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IPM Package of Practices for Turmeric

(For producing quality turmeric 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 Turmeric (For producing quality turmeric for export) was compiled by the DPPQS technical team under the Chairmanship of **Dr. Ravi Prakash, Plant Protection Adviser, and guidance of Dr. Pramod Kumar Meherda, IAS, JS (PP). Dr. S.C. Dubey, ADG (PP), ICAR, New Delhi** provided review from crop specific ICAR institute - Indian Institute of Spices Research, Kozhikode, Kerala.

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आज़ादी का अमृत महोत्सव

FOREWORD

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

Integrated Pest Management (IPM) is a globally accepted strategy for promoting sustainable agriculture. IPM strategy has currently shifted to more ecologically sustainable Agro-Eco System Analysis (AESA) based decision making for selection of appropriate IPM techniques. The AESA based decision making considers relationship among various components of an agro-ecosystem with special focus on pest-defender dynamics, abilities of plant to compensate for the damages caused by the pests and the influence of abiotic factors on pest build up. IPM approach advocates utilization of alternate pest management techniques like cultural, mechanical and biological prior to use of chemical pesticides. Pesticide residue, apart from pest association in agriculture produce, has proved to be a major impediment in export of our agricultural commodities, especially of fresh fruits and vegetables.

Turmeric is one of the important agricultural commodities with high export potential. Sincere efforts have been made by resource personnel of DPPQS & ICAR to incorporate all the aspects that will help in production of pest and pesticide residue free Turmeric that not only help in facilitating export but also provide healthy commodities to Indian citizens. I hope that IPM Package of Practices for Turmeric (For producing quality turmeric for export) will be a handy document for Central and State government functionaries involved in extension, as well as for farmers, and will go a long way in production of residue free quality turmeric in the country.

18/07/2022

Dr. Pramod Kumar Meherda

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FOREWORD

IPM is a science-based, decision-making process that combines biological, cultural, physical and chemical tools to reduce damage from pests and pest management tactics in a way that minimizes overall economic, health and environmental risks.

During the late 90s FAO started advocating Agro-Ecosystem Analysis (AESA) based IPM. Experience in different countries have sine show that AESA, which takes into account ecological principles and relies on the balance that is maintained by biotic factors in an ecosystem has also resulted in reduction in cost of production and increase in yields. AESA based IPM also takes into account the need for active participation of farmers and promotes experiential learning and discovery based decision making by farmers. AESA based IPM in conjunction with ecological engineering for pest management promotes bio-intensive strategies as against current chemical intensive approaches, while retaining the option to apply chemical pesticides judiciously as a measure of last resort.

The resource persons of DPPQS have made sincere efforts in IPM Package of Practices for Turmeric (For producing quality turmeric for export) by incorporating agro-ecosystem analysis, ecological engineering, pesticide application techniques, other IPM options and post-harvest management for the pesticide residues free in turmeric and to export of turmeric with the crop based plant protection measures. I covey my sincere thanks to Dr. S.C. Dubey, ADG(PP), ICAR, New Delhi for providing review from crop specific ICAR institute - Indian Institute of Spices Research, Kozhikode, Kerala

I hope this IPM package will serve as a ready reference for extension functionaries of Central / State Governments, NGOs and farmers for producing exportable turmeric fruits.

Ravi Prakash

Dr. Ravi Prakash
Plant Protection Adviser

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PREFACE

India is the largest producer of turmeric in the world with the production of 1175.74 thousand tonnes and share 80% of total world production. However, India has negligible share on Turmeric fruit export. 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 Turmeric 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 - Indian Institute of Spices Research, Kozhikode, Kerala

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

Om Prakash Verma
Joint Director (IPM)

CONTENTS

1. INTRODUCTION

Turmeric (*Curcuma longa* L.) is a rhizomatous herb, and grows up to a height of three to five feet usually with 7 to 12 leaves, the leaf sheaths forms the pseudo stem which is cultivated extensively in Asia, India, China, and other countries with a tropical climate. It has been used for thousands of years as a remedy in the traditional Indian and folk medicine for the cure of a large variety of illnesses like inflammation, infectious diseases and gastric, hepatic and blood disorders. Turmeric is used to flavour and to colour foodstuffs. It is a principal ingredient in curry powder. The aqueous extract has bio-pesticidal properties. The tuberous rhizomes or underground stems of turmeric have been used from antiquity as condiments, a dye and as an aromatic stimulant in several medicines.



Turmeric is one of the important spices in India which produces nearly entire whole world's crop and consumes 80% of it. Turmeric occupies about 6% of the total area under spices and condiments in India.

In India, it is cultivated in the States of Andhra Pradesh, Telangana, Maharashtra, Orissa, Tamil Nadu, Karnataka and Kerala. Maximum area under turmeric cultivation and production is in Telangana state followed by Karnataka, Andhra Pradesh, Maharashtra and Tamil Nadu.

2. CLIMATIC AND SOIL REQUIREMENTS

Turmeric can be grown in diverse tropical conditions from sea level to 1500 m above sea level, at a temperature range of 20-35˚C with an annual rainfall of 1500 mm or more, under rainfed or irrigated conditions. Though it can be grown on different types of soils, it thrives best in well-drained sandy or clay loam soils with a pH range of 4.5-7.5 with good organic status. The crop cannot stand water logging or alkalinity.

3. CULTIVARS AND VARIETIES

There are about 30 turmeric varieties grown in India. Among them varieties like Alleppey and Madras (Perianadan) are of great commercial importance. Some of the improved varieties and locally popular cultivars are: CO-11983, BSR-11986, Krishna, Roma, Suroma, Ranga, Rasmi, Megha Turmeric-1, Suguna, Sudarshana, Suranjana, Duggirala, Kodur, Suvarna, Varna, IISR Prabha, IISR Pratibha, Rajendra Sonia,Tekkurpet, Sugandham, Amalapuram, Erode local, Salem, Moovattupuzha and Lakadong.

The Lakadong variety of turmeric of the Jaintia Hills district of Meghalaya is considered to be one of the world's best varieties of turmeric with its curcumin content of about 6.8 - 7.5 %. In the world, may be at some point of time this turmeric variety qualifies in the Geographic Indicator List of India.

Export Potential Varieties:

1. **Lakadong**	This variety is mainly cultivated at Meghalaya and it contains high percentage of curcumin which is essential for medicinal uses.
2.**Alleppey**	Highly coloured variety. It is grown in Kerala and marketed as Alleppey turmeric.
3.**Duggirala**	A long duration type (9 months), major variety of Andhra Pradesh. Rhizomes are bright yellow in colour. Grown mostly in Guntur district.

4. PROPAGATION AND PLANTING

Healthy and disease free rhizomes with whole or split mother and finger rhizomes are used for planting. Seed treatment with *P. fluorescens* 10 g/kg and *T. viride* as 4 g/ Kg. A seed rate of 2,500 kg of rhizomes is required for planting one hectare of turmeric.

