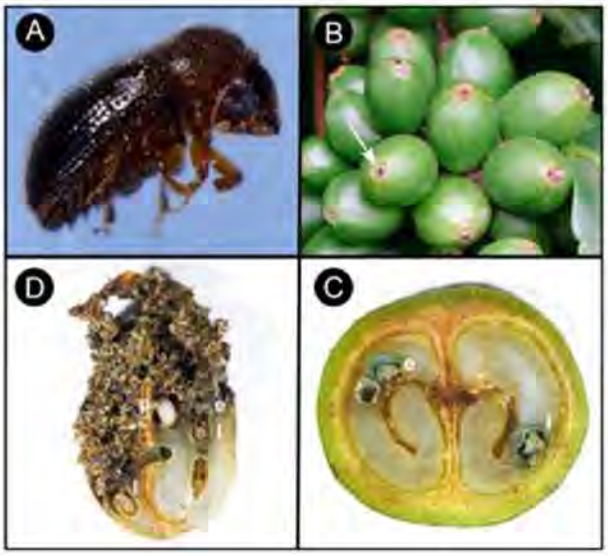
• Deep scrubbing should be avoided (sharp implement may injure the green wood and eventually kill the plant)

• Spraying the main stem and thick primaries with neem kernel extract may afford good control of the pest.

• Field release of predators Apenesia sps for effective control of white stem borer

• Field release of white muscardine fungus Beaveria bassiana (2.5 % field infection reported)

2.Coffee berry borer: Hypothenemus hampei In India, the pest was first noticed on a few plantations in the Nilgiris during early 1990. Symptoms of attack and nature of damage Pin hole at the tip of the berries (novel region)Severe infestation - two or more holes may be seen. Female beetle bores into the berries through the navel region make tunneling and feed inside contentPowdery substance pushed out through the holes



The coffee berry borer life cycle: (A) adult female coffee berry borer; (B) entrance hole with female coffee berry borer (CBB) (arrow) in the central disc of the developing green coffee berries; also note the presence of entomopathogenic fungus Beauveria bassiana (white mycelium protruding from female CBB); (C) reproductive galleries containing eggs (e) and larvae (l) in the coffee bean; (D) advanced stages of bean damage due to larval feeding, with pupae (p), larvae (l), and eggs (e) visible

Management

Proper adoption of cultural practices and phytosanitary measures important for management of coffee berry borer.

Transportation of infested coffee to uninfected areas is the main reason for spread.

Crop bags should be fumigated before delivery to estates to avoid cross infestation.

Timely harvest

Gleaning - spreading gunny bags or polythene sheets on the ground after picking the berries - minimize gleaning.

Maintain optimum shade and good drainage.

Dipping infested berries in boiling water for 2-3 minutes kills all the stages inside.

Drying of coffee beans – prevents breeding of beetles in stored coffee based on moisture content level.

Arabica (10% moisture content) - 16kg/lit

Roubsta (11% moisture content) - 18kg/lit Instal attractant trap to collect and kill the beetles

Instal multiple f unnel trap and pitfall trap to collect and kill the adults

Chlorpyriphos is also effective in controlling the beetle.

Field release of Cephalonomia stephendarix and phymastichus coffea for effective control these pests.

Applications of white muscardine fungus, *Beauveria bassiana* effectively reduce the borer attack(Note: Spraying on ripe berries may not be useful. The time of application could be about 120-150 days after flowering (August – September for Arabica and September – October for Robusta).Field application of Beauveria bassiana Mix 500 ml of groundnut oil with 500 ml of any agricultural wetting agent thoroughly.Add this suspension to 20 l of water and three bags of Beauveria culture the above solution mix well and strain through a muslin cloth.Application of spore suspension on the infested coffee bushes using a bakpak sprayer, targeting the berries. After 5 days application spores germinate and kill the insect.

3. Green scale

• The green scale is a serious sucking pest of coffee, particularly Arabica.

Symptoms of attack and nature of damage

• Nymphs and adults sucks sap from undersurface of the leaves, green shoots, spikes and berries.

• Upward curling and tender twigs drop

• Honeydew excrete – development of sooty mould fungus

• Heavy loss of the sap causes debility or even death of the plant.

Green scales on coffee fruits and leaves

Identification of the pest

- Ants movement
- Nymphs – pale yellow colour
- Adult - flat, oval, light green, blackish spots on dorsum

Green scales on coffee fruits and leaves

Management

- Control ants as in the case of mealy bugs.
- Remove and burn weeds which harbour the scale.
- Spray the affected patches quinolphos 25 EC @ 120 ml using a gator sprayer in 200 l of water and add 200 ml of any agricultural wetting agent in 200 l of the spray solution.

4.Rust: Hemileia vastatrix

Symptoms

- It mostly affects leaves or some time leaves and tender shoots. In earlier stage, 2- 3m.m size yellow spots develop on the lower surface of leaves.
- Rust lesions develop as orange yellow spots on lower surface of leaves. Thousasnds of small rust appear on the leaf. The upper surface of the leaves become yellow to brown.
- At later stages, yellow rusty appearances are found on the entire undersurface of the leaf. The orange yellow spots are followed by black spots followed by necrosis.
- Infected leaves defoliate and branch remains without any leaves. The plants remain stunted with reduced yield. Reduced yileds and reduced profit are obtained in these kind of infected crops.

Management

- Collection and destruction of diseased leaves. Grow S 238, S 395 resistant varieties.
- Spraying of Bordeaux mixture 0.5% before flowering, during rainy and after rainy seasons in the month of may, august- september and october respectively will prevent from the diseases.

5. Brown leaf spot: *Cercospora coffeicola*

Symptoms

- Brown spots with grey centre and brown margin surrounded by

Management:

• Spraying with Bordeaux mixture 0.5%.

Die back or Anthranos: Collectorichum coffeasum

Symptoms

• On leaves circular to grayish spots of 2-3 m in dia.

• On berries small dark coloured sunken spots are farmed. Beans become brown. Die back also occurs.

Management

• Spraying Mancozeb 0.25%

Berry blotch: Cercospora coffeicola

Symptoms

• Neorotic spots on the exposed surface of green berries enlarge and cover the major portion. fruit skin shrivels and sticks fast.

Management

• Spray 1% Bordeaux mixture during june and late august, maintain medium shade overhead.

COFFEE DISEASES


Neorotic spots


Enlarged spots


Shrunken berries


Brown spots


Yellow hallow


Infected leaves

2.INSECT PEST OF TEA

Tea mosquito bug: *Helopeltis theivora*

• It is considered to be a serious pest of a tea.

• The damage more in most shaded areas.

Symptoms of damage:

• Adults and nymphs suck the sap from buds, young leaves and tender stems

• Puncturing the plant tissues with their needle like rostrum and inject toxic saliva.

• Punctures appear as reddish brown spots.

• Leaves curl up, badly deformed and shoots dry up.

Identification of the pest:

• Adult - black colour with red thorax, black and white abdomen and greenish brown wings.

Management:

• Spray Clothianidin 50 WDG 120 g/ha or Thiacloprid 21.7 SC 375 ml/ha or Thiamethoxam 25 WG 100g/ha or Bifenthrin 8 SC 500 ml/ha

Blister blight: Exobasidium vexans

Symptoms

• Small, pinhole-size spots are initially seen on young leaves less than a month old.

• As the leaves develop, the spots become transparent, larger, and light brown.

• After about 7 days, the lowe r leaf surface develops blister-like symptoms, with dark green, water-soaked zones surrounding the blisters.

• Following release of t he fungal spores, the blister becomes white and velvety.

• Subsequently the blister turns brown, and young infected stems become bent and distorted and may break off or die.

Life cycle

• The disease cycle repeats continuously during favorable(wet) conditions, and the spores are readily dispersed by wind.

• Spores that land on a leaf with adequate moisture will germinate and infect it, producing visible symptoms within 10 days.

• The fungus can directly penetrate the leaf tissue.

• The basidiospores have a low survival rate under conditions of drought or bright sunlight.

• The life cycle of the fungus is 3–4 weeks.

Management

Removal of affected leaves and shoots by pruning and destruction of the same have been recommended. Spraying of Bordeaux mixture or Copper Oxy Chloride 0.1% A mixture of 210g of Copper oxy Chloride + 210g of nickel chloride per ha sprayed at 5 days interval from June to September and October to November

12. INSECT PEST COCOA:

1.Mealy bugs: *(Planococcus lilacinus, Planococcus citri, Paracoccus marginatus and Rastrococcus iceryoides)*

• It colonizes on the tender parts of the plant such as growing tips of the shoots, the terminal buds, the flower cushions, the young cherelles and mature pods. Feeding of mealy bugs induces cherelle wilt. Following control measures are recommended.

When the infestation is lesser: Spraying of Neem Oil 3% or fish oil rosin soap 25g/litre

• In case of severe incidence, spraying of any one of the following **chemicals is recommended** : Dimethoate (2 ml/litre) Chlorpyriphos (5 ml/litre), Buprofezin (2 ml/litre), Imidacloprid (0.6 ml/lit), Thiamethoxam (0.6g/litre)

Planococcus lilacinus *Paracoccus marginatus* *Rastrococcus iceryoides*

• In the area where P. marginatus a lon e occurs, field release of Acerophagus papayae, the encyrtid parasitoid @ 100 per hamlet is recommended as the best management strategy.

2.Tea mosquitoe bugs *(Helopeltis antonii)*

• Infested pods develop circular water soaked spots around the feeding punctures . These punctures subsequently turn pitch black in color. Deformation of pods occurs because of multiple feeding injuries.

Acerophagus papayae **Tea mosquitoe bug** **Damage symptom**

Management

• When the infestation is lesser: Spraying of Neem Oil 3% is recommended.

• In case of severe incidence, spraying of any one of the following chemicals is recommended: Imidacloprid (0.6 ml/lit) , Thiamethoxam (0.6g/litre.

DIDEASE OF COCOA

1. Black Pod rot: *Phytophthora palmivora, P. mega-karya, P.citrophthora and P. capsici*

Symptoms

• Infection appears as chocolate brown spot, which spreads rapidly and soon occupies the entire surface of the pod.

• As the disease advances, a whitish growth of fungus consisting of fungal sporangia is produced over the affected pod surface. ultimately, the affected pods turn brown to black.

• The internal tissues as well as the beans become discolored as a result of infection.

Chocolate brown spots

Fully covered brown spots

Infected seeds

Management

• Periodically remove the infected pods.

• Spray 1 per cent Bordeaux mixture with on set of monsoon and also frequent intervals.

• Provide frequent drainage and regulate shade to increases aertion.

• Pseudomonas fluorescens (Pf1) liquid formulations @ 0.5% as soil and foliar spray (3 times per year- June, October & February) was found to be effective in reducing the Cocoa Pod rot and Stem canker.

Stem Canker: *Phytophthora palmivora*

Symptoms

• The cankers appear either on the main trunk, jorquettes or fan branches.

• The earliest symptom is the appearance of a greyish brown water soaked lesion on the outer bark.

• A reddish brown liquid oozes out from these lesions, which later dries up to form rusty deposits.

• The tissues beneath the outer lesion show reddish brown discoloration due to rotting.



Brown water soaked spots | Dried rusty appearance | Rotten bark

Management

• It can be controlled in the initial stages by the excision of diseased bark followed by wound dressing with Bordeaux mixture or copper oxychloride paste.

• Wilted branches should be cut and removed

Vascular Streak Dieback (VSD): Oncobasidium theobromae

Symptoms

• The first indication of the disease is a characteristic yellowing of one or two leaves on the second or third flush behind the growing tip.

• Diseased leaves fall within a few days of turning yellow and the other leaves on the shoot show similar symptoms.

• When the infected shoot is split lengthwise there is always a characteristic brown streaking.

Management

• The disease can be controlled by disposing diseased branches and regular pruning of chupons on the trunk.




Yellow leaf | Defoliation | Yellowing of leaves on shoots | Brown streaking

• Cocoa nurseries should not be located near the diseased area.
• Avoid getting seedlings from diseased tracts.
• Kerala Agriculture University has developed some VSD resistant and high yielding varieties CCRP-1 to CCRP-7.

Cherelle Rot: Colletotrichum gloeosporioides

Symptoms

• The shriveling and mummifying of some young fruits are a familiar sight in all cocoa gardens.
• In the early stages the fruits lose their lustre and in four to seven days they shrivel.
• The fruits may wilt but do not abscise.
• Many other factors like insects, diseases, nutrient competition and over production may also be associated with this problem. Hence, remedial measures will depend upon the nature of the causative factors involved.

Shrivelled seeds

Mumified fruits

MAJOR AND MINOR PESTS OF SUMMER VEGETABLES

Major vegetables under this group include cucurbits, brinjal, and chilies. Insect pests of cucurbit vegetables

1) Red Pumpkin beetle, *Aulacophora foveicollis;* Coleoptera: Chrysomelidae

Red Pumpkin beetles are very serious, important and destructive pest of all cucurbits and occur throughout the country. Adult s beetles are 6 to 8 mm long and having glistering yellowish red to yellowish brown elytra that are uniformly covered with fine punctures. Freshly hatched grubs are dirty white in color where as full grown ones are creamy to yellow and about 22 mm long.

Life cycle: Eggs are laid in soil around the host plant. Eggs are spherical in shape and yellowish pink in color. Eggs are laid to a depth of 25 mm near the plant. A single female lays upto 300 eggs during its life time. Upon hatching the eggs into grubs they start to bore into the roots, stem and later into the leaves. The larvae enter into the soil and pupation occurs into the soil. During winter they hibernate into the soil and reappears onwards May. There are 4 moulting stages and are altogether 5-8 generation in a year.

Eggs 6-7 days Larva (Grub) 13-25 days Pupa 7-17 days Adult

Nature of damage: Both adult and grub are destructive and cause direct damage to plant. Adult beetles feed voraciously on the leaf lamina and make irregular holes on leaf. The maximum damage is done by adult in the cotyledon stage. The adult insect also feed on older leaves of plant by scrapping off their chlorophyll and thus leading to leaves net like appearance. The attacked plants may wither away and photosynthesis is directly affected. The larvae cause damage by boring into the roots and the underground stem portion and also by feeding on the leaves and fruits line in contact with the soil.The infested roots and the underground roots may rot due to infection by the saprophytic fungi.The young and smaller fruits of the infested crop may dry up, whereas mature fruits become unfit for human consumption.

maggots which start to bore the pulp. The attack fruit decay because of secondary bacterial infection. The mature larva comes out of the rotten fruits and may bury inside the soil as pupae. Pupation mainly occurs in the soil around 2 inches below from the ground surface. Sometimes, larva may remain inside the fruit where it pupate and transform themselves into winged adults. There may be 8-10 generation a year.

Management:

1. Follow clean cultivation, collect and destroy infested fruits.
2. Deep ploughing to expose hibernating stages of fly.
3. To prevent egg laying by adult, set up fly traps (pheromons trap) in the field with 1% Cue lure or Methyl Eugenol or Cintronella oil or Vinegar or Acetic acid or Lactic acid or ammonia liquid or Vanilla or Pollard mixture.
4. Cover developing young fruits with paper or polythene cover or muslin cloth.
5. Grow Maize plants as trap crop in rows at a distance of 8-10cm in cucurbit field as flies rest on such tall plants.
6. Use extract of neem fruit, tobacco or zinger to repel female flies.
7. Parasitoid Fopius arisanus introduced in the IPM program.
8. Male sterile technique is accomplished through irradiation, chemo – sterilization.
9. Use protein bait (protein derived from corn, wheat or the other sources).
10. Spray Malathion @ 2 ml/litre of water at fortnightly intervals.

3) Epilachna beetle or Spotted beetle; *Coleoptera: Coccinellidae*

• Epilachna dodecastigma (having 6 black spots in each elytra) • Henosepilachna vigintioctopunctata (having 7 or 14 black spots on each elytra)

Epilachna beetle are major insect pest of gourds, cucumber, bitter gourd, watermelon, muskmelon and other cucurbitaceous crops. It is serious pest of bitter gourd. Many beetles under this group are useful bio-control agents against the aphids and other small insects. Damage is caused by beetles as well as by the grubs. Adults are

6-8mm long and similar to lady bird beetles in appearance. Larvae are 5-7mm long, soft bodied and covered with spines. Both larva and pupa are yellow in color and body is covered with spines. The distinguishing characteristics of H. vigintioctopuntata are deep red and usually have 7-14 black spots on each elytron whereas, E. dodecastigma have 6 black spots on each elytron.

Life cycle Eggs 3-5 days Larva (Grub) 1-2 week Pupa 2-5 days Adult Life cycle passes from 4 stages. The adult hibernate among heaps of dry plants or in cracks and crevice in the soil. Pest remains active during March-April and Egg laying, grub stage and pupation occur on the underside of leaves. A single female can lay upto 400 eggs in her life time. Eggs are yellow in color. Many grubs and adults can be seen on the ventral surface of the leaves The eggs hatch into grubs which feed on the lower epidermis of leaves. The pupae fixed on the leaves, stem, and most commonly at the base of the plants. The grub enters into the adults. Both the adults and grubs cause damage by feeding on the upper surface of leaves. The eaten leaves turn into brown color and may fall in severe damage.

Damage: Both the adult and grub stages feed on the leaf surfaces and skeletonize the leaves and make leaves net like appearance. The attacked leaves turn brown, dry up and fall off. In case of severe infestation the crop shows very unhealthy look. The vigour of the plant and its yield is adversely affected.

Management

1. The pest population can be suppressed effectively, by regular killing and picking of eggs, grubs and adults, if the cropped area is small. 2. Larvae and adults can be shaken down in container of kerosinized water early in the morning. 3. Use neem based pesticide, Margosom.

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4. The pest can be killed by spraying Malathion/ Endosulfan/ Zythiol 50 EC @2 ml per liter of water. The treatment should be applied as soon as the pest appears in the field and repeated at 15 days interval.

4) Cucurbit stink bug, Aspongopus janus; Hemiptera: Pentatomidae

Adults are red and pale-brown bugs. The edges of the abdomen and underside of the insect have orange to orange – brown stripes. They suck the sap from the leaves and tender shoots and devitalize the plants. Both adult and Nymph cause damage with their piercing and sucking type mouth part.

Life cycle Eggs 3-5 days Nymph 4 weeks Adult

Eggs are laid on group s underside of leaf or stem. The nymphs have partial development of wings, whereas the adults have fully grown wings. The total life cycle completes within 4-5 weeks.

Management

1. Hand picking of adult and nymph in small scale. 2. Predators include; Tachnid fly, Trichopoda pennipes that attack older nymphs and adults. 3. Use botanical pesticedes like extract of Neem, Bakaino, asuro etc. 4. Spray malathion 50% EC @ 1.5ml/liter water.

5) Blister beetle, Mylabris orientalis; Coleoptera: Meloidae

Blister beetles are phytophagous in nature and extensively feed on flowers of many crops such as redgram, Hibiscus, peas, beans, potatoes, turnips, tomatoes, etc., resulting in appreciable loss of economic products. Adults are black in color with orange bands on the body surface. They are medium-sized beetles, feed on pollen and petals of flowers; affecting fruit-setting.

Blister beetles have long (3/4" to 1-1/4"), narrow bodies, broad heads, and antennae that are about 1/3 the length of the entire body. The front wings are soft and flexible in contrast to the hard front wings of most beetles.

Damage: The adults feed on leaves in the tops of a plant but are especially attracted to flowers where they feed on nectar and pollen. They gather in groups, so large numbers can occur in concentrated clusters in a field.

Life cycle: Female blister beetles lay clusters of eggs in the soil in late summer. The small, active larvae that hatch from these eggs crawl over the soil surface entering cracks in search for grasshopper egg pods which are deposited in the soil. After finding the egg mass, blister beetle larvae become immobile and spend the rest of their developmental time as legless grubs. The following summer they transform into the pupal stage and soon emerge in the adult stage. This is why blister beetle numbers increase dramatically following high grasshopper populations.

Management 1. Collect and destroy adults manually or by using sweeping nets during morning hour. 2. Use neem oil cake in the soil to kill the larvae.

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3. Spray Malathion @ 2 ml /liter of water for effective control.

6) Snake gourd semilooper, Plusia peponis; Lepidoptera: Noctuidae

Adults are Brown moth with shiny brown forewings. Eggs are white spherical laid singly on tender leaves. Larva is green in colour with longitudinal white stripe, humped last abdominal segments. Pupation takes place inside the leaf fold.

Damage: Mostly caterpillar causes damage by feeding on leaves. The caterpillar cuts the edges of leaf lamina, folds it over and feeds from within rolled leaf.

Management 1. Collect and destroy the caterpillars 2. Encourage activity of Apanteles taragamae, A. plusiae to control moth.

3. Spray insecticides like malathion 50% EC @ 2ml/liter water or dimethoate 30% EC 500 ml/ha.

INSECT PEST OF BRINJAL

1) Brinjal Shoot and Fruit Borer, Leucinoides orbonalis; Lepidoptera: Pyralidae

Brinjal shoot and fruit borer is one of the serious pests in brinjal. Adult is medium sized moth with forewings having black and brown patches and dots on white color wings. Hind wings are opalescent with black dots. Larva is soft, fleshy and pink in color. Eggs are creamy white and Pupa is grayish colored boat shaped cocoon.

The adult lays eggs on leaves, flower and fruits. Within about a week they hatch into larvae. Upon hatching they start boring from the tender shoots and feed on the stem and inside the fruits. There appears wilting in the damaged shoot. In severe infestation the growing points are killed. Full grown larvae come out of their feeding tunnels and pupate in tough silken cocoons among the fallen leaves which again enter into adult. In epidermis, the loss may ranges above 50% however early and heavy rain may lower down the attack to a great extent.

Damage: Larva is most destructive and bore in to the terminal shoots in young plants, causing withering of terminal shoots. Heavy infestation leads to drying of leaves due to boring of petioles, shedding of flower, buds. Boring of larvae on fruits causes fruit rotting and loss of yield. Fruits are found with bore holes, holes are filled with larval excreta. Adults are medium size marked with black and brown patches on forewing.

Management

1. Destruction of infested stems, fruits and fallen leaves from the orchard.
2. Crop rotation, Solanaceous crop year after year in the same field cause increased infestation.
3. Eggplant varieties with round type of fruits are much susceptible to EFSB so grow slender type of fruits (Neupane, 2000).
4. Use nylon net barrier in nurseries to prevent spreading of insect from nursery to main field.
5. Grow location specific eggplant varieties moderately tolerant to EFSB such as Pusa Kranti and Nurki at the Kathmandu valley, Lurki at Baglung and Parbat areas, Pusa long at Dhading, green long and Pusa Kranti at Tarahara areas of Sunsari. 6. Cut and destroy wilted and borer damaged plant parts during pre-flowering and flowering period at weekly intervals. 7. Collect and destroy borer infested flower buds and fruits during each harvest to prevent migration of caterpillar from fruit to fruit. 8. Transplant eggplants in early June to minimize losses by shoot and fruit borer (Leucinodes orbonalis) in Kathmandu valley condition. 9. Grow barrier crops such as maize around the eggplant crop field.

10. Adopt clean cultivation practices.

11. Avoid continuous cropping of eggplants in the same field.

12. Grow EFSB moderately tolerant eggplant varieties, such as Green long, Pusa Kranti, Pusa purple long PBR 129-5, 517-4, H-128, H-129. 13. Install pheromone trap with Lucin-lure for monitoring of male moth. 3-4 moths per traps

indicate to start management operation. 14. Create physical barrier using nylon net of 2m high and cover the eggplant field to check the entry of moths into the healthy field from infested field. 15. Release Trichogramma chilonis in the crop field @ 250000 parasitized eggs per ha @ 50,000 release for 5 times at weekly intervals, starting from flowering. 16. Spray crude Neem seed extract @5% or Neemarin (Azaardiractin 0.03%) @ 5 ml per litre water.

17. Spray Bacillus thuringiensis (Bt) based commercial formulations such as DIPEL or BIOLEP @ 3gm per ltr in the evening hours at 10 days interval.

18. Spray chemical insecticides such as Thiodine 35% EC (endosulfan) @ 1.5 ml per ltr of water to manage borer.

19. Spray of seed kernel extract (NKSE) @5 gm grinded powder/ ltr water or 0.07% solution of Dipel (Bacillus thuringiensis).

2) Brinjal stem borer, Euzophora perticella; Lepidoptera: pyralidae
Host: brinjal, chillies, potato and tomato

Damage: This pest attacks on brinjal, chilies, potato and tomato plants. Pest remains active when hot weather starts. Adult lays eggs on the leaf and axils of young branches. After hatching the

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young larva feed on exposed plant parts before boring into the stem where they make tunnels. Damage is caused by the caterpillars only in the stems but not into the fruits resulting the withering and drying up of plants. Full grown larvae hibernate in the stems of old plants and transform themselves into adults.

Life cycle: Eggs 3-5 days larvae 10-15days pupa 6-8 days adult

Management 1. Plant should not be ratooned. 2. Planting of new seedling should be done each year.

3. Chemical same as fruit and shoot borer.

3. Spotted beetles (Henosepilachna vigintioctopunetata, Epilachna dodecastigma), Coleoptera: Coccinellidae

The life cycle and management may be same as in the cucurbit spotted beetles.

4. Root knot nematodes (Meloidogyne sp)

5. Cotton jassid (Amrasca biguttula biguttula); Homoptera: Cicadellidae

Host: Cotton, Tomato, Potato, Brinjal, Cucumber, Pumpkin

Both nymph and adult of cotton jassid suck cell sap from leaf. The infested leaf turns red and rusted with change in appearance. Leaf turns downward, dry out and fall on the ground. They are also carrier of viral disease in tomato like tomato leaf curl mosaic virus.

Life cycle Eggs

4-11 days Nymph

1 week (in summer) Adult

3 week (in winter) Management Same as whitefly

Management of these pests is same as described in the tomato crops.

6. Aphids (Aphis gossypii); Homoptera: Aphididae

Several aphid species may be commonly found infesting the crops during most of the growing seasons. The most common aphids are the green peach aphid. Honeydew production by aphids can leave a sticky film on the surface of the fruit and cause the development of sooty mold fungi. Various species of aphid can also transmit viruses, notably potato virus Y, which can reduce yields. Aphid infestation may begin in any stage of the crops.

Winged adult aphids develop periodically and disperse from fields following periods of overcrowding. Colonies are found on the undersides of leaves, usually in the lower canopy.

Management:

Many of the insecticides used to control these pests can contribute to rapid increases of aphids. Natural enemies such as lady bird beetles, green lacewings, damsel bugs and hover fly larvae usually control aphid populations adequately. Broad spectrum insecticides, particularly pyrethroid insecticides, can delete these natural enemies and allow aphids populations to develop

. unchecked. Insecticides should only be applied for other insects when necessary, as determined by trap catches and scouting and care should be taken to select insecticides that do not favor secondary aphid problems.

INSECT PESTS OF CABBAGE:

1) Diamond back moth, *Plutella xylostella; Lepidoptera: Plutellidae*

Plutella xylostella is a small greyish brown moth. It measures 12-16mm in body length. Forewings have three white triangular spots along the inner-margin. When at rest the triangular markings of opposite wings gives diamond shape, hence named "Diamond black moth". Hind wings have a fringe of long fine hairs. Larva is Pale yellowish green caterpillar. Pupation takes place on the foliage in a transparent cocoon.

Symptoms of damage: Young caterpillars cause small yellow mines on leaves; they feed by scraping leaf tissue. The infested plant parts get converted into typical white patches. Scrapping of epidermal leaf tissues producing typical whitish patches on leaves. Full-grown larvae make bite holes in the leaves and feeds on curd. There is formation of undersized curd in cauliflower and head formation does not take place in cabbage in severe infestation.

Life cycle: Life cycle completes from 4 stages i.e. adult, egg, larvae and pupa. Adults are dusty in color having three light brown to white, triangular marks on the posterior margin of the front wings, which forms a diamond pattern at rest. Adult lay eggs in batches on the underside of the leaves. Eggs are light greenish in color and nearly oval shape. Eggs hatches abov e 25°C in two days. Newly hatched larvae are pale green in color. The first instar larvae mine the leaf and fed on the mesophyll tissue. Their presence is dedicated with the blackish excreta in the mouth of the tunnel. Full grown larvae seem to green in color having minute hairs. The larvae coils when touched, they feed on matures leaves. The larvae construct an open cocoon on the lower surface of the leaf of the host plants. The caterpillars damage the heart of the first two, central leaves of cabbage and cauliflower which rendered unfit for human consumption. The initia l attack on AugSep. incurred huge crop loss. In the beginning, pupa seems to be green in color but in advance stage, brown in color. Pupation may take around 2 weeks depending on the temperature. Total development time from the egg to pupal stage averages

25 to 30 days, depending on weather, with a range of about 17 to 51 days. The number of generations varies from four in cold climates to perhaps eight to 12 in the hot climate. Eggs 3-6 days Larva 14-21 days Pupa 4-5 days Adult

Diamond back moth

Management

1. Remove and destroy all debris and stubbles after harvest of crop.
2. Grow mustard as trap crop at 2:1 ratio (cabbage: mustard) to attract DBM for oviposition at least 10 days ahead of planting of main crop.

3. Intercrop tomato with cabbage to i nhibit egg laying by moth. (Tomato excret volatile compound that inhibit egg laying)
4. Collect and destroy larvae mechanically in early stage of infestation.
5. Pheromone traps with DBM lure@ 12trap/ha. 7. Crop rotation with cucurbits, beans, peas, tomato and melon
6. Use larval parasitoid: Diadegma semiclausm @ 100,000/ha (Hills below 25 –27° C) Cotesia plutellae (plains) at 20000/ha. Release from 20 days after planting of main crop.

7. Apply Bacillus thuringiensis var kurstaki 2g/lit water.
8. Use neem seed kernel extract 5% or neem based pesticide @ 5ml/lit water.
9. Spray cartap hydrochloride 0.5% at 10, 20 and 30 DAS (nursery) and primordial stage.

2) Mustard Aphids *(Lipaphis erysimi)* and **Cabbage Aphid** *(Brevicoryne brassicae)*; **Homoptera:** Aphididae

Aphids are small, soft-bodied, pearl-shaped insects. Body length measures 1.4-2.4 mm. It is yellowish green or blackish green in color and lightly covered with powder which form a white wax bloom. Male aphids are olive-green to brown in color. Aphid has two modes of producing young**;** fertilization of females by males resulting in the production of eggs (sexual reproduction), and the birthing of live female nymphs by adult females without fertilization by males (parthenogenesis).

Damage: The aphid attacks generally during December and continues till March. The most favorable temperature is 200C or below. Cloudy and cold weather help in accelerating the growth of insects. About 45 generations are completed in a year. Both nymph and adults suck the sap from leaves, buds and pods. Curling of infested leaves occurs and at advanced stage plants may wither and die. Plants remain stunted and sooty molds grow on the honey dew excreted by the insects.

Management
Biological Control

1. Conserve/ release Ladybird beetles viz., Cocciniella septempunctata, Hippodamia variegata and cheilomones vicina are most effcient pradators of the mustard aphid. Adult beetle may feed an average of 10 to 15 adults/day. 2. Several species of syrphid fly i.e., Sphaerophoria spp., Eristallis spp., Metasyrphis spp. , Xanthogramma spp and Syrphus spp. are predating on aphids. 3. The lacewing, Chrysoperla carnea predates on the mustard aphid colony.

Cultural Control

1. Use tolerant varieties.
2. Apply recommended dose of fertilizers. Avoid using excess of nitrogenous fertilizer.
3. Install yellow pan trap with 1% kerosene water or yellow sticky traps at crop height in the field.
4. Dust wood ashes on plant foliage in the morning hours.
5. Spray mixture of wheat flour and water as foliar spray to prevent aphid activity through suffocation and dehydration.
6. Spray cattle urine diluted with water at a ratio of 1:4.
7. Spray aqueous extract of leaf/stem of Mentha arvensis (200g per 1. 33 liter of water) to manage mustard aphid.

Chemical Control

1. Spraying should be done at ETL level.
2. Spraying should be done in evening time.
3. Spray the crop with one of the following insecticides in the aphid appearance; Imidacloprid 17.8% @ 0.25 ml/l water, Dimethoate 30EC @ 1 ml/l of water.

DISEASE OF CABBAGE:
Downy Mildew (*Peronospora parasitica*)
Symptoms

Disease is observed on the leaves. Fine hair like downy growth of fungus is observed on the lower surface of leaves. Corresponding of the fungal growth there is minute pinhead brown necrotic spots visible on the upper surface of leaves, which later on coalesce to each other. It may appear from nursery to curd formation stage.

Management

Field sanitation, disease-free seed and crop ™™ rotation reduce pathogen inoculum. Foliar spray of Mancozeb @ 0.25% at disease initiation ™™ stage and repeat next spray at 6-8 days interval. One spray for Metalaxyl + Mancozeb @ 0.2% in ™™ severe case may be given but do not repeat. Use sticker @ 0.1% with fungicide to avoid runoff of droplets.

Alternaria Leaf Spot (*Alternaria brassicae and A brassicicola)*

Symptoms

Alternaria leaf spot usually appears in early stage of plant growth in caulifl ower while in later stage in cabbage. Alternaria leaf spots are restricted to lower leaves only and do not cause economic loss to the crop except when some of the hybrid varieties of caulifl ower are used. Symptoms appear as circular light brown spots on leaves. Concentric rings are clearly visible on the spots. Black sporulation is observed in humid weather. Cabbage infections do not extend very far in the host tissue. Infl orescence and siliqua are severely infected during seed crop. The curd of caulifl ower infected as brown discoloration of individual fl orets and fl ower clusters.

Management

Alternaria leaf spot of cole crops is eff ectively managed by detaching all the infected lower leaves in morning and then burning. Spray of Chlorothalonil @ 0.2% along with sticker @ 0.1% in evening hour. Use disease-free seeds from healthy crop. One spray of Mancozeb @ 0.25% along with sticker during siliqua formation.

White Rot (*Sclerotina sclerotiorum*)

Symptoms

Disease appears as water soaked rotting of curd, petiole, stalk and stump region of the leaves. Soon after infection, growth of white mycelium is observed all over the infected portion. Caulifl ower grown for seed production is severely aff ected by the disease and entire infl orescence collapses. The mycelium develops honeydew stage after colonization of the tissue. Later on entire rotted portion is converted into compact mycelial mat followed by hard black sclerotial body. This is the resting structure and primary inoculum source.

Management

Main crop of caulifl ower and cabbage should be periodically observed near the stump region in cool, cloudy and moist weather for primary infection. Cut the infected curds, leaves along with some ™™ healthy portion in morning and carefully collect in polythene to avoid falling of sclerotia in the fi eld. Burn all these materials away from field. Foliar spray of Carbendazim @ 0.1% at fl owering ™™ stage, followed by spray of Mancozeb @ 0.25% along with sticker @ 0.1%. Spray must cover stump and lower region of leaves.

