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IPM Package of Practices for Mango

(For Producing Quality Fruits for Export)

Government of India

Ministry of Agriculture & Farmer's Welfare

Department of Agriculture & Farmer's Welfare

Directorate of Plant Protection Quarantine & Storage

NH-IV, Faridabad

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IPM Package of Practices for Mango (For producing quality fruits for export) was compiled by the DPPQS technical team under the Chairmanship of Dr. J. P. Singh, Plant Protection Adviser and guidance of Dr. Pramod Kumar Meherda, IAS, Joint Secretary (PP). Dr. S.C. Dubey, Assistant Director General (PP & BS), ICAR, New Delhi provided review from crop specific ICAR institute - Central Institute of Sub Tropical Horticulture, Lucknow

DPPQS Technical Team:

Chairman: Dr. J. P. Singh, Plant Protection Adviser
Vice-Chairman: Sh. O.P. Verma, Joint Director (PP)

Contributors of DPPQS Technical Team:

1. Dr. Jasvir Singh, Joint Director(E)
2. Dr. A. Siddiqui, Joint Director (E)
3. Dr. Sunita Pandey, Deputy Director (E)
4. Dr. G. P. Singh, Deputy Director (E)
5. Sh. M. P. Goswami, Deputy Director (E)
6. Sh. Gyaneshwer Banchhor, Deputy Director (E)
7. Sh. Vishal Lahu Gate, Plant Protection Officer (PP)
8. Dr. Datchina Murthy K., Assistant Plant Protection Officer (E)

Contributor by ICAR:

1. Director
   Central Institute of Sub Tropical Horticulture, Lucknow

Contact:

APPA - IPM, Directorate of Plant Protection, Quarantine & Storage, CGO Complex, NH IV, Faridabad, Haryana - 121 001.Tel : 0129 2413020, e-mail: ppa@nic.in

डॉ. प्रमोद कुमार मेहरदा, भा.प्र.से.
संयुक्त सचिव
भारत सरकार
कृषि एवं किसान कल्याण मंत्रालय
कृषि एवं किसान कल्याण विभाग
कृषि भवन, नई दिल्ली-110001

सत्यमेव जयते

आज़ादी का अमृत महोत्सव

Dr. Pramod Kumar Meherda, I.A.S.
Joint Secretary
Government of India
Ministry of Agriculture & Farmers' Welfare
Department of Agriculture and Farmers' Welfare
Krishi Bhawan, New Delhi-110001

FOREWORD

Pests and diseases cause significant losses to the farmers. Generally, farmers apply large quantity of pesticides to control pests & diseases during various crop growth stages either calendar based or on noticing damage symptoms in the crop. Indiscriminate use of chemical pesticides is a major cause of ecological imbalance, environmental pollution, pesticide resistance, pest resurgence and pesticide residues.

Integrated Pest Management (IPM) is a globally accepted strategy for promoting sustainable agriculture. Initially IPM strategy allow chemical pesticide application on pest population reaching at economic threshold level which has shifted to more ecologically sustainable Agro-Eco System Analysis (AESA) based decision making for selection of IPM technique. The AESA based decision making considers relationship among various components of an agro-ecosystem with special focus on pest- defender dynamics, abilities of plants to compensate for the damages caused by the pests and the influence of abiotic factors on pest buildup. IPM approach advocates utilization of alternate pest management techniques like cultural, mechanical and biological prior to judicious use of chemical pesticides. Pesticide residues in agricultural produce has emerged as a major impediment for agricultural exports, especially of fresh fruits and vegetables.

Mango is one of the most important fruit crop of India. Sincere efforts have been made by DPPQS & ICAR to incorporate all the aspects in the IPM Package of Practices for Mango that will help in production of pest and pesticide residue free Mangoes. I hope that IPM Package of Practices for Mango (for producing quality fruits for export) will be a handy document for Central and State government field functionaries involved in extension, and for the farmers for production of residue free quality Mango fruits for domestic and export markets.

(Dr. Pramod Kumar Meherda)

सत्यमेव जयते
डॉ. जे.पी. सिंह
Dr. J.P. SINGH
वनस्पति संरक्षण सलाहकार
Plant Protection Adviser

भारत सरकार
कृषि एवं किसान कल्याण मंत्रालय
(कृषि एवं किसान कल्याण विभाग)
वनस्पति संरक्षण, संगरोध एवं संग्रह निदेशालय
एन.एच. IV, फरीदाबाद (हरियाणा) – 121001
Government of India
Ministry of Agriculture & Farmers Welfare
(Department of Agriculture & Farmers Welfare)
Directorate of Plant Protection, Quarantine & Storage
N.H. IV, Faridabad (Haryana) - 121001
Tel. : 0129-2413985, 0129-2412125 (Fax), 011-23385026
Email : ppa@nic.in

FOREWORD

IPM is a science-based, decision-making process that combines biological, cultural, physical and judicious use of chemical to minimize crop loss due to pest in a way that to reduce overall economic loss with due consideration to health and environment.

During late 1990s, FAO started advocating Agro-Ecosystem Analysis (AESA) based IPM practices. Experiences in different countries have shown that AESA, which takes into account ecological principles and relies on the balance approach that is maintained by biotic factors in an agro ecosystem has also resulted in reduction in cost of production and increase in yield. AESA based IPM also takes into account active participation of farmers and promotes experiential learning and discovery based decision making by them. AESA based IPM in conjunction with ecological engineering for pest management promotes bio-intensive strategies against chemical intensive approaches, while retaining the option to apply chemical pesticides judiciously as a last resort.

I am glad to see that resource persons of ICAR & DPPQS have made sincere efforts in developing IPM Package of Practices for Mangoes (For producing quality fruits for export) by incorporating agro-ecosystem analysis, ecological engineering, pesticide application techniques, other IPM options and post-harvest management for the pesticide residues free Mangoes and hope this will certainly support the export of Mangoes after following appropriate plant protection measures including Good Agricultural Practices (GAP).

I covey my sincere thanks to Dr. S.C. Dubey, ADG(PP & BS), ICAR, New Delhi for providing review from crop specific ICAR institute - Central Institute of Sub Tropical Horticulture, Lucknow.

I hope this IPM packages on Mangoes will serve as a ready reference for field functionaries of Central / State Governments, NGOs and farmers for producing good quality, pest and pesticide residue free Mango fruits.

Dr. J. P. Singh
Plant Protection Adviser

संयुक्त निदेशक (आई पी एम अनुभाग)
भारत सरकार
कृषि एवम किसान कल्याण मंत्रालय
कृषि एवम किसान कल्याण विभाग
वनस्पति संरक्षण, संगरोध एवम संग्रह
निदेशालय, फरीदाबाद

सत्यमेव जयते

Joint Director (IPM Division)
Government of India
Ministry of Agriculture & Farmers Welfare
Department of Agriculture & Farmers Welfare
Directorate of Plant Protection Quarantine &
Storage, Faridabad

PREFACE

Phytosanitary and sanitary compliance are major aspects for export of any fresh fruits. Indiscriminate use of chemical pesticides for management of pests/ diseases results in pesticides residue in fruits and fails meeting sanitary requirement of various importing countries. In recent time, most of the countries incorporating Maximum Residue Level (MRL) as major sanitary requirement for import of Agricultural commodities especially for fresh fruits & vegetables. So there is challenge to produce pest as well as pesticide free fruits for export. Adoption of Agro-ecosystem Analysis (AESA) based Integrated Pest Management (IPM) can promise production of pests as well as pesticide residue free fruits and comply with Phytosanitary and Sanitary requirements of most of the Mango importing countries. In addition, AESA based IPM also conserves bio-diversity in agro-ecosystem, reduce environmental pollution and reduce cost of cultivation and thereby increase farmers' income.

I convey my sincere thanks to Joint Secretary (Plant Protection) & Plant Protection Adviser for encouragement and facilities for compilation of this PoP and also to ADG (PP), ICAR, New Delhi for review from crop specific ICAR institute - Central Institute of Sub Tropical Horticulture, Lucknow.