Though transplanting in turmeric is not conventional, it is found profitable. A transplanting technique in turmeric by using single bud sprouts (about 5 g) has been standardized to produce good quality planting material with reduced cost. The technology has been standardized at Horticulture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. The technique involves raising transplants from single

sprout seed rhizomes in the pro-tray and planted in the field after 30-40 days. The advantages of this technology are production of healthy planting materials and reduction in seed rhizome quantity and eventually reduced cost on seeds.

- Select healthy and disease free turmeric rhizomes for seed purpose
- One month before planting, the seed rhizomes are cut into single buds with small piece of rhizomes weighing 5-7 g.
- Fill the pro-trays (98 well) with nursery medium containing partially decomposed coir pith and vermi compost (75:25), enriched with PGPR/Trichoderma 10g/kg of mixture
- Plant the turmeric bud sprouts in pro-trays
- Maintain the pro-trays under shade net house
- Adopt need based irrigation with rose can or by using suitable sprinklers
- Seedlings will be ready within 30-35 days for transplanting

The turmeric seeds are often kept beneath moist straw and left for sprouting before sowing. The planting time in India, is typically just after the pre-monsoon showers. This period varies from state to state. In Kerala and other West Coastal areas where the rainfall begins early, the crop can be planted during April-May with the receipt of pre-monsoon showers. Sowing in the month of May-June is suitable. Small pits are made with a hand hoe on the beds with a spacing of 25 cm x 30 cm. Pits are filled with well decomposed cattle manure or compost, seed rhizomes are placed over it then covered with soil. The optimum spacing in furrows and ridges is 45-60 cm between the rows and 25 cm between the plants.

5. NUTRIENT MANAGEMENT

Farmyard manure (FYM) or compost @ 30-40 t/ha is applied by broadcasting and ploughing at the time of preparation of land or as basal dressing by spreading over the beds or in to the pits at the time of planting. Organic manures like neem oil cakes @ 200 kg/ha with 25:60:108 kg of N.P.K per ha as basal dose; 30 kg of $FeSO_4$ and 15 kg of $ZnSO_4$, 10 kg in each of *Azospirillum* and Phospho-bacteria (PSB) per ha to be applied at the time of planting.

As the soil fertility will be varying with the soil type, agro ecological conditions or management systems, site specific nutrient management based on the soil test results for major nutrient is advocated. The recommended dose of nutrients for varying soil test values of N, P and K is 150:60:108 kg/ha and is applied throughout the cropping period once in 2 - 3

split doses.. For hill zone- N @ 90 kg, P_2O_5 50 kg and K_2O 60 kg/ha is recommended for North Eastern Region.

A basal dose of farmyard manures @ 5-6 tones /ha or 5 tonnes of Vermicompost may be incorporated at the time of land preparation. In addition application of 2 tonnes/ha is desirable. The crop is mulched immediately after planting with green leaves @ 10-12 tonnes /ha. It may be repeated for a second time with 5.0 tonnes/ha at 50^{th} days after planting for Meghalaya Region.

6. AGRO-ECOSYSTEM ANALYSIS (AESA) BASED INTEGRATED PEST MANAGEMENT

The IPM has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment ultimately affecting the interests of the farmers. The economic threshold level (ETL) was the basis for several decades but in modern IPM (FAO 2002) emphasis is given to AESA where farmers take decisions based on larger range of field observations. The health of a plant is determined by its environment which includes physical factors (i.e. soil, rain, sunshine hours, wind etc.) and biological factors (i.e. pests, diseases and weeds). All these factors can play a role in the balance which exists between herbivore insects and their natural enemies. Understanding the intricate interactions in an ecosystem can play a critical role in 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. Participants of AESA will have to make a drawing on a large piece of paper (60 x 80 cm), to include all their observations. The advantage of using a drawing is that it requires the participants/farmers to observe closely and intensively. It is a focal point for the analysis and for the discussions that follow, and the drawing can be kept as a record.

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 a variety resistant/tolerant to major pests
- Select healthy seeds/seedlings/ planting materials
- Treat the seeds/seedlings/planting materials with recommended pesticides especially bio-pesticides
- Follow proper spacing
- Soil health improvement (mulching and green manuring whenever applicable)
- Nutrient management especially organic manures and biofertilizers 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. So, the farmers should apply an adequate 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 situations at least once a week (soil, water, plants, pests, natural enemies, weather factors etc.)
- Make decisions based on the field situations and Pest: Defender ratio (P: D ratio)
- Take direct action when needed (e.g. collection and destruction of egg masses, infested /infected plant/plant parts)

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 insect 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 numbers 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 of turmeric insect pests can be divided into 3 categories; 1. parasitoids; 2. predators; and 3. pathogens.

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 biopesticides and botanicals etc. can be relied upon before resorting to synthetic chemical pesticides.

6.1.6 Decision Taken based on the Analysis of Field Situations

Soil conditions :

Weather conditions :

Diseases types and severity :

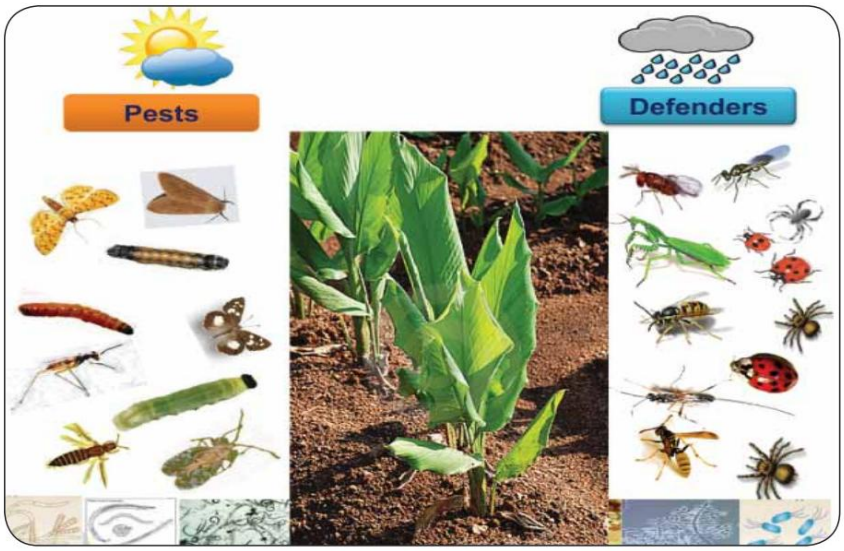
Weeds types and intensity :

Rodent damage (if any) :

No. of insect pests :

No. of natural enemies :

P: D ratio :



6.2 FIELD SCOUTING

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

For Insect Pests:

- **Shoot borer and leaf roller:** Count and record the number of both insects.
- **Rhizome fly:** Count and record the number of adults of rhizome fly present (tapping method also can be used to count flies).

