सत्यमेव जयते

AESA BASED IPM Package

AESA based IPM – Tobacco

रा व स्वा प्र सं
NIPHM

National Institute of Plant Health Management
Rajendranagar, Hyderabad, Telangana

Directorate of Plant Protection Quarantine and Storage
N. H. IV, Faridabad, Haryana

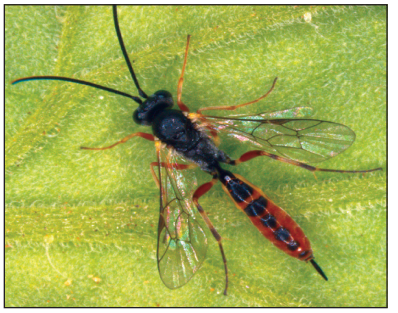
NCIPM

National Centre for Integrated Pest Management
LBS Building, IARI Campus, New Delhi

Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

Important Natural Enemies of Tobacco Insect Pests

Parasitoids



***Campoletis* sp**

***Trichogramma* spp.**

***Bracon* spp.**

***Carcelia* sp**

***Ichneumon* sp**

***Chelonus* sp**

Predators

Lacewing

Ladybird beetle

Spider

Dragonfly

Reduviid bug

Praying mantis

The AESA based IPM - Tobacco, was compiled by the NIPHM working group under the chairmanship of Dr. Satyagopal Korlapati, IAS, DG, 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.

NIPHM Working Group:

Chairman : **Dr. Satyagopal Korlapati,** IAS, Director General

Vice-Chairmen : **Dr. S.N. Sushil,** Plant Protection Advisor

: **Dr. P. Jeyakumar,** Director (PHM)

Core Members:

1. Er. G. Shankar, Joint Director (PHE), Pesticide Application Techniques Expertise
2. Dr. O.P. Sharma, Joint Director (A & AM), Agronomy Expertise
3. Dr. Satish Kumar Sain, Assistant Director (PHM), Plant Pathology Expertise
4. Dr. Dhana Raj Boina, Assistant Director (PHM), Entomology Expertise
5. Sri. D. Chattopadhyay, Assistant Director (PHM), Pathology Expertise

Other members:

6. Dr. B.S. Sunanda, Assistant Scientific Officer (PHM), Nematology Expertise

Contributions by DPPQ&S Experts:

1. Shri. Ram Asre, Additional Plant Protection Advisor (IPM)
2. Dr. K.S. Kapoor, Deputy Director (Entomology)
3. Dr. Sanjay Arya, Deputy Director (Plant Pathology)
4. Dr. Subhash Kumar, Deputy Director (Weed Science)
5. Dr. C.S. Patni, Plant Protection Officer (Plant Pathology)

Contributions by NCIPM Experts:

1. Dr. C. Chattopadhyay, Director

Contributions by External Experts:

1. Dr. Ranjeet Ray, Univ. Professor (Ento.), Rajendra Agricultural University, Bihar
2. Dr. B.K. Shivanna, Associate Professor (Ento.), AINRP (Tobacco) ZARS, Navile, Shimoga
3. Dr. U. Sreedhar, Principal Scientist & Head, Division of Crop Protection, CTRI, Rajamundry
4. Dr. J.V. Prasad, Principal Scientist (Entomology), Division of Crop Protection, CTRI, Rajamundry
5. Dr. H. Raveendra, Professor (Nemetology), ZAHRS, Navile, Shimoga
6. Dr. A.Y. Thakare, Associate Professor (Ento.), Dr. PDKV, Akola
7. Dr. A.S. Halepyati, Professor of Agronomy, College of Agriculture, Raichur
8. Dr. M.B. Patil, Professor of Plant Pathology, College of Agriculture, Raichur
9. Dr. A.G. Sreenivas, Associate Professor (Ag. Entomology), College of Agriculture, Raichur

Citation Satyagopal, K., S.N. Sushil, P. Jeyakumar, G. Shankar, O.P. Sharma, S.K. Sain, D.R. Boina, D. Chattopadhyay, B.S. Sunanda, R. Asre, K.S. Kapoor, S. Arya, S. Kumar, C.S. Patni, C. Chattopadhyay, Ranjeet Ray, B.K. Shivanna, U. Sreedhar, J.V. Prasad, H. Raveendra, A.Y. Thakare, A.S. Halepyati, M.B. Patil, A.G. Sreenivas. 2014. AESA based IPM package for Tobacco. pp. 50.

Front cover picture Model AESA chart for tobacco

Back cover picture Tobacco field

Published by National Institute of Plant Health Management, Rajendranagar, Hyderabad – 500 030

Copies: 1000
For internal circulation only. Not for sale.

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

Printed at Balaji Scan Pvt. Ltd.,
AC Guards, Hyderabad.
Tel : 040-23303424, 25
balajiscan.com; bsplpress@gmail.com

अपर सचिव
भारत सरकार
कृषि मंत्रालय
(कृषि एंव सहकारिता विभाग)
कृषि भवन, नई दिल्ली - 110001

सत्यमेव जयते

Avinash K Srivastava
Additional Secretary
Government of India
Ministry of Agriculture
(Department of Agriculture & Cooperation)
Krishi Bhawan, New Delhi - 110 001

FOREWORD

Intensive agricultural practices relying heavily on chemical pesticides are a major cause of wide spread ecological imbalances resulting in serious problems of insecticide resistance, pest resurgence and pesticide residues. There is a growing awareness world over on the need for promoting environmentally sustainable agriculture practices.

Integrated Pest Management (IPM) is a globally accepted strategy for promoting sustainable agriculture. During last century, IPM relied substantially on economic threshold level and chemical pesticides driven approaches. However, since the late 1990s there is conscious shift to more ecologically sustainable Agro-Eco System Analysis (AESA) based IPM strategies. The AESA based IPM focuses on the relationship among various components of an agro-ecosystem with special focus on pest-defender dynamics, innate abilities of plant to compensate for the damages caused by the pests and the influence of abiotic factors on pest buildup. In addition, Ecological Engineering for pest management - a new paradigm to enhance the natural enemies of pests in an agro-ecosystem is being considered as an important strategy. The ecological approach stresses the need for relying on bio intensive strategies prior to use of chemical pesticides.