This IPM Package of Practices for Mango (For producing quality fruits for export) will prove an important guide for extension functionaries of Central / State Governments, NGOs and farmers for producing exportable Mango fruits.

Om Prakash Verma
Joint Director (IPM)

CONTENTS

1. INTRODUCTION

The Mango (*Mangifera indica* L.; Family: Anacardiaceae) is a perennial woody plant native to south and southeast Asia, from where it has spread to the different part of the world and become one of the most cultivated fruits in the tropics. It is being cultivated in southern Asia for nearly six thousand years. In India it is grown for more than 400 years. Mango Cultivation is the leading fruit crop of India and considered to be the king of fruits. Mango fruit is utilized at all stages of its development both in its immature and mature stage. Raw fruits are used for making chutney, pickles and juices. The ripe fruits besides being used for desert are also utilized for preparing several products like squashes, syrups, nectars, jams and jellies.

India occupies first place in mango production of the world and accounts for almost half of the global production and area. Mango occupies 22 per cent of the total area under fruits cultivation comprising of 1.2 million hectares, with a total production of 11 million tonnes. Uttar Pradesh ranks first in Mango production & productivity with share of 23.47% followed by Andhra Pradesh, Karnataka, Telangana, Bihar, Gujarat, Tamil Nadu, West Bengal, Maharashtra and Madhya Pradesh.

2. CLIMATE

Mango is grown under both tropical and sub-tropical climate from sea level to 1400 m altitude. Places with good rainfall and dry summer are ideal for mango cultivation. It thrives well under humid and dry conditions. High humidity and cloudy weather at the time of flowering are not favourable as it affects pollination and fruit set and encourage diseases. Ideal temperature for mango cultivation is between 24 to 27$^{o^{\circ}}$C and higher temperature during fruit development and maturity gives better quality fruits.

3. CULTIVARS AND VARIETIES

In India, about 1,500 varieties of mango are grown. However, only a few varieties are commercially cultivated.

The Important Mango Varieties Cultivated in Different States of India

State	Varieties grown
Andhra Pradesh	AllumpurBaneshan, Banganapalli, Bangalora, Cherukurasam, Himayuddin, Suvernarekha, Neelum, Totapuri
Bihar	Bathua, Bombai, Himsagar, KishenBhog, Sukul, GulabKhas, Zardalu, Langra, Chausa, Dashehari, Fazli
Goa	Fernandin, Mankurad

Gujarat	Alphonso, Kesar, Rajapuri, Vanraj, Jamadar, Totapuri, Neelum, Dashehari, Langra
Haryana	Dashehari, Langra, Sarauli, Chausa, Fazli
Himachal Pradesh	Chausa, Dashehari, Langra
Jharkhand	Jardalu, Amrapali, Mallika, Bombai, Langra, Himsagar, Chausa, Gulabkhas
Karnataka	Alphonso, Bangalora, Mulgoa, Neelum, Pairi, Baganapalli, Totapuri
Kerala	Mundappa, Olour, Pairi
Madhya Pradesh	Alphonso, Bombay Green, Langra, Sunderja, Dashehari, Fazli, Neelum, Amrapali, Mallika
Maharashtra	Alphonso, Mankurad, Mulgoa, Pairi, Rajapuri, Kesar, Gulabi, Vanraj
Orissa	Baneshan, Langra, Neelum, Suvarnarekha, Amrapalli, Mallika
Punjab	Dashehari, Langra, Chausa, Malda
Rajasthan	Bombay Green, Chausa, Dashehari, Langra
Tamil Nadu	Banganapalli, Bangalora, Neelum, Rumani, Mulgoa, Alphonso, Totapuri
Uttar Pradesh	Bombay Green, Dashehari, Langra, Amrapalli, Safeda, Chausa, Fazli
West Bengal	Bombai, Himsagar, KishenBhog, Langra, Fazli, Gulabkhas, Amrapali, Mallika

Export Potential Varieties in India

Alphanso (Hapus), Totapuri , Kesar, Badami , Rajapuri, Banganapalli, Safeda, Dashehari, Chausa, Langra

4. PROPAGATION AND PLANTING

4.1 Propagation:

Mango is propagated by following methods: -

A. Veneer and Side Grafting: These can be utilized for preparing a grafted plant material or for *in-situ* grafting, i.e. for the rootstocks which are already planted.

Inarching Veneer and Side Grafting

B. Epicotyl /Stone Grafting: This method is widely practiced in the Konkan region of Maharashtra. The germinated seedlings of 8-15 days old are used for grafting.

4.2 Planting:

Different systems of planting like square, rectangular and hexagonal are followed at different places. Planting is usually done in the month of July-August in rainfed areas and during February-March in irrigated areas. The main field is brought to fine tilth. Pits of 1m x 1mx 1m size are dug. These are exposed to sun for about 30 days. Before planting, pits are filled with well-rotten farmyard manure. The top and sub-soil are taken out separately while digging the pits. The grafts should be planted during rainy season.

4.3 Planting method:

The following planting methods are widely used in India.

A. Square Method of Planting: A regular spacing of 10m x 10m in dry zone and 12 m x 12 m in moist zones respectively is recommended in square system of planting.

Square method of planting in mango

B. High Density Planting: A spacing of 5m x 5m or 2.5m x 2.5m is recommended in dwarf verities like Sindhu & Amrapali *etc*.

High Density Planting in Mango

5. CROP MANAGEMENT

5.1 Manures and Fertilizers:

Fertilizers may be applied in two split doses, one half immediately after the harvesting of fruits in June/July and the other half in October, in both young and old orchards followed

by irrigation if there are no rains. Foliar application of 3 per cent urea in sandy soils is recommended before flowering.

The following table gives the details of fertilizer application;

Manures and fertilizers (kg/tree)	1 Year old	Annual increase	6th year onwards
FYM	10.00	10.00	50
N	0.20	0.20	1.0
P	0.20	0.20	1.0
K	0.30	0.30	1.5

5.2 Irrigation:

Frequent irrigation during 2-3 months prior to the flowering season is not advisable Irrigation should be given at 50 per cent field capacity. Generally inter-crops are grown during the early years of plantation and hence frequency and method of irrigation has to be adjusted accordingly. The method usually followed for irrigating mango plants is basin irrigation. However, use of Drip Irrigation will not only reduce the water requirements but it will also help in fertigation in root zones of the plants.

5.3 Growth regulators:

Spray NAA @ 20 ppm at flowering to increase the fruit retention. During February, 0.5 per cent urea (5 g/lit) or 1 per cent KNO_3 (10g in /lit) may be sprayed to induce flowering, if the trees do not flower by that time. Spray 2 per cent KNO_3 at mustard size to increase fruit set and retention of fruits.

Apply Paclobutrazol @ 10 g *a.i.*/full bearing tree during first fortnight of September to get maximum number of fruits and yield during off years.

5.4 Weed Management

Management of weed in mango orchard can be done manually, mechanically and by use of organic or inorganic mulches. In established orchard weed management in interspaces can effectively be done by ploughing the orchard 2-3 times in a year. Polyethylene film (black UV stabilized 100µ thick) is effective for the weed control in nursery and basin of trees in addition to improving the soil health and moisture conservation.

6. AGRO-ECOSYSTEM ANALYSIS (AESA) BASED DECISION MAKING FOR PEST MANAGEMENT

Decision making in pest management requires a thorough analysis of the agro-ecosystem. Farmer has to learn how to observe the crop, how to analyze the field situation and how to make proper decisions for their crop management. This process is called the AESA.