For Diseases:

Whenever scouting, be aware that symptoms of plant disease problems may be caused by any biotic factors such as fungal, bacterial, viral pathogens or abiotic factors such as weather, fertilizers, nutrient deficiencies, pesticides and abiotic soil problems. In many cases, the cause of the symptom is not obvious. Close examination, and laboratory culture and analysis are required for proper diagnosis of the causal agent of disease. Generally fungal diseases cause the obvious symptoms with irregular growth, pattern & colour (except viruses), however abiotic problems cause regular, uniform symptoms. Pathogen presence (signs) on the symptoms can also be observed like fungal growth, bacterial ooze etc. Specific and characteristic symptoms of the important plant diseases are given in description of diseases section.

Root/ Rhizome sampling: Always check plants that appear unhealthy. If there are no obvious symptoms on plants, examine plants randomly and look for lesions or rots on roots and stems. Observe the signs of the causal organism (fungal growth). It is often necessary to wash the roots/rhizome with water to examine them properly. If the roots/rhizome are well developed, cut them to examine the roots for internal infections (discolouration & signs). Count the total number of roots/rhizome infested/infected due to rot should be counted and incidence should be recorded.

Leaf sampling: Examine all leaves and/or sheaths of each plant for lesions. Determine the percent area of leaf infection by counting the number of leaves (leaf area diameter)/ plant infected due to disease and incidence should be recorded.

Pseudo-Stem, flower and rhizome sampling: Carefully examine the pseudo-stem, flower, and rhizome of plants for symptoms and signs of fungal or bacterial diseases. The pseudo-stem, flower, and rhizome should be split or taken apart and examined for discoloration caused by fungi and bacteria. Count the number of root/rhizome/leaf infected due to disease and percent disease incidence should be recorded.

6.3 Blue Pan Water/Sticky Traps:

Set up blue pan water/sticky traps 15 cm above the canopy for monitoring for thrips @ 4-5 traps/acre. Locally available empty tins can be painted blue coated with grease/ Vaseline/ castor oil on outer surface may also be used.

6.4. Light Trap:

Set up light traps @ 1 trap/acre at the height of middle of crop canopy for monitoring and mass trapping of nocturnal insects. Light traps with exit option for natural enemies should be installed and operate during 6 pm to 10 pm.

6.5. Nematode Extraction:

Collect 100 to 300 cm3 (200-300 g) representative soil sample. Mix soil sample and pass through a coarse sieve to remove rocks, roots, etc. Take a 600 cc subsample of soil, pack lightly into a beaker uniformly. Place soil in one of the buckets or pans half filled with water. Mix soil and water by stirring with paddle; allow to stand until water almost stops swirling. Pour all but heavy sediment through 20-mesh sieve into second bucket; discard residue in first bucket; discard material caught on sieve. Stir material in second bucket; allow to stand

until water almost stops swirling. Pour all but heavy sediment through 200-mesh sieve into first bucket; discard residue in second bucket. Backwash material caught on 200-mesh sieve (which includes large nematodes) into 250-ml beaker. Stir material in first bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 325-mesh sieve into second bucket; discard residue in first bucket. Backwash material caught on 325-mesh sieve (which includes small to mid-sized nematodes and silty material) into 250-ml beaker. More than 90% of the live nematodes are recovered in the first 5-8 mm of water drawn from the rubber tubing and the sample is placed in a shallow dish for examination.

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. Ecological engineering for pest management is based on informed ecological knowledge rather than high technology approaches such as synthetic pesticides and genetically engineered crops (Gurr *et al*. 2004 a, b).

Natural Enemies May Require:

1. Food in the form of pollen and nectar.
2. Shelter, overwintering sites and moderate microclimate etc.
3. Natural enemies may also require alternate hosts when primary hosts are not present.

Plants Suitable for Ecological Engineering for Pest Management

Attractant plants


Cluster bean


Carrot


Sunflower


Buckwheat


French bean


Ryegrass


Mustard


Citrus


Anise


Caraway


Dill


Chrysanthemum spp.


Banana


Cowpea


Parsley

Cassava

Papaya

Cotton

Desmodium spp.

Sesbania spp.

Crotolaria spp.

Marigold

Gaillardia spp.

Barrier/Guard crops

Maize

Sorghum

Pearl millet

Intercrop

Tomato

Repellant plants

Spearmint

Ocimum spp.

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 could be based on availability, agro-climatic conditions and soil types.

8. Integrated Pest Management (For Major Pests)

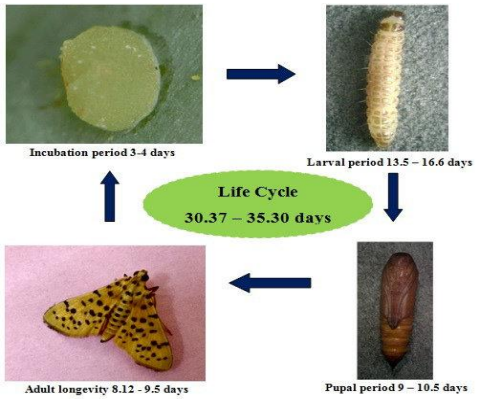
8.1 Turmeric Shoot Borer: *Conogethes punctiferalis* Guenée (Lepidoptera: Crambidae)

Life Cycle:

- **Egg**- Eggs are pink oval flat lay eggs singly or in groups of two or three on leaves and other soft parts of the plants. The incubation period is about 7 days.
- **Larvae**-The larvae are full fed in 14-21 days after passing through 4-5 instars. Throughout the larval period, it remains in concealment under a cover of silk and frass or excreta.
- **Pupa**- Pupation takes place inside the seed or sometimes in the frass that collects after feeding. The pupal period is about 7 days.
- **Adult**- it is medium sized month with a wings span of 20mm adult moths are orange yellow, with black markings on both the wings.The life cycle is completed in 30-37 days. There are three generations in a year.The full grown caterpillar is reddish brown with black blotches all over the body and a pale stripe on the lateral side. It measures 25-30 mm in length.

Turmeric shoot borer **Shoot borer larva**

Source: http://eagri.org/eagri50/ENTO331/lecture27/turmeric/001.html



Life Cycle

Nature of Damage and Symptoms:

- The larvae bore into pseudostem and feed on the growing shoot, resulting in yellowing and drying of shoots.
- The presence of holes in the pseudostem through which frass is extruded and withered are the characteristic symptoms.

Damage on turmeric stems

Source:https://onlinelibrary.wiley.com/doi/abs/10.1111/aab.12457

Management

- Plant ecological engineering plants to attractant, augment and conserve natural enemies.
- Destroy the infested shoots and destroy them to kill harbouring caterpillars
- Place light traps @ 1 /acre and operate between 6 and 10 pm to attract and trap the adult moths. Collect and kill the trapped moths.
- Mulching with green *Lantana camara* and *Vitex negundo* leaves @ 2 t/ acre at 40 and 90 days after planting.
- Use of light trap to keep the moth growth in check
- Release of *Trichogramma chilonis* @ 40,000/acre.
- Conserve and augment entomopathogenic nematodes (EPN) such as *Rhabditis* /*Oscheius turmerici*.
- Conserve natural enemies such as *Angitia* (Dioctes) *tronchanterata*; *Xanthopimpla australis, Theromia inareolata, Bracon hebetor, B. brevicornis, B. nosatoi, B. lasus, Phanerotoma hendecasisella, Myosoma*sp, Apanteles sp, *Brachymeria euloeae*, mermethid nematode, earwigs, robber flies and spiders, ladybird beetle, spiders, chrysopids, *Trichogrammatids* etc.
- Spray neem oil (0.5%) at fortnightly intervals.