Sincere efforts have been made by resource personnel to incorporate ecologically based principles and field proven technologies for guidance of the extension officers to educate, motivate and guide the farmers to adopt AESA based IPM strategies, which are environmentally sustainable. I hope that the AESA based IPM packages will be relied upon by various stakeholders relating to Central and State government functionaries involved in extension and Scientists of SAUs and ICAR institutions in their endeavour to promote environmentally sustainable agriculture practices.

Date : 6.3.2014

(Avinash K. Srivastava)

अपर सचिव
भारत सरकार
कृषि मंत्रालय
(कृषि एंव सहकारिता विभाग)
कृषि भवन, नई दिल्ली - 110001

सत्यमेव जयते

Joint Secretary
Government of India
Ministry of Agriculture
(Department of Agriculture & Cooperation)
Krishi Bhawan, New Delhi - 110001

FOREWORD

IPM as a holistic approach of crop protection based on the integration of multiple strategies viz., cultural, physical, mechanical, biological, botanical and chemical. Over the years IPM underwent several changes, shifting its focus from damage boundary, economic injury to economic threshold. Currently most stake holders rely upon economic threshold levels (ETL) and tend to apply chemical pesticides at the first instance in the event of a pest attack, through Government of India has advocated need based and judicious application of chemicals. This approach is likely to cause adverse effects on agro-ecosystems and increase the cost of agricultural production due to problems of pest resurgence, insecticide resistance and sustainability.

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 NIPHM and DPPQ&S have made sincere efforts in revising IPM packages for different crops by incorporating agro-ecosystem analysis, ecological engineering, pesticide application techniques and other IPM options with the active cooperation of crop based plant protection scientists working in state Agricultural Universities and ICAR institutions. I hope this IPM package will serve as a ready reference for extension functionaries of Central / State Governments, NGOs and progressive farmers in adopting sustainable plant protection strategies by minimizing the dependence on chemical pesticides.

(Utpal Kumar Singh)

National Institute of Plant Health Management
Department of Agriculture & Cooperation
Ministry of Agriculture
Government of India

Dr. K. SATYAGOPAL, IAS
Director General
Telephone : +91-40-24015346,
E-mail : dgniphm@nic.in
Tele-Fax : +91-40-24015346

Rajendranagar
Hyderabad-500030
http://niphm.gov.in

PREFACE

Need for environmentally sustainable agricultural practices is recognised worldwide in view of the wide spread ecological imbalances caused by highly intensive agricultural systems. In order to address the adverse impacts of chemical pesticides on agro-ecosystems, Integrated Pest Management has evolved further from ETL based approach to Agro-ecosystem Analysis based Integrated Pest Management (IPM).

In AESA based IPM the whole agro-ecosystem, plant health at different stages, built-in-compensation abilities of the plant, pest and defender population dynamics, soil conditions, climatic factors and farmers' past experience are considered. In AESA, informed decisions are taken by farmers after field observation, AESA chart preparation followed by group discussion and decision making. Insect zoo is created to enable the farmer understand predation of pests by Natural Enemies. AESA based PHM also results in reduction of chemical pesticide usage and conserves the agro-ecosystems.

Ecological Engineering for Pest Management, a new paradigm, is gaining acceptance as a strategy for promoting Biointensive Integrated Pest Management. Ecological Engineering for Pest Management relies on cultural practices to effect habitat manipulation and enhance biological control. The strategies focus on pest management both below ground and above ground. There is growing need to integrate AESA based IPM and principles of ecological engineering for pest management.

There is a rising public concern about the potential adverse effects of chemical pesticides on the human health, environment and biodiversity. The intensity of these negative externalities, through cannot be eliminated altogether, can be minimized through development, dissemination and promotion of sustainable biointensive approaches.

Directorate of Plant Protection Quarantine and Storage (DPPQS), has developed IPM package of practices during 2001 and 2002. These packages are currently providing guidance to the Extension Officers in transferring IPM strategies to farmers. These IPM package of practices, have been revised incorporating the principles of AESA based IPM in detail and also the concept of Ecological Engineering for Pest Management. It is hoped that the suggested practices, which aim at enhancing biodiversity, biointensive strategies for pest management and promotion of plant health, will enable the farmers to take informed decisions based on experiential learning and it will also result in use of chemical pesticides only as a last resort & in a safe and judicious manner.

(K. SATYAGOPAL)

CONTENTS

AESA BASED IPM PACKAGE FOR TOBACCO

Tobacco plant description:

Tobacco, *Nicotiana tabacum* L. is an herbaceous annual or perennial plant in the family Solanaceae grown for its leaves. The tobacco plant has a thick, hairy stem and large, simple leaves which are oval in shape. The tobacco plant produces white, cream, pink or red flowers which grow in large clusters, are tubular in appearance and can reach 3.5-5.5 cm in length. Tobacco may reach 1.2-1.8 m (4-6 ft) in height and as is usually grown as an annual, surviving only one growing season. Tobacco may also be referred to as Viriginian tobacco or cultivated tobacco and originates from South America.

Tobacco is a traditional item of India's foreign trade. India is one of the leading tobacco exporting countries in the world. India accounts for 5.8% of the international trade and ranks 5th after Brazil, U.S.A, Turkey and Zimbabwe. The principal markets for Indian tobacco are U.S.S.R, U.K, Japan and the Middle East countries.

India ranks 4th in the total tobacco consumption in the world. But India's cigarette consumption ranks 11th in the world. Out of the total production, only 19% of the total consumption of tobacco is in the form of cigarette whereas 81% is in other forms like, chewing, bidi, snuff, gutka paste, Jarda, hookah paste etc.

Even though the cultivation of tobacco is spread all over the country, commercial cultivation of tobacco is concentrated in States like Andhra Pradesh, Karnataka, Gujarat, Maharashtra, Bihar, Tamil Nadu and West Bengal. Cigarette tobacco is mostly cultivated in Andhra Pradesh and Karnataka, Pradesh and Karnataka, Pradesh and Karnataka, whereas bidi tobacco is grown in Gujarat, Karnataka and Maharashtra. Cigar and cheroot tobacco are also grown in Tamil Nadu, Andhra Pradesh and West Bengal and chewing tobacco is grown in Tamil Nadu, Gujarat, Bihar, West Bengal and U.P. Hookah tobacco is grown in UP, and West Bengal.