Bacterial Black Rot *(Xanthomonas campestris pvcampestris)*

Symptoms

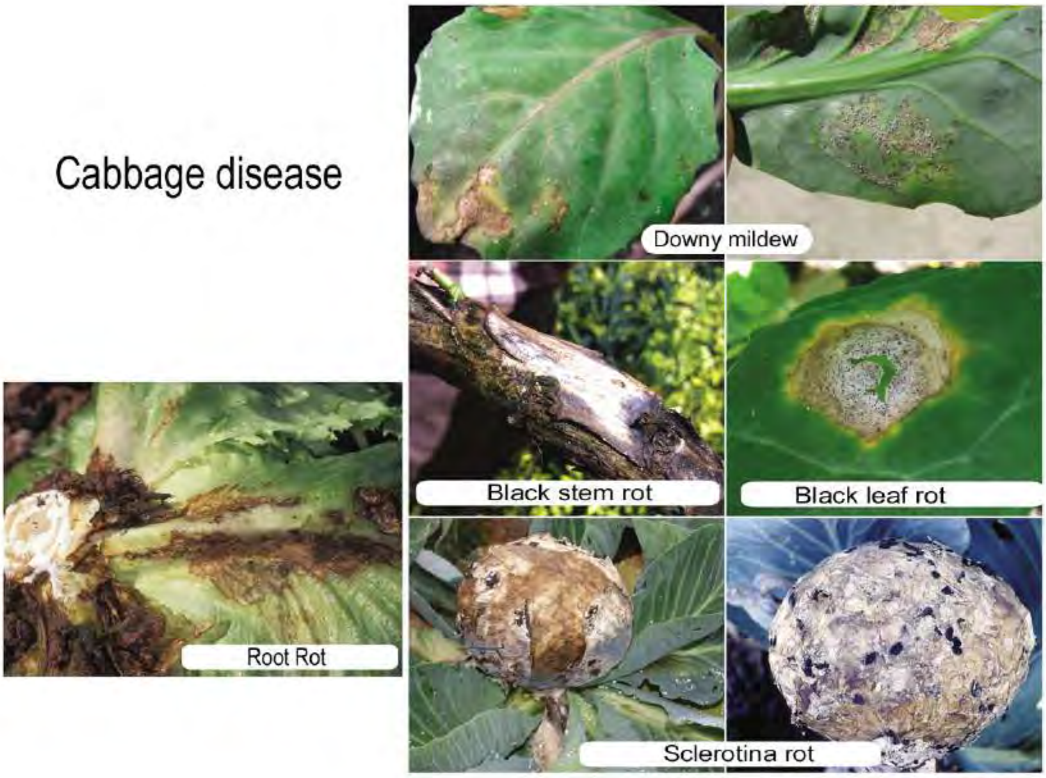
The disease often appears along the margins of leaves as chlorotic lesions and chlorosis progresses in the direction of midrib usually forming V shaped area, which is the most characteristic symptom of the disease. Some of the veins and veinlets within chlorotic area turn black in severe cases. Black vascular scar is observed on any detached infected leaves, midribs and veins. Yellowing of leaves was observed from lower portion of mid vein in severe infection. Disease severity increases rapidly whenever hailstorm is taking place in cropping season. Symptom may appear from any side and centre of the leaves. Severe infection results in complete burning of crop of caulifl ower before the curd formation. The bacterium is transmitted through seed which usually enters in the cotyledons through stomata, pass to the young leaves and progress systematically throughout the plant system. The foliage i nfection and transmission is through water pores, insect injury, infested soil, storm, cultural practices and seedlings.

Management

Always collect seeds from disease-free plants for next year use. Seed treatment with hot water (50™™ 0 C for 30 minutes) or seed dipping in 100 ppm antibiotic solution for 30 minutes. Crop rotation with non-cruciferous crops. Use intercrop of urd and mung as mulches to reduce rain splash. Detach the lower infected leaves in afternoon when dew and bacterial ooze dried up from the leaves and then burn it.

Nursery site should be changed frequently to avoid seedling infection. Use antagonistic bacteria in the soil. Spraying of antibiotic like Streptocycline @ 150-200 ppm or Kasugamycin @ 0.2% at 10-15 days interval. Mixture of steptrocycline @ 100 ppm and copper oxycholoride @ 0.3% with sticker @ 0.1% should be used if Alternaria infection also exists on the foliage giving good control of both the diseases. The cauliflower variety Pusa Snowball K-1, Super Snowball and cabbage variety Pusa Mukta possesses high degree of tolerance to black rot pathogen.

Cabbage disease



Crop Insects pests Cabbage

Tobacco catepillar
Spodoptere litura

Cabbage webworm
Hellula undalis

Cabbage cutworm
Agrotis sp

POTATO PEST AND DISEASE:
POTAO PEST:

1) Potato tuber moth, Phthorimaea operculella; Lepidoptera: Gelechiidae

Potato tuber moth is serious pest of potato both in field and storage condition. Potato tuber moth is pale brown moth with 10mm body length and 12mm wing expansion. Forewings are pale brown with small brown blotches and hind wings are pale grey in color. Larvae are pink or green with dark brown head while they are grey or yellow-white in young stage. They are active at night, and rest under clods of earth or leaves during the daylight.

Damage: Damage is caused by larvae by tunneling in leaves. The mines have a blotchy appearance, and are often associated with brown and dying bits of tissue. One larva makes 3-4 tunnels, gradually filling them with excrement. They create twisting tunnels in fruits and tubers. In potatoes, towards the end of the season, the caterpillars move down the plant towards the exposed tubers in the soil. Here the first sign of infestation is the appearance of grey or whitish frass on the surface of the tubers, usually near the "eyes." Infestation can continue in the potato store room infested potatoes soon become filled with unsightly black tunnels. Larvae can be seen if we cut infested tuber.

Life cycle: Tiny pearly white eggs are laid singly or in clusters of up to six on sheltered spots on the plants, on the ground near the plants, or on exposed potatoes. They are oval in shape and hatch in about a week. Newly hatched larvae wander around briefly before eating their way into leaves, stems or tubers. The rest of the larval development (passing through four instars) takes place within the plant tissues, and takes up to three weeks (depending on temperature). The caterpillars then leave the plant, moving down to the soil, and spin a loose cocoon to pupate. Pupal development takes about a week, but may be much longer during winter. During the summer the whole cycle takes about a month but may extend to ten weeks during winter.

Management

A) In field condition

1) Controlling alternate weed hosts, clean harvesting of potatoes and careful ridging during and at the end of the growing season.

2) Where potatoes are grown all year round control measures may need to be taken early.

3) Releasing egg-larval parasitoid. Chelonus blackbumi at 30,000/ha twice, 40 and 70 days after planting helps in management.

4) Seed tubers should be free from PTM infestation.

5) Synchronize planting time of potato in localities.

6) Practice deep planting of tubers (upto 10cm).

7) Irrigate potato field timely to avoid soil surface cracking during tuber formation.

8) Harvest tubers before drying or yellowing of plants.

9) Spray Roger 30% EC @ 1.5ml/liter water.

B) In storage condition

1) Dispose all discarded tubers by burying under soil.

2) Take away harvested tubers immediately from the field to store room or cold store for storage.

3) Submerge table potatoes in water for 24 hr and shade dried before storage.

4) Use Pheromone trap like PTM1 and PTM 2 to attract male mass @ 4 capsule/100m3 volumes.

5) Avoid mixing together the old lot and new lot.

6) Store potato tubers inside nylon net to avoid contact of PTM with tubers for oviposition.

7) Cold storage (< 5˚c) of potatoes.

8) Mix sweet flag powder with tubers @ 2g/kg.

9) Dip potatoes tubers in 0.05% solution of Malathion 50% EC.

2) Red Ants, *Dorylus orientalis; Hymenoptera: Formicidae*

Damage: Red ants are polyphagous insect pest. Worker ants are responsible for damage in crops. Nest is usually built down the soil at a depth of 1.5-2 meter. Worker ants search for food in an underground trail from their colony to the food resource areas. They feed on underground parts of plant like roots, tubers and underground stems. Plants infested by red ants wilts, turn yellow and dies because of hindrance in translocation of nutrients and water from underground part to foliage. During early infestation, wilting of plant is temporary that occurs during day time and recovers in morning. Permanent wilting occurs in severe infestation. Red ants cause heavy loss in potato, root crops and crucifer crops.

Management

1) Follow cultural practices like deep ploughing which diturb the ant colony before planting of crop. 2) Drench aqueous solution of Azadirachtin @ 100 ml per plant in soil near plant stems.

3) Drench soil around plant with 24 hr fermented and diluted cow urine (5 parts water in 1 part urine) mixed with tobacco dust @ 100 ml/plant at tuber initiation stage and repeat treatment after 30 days of first treatment. 4) Place non poisonous bait into soil at depth of 2 cm to monitor the presence of ant in field. In case of presence of ant, place baits poisoned with chloropyrifos 20% EC @ 1.5 ml per liter water. 5) Apply Chloropyrifos 10% G @ 1 kg per 500m2 before planting. Application of Chloropyrifos in soil has been found effective to manage red ants.

3) Leaf Miner, *Liriomyza huidobrensis; Diptera: Agromyzidae*

Adult leaf miner fly is small, greenish- black, compact bodied insect pest. It is 1-2mm in body length. Maggots are 3.5 mm long with yellow-orange color. The posterior spiracles each have 6 to 9 pores.

Damage: Larvae cause damage by mining into leaves and petiole. Mines are usually white speckles with black brown dried area which is associated with midrib and lateral leaf veins. The feeding punctures and the mines reduce the value of the crop which is rendered unsellable. Photosynthesis is severely affected and there is delayed growth of vegetation (smaller plants, smaller flowers).

Management

Prevention

Sticky traps can be used to monitor adult flies. Crop rotation is an

effective pest management tool as is avoiding varieties which are highly susceptible to leaf-miner infestations (e.g. some chrysanthemums) in greenhouses.

There is little information about leaf-miner tolerance of vegetables in the field.

Mechanical

In field vegetables, cultivation of crop debris or removal of infected plant material is recommended.

Biological

Parasitoid wasps, e.g., Diglyphus isaea and Dacnusa sibirica are available for control in greenhouse crops.

These parasites will not be effective for vegetables growing in the field. However there may be natural parasites present that can reduce the population.

Chemical

Liriomyza huidobrensis adults are resistant to conventional insecticides. At present, the only effective insecticides are translaminar insecticides (abamectin, cyromazine, neem and spinosad), which penetrate the leaves to affect the leaf-miner larvae. Spray Roger 30% EC @ 1ml/liter water.

4) Cutworms, *Agrotis spp., Noctuidae, Lepidoptera a) A. segetum*

Damage: Leaves, stalks and stems of the affected plants show external feeding with abnormal leaf fall. In case of roots and stems both external and internal feedings are visible. The whole leaf may fall off the plant after being cut through at the base of the stalk by the larvae. . Affected plant stages: Seedling and vegetative stages. Affected plant parts: Leaves, roots and stems. Cutworms exhibit two types of feeding patterns depending upon the amount of moisture in the soil and size of plants. Where soil moisture is adequate and plants are small, the larvae hide in the soil during the day and move to the soil surface at night where they cut off plants just above the soil surface. One larva will cut off an average of five corn plants during its development. In situations of dry soil conditions, the larvae do not move to the surface to feed, but instead, they chew into the plant just below the soil surface. This causes the corn plants to wilt and usually die.

MAJOR AND MINOR PESTS OF SUMMER VEGETABLES

Major vegetables under this group include cucurbits, brinjal, and chilies. Insect pests of cucurbit vegetables

1) Red Pumpkin beetle, *Aulacophora foveicollis;* Coleoptera: Chrysomelidae

Red Pumpkin beetles are very serious, important and destructive pest of all cucurbits and occur throughout the country. Adult s beetles are 6 to 8 mm long and having glistering yellowish red to yellowish brown elytra that are uniformly covered with fine punctures. Freshly hatched grubs are dirty white in color where as full grown ones are creamy to yellow and about 22 mm long.

Life cycle: Eggs are laid in soil around the host plant. Eggs are spherical in shape and yellowish pink in color. Eggs are laid to a depth of 25 mm near the plant. A single female lays upto 300 eggs during its life time. Upon hatching the eggs into grubs they start to bore into the roots, stem and later into the leaves. The larvae enter into the soil and pupation occurs into the soil. During winter they hibernate into the soil and reappears onwards May. There are 4 moulting stages and are altogether 5-8 generation in a year.

Eggs 6-7 days Larva (Grub) 13-25 days Pupa 7-17 days Adult

Nature of damage: Both adult and grub are destructive and cause direct damage to plant. Adult beetles feed voraciously on the leaf lamina and make irregular holes on leaf. The maximum damage is done by adult in the cotyledon stage. The adult insect also feed on older leaves of plant by scrapping off their chlorophyll and thus leading to leaves net like appearance. The attacked plants may wither away and photosynthesis is directly affected. The larvae cause damage by boring into the roots and the underground stem portion and also by feeding on the leaves and fruits line in contact with the soil.The infested roots and the underground roots may rot due to infection by the saprophytic fungi.The young and smaller fruits of the infested crop may dry up, whereas mature fruits become unfit for human consumption.

maggots which start to bore the pulp. The attack fruit decay because of secondary bacterial infection. The mature larva comes out of the rotten fruits and may bury inside the soil as pupae. Pupation mainly occurs in the soil around 2 inches below from the ground surface. Sometimes, larva may remain inside the fruit where it pupate and transform themselves into winged adults. There may be 8-10 generation a year.

Management:

1. Follow clean cultivation, collect and destroy infested fruits.
2. Deep ploughing to expose hibernating stages of fly.
3. To prevent egg laying by adult, set up fly traps (pheromons trap) in the field with 1% Cue lure or Methyl Eugenol or Cintronella oil or Vinegar or Acetic acid or Lactic acid or ammonia liquid or Vanilla or Pollard mixture.
4. Cover developing young fruits with paper or polythene cover or muslin cloth.
5. Grow Maize plants as trap crop in rows at a distance of 8-10cm in cucurbit field as flies rest on such tall plants.
6. Use extract of neem fruit, tobacco or zinger to repel female flies.
7. Parasitoid Fopius arisanus introduced in the IPM program.
8. Male sterile technique is accomplished through irradiation, chemo – sterilization.
9. Use protein bait (protein derived from corn, wheat or the other sources).
10. Spray Malathion @ 2 ml/litre of water at fortnightly intervals.

3) Epilachna beetle or Spotted beetle; *Coleoptera: Coccinellidae*

• Epilachna dodecastigma (having 6 black spots in each elytra) • Henosepilachna vigintioctopunctata (having 7 or 14 black spots on each elytra)

Epilachna beetle are major insect pest of gourds, cucumber, bitter gourd, watermelon, muskmelon and other cucurbitaceous crops. It is serious pest of bitter gourd. Many beetles under this group are useful bio-control agents against the aphids and other small insects. Damage is caused by beetles as well as by the grubs. Adults are

6-8mm long and similar to lady bird beetles in appearance. Larvae are 5-7mm long, soft bodied and covered with spines. Both larva and pupa are yellow in color and body is covered with spines. The distinguishing characteristics of H. vigintioctopuntata are deep red and usually have 7-14 black spots on each elytron whereas, E. dodecastigma have 6 black spots on each elytron.

Life cycle Eggs 3-5 days Larva (Grub) 1-2 week Pupa 2-5 days Adult Life cycle passes from 4 stages. The adult hibernate among heaps of dry plants or in cracks and crevice in the soil. Pest remains active during March-April and Egg laying, grub stage and pupation occur on the underside of leaves. A single female can lay upto 400 eggs in her life time. Eggs are yellow in color. Many grubs and adults can be seen on the ventral surface of the leaves The eggs hatch into grubs which feed on the lower epidermis of leaves. The pupae fixed on the leaves, stem, and most commonly at the base of the plants. The grub enters into the adults. Both the adults and grubs cause damage by feeding on the upper surface of leaves. The eaten leaves turn into brown color and may fall in severe damage.

Damage: Both the adult and grub stages feed on the leaf surfaces and skeletonize the leaves and make leaves net like appearance. The attacked leaves turn brown, dry up and fall off. In case of severe infestation the crop shows very unhealthy look. The vigour of the plant and its yield is adversely affected.

Management

1. The pest population can be suppressed effectively, by regular killing and picking of eggs, grubs and adults, if the cropped area is small. 2. Larvae and adults can be shaken down in container of kerosinized water early in the morning. 3. Use neem based pesticide, Margosom.

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4. The pest can be killed by spraying Malathion/ Endosulfan/ Zythiol 50 EC @2 ml per liter of water. The treatment should be applied as soon as the pest appears in the field and repeated at 15 days interval.

4) Cucurbit stink bug, Aspongopus janus; Hemiptera: Pentatomidae

Adults are red and pale-brown bugs. The edges of the abdomen and underside of the insect have orange to orange – brown stripes. They suck the sap from the leaves and tender shoots and devitalize the plants. Both adult and Nymph cause damage with their piercing and sucking type mouth part.

Life cycle Eggs 3-5 days Nymph 4 weeks Adult
Eggs are laid on group s underside of leaf or stem. The nymphs have partial development of wings, whereas the adults have fully grown wings. The total life cycle completes within 4-5 weeks.
Management

1. Hand picking of adult and nymph in small scale. 2. Predators include; Tachnid fly, Trichopoda pennipes that attack older nymphs and adults. 3. Use botanical pesticedes like extract of Neem, Bakaino, asuro etc. 4. Spray malathion 50% EC @ 1.5ml/liter water.

5) Blister beetle, Mylabris orientalis; Coleoptera: Meloidae

Blister beetles are phytophagous in nature and extensively feed on flowers of many crops such as redgram, Hibiscus, peas, beans, potatoes, turnips, tomatoes, etc., resulting in appreciable loss of economic products. Adults are black in color with orange bands on the body surface. They are medium-sized beetles, feed on pollen and petals of flowers; affecting fruit-setting.
Blister beetles have long (3/4" to 1-1/4"), narrow bodies, broad heads, and antennae that are about 1/3 the length of the entire body. The front wings are soft and flexible in contrast to the hard front wings of most beetles.

Damage: The adults feed on leaves in the tops of a plant but are especially attracted to flowers where they feed on nectar and pollen. They gather in groups, so large numbers can occur in concentrated clusters in a field.

Life cycle: Female blister beetles lay clusters of eggs in the soil in late summer. The small, active larvae that hatch from these eggs crawl over the soil surface entering cracks in search for grasshopper egg pods which are deposited in the soil. After finding the egg mass, blister beetle larvae become immobile and spend the rest of their developmental time as legless grubs. The following summer they transform into the pupal stage and soon emerge in the adult stage. This is why blister beetle numbers increase dramatically following high grasshopper populations.

Management 1. Collect and destroy adults manually or by using sweeping nets during morning hour. 2. Use neem oil cake in the soil to kill the larvae.

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3. Spray Malathion @ 2 ml /liter of water for effective control.

6) Snake gourd semilooper, Plusia peponis; Lepidoptera: Noctuidae

Adults are Brown moth with shiny brown forewings. Eggs are white spherical laid singly on tender leaves. Larva is green in colour with longitudinal white stripe, humped last abdominal segments. Pupation takes place inside the leaf fold.

Damage: Mostly caterpillar causes damage by feeding on leaves. The caterpillar cuts the edges of leaf lamina, folds it over and feeds from within rolled leaf.

Management 1. Collect and destroy the caterpillars 2. Encourage activity of Apanteles taragamae, A. plusiae to control moth.

3. Spray insecticides like malathion 50% EC @ 2ml/liter water or dimethoate 30% EC 500 ml/ha.

INSECT PEST OF BRINJAL

1) Brinjal Shoot and Fruit Borer, Leucinoides orbonalis; Lepidoptera: Pyralidae

Brinjal shoot and fruit borer is one of the serious pests in brinjal. Adult is medium sized moth with forewings having black and brown patches and dots on white color wings. Hind wings are opalescent with black dots. Larva is soft, fleshy and pink in color. Eggs are creamy white and Pupa is grayish colored boat shaped cocoon.

The adult lays eggs on leaves, flower and fruits. Within about a week they hatch into larvae. Upon hatching they start boring from the tender shoots and feed on the stem and inside the fruits. There appears wilting in the damaged shoot. In severe infestation the growing points are killed. Full grown larvae come out of their feeding tunnels and pupate in tough silken cocoons among the fallen leaves which again enter into adult. In epidermis, the loss may ranges above 50% however early and heavy rain may lower down the attack to a great extent.

Damage: Larva is most destructive and bore in to the terminal shoots in young plants, causing withering of terminal shoots. Heavy infestation leads to drying of leaves due to boring of petioles, shedding of flower, buds. Boring of larvae on fruits causes fruit rotting and loss of yield. Fruits are found with bore holes, holes are filled with larval excreta. Adults are medium size marked with black and brown patches on forewing.

Management

1. Destruction of infested stems, fruits and fallen leaves from the orchard.
2. Crop rotation, Solanaceous crop year after year in the same field cause increased infestation.
3. Eggplant varieties with round type of fruits are much susceptible to EFSB so grow slender type of fruits (Neupane, 2000).
4. Use nylon net barrier in nurseries to prevent spreading of insect from nursery to main field.
5. Grow location specific eggplant varieties moderately tolerant to EFSB such as Pusa Kranti and Nurki at the Kathmandu valley, Lurki at Baglung and Parbat areas, Pusa long at Dhading, green long and Pusa Kranti at Tarahara areas of Sunsari. 6. Cut and destroy wilted and borer damaged plant parts during pre-flowering and flowering period at weekly intervals. 7. Collect and destroy borer infested flower buds and fruits during each harvest to prevent migration of caterpillar from fruit to fruit. 8. Transplant eggplants in early June to minimize losses by shoot and fruit borer (Leucinodes orbonalis) in Kathmandu valley condition. 9. Grow barrier crops such as maize around the eggplant crop field.

10. Adopt clean cultivation practices.

11. Avoid continuous cropping of eggplants in the same field.

12. Grow EFSB moderately tolerant eggplant varieties, such as Green long, Pusa Kranti, Pusa purple long PBR 129-5, 517-4, H-128, H-129. 13. Install pheromone trap with Lucin-lure for monitoring of male moth. 3-4 moths per traps

indicate to start management operation. 14. Create physical barrier using nylon net of 2m high and cover the eggplant field to check the entry of moths into the healthy field from infested field. 15. Release Trichogramma chilonis in the crop field @ 250000 parasitized eggs per ha @ 50,000 release for 5 times at weekly intervals, starting from flowering. 16. Spray crude Neem seed extract @5% or Neemarin (Azaardiractin 0.03%) @ 5 ml per litre water.

17. Spray Bacillus thuringiensis (Bt) based commercial formulations such as DIPEL or BIOLEP @ 3gm per ltr in the evening hours at 10 days interval.

18. Spray chemical insecticides such as Thiodine 35% EC (endosulfan) @ 1.5 ml per ltr of water to manage borer.

19. Spray of seed kernel extract (NKSE) @5 gm grinded powder/ ltr water or 0.07% solution of Dipel (Bacillus thuringiensis).

2) Brinjal stem borer, Euzophora perticella; Lepidoptera: pyralidae Host: brinjal, chillies, potato and tomato

Damage: This pest attacks on brinjal, chilies, potato and tomato plants. Pest remains active when hot weather starts. Adult lays eggs on the leaf and axils of young branches. After hatching the

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young larva feed on exposed plant parts before boring into the stem where they make tunnels. Damage is caused by the caterpillars only in the stems but not into the fruits resulting the withering and drying up of plants. Full grown larvae hibernate in the stems of old plants and transform themselves into adults.

Life cycle: Eggs 3-5 days larvae 10-15days pupa 6-8 days adult

Management 1. Plant should not be ratooned. 2. Planting of new seedling should be done each year.

3. Chemical same as fruit and shoot borer.

3. Spotted beetles (Henosepilachna vigintioctopunetata, Epilachna dodecastigma), Coleoptera: Coccinellidae

The life cycle and management may be same as in the cucurbit spotted beetles.

4. Root knot nematodes (Meloidogyne sp)

5. Cotton jassid (Amrasca biguttula biguttula); Homoptera: Cicadellidae

Host: Cotton, Tomato, Potato, Brinjal, Cucumber, Pumpkin

Both nymph and adult of cotton jassid suck cell sap from leaf. The infested leaf turns red and rusted with change in appearance. Leaf turns downward, dry out and fall on the ground. They are also carrier of viral disease in tomato like tomato leaf curl mosaic virus.

Life cycle Eggs

4-11 days Nymph

1 week (in summer) Adult

3 week (in winter) Management Same as whitefly

Management of these pests is same as described in the tomato crops.

6. Aphids (Aphis gossypii); Homoptera: Aphididae

Several aphid species may be commonly found infesting the crops during most of the growing seasons. The most common aphids are the green peach aphid. Honeydew production by aphids can leave a sticky film on the surface of the fruit and cause the development of sooty mold fungi. Various species of aphid can also transmit viruses, notably potato virus Y, which can reduce yields. Aphid infestation may begin in any stage of the crops.

Winged adult aphids develop periodically and disperse from fields following periods of overcrowding. Colonies are found on the undersides of leaves, usually in the lower canopy.

Management:

Many of the insecticides used to control these pests can contribute to rapid increases of aphids. Natural enemies such as lady bird beetles, green lacewings, damsel bugs and hover fly larvae usually control aphid populations adequately. Broad spectrum insecticides, particularly pyrethroid insecticides, can delete these natural enemies and allow aphids populations to develop

. unchecked. Insecticides should only be applied for other insects when necessary, as determined by trap catches and scouting and care should be taken to select insecticides that do not favor secondary aphid problems.

INSECT PESTS OF CABBAGE:

1) Diamond back moth, *Plutella xylostella; Lepidoptera: Plutellidae*

Plutella xylostella is a small greyish brown moth. It measures 12-16mm in body length. Forewings have three white triangular spots along the inner-margin. When at rest the triangular markings of opposite wings gives diamond shape, hence named "Diamond black moth". Hind wings have a fringe of long fine hairs. Larva is Pale yellowish green caterpillar. Pupation takes place on the foliage in a transparent cocoon.

Symptoms of damage: Young caterpillars cause small yellow mines on leaves; they feed by scraping leaf tissue. The infested plant parts get converted into typical white patches. Scrapping of epidermal leaf tissues producing typical whitish patches on leaves. Full-grown larvae make bite holes in the leaves and feeds on curd. There is formation of undersized curd in cauliflower and head formation does not take place in cabbage in severe infestation.

Life cycle: Life cycle completes from 4 stages i.e. adult, egg, larvae and pupa. Adults are dusty in color having three light brown to white, triangular marks on the posterior margin of the front wings, which forms a diamond pattern at rest. Adult lay eggs in batches on the underside of the leaves. Eggs are light greenish in color and nearly oval shape. Eggs hatches abov e 25°C in two days. Newly hatched larvae are pale green in color. The first instar larvae mine the leaf and fed on the mesophyll tissue. Their presence is dedicated with the blackish excreta in the mouth of the tunnel. Full grown larvae seem to green in color having minute hairs. The larvae coils when touched, they feed on matures leaves. The larvae construct an open cocoon on the lower surface of the leaf of the host plants. The caterpillars damage the heart of the first two, central leaves of cabbage and cauliflower which rendered unfit for human consumption. The initia l attack on AugSep. incurred huge crop loss. In the beginning, pupa seems to be green in color but in advance stage, brown in color. Pupation may take around 2 weeks depending on the temperature. Total development time from the egg to pupal stage averages

25 to 30 days, depending on weather, with a range of about 17 to 51 days. The number of generations varies from four in cold climates to perhaps eight to 12 in the hot climate. Eggs 3-6 days Larva 14-21 days Pupa 4-5 days Adult

Diamond back moth

Management

1. Remove and destroy all debris and stubbles after harvest of crop.
2. Grow mustard as trap crop at 2:1 ratio (cabbage: mustard) to attract DBM for oviposition at least 10 days ahead of planting of main crop.

3. Intercrop tomato with cabbage to i nhibit egg laying by moth. (Tomato excret volatile compound that inhibit egg laying)
4. Collect and destroy larvae mechanically in early stage of infestation.
5. Pheromone traps with DBM lure@ 12trap/ha. 7. Crop rotation with cucurbits, beans, peas, tomato and melon
6. Use larval parasitoid: Diadegma semiclausm @ 100,000/ha (Hills below 25 –27º C) Cotesia plutellae (plains) at 20000/ha. Release from 20 days after planting of main crop.

7. Apply Bacillus thuringiensis var kurstaki 2g/lit water.
8. Use neem seed kernel extract 5% or neem based pesticide @ 5ml/lit water.
9. Spray cartap hydrochloride 0.5% at 10, 20 and 30 DAS (nursery) and primordial stage.

2) Mustard Aphids *(Lipaphis erysimi)* and **Cabbage Aphid** *(Brevicoryne brassicae)*; **Homoptera:** Aphididae

Aphids are small, soft-bodied, pearl-shaped insects. Body length measures 1.4-2.4 mm. It is yellowish green or blackish green in color and lightly covered with powder which form a white wax bloom. Male aphids are olive-green to brown in color. Aphid has two modes of producing young**;** fertilization of females by males resulting in the production of eggs (sexual reproduction), and the birthing of live female nymphs by adult females without fertilization by males (parthenogenesis).

Damage: The aphid attacks generally during December and continues till March. The most favorable temperature is 200C or below. Cloudy and cold weather help in accelerating the growth of insects. About 45 generations are completed in a year. Both nymph and adults suck the sap from leaves, buds and pods. Curling of infested leaves occurs and at advanced stage plants may wither and die. Plants remain stunted and sooty molds grow on the honey dew excreted by the insects.

முட்டைக்கோஸ்
பயிரைத் தாக்கும் பூச்சி
முட்டைக்கோஸ் அசுவிணி :
பிரவிகாரின் பிராசிகே

Management

Biological Control

1. Conserve/ release Ladybird beetles viz., Cocciniella septempunctata, Hippodamia variegata and cheilomones vicina are most effcient pradators of the mustard aphid. Adult beetle may feed an average of 10 to 15 adults/day. 2. Several species of syrphid fly i.e., Sphaerophoria spp., Eristallis spp., Metasyrphis spp. , Xanthogramma spp and Syrphus spp. are predating on aphids. 3. The lacewing, Chrysoperla carnea predates on the mustard aphid colony.

Cultural Control

1. Use tolerant varieties.
2. Apply recommended dose of fertilizers. Avoid using excess of nitrogenous fertilizer.
3. Install yellow pan trap with 1% kerosene water or yellow sticky traps at crop height in the field.
4. Dust wood ashes on plant foliage in the morning hours.
5. Spray mixture of wheat flour and water as foliar spray to prevent aphid activity through suffocation and dehydration.
6. Spray cattle urine diluted with water at a ratio of 1:4.
7. Spray aqueous extract of leaf/stem of Mentha arvensis (200g per 1. 33 liter of water) to manage mustard aphid.

Chemical Control

1. Spraying should be done at ETL level.
2. Spraying should be done in evening time.
3. Spray the crop with one of the following insecticides in the aphid appearance; Imidacloprid 17.8% @ 0.25 ml/l water, Dimethoate 30EC @ 1 ml/l of water.

DISEASE OF CABBAGE:

Downy Mildew (*Peronospora parasitica*)

Symptoms

Disease is observed on the leaves. Fine hair like downy growth of fungus is observed on the lower surface of leaves. Corresponding of the fungal growth there is minute pinhead brown necrotic spots visible on the upper surface of leaves, which later on coalesce to each other. It may appear from nursery to curd formation stage.

Management

Field sanitation, disease-free seed and crop ™™ rotation reduce pathogen inoculum. Foliar spray of Mancozeb @ 0.25% at disease initiation ™™ stage and repeat next spray at 6-8 days interval. One spray for Metalaxyl + Mancozeb @ 0.2% in ™™ severe case may be given but do not repeat. Use sticker @ 0.1% with fungicide to avoid runoff of droplets.

Alternaria Leaf Spot (*Alternaria brassicae and A brassicicola)*

Symptoms

Alternaria leaf spot usually appears in early stage of plant growth in caulifl ower while in later stage in cabbage. Alternaria leaf spots are restricted to lower leaves only and do not cause economic loss to the crop except when some of the hybrid varieties of caulifl ower are used. Symptoms appear as circular light brown spots on leaves. Concentric rings are clearly visible on the spots. Black sporulation is observed in humid weather. Cabbage infections do not extend very far in the host tissue. Infl orescence and siliqua are severely infected during seed crop. The curd of caulifl ower infected as brown discoloration of individual fl orets and fl ower clusters.

Management

Alternaria leaf spot of cole crops is eff ectively managed by detaching all the infected lower leaves in morning and then burning. Spray of Chlorothalonil @ 0.2% along with sticker @ 0.1% in evening hour. Use disease-free seeds from healthy crop. One spray of Mancozeb @ 0.25% along with sticker during siliqua formation.

White Rot (*Sclerotina sclerotiorum*)

Symptoms

Disease appears as water soaked rotting of curd, petiole, stalk and stump region of the leaves. Soon after infection, growth of white mycelium is observed all over the infected portion. Caulifl ower grown for seed production is severely aff ected by the disease and entire infl orescence collapses. The mycelium develops honeydew stage after colonization of the tissue. Later on entire rotted portion is converted into compact mycelial mat followed by hard black sclerotial body. This is the resting structure and primary inoculum source.

Management

Main crop of caulifl ower and cabbage should be periodically observed near the stump region in cool, cloudy and moist weather for primary infection. Cut the infected curds, leaves along with some ™™ healthy portion in morning and carefully collect in polythene to avoid falling of sclerotia in the fi eld. Burn all these materials away from field. Foliar spray of Carbendazim @ 0.1% at fl owering ™™ stage, followed by spray of Mancozeb @ 0.25% along with sticker @ 0.1%. Spray must cover stump and lower region of leaves.

Bacterial Black Rot *(Xanthomonas campestris pvcampestris)*

Symptoms

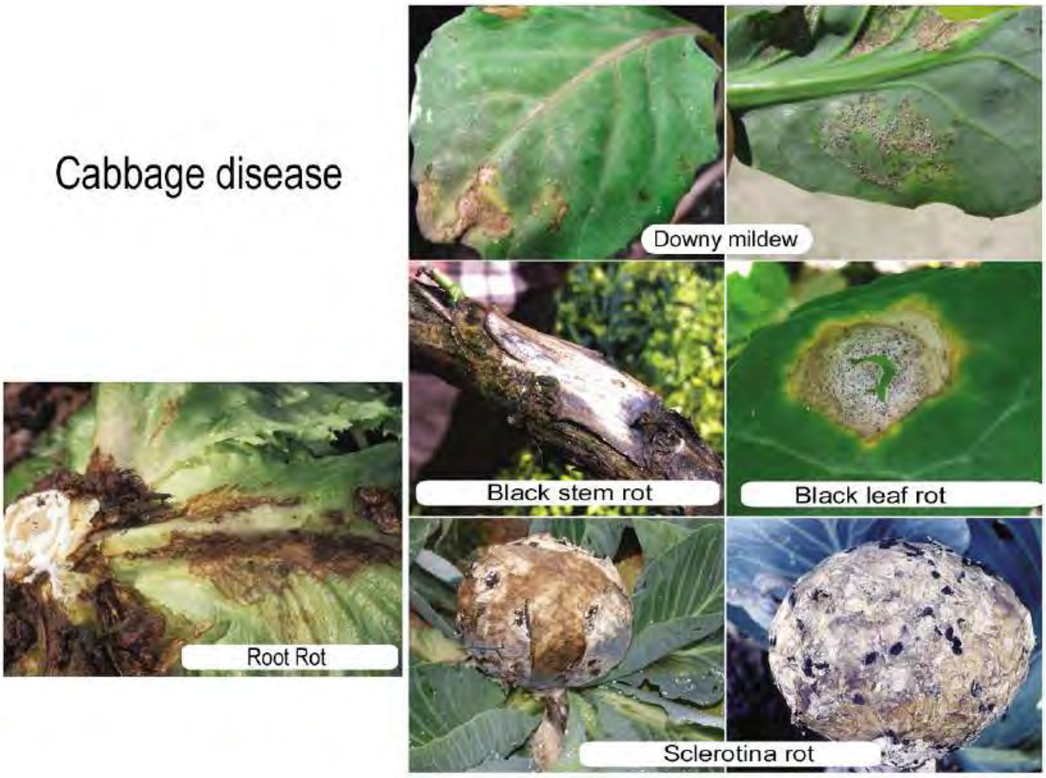
The disease often appears along the margins of leaves as chlorotic lesions and chlorosis progresses in the direction of midrib usually forming V shaped area, which is the most characteristic symptom of the disease. Some of the veins and veinlets within chlorotic area turn black in severe cases. Black vascular scar is observed on any detached infected leaves, midribs and veins. Yellowing of leaves was observed from lower portion of mid vein in severe infection. Disease severity increases rapidly whenever hailstorm is taking place in cropping season. Symptom may appear from any side and centre of the leaves. Severe infection results in complete burning of crop of caulifl ower before the curd formation. The bacterium is transmitted through seed which usually enters in the cotyledons through stomata, pass to the young leaves and progress systematically throughout the plant system. The foliage i nfection and transmission is through water pores, insect injury, infested soil, storm, cultural practices and seedlings.

Management

Always collect seeds from disease-free plants for next year use. Seed treatment with hot water (50™™ 0 C for 30 minutes) or seed dipping in 100 ppm antibiotic solution for 30 minutes. Crop rotation with non-cruciferous crops. Use intercrop of urd and mung as mulches to reduce rain splash. Detach the lower infected leaves in afternoon when dew and bacterial ooze dried up from the leaves and then burn it.