8.2 Rhizome Scale: *Aspidiella hartii* Cockerell, (Hemiptera: Diaspididae)

Life Cycle:

- **Female**-female adults, scales are circular (about 1mm diameter) and light brown to gray and appear as encrustations on the rhizomes.
- **Male**-Male adults are orange coloured with transparent wings, distinct head, thorax and abdomen.

Nature of Damage and Symptoms:

- Adult (female) scales feed on sap and when the rhizomes are severely infested, they become shriveled and desiccated affecting its germination.
- In Initial stage of infestation in, the white coloured scales are seen scattered on rhizomes and later they congregate near the growing buds.
- When the infestation is severe the rhizome and buds shrivel and ultimately the entire rhizome dries.

Scale insect on

Source:http://eagri.org/eagri50/ENTO331/lecture27/turmeric/002.html

Damage rhizome

Source:http://krishiexpert.com/articles/Insect-Pests_com-August2017.pdf

Management

- Discard and do not store severely infested rhizomes
- Collect and destroy damaged leaves
- Select healthy rhizomes free from scale infestation for seed material
- Application of well rotten sheep manure @ 10 t/ha in two splits (once basally and other at earthing up) or Poultry manure in 2 splits can control the insect.

Minor Pests of Turmeric having Regional Significance:

8.3 Bihar Hairy Caterpillar / Leaf Roller, *Spilosoma oblique* Walker, (Lepidoptera-Eribidae)

Life Cycle:

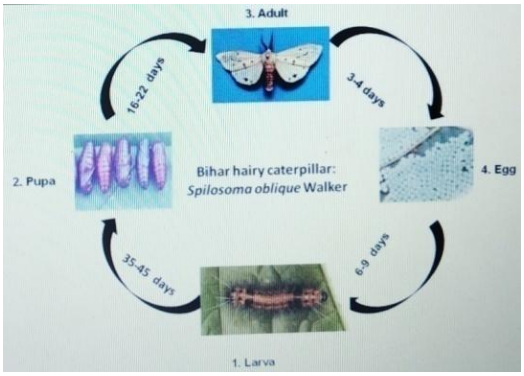
- **Eggs**- eggs are light green spherical in clusters on the under sides of leaves. The eggs hatch after about 6 to 9 days.
- **Larvae**-Fully grown caterpillar measures about 40-45 mm in length and are profusely covered with long greyish hair. The larvae are full fed within 4-8 weeks through 7 stages.
- **Pupa**- The pupa forms thin silky cocoon by inter-woven shed hairs of the leaves. The pupal stage lasts 2-3 weeks in the active period and the moths live for about a week. The life cycle is completed in 6-12 weeks with 3 or 4 generations in a year.
- **Adult**-The moth measures about 50 mm across the wing spread. The head thorax and underside of the body are dull yellow. The antennae and eyes are black.The pest breeds from March to April and again from July to November. It passes the hottest part of the summer (May-June) and winter (December to January) in the pupal stage amidst plant debris. Adults emerge from the over-wintering larvae in March. The incubation period is 8-13 days.

Nature of damage and Symptoms

- The caterpillars eat leaves and soft portions of stems and branches. In severe infestation, the plants may be denuded completely of leaves.

Adult moth

Hairy caterpillar



Source: https://en.wikipedia.org/wiki/Spilosoma_obliqua

Management

- Collect and destroy the egg masses and larvae
- Remove alternate weed hosts near in and around the field
- Conserve the natural enemies such as ladybird beetle, spiders, chrysopids, *Bracon* spp., fire ants, dragon fly, praying mantis, ground beetle and *Trichogrammatids* etc.
- Release *Trichogramma chilonis* @ 20,000/acre.

8.4 Turmeric Skipper/Leaf Roller: *Udaspes folus* Cramer, (Lepidoptera-Hesperiidae)

Life Cycle:

- **Eggs-** The eggs are pinkish oval, flat are laid singly or in groups or 2 or 3 on leaves incubation period is 3 to 4 days.
- **Larva-** There are five larval instars, fully grown larva dark green with black head and constricted neck the pest abundant in the filed during august to October. The larval period last for 12-21 days.
- **Pupa-** pupa is long cylindrical, watery green in colour it has a long conical projections in front of the head. The most striking characteristic of the pupa is its proboscis. The pupal period lost for 6 to 7 days.
- **Adult**-The butterfly is brownish black in colour with forewing having white spots and hind wing has a large patch.

Nature of Damage and Symptoms

- The young larvae web together nearby leaves and remaining inside this web feed on the green matter of leaf, leaving behind the papery epidermis.
- The mature larvae cut and fold leaves, remain within and feed on them.
- Complete defoliation


Larvae


Adult


Rolling of turmeric leaf

Source : https://en.wikipedia.org/wiki/Udaspes_folus

Management

- Hand pick and destroy the larvae and pupae to reduce the intensity of the pest.

8.5White Grub, *Holotrichia* sp., (Coleoptera- Scarabaeidae)

Life Cycle:

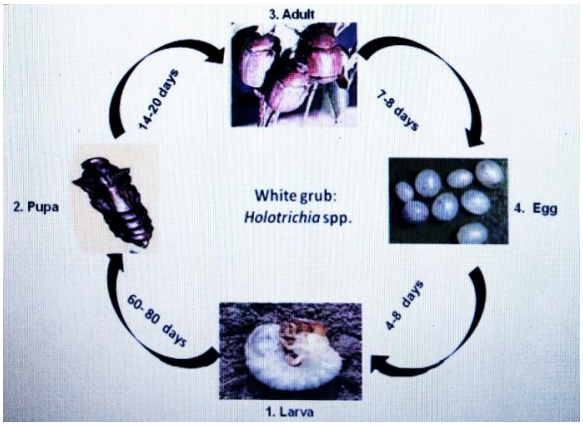
- **Egg-**The females lay eggs singly on the main stem. The eggs are white, almost round in shape.
- **Larva**- The larvae are C shaped, slow movers having globular head and elongated, dorsoventrally flattened body. The young grubs are translucent, white and 5 mm long.
- **Pupa**-Pupation takes place in the larval tunnel.
- **Adult-**Adults of *Holotrichia* spp. are about 18-20 mm long and 7-9 mm wide.