Tobacco contains the alkaloid nicotine, a stimulant. Tobacco use is a risk factor for diseases affecting the heart, liver and lungs. According to the World Health Organization (WHO), tobacco is the single greatest cause of preventable death globally. The annual level for demand of cigarette in India remains the same at 96 billion sticks as it was 15 years ago, despite the cumulative growth in population by nearly 35 percent during the same period. However the consumption of tobacco has been a matter of national debate in view of the emerging anti tobacco drive in the country.

I. PESTS

A. Pests of National Significance

1. Insect Pests

1.1 Leaf eating caterpillar: ***Spodoptera litura*** Fab. (Lepidoptera: Noctuidae)

1.2 Whitefly: ***Bemisia tabaci*** Genn (Hemiptera: Aleyrodidae)

1.3 Stem borer: ***Scrobipalpa heliopa*** Low. (Lepidoptera: Gelechiidae)

1.4 Gram pod borer/bud worm/capsule borer: ***Helicoverpa armigera*** Hub. (Lepidoptera: Noctuidae)

1.5 Tobacco aphid: ***Myzus nicotianae*** Black (Hemiptera: Aphididae)

2. Diseases

2.1 Damping off: ***Pythium aphanidermatum*** (Edson) Fitzp, ***Pythium myriotylum*** Drechsler

2.2 Frog eye leaf spot: ***Cercospora nicotianae*** Ellis & Everh.

2.3 Leaf bight: ***Phytophthora parasitica*** var. ***nicotianae*** Breda de Haa

2.4 Anthracnose: ***Colletotrichum tabacum*** Boning

2.5 Rhizoctonia leaf spot/Sore shin: ***Rhizoctonia solani*** J.G. Kühn

2.6 Black shank: ***Phytophthora parasitica*** var. ***nicotianae*** (Edison) Fitzp

2.7 Fusarium wilt: ***Fusarium oxysporum*** var. ***nicotianae*** Sherb.

2.8 Brown spot: ***Alternaria alternata*** (Fr.) Keissl

2.9 Tobacco mosaic disease: ***Tobacco mosaic virus***

2.10 Tobacco leaf curl disease: ***Tobacco leaf curl virus***

2.11 Cucumber mosaic disease: ***Cucumber mosaic virus***

2.12 Tobacco ring spot disease: ***Tobacco ring spot virus***

3. Nematode

3.1 Root-knot nematode: ***Meloidogyne*** spp. (***M. icongnita, M. arineria, M. javanica***)

4. Weeds

Broad leaf

4.1 Lambs quarter: ***Chenopodium album*** L. (Chenopodiaceae)

4.2 Scarlet pimpernel: ***Anagallis arvensis*** L. (Primulaceae)

4.3 Sweet clover: ***Melilotus indica*** (L.) All. (Fabaceae)

4.4 Fine leaf fumitory: ***Fumaria parviflora*** Lam. (Fumariaceae)

4.5 Corn spurry: ***Spergula arvensis*** L. (Caryophyllaceae)

4.6 Pigweed: ***Amaranthus viridis*** Hook. F. (Amaranthaceae)

4.7 Swine cress: ***Coronopus didymus*** (L.) Sm. (Brassicaceae)

4.8 Black nightshade: ***Solanum nigrum*** L. (Solanaceae)

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

4.10 False amaranth: ***Digera arvensis*** Forssk. (Amaranthaceae)

4.11 Carrot grass: ***Parthenium hysterophorus*** L. (Asteraceae)

Grasses

4.12 Blue grass: *Poa annua* L. (Poaceae)

4.13 Rabbit/crow foot grass: *Dactyloctenium aegyptium* (L.) Willd (Poaceae)

4.14 Crab grass: *Digiteria sanguinalis* (L.) Scop. (Poaceae)

4.15 Barnyard grass: *Echinochloa crusgalli* (L.) Beauv. (Poaceae)

Sedges

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

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

Parasitic

4.18 Broomrape: *Orobanche aegyptiaca* L. (Orobanchaceae)

B. Pests of Regional Significance

1. Insect pests

1.1 Cut worm: *Agrotis ipsilon* Hufnagel (Lepidoptera: Noctuidae)

1.2 White grub: *Phyllophaga* spp. (Coleoptera: Scarabaeidae)

1.3 Rove beetle: *Bledius gracillicornis* (Coleoptera: Staphylinidae)

1.4 Grass hoppers: *Acrida exultata, Cyrtacanthacris tartarica, Atractomorpha crenulata* (Orthoptera: Acrididae)

1.5 Cotton mealybug: *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae)

2. Diseases

2.1 Bacterial wilt: *Ralstonia solanacearum* Smith

2.2 Hollow stalk: *Erwinia carotovora* sub sp. *carotovora* Jones

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. 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

Principles of AESA based IPM:

Grow a healthy crop

- Select a variety resistant/tolerant to major pests
- Select healthy seeds/seedlings/planting materials
- Treat the seed/planting material with recommended pesticides especially biopesticides
- Follow proper spacing
- Soil health improvement (mulching and green manuring wherever 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 amount 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

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

Farmers should

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

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

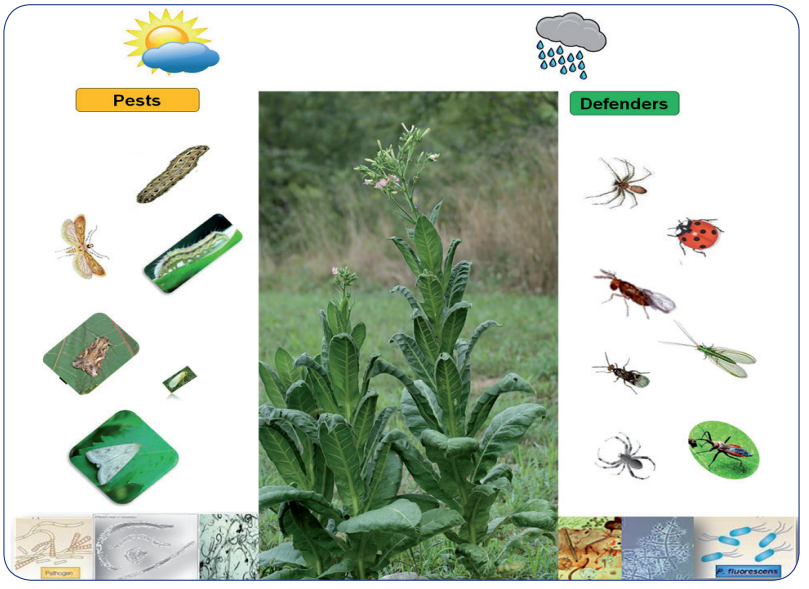
In field various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in crop field. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial and harmful insects. In this method, unfamiliar/unknown predators are collected in plastic containers with brush from the field and brought to a place for study. Each predator 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 tobacco pests can be divided into 3 categories; 1. parasitoids 2. predators and 3. pathogens. The important natural enemies of tobacco insect pests are given in ecological engineering table on page number 14.