Nursery site should be changed frequently to avoid seedling infection. Use antagonistic bacteria in the soil. Spraying of antibiotic like Streptocycline @ 150-200 ppm or Kasugamycin @ 0.2% at 10-15 days interval. Mixture of steptrocycline @ 100 ppm and copper oxycholoride @ 0.3% with sticker @ 0.1% should be used if Alternaria infection also exists on the foliage giving good control of both the diseases. The cauliflower variety Pusa Snowball K-1, Super Snowball and cabbage variety Pusa Mukta possesses high degree of tolerance to black rot pathogen.

Cabbage disease



Crop Insects pests Cabbage

Tobacco catepillar
Spodoptere litura

Cabbage webworm
Hellula undalis

Cabbage cutworm
Agrotis sp

POTATO PEST AND DISEASE:
POTAO PEST:

1) Potato tuber moth, Phthorimaea operculella; Lepidoptera: Gelechiidae

Potato tuber moth is serious pest of potato both in field and storage condition. Potato tuber moth is pale brown moth with 10mm body length and 12mm wing expansion. Forewings are pale brown with small brown blotches and hind wings are pale grey in color. Larvae are pink or green with dark brown head while they are grey or yellow-white in young stage. They are active at night, and rest under clods of earth or leaves during the daylight.

Damage: Damage is caused by larvae by tunneling in leaves. The mines have a blotchy appearance, and are often associated with brown and dying bits of tissue. One larva makes 3-4 tunnels, gradually filling them with excrement. They create twisting tunnels in fruits and tubers. In potatoes, towards the end of the season, the caterpillars move down the plant towards the exposed tubers in the soil. Here the first sign of infestation is the appearance of grey or whitish frass on the surface of the tubers, usually near the "eyes." Infestation can continue in the potato store room infested potatoes soon become filled with unsightly black tunnels. Larvae can be seen if we cut infested tuber.

Life cycle: Tiny pearly white eggs are laid singly or in clusters of up to six on sheltered spots on the plants, on the ground near the plants, or on exposed potatoes. They are oval in shape and hatch in about a week. Newly hatched larvae wander around briefly before eating their way into leaves, stems or tubers. The rest of the larval development (passing through four instars) takes place within the plant tissues, and takes up to three weeks (depending on temperature). The caterpillars then leave the plant, moving down to the soil, and spin a loose cocoon to pupate. Pupal development takes about a week, but may be much longer during winter. During the summer the whole cycle takes about a month but may extend to ten weeks during winter.

Management

A) In field condition

1) Controlling alternate weed hosts, clean harvesting of potatoes and careful ridging during and at the end of the growing season.
2) Where potatoes are grown all year round control measures may need to be taken early.
3) Releasing egg-larval parasitoid. Chelonus blackbumi at 30,000/ha twice, 40 and 70 days after planting helps in management.
4) Seed tubers should be free from PTM infestation.
5) Synchronize planting time of potato in localities.
6) Practice deep planting of tubers (upto 10cm).
7) Irrigate potato field timely to avoid soil surface cracking during tuber formation.
8) Harvest tubers before drying or yellowing of plants.
9) Spray Roger 30% EC @ 1.5ml/liter water.

B) In storage condition

1) Dispose all discarded tubers by burying under soil.
2) Take away harvested tubers immediately from the field to store room or cold store for storage.
3) Submerge table potatoes in water for 24 hr and shade dried before storage.
4) Use Pheromone trap like PTM1 and PTM 2 to attract male mass @ 4 capsule/100m3 volumes.
5) Avoid mixing together the old lot and new lot.
6) Store potato tubers inside nylon net to avoid contact of PTM with tubers for oviposition.
7) Cold storage (< 5°c) of potatoes.
8) Mix sweet flag powder with tubers @ 2g/kg.
9) Dip potatoes tubers in 0.05% solution of Malathion 50% EC.

2) Red Ants, *Dorylus orientalis; Hymenoptera: Formicidae*

Damage: Red ants are polyphagous insect pest. Worker ants are responsible for damage in crops. Nest is usually built down the soil at a depth of 1.5-2 meter. Worker ants search for food in an underground trail from their colony to the food resource areas. They feed on underground parts of plant like roots, tubers and underground stems. Plants infested by red ants wilts, turn yellow and dies because of hindrance in translocation of nutrients and water from underground part to foliage. During early infestation, wilting of plant is temporary that occurs during day time and recovers in morning. Permanent wilting occurs in severe infestation. Red ants cause heavy loss in potato, root crops and crucifer crops.

Management

1) Follow cultural practices like deep ploughing which diturb the ant colony before planting of crop. 2) Drench aqueous solution of Azadirachtin @ 100 ml per plant in soil near plant stems.

3) Drench soil around plant with 24 hr fermented and diluted cow urine (5 parts water in 1 part urine) mixed with tobacco dust @ 100 ml/plant at tuber initiation stage and repeat treatment after 30 days of first treatment. 4) Place non poisonous bait into soil at depth of 2 cm to monitor the presence of ant in field. In case of presence of ant, place baits poisoned with chloropyrifos 20% EC @ 1.5 ml per liter water. 5) Apply Chloropyrifos 10% G @ 1 kg per 500m2 before planting. Application of Chloropyrifos in soil has been found effective to manage red ants.

3) Leaf Miner, *Liriomyza huidobrensis; Diptera: Agromyzidae*

Adult leaf miner fly is small, greenish- black, compact bodied insect pest. It is 1-2mm in body length. Maggots are 3.5 mm long with yellow-orange color. The posterior spiracles each have 6 to 9 pores.

Damage: Larvae cause damage by mining into leaves and petiole. Mines are usually white speckles with black brown dried area which is associated with midrib and lateral leaf veins. The feeding punctures and the mines reduce the value of the crop which is rendered unsellable. Photosynthesis is severely affected and there is delayed growth of vegetation (smaller plants, smaller flowers).

Management

Prevention

Sticky traps can be used to monitor adult flies. Crop rotation is an

effective pest management tool as is avoiding varieties which are highly susceptible to leaf-miner infestations (e.g. some chrysanthemums) in greenhouses.

There is little information about leaf-miner tolerance of vegetables in the field.

Mechanical

In field vegetables, cultivation of crop debris or removal of infected plant material is recommended.

Biological

Parasitoid wasps, e.g., Diglyphus isaea and Dacnusa sibirica are available for control in greenhouse crops.

These parasites will not be effective for vegetables growing in the field. However there may be natural parasites present that can reduce the population.

Chemical

Liriomyza huidobrensis adults are resistant to conventional insecticides. At present, the only effective insecticides are translaminar insecticides (abamectin, cyromazine, neem and spinosad), which penetrate the leaves to affect the leaf-miner larvae. Spray Roger 30% EC @ 1ml/liter water.

4) Cutworms, *Agrotis spp., Noctuidae, Lepidoptera a) A. segetum*

Damage: Leaves, stalks and stems of the affected plants show external feeding with abnormal leaf fall. In case of roots and stems both external and internal feedings are visible. The whole leaf may fall off the plant after being cut through at the base of the stalk by the larvae. . Affected plant stages: Seedling and vegetative stages. Affected plant parts: Leaves, roots and stems. Cutworms exhibit two types of feeding patterns depending upon the amount of moisture in the soil and size of plants. Where soil moisture is adequate and plants are small, the larvae hide in the soil during the day and move to the soil surface at night where they cut off plants just above the soil surface. One larva will cut off an average of five corn plants during its development. In situations of dry soil conditions, the larvae do not move to the surface to feed, but instead, they chew into the plant just below the soil surface. This causes the corn plants to wilt and usually die.

3) **White Grubs** *Phyllophaga spp., Anomala spp.*; Coleoptera: Scarabaeidae

White grubs are economically important pest of cereals and cash crops grown in Nepal. White grubs are immature (grub) stage of different beetle species. Adults are smooth and shiny beetles of 12-25mm in body length. They are light to dark brown in color with well developed brownish head and 3 pairs of legs. Grub is creamy white and fleshy with „C shaped body and swollen abdomen. Phyllophaga are known as "Perennial" white grub or "true white grub".

Damage: White grubs are polyphagous pest. Both grub and adult are destructive. Grub usually feeds on underground parts such as roots, tubers and occasionally on aerial stem near the ground.

Management

1. Collect and destroy grub and beetle mechanically from crop and soil.
2. Deep ploughing of field before sowing to expose the hidden grubs and thereby encouraging the feeding of grub by predatory birds and insects.
3. Apply only well decomposed manure in field.
4. Install light trap in field to attract and destroy adults.
5. Do not leave field fallow and grassy.
6. Mix cropping of highly susceptible crops (cole crops, potato etc.) with less susceptible crops like onion, garlic, tomato etc. helps to reduce the damage.
7. Apply Beauveria bassisna and Metarhizum anisopilae formulation as drenching to soil @ 2kg formulation with 1kg of jagagry in 400 liter of water. 8. Apply Thimet 10%G (Phorate) @ 20-25 kg per hectare or Duraban (Chloropyrifos) 10%G @ 20-25 kg per hectare in soil just before sowing of crop

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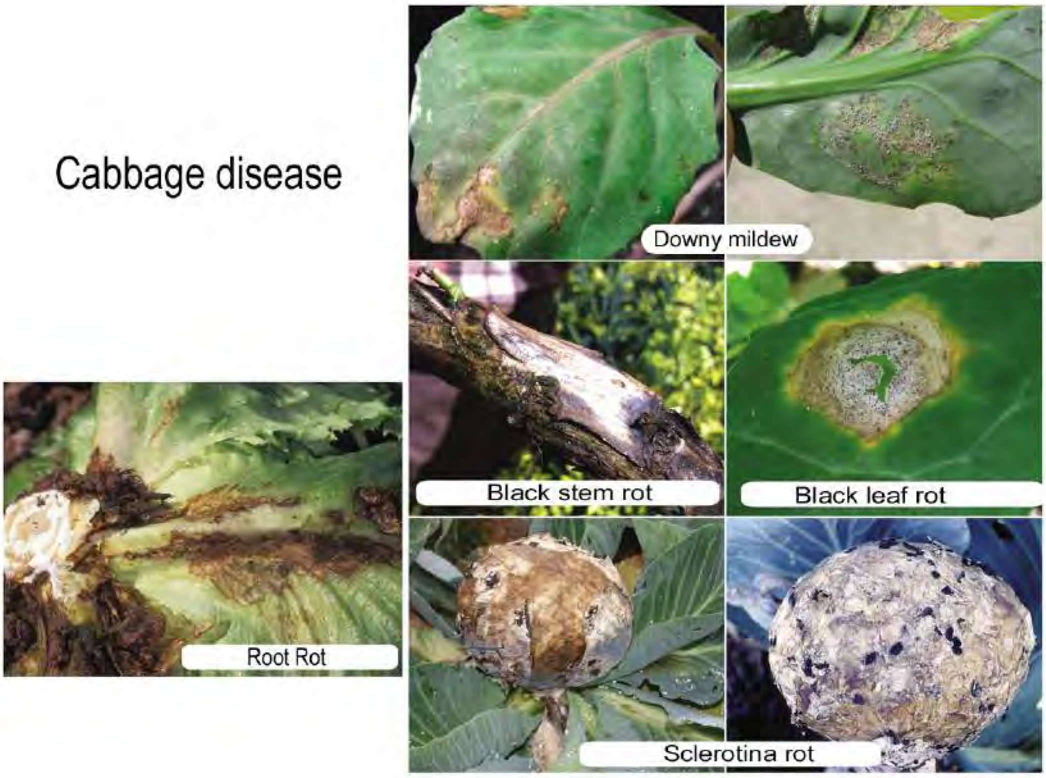

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கேரட் பயிரைத்தாக்கும் நோய்கள்


நோய் பாதிப்பப்பட்ட மென்மையான நீர்த்தன்மையுடைய கேரட்

INSECT PESTS OF BANANA

1) Banana Rhizome (corm) weevil, Cosmopolites sordidus; Coleoptera: Curculionidae Host: Banana

Cosmopolites sordidus is serious pest of banana. Usually old banana plantations are infected with the pest. Adults are black or dark brown weevils. Their body length measures 10-16mm. They have long and curved snout and elytra covers abdomen dorsally. Grubs are creamy white, legless, fleshy, wrinkle and spindle shaped. Fully grown grub is 8-12mm long.

Damage: This is an economically impotent pest of banana that damages the rhizome of banana. Adult can live in the rhizome of the banana plant. Infestation at the early stage reduces the plant vigor. Sick appearance and yellow lines on the top leaves are early symptoms. Where as in advanced stage of infestation, plant show tapering of the stem at crown region, reduction in leaf size, poor bunch formation and choked throat appearance due to grub damage in corms Both grub and adult causes direct damage to plant. Grub feeds on rhizome while adult feeds on pseudostem. Initially grub makes several longitudinal tunnels in the surface tissue till they are able to penetrate the adjacent inner leaf sheath. Then grub bore into pseudostem base and rhizome. If tunneling of pseudo stem base and rhizome is severe plant becomes weak and easily topples down against the gust of air. Leaves die prematurely. Fruits formed on infested plant are of inferior quality.

Banana Insect Pest
Rhizome Weevil

Management

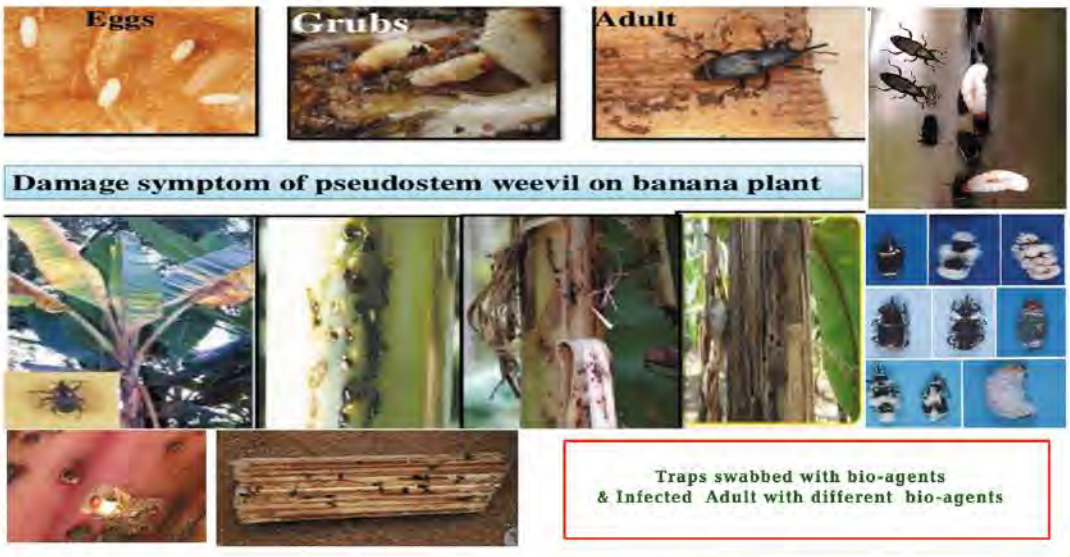
1. Use healthy suckers for planting.
2. Rhizome can be submerged water mixed with insecticide for 2 days before planting is suitable for controlling pest in plant and it prevent new attack of pest.
3. Clean the rhizome with a knife to remove pest inside the rhizome.
4. Crop sanitation also important to reduced pest population .Remove harvested stems and weeds.
5. Annual cultivation can utilize for better banana cultivation. Before new cultivation clean all the banana debris of previous crop.
6. Cut pseudostem of harvested plants and smear with mud to cover the cutting surface to prevent infection.
7. Use healthy, uninfected sucker or rhizomes for planting time. Wash the suckers and dip in a solution of Chlorpyriphos 20 EC @ 2.5 ml/l before planting.
8. Regular monitoring of weevil by keeping banana traps viz. (i) longitudinal cut stem trap of 30 cm size @ 10-15 per acre. In case once weevil is attracted to the laid traps, place longitudinal split banana traps @ 100 ha with bio control agents like entomopathogenic fungus Beauveria bassiana or entomopathogenic nematode, Heterorhabditis indica @ 20 g/trap. These bio control agents have to be swabbed on the cut surface of the stem traps and keep the cut surface facing the ground.

9. In case of post-planting infestation, spray the pseudostem and drench around the base of the tree with Chlopyriphos 20 EC @ 2.5 ml/l. After one week spray and drench with Malathion 50 EC @ 2 ml/l.
10. Cut the banana plant after harvest at the ground level and treat it with carbaryl (1g/liter) or chlorpyriphos (2.5 ml/lit) at the cut surface.
12. Keep pheromone (cosmolure) trap @ 5 traps / ha. The position of traps should be changed once in a month.

2) Banana stem weevil, Odioporus longicollis; Coleoptera: Curculionidae

Odioporus longicollis is serious pest of banana. Adults are small black or reddish brown weevils with black stripes. Body length measures 20-28mm. This weevil has elongate narrow snout.
Adult differs from that of corm weevil in having slender snout. Grubs are soft, fleshy, legless and creamy- white color. Grub is 16-23mm long. Usually single egg is laid in each chamber of banana pseudostem. After hatching larvae feed on pseudostem. Pupation takes place within the pseudostem in a fibrous cocoon made up of banana fibre.

Damage: The banana Pseudostem weevil attacks the plant during flowering and bunch formation stage and cause severe yield loss by preventing the bunch development. The early symptoms are the jelly exudation on the banana stem which indicate the weevil and grub activity inside the stem. Due to feeding of stem by grubs the Pseudo stem becomes hallow and break at the apical region due to gush of wind.



4) Banana aphid, *Pentalonia nigronervosa; Homoptera: Aphididae*

Biology: Reproduction in the banana aphid is entirely parthenogenetic (without mating). Females give birth to live female young. Males are not known for this species. The life cycle (nymph to adult) is completed in 9 to 16 days.

Damage: Like most aphids, the banana aphid is a phloem feeder that uses its long stylets to pierce plant tissues to suck the sap directly from the vessels. This can cause plants to become deformed, the leaves become curled and shriveled, and in some cases galls are formed on the leaves. Young plants may be killed or their growth checked if there is sufficient feeding by the banana aphid. However, direct damage by this aphid is generally negligible.

Aphids vector many plant diseases that cause substantially greater losses than that caused by direct feeding injury. This is often the most damaging feature of an aphid infestation. Both wingless (apterous) and winged (alate) aphids are able to transmit viruses. Transmission is usually in a nonpersistent manner where the virus is taken up into the aphids "mouth" while feeding on an infected plant and transferred to a healthy plant during subsequent feedings. In nonpersistent transmission, the virus reproduces in the plant, and aphids simply aid in transporting the virus. With these types of virus-vector associations, the aphid acquires the virus and is only able to transmit the virus temporarily. Once all the infective charge is reduced by feeding or the passing of time, the aphid is unable to transmit the virus until it feeds on infected tissue again. Banana aphid is vectors of bunchy top disease of bananas. Symptoms of the disease include dark green streaking of the leaves, midrib, and petioles; progressive leaf dwarfing; marginal chlorosis; and leaf curling. Fruits of diseased plants are unsalable because they are small and distorted.

Management

1. Obtain then planting materials from virus free area.
2. Remove infected plants from field.
3. Encourage the population building of lady bird beetle, green lacewing to naturally control aphid population.
4. Install yellow pan trap with 1% kerosene water in aphid infested field to attract and kill nymphs and adults.
5. Spray systemic such as Roger 30%EC @ 2ml/liter water.

5) Banana skipper butterfly, Erionata thrax thrax; Lepidoptera: Hesperiidae

Adult butterflies are brown with three yellow-white areas at the front of their wings. They have a wingspan of around 7cm. Caterpillars roll up banana leaf sections and eat the leaves as they grow. They also exude a fine white powdery material over their body.

Damage: Banana skipper (Erionota thrax) butterfly is from South East Asia, where the caterpillars (larvae) cause the major damage to infested plants. This pest is also known as the banana leaf roller. After hatching, the caterpillars move towards the outer edge of the leaf where they feed and roll the leaf to make a shelter. Within the roll the larva secretes a protective, white, waxy covering. The feeding and rolling destroys the leaves, significantly reducing the plant s leaf area and leading to reduced fruit production, as well as preventing the use of leaves for traditional purpose. Rolled up leaf sections are the most distinctive symptom of banana skipper. Leaf rolls can extend to 15cm in length. Caterpillars also consume the leaves and can quickly cause significant amounts of defoliation.

.**Life cycle:** The adult female lays egg singly on the lower surface of leaves. Egg hatch in 4 – 5 days. The newly hatch larvae are grayish green but become pale green in later larval stages. The larvae are covered with short silky hairs and white powdery substances. The larval period lasts for 3 - 4 weeks. Pupation occurs within the confines of the rolled host leaf and emerges out in 10 days.

Banana Skipper

Management

1. Collect and destroy rolled infected leaves.
2. Collect larvae by hand picking and hanging from banana tree and destroy them.
3. Apply Bacillus thuringiensis based formulation @ 0.3-0.6 k.g. a.i. /hac.
4. Release larval parasitoids Cotesia erionotae 5. Spray Thiodane 35% EC @1ml/liter.

Disease of Banana

Panama Wilt (Fusarium oxysporum f. sp. cubense): This is a soil-borne fungal disease and gets entry in the plant body through roots. It is most serious in poorly drained soil. Initial symptoms are yellowing of lower leaves, including leaf blades and petioles. The leaves hang around the pseudostem and wither. In the pseudostem of the diseased plant, yellowish to reddish streaks are noted with intensification of colour towards the rhizome. Wilt is severe in poor soil with continuous cropping of banana. Warm soil temperature, poor drainage, light soils and high soil moisture are congenial for the spread of the disease.

Banana Fungal Disease -Fusarium Wilt

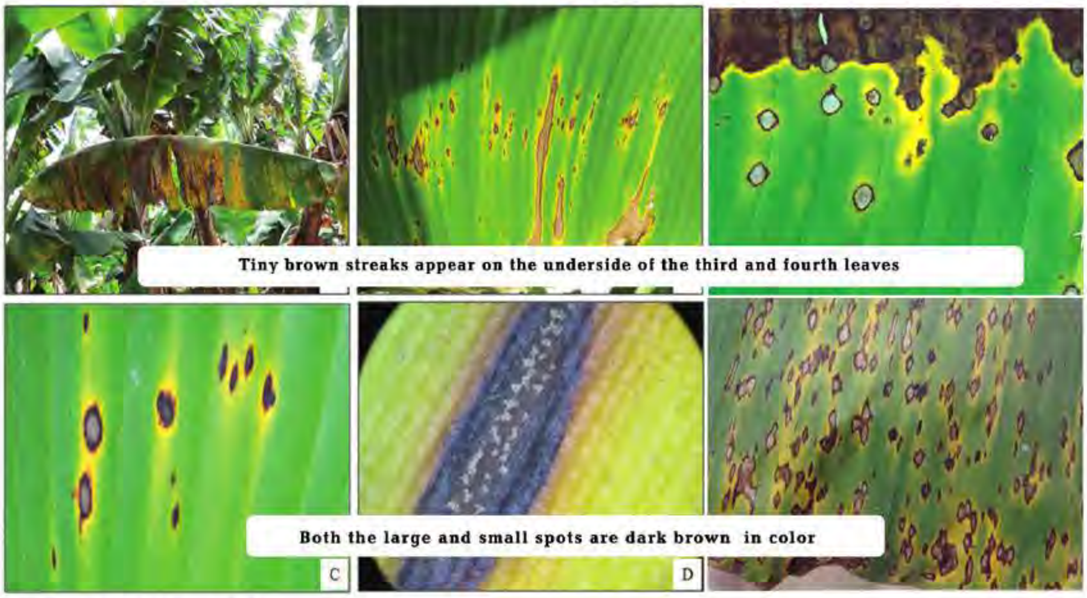
Management:

Severely affected plants should be uprooted and burnt. Highly infected soil should not be replanted with banana at least for 3-4 years. Use of disease-free planting material and resistant cultivar are recommended. Growing of paddy followed by banana for 3-5 years once or twice, use of quick lime near the base of the plant and soaking with water and avoiding sunflower or sugarcane in crop rotation helps to reduce the disease incidence. Dipping of suckers in Carbendazim (10g/10 litres of water) followed by bimonthly drenching starting from 6 months after planting is also recommended. Application of bioagents, such as, Trichoderma viride or Pseudomonas fluorescence in the soil is effective.

Leaf Spot, Leaf Streak or Sigatoka Disease *(yellow sigatoka-Mycosphaerella musicola;black sigatoka or black leaf streak-Mycosphaerella fijiensis)*

Yellow sigatoka is one of the serious diseases affecting the banana crop. Initial symptoms appear in the form of light yellowish spots on the leaves. A small number of these enlarge, become oval; the colour also changes to dark brown. Still later, the centre of the spot dies, turning light grey surrounded by a brown ring. In severe cases, numerous spots coalesce, killing large parts of the leaf. Rainfall, dew and temperature determine the spread of the disease. Conditions favouring mass infection are most common during the rainy season with temperature above 21°C.

Banana Fungal Disease - Sigatoka leaf spots



Management:

Cultural practices such as improved drainage, control of weeds, removal of diseases suckers and adopting correct spacing is recommended. Dithane M-45 WP (in oil-water emulsion) and Dithane M-45 (in water only) controlled Mycosphaerella fjijiensis var. difformis in banana. Foliar spray of Copper Oxychloride (3 g/litre of water) or Thiophanate Methyl 1 g/ litres of water) controls the disease effectively.

Anthracnose (Gloeosporium musae)

The disease attacks banana plants at all stages of growth. Disease attacks the flowers, skin and distal ends of banana heads. The symptoms appear as large brown patches covered with a crimson growth of the fungus. The disease fruit turns black and the fruit is shrivelled.

Management:
Spraying of Chlorothanlonil (0.2%) and Bavistin (1 %) four times at15 days interval is recommended. Minimising bruising; proper sanitation of handling and prompt cooling to 14°C are essential in minimising the disease in cold storage.

Cigar End Tip Rot *(Verticillium theobromae, Trachsphaera fructigena and Gloeosporium musarum)*
A black necrosis spread from the perianth into the tip of immature fingers. The rotted portion of the banana finger is dry and tends to adhere to fruits (appears similar to the ash of a cigar).

Management: Removal of pistil and perianth by hand 8-10 days after bunch formation and spraying the bunch with Dithane M -45 (0. 1%) or Topsin M (0.1%) controls the disease effectively. Minimising bruising; prompt cooling to 14°C; proper sanitation of handling facilities reduce the incidence in the cold storage.

Crown Rot *(Colletotrichum musae, Fusarium sp., Verticillium theobromae, Botryodiploidia theobromae and Nigrospora sphaericu):*
The characteristic symptoms are blackening of the crown tissues, which spreads to the pulp through the pedicel resulting rotting of the infected portion and separation of fingers from the hand.

Management:
Dipping the bunches or hands in Thiobendazole or Benomyl and/or using fungicide impregnated cellulose pad for packing is recommended.

Stem-end Rot *(Thielaviopsis paradoxa)*
The fungus enters through the cut stem or hand. The invaded flesh becomes soft and water-soaked.

Management:
Minimising bruising; prompt cooling to 14°C; proper sanitation of handling facilities and hot water treatment of hands (such as 5 minutes in 50°C water) helps in controlling the disease in cold storage.

Pseudostem Heart Rot *(Botrydiplodia sp.,Gloeosporium sp. and Fusarium sp.):*
The first indication of heart rot is the presence of heart leaves with part of the lamina missing or decayed. In severe cases, the inner leaves of the crown first turn yellow, then brown and finally die. In more severe cases all the leaves and the plant die.

Management:
Adopting field sanitation, good drainage and proper spacing reduce the incidence of the disease. To prevent spread of the disease, spraying of Captan or Dithane M-45 or Dithane Z- 78 is effective.

Head Rot *(Erwinia carotovora):*

Newly planted suckers get affected, leading to rotting and emitting of foul odour. In older plants rotting at the collar region and leaf bases are seen. In advanced cases, trunk base becomes swollen and split.

Management:

Good drainage and soil conditioning can control the disease to some extent. Use of rhizomes with dead central buds and active lateral buds prevents the appearance of the disease.

Bacterial Wilt or Moko Disease *(Pseudomonas solanacearum):*

The young plants are affected severely. In the initial stages the bacterial wilt is characterised by the yellowish discolouration of the inner leaf lamina close to the petiole. The leaf collapses near the junction of the lamina with the petiole. Within a week most of the leaves exhibit wilting symptoms. The presence of yellow fingers in an otherwise green stem often indicates the presence of moko disease. The most characteristic symptoms appear on the young suckers that have been cut once and begin regrowth. These are blackened and stunted. The tender leaves from the suckers turn yellow and necrotic.

Management:

Early detection and destruction of the suspected plants may help in preventing the spread of the disease. All the tools used for pruning and cutting should be disinfected with formaldehyde. As the insects can carry the disease causing bacterium on the male flowers, removal of the male flowers as soon as the last female hand emerge help in minimising the spread of the disease.

Banana Bunchy Top Virus (BBTV):

The disease is transmitted to the plant by the aphid vector Pentalonia nigronervosa and dwarf bananas are very susceptible to this disease. Primary symptoms of the disease are seen when infected suckers are planted. Such infected suckers putforth narrow leaves, which are chlorotic and exhibit mosaic symptoms. The affected leaves are brittle with their margins rolled upwards. Characteristic symptom of bunchy top virus is the presence of interrupted dark green streaks along the secondary veins of the lamina or the midrib of the petiole. The diseased plants remain stunted and do not produce bunch of any commercial value.

Management:

Systematic eradication of the diseased plants, suckers and the clumps is very essential. Planting materials should not be collected from places affected by this disease. The aphid should be controlled to check spread of the disease by spraying with Metasystox (0.1-0.5%).

Plants adjacent to the healthy plants should also be sprayed. The affected plant should be killed with kerosene or herbicides such as 2, 4-D or 2, 4, 5-T. The rhizome should be dug out, cut into small sections and sprayed again so that no suckers can be produced which may harbour the virus.

Banana Streak Virus (BSV):

A prominent symptom exhibited by BSV is yellow streaking of the leaves, which becomes progressively necrotic producing a black streaked appearance in older leaves. . The virus is transmitted mostly through infected planting materials, though mealy bugs (Planococcus citri) and more probably Saccharicoccus sacchari are also believed to transmit it. Shoot tip culture does noteliminate it from vegetatively propagated materials.

Management:

Control strategies include use of clean planting material and quarantine. Eradication of infected plants and control of vectors are effective in controlling the severity of the disease.

Mosaic Virus:

The disease is characterised by typical mosaic symptoms on the leaves. Mosaic plants are easily recognised by their dwarf growth and mottled, distorted leaves. The earliest symptoms appear on young leaves ass light green or yellowish streaks and bands giving a mottled appearance. The aphid vector Aphis gossypii transmits the disease.

Management:

The plantation should be kept free from weeds. Suckers from infected clumps should not be used for planting. Weeds in the nearby area should be removed as the virus survives in them during offseason. Use of suitable insecticide to reduce spread of the disease is also suggested.

Banana Bract Mosaic Virus (BBMV):

The symptoms appear as yellow green bands or mottling over an entire area of young leaves. The affected leaves show abnormal thickening of veins. Bunch development is affected.

Management: Removal and destruction of affected plants along with rhizome. Growing cucurbits in and around banana field should be avoided.

INSECT PEST OF COWPEA:

Aphids Aphis craccivora,Acyrthosiphon pisum

Symptoms

Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in color, but may be pink, brown, red or black depending on species and host plant; if aphid infestation is heavy it may cause leaves to yellow and/or distorted, necrotic spots on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants

Management

If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting; use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use

Armyworms (Beet armyworm, Western striped armyworm) Spodoptera exigua

Spodoptera praefica

Symptoms

Singular, or closely grouped circular to irregularly shaped holes in foliage; heavy feeding by young larvae leads to skeletonized leaves; shallow, dry wounds on fruit; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

Management

Organic methods of controlling armyworms include biological control

Cowpea Diseases

1.Anthracnose Colletotrichum spp.