Nature of Damage & Symptoms

- Grubs are polyphagous and both adults and larvae are damaging stages.
- The grubs live in soil and remain active, feed on the functional roots of the plant, leaving behind only tap root.
- They also burrow into the pseudo stem, close to the soil surface and kill the plant.

- Grub infested plants turn pale, leaves and branches drop down, the plant withers and can be easily uprooted.
- It ultimately dies off resulting in patchy crop growth.
- Root grubs occasionally feed on tender rhizomes, roots and base of pseudo stems causing yellowing and wilting of shoots.

Grub



Life cycle

Source: https://extension.entm.purdue.edu/fieldcropsipm/insects/corn-whitegrubs.php

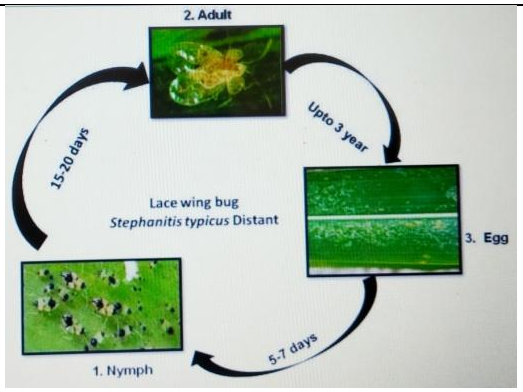
Management

- Uproot the infested plants, collect and destroy the infected plant along with larvae.
- Use well decomposed FYM

8.6 Lacewing Bug, *Stephanitis typicus* STEPTY, (Hemiptera- Tingidae)

Life Cycle:

- Adults are small, dull-coloured or white bugs with transparent shiny lace-like reticulate wings, nymphs are black coloured.
- Small, whitish lacewing bug found in colonies on the foliage, causing a sickly and spotted appearance of the plant.
- The pest infestation is more common during the post monsoon period especially in drier regions of the country

	
Adult	Life cycle

Source: https://www.projectnoah.org/spottings/10338660

Nature of Damage and Symptoms

- Both nymphs and adults feed in colonies on under surface of leaves and cause discolouration.

Management

- Destroy all volunteer plants and old neglected plantations.
- Use healthy and pest free rhizomes for planting. Apply hot water treatment prior to planting.
- Field release of coccinelid like ladybird and lacewings.

8.7 Thrips, *Panchaetothrips indicus*, Bagnall, (Thysanoptera –Thripidae)

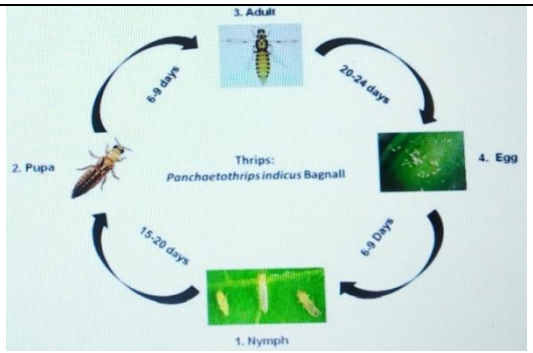
Life Cycle:

- **Egg-** Thrips reproduce by laying eggs
- **Nymph**-Nymphs emerge from the eggs. It takes between 7 and 12 days to develop from eggs into adult thrips.
- **Adult**-The adult thrips are very small, have elongated abdomens and are yellowish or blackish in color. Although the adults have wings, these insect pests do not usually fly. They are often found on plants throughout all growth stages, from sprout development to tuber maturation.

Nature of Damage and Symptoms

- Thrips damage the undersides of leaves by sucking their plant sap.
- They damage young and soft parts of plants such as new leaves and shoots.

- Leaves become rolled up, and turn pale and gradually dry-up. Severe infestation causes young leaves to wilt and dry out.

	
Thrips	Life cycle

Management

- Removal of old crops from field and crop rotation and spacing, weeds removal.
- Selection of healthy planting material.
- Use of resistant varieties.
- Biological control using predatory mites (Hypoaspis and Montdorensis) is an option in protected cropping.

8.8 Leaf beetle/Flea beetle: *Lema praeusta* Fabricius, (Coleoptera: Chrysomelidae)

Life Cycle:

- **Egg-**They lay eggs singly on leaves
- **Grub**- Incubation period is 8-10 days and after the grubs feeding on leaf tissue pupates in the soil. Adults emerged after 15-25 days.
- **Adult-**Adults are small, elliptical or oval shaped, less than 6 mm in length and dark or metallic in colour.

Nature of damage and symptoms

- Both adults and grubs feed on leaf and characteristic shot holes appear on the leaves.

Management

- Sanitation practices of mowing and weeding (especially early in the season) and removing plant debris, can reduce flea beetle populations by minimizing food sources and overwintering habitat.
- Use of white and yellow sticky traps to capture flea beetles as they jump for monitoring.
- Foliar neem solution application as repellants.
- Predators known to feed on flea beetles include lacewing larvae (*Chrysopa carnea*) and field cricket (*Gryllus* sp.)

9. RODENTS MANAGEMENT

In some areas, rodents damage the turmeric crop by making holes in the turmeric fields.

Rodent Pest Management:

- By practicing clean cultivation, destroy the habitat (burrows) of the rodents
- Remove weeds and minimize the alternate food sources present in the field
- Practice burrow smoking using paddy straw or other natural smoking materials or fumigate the burrow for 2-3 minutes.

- Encourage the natural predator like barn owls by establishing barn owl perches in field.
- Apply 2% Zinc phosphide poison baits (96 parts of broken rice + 2 parts of edible oil + 2 parts of 98% ZnP) when the rodent infestation is very high.

10. INTEGRATED DISEASES MANAGEMENT (For Major Diseases)

10.1 Rhizome Rot *(Pythium aphanidermatum)*

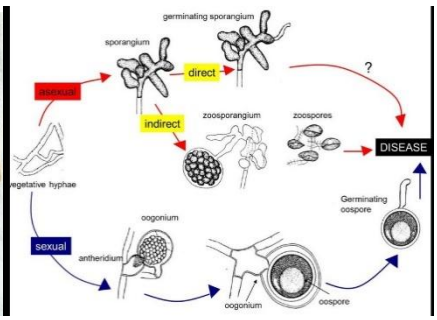
Symptoms

- 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

Disease Development

- The disease is soil-borne. The fungus multiplies with buildup of soil moisture.
- The fungus can survive in two ways: (a) in diseased rhizomes kept for sowing and (b) through resting structures like chlamydospores and oospores that reach the soil from infected rhizomes.
- Younger sprouts are the most susceptible to the pathogen. Nematode infestation aggravates rhizome rot disease.
- Temperature above 30° C and high soil moisture are the important predisposing factors favouring the disease.
- Water logging in the field due to poor drainage increases the intensity of the disease.

Rhizome rot symptoms on turmeric leaves and rhizome



Disease cycle

Source: https://www.invasive.org/browse/detail.cfm?imgnum=5542832

Management

Different management practices should be followed during the crop stages of turmeric.