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.

Feeding/egg laying potential of different parasitoids/predators

Predators/ Parasitoids	Feeding potential/ Egg laying capacity
 Ladybird beetle	Predatory rate of adult coccinellid on aphids is 50 aphids per day
 Hover fly	1st instar larva can consume 15-19 aphids/day; 2nd instar larva can consume 45-52 aphids/day; 3rd instar larva can consume 80-90 aphids/day; In total life cycle they can consume approx. 400 aphids.
 Green lacewing	Each larva can consume 100 aphids, 329 pupae of whitefly and 288 nymphs of jassids during entire larval period
 Spider	5 big larvae/adults per day

Predators/ Parasitoids	Feeding potential/ Egg laying capacity
 Reduviid bug	1st & 2nd nymphal instars can consume 1 small larva/day; 3rd & 4th nymphal instars can consume 2 to 3 medium larvae/day; 5th nymphal instar & adult can consume 3 to 4 big larvae/day; In total life cycle they can consume approx. 250 to 300 larvae
 *Bracon hebetor*	Egg laying capacity is 100-200 eggs/ female. 1-8 eggs/larva
 *Trichogramma* spp.	Egg laying capacity is 20-200 eggs/ female.

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:
    - Plant: Observe the plant height, number of branches, crop stage, deficiency symptoms etc.
    - Pests: Observe and count 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.
    - 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 what field 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. Keeping records of what has happened and help us making an analysis and draw conclusions.

Data to be recorded

- **Plant growth (weekly):** Height of plant; Number of leaves
- **Crop situation (e.g. for AESA):** Plant health; Pests, diseases, weeds; Natural enemies; Soil condition; Irrigation; Weather conditions
- **Input costs:** Seeds; 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 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.

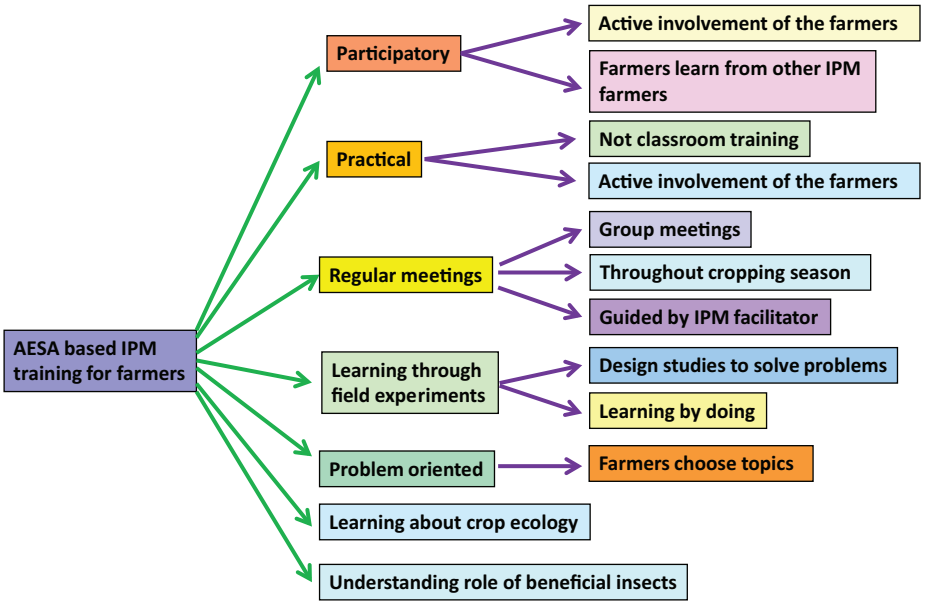
AESA and farmer field school (FFS)

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.

For insect pests:

Aphids and whitefly: Count and record the number of both nymphs and adults on three randomly selected leaves (top, middle and bottom) per plant.

***Spodoptera*:** Count the number of young and grown up larvae on each plant and record.

***Helicoverpa*:** Count the number of plants infested. Total number of capsules damaged due to *Helicoverpa armigera* and number of larvae on individual plants should be counted and recorded.

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 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 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.

Stem, flower and capsule sampling: Carefully examine the stem, flower and capsule of plants for symptoms and signs of fungal or bacterial diseases. The stem, flower and capsule should be split or taken apart and examined for discoloration caused by fungi and bacteria. Count the number of stems, flowers and capsules infected due to disease and percent disease incidence should be recorded.

For weeds:

The goal of weed scouting is to assess the infestation level of known weeds as pests and detect new weeds that may be at very low levels so that action can be taken to control or prevent them from becoming an economic concern. In some cases, early detection of a weed can make eradication possible.

Begin scouting as soon as weeds appear in the field and continue until freeze-up. Record stages of growth of all the weeds and the number of each weed species/square metre.

Frequently, all scouting patterns must be used since weed habitat can be very species specific. Each field usually requires a pattern for a uniform sample and samples in low areas and field margins or ditches to assess immediate or future risk from problem weeds left uncontrolled. Detailed counts of the number of weeds per square metre provide the ideal record of a weed problem. If this is not possible, the following rating system may be useful:

Group I - Wild oats, stinkweed, wild buckwheat, lamb's-quarters, redroot pigweed, hemp-nettle, smartweed, rape, wild mustard, Russian thistle, tartary buckwheat, cow cockle, shepherd's-purse, kochia.