Symptoms

Tan to brown sunken lesions on leaves; lesions merging to girdle stems and petioles; lesions may become covered in pink spore masses during periods of wet weather

Management

The best method of controlling the fungus is to plant resistant varieties if available; plant only certified disease-free seed; practice good field sanitation such as removing crop debris from field after harvest to reduce levels of inoculum

2.Asochyta blight Asochyta phaseolorum

Symptoms

Severe defoliation of plants; extensive lesions on stems and pods; if infection is severe then plants may be killed

Management

Plant disease-free seed; applications of appropriate foliar fungicides, where available, may help to control the disease

3.Brown rust *Uromyces spp.*

Symptoms

Raised brown to black pustules on both sides of leaves; wilting plants; drying leaves dropping from plant

Management

Sprays of sulphur or potassium carbonate can help to control the disease

4.Cercospora and Pseudocercospora leaf spot: Cercospora canscens Pseudocercospora cruenta

Symptoms

Chlorotic spots on upper surfaces of leaves; necrotic spots on leaves; masses of spores on lesions which resemble black mats on lower leaf surface; defoliation of plants; yellowing of leaves; circular, red lesions on leaves

Management

Remove all crop residue from field after harvest; plant disease-free seed

5.Charcoal rot Macrophomina phaseolina

Symptoms

Discoloration of stem at soil line; cankers on stem may spread upwards; leaves may wilt and drop from plant; numerous small black sclerota (fungal fruiting bodies) develop in affected tissues and can be used to diagnose the disease

Management

Organic soil amendments such as the addition of manure or neemcake can be used to reduce levels of inocuum in the soil

6.Fusarium wilt Fusarium oxysporum

Symptoms

Stunted plant growth; yellowing, necrotic basal leaves; brown-red or black streaks on roots that coalesce as they mature; lesions may spread above the soil line

Management

Control relies on cultural practices e.g. do not plant in same area more than once in any 5 year span or treating seeds with an appropriate fungicide prior to planting

7.Powdery mildew *Erisyphe polygani,Sphaerotheca fuliginea*

Symptoms

White powdery fungal growth on upper surfaces of leaves; chlorotic or brown patches on leaves; leaves dropping from plant

Management

Plant resistant varieties if available; use adequate plant spacing to avoid overcrowding and promote good air circulation around plants

8.Rhizoctonia seedling blight *Rhizoctonia solani*

Symptoms

Water-soaked sunken, red-brown lesions on hypocotyls (germinating shoot below seed leaves) and epicotyls (shoot above seed leaves); small, circular brown spots on leaves; large irregular lesions with zonate banding on leaves; lesions with water-soaked borders; leaves that look like they are covered in sand (sclerotia)

Management

Crop rotation helps to reduce the build up of the fungus in the soil; reduce soil compaction; do not plant seeds too deep

9.Southern blight *Sclerotium rolfsii*

Symptoms

Sudden wilting of leaves; yellowing foliage; browning stem above and below soil; browning branches; stem may be covered with fan-like mycelial mat

Management

Remove infected plants; avoid overcrowding plants to promote air circulation; rotate crops with less susceptible plants; plow crop debris deep into soil; provide a barrier to infection by wrapping lower stems of plant with aluminum foil covering below ground portion of stem and 2-3 in above soil line


Anthracnose in cowpea


Powdery mildew in cowpea

10.Bacterial blight *Xanthomonas campestris*

Symptoms

Water-soaked spots on leaves which enlarge and become necrotic; spots may be surrounded by a zone of yellow discoloration; lesions coalesce and give plant a burned appearance; leaves that die remain attached to plant; circular, sunken, red-brown lesion may be present on pods; pod lesions may ooze during humid conditions

Management

Plant only certified seed; plant resistant varieties; treat seeds with an appropriate antibiotic prior to planting to kill off bacteria; spray plants with an appropriate protective copper based fungicide before appearance of symptoms

11.Brownblotch *Colletotrichumcapsici,Colletotrichum truncatum*

Symptoms

Seeds not germinating; death of seedlings; post emergence symptoms include sunken oval lesions on stems, red-brown lesions on leaves, flowers aborting and/or mummified pods; severe defoliation can occur during prolonged periods of wet weather

Management

The best method of controlling the fungus is to plant resistant varieties if available; plant only certified disease-free seed; practice good field sanitation such as removing crop debris from field after harvest to reduce levels of inoculum

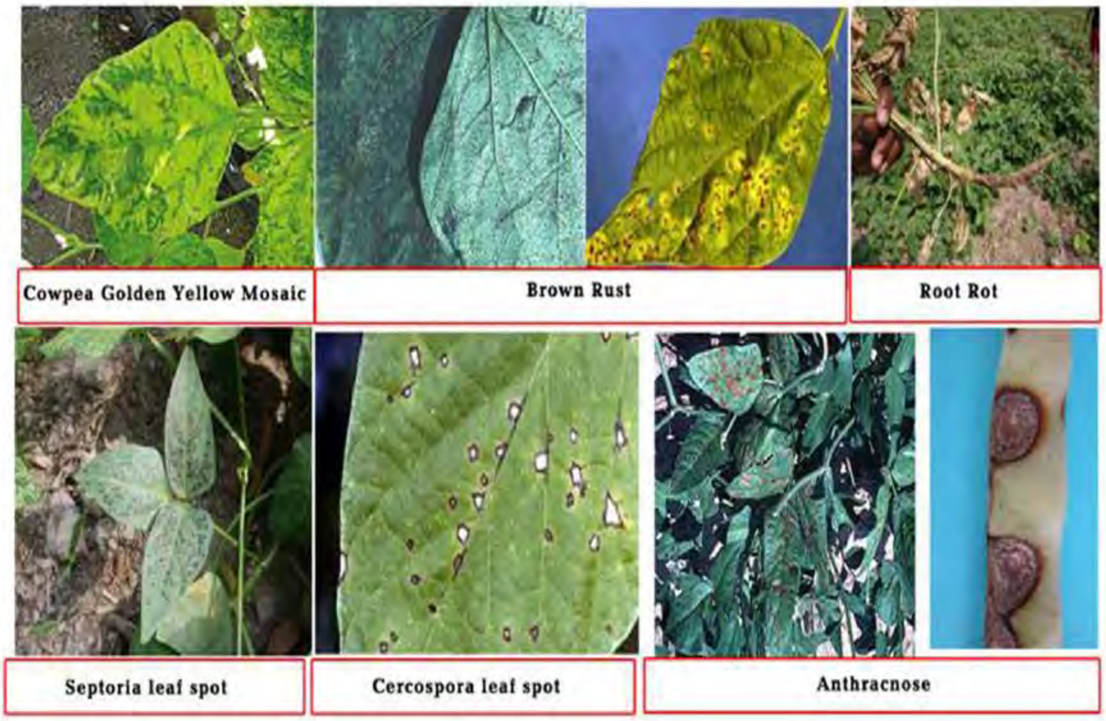
12.Soft stem rot *Pythium aphanidermatum*

Symptoms

Gary to green water-soaked rot girdling stem; plant death; white mycelial growth on stem during high humidity

Management

Plant in well-draining soils or raised bed to reduce soil moisture content; solarizing soil can help reduce levels of inoculum in the soil; soil drenches or seed treatment with appropriate fungicides can help to control the disease

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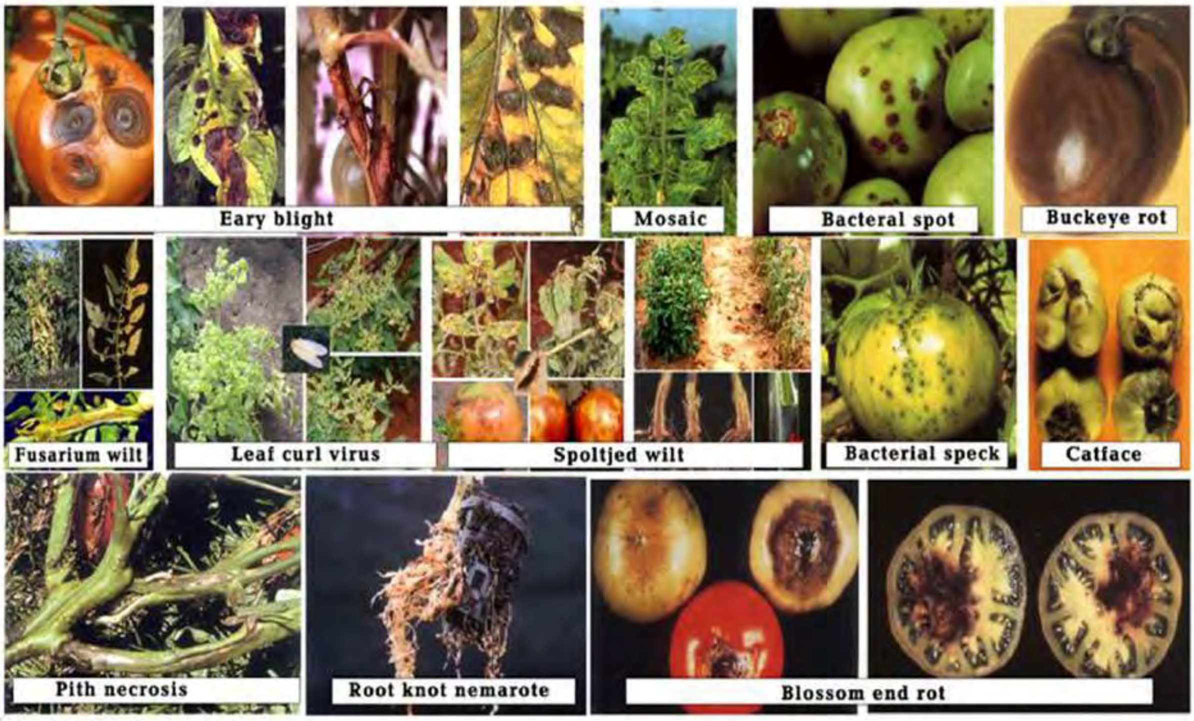

Eary blight
Mosaic
Bacteral spot
Buckeye rot
Fusarium wilt
Leaf curl virus
Spoltjed wilt
Bacterial speck
Catface
Pith necrosis
Root knot nemarote
Blossom end rot

1. INSECT PESTS OF APPLE

1) Wooly aphid, Eriosoma lanigerum; Homoptera: Aphididae Host: Apple, Pear, Almond

The woolly aphid is a sucking insect that lives on plant fluids and produces a filamentous waxy white covering which resembles cotton or wool. Woolly aphid adults are pear shaped, usually 0.13 inch or less in length, and cover themselves with white waxy material. The adults are winged and move to new locations where they lay egg masses. The larvae often form large cottony masses on twigs, for protection from predators. It does not attack on the leaves. Both nymph and adult suck cell sap from bark of the twigs and from the underground roots. Specialized dermal glands produce the characteristics fluffy or powdery wax, which gives E. lanigerum its characteristics woolly appearance.

Damage: Some species feed in groups and cause swellings on bark or roots. Cankers and burs or burls can develop on limbs. On roots, nodular masses of gall tissue may form. Foliage-feeding species can cause infested leaves to curl, distort, discolor, or form into galls. Some species secrete honeydew, which results in growth of blackish sooty mold. Others produce pale waxy secretions, causing white flocculent material to collect on and beneath infested plants. Gallmaking species may confine their honeydew or wax to within distorted tissue so this secretion is not obvious unless galls are cut open.

Management

1. Their numbers are kept low with natural predators like lacewings, ladybugs, hover flies, and parasitic wasps. 2. Prune out and destroy infested branches along with aphid colonies. 3. Spot treat where the aphids are most abundant using insecticidal soap or neem oil. 4. Release nymphal parasitoid Aphelinus mali to suppress aphid population. 5.

19. PEST AND DISEASE OF STRWABERRY:
A.PEST OF STRWABERRY
1. Leaf roller:

Biology:

The adult garden tortrix is a buff-brown moth that is about 1/4 inch (6 mm) long. Each of the forewings is marked with a dark brown diagonal stripe and a marginal spot producing a chevron pattern when at rest. A faint whitish line borders the anterior edge of the brown stripe. This character and the overall lighter color distinguish adult garden tortrix from orange tortrix. The slender caterpillars of the garden tortrix

are nearly 1/2 inch (12 mm) long when mature. Caterpillars have light brown to green bodies and light brown heads. The head has a small, distinct dark brown spot on each side. Larvae and pupae overwinter in debris around the base of the plant.

Damage symptoms:

It ties one or more strawberry leaves together with white webbing to create shelters. • Larvae can also create shelters by binding leaves or the sepals of the calyx to fruit and may feed from these sheltered areas on the surface or internal tissues of fruit.

2. White grub:

Biology: Egg - Eggs hatch in 3 to 4 weeks. A dull pearly white when first deposited, the oval to spherical egg turns dark just before hatching. It may be 1.5 to 3 mm in diameter. Small masses of 15 to 20 eggs occur in cells in the soil.

Larva - Newly hatched grubs feed on plant roots throughout the summer and complete 1/3 of their development before fall. These grubs burrow below the frostline (to a depth of 1.5 meters) and hibernate. The young grub is creamy white and about 5 mm long. The grub is about 26 mm long, and the mature grub about 30 mm long. The C-shaped grub has a distinct brown head; a shiny, smooth body; and three pairs of legs just behind the head. Two rows of hairs on the underside of the last segment distinguish May beetle grubs from similar grubs.

Pupa - The grubs become fully grown by late spring of the third year. At this time, they dig cells in the soil and pupate. Approximately the same size as the adult, the pupa may be creamy white, pale yellow, or dark brown. Pupae become adults by late summer but the beetles do not leave the ground.

Adult - Known as May beetles, the shiny reddish-brown to black adults are 19 to 26 mm long. The adult attack strawberry during spring. New May beetles overwinter in their earthen cells and emerge the following spring to feed and mate

Damage symptoms:

Plants affected by this insect can show early signs of wilting, remain small, weak, and both yield and fruit quality is affected. Soil disclosure at the bottom, the larve is seen gathering on the roots. If large numbers of insects are present, plants may die.

3.Thrips:

Biology:

Egg: Eggs are laid in plant tissue, both in flower bottoms and in leaves.

Larva: Subsequently, the larvae develop in stages. This development also occurs both in the leaves and in the flower bottoms of the plant.

Pupa: In the pre-pupating stage the greater part of the thrips drops on the ground and looks for some dirt or creep under plastic to pupate. When the pupae have come out, the adult thrips will move to the plants again and after a number of days they will start laying eggs.

Adult: Thrips wings are fringed with setae, small hairs. They are also known to be specially active in flying during hot and close weather. The best way to find thrips is by removing petals and the stamina of the flowers.

Damage symptoms: Both nymphs and adult thrips can injure the plant by rasping the plant bud, flower, leaf tissues and then sucking the exuding sap. Thrips feeding on strawberry blossoms cause the stigmas and anthers to turn brown and wither prematurely, but not before fertilization has occurred. With high populations, the surface of the berry may become cracked and discolored. Fruit damage includes surface russeting around planting materials from late green to ripe fruit. The fruit can take on a seedy bronze-like appearance. Larvae and adult thrips will be sucking on the fruits. Brown scaly sucking patches round the planting materials planting materials planting materials.


SI-6 Thrips - Damage

4.Red spider mite:

Biology:

The two-spotted spider mite can live on strawberries, but also on numerous different crops. It is also present in different weeds, such as Black Nightshade, small stinging nettle and gallant soldier. The adult females overwinter in sheltered places in the crops. In spring they become active. Recognizing them, not the color is decisive but rather the two black spots on their body. Life stages comprises of egg, larvae, protonymph, deutonymph and adult. Life cycle will be completing in around 5-20 days depending on temperature.

Egg: From mid April eggs are laid on the underside of the leaves. Female lays 100 eggs in around 10 days, round clear initially and turn whitish as it matures .

Nymph: The nymph vary in color, from yellow to light and dark green. Sometimes they are even orange in color. Adults: males are wedge shaped 0.33mm and females are oval 0.4-0.5 mm, single dark spot on either side of body and generally yellow or greenish in color.

Damage symptoms: Spider mites rasp away leaf surfaces to feed on plant sap. The first signs of damage are speckling and mottling on the surface of leaves. In heavy infestations, leaves turn purple, with white webbing between leaves. Plants that sustain infestations of greater than 75 mites per leaflet may become severely weakened and appear stunted, dry, and red in coloration. Severely damaged leaves die and drop.

5.Root knot nematode

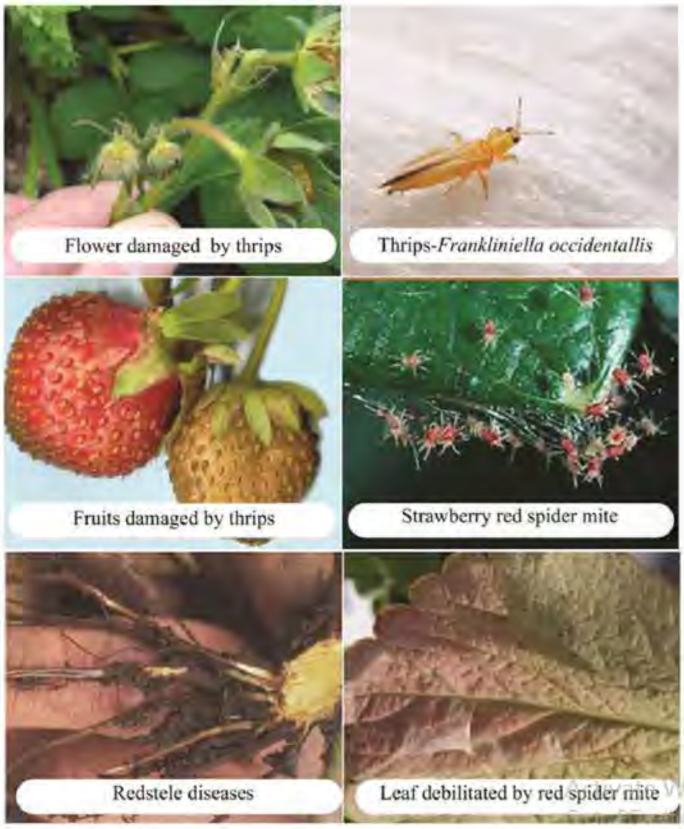
Biology: Most species of plant parasitic nematodes have a relatively simple life cycle consisting of the egg, four larval stages and the adult male and female. They are microscopic in size. • Development of the first stage larvae occurs within the egg where the first moult occurs. Second stage larvae hatch from eggs to find and infect plant roots or in some cases foliar tissues. • Under suitable environmental conditions, the eggs hatch and new larvae emerge to complete the life cycle within 4 to 8 weeks depending on temperature. Nematode development is generally most rapid within an optimal soil temperature range of 70 to 80°F

Damage symptoms:

Infected plants in patches in the orchard, Formation of galls on host root system is the primary symptom , Roots branch profusely starting from the gall tissue causing a 'beard root' symptom,Infected roots become knobby and knotty, In severely infected plants the root system is reduced and the rootlets are almost completely absent. The roots are seriously hampered in their function of uptake and transport of water and nutrients, Plants wilt during the hot part of day, especially under dry conditions and are often stunted ,Seedlings infected in nursery do not normally survive transplanting and those surviving have reduced flowering and fruit production, Nematode infection predisposes plants to fungal and bacterial root pathogens

Strawberry Insects Pests

Friut damaged by Giant African Snail



Flower damaged by thrips

Thrips-*Frankliniella occidentallis*

Fruits damaged by thrips

Strawberry red spider mite

Redstele diseases

Leaf debilitated by red spider mite

B.DISEASE OF STRWABERRY

1. Leaf spots: *Leaf spot is one of the most common diseases of strawberries, occurring worldwide in most cultivars.*

Disease symptoms: Initially, small, deep purple, round to irregularly shaped spots appear on the upper leaf surface. These enlarge to between 3–6 mm in diameter. They retain a dark red margin, but the centers turn brown, then grey and finally white. Spots may join and kill the leaf .The fungi also attacks the petioles, stolons, fruit stalks and fruit as shallow black spots.

2. Grey mold: *This disease occurs on a wide range of flowers, vegetables and fruit, including strawberries.*

Disease symptoms: • The fungi will attack flowers, fruit, petioles, leaves and stems • Flowers and fruit stalks infected during flowering die rapidly. Green and ripe fruit develop brown rot • This spreads over the whole fruit, which becomes covered with masses of dry, greyish spores • The rot may start on any portion of the fruit, but is found most frequently on the calyx end or on the sides of fruit touching other rotten fruit.

Survival and spread: • The fungi over-winters on plant debris and infects flower parts, after which it either rots the fruit or remains inactive until the fruit ripens further. Spores, which are produced continuously throughout the fruiting season, germinate to infect plants By wind and splashing water from rain or overhead irrigation

Favourable conditions: • Low temperature, high humidity and frequent rain

3. Red stele/Red core:

Disease symptoms:

Red stele affected plants become stunted and wilt in dry weather. Older leaves turn yellow or red particularly along the margin. The symptom that helps to identify red stele is the brick red discoloration in the center (stele) of live white roots. The red color may extend the length of the root, or it may show up for only a short distance above the dead root tip. This symptom is obvious only during winter and spring.

• The discoloration does not extend into the crown of the plant. Infected plants usually die by June or July. Growth of the plants will slow down and they will become dull bluish green. In spring the plants will convalesce somewhat. An affected plant will form no or only few flowers.

• The small fruits will dry out. The root-hair of the roots is lacking. When cutting the main roots, it will appear that the central cylinder has discolored red.

Survival and spread: Can be introduced with planting material or from a reserve in the soil from trash from previous crops

Favourable conditions: Found in a wide range of climates. The disease prefers poorly drained soils, high temperatures and plants under moisture stress.

4. Wilt :

This disease occurs through the temperate zones of the world. It affects a wide range of crops like tomato, potato and cotton. Most strawberry varieties are susceptible

Disease symptoms: Plants carrying a large crop will suddenly wilt, usually on a hot day in late spring or summer. • Some plants do not recover, and die within a week. In surviving plants, older leaves take on a scorched look while younger leaves remain pale in colour and turgid until they also die off. Fruit on affected plants do not mature, remain small and have paler appearance Survival and spread: Soils in which susceptible crops have been grown The pathogen can survive in moist soil for many years By water, trash from susceptible crops, weeds, root contact between plants, soil and farm machinery

Favourable conditions: • A period of stress such as sudden increase in temperature, dry conditions or heavy crop load on plants

5. Powdery mildew:

The disease affects all cultivated strawberries worldwide. No variety is resistant, but each differs in susceptibility.

Disease symptoms:

An early symptom of the disease is upward curling of the leaf margins. This is followed by irregular, purple blotching on the upper leaf surfaces, often along major veins. The leaves feel brittle. This disease does not produce the masses of greyish white spores typical of powdery mildew on other crops. Powdery mildew can attack fruit at any stage. Dull immature and mature berries with prominent planting materials.

Survival and spread: Trash from previous and current strawberry crops.

Favourable conditions: *Wind Warm, humid conditions*

6. Alternaria spot:

Disease symptoms: Lesions or "spots" are more numerous on upper leaf surfaces and appear circular to irregular in shape. These lesions often have definite reddish-purple to rusty-brown borders that surround a necrotic area. Lesion size and appearance often are influenced by the host variety and the ambient temperature. The leaf spots sometimes cause severe problems, often depending on the variety planted. Susceptible varieties can be defoliated partly or completely by late summer. In years that are particularly favorable for disease development, they can be severely weakened.

Survival and spread: The fungi overwinter on infected plants, plant debris, and weed hosts. • In the spring, spores are produced and are discharged by splashing rain into air currents. They then land on and infect new leaves. Favourable condition: It is favoured by warm wet weather

7. Black root rot:

Disease symptoms ;

Normal strawberry roots are white, but naturally turn dark on the surface with age. The root system of a plant affected by black root rot is smaller with black lesions or with the roots completely black. Such plants become stunted and produce few berries and runners. Survival and spread: Black spot is spread from infected plants and fruit by rain splash, overhead irrigation and on the hands of fruit pickers. Favourable conditions: • It is favoured by warm, humid and wet conditions.

8. Anthracnose (black spot):

Disease symptoms:

Leaf spot Round black or light gray lesions on leaves. Numerous spots may develop but leaves do not die. Runners and petioles, Dark brown or black sunken, circular lesions on stems, petioles and runners,Plants may be stunted and yellow, Plants may wilt and collapse, Internal tissues discolored red

Crown rot: Youngest plant leaves wilt during water stress in early afternoon and recover in the evening, Wilting progresses to entire plant, Plant death, Reddish-brown rot or streak visible when crown is cut lengthways.

9. Bud rot: Damp, firm dark brown to black rot on buds. Plants with single buds may die and Plants with multiple crown may wilt as disease progresses.

10. Flower blight: Dark lesion extending down pedicel which girdles the stem and kills the flower; flowers dry out and die. Infection after pollination may result in small, hard, deformed fruit.

Fruit rot: Light brown water-soaked spots on ripening fruit which develop into firm dark brown or black round lesions.

4. Angular leaf spot:

Disease symptoms: Very small water-soaked lesions on lower surfaces of leaves which enlarge to form dark green or translucent angular spots which ooze bacteria. Lesions may coalesce to form reddish spots with a chlorotic halo. Survival and spread: Bacterium survives in crop debris and overwintering plants can survive for long periods on plant debris but cannot live free in soil Bacteria can be spread by splashing water.

Favourable conditions: Spring season is responsible for the development of diseases.

20. PEST AND DISEASE OF POMEGRANATE

A. PEST OF POMEGRANATE

Pomegranate butterfly, *Virachola Isocrates; Lepidoptera: Lycaenidae*

Damage

Egg laying on the calyx of the flower, tender fruits singly. After hatching, bore into fruit and feed upon internal portion, as a result fruit droop. Entry hole heals up immediately so symptoms may not appear externally and fruit seems as healthy but inside seeds are eaten. Larvae come out by making hole and juice appear at hole, at that time 50% damage occurs in fruit.

Life cycle

Egg 7-10 days larvae (In calyx) (Inside fruit) 18-47 days pupae 7-34 days (Inside fruit or In fruit stalk) Adult

Caterpillars bore into ripening fruits, feed on the seeds and affected fruits rot and drop

Bore holes / Excreta on infested fruits

Management

1. Collect and destroy the infested fruits. 2. Wrapping of fruit with the help of muslin cloth or by plastic bags in small scale. 3. Spray Sumicidin 20% EC @ 1ml / 2 ltr of water at the time of flowering and fruiting.

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B.DISEASE OF POMEGRANATE

I. Bacterial Blight *Xanthomonas axonopodies pv.punicae*

Symptoms:

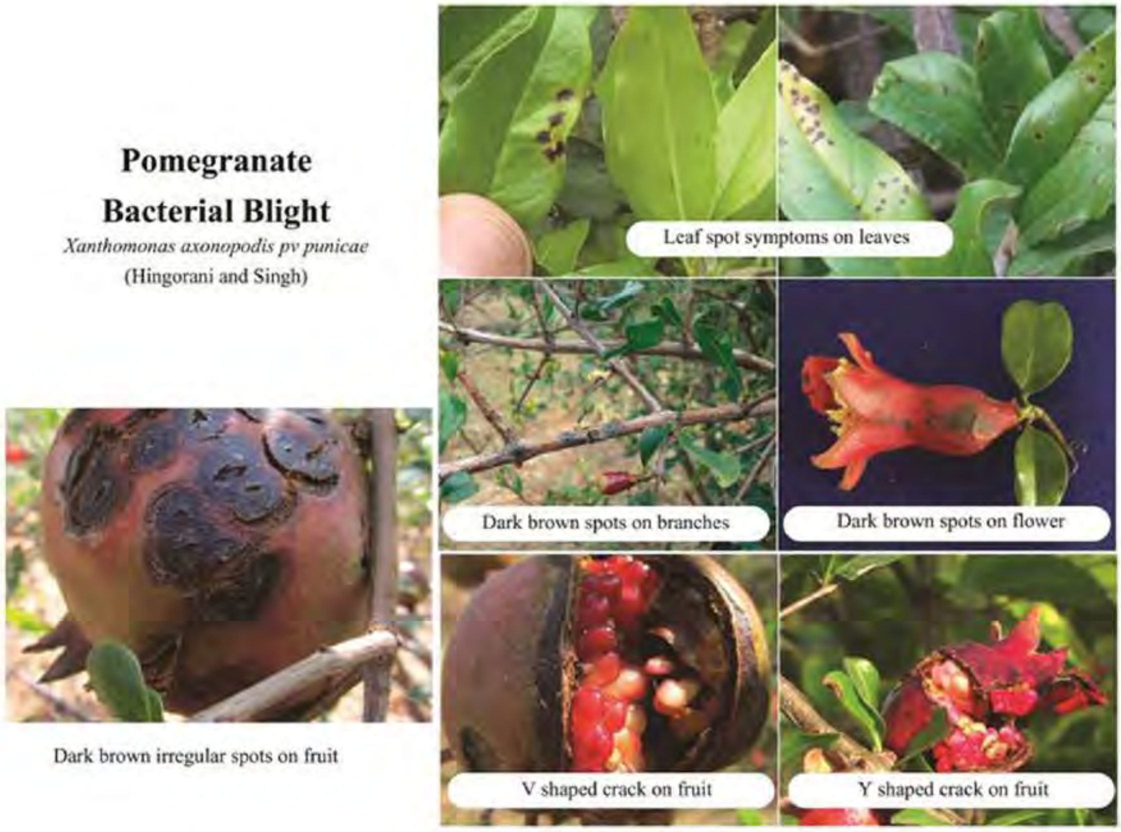
Appearance of one to several small water soaked, dark colored irregular spots on leaves resulting in premature defoliation under severe cases.

The pathogen also infects stem and branches causing girdling and cracking symptoms.

Spots on fruits were dark brown irregular slightly raised with oily appearance, which split open with L-shaped cracks under severe cases.

Disease cycle:

The increase in day temperature (38.6°C) and afternoon relative humidity of 30.4% along with cloudy weather and intermittent rainfall favored the disease initiation and further spread of the disease.



Management:

spray bordeaux mixture altered with streptocycline (0.5g/l)/bronopol @ 0.5g/l mixed with
copper oxychloride (2-2.5g/l).

21. PEST AND DISEASE OF SUGARCANE
PESTS OF SUGARCANE.

1) Sugarcane top borer, *Scirpophaga nivella; Lepidoptera:*

Pyralidae Top borer of sugarcane (Scirpophaga nivella) is one of the most destructive and major pests of sugarcane that cause serious damage to this crop in sugarcane growing areas. Moths are silvery white in colour having one black spot on each of the forewing. Larvae are -35 mm long, creamy white or yellow and brown head, devoid of stripes, with atrophied legs.

Damage: The larvae of sugarcane top borer feed on the top portion of the sugarcane plants. This pest has four to five numbers of generations in one year and all generations cause damage to sugarcane plant. The first two generations or broods of this pest attacked sugarcane at early stage of plants. At this stage special kind of reddish streaks and small holes are seen on the sugarcane plants due to its attack. When cane development take place its attack become limited to the top portion of the sugarcane plants. Due to larval feeding top portion of cane dries and cause heavy economic loss. Infestation also causes a characteristic symptom known as bunchy top of sugarcane plant. It is well recognized fact that sugarcane plant which is attacked by this pest is lower in quality and quantity of juice. Newly hatched larvae enter into main vain of leaf and reaches to shoot by boring in vein. When larvae reaches soft and young part of shoot it feeds on them and top portion of cane dries up. There is formation of bunchy top due to development of young shoots from near of dried portion.

Management :

1. Control and lower down pest population by collecting and destroying egg cluster. 2. Remove dead hearts from field and destroy them. 3. Intercropping of sugercane with onion, methi, and ajwain reduces the infestation of the pest.

4. Use Tricogramma japonicum @ 50,000 per hectare, 4 to 6 times after 60 days of planting at the interval of 10 days to biologically control the pest.

2) **Sugarcane shoot borer**, *Chilo infuscatellus; Lepidopter: Pyralidae*

Sugarcane shoot borer is another major pest of sugarcane and cause considerable economic damage. Adult moth is straw colored with whitish hind wing. Larva is fleshy with five dark violet stripes and dark brown head.

Damage: Larva of sugarcane shoot borer is mainly destructive in nature and feeds on soft tissues of stem. This results in drying and death of young plant. Bore holes are seen at the base just above the ground level. Dead heart can be seen in 1-3 months old crop, which can be easily pulled out. Rotten portion of the dead heart emits an offensive odour.

Management

1. Early planting during main season helps to escape the borer infestation.
2. Intercropping wiht Daincha minimizes shoot borer incidence.
3. Earthing up of sugercane plant 45 Days After Planting (DAP) reduces pest infestation.
4. Follow clean cultivation, remove dead hearts from field destroy them.
5. Spray Granulosis virus 106 – 107 twice on 35 and 50 days after planting (DAP)
6. Use Tachinid parasite Sturmiopsis inferens @ 125 gravid females from 30- 50 days of planting helps to control pest biologically.
7. Spray chlorpyriphos 20 EC @1000 ml / ha or NSKE 5 % twice.

3) Sugercane Internode borer, Chilo sacchariphagus indicus; Lepidopter: Pyralidae Sugarcane internode borer is pale brown moth with whitish hind wing. Larva cause considerable damage by making hole at enternodal region. Infested plant has internodes constricted and shortened with a number bore holes having frass in the nodal region. They feed on soft tissue of stem and pupate in leaf sheath.

Management

1. Follow clean cultivation and remove all the infested plant from field.
2. Collect and destroy the eggs periodically.
3. Avoid use of excessive nitrogen fertilizers
4. Release egg parasitoid *Trichogramma chilonis* @ 2.5 c.c / ha (6 releases from 4th month onwards at 15 days interval).

4) Sugarcane leafhopper, Pyrilla perpusilla; Homopter: Lophopidae

Sugarcane leafhopper is small sized pest that cause considerable level damage to plant leading to high economic loss. Adults are straw colored, head pointing forward as a snout. Nymphs are soft, pale brown dorsally and pale orange ventrally with two characteristic anal filaments. Leafhopper sucks the cell sap form lower leaf surface and secrets honey dew. The secretion of honey dew favors development of sooty mold which hinders photosynthesis of plant. Sugar content of cane decreases due to infestation. In severe condition, infested plant dries up and dies.

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Management

1. Apply balanced dose of fertilizer, avoid excessive use of nitrogenous fertilizer.
2. Set up light trap in field to attract and kill the hoppers.
3. Release lepidopteran parasitoid: Epiricrania melanoleuca @8000 - 10,000 cocoon /ha (or) 8 - 10 lacs egg/ha.
4. Spray Malathion 50 % EC @ 2ml/lit water if use of chemical is required.

5) Sugarcane whitefly, Aleurolobus barodensis; *Homoptera: Aleyrodidae*

Adults of sugarcane whitefly are pale yellow colored small sized pest while nymph are neonate pale yellow which latter on turn shiny black in color.

Damage: Both nymph and adult are destructive and suck cell sap form lower surface of leaf. Leaves become yellow and later on turn pinkish. There is decrease in sugar content of cane. Infestation of whitefly is more on alkaline soil, undrained soil and nitrogen deficit soil.

Management

1. Mange proper drainage facility.
2. Do not plant sugarcane in deep surface.
3. Apply nitrogen 100 kg per hac.
4. Apply metasystox 25 % EC @ 1 ml / litre water .
5.Spray fenitrothion 50 EC @ 2 lit / ha (1000 lit spray fluid)
6.Spray thiamethoxan 25 WG @ 125g/ha, 750 litres of spray fluid.

22. INSECT PEST OF CUCURBITACEOUS VEGETABLES

1. Red Pumpkin Beetle *(Aulacophora foveicollis Lucas & A. lewisii Baly)*

The adults are small, elongated yellow and defoliate the leaves immediately after germination. The larvae feed on roots and plant parts.

Management :

Mechanically collect and destroy the pest if incidence is low.
If the pest incidence is very severe, spray Indoxacarb 14.5 SC @ 0.5 ml/l or Cabaryl 50 WP 4g/l or 25 EC @ 2ml/l or Chlorpyriphos 20 EC2. 5ml/l.

2. Serpentine Leaf Miner *(Liriomyza trifolii Burgess)* This is an introduced pest occurring on many cucurbit vegetables. Heavy incidence is noticed in watermelon, pumpkin, cucumber, etc. However, bitter gourd seems to be resistant. A native larval parasitoid, Hemiptarsenus vericornis is the major parasitoid on this pest.

Management

Soil application of neem cake @ 250 kg/ha immediately after germination.
Destroy cotyledon leaves with leaf mining at 7 days after germination.
Spray PNSPE @ 4% or neem ™™ formulation with 10000 ppm or more (2ml/l) after 15 days sowing and repeat after 15 days, if necessary.

If the incidence is high first remove all severely infected leaves and destroy. Then mix neem soap 5 gm and hostothion 1 ml/l and spray. After one week, spray neem soap 1% or PNSPE or neem formulation with 10000 ppm or more (2ml/l). Never spray the same insecticide repeatedly.™™

3.Fruit Fly *(Bactocera cucurbitae Coquillett).*

This is the major pest of cucurbits. The damage by maggots results in rotting of young and ripened fruits or drying and shriveling of fruits before maturity. Sometimes even the base of the plant gets attacked and plant start wilting. The incidence is more in wet climate.

Management:.™™

Soil application of neem cake @ 250 kg/ha immediately after germination and repeat at flowering followed by sprays of neem soap 1% or PNSPE 4% at 10 days interval after flowering. Crush pumpkin 1 kg and add 100 gm jaggery and ™™ 10 ml Malathion and keep in the plot (4-6 places per acre). Adults are attracted to the fermenting pumpkin and lay eggs and get killed. Repeat the process 2-3 times in the cropping season. Erect cuelure (para pheromone trap) 3 per acre to ™™ attract and trap male fruit flies. Spray Indoxacar 0.5 ml/l.

4. Red Spider Mite *(Tetranychus neocaledonicus Andre)*

This pest is serious on cucurbits during warmer climate. Colonies of mites with in silk web can be observed on ventral leaf surface when incidence is high.

Management

Spray neem or pongamia soap at 1% on lower ™™ surface thoroughly. Alternately, spray Dimethoate 30 EC @ 2ml/l or Ethion 50 EC @ 1ml/l or Wettable Sulphur 80 WP @ 3g/l.

5. Thrips *(Thrips palmi Karny)* Both nymphs and adults feed on the young shoot tips and floral parts and is suspected vector of Tospo virus. They are serious during summer months.

Management

Soil application of neem cake (once immediately after germination and again at flowering) followed by NSPE @ 4% and neem soap 1% alternately at 10-15 days interval.

Root-knot Nematodes *(Meloidogyne incognita)*

The root-knot nematodes cause root galls from the initial stages of the crop growth. The larvae feed on the roots, which show typical galls, and later the entire root system shows heavy galling. The foliage becomes light yellowish; the plants become stunted and results in fl ower and fruit drop. In spite of irrigation the plants appear sick and drooping during daytime.

Management

Seed treatment with bio-pesticide Pseudomonas fluorescens @ 10g/kg seed.

Apply 2 tons of FYM enriched with Pochonia chlamydosporia and Paecilomyces lilacinus per acre before sowing, along with 100-200 kg of neem or pongamia cake.

DISEASE OF CUCRBITACEONS VEGITABLES

1. Anthracnose *(Colletotrichum orbiculare & C. lagenarium)*

Symptoms

Disease on leaves is observed as water soaked small yellow spots that enlarge and turn to brown. The necrotic portion dries and shatters. Elongated water soaked, sunken lesions appear on stem. Light yellow to brown discoloration of these stem lesions is due to abundant sporulation. Severe incidence resulting infection in juvenile fruits as small, sunken, light brown, cracked spots are observed. Two species are involved in cucurbits because the size of spots is distinct and appear in diff erent weather condition.

Management

Always seed should be collected from healthy fruits and disease-free area. Seeds must be treated with Carbendazim @ 0.25%.™™

Field sanitation by burning of crop debris.™™

Grow crop on bower system to avoid soil contact.™™

Maintain proper drainage in the fi eld.™™ Seed production should be preferably carried out in summer season because summer crop is often free from pathogen.

Foliar sprays of Carbendazim @ 0.1% or Chlorothalonil @ 0.2% but spray must be started soon after infection.

2. Downy Mildew *(Pseudoperonospora cubensis)*

Symptoms

Disease appears as irregular, numerous, small, yellow areas surrounded by green tissues scattered all over the leaf lamina. It appears just like in defi nite mosaic pattern particularly in cucumber. The yellow areas are angular and bounded by veins. Symptoms on bitter gourd are light brown while grayish brown on pointed gourd without prominent yellowing on these hosts. In high humid weather, faint white downy growth of fungus is observed.

Management

Crop should be grown with wide spacing in well-drained soil. Air movement and sunlight exposure helps in checking the disease initiation and development. Bower system of cropping reduces the disease ™incidence.