- Use of resistant varieties for rhizome rot.
- Crop rotation with maize, cotton, soybean.
- Planting of disease-free seed rhizomes.
- Use raised beds of 30 cm height.
- Flooding treatment for 30 days, soil solarisation during hottest months for 60 days
- Treat the rhizomes with hot water at 51° C for 10 minutes.
- Rhizomes treatment can be done by keeping them under clear polythene sheet under direct sunlight for raising the temperature 48^{o} C for 30 minutes.
- Use bio-fumigation using cabbage and mustard plant refuses.
- Use raised beds of 15-30 cm height, 1 m width and of convenient length may be prepared giving at least 50 cm spacing between beds.
- Planting of perennial / seasonal flowering plants like basil, marigold, fennel, sunflower etc. along the border to attract and enhance the population of biocontrol agents for managing pests/disease.
- Application of pine needle and neem cake powder treatments @ 100 Kg/ acre
- Application of oil cakes made from *Azadirachta indica*, *Calophyllum inophyllum*, *Pongamiaglabra*, *Hibiscus sabdariffa* and *Brassica campestris* @ 0.8 tonnes/ acre
- Maintain proper drainage by using 30 cm raised bed and avoiding the water stagnation
- Adopt phytosanitary measures like infected plants should be uprooted and destroyed.
- Adopt crop rotation with non-host crops like ragi, paddy, maize, sorghum etc.
- Mulching with green leaves (Lantana camara and Vitex negundo) @ 4- 4.8 t/acre at the time of planting. (It is repeated @ 5 t/acre 40 and 90 days after planting).
- Foliar application of neem oil @ 0.5% twice at fortnightly interval.
- Cow dung slurry or liquid manure may be poured on the bed after each mulching to enhance microbial activity and nutrient availability

- Maintain proper drainage by using 30 cm raised bed and avoiding the water stagnation
- Adopt phytosanitary measures like infected plants should be uprooted and destroyed.
- Adopt crop rotation with non-host crops like ragi, paddy, maize, sorghum etc.
- Mulching with green leaves (*Lantana camara* and *Vitex negundo*) @ 4- 4.8 t/acre is at the time of planting. (It is repeated @ 2 t/ acre 40 and 90 days after planting).
- Use Fermented Plant Extract (FPE) prepared by using (garlic + onion leaves + *Canabis* sp + wild poisonous plant) + (cow urine) + (EM solution) + (extract after washing polished rice) + (alcohol) + (water) (1:1:1:1:1:15), sufficient for 1.0 ha for seed treatment against soft rot.
- FPE to be applied after every fortnight by using watering can for next 2 month *i.e.* up to July end.
- Soil application of *Pseudomonas fluorescens* talc formulation (2.5 kg/ha)
- Soil drenching with (Azoxystrobin 18.2% + Difenoconazole 11.4% w/w SC) fungicide(0.1% or 1 ml/liter per hectare) in and around affected plants.

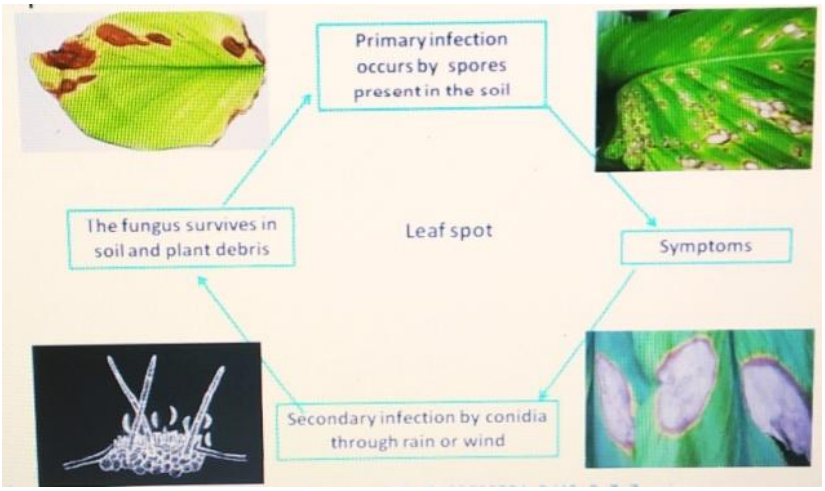
10.2 Leaf Spot *(Colletotrichum capsici)*

Symptoms

- Symptom appears as brown spots of various sizes on the upper surface of the young leaves
- The spots are irregular in shape and white or grey in the centre.
- Later, spots may coalesce and form an irregular patch covering almost the whole leaf.
- The centre of spots contains fruit head shaped fruiting structures

Leaf spot symptoms (yellow halo on turmeric)

Source: https://agritech.tnau.ac.in/crop_protection/turmeric_diseases1.html



Disease development

- Disease is soil borne and survives in plant debris.
- The disease spreads through rain splashes during intermittent showers.
- The incidence of the disease is severe in turmeric grown under exposed conditions
- Disease is soil-borne noticed on the leaves from July to October.
- High soil moisture, temperature 25 OC and leaf wetness.

Management

- Pluck and remove the infested leaf and uproot the infested plants and destroy them.
- Use proper green mulching to reduce soil splashes.
- Field sanitation should be practiced.

- Follow crop rotation with cereal and legume crops to reduce the inoculum build up.
- Use of plant extracts such as garlic extracts is effective against foliar pathogens.
- Spray of an extract of asafoetida, turmeric and water pathogens including nematodes.
- Foliar application with (Azoxystrobin 18.2% + Difenoconazole 11.4% w/w SC) fungicide (0.1% or 1 ml/liter per hectare) for affected plants

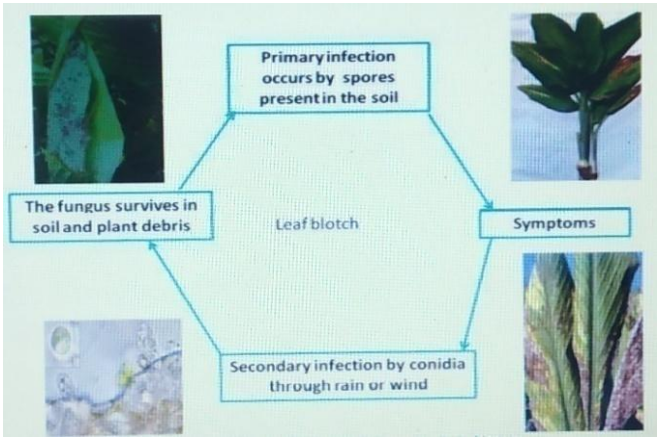
10.3 Leaf Blotch *(Taphrina maculans)*

Symptoms

- Disease symptom appears as small, oval, rectangular or irregular brown spots on either side of the leaves which soon become dirty yellow or dark brown.
- The leaves also turn yellow.
- In severe cases the plants present a scorched appearance and yield is reduced.