Light	Medium	Heavy
1-10 plants/m^2	10-30 plants/m^2	More than 30 plants/m^2

Group II - Chickweed, green foxtail, corn spurry

Light	Medium	Heavy
1-20 plants/m^2	20-70 plants/m^2	70 or over plants/m^2

Group III - Canada thistle, sow-thistle, dandelion

Light	Medium	Heavy
1-2 plants/m^2	2-10 plants/m^2	10 or over plants/m^2

These definitions can be used to help standardize ratings. With experience, infestations can be visually estimated. These groupings are based on the competitive characteristics and life cycles of these weeds.

C. Surveillance through pheromone trap catches for *Helicoverpa* and *Spodoptera*

Pheromone traps for two insects viz., *Helicoverpa armigera* and *Spodoptera litura* @ 4-5/acre have to be installed. Install the traps for each species separated by a distance of >75 feet in the vicinity of the field. Fix the traps to the supporting pole at a height of one foot above the plant canopy. Change of lures should be made at 2-3 week

interval (regular interval). Total number of moths of *Helicoverpa armigera* and *Spodoptera litura*/trap/week should be recorded. The trapped moths should be removed and destroyed after each recording.

D. Yellow pan water/sticky traps

Set up yellow pan water/sticky traps 15 cm above the canopy for monitoring aphids, whitefly @ 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. Count the number of aphids and white flies on the traps daily and take up the intervention when the papulation exceeds 100 per trap.

E. Light traps

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

F. Nematode extraction

Collect 100 to 300 cm^3 (200-300 g) representation 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 60-mesh sieve to collect the egg masses into first bucket; discard residue in second bucket. 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.

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. The cultural practices are informed by ecological knowledge rather than on high technology approaches such as synthetic pesticides and genetically engineered crops (Gurr *et al.* 2004).

Natural enemies may require

1. Food in the form of pollen and nectar for adult natural enemies.
2. Shelter such as overwintering sites, moderate microclimate etc.
3. Alternate host when primary host are not present.

Ecological engineering for pest management – Above ground:

- 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 like *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.

Ecological engineering for pest management – Below ground:

- Crop rotations with leguminous plants which 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 below ground biodiversity.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Apply balanced dose of nutrients using biofertilizers.
- Apply mychorrhiza and plant growth promoting rhizobacteria (PGPR)
- Apply *Trichoderma* spp. and *Pseudomonas fluorescens* as seeds/seedling/planting materials, nursery treatment and soil application (If Commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

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

Good insectary plants belonging to Compositae, Leguminaceae, Umbelliferae, Brassicaceae etc. families