Field sanitation by burning crop debris to reduce the inoculums.

Seed production should be preferably carried out in summer season because summer crop is often free from disease.

Use tolerant cucumber lines like Summer Prolifi c.

Protective spray of Mancozeb @ 0.25% at seven ™™ days interval gives good control. In severe case one spray of Metalaxyl + Mancozeb @ 0.2% may be given but it should not be repeated.

3.Powdery Mildew *(Sphaerotheca fuligena and Erysiphe cichoracearum)*

Symptoms

Disease appears on all foliar part as white to dull white, powdery growth. This white growth quickly covers most of the leaf surface and leads to heavy reduction in photosynthesis area. Plants may wither and die. Growth of plant and fruits seized. Transpiration rate is very fast from infected leaves.

Management

Foliar sprays of Penconazole @ 0.05% or Tridemorph @ 0.1% or Carbendazim @ 0.1%, give very good control of the disease. Use tolerant line.™™

4.Fruit Rots *(Phytophthora cinnamomi, Pythium, Rhizoctonia, Phomopsis cucurbitae)*

Symptoms

Disease is mostly observed on matured fruits as comparatively dry rotting with characteristic pycnidia over it. Generally lower portion of fruits touching soil surface are aff ected. P. cinnamomi is causing rotting of vines, leaves and fruits of pointed gourd, Rhizoctonia fruit rot is most severe in muskmelon, while Phomopsis fruit rot on ash gourd.

Management

Avoid soil contact of fruit by using bower system ™™ of cultivation and staking of plant. Provide proper drainage in the fi eld.™™

Green manuring followed by soil application of ™Trichoderma @ 5 kg/ha in soil is very eff ective in checking most of the fruit rotting. Collect aff ected fruits and burn them to reduce primary inoculum.

5. Gummy Stem Blight *(Didymella bryoniaeteleomorph and Phoma cucurbitacearum anamorph)*

Symptoms

This disease is now becoming severe in muskmelon, bottle gourd and sponge gourd. Most of the hybrids are susceptible to the disease. Introduction of hybrids introduced this disease in all cucurbits growing area. Initially water soaked area are observed on the stem near soil line. Later on translucent gum like exudates released from the aff ected portion is deposited over it. Black dot like pycnidia is also observed on the aff ected bark.

Gummy stem lesions on muskmelon

Management

Avoid exotic hybrids and varieties due to high ™™ degree of susceptibility. Summer ploughing and green manuring followed ™by Trichoderma application. Maintain proper drainage and aeration in the fi eld.™™ Seed treatment with Carbendazim @ 0.25%.One drenching of Carbendazim @ 0.1% near collar region. Avoid injury near collar region.

6. Leaf Spots *(Cercospora citrullina, Alternaria cucumerina and Corynespora melonis, Didymella bryoniae (teleomorph) and Phoma cucurbitacearum anamorph)*

Symptoms Severity of the disease is increasing every year and engulfi ng ridge gourd, bottle gourd, pointed gourd, pumpkin and sponge gourd. Hybrids and exotic materials of bottle gourd and ridge gourd are highly susceptible to Didymella leaf blight. It is spreading throughout the cucurbits growing area. Papery with rhythmic large spots followed by shot hole is observed in Didymella. Black small dot like fruiting structures are also observed on the old spots. White fungus growth is clearly visible on outer margins of the spots in morning periods. Several other types of leaf spots occur on diff erent cucurbits. Often these leaf spot diseases are more pronounced at maturity stage.

Management

Field sanitation, selection of healthy seeds and ™™ crop rotation reduces disease incidence.

Fungicidal sprays of Mancozeb @ 0.25% alternated ™™ with one spray of Hexaconazole @ 0.05%.

Seed production should be preferably carried out ™™ in summer season because summer crop is often free from disease.

7.Bacterial Wilt *(Erwinia tracheiphila)*

Symptoms

Bacterial wilt is a common and often destructive disease on cucumber, muskmelon, squash and pumpkin. The fi rst signs of wilt appear usually on individual leaves as drooping, which become fl accid in sunny weather.

As the disease progresses, more leaves wilt and eventually an entire plant is wilted. When wilted stems are cross-sectioned, viscid and sticky bacterial matrix exudates from the vascular bundles is observes. This feature is used as a means of diagnosis. This is vascular pathogen and diff ers from other Erwinia spp. unable to degrade middle lamella. The bacteria lives in the bodies of adult cucumber beetles particularly red striped and spotted beetle. Primary infection is produced when beetles feed upon young leaves or cotyledons. The bacteria present in the vessels of infected plants die within 1 or 2 months after the dead plants dry up.

Management

Control of cucumber beetles at initial stage from ™™ the soil with neem cake or systemic granular insecticides. Tolerant varieties with restricted use of exotic ™™ cucumber lines should be grown. Summer polughing of soil to expose all the stages ™™ of beetles.

8. Mosaic and Leaf Distortion

Symptoms

Most of the cucurbits grown in rainy season are aff ected by virus disease like cucumber mosaic, green mottle, leaf distortion, water mosaic etc. Generally alternate green and yellow patches with mottling symptoms are observed. Sometimes leaves deform and curl downwards. Smalling and narrowing of the leaves is also observed in leaf distortion virus. Plants become small and excessive branching, proliferation of the leaves, twigs, petioles, bushy appearance of the plants are observed.

Management

Management of the disease involves destruction of diseased hosts and weeds. Virus free seeds must be used to check the seed ™™ transmission.

Initial rouging of the infected plants.™™

Periodical spray of systemic insecticides up to ™™flowering stage to control vectors. Seed production should be preferably carried out ™™ in summer season because summer crop is often free from virus infection.

Restricted use of exotic hybrids and varieties in bottle gourd, bitter gourd and cucumber.

2.3 INSECT PEST OF ONION AND GARLIC:

Thrips *(Thrips tabaci Lindeman)*

Thrips feed on a wide range of cultivated plants and weeds. Some of the principal alternate hosts include cabbage, cotton, tomato, cucumber, melons, pumpkins, strawberries and many fl owering plants. Thrips are pestiferous in diverse ways. They cause direct damage to leaves and bulbs, aggravate fungal diseases and even vector virus.

Management

Monitoring: Sticky traps are commonly used for detecting thrips population. Various colours were found attracting diff erent species of thrips in various geographical areas; widely used ones are yellow and bright blue traps.

Cultural Good crop management practices can be readily manipulated to the disadvantage of thrips. Field sanitation techniques such as removing ™™ alternate weed host on bunds and destruction of culls of onion and garlic are helpful to some extent in bringing down thrips population. Avoid successive planting of onion and garlic or ™™ other preferred host. Therefore, planting in upwind direction could be helpful in escaping infestation from old planting to some extent in the initial stages.

Planting

Date By making adjustments in transplanting dates, onions can be made tolerant to early thrips attack and satisfactory yields can be obtained with minimum chemical intervention.

Mulching

Thrips being colour-sensitive, coloured mulches ™™ may be employed for their control. Reflective plastic silver colour and aluminium ™™ painted black mulches were effective in repelling the thrips in seed crop.

Irrigation

Sprinkler irrigation reduces thrips population considerably compared to drip and surface irrigation. Insects would be washed off or drowned in the water accumulated in the leaf bases. Due to continuous retention of moisture in the soil, the pupae get rotten. In case of garlic, sprinklers are not that effective as in case of onion mainly due to the closer inner leaf alignment that protects the thrips from splashes of water.

Barriers

Two rows of maize or inner row of wheat and outer row of maize surrounding the onion plots.

Biological Control

These include lady beetles, minute pirate bugs, ™™ ground beetles, big-eyed bugs, lacewings, hover flies, predatory mites and spiders. So far limited success has been achieved in biological control of T. tabaci in many parts of the world. A predator, minute pirate bug, ™™ Orius tantillus and anthocorid bug, found effectively feeding on thrips on garlic. Metarhizium ansopliae, Paecilomyces fumosoroseus, ™™ Verticillium lecani and Frankliniella also killed T. tabaci sp. Mortality of thrips was highest with B. bassiana at 260 C and 75% RH.

Plant Resistance

Commercial varieties, N-2-4-1 and Pusa Ratnar were found resistant to T. tabaci in Punjab but the former was susceptible to thrips in Maharashtra. The variety B-780 is moderately resistant to thrips. In Bihar, Pusa Red and N-53 had lowest thrips population while Arka Niketan had highest infestations.

Botanicals

Neem was found effective when mixed with insecticides.

Chemical

Many insecticides like dimethoate (0.06%) and Methyl Demeton (0. 05%) are recommended for thrips control. Cypermethrin at 60 g ai/ ha offers good control of this pest. Carbosulfan (0.05%) and Lambda cyhalothrin also effectively suppress thrips population. Addition of a spreader or sticker (0.05-1.0%) is useful for retention and spread of spray fluid on erect leaves of onion. Avoid repeated use of the same insecticide to minimise development of insecticide resistance. In seed crop, control of thrips is often difficult. The ™™ umbels will provide excellent hiding site and it is difficult to reach them with insecticide. From the beginning, seed crop should be ™™ monitored regularly for thrips and should be controlled well before flowers open. Avoid sprays after flower opening.™™ If necessary, safer insecticide should be used late in the evening when no bees are foraging.

PRINCIPLES AND STRATEGIES OF INTEGRATED PEST MANAGEMENT & THE CONCEPT OF ECONOMIC THRESHOLD LEVEL

IPM is an approach to solving pest problems by applying our knowledge about pests to prevent them from damaging crops, harming animals, infesting buildings or otherwise interfering with our livelihood or enjoyment of life. IPM means responding to pest problems with the most effective, least-risk option. Under IPM, actions are taken to control pests only when their numbers are likely to exceed acceptable levels. Any action taken is designed to target the troublesome pest, and limit the impact on other organisms and the environment.

Applying pesticides to crops, animals, buildings or landscapes on a routine basis, regardless of need, is not IPM. Applications of pesticides are always the last resort in an IPM program.

Objectives of Pest Management

i. To reduce pest status below economic injury level. Complete elimination of pest is not the objective.

ii. To manage insects by not only killing them but by preventing feeding, multiplication and dispersal.

iii. To use ecofriendly methods, which will maintain quality of environment (air, water, wild life and plant life)

iv. To make maximum use of natural mortality factors, apply control measures only when needed.

v. To use component in sustainable crop production

Need for Pest Management

i. Development of resistance in insects against insecticides e.g. OP and synthetic pyrethroid resistance in Helicoverpa armigera.

ii. Out break of secondary pests e.g. Whiteflies emerged as major pest when spraying insecticide against H. armigera.

iii. Resurgence of target pests e.g. BPH of rice increased when some OP chemicals are applied.

iv. When number of application increases, profit decreases.

v. Environmental contamination and reduction in its quality.

vi. Killing of non-target animals and natural enemies.

vii. Human and animal health hazards. viii.

Integrated Pest Management

The term IPM is defined as the intelligent selection and use of pest control tactics that will ensure favourable economical, ecological and sociological consequences

2.3.1.Basic principles of Integrated Pest Management :

a) 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 behaviour 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.

b) Pest Surveillance : 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.

c) Utilization of Economic Threshold Levels (ETL): 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.

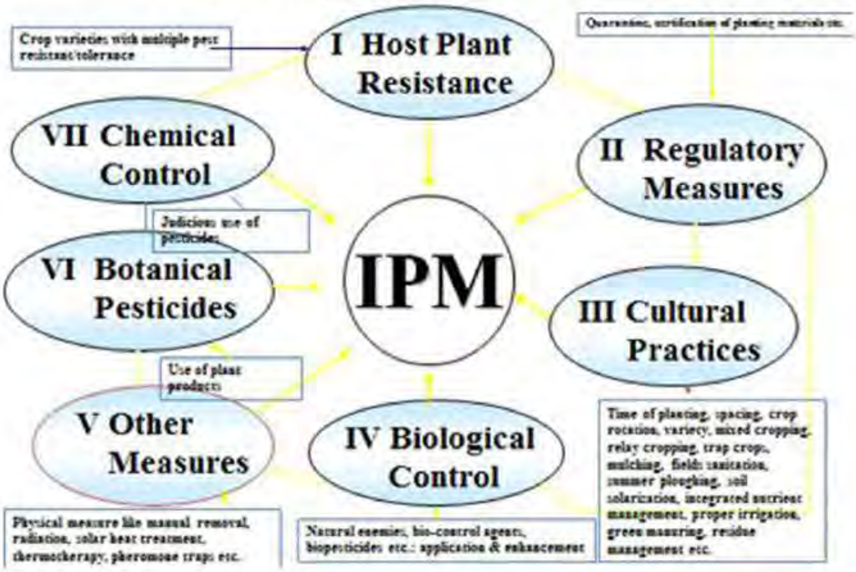
d) Application of minimum selective hazards : The application of chemical measures to pest population has to be in such a manner that target pest populations are just kept below economic injury thresholds. By observation of this principle the development of resistant populations of pest is avoided or 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.

Components of IPM

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

Components of IPM



IPM requires competence in the following three areas:

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. 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.

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.

a) Cultural control: Cultural methods of pest control consist of regular farm operations in such a way which either destroy the pests or prevent them from causing economic loss. The various cultural practices have been grouped as under.

Normal agricultural practices (clean cultivation), which incidentally ward off certain pests Systematic cutting and removal of infested parts: Keeps down subsequent infestation

Crop rotation: Crop rotation is most effective practice against pests that have a narrow host range and dispersal capacity

Mixed cropping: Intended for getting some return when one crop is attacked, the other escapes.

Growing resistant varieties: certain varieties resists pest attack Manipulation of planting time helps to minimize pest damage

Trap cropping: Growing of susceptible or preferred plants by important pests near a major crop to act as a trap and later it is destroyed or treated with insecticides

Trimming field buds: Grasshopper eggs, which are laid in field bunds are destroyed by trimming field bunds

Flooding the field: Flooding of fields is recommended for reducing the attack of cutworms, army worms, termites, root grubs etc.

Draining the fields: In case of paddy case worm Nymphula depunctalis which travel from plant to plant via water. it can be eliminated by draining or drying the field

Alley ways: Formation of alley ways for every 2 m in rice field reduces the BPH

Nilaparvata lugens

Raking up and hoeing of the soil around gourds, mango and other fruit trees serves to destroy pupae of fruit flies.

Adoptation of high seed rate in sorghum and later removal and destruction of shoot fly (Atherigona soccata) affected ones.

Trash mulching @ 3 t/ha 3 days after planting or earthing up at a month or two after planting minimize early shoot borer (Chilo infuscatellus) attack in sugarcane

Destruction of crop residue: Stubbles of sugarcane and paddy that harbour borers should be ploughed up and burnt.

Deep ploughing in summer exposes most of the soil inhabiting insects to sun and hot winds and get them killed

Periodical drying of stored produce against stored grain pests.

Pruning of dried twigs/ branches to eliminate pests like scales and orange borer

b) Mechanical Methods

Hand picking and collection with hand nets and killing insects

Provision of preventive barriers: Digging trenches around field, Bagging / wrapping of fruits and tin bands are fixed over coconut palms to prevent damage by rats

Extraction of adult Rhinoceros beetle (Oryctes rhinoceros) from the crown of coconut trees using an arrow headed rod/hook.

Construction of rat proof godowns, use of an alkathene band around the tree trunks of mango to check the migration of first instar nymphs of mealybugs and red ants

Sticky bands around tree trunks against red tree ant (Oecophylla samaragdina)

Systematic shaking of root grub adults harbored trees during evening hours to dislodge and destroy by dumping in fire.

Shaking of redgram plants to collect and destroy later instars of Helicoverpa armigera

Shaking the trees and bushes by which the insects fall to the ground and they can be collected.

Sieving and winnowing against stored grain pests Using mosquito nets fly proof cages etc.

c) Physical Methods: Use of certain physical forces to minimize the pests Artificial heating and cooling of stored products will prevent insect damage Steam sterilization of soil kills soil insects

Vapour Heat Treatment (VHT) against fruit flies in mango

Use of male sterile technique against screwworm fly (Cochliomyia hominivorax)

Light traps are arranged for attracting the insects Use of flame throwers

Biological control: Biocontrol is use of living organisms to manage crop damaging living organisms (pests). Some of the common biocontrol agents are

Advantage of Integrated Pest Management

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

1. Fits better in National Economy. Pest control activities at present are mainly based on the application of chemical pesticides, quite a large proportion of which has to be imported. The expenditure envisaged for plant protection runs into crores of rupees even when only one or at the most two pesticide application are envisaged per crop. High yielding varieties show that many more pesticide applications are called for many crops if pest control has to depend only on the use of pesticide. Thus a time has come where Integrated Pest Management is not only advisable but also inevitable.

2. More efficient and cheaper method. In IPM schedule efforts are made to utilize various methods of control including use of pesticides but some times and in some cases it is feasible to nip the trouble in the bud itself even by a mechanical campaign like destruction of egg

masses of some pests or collecting the caterpillar stages. In such cases it envisages a lot of saving in the use of pesticides, this means saving of money and saving of foreign exchange and also the destruction of the pest before it has been able to inflict damage.

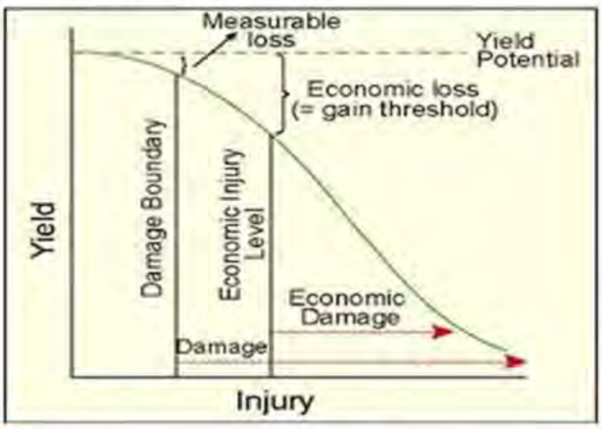
3. Avoid upsetting the balance of nature. Chemical control has often been reported to upset the balance of nature at times leading to upsurge of new type of pest problem which did not exist before. The seriousness of mites in many parts of the world has occurred by the use of DDT. It is confidently expected that such adverse side effects will be much less as a result of integrated pest management schedule.

4. Minimises residue hazards of pesticides : It is obvious that in an IPM schedule the use of pesticides will be considerably reduced, hence the pesticide residue hazards will also get automatically minimised.

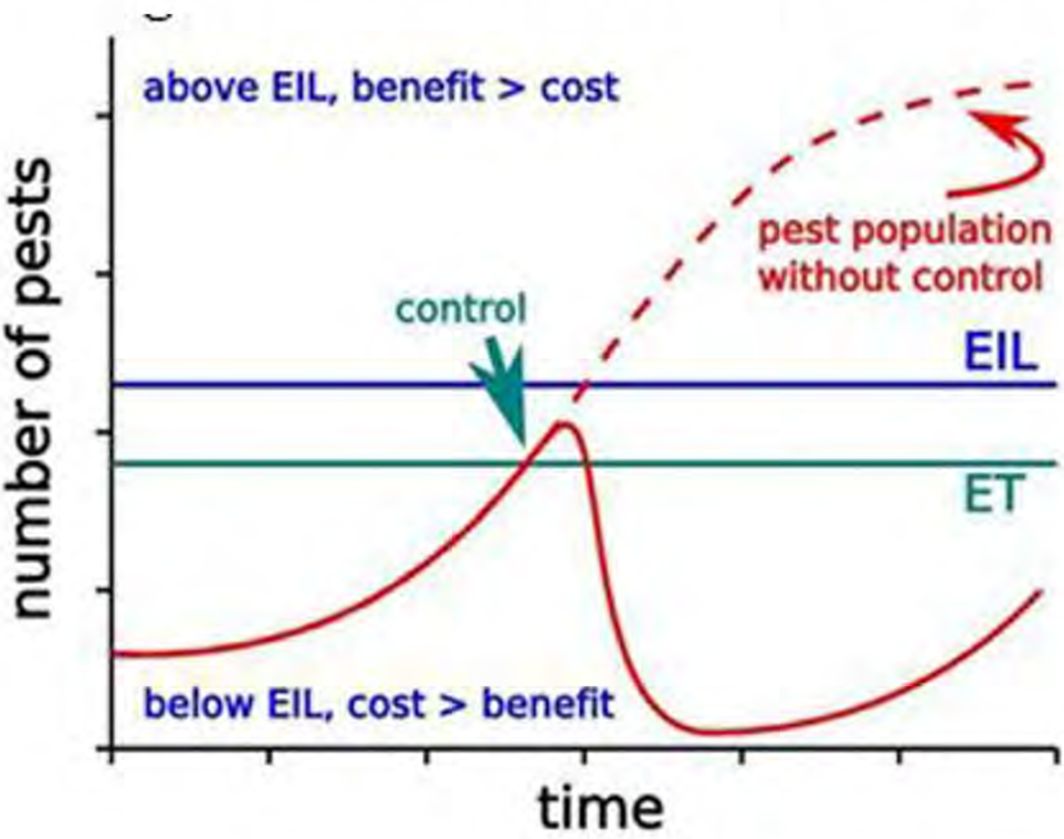
Concept of ETL and EIL

The presence of a pest does not always cause a loss in quality or quantity of an agricultural product. To justify the cost of control, pest populations must be large enough to cause significant damage. Using IPM can help agricultural producers to determine if the benefits of pesticides and other pest management tactics exceed the costs of control. If benefits don't exceed costs, time and money are wasted. A number of economic concepts are helpful in determining the point at which it pays to use pesticides or other treatment.

Economic Injury level (EIL): It is defined as the lowest population density of insect that will cause economic damage OR the critical density of insect population where the loss caused by the pest equals the cost of control measures.



Economic Threshold Level (ETL) or Action threshold: It is defined as the pest density at which control measures should be applied to prevent an increasing pest population from reaching EIL.



Pesticides and their Recommendation

The pesticide recommendation for an insect pest or disease problem needs to suggested based con the recommendations of the state government based on the label claim or referring into the recommendations of the Central Insecticides Board of government of India. Pesticide recommendation needs to be given based on active ingredient or quantity of formulation along with quantity of spray fluid. The list of pesticide recommended for rice crop is given below for reference:

Crop	Common name of the pest	Dosage / ha			Waiting Period (days)
		a.i (gm)	Formulatio(gm/ml)	Dilution in Water	
ACEPHATE 75% SP					
Rice	Stem Borer, LeafFolder, Plant Hoppers, Green	500-750	666-1000	300-500	15
ACETAMIPRID 20% SP					
Rice	BPH	10-20	50-100	500-600	7
AZADIRACHTIN 0.3% (3000 PPM) MIN. NEEM SEED KERNEL BASED E.C.					
Rice	Thrips, Stem borer, Brown Plant hopper, Leaf folder	-	1500 – 2500	500	5
***BACILLUS THURINGIENSIS VAR. KURSTAKI*, SEROTYPE H-39, 3B, STRAIN Z-52 BIO-TECH. INTERNATIONAL**					
Rice	Stem borer & Leaf folde	1.50 kg.	500-750	-	
Rice	Stem borer, Leaf folder,	1000	33000		20
Rice	Stem borer Green leaf hopper Brown plant hopper Leaf folder, Gall midge	375	25000		7
FENOBUCARB (BPMC) 50% EC					
Rice	Brown Plant Hopper, Green Leaf Hopper	250-750	500-1500	500	30
FENPROPATHRIN 30% EC					
Rice	Yellow Stem borer, Leaf folder	100	333	500	30
FIPRONIL 0.3% GR					
Rice	Stem borer, Brown plant hopper, Green leaf hopper, Rice leaf	50-75	1000-1500	500	32
Fipronil 0.6% w/w GR					
Rice	Stem borer & Leaf	60	10	65	-
FIPRONIL 80%WG					
Rice	Stem borer, Leaf folder	40-50	50 – 62.5	375-500	19
FLONICAMID 50% WG					
Rice	Brown plant hopper, white backed plant hopper, Green leaf	75	150	500	36
FLUBENDIAMIDE 20% WG					
Rice	Stem borer, Leaf borer	25	125	500	30

Pesticide selection for the particular pest in a particular crop need to be made based on ETL level and unless it is recommended combined use of pesticides or fungicides and plant growth promoters are not recommended as they affect efficacy of product sometime causes phyto- toxicity and other hazards

The details on Insecticides registered for agriculture use in various crops along with dose and active ingredient are available at are given in Annexure 6 or (http://ppqs.gov.in/divisions/cib- rc/major-uses-of-pesticides)

NON CHEMICAL METHODS OF PEST CONTROL FOR INTEGRATION WITH CHEMICAL CONTROL

A. Cultural Control:

Definition : Manipulation of cultural practices to the disadvantage of pests

S.No	Cropping Techniques	. Pest Checked
1.	Ploughing Puddling	Red hairy caterpillar
2.	Trimming and plasteringPest free	Rice mealy bug Rice
3.	seed material High seed rate	grass hopper Potato
4.	Rogue space plantingPlant density	tuber moth Sorghum
5.	Earthing up Detrashing	shootfly
6.	Destruction of weed hosts	Rice brown
7.	Destruction of alternate host	planthopper
8.	Flooding	Rice brown
9.	Trash mulching Pruning / topping	planthopper Sugarcane
10.	Intercropping Trap cropping	whitefly Sugarcane
11.	Water management	whitefly Citrus
12.	Judicious application of fertilizers	fruit sucking
13.	Timely harvesting	moth
14.		Cotton whiteflyRice
15.		armyworm
16.		Sugarcane early shoot
17.		borer
18.		Rice stem borer
19		Sorghum stem borer
		Diamond back moth
		Brown planthopper
		Rice leaf folder
		Sweet potato weevil

Community level practices:

1. Synchronized sowing : Dilution of pest infestation (eg) Rice, Cotton
2. Crop rotation : Breaks insect life cycle
3. Crop sanitation

i. Destruction of insect infested parts (eg.) Mealy bug in brinjal

ii. Removal of fallen plant parts (eg.) Cotton squares

iii. Crop residue destruction (eg.) Cotton stem weevil

B. Physical Control: Modification of physical factors in the environment to minimise (or) prevent pest problems. Use of physical forces like temperature, moisture, etc. in managing the insect pests.

a) Manipulation of temperature

a. Sun drying the seeds to kill the eggs of stored product pests.

b. Hot water treatment (50 - 55oC for 15 min) against rice white tip nematode.

c. Flame throwers against locusts.

d. Burning torch against hairy caterpillars.

e. Cold storage of fruits and vegetables to kill fruitflies (1 – 2 oC for 12 - 20 days).

b) Manipulation of moisture

a. Alternate drying and wetting rice fields against BPH.

b. Drying seeds (below 10% moisture level) affects insect development.

c. Flooding the field for the control of cutworms.

c) Manipulation of light

a. Treating the grains for storage using IR light to kill all stages of insects (eg.) Infra-red seed treatment unit (Fig.1).

b. Providing light in storage go downs as the lighting reduces the fertility of Indian meal moth, Plodia.

c. Light trapping.

d) Manipulation of air: Increasing the CO2 concentration in controlled atmosphere of stored grains to cause asphyxiation in stored product pests.

e) Use of irradiation: Gamma irradiation from Co 60 is used to sterilize the insects in laboratory which compete with the fertile males for mating when released in natural condition. (eg.) cattle screw worm fly, Cochliomyia hominivorax control in Curacao Island by E.F.Knipling.

f) Use of greasing material: Treating the stored grains particularly pulses with vegetable oils to prevent the oviposition and the egg hatching. eg., bruchid adults.

g) Use of visible radiation : Yellow colour preferred by aphids, cotton whitefly : yellow sticky traps.

h) Use of Abrasive dusts

i. Red earth treatment to red gram : Injury to the insect wax layer.

ii. Activated clay : Injury to the wax layer resulting in loss of moisture leading to death. It is used against stored product pests.

iii. Drie-Die : This is a porous finely divided silica gel used against storage insects.

C. Mechanical Control: Use of mechanical devices or manual forces for destruction or exclusion of pests.

a. Mechanical destruction: Life stages are killed by manual (or) mechanical force.

Manual Force

i. Hand picking the caterpillars

ii. Beating : Swatting housefly and mosquito

iii. Sieving and winnowing : Red flour beetle (sieving) rice weevil (winnowing)

iv. Shaking the plants : Passing rope across rice field to dislodge caseworm and shaking neem tree to dislodge June beetles

v. Hooking : Iron hook is used against adult rhinoceros beetle

vi. Crushing : Bed bugs and lice

vii. Combing : Delousing method for Head louse

viii. Brushing : Woolen fabrics for clothes moth, carper beetle.

Mechanical force

i. Entoletter : Centrifugal force - breaks infested kernels - kill insect stages - whole grains unaffected - storage pests.

ii. Hopper dozer : Kill nymphs of locusts by hording into trenches and filled with soil.

iii. Tillage implements : Soil borne insects, red hairy caterpillar.

iv. Mechnical traps : Rat traps of various shapes like box trap, back break trap, wonder trap, Tanjore bow trap.

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Mechanical exclusion: Mechanical barriers prevent access of pests to hosts.

i. Wrapping the fruits : Covering with polythene bag against pomegrante fruit borer.

ii. Banding : Banding with grease or polythene sheets - Mango mealybug.

iii. Netting : Mosquitoes, vector control in green house.

iv. Trenching : Trapping marching larvae of red hairy catepiller.

v. Sand barrier : Protecting stored grains with a layer of sand on the top.

vi. Water barrier : Ant pans for ant control.

vii. Tin barrier : Coconut trees protected with tin band to prevent rat damage.

viii. Electric fencing : Low voltage electric fences against rats.

Appliances in pest control:

Light traps : Most adult insects are attracted towards light in night. This principle is used to attract the insect and trapped in a mechanical device.

Incandescent light trap : They produce radiation by heating a tungsten filament. The spectrum of lamp include a small amount of ultraviolet, considerable visible especially rich in yellow and red. (eg.) Simple incandescent light trap , portable incandescent electric. Place a pan of kerosenated water below the light source.

Mercury vapour lamp light trap : They produce primarily ultraviolet, blue and green radiation with little red. (eg.) Robinson trap . This trap is the basic model designed by Robinson in

1952. This is currently used towards a wide range of Noctuids and other nocturnal flying insects. A mercury lamp (125 W) is fixed at the top of a funnel shaped (or) trapezoid galvanized iron cone terminating in a collection jar containing dichlorvos soaked in cotton as insecticide to kill the insect.

Black light trap : Black light is popular name for ultraviolet radiant energy with the range of wavelengths from 320-380 nm. Some commercial type like Pest-O-Flash, Keet-O-Flash are available in market. Flying insects are usually attracted and when they come in contact with electric grids, they become elctrocuted and killed.

Pheromone trap: Synthetic sex pheromones are placed in traps to attract males. The rubberised septa, containing the pheromone lure are kept in traps designed specially for this purpose and used in insect monitoring / mass trapping programmes. Sticky trap water pan trap and funnel type models are available for use in pheromone based insect control programmes.

Yellow sticky trap: Cotton whitefly, aphids, thrips prefer yellow colour. Yellow colour is painted on tin boxes and sticky material like castor oil /vaseline is smeared on the surface (Fig.9). These insects are attracted to yellow colour and trapped on the sticky material.

Bait trap: Attractants placed in traps are used to attract the insect and kill them. (eg.) Fishmeal trap: This trap is used against sorghum shootfly. Moistened fish meal is kept in polythene bag or plastic container inside the tin along with cotton soaked with insecticide (DDVP) to kill the attracted flies

Pitfall trap helps to trap insects moving about on the soil surface, such as ground beetles, collembola, spiders. These can be made by sinking glass jars (or) metal cans into the soil. It consists of a plastic funnel, opening into a plastic beaker containing kerosene supported inside a plastic jar

Probe trap: Probe trap is used by keeping them under grain surface to trap stored product insect

Emergence trap: The adults of many insects which pupate in the soil can be trapped by using suitable covers over the ground. A wooden frame covered with wire mesh covering and shaped like a house roof is placed on soil surface. Emerging insects are collected in a plastic beaker fixed at the top of the frame

Indicator device for pulse beetle detection: A new cup shaped indicator device has been recently designed to predict timely occurrence of pulse beetle Callosobruchus spp. This will help the farmers to know the correct time of emergence of pulse beetle. This will help them in timely sun drying which can bill all the eggs.

3. Biological Control and its Importance in Pest Management

Biological Control: Biological control is "the action of parasites, predators, or pathogens in maintaining another organism's population density at a lower average than would occur in their absence. \Biocontrol is defined as "use of living organisms to manage crop damaging living organisms (pests)". Some of the common biocontrol agents are

Predators Parasitoids Pathogens Nematodes

Predators and Parasites

Predators are free living organisms that feed on other animals, their prey, devouring them completely and rapidly whereas parasitoids are organisms that depend on their host for some essential metabolic factor on another throughout its all life stages, which is always larger than itself

Sl. No.	Predator	Parasitoid
1	Bigger than the prey	Smaller than its host
2	Very active	Usually sluggish once the host in secured
3	Organ of locomotives, sense organ and mouth parts are well developed.	Organ of locomotives, sense organ and mouth parts not well developed
4	Habitat is independent of its prey	Habitat in same that of its host.
5	Life cycle in longer than the host.	Life cycle shorter than the host
6	A single predator may attack severalhost in in its life period	It usually completes development in a single host.

Role of parasitoids and predators in IPM

i. Since biological control is safe to environment, it should be adopted as an important component of IPM.

ii. Biological control method can be integrated well with other methods namely cultural, chemical methods and host plant resistance (except use of broad spectrum insecticides)

iii. Biological control is self propagating and self perpetuating

iv. Pest resistance to NE is not known

v. No harmful effects on humans, livestock and other organisms

vi. Biological control is virtually permanent

vii. Biological agents search and kills the target pest

IDENTIFICATION OF POTENTIAL INSECT PREDATORS AND PARASITOIDS USED FOR PEST CONTROL

Aim: To make familiar on the parasitoids and predators of agricultural significance to facilitate judicious use of selective insecticides.

Methodology: The participants will be exposed to key parasitoid and predator in agricultural production system

Approach: Exposure to biocontrol lab besides showing key specimens in the laboratory conditions

Identification of Potential Insect Predators and parasites used for pest control 1.Predators:

Order	Family	Species	Hosts
Coleoptera	Coccinellidae	*Cryptolaemus montrouzieri*	Aphids, Scales,Mealybugs, Eggs of lepidopterans
		Rodalia cardinalis	
		Cheilomenes sexmaculata	
		Harmonia octomaculata	
		Chilocoris nigrata	
		Scymnus coccivora	
		Parascymnus horni	
		Coccinella transversalis	
Coleoptera	Cicindelidae	*Cicindella sexmaculata*	Aphids, Scales, Mealybugs,Eggs of lepidopterans
	Carabidae	*Cosnoidea indica, Anthia sexguttata*	Aphids, Scales, Mealybugs,Eggs of lepidopterans
Odonata		*Dragon fly and damsel flies*	Caterpillars
Mantodea		*Mantis religiosa*	Caterpillars and Grasshoppers
Neuroptera	Chrysopidae	*Chrysoperla zastrowi*	Aphids, Scales, Mealybugs,Eggs of lepidopterans
	Hemerobiidae	*Micromus igoratus*	
Hemiptera	Miridae	*Cyrtorrhinus lividipennis*	Hemipterans
	Ruduviidae	*Platymeris laevicollis*	Lepidopteran larvae

	Pentatomidae	*Eucantheconafurcelleta*	Caterpillars
Lepidoptera	Epipyropidae	*Dipha aphidivora*	Aphids
Diptera	Asilidae	*Asilus sp*	Small insects
	Syrphidae	*Ischiodon scutellaris*	Small insects

Stage	Family	Species	Hosts
Egg parasitoid	Trichogrammati dae	*Trichogrammachilonis*	Eggs of sugarcane internode borer, cotton bollworm, rice leaf folder
		T. japonicum	Eggs of rice stem borer
	Scelonidae	*Telenomus rowani*	Eggs or rice stem borer
		Telenomus remus	Eggs of tobacco caterpillar
Egg-larva lparasitoid	Braconidae	*Chelonus blackburni*	Eggs of cotton spotted bollworm
	Encyrtidae	*Copidosoma koehleri*	Potato tuber moth
Larval parasitoid	Braconidae	*Bracon brevicornis*	Larvae of CBHC
		Bracon hebetor	Larvae of CBHC
		Cotesia plutellae	Larvae of diamondback moth
	Bethylidae	*Goniozus nephantidis*	Late larval CBHC
	Platygastridae	*Platygastor oryzae*	Larvae of rice gall midge
	Ichneumonidae	*Campoletis chloridae*	Larval Spodoptera or Helicoverpa
		Erioborus trochanteratus	Larval CBHC
Larval – Pupal parasitoid	Ichneumonidae	*Isotima javensis*	Pre – pupal parasite of top shoot borer of sugarcane
Pupal parasitoid	Ichneumonidae	*Xanthopimplapunctata*	Larvae of Lepidopteran
	Eulopidae	*Trichospilus pupivora*	Pre-pupal, Pupal, CBHC
		Tetrastichus israeli	Pre-pupal, Pupal, CBHC
	Chalcididae	*Brachymeria nephantidis*	Pupal, CBHC

Nymphal and adult parasitoid	Epiricanidae	*Epiricania melanoleuca*	Nymphal, adult
	Aphelinidae	*Aphelinus mali*	Nymphal, Aphids
		Encarsia formosa	Nymphal, WF, MB, SC
		Encarsia favoscutellum	Nymphal, WF, MB, SC
Larval parasitoid	Tachanidae	*Eucelatoria bryani*	Larval, Lepidopteran
		Sturmiopsis inferens	Larvae of sugarcane early shoot borer
		Spoggosia bezziana	Larvae of coconut black headed caterpillar
Larval – pupal parasitoid	Tachanidae	*Eucelatoria bryani*	Larvae of *H.armigera*

FIELD USE METHODOLOGY FOR RELEASE OF INSECT PARASITOIDS AND PREDATORS

(i) Inoculative release: Control expected from the progeny and subsequent generations only.

