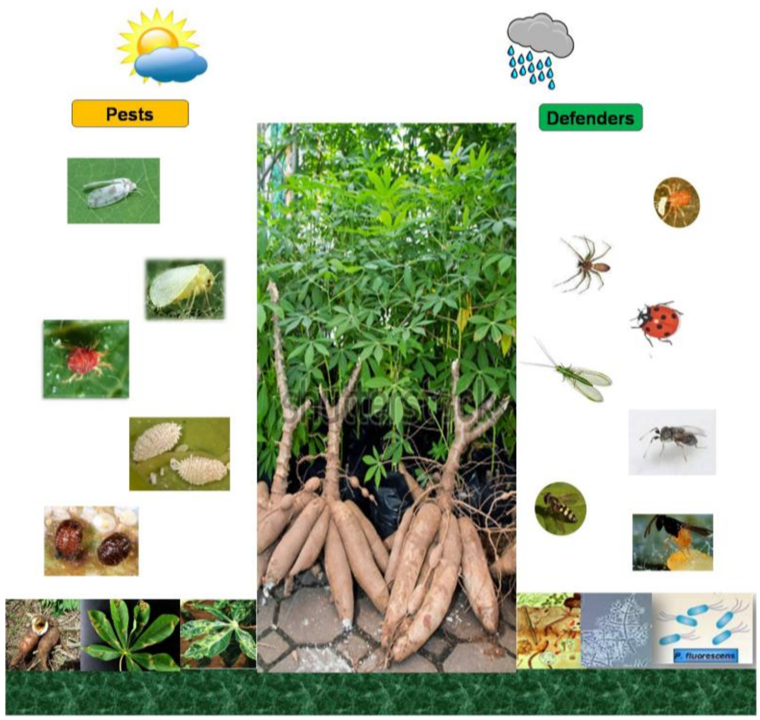
AESA BASED IPM PACKAGE

TAPIOCA



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Ministry of Agriculture and Farmers Welfare
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The AESA based IPM – Tapioca was compiled by the NIPHM working group under the Chairmanship of Smt. V. Usha Rani, IAS, Director General, NIPHM and guidance of Shri. Utpal Kumar Singh, IAS, JS (PP). The package was developed taking into account the advice of experts listed below on various occasions before finalization.

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CONTENTS

AESA BASED IPM PACKAGE FOR TAPIOCA

Tapioca- Plant description:

Tapioca (*Manihot esculenta* Crantz belonging to the family Euphorbiaceae) commonly known as cassava, Brazilian arrowroot, manioc and yuca is a perennial shrub grown primarily for its storage roots for food, feed and industrial products. Cassava grows to a height of 1-3 m with erect stems and spirally arranged simple lobed leaves with petioles. The plant produces flowers on a raceme. Tubers are usually cylindrical , tapered and brown in color and can be harvested 5-12 months after planting.

Tuber are eaten raw and after cooking. It is also used as a source of starch,flour and ethanol. The starch from cassava tubers are used in the production of adhesives, textiles and cosmetics. Cassava leaves are used as animal feed and recently the ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram has developed very potent bio pesticides against certain important sucking and borer pests of horticultural crops by isolating the insecticidal molecules from cassava leaf. T

I. PESTS

A. Pests of National Significance

1. Insect and mite pests

1.1 Spiralling whitefly: *Aleurodicus dispersus* Russell (Hemiptera: Aleyrodidae)

1.2 Cassava whitefly: *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae)

1.3 White mussle scale/ tapioca scale : *Aonidomytilus albus* (Cockerell) (Hemiptera: Diaspididae)

1.4 Thrips: *Retithrips syriacus* Mayet (Thysanoptera: Thripidae)

1.5 Papaya mealybug: *Paracoccus marginatus* Williams & Granara de Willink (Hemiptera: Pseudococcidae)

1.6 Cassava mealybug: *Pseudococcus filamentosus* Cockrell (Hemiptera: Pseudococcidae)

1.7 Termites: *Odontotermes* spp. (Isoptera: Termitidae)

1.8 White grub: *Leucopholis coneophora* Burm (Coleoptera: Scarabaeidae)

1.9 Tetranychid spider mites : *Tetranychus telarius* (Linnaeus) (Acarina: Tetranychidae). *Tetranychus neocaledonichus* Andre, *Eutetranychus orientalis* Klein, *Oligonychus biharensis* Hirst.

2. Diseases

2.1 Cassava mosaic disease: Indian *cassava mosaic virus* (ICMV)

2.2 Brown leaf spot: *Cercospora henningsii Allescher.*

2.3 Cassava tuber rot: *Phytophthora palmivora* Butler

3. Weeds

Broadleaf weeds

3.1 Spiny amaranth: *Amaranthus spinosus* L. (Amaranthaceae)

3.2 Common purselane: *Portulaca oleracea* L. (Portualacaceae)

3.3 Red spiderling: *Boerhavia diffusa* L. (Nyctaginaceae)

3.4 Benghal dayflower: *Commelina benghalensis* L. (Commelinaceae)

3.5 Goat weed: *Ageratum conyzoides* L. (Asteraceae)

3.6 Coat buttons: *Tridax procumbens* L. (Asteraceae)

Grassy weeds

3.7. Crowfoot grass: *Dactyloctenium agegyptium* L. (Poaceae)

3.8 Congon grass: *Imperata cylindrica* L. (Poaceae)

Sedges

3.9 Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)

3.10 Flat sedge: *Cyperus iria* L. (Cyperaceae)

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

A. AESA:

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. sun, rain, wind and soil nutrients) and biological factors (i.e. sun, rain, sunshine hours, wind etc.). 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
- Pests and defenders population dynamics
- Soil conditions
- Climatic factors
- Farmers past experience

Principles of AESA based IPM:

Grow a healthy crop

- Select a variety resistant/tolerant to major pests & diseases
- Select healthy planting materials
- Treat the seed with recommended biopesticides
- Follow proper spacing
- Soil health improvement (mulching and green manuring)
- Observe the soil physical condition, moisture level, etc.
- Take representative soil sample and get the soil analysis report showing soil pH, electrical conductivity (EC), organic matter and nutrient status.
- Observe the number and species of weeds found in per square meter area in five randomly selected spots/acre.
- Proper irrigation
- Crop rotation

Observe the field regularly (climatic factors, soil and biotic factors)

Farmers should

- Monitor the field situations at least once a week (soil, water, plants, pests, natural enemies, weather factors etc.)
- Make decisions based on the field situation and Pest: Defender ratio (P: D ratio)
- Take direct action when needed (e.g. collect egg masses, remove infested plants etc.)

http://www.tpd.gov.kh/cambodiaproduct/images/stories/cassava_farm.jpg

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 herbivory 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.

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

Insect zoo

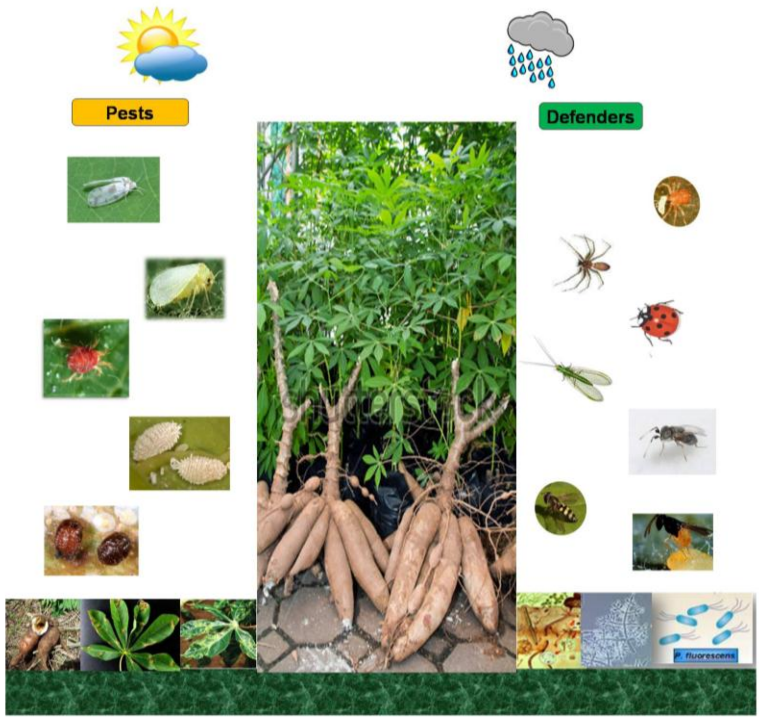
In field various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in crop field. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial and harmful insects. In this method, unfamiliar/unknown insects are collected in plastic containers with brush from the field and brought to a place for study. Each insect is placed inside a plastic bottle together with parts of the plant and some known insect pests. Insects in the bottle are observed for certain time and determined whether the test insect is a pest (feeds on plant) or a predator (feeds on other insects).