AESA is an approach, which can be gainfully employed by extension functionaries and farmers to analyze the field situations with regards to pests, defenders, soil conditions, plant health and the influence of climatic factors and their relationship for growing a healthy crop. The basic components of AESA are

- Plant health at different stages
- Built-in compensation abilities of plants
- Pest and defender population dynamics
- Soil conditions
- Climatic factors
- Farmers past experience

6.1 Principles of AESA based IPM:

6.1.1 Grow a Healthy Crop

- Select healthy seeds/seedlings/ planting material.
- Treat the seed/seedlings/planting material with recommended pesticides especially bio-pesticides.
- Follow proper spacing.
- Improve the soil health by mulching and green manuring, whenever applicable.
- Nutrient management especially with organic manures and bio-fertilizers based on the soil test results. If the dosage of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dosage is too low, the crop growth is retarded. Apply an adequate amount for nutrients for best results. The phosphatic fertilizers should not be applied each and every season as the residual phosphate of the previous season will be available for the current season also.
- Proper irrigation
- Crop rotation

6.1.2 Observe the Field Regularly (Climatic Factors, Soil and Biotic Factors)

Monitor the field situation at least once a week (soil, water, plants, pests, natural enemies, weather factors, etc.). Make decisions based on the field situation and Pest: Defender (P:D) Ratio. Take immediate action when needed (e.g. collection and destruction of egg masses, infested/infected parts/plants, etc.

6.1.3 Plant Compensation Ability

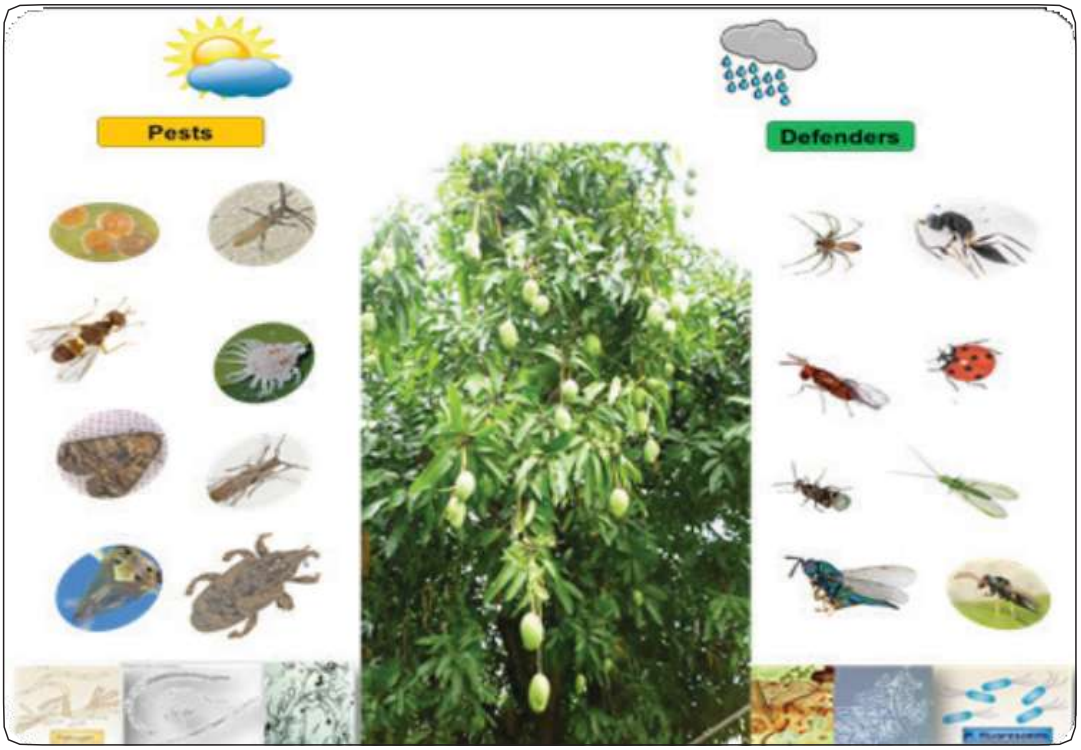
Compensation is defined as the replacement of plant biomass lost to herbivores and has been associated with increased photosynthetic rates and mobilization of stored resources from source organs to sinks (e.g., from roots and remaining leaves to new leaves) during active vegetative growth period. Plant tolerance to herbivore can arise from the interaction of a variety of plant traits and external environmental factors. Several studies have documented such compensation through increased growth and photosynthetic rate.

6.1.4 Understand and Conserve Defenders

- Know defenders/natural enemies to understand their role through regular observations of the agro-ecosystem.
- Avoid the use of chemical pesticides especially with broad-spectrum activity.

6.1.5 Pest: Defender (P: D) Ratio:

Identifying the number of pests and beneficial insects helps the farmers to make appropriate pest management decisions. Sweep net, visual counts, etc. can be adopted to arrive at the number of pests and defenders. The P: D ratio can vary depending on the feeding potential of natural enemy as well as the type of pest. The natural enemies can be divided into three categories like 1. Parasitoids; 2. Predators; and 3. Pathogens. The important natural enemies in mango are given in ecological engineering table.



6.1.6 Decision Taken based on the Analysis of Field Situations:

Soil conditions :
Weather conditions :
Diseases types and severity :
Weeds types and intensity :
Rodent damage (if any) :
No. of insect pests :
No. of natural enemies :
P: D ratio :

The general rule to be adopted for management decisions relying on the P: D ratio is 2:1.However, some of the parasitoids and predators will be able to control more than one pest. Wherever specific P:D ratios are not found, it is safer to adopt the 2:1, as P: D ratio. Whenever the P: D ratio is found to be favourable, there is no need for adoption of other management strategies. In cases where the P: D ratio is found to be unfavourable, the farmers can be advised to resort to inundative release of parasitoids/predators depending upon the type of pest. In addition to inundative release of parasitoids and predators, the usage of bio pesticides and botanicals, etc. can be relied upon before resorting to synthetic chemical pesticides.

6.2 Field Scouting:

Surveillance on pest occurrence at the main field should commence soon after crop establishment after transplanting and at weekly intervals thereafter. In each of the fields, select five spots randomly. Select five random plants at each spot for recording counts of insects as per procedure finalized for individual insects.

6.2.1. For Insect Pests:

i. Mealy bug: Count the number of mealy bug infested shoots per five tender shoots from each of the four directions on randomly selected five plants. Observe for mealy bug eggs in soil around the tree.

ii. Leaf Webber: Count the number of webs formed in each direction, on randomly selected five plants.

iii. Scale insects: Count the number of scale infested shoots per five tender shoots from each of the four directions on randomly selected five plants.

iv. Defoliator/ borers: Count the number of young and grown up larvae on each plant and record.

v. **Mango Hopper**: Count the number of mango hopper infested shoots per five tender shoots from each of the four directions on randomly selected five plants.

vi. Fruit fly: Observe fallen fruits for fruit fly infestation, install methyl eugenol trap & observe regularly.

6.2.2 For Diseases:

i. Leaf sampling: Examine 20 leaves from each plant of five randomly selected.

ii. Stem, flower and fruit sampling: Carefully examine the stems, inflorescence and fruits of five randomly selected plants for signs of fungal or bacterial diseases or lesions.

6.3 Monitoring Through Pheromone Trap:

Install Methyl Eugenol pheromone traps for fruit fly @ 4-5/acre. Fix the traps to the supporting pole at mid canopy height. Change lures at 2-3 week interval. Observe & record fruit fly catches at weekly intervals.

6.4 Yellow/Blue Sticky Traps:

Set up yellow sticky traps 1 foot above the canopy for monitoring mango hopper and blue stick trap for monitoring thrips @ 4-5traps/acre. Locally available empty tins/ pots can be painted yellow/ blue and coated with grease/ Vaseline/castor oil on outer surface may also

be used as yellow/blue sticky trap. Count the number of mango hopper/ thrips on the traps daily.

6.5 Light Traps:

Set up light traps 1 trap/acre 1 foot above the crop canopy for monitoring and mass trapping insects. Light traps with exit option for natural enemies should be installed and operate around from dusk time for 3 hours.

7. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

Ecological engineering for pest management has recently emerged as a paradigm for considering pest management approaches that rely on the use of cultural techniques to effect habitat manipulation and to enhance biological control. The cultural practices are informed by ecological knowledge rather than on high technology approaches such as synthetic pesticides and genetically engineered crops.

7.1 Natural Enemies May Require

1. Food in the form of pollen and nectar for adult natural enemies.
2. Shelters such as overwintering sites, moderate microclimate, etc are needed.
3. Natural enemies may also require alternate host when primary host are not present.