(ii) Inundative release: NE mass cultured and released to suppress pest directly.

Dose for field application of insect parasitoids and predators

Species	Host/s	Dose
Trichogramma chilonis	Sugarcane borers: *Chilo infuscatellus, Chilo sacchariphagus indicus* Cotton (Non Bt) bollworms: *Helicoverpa armigera, Pectinophora gossypiella Earias spp.* Maize stem borer: *Chilopartellus* Diamond back moth: *Plutella xylostella* Tomato fruit borer: *Helicoverpa armigera*	50,000/ha on sugarcane and vegetables; 100,000/ha on maize and 1,50,000/ha on cotton Sugarcane: 4 to 6 releases at 10 days intervals for early shoot borer; 8 to 10 releases for stalk, internode and Gurdaspur borers Cotton (Non Bt) & Vegetables: 6 weekly releases Maize: 3 releases at five days intervals
Trichogramma japonicum	Top shoot borer of sugarcane: *Scirpophaga nivella* Paddy stem borer: *Scirpophaga incertulas*	Sugarcane & Paddy: 50,000/ha Sugarcane: 4 to 6 releases at 10 days intervals on observing pest or from 60th day Paddy: 6 releases on appearance of pest or from 30th day after transplantation

Trichogramma brasiliensis	Helicoverpa armigera	1.50-2.50 Lakh/ha
Goniozus nephanidis	Coconut blackheaded caterpillar	10 adults per palm (4 releases)
Bracon brevicornis	*Antigastra catalaunalis, Earias sp., Helicoverpa armigera, Opisina arenosella, Pectinophora gossypiella, Chilo partellus*	10 adult/tree for coconut block headed caterpillar. 20000 adults/ha for cotton bollworm
Bracon bebetor	*Corcyra cephalanica, Dichocracis punctiferalis, Hellula undalis, Helicoverpa armigera , Opisina arenosella*	10 adult/tree for coconut block headed caterpillar. 20000 adults/ha for cotton bollworm
Chelonus blackburni	Potato tuber moth *Phthorimaea operculella,*	50000 adults /ha in the field (2 releasesat weekly intervals) 2 adults per kg of potatoes in godowns (3 to 4 releases at fortnightly intervals)
Cotesia plutellae	Diamond Back Moth	25000-50000/ha, 10-15/plant
Trichospilus pupivora	Coconut Black Headed Caterpillar	10-15/plant
Tetrastichus israeli	Coconut Black Headed Caterpillar	10-15/plant
Brachymeria nephantidis	Coconut Black Headed Caterpillar	10-15/plant
Species	**Host/s**	**Dose**
Cryptolaemus montrouzieri	mealybugs	3000-4000/ha
Rodalia cardinalis	Aphids/scales/mealy bugs	3000-4000/ha
Chilocoris nigrata	Aphids/scales/mealy bugs	3000-4000/ha or 10-12/plant
Chrysoperla zastrowi	Aphids/scales/mealy bugs/ Eggs of lepidopterans	1.00-1.50 lakh/ha

Micromus igoratus	Aphids	5000-6000/ha
Cyrtorrhinus lividipennis	Hemipterans	50-60 bugs/100m2
Dipha aphidivora	Aphids	5000-6000/ha

C. PESTICIDE APPLICATION

1. Principles of Pesticide Application

Pesticide application plays an important role in pest management. Proper technique of application of pesticide and the equipment used for applying pesticide are vital to the success of pest control operations. The application of pesticide is not merely the operation of sprayer or duster. It has to be coupled with a thorough knowledge of the pest problem. The use of pesticides involves knowledge not only of application equipment, but of pest management as well.

Objective of pesticide application

The objective of the application of pesticide is to keep the pest under check. The pest population has to be kept suppressed to minimum biological activities to avoid economic loss of crop yields. Thorough killing of pest or eradication of pest is neither practical nor necessary. The objective of pesticide application besides keeping the pest population under check should also be to avoid pollution and damage to the non-targets.

The main purpose of pesticide application technique is to cover the target with maximum efficiency and minimum efforts to keep the pest under control as well as minimum contamination of non-targets. All pesticides are poisonous substances and they can cause harm to all living things. Therefore their use must be very judicious. The application techniques ideally should be target oriented so that safety to the non-targets and the environment is ensured. Therefore, proper selection of application equipment, knowledge of pest behaviour and skilful dispersal methods are vital.

Different types of pesticides are used for controlling various pests. For example Insecticides are applied against insect pests, Fungicides against crop diseases, Herbicides against weeds etc. in order to protect the crop losses. But it is essential that besides choosing an appropriate pesticide for application it has to be a quality product i.e., proper quantity of pesticide active ingredient (a.i) must be ensure that the quantity is maintained in production and marketing of pesticide formulations.

The application of pesticide is very successful when applied at the most susceptible stage of the pest. If the timing of pesticide application is carefully considered and followed, the results will be good pest control and economy. Therefore for large area treatment careful selection of equipment becomes necessary so that within the available 'Time' the area could be treated.

Even though good quality pesticide is used and optimum timing for the application of pesticide is also adopted; unless the pesticide is applied properly it will not yield good results. Therefore, the quality of application of pesticides is very important in pest control operations. Adherence to the following points can ensure it:

1. Proper dosage should be applied evenly
2. The toxicant should reach the target
3. Proper droplet size
4. Proper density of droplet on the target

The dosage recommendation are generally indicated for acre or hectare e.g. kg/ha or lit/ha. It should be properly understood and the exact quantities of the formulated pesticide should be applied.

Pesticides are dispersed by different methods like spraying, dusting etc. For spraying of pesticides different types of nozzles such as hydraulic, air blast, centrifugal and heat energy type are used. Water is a common carrier of pesticides but air or oils are also used as carriers. Selection of proper droplet is an important consideration. The shape, size and surface of the target vary greatly. For spraying against flying insects, the hydraulic nozzles will not be effective. Here we need fine size spray particles to remain airborne for longer time. However, for weed control operation usually the requirement is drift free application or coarse spray droplets. Adequate number of spray droplets should be deposited necessarily. For fungicide application the number of droplets deposited per unit area should be more and may be for translocated herbicide application it can be less in number. It may need fewer numbers of droplets to be deposited in case of highly mobile (crawling) insect pest.

The pesticides are formulated in liquid form, dust powder or granule forms such that it makes possible to apply small quantities of pesticides over large area. Some of the pesticides are applied as low as few gram a.i. per hectare. Therefore adoption of proper Application Technique is vital for uniform depositing of pesticide. The method of setting the pesticide application equipment to ensure even distribution of certain quantity of pesticide over the desired area is called Calibration.

Spraying Techniques
Most of the pesticides are applied as sprays.

The liquid formulations of pesticide either diluted (with water, oil) or directly are applied in small drops to the crop by different types of sprayers. Usually the EC formulations, wettable powder formulations are diluted suitably with water which is a common carrier of pesticides. In some cases however, oil is used as diluent or carrier of pesticides.

The important factors for spray volume consideration are:

The volume of spray liquid required for certain area depends upon the spray type and coverage, total target area, size of spray droplet and number of spray droplets. It is obvious that if the spray droplets are coarse-size then the spray volume required will be larger than the small size spray droplets. Also if the thorough coverage (eg. both the sides of leaves) is necessary then the spray volume requirement has to be more.

On the basis of volume of spray-mix the technique of spraying is classified as:

1. High volume spraying
2. Low volume spraying
3. Ultra low volume spraying

The range of volume of spray mix in each of the above case is arbitrary. Usually for field crop spraying the following spray volume ranges are taken as guide.

High Volume Spraying 300 - 500 L/ha
Low Volume Spraying 50 - 150 L/ha
Ultra Low Volume Spraying < 5 L/ha

There is distinct advantage in the case of lower volume of application over the high volume application. The higher the volume to be applied the more the time, the more the labour and the more the cost of application due to labour cost. However the lower volume applications are concentrated spraying of pesticide which should also be considered properly.

2. Types of Sprayers and Dusters

Based on the type of energy use pattern, the application equipment may be classified as follows:

Sprayers (Hydraulic energy)

Manually operated	Powered operated
1. Syringes, slide pump	1. High pressure sprayer (hand carried type)
2. Stirrup pumps	2. High pressure trolley/ Barrow mounted

3. Knap sack or shoulder-slung:
Lever operated K.S. sprayer
Piston pump type Diaphragm pump type

3. Tractor mounted/ trailed sprayer

4. Compression sprayer Hand compression sprayer
Conventional type
Pressure retaining type

4. High pressure knap sack sprayer

5. Stationary type
Foot operated sprayer
Rocker sprayer

5. Air craft, aerial spraying (Fixed wing, helicopter)

Sprayers (Gaseous energy)

Manually operated Powered operated

1. Hand held type

1. Knap sack, motorized type
2. Hand/ Stretcher carried type
3. Tractor mounted

Sprayers (Centrifugal energy)

1. Hand held battery operated ULV sprayer.
2. Knapsack motorized type
3. Tractor/ vehicle mounted ULV sprayer
4. Aircraft ULV sprayer

Other sprayers

1. Aerosol sprayers
2. Liquefied-gas type dispensers
3. Fogging machines
4. Exhaust Nozzle Sprayer

Dusting equipment

Manually operated Powered operated

1. Plunger duster 1. Knapsack motorized duster
2. Bellow duster 2. High pressure trolley/ Barrow mounted
3. Rotary duster: 3. Tractor mounted/trailed duster
Belly mounted model
Shoulder-slung model
4. Aircraft

Granule applicator

Manually operated	*Powered operated*
1. Broad-casting tins	1. Knapsack motorized type
2. Knapsack Rotary granule	2. Tractor mounted/ trailed duster
	3. 3. Aircraft

High volume spraying applicators

This is very common and popular method of pesticide spraying. The spray solution is prepared by mixing water with pesticide formulation in appropriate quantities. This diluted mixture is sprayed through hydraulic nozzles. The spraying is usually to the point of drip from foliage. In this method large volume of spray liquid is applied. Usually the spraying volume is 300-500 L/ha. The spray volume is not always rigid. The spray volume requirement depends on many factors eg. Sprayer capability, nozzle charecteristics, stage of growth of crop, type of crop etc.

A variety of high volume sprayers are available in the market. Almost all types of high volume sprayers have some kind of pump to supply pressurised spray liquid to the hydraulic nozzle which breaks the liquid into spray droplets and throws the spray away from it. The high volume sprayers are both manually operated or power operated type.

Slide pump or hand sprayers

This is a simple sprayer. It creates hydraulic pressure by forcing spray solution to a nozzle by the direct action of hand pumping. The spray solution is filled in a plastic can (5-10 L) which is usually shoulder slung. A dip-tube draws liquid from the tank due to hand actuation of the plunger. Held by both the hands the piston pump is worked by sliding action. For want of a pressure chamber it is not possible to retain pressure and therefore the operator has to pump continuously without break. Due to constant engagement of both the hands it is difficult for the operator to ensure thorough coverage. Further due to pressure fluctuation the nozzle performance is not stable. The discharge rate varies, spray angle changes and spray droplets size fluctuates. This sprayer is suitable for small scale application in nursery or kitchen gardens etc. It is not a good sprayer for large area treatment. The capacity of this sprayer is about 0.5 acre per day.

Stirrup pump sprayer

This is a simple hydraulic sprayer. It consists of hand operated hydraulic pump. The suction part of the pump is immersed in the spray solution kept on floor in a bucket. The pump is operated by hand by one person while the other person holding the delivery line, trigger cut-off device and lance nozzle sprays pesticide. In few models an air chamber is also provided in the pump system which helps continuous spraying. Also in some models provision of hydraulic agitation is made. This sprayer is used both for public health spraying and agricultural spraying purposes.

Compression sprayer

It comprises of a cylindrical metal tank for holding the spray liquid, a hand operated piston type air pump, a filler hole in the tank out let with delivery pipe, cut-off, lance and hydraulic nozzle. There is metal or plastic skirt as the base of the tank. A pair of adjustable shoulder straps is provided for mounting the sprayer on the back of the operator.

The sprayers with tanks of different capacities are manufactured, but 18 litre capacity sprayers are commonly used for field spraying. The filtered spray solution is filled to 2/3 of the tank capacity. Then the air pump is operated by hand and air pressure (50-60 psi) is built up. The compressed air exerts pressure to move spray liquid to the nozzle via delivery pipe, cut-off device & lance system.

The spray design is strong and sturdy. It is also easy to operate. The operator need not pump continuously so that he can divert his attention to better coverage. However, as the pressure cannot remain constant due to gradual decrease of pressure, the nozzle discharge rate changes so also angle of spray and droplet size. This sprayer is not recommended for herbicide spraying due to high initial pressure. The field capacity is 0.75 - 1.0 acre/day.

Foot operated sprayer

The pump of the sprayer is worked by operating a pedal lever by the foot of the operator. It requires two persons to work. The spray liquid is kept in bucket or container and it is sucked by a suction hose through a filter (strainer) due to piston movement. A suitable ball valve is provided in the piston assembly to serve as suction valve. The liquid from the pump cylinder is then delivered into a pressure chamber where from the pressurized liquid reaches hydraulic nozzle. Minimum two person team is required to work on this machine. Hydraulic

pressure of 10 kg/cm2 can be achieved which is necessary to project the jet of spray to tall trees simultaneously from two spray nozzles.

The foot operated sprayer is basically for orchard and tree spraying. The design is strong and sturdy. Hydraulic pressure of 10 kg/cm2 can be achieved which is necessary to project the jet of spray to tall trees simultaneously from two spray nozzles. An adjustable type hydraulic nozzle (Triple Action Nozzle) is generally used which can generate different types of spray patterns viz., fine spray (hollow cone), medium spray and coarse spray (jet). The fine and medium spray are suited for low height orchards, jet spray are necessary for tree spraying. The spray jet can reach height of 15 - 20 feet. For spraying taller trees an extra extension like bamboo lance may be used to gain additional height by 8 - 10 feet.

It is difficult to treat field crops by foot sprayers because the sprayer is kept on ground and pesticide solution tank is also kept on ground separately and so movement of the long delivery hose becomes very difficult.

Rocker sprayer

It is very much similar to the foot sprayer. The main difference is the operation of pump. The pump actuation is done by hand of the operator. The sprayer pump mounted on wooden platform is kept on ground and the spray solution is kept in a separate tank or container. It can develop high pressure 10 kg/cm2. For spraying tall trees, an extension bamboo lance can be fitted. The adjustable type hydraulic nozzle (Triple Action Nozzle) is normally used.

Lever operated knapsack sprayer

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High pressure power sprayer

These are high capacity power operated hydraulic sprayers. They are the high volume spraying machines good for large scale application in orchards and tree crops. The source of power is engine or electrical motor. A pressure regulator is used to control the pressure in the discharge lines and bye-pass from the pressure regulator is used for hydraulic agitation in spray tank. High pressure like 400 psi can be built up and large spray discharge rate like 30 L/min. can be obtained. The engine or electrical motors 3 - 5 H.P capacity power the sprayer.

Low volume spraying applicators

The high volume spraying is labour intensive and time consuming. In water scarcity area it is difficult to practice high volume spraying. Also in situation where large area treatment in very short time is important, the high volume spraying has limitations. The low volume spraying methods essentially reduce quantity of spray solution. Spraying as against 300 to 500 L/ha in

spraying technique is reduced to 50 to 150 L/ha in L.V. spraying technique.

Motorised knapsack sprayer, also called Mist blower is a L.V. sprayer in which gaseous energy nozzle is used for fine breakup of spray liquid. This type of nozzle is also called Air blast nozzle. The force of escaping air at high velocity is utilised to shear down the spray liquid into fine spray droplets. The size of spray droplets depends upon:

1. Air velocity and volume
2. Liquid flow rate
3. Properties of spray liquid

The spray droplets are then blown away from the nozzle outlet. The blast of air disperses the droplets over wide area and helps penetration of spray into the crop canopy. The gyrating movement of droplets in the canopy improves the under leaf depositing of the spray particles.

A two-stroke petrol engine (35 cc capacity) is used as prime mover to run a fan blower. The engine runs usually at 5000 - 6000 RPM and the blower emits at nozzle outlet about 5 m3 air per minute and at about 170 km/hr velocity.

The spray droplets are about 150 - 220 micron VMD size. The nozzle flow rate can be adjusted by a regulator provided in the liquid line. The regulator can be a variable restrictor type or different size fixed aperture type. The later type is better because in the variable restrictor type regulator, it is difficult to achieve exact repeat application rates. The flow rate up to 2 L/min can be obtained.

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Belly mounted model
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For low volume spraying the aircrafts are also used to spray pesticides at 20 - 25 L/ha. Tractor mounted air carrier sprayers are also used for low volume spraying in orchard and tree spraying. For tall tree spraying like Rubber plantation a mist blower type system run by 3 H.P engine and carried by two persons on stretcher poles is available, called turbo-sprayer.

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Ultra-low volume spraying applicators

The ULV spraying is the method of pesticide application at minimum volume to achieve economic pest control. In this technique of pesticide application the volume applied per hectare is less than 5 litres which is extremely low as compared to the conventional High Volume and Low Volume spraying methods.

The spray droplets in ULV spraying methods are very fine in size. Therefore, the nozzles used in these methods are different. Various designs of rotary atomiser are used to generate droplets of 70 to 100 μ VMD. The vortex nozzles produce droplets in aerosol range i.e. 20 μ VMD. For large area ULV spraying as in the case of locust control exhaust nozzle sprayer which is mounted on a vehicle is used where thermal energy of the engine exhaust gases is used to atomise the pesticide liquid in droplets of 20–50 μ. The thermal foggers using pulse jet engines are used for indoor ULV application. The fogging machines are also used by public health personnel for mosquito control.

The rotary atomiser utilises centrifugal energy to break the pesticide liquid into droplets. The range of spray droplet diameter produced by centrifugal nozzle is generally narrow spectrum. Therefore, this method of ULV spraying with the help of centrifugal energy nozzle is also called as Controlled Droplet Application (CDA).

The movement of extremely fine spray droplets depends upon natural air movement. These small particles usually take long time to settle and very much influenced due to prevailing wind.
The spray therefore is not direct type but it is drift spraying. Obviously for small field treatment the pesticide spray may be drifted to outside the target. Thus the drift hazard is always present in this technique of spraying.

A hand held battery operated model of ULV sprayer is very simple and convenient. This sprayer consists of a spray head which includes an electric motor with a spraying disc and liquid container mounted on the spray head, a holding stick, source of battery power and off- on switch. The electrical motor is a 6 V or 12 V DC motor. The motor drives a directly fitted spinning disc usually plastic 2" to 3" diameter revolving at 6000 - 10000 RPM. The spinning disc is very light weight plastic disc flat or cup shaped having fine serrations cut on its periphery. In certain designs fine feeder channels are also provided on the disc such that the liquid is fed uniformly through these channels to the disc serrations. The pointed edge at the disc periphery serves as zero issue point so that uniform size spray droplets are released from the disc. The pesticide container is usually one liter capacity plastic bottle which is screwed on the spray head. The flow of pesticide from the container is simply due to gravity and depends upon the size of opening provided in the spray head. However, in certain models the rate of flow of liquid can be changed by replaceable orifice plates of different diameter or by changing liquid flow tubes of different size opening. The dry cells (4 or 8 Numbers) or rechargeable storage battery supply 6 V or 12 V DC power to run the electric motor which rotates the plastic disc. The chemical moves by gravity to the spinning disc and due to

centrifugal energy the liquid is broken into very fine spray droplets.The rate of flow of chemical liquid is from 50 to 100 ml/min.

The ULV spraying is good in dry land areas where water is scare and therefore conventional high volume spraying is not feasible. This technique is also called waterless spraying due to special ULV formulations. But as the ULV formulations are not available, the advantage of this method is not being availed at present.

The speed of rotation of the disc depends upon the battery condition. The run-down or used up battery are of no use as they cannot run the electric motor at proper speed. The spray droplets size tends to become large if the rotational speed of the disc is reduced. The speed should not come below 4000 RPM otherwise the droplet size shall increase drastically which will affect the coverage and swath width. A set of battery can last for 8-10 hours of spraying time. But the life of battery really depends upon the quality of electric motor. Some electric motors consume more power and hence less battery life. Usually these electric motors consume 3 - 8 W of power. If rechargeable battery is used to run the motors then it should be kept fully charged.

Dusters and dust applications

The dusting powders are low concentration ready to use type, dry formulations containing 2 to 10% pesticide. The inert material or dry diluents is talc, soapstone, attapulgite, etc., and it is nontoxic. The sulphur dust is not diluted with inert material.

The advantages of pesticide dusting application are:

1. Ready to use product reduces field tasks concentrate handling and further dilution (as in case of spraying)
2. In dryland agriculture where water is scare.

But the important disadvantage is pesticide drift. The fine dust particle cause serious drift problems and the operator and field labourer are exposed to dermal and inhalation hazards, besides pesticide being carried to neighbouring field/area and causing pollution. This is the main reason why the herbicides are not formulated as Dusting Powders. Precise metering and even distribution of dusting powders in field conditions is very difficult.

The dusts are applied at 20 - 50 kg/ha. It should be noted that the application is done in highly concentrated form, as compared to high volume or low volume spraying technique. Therefore, adequate precautions must be taken in handling the dust and during the application in field. The dusters are available both manually operated and power operated models.

2.4.1 Manually operated dusters

a. Plunger duster:

They are very simple, low cost machines and useful in a limited way. The field application capacity is low. They hold 200 to 400 g of dust in a chamber into which air is pushed by an adjoining piston type air pump operated by hand. The dust cloud is issued from the discharge outlet.

b. Bellows type duster:

This is also a simple design low cost dusting machine. A collapsible bellows pushes air into a dust hopper of 1-2 kg capacity and dust is discharged from the nozzle outlet.

c. Hand rotary duster:

This type of duster makes use of a fan or blower to flow large volume of air at high speed. The dust powder is fed into the stream of air and blown from the outlet tube. The fan or blower rotates at high speed by hand cranking handle, which is geared to it. The higher gear-ratio and better blower design provide easy cranking and good volume of air is emitted. The dust hoppers are generally cylindrical and are provided with agitator, feeders and dust metering mechanism.

d. Power duster

These are bigger machines run with the help of engine or electrical motor. Some power dusters are tractor mounted type and are driven by tractor P.T.O. The equipment is mounted on iron frame (stretcher) and can be carried by 2-3 men. The engine/motor drives a centrifugal fan usually via V- belt drive. The engine is petrol/ diesel run and 3 - 5H.P The fan displaces 20 m3 air/min or more at 100- 250 km/hr air velocity. These dusters are good for large area treatment and suitable for application on tall trees. In this type of duster design, usually thedust powder is not rotated in the fan-case but dust powder is aspirated in the delivery channel by air blast. The dust hopper capacity is 10-20 kg and dust can be discharged at a rate of 1 to 8 kg/min. A power duster can cover about 10 ha/day.

e. Knapsack duster

The motorised knapsack sprayer can be converted to a duster by replacing some plastic fittings inside the hopper. Almost all mist blowers have provision of converting them from spraying unit to dusting unit. The two stroke petrol engine runs a blower fan and delivers the air through a hose pipe system.

The dust is agitated and lifted by the blast of air in the hopper and it is fed into the main air hose or a long dusting hose (40-50 ft long polythene perforated hose) can also be attached to knapsack duster. Such an attachment is very good for large area treatment in less time. The dust output can be adjusted from 0 to 1.5 kg/min. The motorised knapsack sprayer-cum-duster unit is therefore useful for both low volume spraying and dusting operation.

Precautions

The dusting powers are very finely divided particles which can remain air-borne for long time and can drift far distances. The fine particles can very easily enter into body system by inhalation. Therefore, the operator should wear protective clothing. He must cover his nose and mouth in order to avoid inhalation of pesticide drift.The operator should never operate against the wind direction. Also if the wind velocity is more or wind turbulence exists, the dusting application should not be done. It is better to apply the dust power in early morning hours and in late evening hours, avoid in the mid-day and afternoons.

Maintenance

The dry and well sieved dust power should be loose filled in hopper. It should not be hand compacted. The dust powders often absorb atmospheric moisture and clods are formed, such clods should be crushed before filling into the hopper. After the completion of the work the dust powder should be removed from the hopper carefully. The dust materials which still remain in the hopper, feeders, discharge tube should also be removed by briskly cranking and blowing action. Finally, a dry brush should be used to dust off from inside the hopper, etc. The lubricating oil should be applied on moving parts e.g., gearbox, crank handle, agitator, fan bearing, etc.

3. Spray Nozzles and Their Classification

All types of sprayers generally speaking emit pesticide solution in very fine spray form. Spraying nozzle thus is a device for emitting spray liquid, breaking it up into small droplets and throwing the droplets away from the nozzle orifice. Different designs of nozzle are used to produce appropriate droplet size spectrum. In order to break the liquid into droplets energy is needed. The spray nozzles therefore are classified as:

Hydraulic energy nozzles Gaseous energy nozzles Centrifugal energy nozzles Thermal energy nozzles

Almost all sprayers used for high volume spraying methods are fitted with hydraulic nozzles. The knapsack type low volume sprayers are generally worked with air blast nozzle or gaseous energy nozzle. The hand held battery operated sprayers also called CDA sprayers are fitted with spinning disc type nozzle which works on centrifugal energy. Thermal energy nozzle also called hot tube nozzles are used with fogging machines for ULV applications. Recently electrical energy has also been used to produce charged spray droplets for ULV application of pesticides.

Hydraulic energy nozzles

The hydraulic nozzles are most commonly used spray nozzles for pesticides application. Almost all the hydraulic sprayers use this type of nozzle. The following types of hydraulic nozzles are used for spraying pesticides:

1. Hollow cone type
2. Fan type
3. Impact type

Hollow cone nozzles:

This is a very popular type of hydraulic nozzle for spraying insecticides and fungicide. It produces a hollow cone pattern of spray consisting of mixture of different sizes droplets. In its simplest design this type of nozzle is made of brass metal having orifice hole drilled in it and tangential cut grooves provides swirl motion to spray liquid which breaks down into droplet when emerging from the nozzle under pressure. This simple brass nozzle is screwed onto a hand lance/ boom.

There are different designs of hollow cone nozzle. Other designs of nozzles consist of a stainless steel disc with a central circular hole through which the spray emerges from a swirl chamber behind it. The disc and the swirl plate (core) are suitably fitted in the body of the nozzle which has threads for screwing (fitting) it to the lance/ boom. The normal working pressure of hollow cone nozzle is about 40 psi.

Fan nozzle:

They are also called flat fan nozzles. The spray liquid is thrown from an orifice which is elliptical to give a flat shaped sheet of spray. These are used for band spraying. These nozzles are generally used on booms with propor distance in

between and overlapping to give even distribution. The normal working pressure is about 40 psi. However these fan nozzles can also be used for herbicide application but the application is done at low pressure like 15 - 20 psi to avoid drift of fine droplets.

Impact nozzle:

These nozzles are also known as deflector nozzles or flood jet nozzles. In these nozzles, the spray liquid emerging from a circular hole strikes an inclined smooth face and is deflected at an angle. The liquid thus spreads as a sheet in a wide angled fan pattern. These nozzles are used for herbicide spraying and are low pressure (15 - 25 psi). The spray pattern essentially consists of coarse droplets.

Adjustable nozzle:

These are also called as tripple action nozzle. They are so called because of varying patterns of sprays that can be obtained by manipulating the swirl velocity of spray liquid in the eddy chamber. The hollow cone spray pattern consisting of fine spray particles, or a jet spray for orchard/ tree spraying and a medium coarse spray patterns can be obtained by simple adjustments. These nozzles are generally used with foot operated sprayers, rocking sprayers or high pressure hydraulic sprayers for spraying trees.

condenses when issued out of the nozzle due to outside temperature and forms fog of fine droplets. Exhaust nozzle sprayers (vehicle mounted) are used for ULV application in locust control operation. Pulse jet engine models are used for pesticide fogging for public health purposes.

Different target and optimum droplet size

Flying insects	1 - 50 µm
Insects on foliage	30 - 50 µm
Foliage soil (and avoidance of drift)	250- 500µm

4. Calibration and Care of Pesticide Application Equipment

Methods of calibration:

The rate of application of pesticide should be uniform over the whole of the field area. Too much application as well as too less application of pesticide dose is both undesirable.

Too much application - Wastage, crop injury, uneconomical

Too less application - Poor pest control, wastage of pesticide, time and money

The pesticide distribution by any sprayer is regulated by:

1. Nozzle spray discharge rate
2. Swath width
3. Walking speed of operator

Some equipment manufacturers provide tables about use and capacity of their equipment. But it is difficult to always fully relay on such tables. As the sprayer gets old the pump and the nozzle also wear out. The performance of sprayer then changes and rate of application becomes different. The calibration of sprayer, therefore, is essential to make sure that the pesticide is applied correctly and evenly. The sprayer should be checked and calibrated frequently.

There are many methods described for calibration of sprayer. The sprayer can be calibrated theoretically and practically in the field. It is good to frequently verify the correctness of theoretical calibration with field practical calibration.

A very simple and easy to remember formula is

$$F = \frac{SDA}{10000}$$

Where F - flow rate in L/min (This represents flow rate from all the nozzles of sprayer if they are more than one. But if there is only one nozzle, then flow rate from one nozzle only)

S - Swath width in meter

D - Operator's walking speed in m/min A - Application rate in L/ha

The above formula is useful for calibration of any type of field spraying system ie. high volume, low volume, ultra-low volume, tractor mounted sprayer or aerial spraying. If any three variables in this formula are known, the value of the remaining fourth variable can be found out.

Care and maintenance of plant protection equipment

General maintenance:

1. Clean outer surface with brush or cotton waste by using kerosene oil or plenty of water.
2. Oil the moving or rubbing surfaces of parts with lubricating oil (SAE 30) or grease, if needed.
3. Filter or strain the chemical solution/ fuel oil mixture while pouring into the tanks. Make the caps or lids leak-proof with gaskets.
4. Flush the equipment with clean water to wash inside parts of containers, tubes and nozzles to be free from chemicals.

Care and upkeep of hand sprayer & duster:

1. Dry and sieved dust should be used for dusters.
2. Grease the duster gear box once in a month.
3. Clean the duster after the work by removing all dust from the hopper.

4. Oil the cup washers and bucket washers of sprayer frequently.
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6. Lances and nozzles should not keep on the ground. Nozzle parts should be cleaned with a brush.

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1. Lubricating oil level should be checked and maintained in four stroke engines daily.
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3. Clean the Air and Fuel filters with petrol frequently.
4. All the nuts and bolts should be tightened once in a week.
5. Check up the pressure gauges and safety valves frequently.
6. Drain the fuel tank after the day's work.
7. Stop two stroke engines by closing the petrol cock.
8. Belts should be kept tightened always, to be free from slip and slackness.
9. Keep proper inflated pressure in the tyred wheels of power sprayers.
10. Rubber tyre equipment should be rested on steel props when stationed.
11. Rubber hoses should not be bent at angles and dragged on the ground.
12. Equipment should be stored in clean, dry, cool store room.

Care and upkeep of pp equipment when not in use:

1. Plant Protection Equipment should be arranged properly in a store house. They should be protected from sunlight.
2. Equipment of one category should be kept at one place and not in a mixed up fashion i.e., do not dump the equipment.
3. Attachment like discharge lines, lances, and nozzles should not be kept attached to the equipment.
4. The equipment should be cleaned with cotton waste every day and polished once in a month.

5. The rubber/ plastic delivery hose should be coiled forming a big circle instead of small spool. Otherwise the hose pipes break or crack when they are straightened.
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1. Always carry tools required for attending to field troubles.
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III. PESTICIDES FOR HEALTH AND HUMAN WELFARE

1. Toxicity of Pesticides and Antidotes

Introduction:

The toxicity of a pesticide is its capacity to cause injury to a living system, may be a human body, or parts of the body (such as the lungs or the respiratory system) and the ecosystem, 11` a pond, a forest and those creatures that live there.

The toxicity of a pesticide depends on -

1. Dose: It is the quantity of a pesticide that a surface, plant, or animal is exposed to.
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Types of Toxicity

a. Acute toxicity refers to how poisonous a pesticide is to a human, animal, or plant after a single short-term exposure. A pesticide with a high acute toxicity is deadly even when a very small amount is absorbed.

b. Chronic toxicity is the delayed poisonous effect from exposure to a pesticide. Chronic toxicity of pesticides concerns the general public, as well as those working directly with pesticides because of potential exposure to pesticides on/in food products, water, and the air.

Routes of Entry

There are three specific ways in which pesticides may enter your body:

i. Dermal Route

Pesticides can be absorbed through skin. Oil or paste forms allow greater absorption than water-based pesticides. The eyes, eardrums, scalp and groin areas absorb more quickly than other areas on the body. Once they are absorbed through skin, pesticides enter the blood stream and are carried throughout the body.

ii. Inhalation Route

Dusts, spray mist, or fumes can be drawn into lungs as one breathes. Inhalation can occur during the mixing, fumigating or spraying etc. The larger particles tend to stay on the surface of the throat and nasal passages but smaller particles can be inhaled directly into the lungs and enter the blood stream.

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Oral ingestion can occur when hands are not properly washed before eating, swallowing by mistake or purposefully. Ingested materials can be absorbed anywhere along the gastrointestinal tract (mainly by the small intestine) and entered the blood stream and circulate throughout the body.

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iii. Oral Route

Oral ingestion can occur when hands are not properly washed before eating, swallowing by mistake or purposefully. Ingested materials can be absorbed anywhere along the gastrointestinal tract (mainly by the small intestine) and entered the blood stream and circulate throughout the body.

The toxicity of a pesticide varies person to person depending on:

a. Health conditions: Individuals with poor health condition are more sensitive.

b. Age: youngest and oldest individuals tend to be most sensitive.

c. Gender/sex: Females are more sensitive.

d. Body size: the effect of a dose is closely related to body weight.

Effects of Toxicity

a. Local or systemic (Both effects can occur with same pesticides.)

Local effects take place at the site of contact with a material e.g. skin inflammation, irritation of the mucous membrane lining the lungs due to inhalation of toxic fumes etc. Systemic effects occur away from the original point of contact when pesticides are distributed throughout the body, or "system".

b. Immediate or delayed (Both effects can occur with same materials.)