Pest: Defender ratio (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 Tapioca insect pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens.

Model Agro-Ecosystem Analysis Chart

Date:
Village:
Farmer:



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 2 pests. 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 microbial biopesticides and biochemical biopesticides such as insect growth regulators, botanicals etc. can be relied upon before resorting to synthetic chemical pesticides.

Decision making

Farmers become experts in crop management

Farmers have to make timely decisions about the management of their crops. AESA farmers have learned to make these decisions based on observations and analysis viz. abiotic and biotic factors of the crop ecosystem. The past experience of the farmers should also be considered for decision making. However, as field conditions continue to change and new technologies become available, farmers need to continue improving their skills and knowledge.

- Farmers are capable of improving farming practices by experimentation
- Farmers can share their knowledge with other farmers

AESA methodology

- Go to the field in groups (about 5 farmers per group). Walk across the field and choose 20 plants/acre randomly. Observe keenly each of these plants and record your observations:at regular interval.

    - Plant: Observe the plant height, number of leaves, crop stage, deficiency symptoms etc.
    - Insect Pests: Observe and count insect pests at different places on the plant.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
    - Rats: Count number of plants affected by rats.
    - Weeds: Observe weeds in the field and their intensity.
    - Water: Observe the water situation of the field.
    - Weather: Observe the weather condition.

- While walking in the field, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the field situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on whatfield management is required in the AESA plot.

- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording

Farmers should record data in a notebook and drawing on a chart

- Maintain records to analyse and draw conclusions.

Data to be recorded

- **Plant growth (fortnightly):**Height of plant; Number of leaves, Number of fallen leaves, Girth of the stem, etc., (
- **Crop situation (e.g. for AESA):Pl**ant health, pests, diseases, weeds, natural enemies, Soil conditions, Irrigation,
- Wea**ther conditions**
- **Input costs: see**ds, fertilizer, pesticides, labour
- **Harvest:** Yield (kg/acre), Price of produce (Rs./kg)

Some questions that can be used during the discussion

- Summarize the present situation of the field.
- What crop management aspect is most important at this moment?
- Is there a big change in crop situation compared to last visit? What kind of change?
- Is there any serious pest or disease outbreak?
- What is the situation of the beneficial insects?
- Is there a balance in the field between pests and defenders?
- Were you able to identify all pests and diseases?
- Do you think the crop is healthy?
- What management practices are needed at this moment?
- When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.
- Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest buildup?
- What are the problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.


Advantages of AESA over ETL

One of the problems of the ETL is that it is based on parameters that are changing all the time, and that are often not known. The damage or losses caused by a certain density of insects cannot be predicted at all. In ETL the due recognition of the role of natural enemies in decreasing pest population is ignored. Farmers cannot base their decisions on just a simple count of pests. They will have to consider many other aspects of the crop (crop ecology, growth stage, natural enemies, weather condition, etc.) and their own economic and social situation before they can make the right crop management decisions. In ETL based IPM, natural enemies, plant compensation ability and abiotic factors are not considered. In AESA based IPM emphasis is given to natural enemies, plant compensation ability, abiotic factors and P: D ratio.

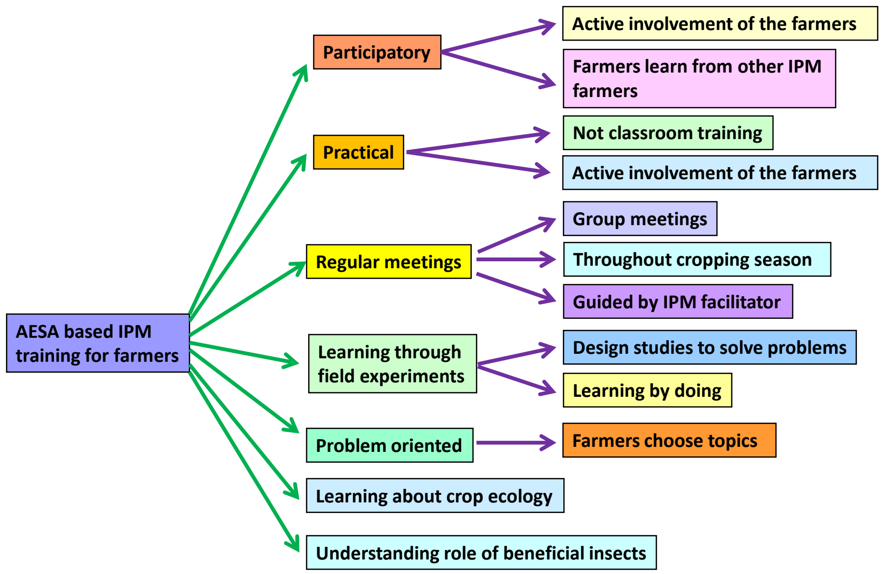
AESA and farmer field school (FFS)

AESA is a season-long training activity that takes place in the farmer field. It is season-long so that it covers all the different developmental stages of the crop and their related management practices. The process is always learner-centered, participatory and relying on an experiential learning approach and therefore it has become an integral part of FFS.

Farmers can learn from AESA

- Identification of pests and their nature of damage
- Identification of natural enemies
- Management of pests
- Water and nutrient management
- Influence of weather factors on pest buildup
- Role of natural enemies in pest management

FFS to teach AESA based IPM skills



B. Field Scouting:

AESA requires skill. So only the trained farmers can undertake this exercise. However, other farmers also can do field scouting in their own fields at regular intervals to monitor the major pest situation.

Surveillance on pest occurrence in the main field should commence soon after crop establishment and at weekly intervals thereafter. In 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 pest:

Mite, scale, mealybug, thrips and whitefly: Count and record the number of both nymphs and adults on five randomly selected plant.

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.

Tuber 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 tuber and stems. Observe the signs of the causal organism (fungal growth or ooze). It is often necessary to wash the roots with water to examine them properly. If the roots are well developed, cut them to examine the roots for internal infections (discolouration & signs). Count the total number of roots damaged/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. Leaf diseases cause most damage during the seedling and flowering stages of plant growth. Observe for the symptoms and signs on the infected plant parts. 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.

C. Yellow/ sticky traps:

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

D. Light traps:

Set up light traps 1 trap/acre 15 cm above the crop canopy for monitoring and mass trapping of nocturnal insects. Light traps with exit option for natural enemies of smaller size should be installed and operated around the dusk time (6 pm to 10 pm).

III. 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).

Ecological Engineering for Pest Management – Below Ground:

There is a growing realization that the soil borne, seed and seedling borne diseases can be managed with microbial interventions, besides choosing appropriate plant varieties. The following activities increase the beneficial microbial population and enhance soil fertility.