Ecological Engineering Plants (Attractant plants)

Cow Pea

Carrot

Sunflower

Buck Wheat

Alfa Alfa

Mustard

Cosmos

Marigold

Dill

Ecological Engineering Plants (Repellants plants)

Ocium

Peppermint Spear Mint

Border Plants

Sorghum

Maize

Pearl Millet

Inter Crops

French Bean

Black gram

Green gram

The flowering plants suggested under Ecological Engineering for pest management strategy are known as attractant plants to the natural enemies of the selected pests. The information is based on published research literature; however, the actual selection of flowering plants should be based on availability, agro-climatic conditions and soil types.

8. INTEGRATED PEST MANAGEMENT ON MANGO

8.1. Mango Hopper: *Idioscopus clypealis* (Lethierry); *I. nitidulus* (Walker) *I. niveosparsus* (Leth) and *Amritodus atkinsoni* (Lethierry); (Hemiptera: Cicadellidae)

Life Cycle:

Egg: Each female can lay upto 200 eggs. Eggs are laid singly into the tissues of young leaves, shoots, flower stalks and unopened flower buds. Egg period is 4-7 days.

Nymph: The nymphs are greenish with black or brown markings, cannot fly and move rapidly on the plant. Nymphal period is 8-13 days.

Adult:

A. atkinsoni	***I. clypealis***	***I. niveosparsus***
Bigger in size (4.2 to 5 mm long), dark grey in colour having two spots on abdomen and scutellum 	Smallest (3.5 mm) with two spots on the scutellum, dark spots on the vertex and light brown in colour 	Slightly smaller (4 to 4.8 mm long) with three spots on the scutellum and a prominent band across its light brown wings 

Nature of Damage and Symptoms:

Adults and Nymphs suck sap from tender shoots &flowers, causing drying of flowers and subsequent dropping. It secretes honey dew that develops sooty mould causing less photosynthesis. Heavy puncturing and continuous draining of the sap cause curling and drying of the infested tissue. Hopper complete 3-4 generations in a growing season, population build up in February-April and June-August. Hoppers shelter in the cracks and crevices of the bark or underside the leaves of the trees during the off season.

Infestation of Mango Hopper on leaf

Damage symptoms of Mango Hopper

Management:

- Pruning of orchards during December, orchard sanitation and rouging.
- Removal of weeds & alternate host plants like hibiscus, custard Mango, guava etc.
- Avoid dense plantings, maintain open canopy; prune overcrowded overlapping branches after rainy season.
- Avoid excess use of nitrogenous fertilizers.
- Smoking of orchards by burning of crop residues/cow dung cake during evening hours.
- Conservation of bio control agents like predator, *Mallada boninensis*, *Chrysoperla ciperda*, egg parasitoid, *Polynema spp. Gonatocerus spp. Tetrastichus spp*. and fungus, *Verticillium lecanii.*
- Application of bio-agents, *Metarhizium anisopliae* @ 1x 10^8 cfu/ml or *Beauveria bassiana* @ 10^8 cfu /ml on tree trunk once during off season and twice at 7 days interval during flowering season.
- Spraying of 0.2% Nimbicidin or Azadirachtin 3000 ppm @ 2.0 m/l at initial stage of hopper population.
- Apply need based CIB&RC approved chemical pesticide;

8.2. Mango Mealy Bug: *Drosicha mangiferae* (Green) (Hemiptera: Pseudococcidae)

Life Cycle:

Egg: Each female can lay up to 150 eggs. Females lay oval shining pink eggs directly on the host in a fluted ovisac that is attached to the body of the adult female or in the soil. Egg hatching starts at the end of December and continues up to month.

Nymph: The First instars nymphs are also called as crawlers, which are mobile, climb and ascend the trees immediately start sucking the sap and form the colonies. In general they have three female nymphal instars and five male nymphal instars.

Adults: Females are hermaphrodites that frequently inseminate themselves. Adult longevity for male and female is 7 and 15-35 days respectively. Female lays eggs for 22-47 days during April-May. Adults are oval, flat, body covered with white mealy powder. Adult males have one pair of black wings and are crimson red and mate with females. The female adult mealy bug crawls down the tree in the month of April-May and enter in the cracks in the soil for laying eggs.

Nature of Damage and Symptoms:

Nymphs and adults suck plant sap and it secretes honey dew that develops sooty mould.

Shoot infested

Fruit infected

Management:

- Remove weeds like *Clerodendrum infortunatum* and grasses during June-July.
- Destruction of infested fallen leaves in July –August
- Flooding of orchard with water in the month of October to kill eggs
- Plough orchards during summer to expose eggs to natural enemies and heat.
- Band the trees with 20 cm wide alkathene of polythene (400 gauge) in the middle of December (50 cm above the ground level and just below the junction of branching). or Tie stem with jute thread and apply a little mud of fruit tree grease on the lower edge of the band.
- Release Australian ladybird beetle, *Cryptolaemus montrouzieri* @ 10/tree
- Spray need based label claim insecticides viz., Dimethoate 30 % EC, Malathion 50% EC.

8.3. Bark Eating Caterpillar: *Indarbela quadrinotata* (Walker) (Lepidoptera: Metarbelidae)

Life Cycle:

Eggs: Each female lay15-25 eggs in clusters under loose bark of the trees Eggs are reddish in colour & oval in shape Hatch in 8-10 days.

Larva: Larvae are pinkish white with brown spot. Larval period is 9-11 months and then

Pupa: Pupae are brown in Pupal stage is 3-4 months. Pupates inside the stem

Adults: Male is reddish brown in colour &forewing with numerous dark bands. Female is yellowish orange in color with markings as in the male.

Nature of Damage and Symptoms:

Caterpillars bore into the trunk or junction of branches make zig zag galleries. Presence of gallery made out of silk and frass is the key symptom. They remain hidden in the

tunnel during day time, come out at night and feed on the bark. Due to infestation, flow of sap is hindered, plant growth arrested and fruit formation is drastically reduced. Heavy infestations retard the growth of tree and affect the fruits yield.


Male


Female


Larvae

Management:

- Kill caterpillars by inserting an iron spike into the tunnels.
- Injecting Ethylene glycol and kerosene oil in the ratio of 1:3 into the tunnel by means of a syringe and then seal the opening of the tunnel with mud.
- Dip a small piece of cotton in any of the fumigants, like petrol or kerosene, introduce into the tunnel and seal the opening with clay or mud.
- Avoid growing plant varieties susceptible to bark eating caterpillars.
- Collect and burn affected branches.
- Use a light trap to attract adult moths.
- Control when eggs are hatching and caterpillars are small

8.4. Mango fruit fly: *Bactrocera dorsalis* (Hendel), (Diptera: Tephritidae).

Life Cycle:

Egg: A female flies can lay upto 3000 eggs& under the skin of fruit in clusters of 10 to 50 below the fruit surface. The eggs are white, elongate and elliptical. They hatch in 1-2 days.

Maggot: Maggot is white in colour, legless and resembles an elongated cone. Maggot stage last for 11-15 days.

Pupa: Pupate in the soil. The puparium is yellowish-brown and seed-like. Pupal period is about10 days.

Adult: Prothorax has two lateral vitae. Faces have two black spot in *B. dorsalis* & *B zonata* & black transverse line in *B. correcta*. *B. dorsalis* & *B. correcta* is dark in colour while *B. zonata* is orange in colour.


Eggs


Maggot


Pupa


Adult

Nature of Damage and Symptoms:

The female punctures fruits with its pointed ovipositor and insert eggs inside. Infested fruits exhibit puncture marks & oozing. After hatching, maggot feeds on the pulp of fruit which result in dropping & rottening of fruit.