Leaf blotch of turmeric

Source:https://agritech.tnau.ac.in/crop_protection/turmeric_diseases2.html



Disease cycle

Disease Development:

- High soil moisture, temperature 25 °C and leaf wetness.
- Occurrence: Soil and rhizome borne
- Soil and rhizome borne and survive in soil on infected plant debris.

Management

- Use proper green mulching to reduce soil splashes.
- Field sanitation should be practiced.
- Follow crop rotation with cereal and legume crops to reduce the inoculum build up.
- Use of plant extracts such as garlic extracts is effective against foliar pathogens.
- Foliar application with (Azoxystrobin 18.2% + Difenoconazole 11.4% w/w SC) fungicide (0.1% or 1 ml/liter per hectare) for affected plants

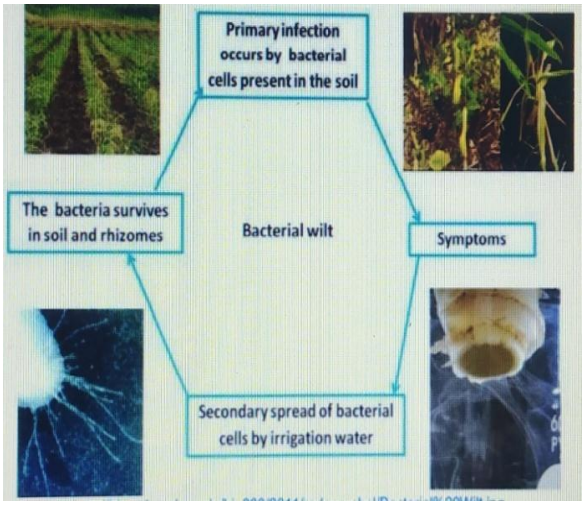
Minor Diseases of Turmeric having Regional Significance:

10.4 Bacterial wilt (*Ralstonia solancearum*)

Symptoms

- Rapid wilting and death of the entire plant without any yellowing or spotting of leaves are the characteristic symptom.
- All branches wilt at about the same time.
- When stem of wilted plant is cut across, pith has a darkened, water-soaked appearance.
- Greyish slimy ooze comes out on pressing the stem.
- In later stages of the disease, decay of pith may cause extensive hollowing of the stem.

Bacterial wilt symptoms of turmeric



Disease cycle

**https://link.springer.com/article/10.1007/s10327-015-0596-9

Disease Development:

- The bacterium is especially destructive in moist soils at temperatures above 24° C.
- High soil temperature and moisture are favourable for disease.

Management

- Soil solarisation for 60 days during summer
- Planting of disease-free seed rhizomes.
- Use crop rotation with non-host crops like ragi, paddy, maize, sorghum etc.
- Avoid crop rotation with tomato, potato, chillies, brinjal and peanut, as these plants are hosts for the wilt pathogen *Ralstonia solanacearum*.
- Rhizome treatment with hot water 47° C for 3 minutes.
- Use bio-fumigation using cabbage and mustard plant refuses.
- Avoid over irrigation, and flood irrigation in disease affected areas.
- It is sensitive to high pH (alkaline soils).

10.5 Dry Rot (*Rhizoctonia bataticola*)

Symptoms

- The disease causes root rot and rhizome rot resulting in typical dry rot of rhizomes from October onwards.

- The affected rhizomes appear soft and shrunken to start with, later dry up and become hard.
- Foliar yellowing and drying up of foliage which are the normal symptoms of maturity of the crop during October - November would be indistinguishable from the symptoms of the disease affected clumps.
- When infected rhizomes are cut open, the infected zones typically appear as dull brown and dark.

Dry rot of turmeric

Source: http://eagri.org/eagri50/PATH272/lecture07/004.html

Disease development:

- The pathogen is facultative parasites and lives as a saprophyte on the organic matter in the soil for several years.
- It spreads from vulnerable plants
- The disease is favoured by 35 °C soil temperature, 15-20 percent soil moisture andalluvial or sandy soils.

Management

- Field sanitation should be practiced.
- Follow crop rotation with cereal and legume crops reduce the inoculum build up.

Important Nematode infection in Turmeric:

10.6 Root knot (*Meloidogynae* sp.), Burrowing (*Radopholus Similis*) and Lesion Nematode (*Pratylenchus* spp.)

Damage symptoms

- Root-knot nematode feed on tender rhizomes, roots and base of pseudostem causing stunting, chlorosis, poor tillering and necrosis of leaves are the common aerial symptoms.
- Characteristic root galls and lesions that lead to rotting are generally seen in roots. The infested rhizomes have brown, water soaked areas in the outer tissues.
- Nematode infestation aggravates rhizome rot disease.

Symptom of Root Knot nematode

Symptom of burrowing nematode

Symptom of lesion nematode

Source:https://kvk.icar.gov.in/API/Content/PPupload/k0218_69.pdf

- Nematodes survive in soil and infected rhizomes as primary inoculums. Therefore, tissues from infected crops remaining in the field serve as a reservoir of the fungus.
- It spreads from infected plants or through soil.
- Warm, moist soil is favourable conditions.

Management

- Uproot and destroy the infested plants.
- Treat infested rhizomes with hot water (50° C) for 10 minutes, using nematode free seed rhizomes and solarizing turmeric beds for 40 days.
- Intercropping of marigold
- Deep ploughing or solarized beds of infested fields during summer.

- Follow crop rotation with cereal crops, marigold, *Chrysanthemum*, *Sesbania*, *Crotalaria* spp., gaillardia, castor bean and *Desmodium* spp., (parasitic nematodes)
- Border crops: Strips of rye grass, cover crops and mulch beds (rove beetle)
- Intercropping *of* turmeric with *Chrysanthemum coronarium*, *Tagetes erecta*, or growing *Tagetes erecta* as border crops.
- Very effective method and often farmers incorporate leaves of these trap crops into the soil to enhance effectiveness and nutrients enrichment of crops.
- An extract of asafoetida, turmeric and water is effective against several plant pathogens including nematodes.
- Application of neem (*Azaradirachta indica*) seed cake 100 Kg/acre before planting
- *Pochonia chlamydosporia*, a nematode biocontrol agent can be incorporated in turmeric beds (20 g/bed at 106 cfu/g) at the time of sowing.

11. WEEDS MANAGEMENT

Management of Turmeric Weeds

- Deep summer ploughing and solarization during summer reduces weed infestation, soil borne diseases, nematodes, etc.
- Use raised beds (30 cm with 1 meter width).
- At the time of field preparation, adopt stale seed bed technique to minimize weeds menace in field.
- Hand hoeing and weeding are necessary at 60, 90, 120 and 150 days after planting in light soils.
- Green mulching: The first mulching is done at the time of planting with green leaves @ 4.8- 6 tonnes/acre.
- Mulching is to be repeated @ 3 tonnes/acre at 45 and 90 days after planting, immediately after weeding, application of fertilizers and earthing up.
- Immediately the plants have to be earthed up.
- In black soils where ridge and furrow method of planting and wider spacing are adopted country plough can be worked for earthing up and removal of weeds and followed by weeding in the lines.