- Crop rotations with leguminous plants to enhance nitrogen content.
- Keep soils covered year-round with living vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance beneficial fauna and flora.
- Application of balanced dose of nutrients using biofertilizers based on soil test report.
- Application of biofertilizers with special focus on mycorrhiza and plant growth promoting rhizobacteria (PGPR)
- To promote the below ground biodiversity and to enhance activities of beneficial microbes in soil, use Biofertilizers, *Trichoderma*, VAM, etc along with FYM or Vermicompost

Ecological Engineering for Pest Management – Above Ground:

Natural enemies play a very significant role in control of foliar insect pests. Natural enemy diversity contributes significantly to management of insect pests both below and above ground.

In order to attract natural enemies following activities should be practiced:

- Raise the flowering plants / compatible cash crops along the field border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population
- Grow flowering plants on the internal bunds inside the field.
- Not to uproot weed plants those are growing naturally such as *Tridax procumbens, Ageratum* sp, *Alternanthera* sp etc. which act as nectar source for natural enemies,
- Not to apply broad spectrum chemical pesticides, when the P: D ratio is favourable. The plant compensation ability should also be considered before applying chemical pesticides.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Select and plant appropriate companion plants which could be trap crops and pest repellent crops. The trap crops and pest repellent crops will also recruit natural enemies as their flowers provide nectar and the plants provide suitable microclimate.

Due to enhancement of biodiversity by the flowering plants, parasitoids and predators (natural enemies) number also will increase due to availability of nectar, pollen and insects etc. The major predators are a wide variety of spiders, ladybird beetles, long horned grasshoppers, lacewing, earwigs, etc.

Plants suitable for Ecological Engineering for Pest Management

Attractant plants

Cowpea

Carrot

Sunflower


Buckwheat


French bean


Alfalfa


Mustard


Cosmos


Anise


Caraway


Dill


Parsley


White Clover


Tansy


Yarrow

Marigold

Repellent plants

***Ocimum* spp** **Peppermint/Spearmint**

Barrier plant

Rye grass

Border plants

Maize **Sorghum**

Inter crop

Groundnut

Cowpea

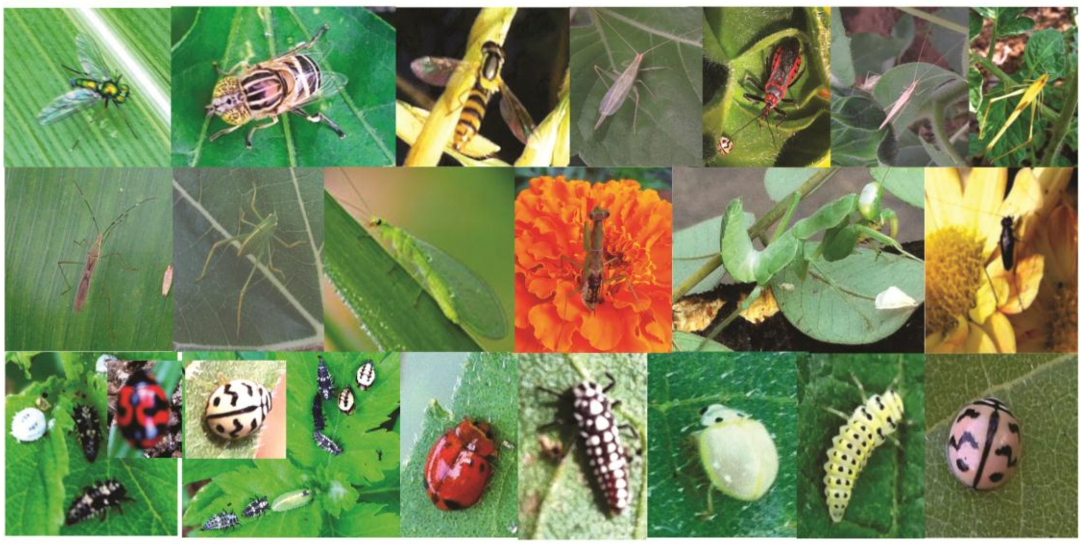
French bean

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.

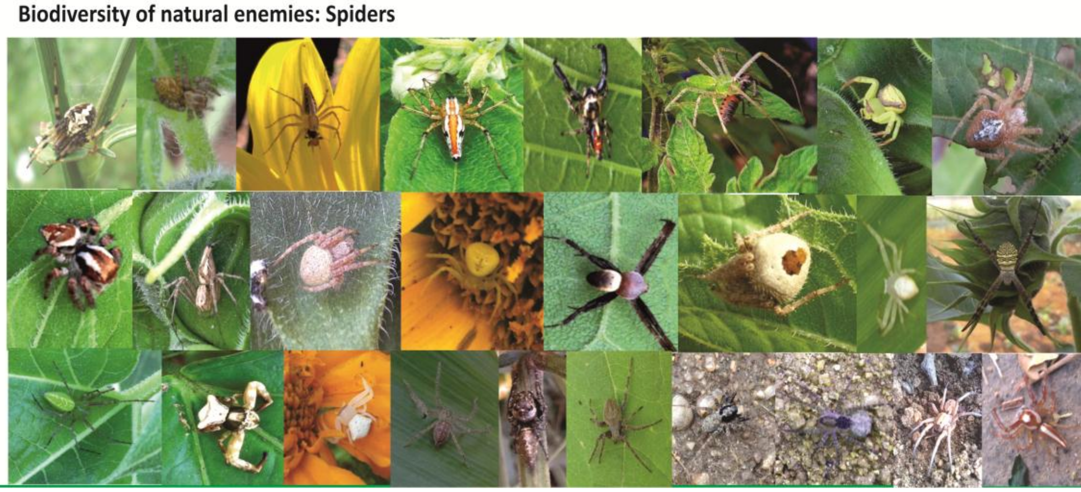
Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



IV. RESISTANT/ TOLERANT VARIETIES

Pest/ Disease	Tolerant/ resistant varieties
Cassava mosaic disease	M4, H 97, H 165 Sree Swarna, Sree Padmanabha
Brown leaf spot disease	S-856, H-97 and Sree Visakham
Spider mites	Sree Sahya,Sree Visakham,Sree Harsha, Sree Jaya, Sree Apoorva,Sree Athulya

V. CROP STAGE-WISE IPM

Management	Activity
Pre planting*	
	Common cultural practices: • Summer deep ploughing to a depth of 30-50 cm • Field sanitation, rogueing • Avoid water logged conditions in the field • Follow crop rotation • Apply manures and fertilizers as per soil test recommendations
Nutrient	• Plough the field 4 – 5 times to get a fine tilth. The soil depth should be at least 30 cm and form ridges, furrows and mounds • Nutrients should be applied on the basis of soil test report and recommendation for the particular area • Apply 5 to 12.5t/ha FYM and incorporate at the time of ploughing along with P fertilizers if needed based on soil test report (see Table 1,2,3)
Weed	• Destroy all the weeds from the plot by deep ploughing during summer • Remove all the perennial weeds and their rhizomes/suckers before the onset of monsoon.
Planting*	
	Common cultural practices: • Use healthy, disease free cassava stem cuttings (setts). Weeding as and when required (Field sanitation) • Crop rotation
Nutrients	• General Package of practices recommendation is NPK @100:50:100 kg/ha + FYM @12.5 t/ha. Apply full FYM along with full P at the time of land preparation and planting. Half N and half K within 15 days of sprouting the setts and the remaining half N and K within 45 days of first application • Apply manures and fertilizers as per soil test recommendations (see Table 1,2,3).