Management:

- 30-40 days prior to harvest collect and dispose infested and fallen fruits ploughing of orchard to expose pupae to sun's heat.
- bait splash on the trunk only, once or twice at weekly interval-to prepare bait splash, mix 100 gm of jaggery in one liter of water and add 1- 2 ml of Deltamethrin by using an old broom.
- Male annihilation technique: Set up fly trap using methyl eugenol (methyl eugenol 1 ml/l of water + 1 ml of malathion) Take 10 ml of this mixture per trap and keep them at 25 different places in one ha between 6 and 8 am. Collect and destroy the trapped adult flies.
- Use bait sprays at 2 weeks interval before ripening of fruits - protein hydrolysate or molasses or Jaggery @ 10 gm per liter of water with Malathion 50EC 2 ml/l or Dimethoate 30 EC 1 ml/l

Different types of Mango Fruit Fly Traps

8.5. Inflorescence Midge: *Erosomyia mangiferae* (Grover), (Dipter: Cecidomyiidae)

Life Cycle:

Egg: A female can lay 150 eggs singly on vegetative buds, inflorescence buds, the inflorescence axis or in open flowers. The eggs hatch within 2-3 days.

Maggot: The minute maggots penetrate the tender parts where the eggs have been laid and start feeding on them. The mature larvae drop down in to the soil for pupation. The larval period varies from 7-10 days, while pupal period varies from 5-7 days.

Pupa: Pupae are yellowish-brown and 1-2 mm long, with male pupae generally smaller than female.

Adult: Adults are small midges with a wing length of 1.0-1.5mm.Female has protractible ovipositor.

Nature of Damage and Symptoms:

It attacks floral buds, tender fruits & tender leaves. The Infested mango buds, shoots and young fruits develop many small blister galls, about 3-4 mm long, each containing a yellow maggot. In severe attacks the affected plant parts shrivel and die also small emergence holes may be detected on galls.

Management:

- Ploughing of the orchard to expose pupating larvae to sun.

8. 6. Mango stem borer: *Batocera rufomaculata* (Coleoptera: Cerambycidae)

Life Cycle:

Eggs: A female can lay 250 Eggs singly on the bark or cracks and crevices on the tree trunk or branches. Egg period lasts up to 1-2 weeks.

Grub: Yellow in colour, apodous. Larval period: 6 months

Pupation: Pupal Period lasts up to 19-36 days.

Adults: Beetle is greyish in colour with two pink dots and lateral spine on the thorax and long antennae reaching to end of the body, adult longevity is 6 months.

Nature of Damage and Symptoms:

Grubs start feeding below the bark of branches making tunnels, subsequently bore into the main stem. Frass coming out of the entry point indicates presence of trunk borer. Damage results in yellowing of leaves followed by drying of terminal shoots and branches, leading to the death of whole tree.

Larva

Adult

Infested tree

Management:

- Grow tolerant varieties viz., Neelam, Humayudin
- Remove and destroy dead and severely affected branches
- Avoid injury at the base of trunk while pruning
- Remove alternate hosts like moringa, silk cotton near vicinity of mango orchards.
- Keep the orchards clean & healthy
- Use green muscardine fungi, *Metarhizium anisopliae or Beauveria bassianna*
- Remove grubs from the infected trunk holes by using iron wire / hook.
- During off-season, apply absorbent cotton soaked in 10 ml Monocrotophos36 SL per tree by padding

- Use a needle or long wire to pull out grubs from bore holes. Bore holes may be filled with monocrotophos 36 WSC 10 to 20 ml or one celphos tablet (3 g aluminum phosphide) per hole and plug with clay + Copper oxychloride paste.
- Swab Coal tar + Kerosene @ 1:2 (basal portion of the trunk - 3 feet height) after scraping loose bark to prevent oviposition by adult beetles.

8.7. Mango Seed / Stone Weevil: *Sternochaetus mangiferae,* (Coleoptera: Curculionidae)

Life Cycle:

Egg: A female can lay upto 300 eggs singly in small cavities made by female in the skin of young fruits and under the rind of ripening fruits. Eggs are oval in shape, about 0.8 mm X 0.3 mm size and creamy-white in colour when freshly laid. ,

Grub: Grubs are white with a curved body, brown heads and leg less. Newly hatched larvae are about 1 mm long while mature larvae are about 17mm long. After hatching, the larva burrows through the flesh of the fruit and into the seed where they feed until pupation. Grub period is 22-70 days.

Pupa: Pupa is whitish when newly formed, but change to very pale red colour just before the adult emerges. Pupation takes place in the seed within the stone of the fruit. Pupal period is about 7 days.

Adults: Weevil with a compact body, dark brown with mottled markings on the wing, about 8 mm long, usually active at dusk and can fly. Female starts egg laying 3 to 4 days after mating. Adult longevity is about 60 days & diapause under loose bark on mango tree trunks, in branch crevices during non-fruiting season.




Grub **Adult** **Pupa**

Management:

- Collection and destruction of infested and fallen fruits at weekly interval till harvest.
- Clean junctions of Branches on the Trunk Prior to Flowering (October) to disturb the resting weevils.
- Ploughing of orchard after harvest to expose hibernating adults. Destroy all left over seeds in the orchard and also in the fruit processing industries.

8.8. Mango Leaf Webber: *Orthaga exvinacea* (Lepidoptera:Pyralidae)

Nature of Damage and Symptoms:

Larva is pale green with brown head and prothoracic shield. Adult is brownish moth with wavy lines on forewings.Initially caterpillars feed on leaf surface gregariously by scrapping.Later they make web on tender shoots and leaves together and feed within. Several caterpillars may be found in a single webbed up cluster of leaves.

Mango Leaf Webber

Management:

- Pruning of overcrowded and overlapping branches and mechanical removal of infested webs by leaf web removing device and burning them.
- Ploughing of orchard checks its population by destroying the hibernating pupae.

8.9. Mango Fruit Borer/ Red Banded Mango Caterpillar: *Deanolis albizonalis* (Lepidoptera: Pyralidae)

Life Cycle:

Egg: Eggs are round and cream in colour, laid in clusters of two to six eggs on fruit, and the fecundity ranges from 4 to 38 eggs.

Larvae: Mature larva has 11 bands along the back pink at first & then turns red. Laval period is about 16 days.

Pupa: Pupation takes place in soil or in/or under the bark protected with silk cocoon. Pupal period is about 14 days.

Adult: The brown adult moth is approximately 12 mm in size & has prominent snout

Nature of Damage and Symptoms:

After hatching larvae bore into fruits. Caterpillars bore into the fruit at the bottom (beak region) and feed inside reaching Kernels. Entrance hole is plugged with excreta. Affected fruits rot and fall prematurely.

Mango Fruit borer infested fruits

Management:

- Collection of fruits and dead wood after fruit harvest &destroy all fallen fruits.
- Spray of 5% NSKE/ Neem oil 3%

8.10. Mango Pulp Weevil: *Sternochetus frigidus* Fabr. (Coleoptera: Curculionidae)

Life Cycle:

Eggs: A female can lay upto 180 eggs**.** Eggs are about 0.6 x 0.3mm long, roughly oval and white to pale yellow in colour. Egg period is 4-65 days.

Larvae (Grub): The larval body is white to creamy-white, about 7.5-10.0 mm long, moderately curved.

Pupae: Up to 10mm in length, and vary from white to pale red in colour.

Adult: 6-9 mm long mottled brown colour with long snout mango pulp weevil has been reported to produce 1 generation per year, with the species completing the egg to adult life cycle in 35–53 days.

Nature of Damage and Symptoms:

Hatched larvae tunnel through the flesh forming a chamber next to the seed. From there each larva continues to tunnel through the mango flesh leaving brown granular faces behind.

Management:

- Collection and destruction of infested and fallen fruits at weekly interval till fruit harvest.
- Clean Junctions of Branches on the Trunk Prior to Flowering (October) to disturb the resting weevils.
- Ploughing of orchard after harvest to expose hibernating adults.
- Destroy all left over seeds in the orchard and fruit processing industries.

8.11. Mango Scale Insects: *Chloropulvinaria polygonata, Aspidiotus destructor,* (Hemiptera: Diaspididae)

The nymphs and adult scales suck sap of leaves and other tender parts and reduce the vigour of the plants. They also secrete honeydew, which helps in the development of sooty mould. In case of severe scale infestation, growth and fruit bearing capacity of the mango tree is affected adversely.