Mustard


Sunflower


Buckwheat


Carrot


Alfalfa


Marigold


Chrysanthemum


Maize/Corn


Cowpea

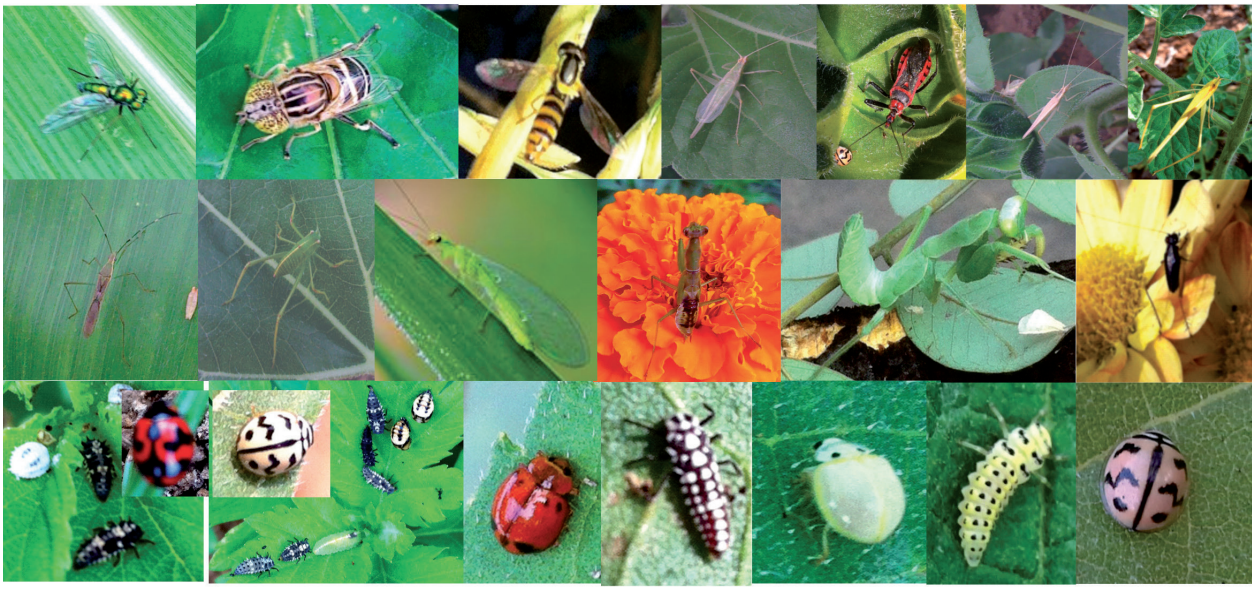

Castor

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

Flowering plants that attract natural enemies/repel pests

Natural enemies	Attractant/repellent/trap plants
Gram pod borer:	
Parasitoids: *Trichogramma chilonis* (egg), *Tetrastichus* spp. (egg), *Telenomus* spp. (egg), *Chelonus blackburni* (egg-larval), *Carcelia* spp. (larval-pupal), *Campoletis chlorideae* (larval), *Goniophthalmus halli* (larval), *Bracon* spp. (larval) etc. **Predators:** *Chrysoperla* sp, *Nesidiocoris tenuis* king crow, *Braconid* wasp, dragon fly, spider, robber fly, reduviid bug, praying mantis.	• Border crop sorghum or maize in 4 rows all around tobacco crop as guard crop. • Rotate the tobacco crop with a non host cereal crop, cucurbit, or cruciferous vegetable. • Attractant plants: Basil, marigold, *Nicotiana rustica.*
Tobacco caterpillar:	
Parasitoids: *Trichogramma chilonis* (egg), *Telenomus* spp. (egg), *Campoletis chloridae* (larval), *Peribea orbata* (larval), *Glipapanteles africanus* (larval), *Cotesia ruficrus* (larval), *Chelonus carbonator* (larval), *Blepherella setigera* (pupal), *Sarcophaga dux* (pupal), *Sarcophaga albiceps* (pupal), *Brachimoria lasus* (pupal), *Lasiochalcidia erythropoda* (pupal) **Predators:** *Chrysoperla zastrowi sillemi*, *C. crassinervis*, king crow, braconid wasp, dragon fly, spider, praying mantis, *Harpactor costalis, Rhynocoris fuscipes, R. squalis , Polistes stigma, Coranus spiniscutis, Andrellus spinidens.*	• Castor can be grown as a trap crop along the field border to attract the egg laying female adult moths. • Attractant plants: Carrot family, sunflower family, buckwheat, alfalfa, corn, shrubs (minute pirate bug and lacewing). • Nectar rich plants with small flowers i.e. anise, caraway, dill, parsley, coriander, mustard, sunflower, buckwheat and cowpea (wasp).
Whitefly:	
Parasitoids: *Encarsia* sp., *Eretmocerus mundus*, *Amitus aleurolobi* (pupal) **Predators:** Spiders, *Chelomenus sexmaculatus, Verania discolor, Coccinella septumpunctata, Harmonia octomaculata.*	• Attractant plants: Potatoes, chilli, brinjal, maize, pea, ginger, cole crops, groundnut, napier grass. • Trap crop: African marigold, sunflower, castor. • Repellent crop: Garlic.
Cut worm:	
Parasitoids: *Microgaster* sp., *Bracon kitcheneri*, *Fileanta* ruficanda (larval). **Predators:** *Broscus punctatus, Liogryllus bimaculatus.*	• Attractant plants: Vegetables, sorghum, sugarbeet. • Weeds: *Poa pratensi, Rumex crispus; Chenopodium album; Barbarea vulgaris.*

A. Resistant/Tolerant varieties of tobacco

Pest	Tolerant/ Resistant Variety*
Caterpillar	Meenakshi (CR)
TMV	VT-1158, CTRI Special (MR), Jayasree (MR)
Black Shank	FCV (29)
Wilt	FCH-222
Other varieties	Burley (3), Natu (5), Lanka (2), Chewing (17), Bidi (15), Cheroot (3), Cigar (4), Hookah & chewing (15), K 326, Rathna

*** For detailed information and further updates nearest KVK, SAU / ICAR Institutes may be contacted**

IV. CROP STAGE WISE IPM

Management	Activity
Presowing*	
Nutrients	• Apply 3.2 to 4 t/acre FYM or 2 t/acre vermicompost or 2.4 t/acre press mud and incorporate in the soil at the time of last preparatory cultivation. • Use leguminous green manure crops like pigeon pea, black gram, cowpea, cluster bean, French bean etc.
Weeds	• Deep ploughing during summer and leave the field for 25-30 days. • At the time of field preparation, adopt stale seed bed technique to minimize the weeds menace in field. • Soil solarization with transparent polyethylene sheet may be adopted. • Rotation of tobacco crop with pulses should be practiced in for better control of broomrape (*Orobanche* spp.). • Raising 'tray nursery' is effective for growing weed free seedlings.
Insect pests and soil borne pathogens	**Cultural control:** • Collect and destroy the plant debris. • Deep plough the field to expose the soil borne pathogens and hibernating stage of defoliators and subterranean pests.
Nursery*	
Nutrients	• Top dressing 35 : 0: 26.8 N:P: K Kg/acre in 6-8 splits
Damping off, frog eye leaf spot, leaf blight, anthracnose, black shank	**Cultural control:** • Irrigation by rose can (anthracnose). **Chemical control:** • Benomyl 50% WP @ 90 g in 300 l of water/acre (frog eye leaf spot) • Copper oxychloride 50% WP @ 1 Kg in 300-400 l of water/acre (black shank and frog eye leaf spot) • Metalaxyl 8% + mancozeb 64% WP@ 800 g in 400 l of water/acre (leaf blight) • Zineb 75% WP @ 750-800 g in 300-400 l of water/acre (frog eye leaf spot)

Tobacco caterpillar	**Cultural control:** • Deep summer ploughing. • Growing of castor as trap crop for oviposition. • Collection and destruction of egg masses and early instar larvae. • Removal of weeds. **Mechanical control:** • Installation of pheromone traps @ 4-5/acre. • Installation of light trap with exit option for natural enemies @1/acre. **Biological control:** • *Bacillus thuringiensis* var. *kurstaki*, Serotype H-3a, 3b, Strain Z-52 @ 0.6-0.8 kg in 200-300 l of water/acre. • NPV of *Spodoptera litura* 0.5% AS ($1x10^9$ POB/ml) @ 600 ml in 160-240 l of water/acre. • Release egg parasitoids *Trichogramma chilonis* 20,000 per acre, *Tetrastichus* spp., *Telenomus* spp. • Spraying NSKE 5% against eggs and first instar larva. • Larval parasitoids: *Ichneumon promissorius, Bracon* sp, *Carcelia* spp, *Chaetopthalmus, Campoletis chloridae.* • Pupal parasitoids: *Lissopimpla excels, Ichneumon promissorius.* • Neem extract containing 5% azadirachtin W/W@ 80 ml in 160 l of water/ acre.
Stem borer	**Cultural control:** • Removal of infested plants. • Piercing the infested plants with a sharp needle to kill the caterpillar in the stem. • Use light trap @1 trap/acre **Biological control:** • Conserve the natural enemies in the crop ecosystem.
Whitefly and Grass hoppers**	**Cultural control:** • Field sanitation and rogueing of alternate hosts. • Plant tall border crops like maize, sorghum or pearl millet to reduce white fly infestations. • Use yellow sticky traps or cards. **Biological control:** • Conserve the available natural enemies such as *Encarsia formosa, Eretmocerus* spp., *Dicyphus hesperus, Chrysocharis pentheus,* spiders, coccinellids, lacewings etc. **Chemical control:** • Spray oxydemeton–methyl 25% EC @ 400 ml in 200-400 l of water/acre.
Root-knot nematode	**Cultural control:** • Crop rotation with graminaceous crops. • Intercropping of marigold reduces nematode population. • Nursery should be raised in nematode free sites or fumigated or solarized.