Weeds	• Weed control ground cover mulch can be used over the mounds/ridges/furrows after first interculture and fertilizer application (45-60 days after planting) • Hand weeding twice during 30-45 days and 60-75 days • Application of pre emergent herbicide oxyflourfen @ 0.2kg/ha (Either of the above can be adopted) •
Insect pests and diseases	• Follow common cultural, mechanical and biological practices. **<u>Cultural control:</u>** • Use of pests and diseases free planting material • Storing the stems in a vertical position under shade. • Destroy infested stems **<u>Biological control:</u>** • Incorporate 1kg of *Trichoderma* enriched .farm yard manure(FYM) per plant (10^7 cfu/g of FYM)...............
Vegetative stage	
	<u>Common cultural practices:</u> • Field sanitation (Freequent weeding), removal of infected/ infested plants • Provide irrigation at critical stages of the crop (Water requirement is 3mm/day. Provide half to one ltre water per plant during summer monthsAvoid water logging • Judicious use of fertilizers as mentioned above **<u>Common mechanical practices:</u>** • Use yellow sticky traps @ 4-5 trap/acre **<u>Common biological practices:</u>** • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies
Nutrient	• In general, fertilizers may be applied as mentioned in (General recommendation of NPK @100:50:100 kg NPK+FYM@12.5 t/ha) (Table 1)NPK based on soil test report of soil organic carbon, soil available P and K can be given as per Table 2 • Otherwise, if the N,P,K content of the soil is found high , apply 75% of the POP, if medium, apply the rate as per POP and if low apply 25% more of POP. • Apply full P at the time of land preparation • Half N and half K within 15 days of sett sprouting • Remaining half N and half K within 45 days of first application (see Table 1,2,3)

	• If *Azospirillum* and *Phosphobacterium* is used, the dose of N and P can be reduced to 50% • They are applied @ 5g each per plant within one week of sprouting the setts • A time gap of 5-10days is given between fertilizer and biofertilizer application
Weed	• If weed control ground cover mulch (the same sheet can be used for five consecutive seasons) is used, it will take care of the weed management till harvest • Other weed control measures as mentioned above also can be adopted
Whitefly	• Follow common cultural, mechanical and biological practices. **Cultural control:** • Remove alternate host **Mechanical control:** • Use yellow sticky traps @ 4-5 traps / acre **Biological methods:** • Conserve and augment biocontrol agents. • Spray 0.5% Neem oil.
Red spider mites	• Follow common cultural, mechanical and biological practices **Cultural control:** • Regular field monitoring for pest and defender population. Use sprinkler irrigation **Biological control:** • Conserve and augment biocontrol agents. • Spray 0.5% neem oil formulation (Eg. ICAR-CTCRI developed biopesticide *Nanma*) .
Mealybug	• Follow common cultural, mechanical and biological practices **Cultural control:** • Monitoring to detect early presence of the mealy bug. • Pruning and burning of infested branches. • Removal of weeds/alternate host plants .. • .Prevention of the movement of ants and destruction of already existing ant colonies. • Cleaning of farm implements before moving it to the uninfested crop. **Biological control:** • Conserve and augment biocontrol agents.
Scale insects	• Follow common cultural, mechanical and biological practices

	Cultural control: • Initiate control measures during early stages of pest infestation. **Biological control:** • Spraying of 0.5% of neem oil formulations.
Cassava mosaic disease	• Using virus free healthy planting material • Removal of infected stems left out in the field to avoid source of inoculums • Using CMD resistant variety, Sree Padmanabha
Brown leaf spot	• Field sanitation • Crop rotation • Spraying mancozeb 0.2% after the first appearance of the symptom three times at fortnight interval.
Tuber initiation	
Nutrient	• In laterite and red soils, $MgSO_4$ @ 20kg/ha, ZnSO4 @ 12.5 kg/ha and Borax @ 10 kg/ha can be applied after 2 months of planting cassava, • In saline and calcareous soils of Tamil Nadu, lime induced Fe chlorosis can be corrected by foliar application of 1% ferrous sulphate along with 1% Zinc sulphate • Is any S deficiency is noted apply S@10-20 kg/ha S as elemental S or gypsum or use of sulphur containing fertilizers like ammonium sulphate, single super phosphate or potassium sulphate • For soil test based application of Mg, Zn and B (see Table 1,2,3)
Weed	• Keep the field weed free. As described above
Whitefly	• Follow common cultural, mechanical, biological methods
Termites	• Follow common cultural, mechanical, biological methods **Cultural control:** • Apply well rotten FYM only to discourage termite infestation. • Use of crude oil emulsion to destroy the termite colony in the termatorium. **Mechanical control:** • Dismantle termitaria (termite mounds) around field and kill the termite queen. **Biological control:** • Spray Entomopathogenic nematodes (EPN)
Tuber development stage	
Cassava tuber rot	• Removal of infected tubers • Deep ploughing with chisel plough

	• Ridge planting • Good drainage and controlled irrigation • Soil application of neem cake, and *Trichoderma viride* • Follow common cultural, mechanical and biological practices

Note: The dosages of pesticides use are based on high volume sprayer

Table 1 Fertilizer schedule for cassava

Sl. No.	Name of Fertilizer	I application (kg/ha)	II Application (kg/ha)	Remarks
1.	Urea	100	110	Either of the four schedule can be used depending upon the availability
2.	Mussooriephos/Rajphos	250	-	
3.	Muriate of Potash (MOP)	85	85	
		OR		
1.	Urea	100	100	
2.	Single super phosphate	300	-	
3.	Muriate of Potash (MOP)	85	85	
		OR		
1.	Urea	65	110	
2.	Di ammonium phosphate	110	-	
3.	Muriate of Potash (MOP)	85	85	
		OR	110	
1.	Urea	-		
2.	Ammonium phosphate/ Factomphos	250	-	
3.	Muriate of Potash (MOP)	85	85	

Table 2. Chart to be used to arrive at the soil test based fertilizer recommendation for cassava

Organic carbon (clayey/loamy soil) (%)	Sandy	Recommendation of N as % of general (POP) recommendation	Available P (kg/ha)	Exchangeable K (kg/ha)	Recommendation of P and K as % of general (POP) recommendation	Remarks
0.00-0.16	**0.00-0.10**	**128**	**0.0-3.0**	**0-35**	**128**	**Soil test based N, P,K recommendation will be percentage of the existing POP based on soil test result of organic Carbon, available P and K**
0.17-0.33	0.11-0.20	117	3.1-6.5	36-75	117	
0.34-0.50	0.21-0.30	106	6.6-10.0	76-115	106	
0.51-0.75	0.31-0.45	97	10.1-13.5	116-155	94	
0.76-1.00	0.46-0.60	91	13.6-17.0	156-195	83	
1.01-1.25	0.61-0.75	84	17.1-20.5	196-235	71	
1.26-1.50	0.76-0.90	78	20.6-24.0	236-275	60	
1.51-1.83	0.91-1.10	71	24.1-27.5	276-315	48	
1.84-2.16	1.11-1.30	63	27.6-31.0	316-355	37	
2.17-2.50	1.31-1.50	54	31.1-34.5	356-395	25	

Table 3. Rate of application of Mg, Zn and B based on soil test data

Mg		Zn		B	
Status (meq $100g^{-1}$)	**Rate (kg ha^{-1})**	**Status (ppm)**	**Rate (kg ha^{-1})**	**Status (ppm)**	**Rate (kg ha^{-1})**
0-0.25	**20**	**<0.2**	**12.5**	**<0.2**	**10**
0.25-0.50	**15**	**0.2-0.3**	**10**	**0.2-0.5**	**7.5**
0.50-0.75	**10**	**0.3-0.4**	**7.5**	**0.5-1.0**	**5**
0.75-1.00	**5**	**0.4-0.6**	**5**	**1-2**	**2.5**
>1.00	**2.5**	**>0.6**	**2.5**	**>2**	**0**

VI. INSECTICIDE RESISTANCE AND ITS MANAGEMENT

Insecticide resistance: Resistance to insecticides may be defined as 'a heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species' (IRAC). Cross-resistance occurs when resistance to one insecticide confers resistance to another insecticide, even where the insect has not been exposed to the latter product.

Causes of resistance development: The causes and rate at which insecticide resistance develops depend on several factors, including the initial frequency of resistance alleles present in the population, how rapidly the insects reproduce, the insects' level of resistance, the migration and host range of the insects, the insecticide's persistence and specificity, and the rate, timing and number of applications of insecticide made. For instance, insect pests that survive in large populations and breed quickly are at greater advantage of evolving insecticide, especially when insecticides are misused or over-used.