Scale insects

Scale infestation on leaves

Eggs, crawlers and male

8.12. Mango shoot gall psylla: *Apsylla cistellata* Buckton; (Homoptera: Psyllidae)

Shoot gall psylla is a monophagous pest of mango in northern India. Nymphs emerge during August-September and suck cell sap from adjacent buds. As a result of feeding, buds develop into hard conical green galls. The galls are usually seen during September-October. Consequently, there is no flowering and fruit setting. Nymphs over winter inside the galls.

Mango shoot gall psylla

Management:

- Practice of removal of eggs bearing leaves from a shoot during March last week.
- Pruning of shoots upto 30 cm which bears galls during September to check further spread of incidence.
- Galls with nymphs should be collected and destroyed.
- Two sprays of CIB&RC approved label claim pesticides in the month of August at 15 days interval.

8. 13. Mango Thrips: *Coliothrips indicus, Rhipiphorothris cruentatus, Scirtothrips dorsalis,* (Thysanoptera:Thripidae)

Nymphs and adults lacerate the tissues and suck the oozing cell sap. Thrips feeds on leaves, florescence, and young fruits. Leaf feeding species feed on mesophyll tissues near leaf tips. Affected leaves show silvery shine, leaf edges curl upward and bear small spots of fecal matter. Affected fruits show corky appearance.

Management:

- Spray of 5% NSKE/ other neem based formulations.
- Need based spay of CIB&RC approved label claim pesticides.

8. 14. Red tree ant: *Oecophylla smaragdina* (Hymenoptera: Formicidae)

The ants web and stitch together a few leaves, usually at the top of the branches and build their nests. The ants are carnivorous and prey upon small insects. However, indirect damage is caused by protecting insects like aphids and scales, which excrete honey dew.

Management:

- Nests should be removed and destroyed mechanically by web cutting device.

9. INTEGRATED DISEASE MANAGEMENT

9.1 Powdery Mildew: *Oidium mangifera*

Symptoms:

- It attacks the leaves, flowers, stalks of panicle and fruits, causing superficial white powdery appearance on it.
- The disease spread by wind very rapidly. Generally the infection starts from the inflorescence and spreads downwards covering the floral axis, tender leaves and soft stem.
- Flowers fail to open, blacken or become brown, dry and may fall from panicles.

Damage Symptoms on mango inflorescence Damage Symptoms on leaves

Disease Development:

Spread of the disease occurs when rains or mists accompanied by cooler nights during flowering especially when the weather is cool and dry. Minimum temperature of 13- 15^{o}C,

maximum temperature of 23-25°C with moderate relative humidity (64-72%) favours disease development. Pathogen survives in affected plant debris and under favourable conditions; air borne conidia is disseminated by wind.

Management:

- Prune branches to keep them short for easy orchard management, entry of sun light and air flow within the canopy
- Apply balance dose of fertilizers
- Resistant varieties like Neelum, Zardalu, Banglora, Torapari-khurd and Janardhan pasand should be grown.
- Need based spray of CIB&RC approved label claim fungicides

9.2. Anthracnose: *Colletotrichum gloeosporioides* (Glomerella cingulata)

Symptoms:

- On leaves, lesions start as small, angular, brown to black spots that can enlarge to form extensive dead areas.


Anthracnose

- The first symptoms on panicles are small black or dark-brown spots, which can enlarge coalesce and kill the flowers before fruits are produced. Petioles, twigs, and stems are also susceptible and develop into typical black colour.

- Twig dieback occurs when severe, elongated, blackened lesions form on stems and twigs die back apically.

- Ripe fruits affected by anthracnose develop sunken, prominent, dark brown to black decay spots, fruits may drop prematurely.

Disease Development:

Under favourable climatic conditions of high humidity, frequent rains and a temperature of 24 - 32° C coinciding with flowering favours anthracnose infections in the field. The pathogen survives between seasons on infected and defoliated branch terminals and mature leaves.

Management:

- Prune trees yearly and remove fallen plant debris.
- Wider plant spacing and intercropping with non-host plant inhibit severe epidemics.
- Need based spray of CIB&RC approved label claim fungicides

- **9. 3. Mango malformation: *Fusarium moliliforme* var. *subglutinans***

There are two types of malformation symptoms namely :

1) Vegetative Malformation 2) Floral Malformation.

Symptoms:

- **Vegetative Malformation:** It is more commonly found on young seedlings. It is characterized by disrupting of apical growth resulting in several small flushes.. The multi-branching of shoot apex with scaly leaves is known as “Bunchy Top” or “Witches’ Broom”. The malformed seedlings, remain stunted and die.
- **Floral Malformation:** In malformation of inflorescens, shows variation in the panicle. Malformed head dries up in black mass and persist for long time

Vegetative Malformation

Floral Malformation

Disease Development:

Disease spreads through propagating materials. The fungus does not sporulate *insitu* but sporulates on dried malformed panicles. The disease is severe at temperatures between 10-15 ^{o}C during December to January before flowering. Disease is mild in areas with 15-20 ^{o}C, sporadic between 20-25 ^{o}C .. Plants at 4- 8 years are susceptible. In some cases mites have been reported to be carrying the fungus and cause spread.

Management:

- Diseased plants should be destroyed
- Use of disease-free planting material
- Incidence reduced by spraying 100-200ppm NAA during October.
- Pruning of diseased parts along the basal 15-20 cm apparently healthy portions.

9. 4. Bacterial Canker: *Xanthomonas campestris* pv. *Mangiferae indicae*

Symptoms:

- The disease is noticed on leaves, leaf stalks, stems, twigs, branches and fruits, initially producing water-soaked lesions, later turning into typical canker.
- Water-soaked irregular satellites to angular raised lesions measuring 1-4 mm in diameter are formed. These lesions are light yellow in colour, initially with yellow halo but with age enlarge or coalesce to form irregular necrotic cankerous patches with dark brown colour.
- Water-soaked, dark brown to black-coloured lesions are observed which gradually developed into cankerous, raised or flat spots. These spots often, burst extruding gummy substances containing highly contagious bacterial cells.

Damage symptoms Bacterial Canker

Disease Development:

The bacteria enters through natural openings such as stomata, wax and oil glands, leaf and fruit abrasions, leaf scars, and at the apex of branches in the panicle. Periods of high humidity, surface wetness and wind accompanied with rain cause most rapid and maximum dissemination of bacteria. Survives in infected plant parts and spread through rain splashes and wind. Disease is rapid during rainy days.

Management:

- Sanitation and seedling certification are recommended as preventive measures.
- Mango stones for raising seedlings (root stock) should always be taken from healthy fruits.
- Use of wind-breaks helps in reducing brushing/ wounding

9. 5. Dieback: *Lasiodiplodia theobromae*

Symptoms:

- The pathogen causing dieback, tip dieback, graft union blight, twig blight, seedling rot, wood stain, stem-end rot, black root rot, fruit rot, dry rot, brown rot of panicle etc.
- The disease is most conspicuous during October-November.
- It is characterized by drying back of twigs from top to downwards, particularly in older trees followed by drying of leaves which gives an appearance of fire scorch.
- Internal browning in wood tissue is observed when it is slit open along with the long axis.
- Cracks appear on branches and gum exudes before they die out.

Disease Development

- Pathogens survive in plant debris which is the source of primary inoculum. High humidity and moist conditions favours the development of disease. The disease is most common in October -November.

Management:

- Scion wood selected for propagation should be free from infection
- Every care should be taken to prevent introduction of disease in newly planted orchards.
- Any infected portion should immediately be pruned, followed by spraying/ pasting of Copper oxychloride or pasting with cow dung at the cut ends.
- Pruning should be done in such a way that some healthy portion is also removed, to ensure complete eradication of pathogen (3" below the infection site).

9.6. Root Rot & Damping Off: *Rhizoctonia solani*

Symptoms:

- Sudden dropping of leaves after the emergence of seedlings
- During prolonged rainy and humid weather, infection occurs at / or below the ground level with circular to irregular water soaked patches. These patches enlarge and ultimately girdle the entire base of the seedlings.