Immediate toxic effects occur shortly after exposure. (e.g. a sneezing attack in response to inhaling pesticides during mixing). Delayed effects occur after some time of exposure. e.g. Tumors observed after 20 to 30 years of original exposure to a "carcinogenic" chemical.

c. Reversible or irreversible

Reversible effects are not permanent and can be changed or remedied. e.g. Skin rash, nausea, eye irritation, dizziness, etc. Irreversible effects are permanent and cannot be changed once they have occurred. e.g. Injury to the nervous system, birth defects, mutations, cancer etc.

d. Additive, antagonistic, or synergistic

In additive effect, the combined effect of two pesticides is equal to the sum of the effects of each (i.e. 2 + 2 = 4). An antagonistic effect occurs when the toxic effect of the combination of pesticides is less than what would be predicted from the individual toxicities (i.e. 2 + 2 = 3). A synergistic effect occurs when the combined toxic effect of two pesticides is much greater, or worse, than the sum of the effects of each by itself (i.e. 2 + 2 = 5).

These all effects may result in:

a. Reproductive effects: effects on the reproductive system

b. Teratogenic effects: effects on unborn offspring (birth defects)

c. Carcinogenic effects: produces cancer in living animal tissues.

d. Mutagenic effects: permanent effects on genetic material that can be inherited.

e. Neurotoxicity: poisoning of the nervous system, including the brain.

f. Immunosuppression: blocking of natural responses of the immune system of the body.

Measurement of Toxicity

Animals like rats, rabbits, mice, guinea pigs etc. are used to test pesticide toxicity. Due to some differences between the ways human and animal body work, toxicity studies are just guidelines for estimating and comparing toxic effects of pesticides.

a. Acute Toxicity Measures

Experimental doses are given orally, as well as put on the eyes, skin, and in the air that the test animals breathe. The animals are then observed carefully for changes.

i. Lethal Dose Fifty (LD50): The amount of a pesticide that can kill half of the animals in a laboratory test. The smaller the LD50 value of a pesticide means it more poisonous. Measured in units as Milligrams per kilogram (mg/kg)

ii. Lethal Concentration Fifty (LC50): It is a measure of "acute inhalation toxicity" of a pesticide. The concentration of a pesticide that causes half of the animals to die is called LC50. Measured in milligrams per liter (mg/L), ppm or milligrams per cubic meter (mg/m3).

b. Chronic Toxicity Measures

There is no standard measure for chronic toxicity studies. Often the length of the experiment is in days, months, or years and the amount of each dose is stated.

No Observable Adverse Effect Level (NOEL)

A level in the total diet that causes no adverse effect in treated animals when compared to untreated animals maintained under identical conditions. In animal feeding studies, the pesticide under investigation is incorporated into the daily diet and fed to animals from a very young to a very old age. These, as well as the reproductive effects studies, are designed to arrive at a NOEL. This NOEL is expressed as mg/kg of body weight/day basis.

Symptoms of Poisoning:

Improper use of pesticides may result in toxicity, which is refers to the ability of pesticide to produce adverse effects. Adverse effects may range from headaches to coma and convulsions which is identified by mild or moderate or severe symptoms of poisoning. Antidote is a substance which can counteract a form of poisoning.

Table: Various degrees of Symptoms of Poisoning

S.No	Mild poisoning	Moderate poisoning	Severe poisoning
1.	Headache	Vomiting	Convulsions
2.	Nausea	Blurred vision	Respiratory failure
3.	Dizziness	Stomach cramps	Loss of consciousness
4.	Fatigue	Rapid pulse	Loss of pulse
5.	Irritation of skin, eyes, throat, nose.	Breathing difficulty, Constricted pupils	
6.	Perspiration	Excessive precipitation	
7.	Loss of appetite	Trembling and twitching of muscles.	

Table : Symptoms of Poisoning for different Groups of Pesticides

S.No	Pesticides	Mode of Action	Symptoms of poisoning
1.	OPs	Cholinesterase inhibition	Headache, fatigue,muscle twitching, stomach cramps, unconsciousness, death
2.	Carbamates	Cholinesterase inhibition	Running nose, chest tightness, shortness of breath, seizers paralysis and death
3.	Pyrethroids	Sodium channel modulators	Allergic reaction, incoordination, tremor, salivation, vomiting, convulsions
4.	Rodenticide	Anticoagulant and stomachpoisoning	Nausea, vomiting, pulmonary edema and death
5.	Organo chlorine	Sodium channel modulators	Tremors, headache, dizziness, nausea, dermal irritation

First Aid for pesticide Poisoning:

Pesticides can enter in to the human body through different routes such as dermal (through skin), Oral (through mouth) or inhalation (through nose) and accordingly first aid should be done

a) Pesticide spilled on the skin or clothing

Immediately strip off all clothing and thoroughly wash the skin with soap and water.

Some pesticides are absorbed through the skin very rapidly. Wash contaminated clothing separately to prevent contamination of other clothes. It may be best to dispose of heavily contaminated clothing.

b) Pesticide inhaled:

First, get the victim to fresh air. Have the victim lie down and loosen all clothing. Keep the victim warm, and administer first aid if needed. Contact a physician as soon as possible.

c) Pesticide swallowed.

i. Don't induce vomiting.

ii. Usually, it is best to void the swallowed poison fast, but never induce vomiting if the victim is unconscious or is having convulsions.

iii. The words "emulsifiable concentrate" on the pesticide label are signals not to induce vomiting.

iv. Never induce vomiting if the victim has swallowed a corrosive poison, a strong acid or alkali (base). The victim may experience severe pain and have extensive mouth and throat burns.

Antidotes for Pesticide Poisoning:

a) Universal antidote: 7g of activated charcoal + 3.5g of Magnesium Oxide + 3.5g of tannic acid in half glass warm water follwed by gastric lavage.

b) Specific Antidotes: Atropine 2-4 mg or 2-PAM (1-2g) IV for OP and Carbamate Poisoning.

c) Administer oxime or pralidoxime @ 30mg/kg by intravenous therapy.

d) Convulsions may be treated with Diazepam.

e) Zinc phosphide poisoning -Morphine for the relief of abdominal pain, Soluble Vitamin K

f) Fumigant poisoning – administer aminophylline for normal liver functioning, Dimercaprol injection.

Government of India has taken several measures to create awareness for proper use of pesticides by the farmers in the country. The concept of Integrated Pest Management (IPM) which promotes biological, cultural and mechanical methods of pest and advocates need based, judicious use of pesticides is also being promoted.

3. IMPORTANCE OF LABEL AND LABELING

2.1. Introduction:

The most important source of information about a pesticide is the label. Manufacturers are required to provide information regarding what the pesticide is to be used for, how it can be used, how toxic it is, how to mix it, rate of application, precautions to take, re-entry times, kind of clothing and personal protective equipment needed, what the antidote is (if there is one), and the symptoms of poisoning if exposed to the pesticide. Other information about the use, storage, handling, or disposal of the pesticide may also be found on the label.

Importance of label:

Pesticide Labels are legal documents providing information of a pesticide product. The pesticide label on the container gives the user information about the product. The product label tells the purchaser and user:

a) What is the kind of pesticide, brand name and common name

b) Who made or supplied the product

c) Registration number of insecticide

d) What type and degree of hazard it presents.

e) What type of formulation and active ingredient

f) When is the date the insecticide expire

g) What to do if adverse effects occur/antidotes.

Failure to display mandatory warning or caution on labels of pesticides product is defined as "misbranding" under Sec 3 (k) (iii) and is liable to be prosecuted for an offence under Sec 29
(1) (a) of the Insecticides Act, 1968.

Manner of labeling:

The following particulars shall be either printed or written in indelible ink on the label of the innermost container of any insecticide and on the outer most covering in which the container is packed:

Name of the manufacturer (if the manufacturer is not the person in whose name the insecticide is registered under the Act, the relationship between the person in whose name the insecticide has been registered and the person who manufactures, packs or distributes or sells shall be stated)

a. Name of insecticide (brand name or trade mark under which the insecticide is sold).

b. Registration number of the insecticide.

c. Kind and name of active and other ingredients and percentage of each. (Common name accepted by the International Standards Organization or the Indian Standards Institutions of each of the ingredients shall be given and if no common name exists, the correct chemical name which conforms most closely with the generally accepted rules of chemical nomenclature shall be given).

d. Net content of volume. (The net contents shall be exclusive of wrapper or other material. The correct statement of the net content to terms of weight, measure, number of units of activity, as the case may be, shall be given. The weight and volume shall be expressed in the metric system).

e. Batch number.

f. Expiry date, i.e. up to the date the insecticide shall retain its efficiency and safety.

g. Antidote statement

2. The label shall be so affixed to the containers that it cannot be ordinarily removed.

3. The label shall contain in a prominent place and occupying not less than one-sixteenth of the total area of the face of the label, a square, set at an angle of 450(diamond shape). The dimension of the said square shall depend on the size of the package on which the label is to be affixed. The said square shall be divided into two equal triangles, the upper portion shall contain the symbol and signal word as specified and the lower portion shall contain the colour specified.

4. The upper portion of the square, shall contain the following symbols and warning statements—
Insecticides belonging to Category I (Extremely toxic) shall contain the symbol of a skull and cross-bones and the word "POISON" printed in red. The following warning statements shall also appear on the label at appropriate place, outside the triangle,

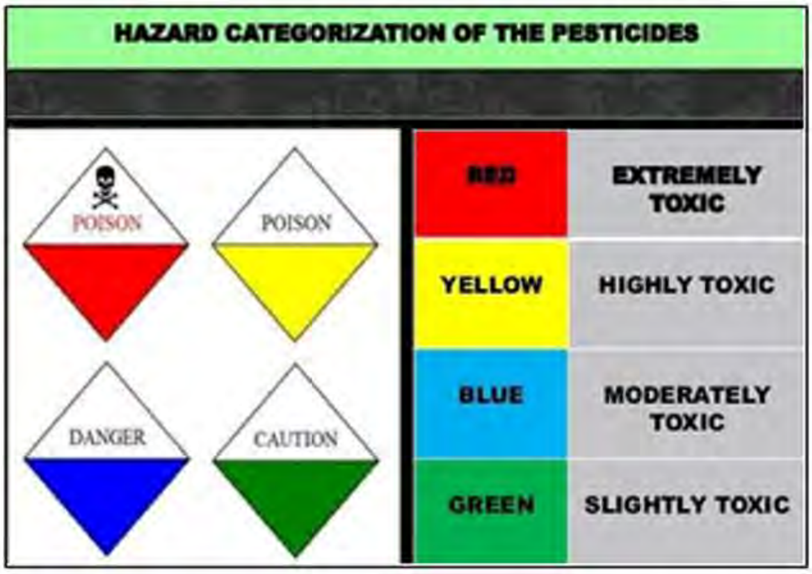
a) "Keep out of the reach of children"

b) "if swallowed, or if, symptoms of poisoning occur call physician immediately"

Insecticides in Category II (highly toxic) will contain the word "POISON" printed in red and the statement "keep out of the reach of children"; shall also appear on the label at appropriate place, outside the triangle.

Insecticides in Category III (moderately toxic) shall bear the word "DANGER" and the statement "Keep out of the reach of children";

shall also appear on the label at suitable place outside the triangle.



Insecticides in Category IV (Slightly toxic) shall bear the word "CAUTION" in the lower portion of the square

5. In addition to the precautions to be undertaken the label to be affixed in the package containing insecticides which are highly inflammable shall indicate that it is inflammable or that the insecticides should be kept away from the heat or open flame and the like.

6. The label to be affixed or attached to the package containing insecticides shall be printed in Hindi, English and in one or two regional languages in use in the areas where the said packages are likely to be stocked, sold or distributed.

7. Labelling of insecticides must not bear any unwarranted claims for the safety of the producer or its ingredients. This includes statements such as, "SAFE", "NON- POISONOUS", "NON-INJURIOUS" or "HARMLESS" with or without such qualified phrase as "when used as directed".

IV. PESTICIDE RESIDUES & SAFETY TO CONSUMER

1. Definition and Concepts of Pesticide Residue

1. 1. Introduction

Pesticides are a broad class of bioactive compounds used in crop protection, food preservation, and human health. They differ from other chemical substances because they are spread deliberately into the environment. Presently, about 1000 active ingredients have been registered the world over, that can be grouped into more than 40 classes of chemical families. Exposure to pesticides through the most important routes of uptake (oral, dermal, and inhalation) depends on the physicochemical characteristics of the pesticide and the nature of the contact, varying with the edge, lifestyle, and working conditions. The level of pesticides in different environmental compartments—such as water, agricultural foods, and products of animal origin—has become a relevant issue. Unlike other contaminants, pesticides may affect both workers and the general population as a result of the consumption of contaminated food and water, domestic use, and proximity to agricultural settings. Information about actual human exposure to pesticides has important uses, including informing risk assessments, helping predict the potential consequences of exposures, and developing exposure criteria for regulations and other public policy guidance. Pesticide exposure can be measured through the bio-monitoring of the parent compounds and/or metabolites in such body fluids as urine, blood, serum, and saliva, among others. Contamination of food represents one of the most pervasive sources of pesticide exposure for the general population.

1. 2. Definition:

The pesticide residue may be defined as the quantity of pesticide and its derivative or metabolites present in or on any agricultural produce, animal feed, food items of human beings and environment. It is usually expressed as parts per million (ppm) or parts per billion (ppb) or parts per trillion (ppt) on weight by weight basis.

Definition by WHO: "Any substance or mixture of substances in food for man or animals resulting from the use of a pesticide and includes any specified derivatives, such as degradation and conversion products, metabolites, reaction products, and impurities that are considered to be of toxicological significance."

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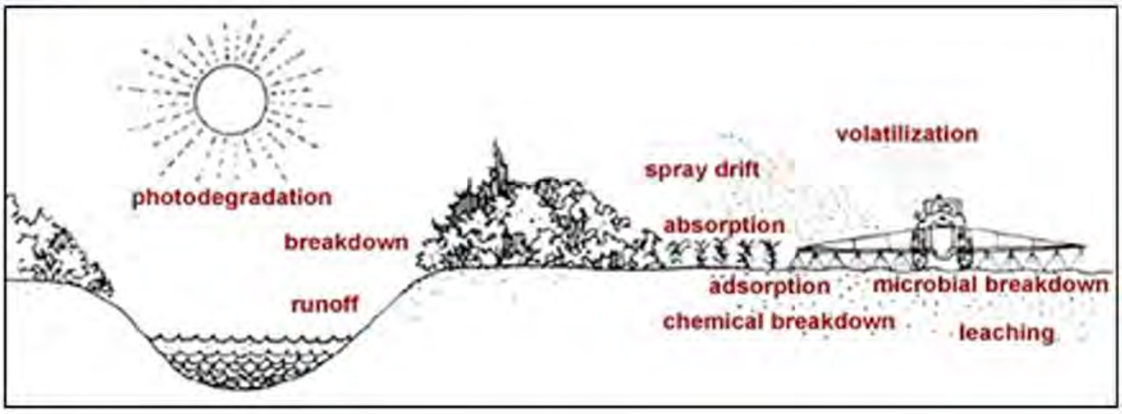
The pesticides applied on the field crops, horticultural crops and domestic pest control, do under go degradation during the course of time by many ways as follows: Runoff, Leaching, Volatilization, Microbial Degradation, Physical Degradation (Hydrolysis, Photolysis & Pyrolysis). Though all the pesticides were thoroughly tested and evaluated before approval, their residue may be present because of extensive use in agriculture to control pests & improve yields, more than 1000 different active substances are used & most of them are persistent in nature. Sometimes not applied in accordance with intended purpose, Good Agriculture Practice sometimes not respected Accidental contamination

Dissipation of pesticides

Millions of tons of pesticides are applied annually; however, less than 5% of these products are estimated to reach the target organism, with the remainder being deposited on the soil and non-target organisms, as well as moving into the atmosphere and water. Dissipation of pesticides is defined as loss of pesticide residues from an environmental compartment due to degradation and transfer to another environmental compartment. The dissipation includes various processes like adsorption, transfer, breakdown and degradation.



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Adsorption is the binding of pesticides to soil particles. It is varies with the type of pesticide, soil, moisture, soil pH, and soil texture. Pesticides are strongly adsorbed to soils that are high in clay or organic matter and not strongly adsorbed to sandy soils. Most soil-bound pesticides are less likely to give off vapours or leach through the soil. They are also less easily taken up by plants.

b) Transfer Processes

Volatilization is the process of solids or liquids converting into a gas, which can move away from the initial application site. This movement is called vapour drift. Pesticide volatilization occurs most readily from sandy and wet soils. Hot, dry, or windy weather and small spray drops increase volatilization. Where recommended, incorporating the pesticide into the soil can help reduce volatilization.

c) Spray Drift is the airborne movement of spray droplets away from a treatment site during application. It is affected by spray droplet size - the smaller the droplets, the more likely they will drift, wind speed - the stronger the wind, the more pesticide spray will drift, distance between nozzle and target plant or ground - the greater the distance, the more the wind can affect the spray

Drift can damage crops or can contaminate crops ready to harvest. It may also be a hazard to people, domestic animals, or pollinating insects and contaminate water in ponds, streams, and ditches and harm fish or other aquatic plants and animals. Excessive drift also reduces the pesticide applied to the target and can reduce the effectiveness of a treatment.

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Pesticide runoff can be reduced by using minimum tillage techniques to reduce soil erosion, grading surface to reduce slopes and leaving border vegetation and plant cover to contain runoff. Pesticide losses from runoff are greatest when it rains heavily right after spray. It reduces the chances of runoff by watching the weather forecast.

e) Leaching is the movement of pesticides in water through the soil which occurs downward, upward, or sideways. The factors influencing whether pesticides will be leached into groundwater include characteristics of the soil and pesticide, and their interaction with water from a rain-event such as irrigation or rainfall. Leaching can be increased when the pesticide is water soluble, the soil is sandy, a rain-event occurs shortly after spraying and the pesticide is not strongly adsorbed to the soil.

f) Absorption is the uptake of pesticides and other chemicals into plants or microorganisms. Most pesticides break down once they are absorbed. Pesticide residues may be broken down or remain inside the plant or animal and be released back into the environment when the animal dies or as the plant decays. Some pesticides stay in the soil long enough to be absorbed by plants grown in a field years later leaving residues in future crops.

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Pesticide Residue Analysis

It may be defined as the qualitative and quantitative analyses of the representative samples drawn from agricultural fields, market and environment for pesticides and their toxic metabolites.

Though all the pesticides were thoroughly evaluated before approval, their residue may be present in the food and other environmental components. Therefore, there are significant public concerns about the usage of pesticides and presence of pesticide residues in/on food commodities and other environmental parameters. Furthermore, the report of pesticide residues also needed for regulatory requirements.

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a. To study the kinetics of pesticide disappearance.

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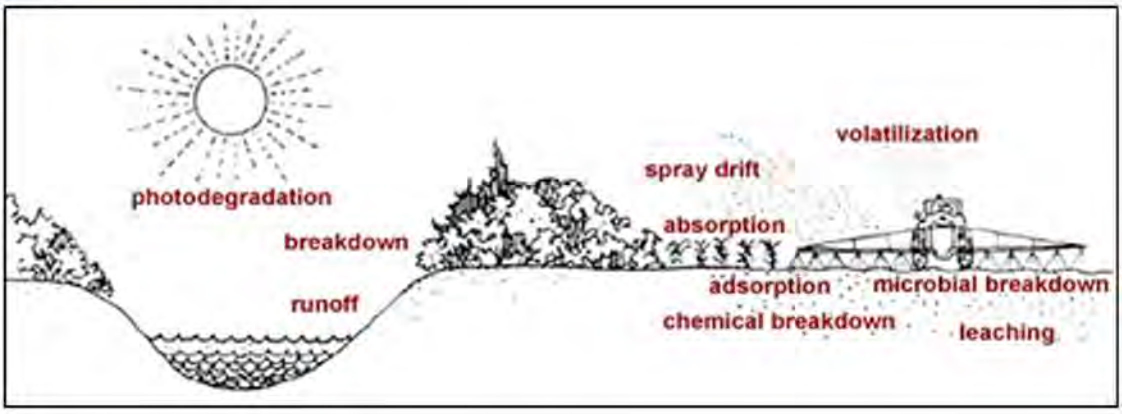

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e. To conduct market survey of agricultural produce on the basis of which dietary intake of pesticides can be predicted and thus assess the risk to general public on account of pesticide residues by comparing daily dietary intake of pesticides with ADI

f. To study the effect of storage and various types of processing/cooking on the persistence of pesticide residues.

g. To monitor agricultural produce and food commodities for pesticide residues under the f Food Safety and Standard Act, 2006

h. To monitor agricultural produce and food commodities for pesticide residues for global trade.

Pesticide Residues and Food Safety

Pesticides have been the most powerful weapon available to mankind for combating pests of agriculture and public health. These are highly regulated chemicals, but as a result of continuous use, over use and misuse or non prescriptive use, at times their residues find the place in edible parts, soil, water, animal and human tissues the world over. Thus there is a potential for the intake of such residues from contaminated food and can result in situations posing health risks to humans and other forms of the life. This can otherwise be taken as trade barriers in WTO regime. Such residues in food are not permitted unless they are proven to be safe at the highest levels of exposure anticipated based on Good Agricultural Practices (GAP) and to ensure that the Acceptable Daily Intake (ADI) of the pesticide is not exceeded. The best assurance that exposure to residues are within safe limits is obtained from dietary intake studies.

Concept of pesticide safety-MRL, Safe waiting period & FSSAI

In India, maximum exposure of pesticides to consumer has been through vegetables, fruits and animal products such as milk and milk products, meat, fish etc. The high residue content in vegetables can be attributed to the frequent pesticide application and non-compliance of the recommended waiting period. A high residues found in animal products can be attributed towards feeding of animals with contaminated feed and fodder with persistent type of pesticides like BHC, DDT etc. which accumulate in body.

The adverse effects of pesticide residues depend on the nature of the pesticide, as well as the amount and duration of exposure. Eating food with excessive pesticide residues may cause acute and/or chronic adverse health effects.

The use of pesticide might leave some residues on food crops. However, if pesticide is used in accordance with good agricultural practice, the residual level would be low and consumption of these vegetables will not affect health. Excessive pesticide residues in food may arise from the trade not observing good agricultural practice, e.g. the use of excessive pesticide and not allowing sufficient time for pesticide to decompose before harvesting. The amounts of residues found in food must be safe for consumers and must be as low as possible.

Maximum Residue Limit (MRL)

It is the maximum concentration for a pesticide residue on crop or food commodity resulting from the use of pesticides according to good agricultural practice. The concentration is expressed in milligrams of pesticide residue per kilogram of the commodity. Good agricultural practice (GAP) in the use of pesticides is the officially recommended or authorized usage of pesticides under practical conditions at any stage of production, storage,

transport distribution and processing of food, agricultural commodities and animal feed bearing in mind the variation in requirements within or between regions, which takes into account, applied in a manner so as to leave a residue which is the smallest amount practicable and which is toxicologically acceptable. The MRLs do not directly define health, safety or risk levels for consumers and should not be confused with any estimate of consumer exposure or the evaluation of long term risk to human health.

Acceptable Daily Intake (ADI)

Acceptable daily intake of a pesticide is the daily intake which during the entire life time appears to be without appreciable risk to the health of the consumer on the basis of all the facts known at the time of evaluation of the pesticide. It is expressed in the milligrams of the chemical per kilogram of body weight. The ADI is derived from the results of long term feeding studies with laboratory animals. The intake causing no toxicological significant effect in animals when given daily over their life span is determined.

1.6.3 Food Factor

The average fraction of the total diet made up by the food or class of food. First the food consumption pattern/data of different areas in a country is worked out on the basis of which an average dietary intake values are calculated.

No Observable Adverse Effect Level (NOAEL)

It is the highest dose of a substance that does not cause any detectable toxic effect in experimental animals and is usually expressed in milligrams per kilogram of body weight per day.

Processing Factor

It is the ratio of residue level in the processed commodity to the residue level in initial commodity.

National Theoretical Maximum Daily Intake

This is a prediction of the long term daily intake of a pesticide residue, assuming that residues of the pesticide are present at national maximum residue levels or at Codex MRLs and that an average daily consumption of food per person is represented by national food balance sheets. This is expressed in milligrams of residue per person.

Risk Assessment

A scientifically based process consisting of (i) hazard identification, (ii) hazard characterization, (iii) exposure assessment, and (iv)risk characterization. All human risk situations are a function of a hazard and exposure to that hazard. If the hazard is small and fixed than the risk will be proportional to the exposure which can be reduced to be low and occasional. When both the hazard and the exposure can be quantified then a realistic estimate can be made of the risk involved on consuming food stuffs containing some pesticide residues.

From the relationship Risk=Hazard X Exposure it can be seen that 'Zero risk' can be approached only if either the hazard or the exposure approach zero. Since pesticides are wide spread in worldwide food production then zero hazard or zero exposure are not possible if either or both can be considerably reduced in practice. Therefore asking for zero risk is uncertainly and can find place only in imagination.

Pre Harvest Interval (also termed as with holding period or waiting period) is the time interval from the application of pesticide to harvest under good agricultural practice so as to see that the pesticide residue falls below the MRL value.

The level of food additive usage varies by country as the forms of agriculture are different in regions according to their geographical or climatical factors and hence different countries adopt their own agricultural policies and Maximum Residue Limits (MRL) and Acceptable Daily Intake (ADI). However, the MRLs, fixed by CodexAlimentarius Commission are considered as standards for international trade purposes.

Codex Alimentarius Commission (CAC)

In the early 1960s, the Food and Agriculture Organization (FAO) of the United Nations and the World Health Organization (WHO) recognized the importance of developing international standards for the purposes of protecting public health and minimizing disruption of international food trade. Codex Alimentarius Commission (CAC), established by FAO and WHO in 1963, develops harmonized international food standards, guidelines and codes of practice to protect the health of the consumers and ensure fair trade practices in the food trade. The Joint Food and Agriculture Organization (FAO) / World Health Organization (WHO) Meeting on Pesticide Residues (JMPR) is responsible for evaluating the safety of pesticides and estimating safety reference values (i.e. Acceptable Daily Intake, ADI) for individual pesticide.

Regulation of Food Products for MRLs in India

The Food Safety and Standards Authority of India (FSSAI), established under the Food Safety and Standards Act, 2006, Ministry of Health and Family Welfare has been designated as the nodal point for liaison with the Codex Alimentarius Commission. The Ministry of Health and Family Welfare regulates MRLs of pesticide and agrochemical in food products through the Food Safety and Standards Act (FSSA), 2006.

All food products sold in India have to comply with the MRLs established in the FSSA / Food Safety Standard Regulations for all the approved insecticides and agrochemicals. The FSSAI and state appointed inspectors have the authority to test products, both basic commodity and processed food products, for adherence to the MRLs. If products are found to be non- compliant, inspectors can take punitive action against the processor/trader/ retailer.

In 2005-2006, the Department of Agriculture & Farmers Welfare, Ministry of Agriculture& Farmers Welfare initiated a program to monitor pesticide residues at the national level through the Indian Council of Agricultural Research. Laboratories under the scheme collect and analyze samples of vegetables, fruits, spices, pulses, cereals, milk, fish, tea, honey, meat, animal feed and ground water. The results of the survey are published on the FSSAI website: Survey Results. In case of food grain, fruits, vegetables, dry fruits, tree nuts other basic commodities, the Ministry of Agriculture works through the Plant Quarantine Office at the Port to test for the presence of banned pesticides and agrochemicals.

MRL Fixation procedure

Maximum Residue Limits (MRLs) are a trading standard and a measure of the highest level of a pesticide residue that is legally tolerated in or on food or feed when pesticides are applied correctly. MRLs are set well below safety margins to ascertain foods produced with pesticides are suitable for consumption. MRLs ensure that consumers can trust the safety and quality of the foods they buy. Governments around the world monitor pesticide residues by testing samples. MRLs, based on residue trials set by regulators, verify if farmers have used pesticides correctly. Demonstrated consumer safety is an indispensable pre-condition for granting MRLs. Traders and importers can trust that the foods they order fulfill safety and quality requirements, thus ensuring trade and marketability of produce. If an MRL is exceeded, it is against the law so the produce cannot be sold and will be destroyed. Farmers follow good agricultural practices to ensure that potential residues are below MRLs. It is essential for farmers to comply with MRL requirements in order to sell their crops locally and for export. There are many different systems for setting MRLs around world, such as in the United States and EU, as well as provided by Codex Alimentarius internationally. In each market, an MRL is set routinely before a pesticide product is registered but not automatically in import markets. If a product is not registered in an import market, the manufacturer must ask regulators of the importing market to set an import tolerance, which ideally should be the MRL in the exporting market. Until recently, food was mainly produced, sold and consumed locally. Over the last century, the amount of food traded internationally has grown exponentially. A crop is not legally tradeable if it exceeds MRLs. There are no globally harmonized MRLs, farmers must comply with MRLs in both exporting and various importing countries. Farmers need to be well informed about MRL requirements of all their markets.

Recommended Practices for Input Dealers:

1) Use of pesticides as per the recommended doses of pesticides helps in reducing the presence of residues on crop
2) Always recommend the pesticides that are approved for usage on the crop
3) Educate the farmer on waiting periods to reduce the residue occurrence.

2. Culinary methods for Decontamination of Pesticides

INTRODUCTION:

Pesticides have been found effective for protection and improvement of the quality and quantity of food commodities, building materials, clothing and animal health and to control certain diseases transmitted by insect vectors. One Rupee spent for pesticide leads to a profit of 3 Rupees for the farmer. Pesticides have therefore become an integral part of modern agriculture. The use of pesticides over the past five decades has helped globally to enhance and stabilize agricultural productivity. It is necessary that the waiting period or pre harvest intervals for the crops are maintained to reduce the residue load on the produce. SConsumable commodities, if suspected to have pesticide residues, can be decontaminated using culinary methods.

Decontamination

No single treatment system can be universally applied for decontamination due to diversity in chemical properties of pesticides and their formulations, the quality or composition of pesticide wastes and residues. Decontamination methods may be classified as:

i. Traditional
ii. Physical
iii. Chemical
iv. Biological

Culinary methods for fruits and vegetables

Pesticides when used to control pests may leave some residues on edible commodity. These residues might be above the maximum permissible limit (MRL) depending upon the chemical property of the pesticide and the time interval between the last spray and harvest. Pesticide residues are toxic, need to be removed.

Methods for Removal of pesticide Residue


Washing the vegetables under running waterhelps in removal of pesticide residues

The residues from the agricultural use of some pesticides persist over a periods before completely degraded by natural processes and these residues remains in the food materials, fruits, vegetables and accumulated or contaminated into animals, air, water and soil systems through bio magnification which leads to health hazard and environmental pollution. Indiscriminately and excessively used of pesticides throughout the globe create risk to the human health and in the environment.

The persistence of a pesticide residue is a complex matter affected not only by the chemical and physical characteristics of the parent compound and its degradation products, but also by the nature of the formulation applied, the adsorbents or solvents employed. The persistence may also depend on characteristics of the host. The waxy surfaces of plants tend to localize and trap many pesticides which thereby become more resistant to removal than they would as true surface residues. Similarly, the fats in milk hold residues during the manufacture of various dairy products.

Hence, the removal or to minimize pesticide residues from food commodities utilizing different processing methods is very important and challenging for food safety. Remedial measures have been suggested for the public to remove contamination at national level by Department of Agriculture & Corporation for food safety.

Ways & Means to minimize residues on Fruit & Vegetables before Consumption:

There are several ways & means to reduce pesticide residues on fruits & vegetables before consumption, as under:-

(a) Dry produce (fruits, vegetables) with a clean cloth towel or paper towel reduces residues.

Peeling method reduces pesticide residues

Dipping the vegetables in 2% salt solution removes residues

(b) Scrub firm fruits and vegetables such as melons, root vegetables such as carrot and tubers, like potatoes. Soft brush can be used to scrub the fruits and vegetables for five to ten seconds before rinsing with slightly warm water.

(c) Discard outer layer of leafy vegetables, like,
cabbage, lettuce, etc before washing as they grow close to the ground where soil could be tainted.

(d) Peeling reduces residues considerably. Peeling and trimming fruits such as mango, citrus, apple, pear, peach and kiwi and vegetables, like, gourds reduces pesticide residues.

(e) Washing in clean running, preferably drinking water reduces pesticide residues as it has abrasive effect.

(f) Washing of vegetables, like, cauliflower, broccoli, cabbage, spinach and green beans with hot water containing 2 per cent common salt removes residues.

(g) Carrot, okra, brinjal, cabbage and cauliflower, can be washed with 1 per cent tamarind solution.

(h) Salad spinner can be used to wash and dry lettuce or leafy greens. Colander can be used, followed by drying with a paper towel.

(i) Don't use any soap, detergents, chemicals, which could leave their own harmful residues.

(j) Cut away damaged or bruised areas on fresh fruits and vegetables before eating/cooking. Discard any portion that appears rotten.

(k) Vegetables and some of the fruits, which are consumed along with the peel, can be soaked in water for half-an-hour to one hour and rinsed a few times before use. Soaking fruits and vegetables five to ten minutes in a solution of diluted form of hydrochloric acid with four tablespoons of salt and juice of half a fresh lime and rinsing thoroughly with clean water helps in reducing residues. Use of dilute vinegar/acetic acid followed by thorough rinsing is also recommended.

(l) Vegetables can be kept in boiling water just for a minute and rinsed in running thereafter to reduce pesticide residues.

(m) Steaming and cooking of vegetables eliminate most of the residues that are not removable by washing or peeling.

(n) Variety of fruits and vegetables helps in maintaining a balanced diet and also avoiding excessive consumption of pesticide residues from a small range of food items.

(o) Juicing of fruits, like, grapes reduces the residue level. Clarification processes, such as centrifugation and filtering, further reduce the residues.

(p) Highly concerned individuals may opt for fruits and vegetables grown under Certified Organic Methods. However, even organically grown fruits and vegetables cannot be guaranteed for total freedom from pesticide residues though they might help in reducing the intake of pesticide residues. They are expensive too.

(q) Lemon/Baking Soda Wash: Mixture of 1 Tablespoon of lemon juice (natural disinfectant), 2 Tablespoon baking soda (neutralizes the pH level of pesticides) and 1 cup (250 ml) of water. Put the mixture in a spray-topped bottle. Spray the fruit or vegetables, leave it to for 5-10 minutes, and then rinse well.

(r) Lemon/vinegar Wash: Mixture of 1 Tablespoon Lemon juice (natural disinfectant), 2 Tablespoon white vinegar (cleans the fruits and vegetables and neutralizes most pesticides) and 1 cup (250 ml) of water in a spray-topped bottle. Spray the fruits or vegetables, wipe and eat.

(s) Vinegar/Salt Wash: ¼ cup vinegar (cleans the fruits and vegetables and neutralizes most pesticides) 2 tablespoon salt (draws out dirt and insects). Just fill a sink or a large bowl with water and the above ingredients (depending on the method you choose) and let the vegetables sit for about 20 minutes, then rinse or else you can fill an empty water bottle and spray onto your produce and then rinse and wipe.

(t) For particularly waxy fruit and vegetables: Mixture of 1 cup (250 ml) water, ½ a cup (115 ml) vinegar, 1 tablespoon of baking soda and Dash of grapefruit seed extract. Spray onto the produce and leave for an hour before rinsing and eating.

(u) Exposure to ozone gas (O3) and dipping in ozonated water helps in reduction of pesticide residues. Gaseous ozone treatment during storage degrades contemporary pesticides. Ozone sanitation method does oxidize pesticide residues. An extended wash in clean water can help further reduction in pesticide residues. Some companies have started marketing the equipment for ozone sanitation.

(v) Some of the Commercial Fruit cleaners available on the market are made up of 100% natural produce – normally some form of citric acid. These claim to remove wax, pesticides and 99% bacteria. However, ammonia-based products to be avoided.

Many research work also revealed that the removal of pesticide residues from food commodities in fruit and vegetables samples have got substantial reduction by different house hold processing methods such as washing under running tap water, washing with 2% salt solution, dipping in 2% tamarind solution and direct cooking.

Best Practices to be followed for disposal of used containers and removal of residues:

1. Insist the farmer to triple rinse the containers always.
2. Educate the farmer to crush the container after use and not to reuse the empty containers again.
3. Residues of pesticides on fruits and vegetables can be removed by tap water washing for 20 minutes or dipping the food commodity in hot water for 20 minutes.
4. Dipping the food commodity in 2 per cent salt solution for 20 minutes followed by tap water wash and dipping the food commodity in 1 per cent solution of vinegar in water for 20 minutes followed by tap water wash also reduces the residues of pesticides.