12. DO'S AND DON'TS IN IPM

S No	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days. The field should be kept exposed to sun light at least for 2-3 weeks	Do not plant or irrigate the field after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Adopt crop rotation.	Avoid monocropping
3.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
4.	Always treat the rhizome/planting material with approved chemicals/biopesticides for the control of seed borne diseases/pests.	Do not use rhizome/planting material without seed treatment with biopesticide/ chemicals.
5.	Sow in rows at optimum depths under proper moisture conditions for better establishment.	Do not sow rhizome/planting material beyond 5-7 cm depth
6.	Use NPK fertilizers as per the soil test recommendation	Avoid imbalanced use of fertilizers
7.	Use micronutrient mixture after sowing based on soil test recommendations.	Do not apply any micronutrient mixture after sowing without soil test recommendations.
8.	Conduct AESA weekly 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: Dratio
9.	Release parasitoids only after noticing adult moth as per field observation	Do not apply chemical pesticides within seven days of release of parasitoids.
10.	In case of pests which are active during night spray recommended biopesticides/ chemicals at the time of their appearance in the evening.	Do not spray pesticides at midday since, most of the insects are not active during this period
11.	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
12.	Follow the recommended procedure of trap crop technology.	Do not apply long persistent pesticides on trap crop, otherwise it may not attract the pests and natural enemies

13. HARVEST AND POST HARVEST MANAGEMENT

A. During Harvest:

- Harvest the crop only when it is fully matured.
- Maturity is indicated by the drying up of the plant including the base of the stem.
- While harvesting, care should be taken not to cause any damage to the rhizomes.
- The leafy stems are then cut off, roots removed to the adhering earth shaken off.
- The rhizomes are washed well with water to remove the mud and dirt adhering to them. The fingers are separated from the bulbs.

B. During Storage:

- Turmeric should be stored ensuring protection from dampness.
- Drainage should be provided to stack the packed bags to prevent moisture ingress from the floor.
- Care should be taken to stack the bags 50 to 60 cm away from the walls.
- No insecticide should be used directly on dried turmeric.
- Stored turmeric should be subjected to periodic fumigation for which only authorised persons should be engaged.
- Insects, rodents and other animals should be effectively prevented from getting access to the premises where turmeric is stored.
- Stored turmeric should be periodically exposed to the Sun.
- If care is taken in all stages of cultivation, harvesting, post harvest handling, processing, packing, storage and transportation by following sound methods and practices we will be able to prevent contamination and deterioration of quality in any farm produce including turmeric and ensure consumer satisfaction.

C. Preservation of Seed Rhizomes

- Rhizomes for seed purpose are generally stored by heaping in well ventilated rooms and covered with turmeric leaves.
- The seed rhizomes can also be stored in pits with saw dust, sand along with leaves of Stychnos nux-vomica (Kanjiram).
- The pits are to be covered with wooden planks with one or two openings for aeration.

Post Harvest Processing

- The harvested turmeric rhizomes before entering into the market is converted into a stable commodity through a number of post harvest processing operations like boiling, drying and polishing.
- Boiling of turmeric is taken up within 3 or 4 days after harvest.
- The fingers and bulbs (or mother rhizomes) are separated and are cured separately, since the latter take a little longer to cook.
- The dry recovery of the different turmeric varieties vary widely ranging from 19 to 23%.

Drying

- The cooked fingers are dried in the sun by spreading in 5-7 cm thick layers on the drying floor.
- A thin layer is not desirable, as the colour of dried product may be adversely affected.
- It may take 10-15 days for the rhizome to become completely dry.
- The bulbs and fingers are dried separately, the former takes more time to dry.
- Turmeric should be dried on clean surface to ensure that the product does not get contaminated by extraneous matter.
- Care should be taken to avoid mould growth on the rhizomes.
- Rhizomes are turned intermittently to ensure uniformity in drying.

Polishing and Colouring

- The appearance is improved by smoothening and polishing the outer surface by manual or mechanical rubbing.
- Polishing is done till the recommended polish of 7-8% is achieved.
- Usually 5 to 8% of the weight of turmeric is the polishing wastage during full polishing and 2 to 3% during half polishing.
- Polishing of dried turmeric also helps in removing the wrinkles.
- Polishing is done by using hand operated barrel or drum mounted on a central axis, the sides of which are made of expanded metal screen.
- Large scale polishing units with capacity to polish 500 to 1000 kg per batch is used for polishing turmeric rhizomes at commercial units which takes about 45-60 minutes per batch and about 4% is wasted as dust.
- The yield of polished turmeric from the raw materials varies from 15-25%.

- In order to impart attractive yellow colour, turmeric suspension in water is added to the polishing drum in the last 10 minutes.
- Composition of emulsion for colour coating of 100kg of half boiled turmeric is Alum 0.04kg, turmeric powder 2kg, castor seed oil 0.14kg, sodium bisulphate 30g, concentrated hydrochloric acid 30ml.
- When the rhizomes are uniformly coated with suspension, they may be dried in the sun.
- The colour of the processed turmeric influences the price of the produce. Hence, to obtain attractive product, turmeric powder is sprinkled during the last phase of polishing.

Cleaning, Grading, Packing and Storage

- Although Indian turmeric is considered to be the best in the world, about 90% of the total produce is consumed internally and only a small portion of the production is exported.
- Turmeric of commerce is described in three ways:
- **Fingers:** These are the lateral branches or secondary 'daughter' rhizomes which are detached from the central rhizome before curing. Fingers usually range in size from 2.5 to 7.5 cm in length and may be over 1 cm in diameter.
- **Bulbs:** These are central 'mother' rhizomes, which are ovate in shape and are of shorter length and having larger diameter than the fingers. **Splits**: Splits are the bulbs that have been split into halves or quarters to facilitate curing and subsequent drying.
- Turmeric being a natural produce, is bound to gather contaminants during various stages of processing.
- A sifter, destoner, and an air screen separator will help remove materials such as stones, dead insects, excreta, and other extraneous matter.
- Cleaned and graded material is packed generally in new double burlap gunny bags and stored over wooden pallets in a cool, dry place protected from light.
- The stores should be clean and free from infestation of pests and harborage of rodents.
- It is not recommended to apply pesticides on the dried/polished turmeric to prevent storage pests.

14. EXPORT PROCEDURES

Turmeric rhizome fresh, dried & powder are exported to various countries as per phytosanitary requirement of the importing countries. These phytosanitary requirements may include registration of farm with State Agriculture/ Horticulture Departments, implementation of Good Agriculture Practices, grading, packing & storage in pack house registered with DPPQS / Spices Board, specific treatment, specific packaging, phytosanitary inspection & certification.

Every consignments of turmeric 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.

15. ACKNOWLEDGEMENT & REFERENCES:

1. https://www.mofpi.gov.in/pmfme/enewsaugust9/markettrends1.html

2. https://www.spices.res.in