Root rot **Damping off**

Disease Development

Disease is soil borne and pathogen survives in soils of orchards. Primary infection occurs by soil and secondary by conidia through rain or wind.

High humidity, high soil moisture, cloudiness and low temperatures below 24° C for few days are ideal for infection and development of disease.

9.7. Diplodia stem end rot: *Diplodia natalensis*

Symptoms:

- Epicarp darkens around the base - pedicel.Circular, black patch which under humid atmosphere.
- Soft rot aid of pectinolytic & cellulolytic enzymes.More portions of fruit turn black and soften. Lose ascorbic acid & non- reducing sugars rapidly

Diplodia stem end rot

Disease Development:

The fungus persists in infected plant parts which serve as source of inoculums RH - 80 %, with a temp range of 25.9 ^{0}C - 31.5^{0}C and.

9.8. Brown Spot: *Pestalotia mangiferae*

Symptoms:

On matured green fruits, small brown spots appear with greyish white centre which later turn to bigger lesions with large number of acervuli seen as black dots.

Brown spot on leaves Black spots on twigs Black spots on fruits

Disease Development:

Temp between 20 to 25^{0}C enhance mycelial growth with sporulation takes place at pH 5.5 to 6.0.Wounding leads to more disease incidence.

9.9. Phoma Blight: *Phoma glomerata*

Symptoms:

- Symptoms of the disease are noticeable only on old leaves
- Initially, the lesions are angular, minute, irregular, yellow to light brown, scattered over leaf lamina.

- As the lesions enlarge their colour changes from brown to cinnamon and they become almost irregular.
- Fully developed spots are characterized by dark margins and dull grey necrotic centres.
- In case of severe infection such spots coalesce forming patches measuring 3.5-13 cm in size, resulting in complete withering and defoliation of infected leaves.

Disease Development:

The pathogen is seed borne fungus and inoculum present in the seeds is source of primary infection. Fungus also survives on glumes, fruit and plant debris.

Rainy seasons favour the development of disease.

Management:

- Follow common cultural, mechanical and biological practices
- The affected branches should be collected and burnt.
- Balanced nutrition provides resistance to phoma blight.

9.10. Scab: *Elsinoe mangiferae*

Symptoms:

- The scab fungus attack leaves, panicles, blossoms, twigs, bark of stems and mango fruits.
- Spots are circular, slightly angular, elongated, 2-4 mm in diameter, brown. On young fruits, the infection is grey to grayish brown with dark irregular margins.
- As the fruit attains in size, spots also enlarge and the centre may become covered with the crack fissure and corky tissues.

Disease Development:

The pathogen survives in the form of resting spore in the soil debris. Suitable temperatures and moisture promote the release of *Elsinoe mangiferae* spores. This cycle of secondary infections continues throughout the summer, until the leaves and fruit fall from the tree at the onset of winter.

Scab Disease symptoms:

9.11. Red Rust: *Cephaleuros virescens*

Symptoms:

Red rust caused by algae causes reduction in photosynthetic activity and defoliation of leaves.

- The disease can easily be recognized by the rusty red spots mainly on leaves and sometimes on petioles and bark of young twigs and is epiphytic in nature.
- The spots are greenish grey in colour and velvety in texture. Later, they turn reddish brown. The circular and slightly elevated spots sometimes coalesce to form larger and irregular spots.

Disease Development:

Disease is common in closed plantations. High humidity favours development of fruiting bodies. The pathogens reproduce and survive in spots on leaves or stems and in fallen plant host debris. Frequent rains and warm weather are favorable conditions for these pathogens. For hosts, poor plant nutrition, poor soil drainage, and stagnant air are predisposing factors to infection by the algae.

9.12. Black soft rot: *Phomopsis mangiferae*

Symptoms:

- Discrete and discolored areas all over.
- Turn dark brown – black at maturity.

- Black fruit in bodies appear on the spots.

Disease Development:

Soil-borne conidia and transmitted by wind & rain water.

10. PHYSIOLOGICAL DISORDERS

10.1. Black Tip (Chimney Disease):

Symptoms:

- Symptoms become visible when the mango fruits attain marbel size.
- Small etiolated area develops near the distal end of the fruit which gradually spreads, turns nearly black and covers the tip of the fruit completely.
- The black area remains hard and the growth of the fruit is checked.

Black tip disease

Internal necrosis

Management:

It can be minimized by the spray of borax (1%). The first spray should be done positively at pea stage followed by two more sprays at 15 days interval. Planting of mango orchard in north-south direction and 5-6 km away from the brick kilns reduce the incidence.

10.2. Internal Necrosis (Boron Deficiency):

Symptoms:

First, water-soaked grayish spots develop on the lower side of the fruit. Later, spots enlarge and develop into dark brown necrotic area& internal tissue starts disintegrating and result in exposing flesh. Yellow coloured droplets also come out and fruits drop easily.

Management:

Foliar spay of borax (1%) at pea stage followed by two more sprays at 15 days interval. Application of 250 g boron per tree (10–15-year-old) around the tree basin.

10.3. Spongy tissue:

Spongy tissue in fruit develops non-edible sour patch in the mesocarp of mango . It is specific in Alphonso mango. Fruits from outside look normal, but inside a patch of flesh become spongy, yellowish and sour. These can be detected only on cutting fruit. Inactivation of ripening enzyme due to high temperature, convective heat and post-harvest exposure to sunlight are the causes.

Management:

Use of mulching are useful in reducing its incidence. Mango hybrids Ratna and Arka Puneet which have Alphonso like characters do not suffer from this disorder. Harvesting mangoes when they are three-fourths matured rather than fully matured also reduce incidence. The use of wind-breaks for protecting the orchard from warm air during May.

11. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The field should be kept exposed to sun light at least for 2-3 weeks	Do not irrigate the field after ploughing, at leastfor2-3weeks, to allow desiccation of bulbs and/or rhizome so perennial weeds.
2.	Grow only recommended varieties.	Do not grow susceptible varieties.
3.	Apply only recommended pesticides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
4.	Use fertilizers and micronutrient as per the soil test recommendation.	Avoid imbalanced use of fertilizers.

5.	Conduct weekly AESA in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P:D ratio only.	Do not take any management decision without considering AESA and P:D ratio
6.	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
7.	In case of pests which area active during night spray recommended biopesticides/chemicals pesticides at the time of their appearance in the evening.	Do not spray pesticides at mid-day since, most of the insects are not active during this period.
8.	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, and other sucking pests harboring the lower side of leaves.	Do not spray pesticides only on the upper surface of leaves.
9.	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.

12. Harvest &Post-Harvest Management

12.1 Harvest Care:

Harvesting of mangoes coincides with high temperature and high relative humidity posing a problem for further supply chain management. One of the most common mistake growers make is to harvest fruit crops early in the season to fetch the market price even though fruits are immature and do not develop characteristics quality, flavour and taste. If the crop is allowed to grow, fruits will not be uniformly ripe for good eating quality, further it develops jelly formation around the stone. If all the fruits are harvested at once there is every likelihood to have under-mature or over-mature. Mechanical damage during harvesting becomes a serious problem, as injuries predispose the fruits to decay, increased water loss and increased respiration and ethylene production leads to quick deterioration. Manual harvesters should be well trained in the proper way to harvest the fruits to minimise the damage and waste. Mangoes should be picked with care by snapping, cutting or pulling the fruit from the plant in least damaging manner. Exposure to sun should be avoided as much as possible during and after the harvest of fruits. To prevent from becoming warmer than air temperature and reduce the field heat, fruits are placed in the shade or loosely covered. Evening or early morning harvest is best option for harvesting mangoes, when internal temperatures are relatively low; reduce the energy needed for subsequent cooling.

12.2 Post-harvest Processing:

Harvested mangoes should be placed in field containers of not more than 25 Kg capacity for movement to packing sheds. The fruits are kept in shade with their stalks upwards before transporting to sheds.