V. Safe Use of Pesticides and Disposal of Pesticides and their Containers

Introduction:

Prospective users of pesticides must identify their pest problem and, if necessary, seek experienced advice from agricultural officials, research stations or company advisers. There may be circumstances where the use of pesticides would not be appropriate, such as where cultural or biological methods of control are more effective. Where the use of a pesticide is considered necessary, information must be obtained on:

a) Recommended products, and where obtainable
b) Dose rates, dilutions, timing and frequency of application
c) Method(s)of application
d) Precautions to be taken
e) Cost per unit area

General precaution for the Usage of Pesticides:

Selection of pesticides

a) Use pesticides when really needed.
b) Use pesticides recommended by competent authorities. If several pesticides are recommended against a pest, use the least hazardous one (i.e. the chemical with least mammalian toxicity).

Purchase of pesticides

a) Buy from a reliable and authorized dealer.

b) Buy the packing of a quantity needed for a given operation.

c) Make sure that the label on the container is not defaced.

d) Collect the leaflet provided by the manufacturer with each pack of pesticide.

Safe storage

a) Store pesticides in their original containers with the labels intact and legible. Never transfer them into containers used for storing food, water or liquor.

b) Do not store pesticides near food, feed, medicines or source of potable water. Never store pesticides in living room or kitchen.

c) Store pesticides in dry, ventilated places away from the direct sunlight and fire.

d) Keep pesticides away from the reach of children, irresponsible and mentally disturbed persons and pets. Keep them in locked cupboards and inform all adult family members about their storage.

e) If there is any possibility of dampness on floor or sidewalls, cover such areas with polythene sheets before storing granules, dusts and wettable powders.

f) To rule out the possibility of cross-contamination, store herbicides separate from other groups of pesticides.

g) Check periodically the stored pesticides for signs of damage and leaks. Dispose of torn and leaking packings.

h) Avoid sudden entry into stores where pesticides are kept. Open windows and doors about half an hour before entering such places.

Precautions while using pesticides

a) Before application:

Always read labels on containers before you open them. It gives important information. Make necessary calculations to estimate the amount of formulation and water required. Make sure that the pesticide-applicator is in working order. If not, get it repaired from a qualified mechanic. Check that appropriate protective clothing is available to all operators. Ensure that clean clothes are available so that the workers change into them after pesticide application. Ensure that plenty of water, soap and towels are available at the site of operation. If there are apiaries in the neighborhood, inform their owners about your pesticide application program, so that they can take appropriate precautions. Pluck ripe fruits, vegetables and other edible plant parts before pesticide application.

Fig: Different respirators

Protective clothing and aids:

The following basic protective equipment are a must while pesticide application:

i. Chemical resistant coveralls without pockets, high neck, full sleeves with buttons at the cuffs and narrow bottoms

ii. Nose mask

iii. Cap

iv. Goggles or plain glasses

v. Gloves

vi. Shoes

Depending on the circumstance respirators, cartridge- filters, masks and breathing equipment may also be required. The Respiratory devices of different types of respirators such as chemical cartridge respirator,

Supplied air respirator, Demand flow type respirator, Full face or half face gas masks with canister should be used.

Clean protective clothing should be worn and should be washed regularly. Make sure that your shoes and gloves have been washed from inside and outside before you put them on.

b) Mixing and handling of pesticides

Mixing and preparation of pesticide dilutions should be carried out in the open or in well- ventilated places. Always stand with the wind blowing from your back while mixing the pesticides.

Open the containers carefully to avoid splashing of the liquids or puffing up of the powder formulations. Special care should be taken while opening factory- sealed containers. Open bags or sacks with scissors, knife or blade.

While pouring the pesticides, keep the pesticide container close to the vessel to be used for making dilution. Don't position any part of the body below the container while pouring. Never use mouth to siphon a pesticide from container.

Measure and mix the quantities of pesticides and water accurately. Measure the pesticides before pouring them in dilution tank. Never pour pesticides directly from container into dilution tank.

Use a long-handled stirrer to mix pesticides. Never use bare hands for this purpose. Food or beverage containers or buckets to be used later for bathing and storing drinking water should not be used for the preparation of spray fluids. Use Funnel while pouring of pesticide solution into the spray pump. Don't let the liquid splash.

c) During application

a) Never work alone while handling pesticides.

b) Do not allow children or irresponsible persons near the site of the pesticide application. Never allow them to handle pesticides.

c) Recheck the instructions for use. Never leave pesticides unattended to in the field.

d) Wear clean protective clothing before handling pesticides. If clothing gets contaminated during operation, replace it immediately.

sticks and measuring cups, used for making dilutions, in a similar manner. Water contaminated in these processes should be disposed of over the barren land.

d) Take bath with soap and plenty of clean water and change into fresh clothes. Do not stay in work-clothes after spraying. Wash clothes separately. Do not take soiled clothes home for getting them washed along with other clothes.

e) Wash caps, hats, shoes, belts, goggles or spectacles worn during pesticide application. These items are often left unwashed and can pose a hazard when worn again.

e) Handling Spillage:

a) Spillage should be dealt with as soon as it is discovered. For liquid formulations, cover spilled material with dry adsorbent material like clay, sand or sawdust. Remove such covering material without touching it and discard it as indicated in the item dealing with the disposal of empty containers. If' spillage occurs on clayey floor or in the field, the soil up to the depth to which liquid has percolated should be scraped and discarded. If spillage occurs on cemented floor, flush the site with detergent and water.

b) Remove the spilled material of powder or granular formulations with a broom. Discard sweepings and broom as indicated in the item dealing with the disposal of empty containers.

Disposal of Pesticides and their Remnants:

The disposal of pesticide remnants resulting from the left over portion of usage, unsold/unused, excess stocks, date expired and substandard or obsolete and after the analysis for quality control, is a matter of concern and has to be taken up scientifically lest it leads to environmental contamination and pollution. The following are the ways and means for the disposal of pesticides;

Disposing of Unwanted Spray Mix:

Avoid mixing surplus spray by carefully calculating rates, measuring field size, and calibrating your sprayer. Extra pesticide spray mixes can be applied to another crop or site listed on the pesticide label. If no such area can be found, spray the mixture over an area on your property where it will cause no damage. Never re-spray the treated field with extra tank mix. Spraying an area twice will double the rate and may result in high residues in the crop or soil.

Disposing of pesticide remnants:

1. The best way to dispose of small amounts of excess pesticides is to use them - apply them - according to the directions on the label.
2. If it cannot be used, then the same may be offered to the neighbors whether they have a similar pest control problem and can use them.
3. If large amount of pesticide is left over which can be put to use, the same may be offered to any public organization which can use the pesticide in public gardens, urban forestry or to the forest department.
4. If all the remaining pesticide cannot be properly used, check with your local solid waste management authority, environmental agency/Pollution Control Board or health department to find out whether your community has a household hazardous waste collection program or a similar program for getting rid of unwanted, leftover pesticides. These authorities can also inform you of any local requirements for pesticide waste disposal.

Disposing of Empty Pesticide Containers:

Empty pesticide containers are considered hazardous waste, by law, unless they are drained and rinsed properly. Plastic, metal and glass containers must be rinsed 3 times. The rinse water must be poured into the sprayer and applied with the pesticide. Paper and plastic bags must be rinsed once. Pressurized containers and Domestic pesticides do not need to be rinsed.

a) Cleaning methodologies

The cleaning methodology depends on the physico-chemical characteristics of the pesticide. Rinsing with water using the manual triple rinsing technique, pressure rinsing or integrated rinsing can be done for formulations like emulsifiable concentrates, water soluble products, water soluble solids and rinsing with solvent is required for oil and solvent based products.

Triple rinsing is the method to use in the absence of ad hoc mechanical rinsing equipment. It is likely to be the most practical option in developing economies. It can be used to clean all sizes of containers but the technique is slightly different for small containers that can be shaken by hand, and large containers that are too big to shake. For triple-rinsing:

1. Remove the cap from the pesticide container and empty all the remaining pesticide into the application equipment or a mix tank and drain for at least 30 seconds after the flow begins to drip.
2. Fill the container at least 25 per cent full with clean water or rinse solution and secure the pesticide container cap.
3. Shake, rotate and invert the container so that the water reaches all the inside surfaces. [For large containers, tilt container on its side and roll it back and forth, ensuring at least one complete revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times.]
4. Either add the rinsate to the application equipment or the mix tank or store it for later use or disposal.
5. Allow the container to drain for 30 seconds or more after the flow begins to drip.
6. Repeat the procedure two more times until the container appears clean. Puncture the container to prevent its misuse. Return the container to the supplier or pesticide container recycling site or dispose it off according to label directions.

b) Disposal of Secondary packaging

Clean secondary packaging, such as pallets and outer cardboard cartons, which has not come into direct contact with pesticides can be assumed to be uncontaminated. This can be disposed of as municipal waste. Material recycling and energy recovery are the disposal routes of choice but if neither option is available, the secondary packaging may be disposed of as municipal waste.

The best way to dispose of empty pesticide containers is to take them to a pesticide container collection site if any. Containers taken to these sites are recycled into fence posts for agricultural use, highway guardrail posts, or used for energy.

Post treatment considerations:

Some pesticides, especially the organophosphates cause toxicity when the plants treated with them recently are touched by human beings or animals. So, mark the fields where the pesticides have been applied and take steps to prevent the entry of persons or cattle into them for at least 24 hours. After pesticide application, delay using the crop as food or feed for the period recommended as the 'waiting period'.

Emergencies

Accidents while using pesticides may occur in spite of taking all necessary precautions. After exposure, the symptoms of poisoning can occur immediately or after several hours. So it is important to be vigilant about the appearance of symptoms of pesticide poisoning and consult a doctor, if there is an indication of such symptoms.

Best Practices to be followed for Safe and Judicious use of Pesticides by Input dealers:

a) Be sure that the pesticide is registered for the particular use.

b) Be sure that the application conditions, timing, site harvest interval etc. are complied with.

c) Always be sure that the right kind of pesticide with approved uses is sold to the farmer.

d) Insist the farmer to read the label or help him to read the label for the recommended doses and toxicity hazards associated with pesticide.

e) Advice the farmer to use the protective equipment while applying pesticides

f) Insist the farmer to follow the instructions on the manufacturer's label pertaining to herbicide usage.

g) Make the farmer aware of the environmental hazards associated with pesticide usage

h) Educate the farmer to avoid contamination of water ways and sensitive plants

i) In case of accidental poisoning, administer first-aid and take the victim to the hospital immediately.

j) In case of poisoning cases, as the label and leaflet of pesticide contain the antidote information, it is advisable to take them to the physician to enable him to act fast.

Annexures:

Annexure VI Major uses of Insecticides
Annexure VII Major uses of Fungicides
Annexure VIII Major uses of Herbicides
Annexure IX Major uses of bio-pesticides

1. PROCEDURE FOR ENRICHMENT OF FYM WITH BIO-AGENTS

Use one kg of bio-pesticide-Trichoderma harzianum + Paecilomyces lilacinus / Pochonia chlamydosporia / Pseudomonas fluorescens + 50 kg of neem or pongamia cake to enrich 1 ton of farmyard manure and leave it under shade for 15 days. Once in 5 days, mix the FYM thoroughly by maintaining optimum moisture.

2.PREPARATION OF BIOPESTICIDES AT FARMERS' LEVEL

1. Neem Seed Kernel Extract (NSKE 4%)

Method of preparation

Dried neem seed kernels (400g) are grinded to coarse powder.

Take 40 g of this powder and tie it in a fine muslin cloth, soak overnight in 400-500 ml of water in a container. Shake and filter the suspension with water to make 1000 ml volume. Add 2 g of soap to this solution (NSKE 4%) and use for spray.

NSKE helps in the management of Spodoptera, Helicoverpa, semiloopers, leaf folders and sucking pests including mites.

2.Tobacco Decoction

Method of preparation

Boil 1 kg tobacco dust in 10 liters of water for 30 minutes to attain coffee red colour.

Add water to the boiling solution to make 10 litres ™™ volume. Cool and filter the decoction using a thin muslin ™™ cloth. Add soap @ 2 g/l and dilute to 80 to 100 litres for ™™ spray. This preparation is effective against whitefly, ™™ aphids, and leafhoppers.

Note: Tobacco decoction should not be used for more than once, as it is toxic to natural enemies.

Cattle-dung and Urine Extract

Method of preparation

Mix Cattle-dung (5 kg) and urine (5 liters) thoroughly in 5 liters of water in a container and allow this mixture for 4 days by keeping a lid over the container. After 4 days, filter and add 100 grams of lime to this solution. Dilute the solution in 80 liters of water, which is ™™ sufficient for spraying an acre. Spraying cow dung urine solution prevents eggs ™™ laying by the moth, e.g. Helivoerpa and Spodoptera, etc. It is found to give protection against some diseases ™™ and the sprayed crop looks green and healthy.

Nuclear Polyhedrosis Virus (NPV)

Method of preparation

Collect 400 NPV infected Helicoverpa or 200 Spodoptera larvae from field. Grind the collected larvae. Filter the solution obtained using a thin cloth. Dilute the NPV solution to 100 litres and add 100 g of Robin Blue to protect from UV light in the field.Spray this solution during evening hours. Insects Controlled: Helicoverpa, Spodoptera Virus of one insect species does not kill the other insect species. Virus infected dead larvae are observed hanging head down from top branches 2-5 days after spraying the solution in the case of Helicoverpa and split body in case of Spodopter.

3. PREPARATION OF STICKY TRAPS AT FARMERS' LEVEL

1. Yellow sticky traps

Pest attracted: White flies, aphids, leaf miners

Methodology 1:

Materials required:

- ✓ Ply wood board or hard board or card board (1.5 ft X 1.0 ft size)
- ✓ Yellow colour oil paint
- ✓ Glue or white grease
- ✓ Bamboo poles
- ✓ Wire or rope

Procedure for making yellow sticky trap:

Take new or used sheet of ply wood board or hardboard or card board.
Paint it with Yellow colour oil paint.
Allow it for drying.
Apply grease or glue on the painted board.
Erect these traps above crop canopy with the help of bamboo poles.

Methodology 2:

Materials required:

- ✓ Used empty oil tin (1 or 2 litre size)
- ✓ Yellow colour oil paint
- ✓ Glue or white grease
- ✓ Bamboo poles
- ✓ Wire or rope

Procedure for making yellow sticky trap:

- ✓ Take new or used empty 1 or 2 litres oil tin. Paint it with yellow colour oil paint.
- ✓ Apply grease or glue around the tin.
- ✓ Erect these traps above crop canopy with the help of bamboo poles.
- ✓ Cleaning of traps:
- ✓ Clean the tin or plywood or hardwood traps by dipping into the hot water for couple of minutes to soften the sticky coating.
- ✓ Discard dead insects by using brush or duster. Dry the traps completely and recoat with similar glue for reinstallation. Card board traps should be discarded after use.

Benefits:

Highly effective, non-toxic and easy to use.

No. of traps per acre: 6-8

2. Blue sticky traps

Pest attracted: Thrips

Methodology 1:

Materials required:

- ✔ Ply wood board or hard board or card board (1.5 ft X 1.0 ft)
- ✔ Blue colour oil paint
- ✔ Glue or white grease
- ✔ Bamboo poles
- ✔ Wire or rope

Procedure for making yellow sticky trap:

Take new or used sheet of ply wood board or hardboard or card Board.

Paint it with blue colour oil paint.

Allow it for drying.

Apply grease or glue on the painted board.

Erect traps above crop canopy with the help of bamboo poles.

Methodology 2:

Materials required:

- ✔ Used empty oil tin (1 or 2 litre size)
- ✔ Blue colour oil paint
- ✔ Glue or white grease
- ✔ Bamboo poles
- ✔ Wire or rope

Procedure for making blue sticky trap:

Take used empty 1 or 2 litres oil tin.

Paint it with blue colour oil paint.

Apply grease or glue around the tin.

Erect traps above crop canopy with the help of bamboo poles.

Cleaning of traps:

Clean the tin or plywood or hardwood traps by dipping into the hot water for couple of minutes to soften the sticky coating. Discard dead insects by using brush or duster. Dry the traps completely and recoat with similar glue for reinstallation. Card board traps should be discarded after use.

Benefits:

Highly effective, non-toxic and easy to use.

No. of traps per acre: 10-15

3. Fruit fly traps

Pest attracted: Fruit flies

Materials required:

- Plastic bottle/jar 1 litre
- Latex gloves
- Galvanized utility wire

Methodology:

Make 10 to 12 holes into an old 1 liter plastic bottle or 3 holes on each side of 1 liter ice cream container, to allow flies to enter. Heat a small piece of metal to make the holes easily. Put a wire from the cover to suspend the bait. Secure the pheromone dispenser aligns with the entrance holes inside the trap. Make a rectangular opening into the lower part of the container for removing the flies caught. Half-fill the trap with soapy water. Put bait in the pheromone dispenser or suspend the pheromone capsule from the lid using string or wire. Close the container. Attach the trap to a bamboo or wooden stake or hang on branch of a tree. Place traps for different pests at least 3 meters apart. If traps are used for monitoring the pests, 2-3 traps are enough for 1 ha field.

Reminders while using pheromone traps:

Buy the pheromone that lures the pest you want to control. Always label the trap. The name of the species you are trapping, the date the bait was placed, and the name of the bait if you are using several. Change bait according to manufacturer's recommendation. Dispose properly the bait wrappers. The tiny amount of pheromone left near the traps will compete with your bait. Wash your hands between handling baits. Minute traces of other chemicals can render the baits completely ineffective. Always remove all captured adults during each visit. Discard them away from the field. Put live ones into a bucket with soap solution to drown.

No. of traps per acre:

- ✓ Cue Lure: Melon Fly - Use 2-3 traps/acre
- ✓ Methyl Eugenol: Oriental Fruit Fly - Use 3-5 traps/acre
- ✓ Trimedlure: mediterranean fruit fly - Use 3-5 traps/acre

4. Fruit fly traps using ripe banana, apple or mango peel

Pest attracted: Fruit flies

Materials required:

- ✓ Plastic jar 1 litre
- ✓ Ripe banana or apple or mango
- ✓ jaggery/Sugar solution
- ✓ Wires/ropes for hanging the trap

Methodology:

Cut fruit peels into small pieces and mix with sugar and water. Make circular holes randomly on the plastic jar. Place sugary water inside the container. Hang the bait/lure from the lid with the help of a wire/rope. Use wire/rope for hanging the trap close to the plant canopy. Change the lures once in 15-20 days. Flush out the trapped insects periodically.

No. of traps per acre: 4-5.

Materials required:

- ✓ Plastic buckets 5-10 lts.
- ✓ Metal light shade (2 nos.)
- ✓ Fluorescent light with holder
- ✓ Electrical wires
- ✓ Coated metal rods (4 nos.)
- ✓ Tin sheets
- ✓ String/ flexible wire
- ✓ Nut bolts & Screws
- ✓ Rubber plug for drainage hole
- ✓ Soap water or Kerosinized water

Methodology:

Take a bucket and make 4 holes at the top rim and one larger hole at the bottom rim. Adjust small sized light shade on the bucket in inverse direction. Fix four rods with screws/nuts with the bucket for holding up the large sized light shade. Fix the light source as shown in the figure. Hang the light trap on the large sized light shade. Drainage hole on the bucket should be kept closed by the rubber plug while filling it with soap water/kerosinized water. Collect/drain out trapped insects periodically.

Procedure for installation:

- ✓ Install the light trap near or within the field where you want to trap the flying insects
- ✓ Secure the poles firmly on the ground
- ✓ Mount the lamp or the bulb on the frame, five meters from the ground
- ✓ When using electric bulb, make sure that the bulb and wiring are not in contact with water to avoid electrocution
- ✓ Place the shallow basin with soapy water or the jute sack underneath the light
- ✓ Put the light trap from early evening 6:00 PM to 10:00 PM. Collect the trapped insects daily and dispose them properly.

No. of traps per acre: 2

PREPARATION OF BIOPESTICIDES AT FARMERS' LEVEL

Mass production of Beauveria bassiana (white muscardine fungus)

Materials required:

- Sorghum
- Water
- Chalk powder
- Autoclave

Methodology:

- Soak 1 Kg of Sorghum in water for 48 hours.
- Replace water after 24 hrs, after 48 hrs. rinse water completely.
- Separate equally in 10-15 flasks and plug with hard cotton cushion and wrap with double aluminum foil.
- Sterilize for 40 minutes with 21 psi. Inoculate the each flask containing jowar with 2-3 drop of nucleus culture after cooling.
- Beauveria culture will grow fully after 20-25 days.
- Mix 2 Kg of chalk powder in Beauveria culture and dry in shade.

Beauveria bassiana

Dose: 1 gram/liter of water or 1 Kg/1000 liter of water/ha (Repeat application after 10-20 days interval)

8. Mass production of *Metarhizium anisopliae (green muscardine fungus)*

Pest managed: Rhinoceros beetle, Oryctes rhinoceros A. On coconut water

Material Required:

- Coconut water
- Flat glass bottles
- Cotton plug
- Pressure cooker
- Injection syringe
- Bunsen burner
- Laminar flow chamber
- Mixer grinder

Methodology:

Take glass bottles containing 40 ml of coconut water. Plug these bottles with cotton plug and sterilize in autoclave for 20 minutes at 15 psi. The bottles are inoculated with 1 ml suspension containing spores of the fungus with the help of a sterile injection syringe. Sterilize the bottles with the help of burner. Spores are inoculated in bottles with the help of syringe in a laminar flow chamber. Keep inoculated bottles till the surface of medium is fully covered by the olive green sporulated fungus. Whole culture is grinded thoroughly in mixer. Keep culture in cool and dry place in packets.

B. In Carrot broth

Material Required:

- ✓ Carrots
- ✓ Conical flask (250 ml)
- ✓ Distilled water
- ✓ Autoclave
- ✓ Laminar flow chamber

Methodology:

Wash thoroughly cut pieces of carrots put in conical flask. Add 15 ml of distilled water in conical flask.

Conical flasks are plugged with cotton and autoclaved for 20 min at 15 psi and allow for cooling.

Inoculate mother culture in slant loop full quantities of M. anisopliae spores in flasks. The flasks are incubated at room temperature. Spores will be ready in 15 days.

Mass multiplication of Pseudomonas

An easy, farmer-friendly field level multiplication method for Pseudomonas fluorescens in coconut water is described. Pseudomonas fluorescens was multiplied in boiled coconut water under non-sterile conditions and the population reached to 109 cfu/ml after 48 hours. Though the inoculation of the growth medium was done without complete sterilization, there was no detectable growth of contaminants in the inoculated boiled coconut water. Since the population level of the bacterial strain in the inoculated bottles had gone up to 108-9 cfu/ml, the same preparation could be further diluted up to 10 to 50 times and could be applied to plants in the form of spray or soil drench.

Methodology 1:
Material Required:

- ✔ Coconut water
- ✔ Steel vessel
- ✔ Plastic mineral water bottles (one litre capacity)
- ✔ Bio-control bacterium Pseudomonas fluorescens

Procedure:

Collect two liter fresh coconut water.

Boil covered stainless steel vessel for 15 minutes on a hot plate under non-sterile room conditions.

Allow to cool to room temperature (around 30C).

Boiled coconut water transfer to plastic mineral water bottles (one litre capacity).

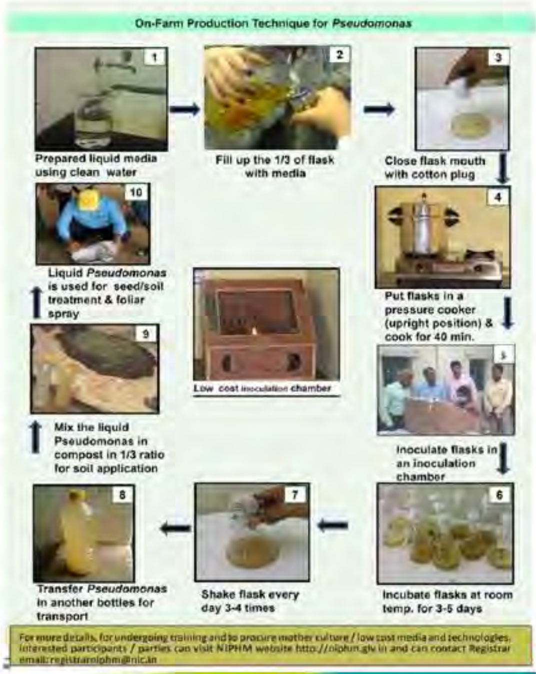
Before transfer of the boiled coconut water, the bottles are thoroughly rinsed 2-3 times with boiled water.

The mineral water bottles are filled with 500 ml and 150 ml of the boiled coconut water respectively. Immediately after the transfer, bottles must be capped.

One ml of the liquid formulation of the bio-agent is used for inoculation of the coconut water filled bottle.

The bottle is sealed tight with the cap and mixed thoroughly by shaking 4-5 times.

Keep for Incubation under ordinary room temperature (30 + 20C) up to 48 hours.



Mass production of Trichoderma:

Materials Required:

- ✓ Rice/Wheat/ Sorghum/ Maize
- ✓ Mother Culture (may be procured from CIPMCs or State bio control laboratory)
- ✓ 8" x 12 " plastic bag
- ✓ Cotton
- ✓ Rubber band
- ✓ Plastic pipe of 1 ½ inch length and 1 ½ cm – 2 cm diameter having both side open (or even a bamboo of same size and diameter, can be used removing the internodes)
- ✓ Pressure cooker of 5 Lts. or above
- ✓ Stone/wood
- ✓ Heating system (gas/electric heater)
- ✓ Fresh Water
- ✓ Candle
- ✓ Spoon

Methodology:

Take 200g of Rice/Wheat/Jower/Maize in the poly pack and add 200 ml of fresh water in the pack (if grains contain dust then wash it twice before adding fresh water). Place the plastic pipe/Bamboo in the middle of the plastic pack (opening end) in such a way that level of the pipe and plastic remain equal. Tie it with the help of rubber band. Plug the opening end of the pipe tightly with the help of the cotton. Cover the cotton plug with a paper using rubber band. Place the thick paper inside the pressure cooker surrounding the cooker wall. Place the stone/wood in the cooker and add water into the cooker just below the stone/wood. Place the plastic pack inside the cooker and put it on heating system. Wait until 3 times gas release from the cooker (3 whistles). Remove the packet from the cooker until totally cool down.

Inoculation method:

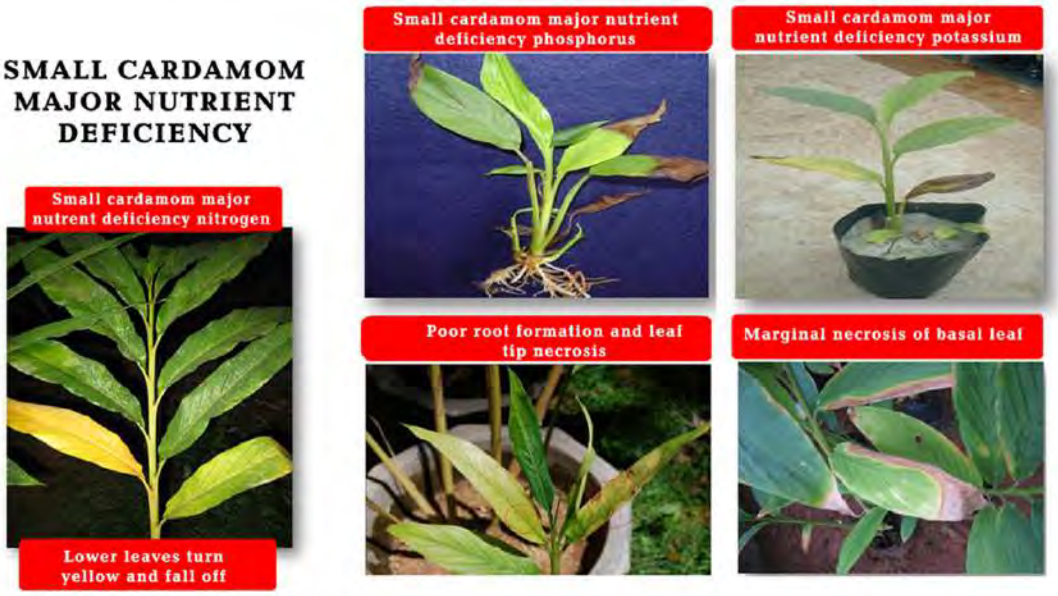
Place a candle at the corner of the room and wait for 3-4 min. Wash hand and the spoon with Dettol.

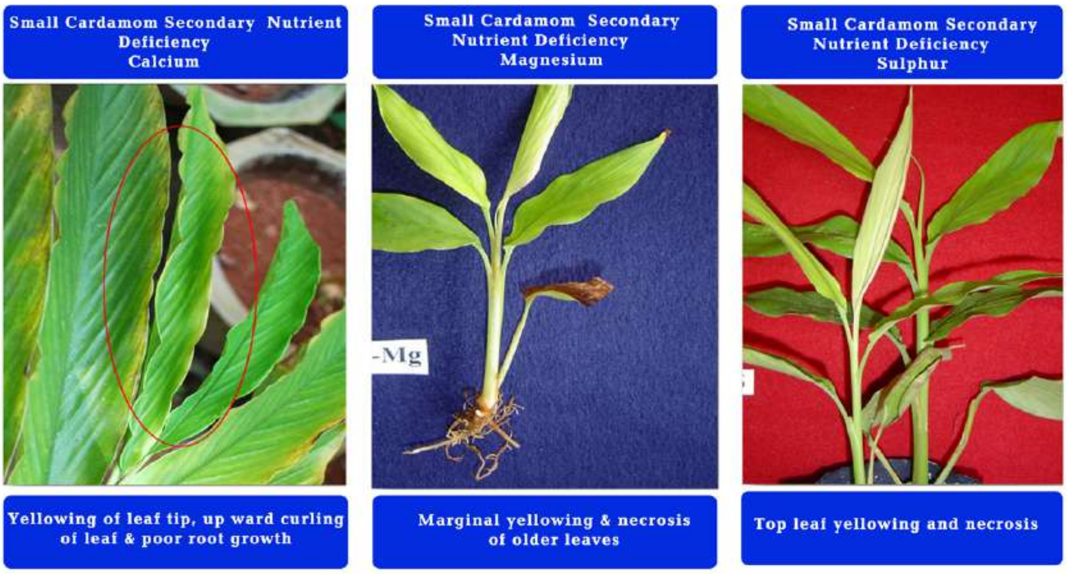
Open the paper cover from the plastic pack. Take mother culture (Talc based) by using opposite end of the spoon and pour it in to the plastic pack, removing cotton plug in front of candle. Plug it again and keep the plastic pack in room temperature for 10-12 days. The entire grain based medium will turn green due to sporulation of Trichoderma

Precautions:

- ✓ Do not open the cotton plug until use.
- ✓ Keep it in a cold place (refrigerator preferably after sporulation)
- ✓ Avoid direct sunlight until use.

38. MACRO AND MICRO NUTRIENT DEFICIENCY

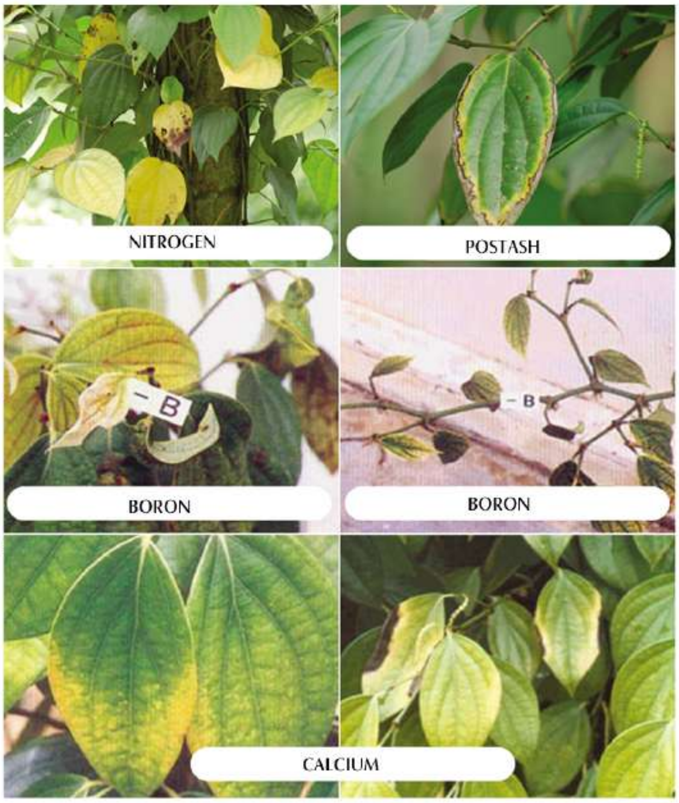




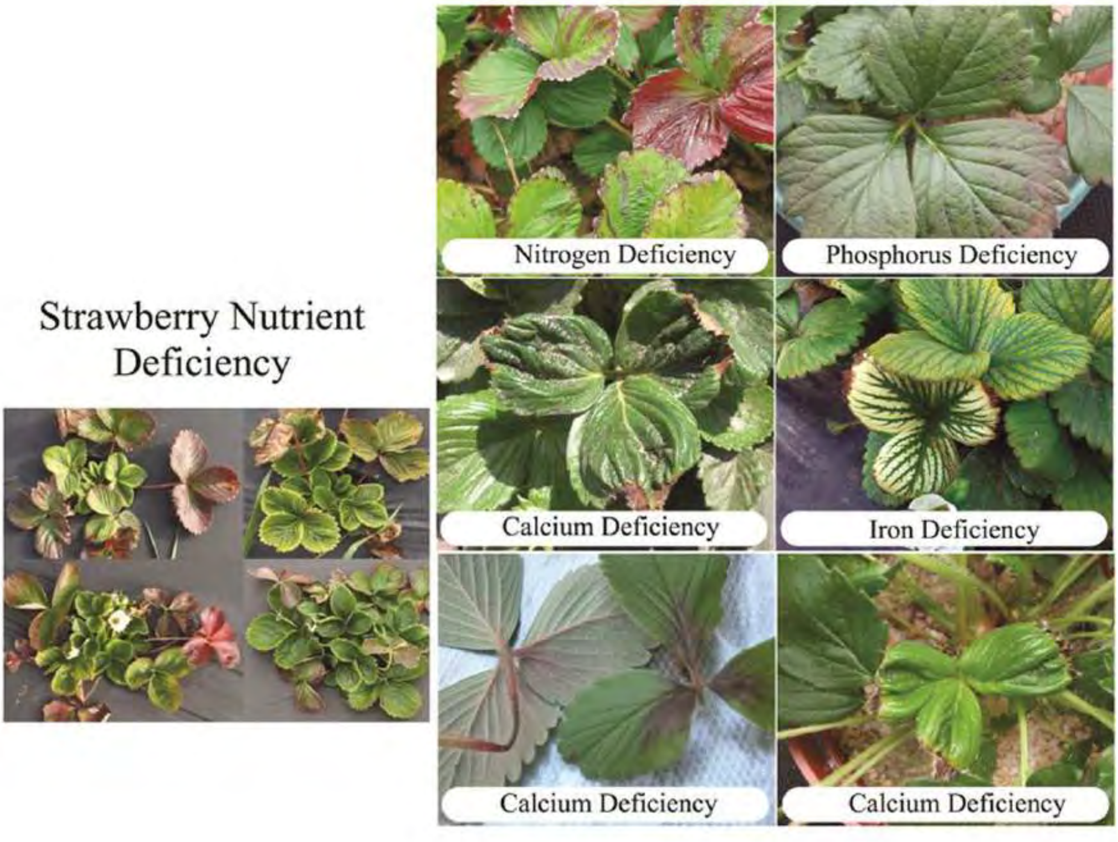
MAJOR NUTRIENT

DEFICINCY

MAGNESIUM



Strawberry Nutrient Deficiency



Strawberry
Boron Deficiency

Boron toxicity

Mahali / kolerogo/
fruit rot:
Phytophthora palmivora
Phytophthora katsurae
Phytophthora arecae

Shedding of immature nuts

Optimum use of PPC chemicals
Prepare for weather glitches
Crop Spraying
Check Crop Health
Advantage of drone in agriculture
Geo Fencing
Pollution Control
Soil and field analysis
Crop Monitoring
Plantation
Monitor Growth

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Advantage of drone in agriculture
Optimum use of PPC chemicals
Prepare for weather glitches
Crop Spraying
Check Crop Health
Geo Fencing
Pollution Control
Soil and field analysis
Crop Monitoring
Plantation
Monitor Growth