General strategy for insecticide resistance management: The best strategy to avoid insecticide resistance is prevention and including insecticide resistance management tactics as part of a larger integrated pest management (IPM) approach.

1) **Monitor pests:** Monitor insect population development in fields to determine if and when control measures are warranted. Monitor and consider natural enemies when making control decisions. After treatment, continue monitoring to assess pest populations and their control.
2) **Focus on AESA.** Insecticides should be used only as a last resort when all other non-chemical management options are exhausted and P: D ratio is above 2: 1. Apply biopesticides/chemical insecticides judiciously after observing unfavourable P: D ratio and when the pests are in most vulnerable life stage. Use application rates and intervals as per label claim.
3) **Ecological engineering for pest management:** Flowering plants that attract natural enemies as well as plants that repel pests can be grown as border/intercrop.
4) **Take an integrated approach to managing pests.** Use as many different control measures as possible viz., cultural, mechanical, physical, biological etc. Select insecticides with care and consider the impact on future pest populations and the environment. Avoid broad-spectrum insecticides when a narrow-spectrum or more specific insecticide will work. More preference should be given to green labeled insecticides.
5) **Mix and apply carefully.** While applying insecticides care should be taken for proper application of insecticides in terms of dose, volume, timing, coverage, application techniques as per label claim.
6) **Alternate different insecticide classes.** Avoid the repeated use of the same insecticide, insecticides in the same chemical class, or insecticides in different classes with same mode of action and rotate/alternate insecticide classes and modes of action.
7) **Preserve susceptible genes.** Preserve susceptible individuals within the target population by providing unsprayed areas within treated fields, adjacent "refuge" fields, or habitat attractions within a treated field that facilitate immigration. These susceptible individuals may outcompete and interbreed with resistant individuals, diluting the resistant genes and therefore the impact of resistance.

VII. NUTRITIONAL DISORDERS

Common nutritional disorders noticed in cassava is attached below:

N deficiency: Stunted growth, yellowing and drying of the older leaves

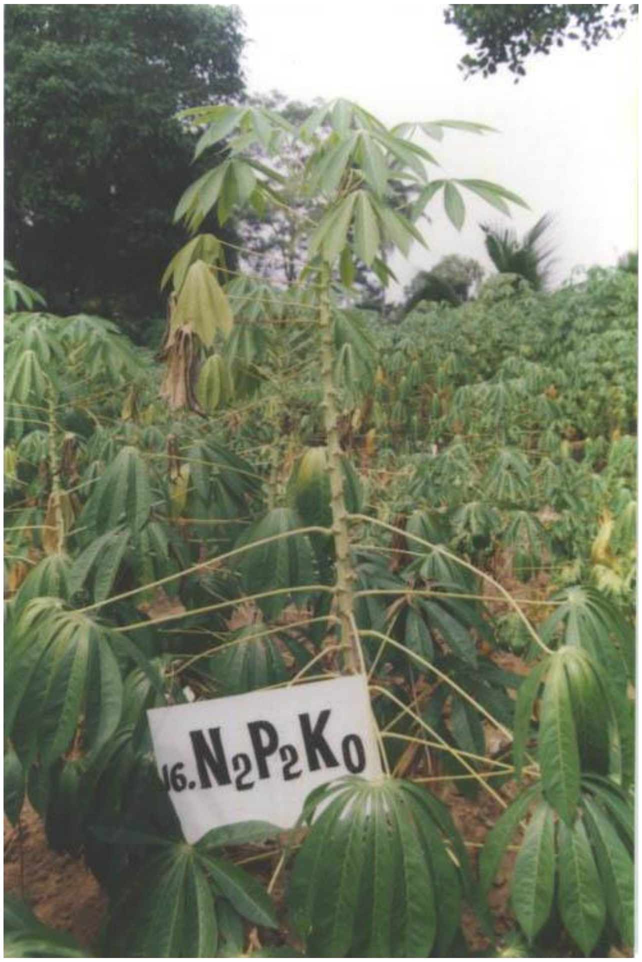
K deficiency: Curling inward and cupping of the lower leaves followed by drying and fall off

Ca deficiency: Tip of younger leaves becoming obtuse instead of pointed tips

Mg deficiency: Interveinal chlorosis of the lower leaves

S deficiency: Younger leaves becoming pale yellow

Lime induced iron chlorosis in saline and calcareous soils: Pale interveinal chlorosis of the entire leaves of the plant



Imbalanced plant nutrition: Leaves in the middle of the plant shed, remaining leaves dry and fall and the plants dry off

B deficiency: Broom like appearance of the plant at the tip

VIII. COMMON WEEDS

1. Spiny amaranth: *Amaranthus spinosus* L. (Amaranthaceae)

2. Common purselane: *Portulaca oleracea* L. (Portualacaceae)

3 Red spiderling: *Boerhavia diffusa* L. (Nyctaginaceae)

4. Benghal dayflower: *Commelina benghalensis* L. (Commelinaceae)

5. Goat weed: *Ageratum conyzoides* L. (Asteraceae)

6. Coat buttons: *Tridax procumbens* L. (Asteraceae)

7. Crowfoot grass: *Dactyloctenium agegyptium* L. (Poaceae)

8. Congon grass: *Imperata cylindrica* L. (Poaceae)

9. Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)

10. Flat sedge: *Cyperus iria* L. (Cyperaceae)

IX. DESCRIPTION OF INSECT AND MITE PESTS

1. Spiralling Whitefly:

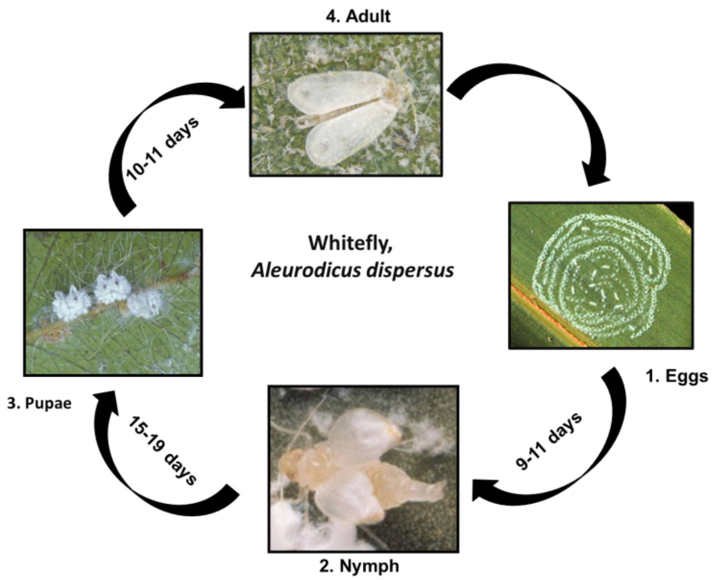
<u>Biology:</u>

Egg: Eggs are tiny, elliptical, smooth surfaced, yellow to tan coloured seen usually at the under surface of the leaf in a spiralling manner and , covered by waxy coating.

Nymph: Each egg hatches into a tiny active crawler, roughly the same size as the egg. This crawler moves out over the foliage of the host plant and then transforms into, sedentary (nymph) stage and sucks nutrients from the leaves. Nymph have waxy tufts and the final larval stage (pupa) has glass like rods of wax along the sides of the body.

Pupa: The final and fourth immature stage is considered the pupa of this species. This stage feeds during the earlier phases then stops feeding and undergoes internal tissue reorganization before molting into the adult.

Adult: The adults are white and quite small in length and coated with a fine dust-like waxy secretion. They are most active during the morning hours.



Damage symptoms:

- Chlorotic spots on the leaves which latter coalesce forming irregular yellowing of leaf tissue
- Severe infestation results in premature defoliation
- Development of sooty mould

*For the management refer page no……….

2. Scale insect

Biology:

Found mainly on tapioca stem surfaces.

Egg: Eggs are laid beneath the scales. The eggs hatch in 3-4 days.