12.3 Storage:

Shelf life of mangoes being short (2 to 3 weeks) they are cooled as soon as possible to storage temperature of 13^{o}C.

12.4 De-sapping:

This is the method to remove the sap present in the fruits. This sap if falls on fruit causes sap injury and deteriorates quality leading to fungal infections. De-sapping is completed in 2-3 hours.

12.5 Cleaning and Washing:

The fruits are washed manually with clean water to remove dust, dirt or other contaminations. These are then transferred to tank containing solution of liquid detergent like teapol, inditron (0.1%). This takes about 3-5 minutes.

12.6 Dipping in Sodium Hypo chloride:

During hot water treatment fruits are dipped in sodium hypo chlorite solution of 200 ppm for surface sterilization. Then the fruits are dried with fans for 1-2 hrs to remove the moisture from the fruit.

12.7 Grading and Sorting:

The fruits are graded as per the variety. It is ensured that the graded fruits should be of even size and are fully matured. Sorting and grading is done on sorting table as per codex Alimenterious guidelines, trained workers wearing gloves. Oversized and undersized fruits, damaged, immature and diseased fruits are rejected. After this mangoes are graded according to the weight. Trained workers under supervision of quality supervisors grade the fruits.

Variety	Countries				
	Middle East	Netherlands / Germany	U.K.	Japan	USA
Alphonso	Wt. 200-250 gm	Wt. 250-300 gm	Wt. 250-300 gm	Wt. 250-300 gm	Wt. 250-300 gm
Kesar	Wt. 200-250 gm	Wt. 225-250 gm	Wt. 225-250 gm	Wt. 250-300 gm	Wt. 250-300 gm
Packing	1 Doz/2.5 kg	1 Doz/2.5 kg	1 Doz/2.5 kg	1 Doz/3.5 kg	1 Doz/3.5 kg
Storage Temp	13 °C	13 °C	13 °C	13 °C	13 °C
Export	By Sea	By Air	By Air	By Air	By Air

12.8 Packaging and Labeling:

Graded fruits are packed in single layer in compressed fiberboard cartons of interlocking types. These boxes have water proof coating to prevent damage during cold storage. All the holes are covered with insect proof screen. All packaged boxes are then labeled according to specifications.

13. Export procedures

Fresh mangoes and mango pulp are the important items of Agri-exports from India. India's main export destinations for mangos are UAE, Kuwait and other Middle East countries, European Union countries USA, Japan, South Korea, Australia, New Zealand *etc*.. India's share in the world mango market is about 15 percent. Mango accounts for 40 percent of the total fruit exports from India.

Mango fruits are exported to various countries as per phytosanitary requirement of the importing countries. These phytosanitary requirements may include registration of orchards with State Agriculture/ Horticulture Departments, implementation of Good Agriculture Practices, grading, packing & storage. in pack house registered with DPPQS / APEDA, specific treatment, specific packaging, phytosanitary inspection & certification such as;

USA- Registration of orchard, processing & packing in DPPQS / APEDA registered packhouses, hot water treatment with sodium hypochloride, irradiation as per agreed Offical Workplan.

Japan, New Zealand- Registration of orchard, processing & packing in DPPQS / APEDA registered packhouses, Vapour Heat Treatment.

Australia- Registration of orchard, processing & packing in DPPQS / APEDA registered packhouses, Mango nut weevil free area+Vapour Heat Treatment, irradiation.

Eropean Union Countries, South Korea- Registration of orchard, processing & packing in DPPQS / APEDA registered packhouses, Hot Water Immersion Treatment.

Every consignments of fruits must be accompanied with Phytosanitary certificates (PSCs) issued by the notified PSC issuing authorities. Phytosanitary Regulations related to export is available in PQIS website http://plantquarantineindia.nic.in.

Annexure

CIB & RC APPROVED AND REGISTERED PESTICIDES FOR MANGO CROP

Crop	Crop Common Name of the pest	Dosage/ha			Waiting Period (days)
		a.i (gm)	a.i (gm) Formulation (gm/ml) Dilution in Water (Liter	Dilution in Water (Liter)	
Mango Pest					
Buprofezin 25.00% SC					
	Hoppers	0.025%-0.05%	1-2 ml/lit	5-15 liter per tree	20
Deltamethrin 02.80% EC					
	Hoppers	0.03-0.05%	0.33-0.5 ml/lit	As per spray field requirement	01
Dimethoate 30.00% EC					
	Mealy bug	0.05%	2475-3300	1500-2000	-
	Hopper	0.05%	2475-3300	1500-2000	-
Imidacloprid 17.80% SL					
	Hopper	0.40-0.80 g/tree	2.0-4.0 ml/tree	10 litre	45
Lambda-Cyhalothrin 05.00% EC					
	Hoppers	0.0025 - 0.005 %	0.5 - 1.0 ml/l of water	-	07
Malathion 50.00% EC					
	Mealy scale, Mango hoppers	0.075 %	2250 - 3000	1500- 2000 lt/tree	--
Monochrotophos- 36.00 % SL					
	Gall maker, Hopper, Mealy bug, Shoot borer	0.04 %	1500 - 2000	500-2000 lt/tree	20 days
	Bug mite	0.040%	1500-2000	500-2000	-
Oxydemeton-methyl 25.00% EC					
	Hoppers	0.025 %	1500 - 2000	1500- 2000	-
Thiamethoxam 25.00% WG					
	Hoppers	25.0 %	100	1000	30
Tolfenpyrad 15 % EC					
	Hoppers, Thrips	150.0	1000	500	7
Spirotetramat 11.01 % + Imidacloprid 11.01 % w/w SC					
	Mealy bug	0.018%	0.075%	Spray fluid as required depending upon size of tree.	15
Mango Disease					
Azoxystrobin 23% SC					
	Anthracnose,	0.025 %	0.1 %	100ml/ 100 Ltr.	5

	Powdery mildew				
Carbendazim 46.27% SC					
	Powdery mildew	0.046 % or 46 g/100 lit. water	0.1 % or100 ml/100 lit. Water	As required	15
Copper Oxychloride 50% WG					
	Anthracnose	0.12 % or 120 g/100 Ltr. water	0.24 % or 240 g/100 Ltr. water	depending up on PP equipment	10
Dinocap 48% EC					
	Powdery mildew	2.4gm	5gm	10	--
Hexaconazole 5% EC					
	Powdery mildew	0.005 % (5g/100 lit)	0.1 % (100ml/100 lt)	As required	30
Hexaconazole 5% SC					
	Powder ymildew	0.01 % (10 g/100 lt. water)	0.2 % or (200 ml/100 lt.water)	depending on size of tree and equipment	27
MeptyDinocap 35.7% EC					
	Powdery mildew	108-120	308.6-342.8	1000	7
Metrafenone 500 g/l SC					
	Powdery mildew	200	0.2ml/l	1000	35
Penconazole 10% EC					
	Powdery mildew	0.005 % or 5 gm/100 Ltr. water	50 ml/100 Ltr. water	10 Ltr. Water per tree	30
Sulphur40%SC					
	Powdery mildew	1.5 -2Kg	3.75-5.00 Kg	1000	--
Sulphur 55.16% SC					
	Powdery mildew	0.165 % or 165g/10Lt r. water	0.30 % or 300 ml/100Ltr. water	As required	10
Sulphur 80% WP					
	Powdery mildew	2.5kg	3.13 Kg	750-1000	
Sulphur80%WDG					
	Powdery mildew	1.5 - 2 kg	1.875 - 2.50 Kg	750-1000	
Tetraconazole 3.8% w/w EW					
	Powdery mildew	50	1250	1000	24
Carbendazim12%+ Mancozeb 63%WP					
	Powdery mildew & Anthracnose	0.11%	0.15 %	depending on crop canopy	7
Fluxapyroxad 250g/l + Pyraclostrobin 250g/l SC					
	Powdery mildew	75-100	150-200	1000	38
Tebuconazole 50% + Trifloxystrobin 25% WG					
	Powdery mildew & Anthracnose	0.056 % - 0.075 %	0.075 % - 0.1 % (75- 100g/100 lit water)	depending on size of tree	15