	• Deep summer ploughing at 10 days interval reduces juvenile population. • Repellant plants: Marigold. • Crop rotation : Marigold, *Chrysanthemum*, sesbania, *Crotalaria* spp., *Gaillardia*, castor and *Desmodium* spp., **(**Parasitic nematodes**)**. • Application of decomposed poultry manure @ 200 g/sq. m. **Chemical control:** • Dazomet Technical @ 12-16 g/acre.
*Apply *Trichoderma* spp. and *Pseudomonas fluorescens* as seeds/seedlings/planting materials, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).	
Transplanting	
Nutrients	• Apply basal dose of NPK at the time of sowing @ 12 Kg N, 16 Kg P_2O_5 and 24 Kg K_2O per acre in main field at the time of transplanting.
Weeds	• Hardened & healthy seedlings, obtained from pure seeds are desirable for better quality tobacco production and suppression of weed growth. Line sowing with recommended row spacing. • Timely planting should be done to obtain the healthy tobacco plants.
Damping off	**Cultural control:** • Optimum seed rate 1.4 Kg/acre to avoid over-crowding. • Raising of seed bed upto10–12 cm height. **Biological control:** • Same as pre-sowing stage. **Chemical control:** • Metalaxyl 8% + mancozeb 64% WP @ 2 Kg in 2000 l of water/acre. • Captan 75% WS@ 20-30 g/Kg seeds.
Vegetative	
Nutrients	• Apply N and K as top dressing @ 8 kg N and 8 kg K_2O per acre between 20 and 25 days after transplanting. • In K 326 and Rathna varieties apply additional dose of N @ 4 Kg per acre as IInd top dressing at 30-35 days after transplanting.
Weeds	• In standing crop, hand weeding or hoeing at 15 days interval. • Spreading of mulch helps in suppressing the weeds quite effectively and also preserves the soil moisture. Therefore straw or plastic mulch should be used.
Damping off, Frog eye leaf spot, Leaf blight, Anthracnose, Sore Shin	• Same as in nursery stage.
Whitefly	• Same as in nursery stage.
Stem borer	• Same as in nursery stage.
Tobacco caterpillar	• Same as in nursery stage.
Tobacco aphid	**Cultural control:** • Yellow sticky traps or may reduce the density of pest.

	• If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control; check transplants for aphids before planting. • Reflective mulches such as silver colored plastic can deter aphids from feeding on plants. • Sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves. **Biological control:** • Conserve predators such as ladybird beetles viz., *Cocciniella septempunctata*, *Menochilus sexmaculata, Hippodamia variegata* and *Cheilomones vicina* etc. Adult beetle may feed an average of 10 to 15 adults/day, syrphid flies i.e., *Sphaerophoria* spp., *Eristallis* spp., *Metasyrphis* spp., *Xanthogramma* spp., *Syrphus* spp., lacewing, *Chrysoperla zastrowi sillemi* etc., • Entomogenous fungus *Verticillium lecanii* infects aphids. • Neem extract containing 5% azadirachtin W/W@ 80 ml in 160 l of water/ acre. **Chemical control:** • Oxydemeton–methyl 25% EC @ 400 ml in 200-400 l of water/acre
Gram pod borer, bud worm/capsule borer, cut worm**	**Cultural control:** • Hand pick the caterpillar once in three to four days and destroy. • Trim or top (topping) the flower heads to bring down the incidence of this pest. • Erect bird perches for encouraging predatory birds. • Use ovipositional trap crops such as marigold and *Nicotiana rustica.* **Mechanical control:** • Install pheromone traps @ 4-5/acre. **Biological control:** • *Bacillus thuringiensis* var. *kurstaki*, Serotype H-3a, 3b, Strain Z-52 @ 0.6-0.8 kg in 200-300 l of water/acre. • Conserve larval parasitoids such as *Bracon* sp, *Carcelia* sp, *Campoletis chlorideae,* pupal parasitoids such as *Lissopimpla excels, Ichneumon promissorius.* • Inundative release of *Trichogramma pretiosum* @ 40,000 nos./acre/release starting from flower formation stage for 6 times at weekly interval. • Conserve predators such as *Chrysoperla zastrowi sillemi,* coccinellids, King crow, Braconid wasp, dragon fly, spider, robber fly, reduviid bug, praying mantis, fire ants etc.
Flowering	
Nutrients	• Severe micronutrient deficiency should be corrected by foliar application of that particular nutrient.
Weeds	• Remove left over weeds/weed top from field to check weed seed production and spread in field.

Black shank	**Cultural control:** • Removal and burning of plant residues and debris. • Avoiding of water logging. • Growing resistant/tolerant varieties. **Chemical control:** • Copper oxy chloride 50% WP @1 Kg in 300-400 l of water/acre
Wilt**	**Cultural control:** • The affected plants should be removed and destroyed. • Crop rotation with a non-host crop such as cereals. • Growing of resistant variety FCH-222. **Biological control:** • Same as in pre-sowing stage.
Brown spot	**Cultural control:** • Removal and destruction of all diseased debris minimises the pathogen in the soil. **Chemical control:** • Zineb 75% WP @750-800 g in 300-400 l of water/acre.
Cucumber mosaic disease	**Cultural control:** • Rogucing of the affected seedling/ plants before first inter-culture operation. • Removal of weeds (*Solanum nigrum*) and plant (Brinjal, Tomato, Chillies) susceptible to the virus. • Workers should disinfect their hands with soap and running water before handling seedlings, weeding or doing other cultural operations. Use of tobacco (smoke, snuff, or chewing) should be prohibited strictly while working in seedbeds or field. • Growing of resistant varieties. • Spray leaf extracts of *Basella alba*, Bougainvillea (one litre of extract dissolved in 100-150 litre of water) on 30th, 40th and 50th days after transplanting. • Use yellow sticky traps for the management of aphid vector.
Tobacco leaf curl, tobacco ring spot, mosaic disease	**Cultural control:** • Deep summer ploughing for management of nematode vector *Xiphinema americanum* for ring spot virus. • Remove and destroy the diseased tobacco seedlings before and after planting whenever they are seen in the field. Fill the gaps with healthy seedlings if it is not too late. • Alternate weed hosts for whitefly should be removed and destroyed. • In endemic areas *Sesbania* sp. may be grown as a barrier crop around tobacco fields. • Install 4-5 yellow sticky traps to manage the white fly and aphid as pest and as a vector for the management leaf curl virus and cucumber mosaic virus respectively. • Install 4-5 blue sticky traps to manage the thrips as vector. **Chemical control:** For control of vector. • Oxydemeton–methyl 25% EC@ 400 ml in 200-400 l of water/acre.