Nymph: In 20-25 days the immature stages are fully grown. The first-instar crawlers are the primary dispersal stage and walk to new areas of the plant or are dispersed by wind or animal contact. Mortality due to abiotic factors is high in this stage. There are two immature instars in the female and four in the male (including non-feeding pre-pupal and pupal stages).

Adult: The adult produces a white waxy secretion over itself which develops into a scale. In 20-25 days the nymphs become full grown. The male is winged and the female is wingless and sedentary.

The females are wingless, firmly attached to the stems, and covered with white material. The males have wings. Method of spread: Males of the tapioca white scale can fly. However, the pest spreads mainly by wind and the transport and planting of infested stem cuttings.

Reproduction is sexual. The sessile females mate with winged males, and begin to lay eggs approximately 2 days after reaching maturity

Damage symptoms:

- *A. albus* coats the stems, side shoots and even sometimes the leaf petioles and leaf undersides.
- Infestation in the field occurs in patches around a cutting that was infested at planting.
- Heavy infestation causes desiccation of the stems, making them become thin and weak so that they often break in the wind; death of the plant may result.
- The breakage of stems leads to profuse branching so infested plants often appear bushy.
- Tuber development in infested plants is poor, and the tuber become unpalatable

Damage symptoms

http://www.rfpp.ethz.ch/fellowships/concluded_fellowships/africanrootandtuberscale/Fotso2.jpg?hires
http://agritech.tnau.ac.in/govt_schemes_services/aas/tapioca_ex.html

*For the management refer page no……….

3. Red spider mite

Biology:

Egg: The egg is smooth, plain and elliptical. Newly laid eggs are shiny bright orange.

Nymph: The newly-hatched larva is bright red-orange and ovoid. It can be identified through its three pairs of short stout legs, the first two pairs positioned anteriorly. Mated females lay eggs for both sexes whereas the unmated ones produce only male eggs. Incubation period is 1-3 days. Egg hatchability is 97%.

Adult: The adult is similar to the deutonymph but bigger and the dorsal spots are brighter. The legs and chelicerae are distinct. The preoviposition period lasts one to two days. The adult female can lay an average of 43 eggs in 20 days.

The total developmental period (egg to adult) is about two weeks. The male to female ratio of the progenies of the mated females is 1.0:2.82. Adult males have shorter life span (18 days) than females (21 days).

Life cycle:

Damage symptoms:

- Mites suck the sap from leaves and cause leaf deformation, with a rough, thickened and shrivelled appearance.
- The back of the leaf may appear scorched (turn yellowish brown) and dotted with inconspicuous whitish feeding punctures.
- During heavy infestation stunting occurs.

Damage symptom

http://www.infonet-biovision.org/default/images/74/pests

Predators: Ladybird beetles, phytoseiid mites such as *Amblysieus linearis* and *A. longispinosus*

*For the management refer page no……….

4. Mealybug:

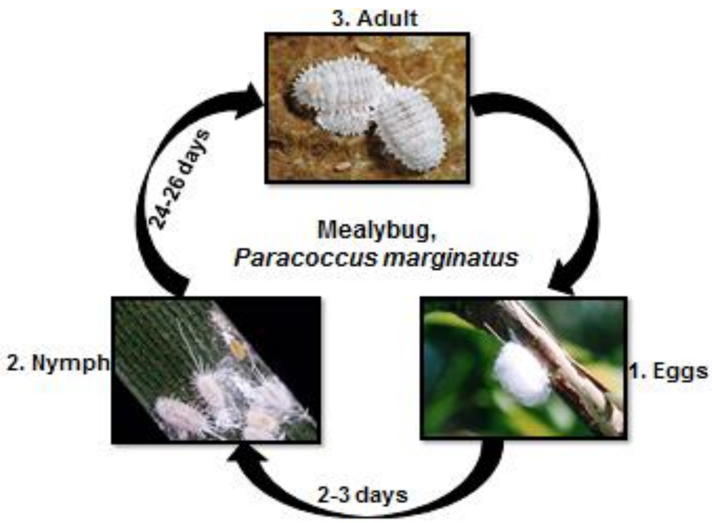
Biology:

Eggs: Females lay their eggs directly on the host in a fluted ovisac that is attached to the body of the adult female.

Nymphs: The first instar nymphs (crawlers) are mobile. They settle on the plants, start sucking the sap and form the colonies

Adults: In general they have 4 female instars and 5 male instars, but unlike most other scale insects, the prepupa is quite mobile and although it may have wing buds, the legs and antennae are well developed**.**.

Life cycle:



1,2. http://mrec.ifas.ufl.edu/lso/mealybugs.htm
3. http://www.nbair.res.in/Introductions/Insects/Invasives/paracoccus2.jpg

Damage symptoms:

- Nymphs and adults sucks the sap from tapioca leaves, petiole and stem
- Reduction in lengths of internodes and causes the leaves to clump together into "bunchy tops".
- The pest also distorts the stems, dries up the leaves.
- Defoliation of plants at severe infestation.
- The damage is more severe in the dry than in the wet season.

Tapioca leaves damaged by mealybug

Natural enemies of mealybug:

Predators: *Cryptolaemus montrouzieri*, lacewings, hover flies *Scymnus* sp., *Spalgis epius,*

Parasitoids: *Anagyrus* sp.,

*For the management refer page no……….

5. Termites

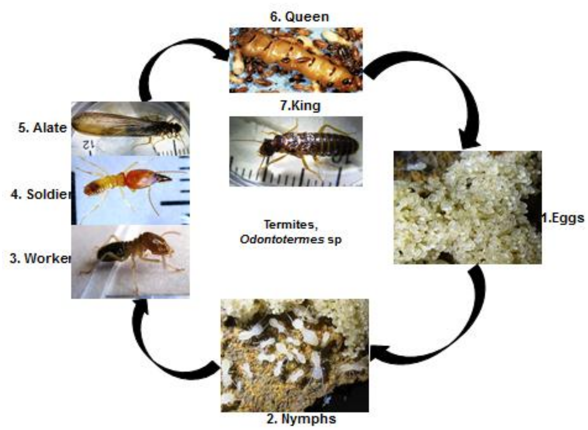
Biology:

Egg: Eggs are dull; kidney shaped and hatches in 30-90 days.

Nymph: Nymphs moult 8-9 times and are full grown in 6-12 months.

Adult: Adult creamy coloured tiny insects resembling ants with dark coloured head.

Life cycle:



http://www.termitenewyorkcity.com/more-about-termites/life-cycle/

Damage symptoms:

- Affected stem cuttings grow poorly, die and rot.
- This weakens the stems and causes them to break easily.
- Termite damage occurs mostly in the dry season.

Tapioca stem cutting destroyed by termites and Stem of a mature tapioca plant chewed

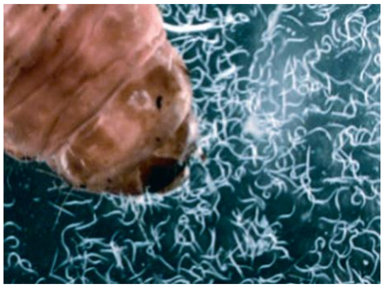
off by termites

http://agritech.tnau.ac.in/govt_schemes_services/aas/tapioca_ex.html

Biological control of termites through EPNs:

The infective juveniles (IJ) of EPN emerge from cadaver, search for termites, infect, kill and again multiply and remain in the moist soil.. EPN can be produced even at farmer level using either Galleria or Corcyra as a host.

Mass multiplication of EPNs



Emergence of EPNs

Termite killed by EPNs

*For management refer to page number

X. DESCRIPTION OF DISEASES

1. *Cassava mosaic disease*:

Disease symptoms:

- White or pale-yellow or pale-green patches on infected leaves.
- Leaves often twisted, distorted, and stunted.
- The leaflets have localized mosaic pattern.
- Heavily infected plant is distorted, retarded, and dwarfed.
- Whitefly (*Bemisia tabaci*) is the carrier of the virus and transmission is through their feeding habits.

Leaves infected with *Cassava mosaic virus* exhibit bright yellow patches

Survival and spread:

- The severity of cassava mosaic disease is influenced by environmental factors such as wind, rainfall, plant density and temperature.
- The viruses are transmitted through infected cuttings and by whitefly and the spread of the virus largely dependent on the vector population

Favourable conditions:

Vector-preferred temperature estimates vary from 27°C to 32°C but generally high temperatures associated with high fecundity, rapid development, and greater longevity.

*For the management refer page no……….

2. Brown leaf spot

Disease symptoms:

- The disease is caused by the fungus *Cercospora henningsii.* The symptoms of the disease appear on the leaves, On the leaves, the disease appears as Small brown coloured necrotic spots surrounded by yellow halo
- The damaged leaves do not become distorted in shape as occurs with leaves damaged by cassava mosaic disease.
- In severe cases abnormal leaf fall occurs

1. Cassava leaves with brown spot

Survival and spread:

The pathogen survives in the debris which will be carried over to next season. The pathogen spreads through air within the season

Favourable conditions:

- Disease emergence favored by high temperature and humidity

*For the management refer page no……….

3. Cassava tuber Rot Disease:

Disease symptoms:

- Cassava root rot diseases are caused by the fungus *Phytophthora palmivora* in the soil.
- In poorly drained soils, where there is a prolong wet period, the damage caused by these microorganisms may be greater.
- There is no external symptom. When uproots the tuber only we could see the symptom
- The symptom starts as small water soaked brown lesions in tuber , as the disease advances it cover the entire tuber . Finally the tuber will rotten and exhibit foul smell

- .

Tuber rot of Cassava

Survival and spread:

- The disease spreads by water to new cassava roots.
- Infected plant debris serve as a primary source of inoculum.
- The pathogens may also be transmitted through wounds caused by pests or farming tools.

Favourable conditions:

- Tuber rot disease emergence is often favoured by waterlogged, poorly-drained soils

*For the management refer page no……….

XI. SAFETY MEASURES

A. At the time of harvest:

Harvesting is still generally a manual operation, although equipment to facilitate this operation is being considered. The day before harvesting, the plants are topped—the stalks are cut off manually 40 to 60 cm above ground or by using a machete or machine and piled at the side of the field. The 40 to 60 cm length of stalk is left as a handle for pulling the tubers from the soil. Material required for the next planting is selected and the rest is burned. In light soils the tubers are slowly drawn from the soil by the stems or with the help of a kind of crowbar, and the tubers are cut off the stock. In heavier soils a hoe may be required to dig up the tubers before the plants are pulled out. It must be noted that once the plants have been topped, the roots must be lifted without delay or they will sprout and the starch content will fall drastically.

Because of the way the tubers grow, cassava is not a crop that readily lends itself to mechanical harvesting. The tubers may spread over 1 m and penetrate the soil 50 to 60 cm deep. If care is not taken when machinery is used during harvesting, the tubers may be damaged and may darken as a result of oxidation. This will lower the value of the flour produced. Mouldboard ploughs can be used to make hand-harvesting less tedious. Stalks can be successfully cut by means of a mid-mounted mower or a topping machine, and the tubers must be mechanically lifted with a mid-mounted disk tracer. A modified beet or potato harvester has been suggested for use behind the tractor, with a pulling mechanism instead of the digging shares to raise the tubers by the cut stems left after the topping process.

B. During post-harvest storage:

In the processing of cassava starch it is vital to complete the whole process within the shortest time possible, because as soon as the tubers have been dug up, and also during each of the subsequent stages of manufacture, enzymatic processes tend to have a deteriorating effect on the quality of the end-product. This will require a well-organised supply of tubers within a relatively short distance of the processing plant, and the stages of processing will have to be scheduled so as to minimise delays in manufacturing. Thus, while basic in principle, the production of good-quality cassava flour still requires great care. The tubers are normally received from the field as soon as possible after harvest and cannot be stored for more than two days. Since the presence of woody matter or stones may seriously interfere with the rasping process by causing stoppages or by breaking the blades, the woody ends of the tubers are chopped off with sharp knives before the processing operations begin.

Peeling and washing: In small and medium-sized mills the general practice is to remove the peel (skin and cortex) and to process only the central part of the tuber, which has a much softer texture. With the relatively primitive apparatus available and limited power, the processing of the whole tuber would entail difficulties in rasping and in removing dirt, crude fibre and cork particles, while comparatively little extra starch would be gained. The roots are longitudinally and transversely cut to a depth corresponding to the thickness of the peel, which can then be easily removed. Any dirt remaining on the smooth surface of the core of the tuber can be washed off without any trouble and the peeled tubers can be deposited in cement basins where they will remain immersed in river water until taken out for rasping. In the larger factories, whole tubers are generally processed. The washing here serves to remove the outer skin of the tubers as well as the adhering dirt. Provided the tubers are sufficiently ripe, the skin may be removed without the use of brushes. Only the outer skin or corky layer is removed, as it is profitable to recover the starch from the cortex. The inner part of the peel represents about 8% to 15% of the weight of the tuber.

Rasping and pulping: One has to rupture all the cell walls in order to release the starch granules. This can be done by biochemical or mechanical action. The biochemical method, an old one, allows the tubers to ferment to a certain stage. Then the roots are pounded to a pulp from which the starch is washed with water. This method does not give complete yields and the quality of the resulting starch is inferior. Mechanical action requires the roots to be and then rasped, grated or crushed, which tears the flesh into a fine pulp. By pressing the tuber against a swiftly moving surface provided with sharp protrusions, the cell walls are torn up and the whole of the tuber is turned into a mass into which the greater part, but not all, of the starch granules is released. The percentage of starch set free is called the rasping effect. Its value after one rasping may vary between 70% and 90%. The efficiency of the rasping operation therefore to a large extent determines the overall yield of starch in the processing. It is difficult to remove all the starch in a single operation, even with efficient rasping devices. Therefore, the pulp is sometimes subjected to a second rasping process after screening. The rasping is carried out in different ways and with varying degrees of efficiency.

Hand and mechanical rasping: On tiny smallholdings in some cassava-growing regions, the tubers are still rasped by hand on bamboo mats. Where daily production amounts to several hundred kilograms of flour, basic mechanical implements are used.

XII. 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 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 monocroping.
3.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
4	Sow early in the season	Avoid late sowing as this may lead to reduced yields and incidence of white grubs and diseases.
5	Always treat the seeds with approved biopesticides / chemicals for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with biopesticides/ chemicals.
6.	Sow in rows at optimum depths under proper moisture conditions for better establishment.	Do not sow seeds beyond 5-7 cm depth.
7.	Apply only recommended herbicides 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.
8.	Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition	Crops should not be exposed to moisture deficit stress at their critical growth stages.
9	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
10	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
11	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: D ratio
12	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).

13	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per field observation	Do not apply chemical pesticides within seven days of release of parasitoids.
14	Apply HaNPV or SlNPV at recommended dose when a large number of egg masses and early instar larvae are noticed. Apply NPV only in the evening hours after 5 pm.	Do not apply NPV on late instar larva and during day time.
15	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
16	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.

XIII. Safety parameters in pesticide usage

S. No	Pesticide classification as per insecticide rules 1971 Colour of toxicity triangle	WHO classification of hazard	Symptoms of poisoning	First aid measures and treatment of poisoning	Safety interval (days)
Fungicide					
1	Mancozeb Slightly toxic 	Unlikely produce acute hazard	Headache, palpitation, nausea, vomiting, flushed face, irritation of nose,throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic	10

XIV. BASIC PRECAUTIONS IN PESTICIDES USAGE

A. Purchase

1. Purchase only just required quantity e.g. 100, 250, 500, 1000 g/ml for single application in specified area.
2. **Do not** purchase leaking containers, loose, unsealed or torn bags; **Do not** purchase pesticides without proper/approved labels.
3. While purchasing insist for invoice/bill/cash memo

B. Storage

1. Avoid storage of pesticides in house premises.
2. Keep only in original container with intact seal.
3. **Do not** transfer pesticides to other containers; **Do not** expose to sunlight or rain water; **Do not** store weedicides along with other pesticides.
4. Never keep them together with food or feed/fodder.
5. Keep away from reach of children and livestock.

C. Handling

1. Never carry/ transport pesticides along with food materials.
2. Avoid carrying bulk pesticides (dust/granules) on head shoulders or on the back.

D. Precautions for preparing spray solution

1. Use clean water.
2. Always protect your nose, eyes, mouth, ears and hands.
3. Use hand gloves, face mask and cover your head with cap.
4. Use polythene bags as hand gloves, handkerchiefs or piece of clean cloth as mask and a cap or towel to cover the head (Do not use polythene bag contaminated with pesticides).
5. Read the label on the container before preparing spray solution.
6. Prepare the spray solution as per requirement
7. **Do not** mix granules with water; **Do not** eat, drink, smoke or chew while preparing solution
8. Concentrated pesticides must not fall on hands etc while opening sealed container. Do not smell pesticides.
9. Avoid spilling of pesticides while filling the sprayer tank.
10. The operator should protect his bare feet and hands with polythene bags

E. Equipments

1. Select right kind of equipment.
2. Do not use leaky and defective equipments
3. Select right kind of nozzles
4. Don't blow/clean clogged nozzle with mouth. Use old tooth brush tied with the sprayer and clean with water.
5. Do not use same sprayer for weedicide and insecticide.

F. Precautions for applying pesticides

1. Apply only at recommended dose and dilution
2. **Do not** apply on hot sunny day or strong windy condition; **Do not** apply just before the rains and after the rains; apply against the windy direction.
3. Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer

4. Wash the sprayer and buckets etc with soap water after spraying
5. Containers buckets etc used for mixing pesticides should not be used for domestic purpose
6. Avoid entry of animals and workers in the field immediately after spraying

G. Disposal

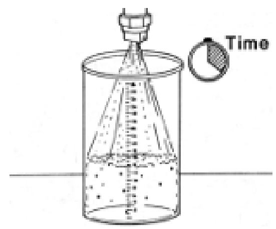
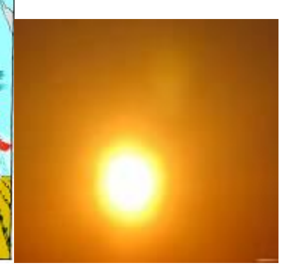
1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

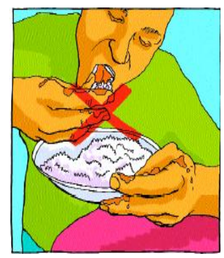
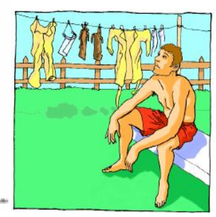
XV. PESTICIDE APPLICATION TECHNIQUES

		Equipment	
Category A: Stationary, crawling pest/ disease			
Vegetative stage i) for crawling and soil borne pests ii) for small sucking leaf borne pests	Insecticides and fungicides	• Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min ***or*** • Motorized knapsack sprayer or mist blower (Droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle	 
Reproductive stage	Insecticides and fungicides	• Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min	
Category B: Field Flying pest/ airborne pest			
Vegetative stage	Insecticides and fungicides	• Motorized knapsack sprayer or mist blower (Droplets of small size)	

Reproductive stage *(Field Pests)*		• Airblast nozzle • Operating speed: 2/3rd throttle ***Or*** • Battery operated low volume sprayer (Droplets of small size) Spinning disc nozzle	 
Mosquito/ locust and spatial application *(migratory* Pests)	Insecticides and fungicides	• Fogging machine and ENV (Exhaust nozzle vehicle) (Droplets of very small size) • Hot tube nozzle	 
Category C: Weeds			
Post-emergence application	Weedicide	• Lever operated knapsack sprayer (Droplets of big size) • Flat fan or floodjet nozzle @ 15 to 20 psi • Lever operating speed = 7 to 10 strokes/min	    
Pre-emergence application	Weedicide	• Trolley mounted low volume sprayer (Droplets of small size) • Battery operated low volume sprayer (Droplets of small size)	  

XVI. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

1.	For application rate and dosage see the label and leaflet of the particular pesticide.	 
2.	It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.	 
3.	Clean and wash the machines and nozzles and store in dry place after use.	  
4.	It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides.	 
5.	Do not apply in hot or windy conditions.	 

6.	Operator should maintain normal walking speed while undertaking application.	
7.	Do not smoke, chew or eat while undertaking the spraying operation	   
8.	Operator should take proper bath with soap after completing spraying	  
9.	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

XVII REFERENCES

- http://en.wikipedia.org/wiki/Cassava
- http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insect_veg_Tapioca.html
- http://agritech.tnau.ac.in/crop_protection/crop_prot_crop%20diseases_veg_cassava.html
- https://www.plantvillage.com/en/topics/cassava-manioc/infos/diseases_and_pests_description_uses_propagation
- http://upload.wikimedia.org/wikipedia/commons/9/99/Iwata_kenichi_cassava.jpg
- https://mallar.files.wordpress.com/2012/01/tapioca.jpg
- http://www.cardi.org/cfc-rt/files/downloads/2012/08/PESTS-AND-DISEASES-OF-CASSAVA-2-3.pdf
- https://www.plantvillage.com/en/topics/cassava-manioc/infos/diseases_and_pests_description_uses_propagation
- http://ciat-library.ciat.cgiar.org/articulos_ciat/proceedings_workshop_02/264.pdf
- http://www.cabi.org/isc/datasheet/5854
- http://www.ripublication.com/ijafst_spl/ijafstv4n2spl_05.pdf
- http://www.apsnet.org/publications/imageresources/Pages/Cassavaleaves.aspx
- http://www.extento.hawaii.edu/Kbase/crop/type/a_disper.htm#BIOLOGY
- http://www.infonet-biovision.org/default/ct/114/crops#_1770_1466
- http://agritech.tnau.ac.in/govt_schemes_services/aas/tapioca_ex.html
- http://en.wikipedia.org/wiki/Cassava_mosaic_virus
- http://www.apsnet.org/publications/apsnetfeatures/Pages/cassava.aspx
- http://www.infonet-biovision.org/default/ct/114/crops
- http://ctcritools.in/cassavaexpert/bls.php
- http://www.cassavabiz.org/production/proddocs/Disease%20control.pdf
- http://ctcritools.in/cassavaexpert/literature/castat.pdf
- http://www.infonet-biovision.org/default/ct/114/crops
- https://www.plantvillage.com/en/topics/cassava-manioc/infos/diseases_and_pests_description_uses_propagation
- http://www.icargoa.res.in/dss/cassava.html
- APHU (2010). Package of practices of important Horticultural Crops. Venkataramannagudem, West Godavari District – 534 101 (A.P.).
- Naidu, V.S.G.R. 2012, *Hand Book on Weed Identification.* Directorate of Weed Science Research, Jabalpur, India Pp 354
- http://agritech.tnau.ac.in/horticulture/horti_vegetables_tapioca.html
- http://agropedia.iitk.ac.in/content/tapioca
- https://d3an9inho3qicd.cloudfront.net/images/pics/000/062/346/large/7676928300_034982bdf6_o.jpg?1458331302
- https://d3an9inho3qicd.cloudfront.net/images/pics/000/001/098/large/Root_rot_3.jpg?1375900967
- https://d3an9inho3qicd.cloudfront.net/images/pics/000/001/096/large/Root_rot_1.jpg?1375900892
- http://images.bugwood.org/images/192x128/1570296.jpg
- http://www.primejournal.org/PRB/pdf/2012/july/Jolly%20and%20Ashwani.pdf