Note : The pesticide dosages and spray fluid volumes are based on high volume sprayer.

** Pests of regional significance

V. 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.

VI. NUTRITIONAL DEFICIENCIES

Nitrogen: Leaves become yellowish (chlorotic) starting from lower leaves and move upward as the deficiency increases. N deficient plants are stunted, leaves are smaller and more upright than normal plants.

Correction Measure: Foliar spray of Urea 1% or DAP 2% twice at weekly intervals.

Phosphorus: Slow and stunted growth, maturity delayed Leaf colour becomes dark green. Mid-day wilting and brown spots on leaves may be observed under mild P deficiency.

Correction Measure: Soil application of recommended dose of phosphorous should be applied at the time of sowing or planting.

Foliar spray of DAP 2% twice at fortnightly intervals.

Potassium: Since potassium is very mobile within the plant, symptoms appear first on lower leaves. Older leaves become yellow and necrotic.

Mottled or scorched appearance develops at the tips and along the margins of leaves. The plants are less stunted as compared to P & N deficiency.

Correction Measure: Foliar application of K_2SO_4 @1% twice at weekly interval.

Calcium: Calcium deficiency in tobacco occurs in sandy soil with low pH conditions. As the Ca is immobile in plant, the symptoms first appear on the youngest leaves or buds. Younger leaves develop pale green colour followed by rolling and downward curling. Under extreme deficiency, terminal bud dies while lower leaves develop darker colour.

Correction Measure: Foliar spray of $CaSO_4$ @1% twice at fortnightly interval.

Source: http://www.ipmimages.org/images

VII. DESCRIPTION OF COMMON WEEDS

Broad leaf

1) Lambs quarter: *Chenopodium album* L. (Chenopodiaceae)

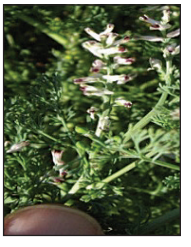
It is an annual weed found in mustard fields. It is a polymorphous, non-aromatic, erect herb**,** 0.3-3 m tall with angled stems that are often striped green, red or purple. Leaves are variable in size and shape, lower leaves are toothed or irregularly lobes, 10-15 cm long, with petioles often as long as leaf blades. Flowers are green, borne in clusters forming a compact or loosely panicled axillary spike. Fruits utricle, seeds round, compressed, black and shining.

2) Scarlet pimpernel: *Anagallis arvensis* L. (Primulaceae)

A low-growing annual, up to 30 cm tall with branched or erect herbaceous, 4-angled, glabrous to pubescent stem. Sometimes rooting observed at the nodes. Leaves are opposite, entire, sessile, ovate variously pubescent, margins somewhat tuberculate. Flowers are bright blue, solitary arising from the area between the stem and leaves (leaf axils) and occur on relatively long stalks (pedicels). Fruits capsule, globose, seeds1.3 mm long, trigonous, brown.

3) Sweet clover: *Melilotus indica* (L.) All. (Fabaceae)

It is a sweet-smelling erect herb, up to 10-60 cm height with hairless, spreading or erect stem. Leaves odd-1-pinnate; leaflets 1-2.5 cm, inverted, lance-shaped to wedge-shaped, generally sharply toothed on the broader part. Flowers yellow; appear in slender, compact racemes that are 1-2 inches in length. Plant bear papery, small, round, 2-3 mm long, yellow or grey, reticulately wrinkled and slightly hairy pods. Seeds 2 mm long; 1.5 mm wide; broadly oval, one side plane, the other side rounded; yellowish green; roughened by minute tubercles.



4) Fine leaf fumitory: *Fumaria parviflora* Lam. (Fumariaceae)

Annual herb, up to 60 cm tall. Stem Slender, much branched and succulent. Leaves 2-3 pinnatisect, 2-5 cm long, segments linear oblanceolate, apiculate. Flowers Purplish-red, spurred, in terminal or leaf opposed bracteate racemes. Fruits are rounded nuts, 2-3 mm in diameter, wrinkled when dry.

5) Corn spurry: *Spergula arvensis* L. (Caryophyllaceae)

A diffuse annual herb. Stem branched from the root, grooved. Leaves are in pseudo whorls, fleshy, linear-subulate, spreading. Flowers small, white. Fruits capsule rounded, five valved. Seeds are circular, thick lens shaped in cross section; margins winged with one small notch. Seeds are greyish black to black with margins usually light brown.

6) Pigweed: *Amaranthus viridis* Hook. F. (Amaranthaceae)

It is an erect 6 to 100 cm tall annual herb with especially upwards glabrous to pubescent stem. Leaves are also glabrous or pubescent on the veins of the lower surface; petioles long (up to 10 cm), occasionally longer than the blade; blade ovate to rhombic-oblong, base tapered to blunt, tip rounded. Flowers green, unisexual, male and female intermixed, in slender axillary to terminal paniculate spikes 2-12 cm long and 2-5 mm wide, or in dense axillary clusters in the lower part of the stem. Fruits are capsule almost round shaped 1.25-1.75 mm long with rough surface. Seeds 1-1.25 mm, round, slightly compressed, dark brown to black with a paler thick border.

7) Swine cress: *Coronopus didymus* (L.) Sm. (Brassicaceae)

An annual herb with, horizontal or ascending stem, multiple from the base, radiating from a central point; glabrous, green. Leaves are alternate, petiolate, pinnate, 4-5 cm long, 2 cm broad, glabrous. Divisions of the leaves opposite, lobed or devided, linear-elliptic to linear oblong. Inflorescence is a small raceme, up to 4 cm long, opposite to one of the stem leaves, compact. Flowers minute, greenish. Fruits are glabrous, 3-4 mm broad, 2 mm long, slightly compressed, sub-globose, 2-seeded.

8) Black nightshade: *Solanum nigrum* L. (Solanaceae)

A variable annual herb upto 1 m tall with an erect, glabrous or sparsely pubescent stem and staggered branching pattern. Leaves are 2.5-9 cm long and 2-5 cm wide, ovate, glabrous, thin, margins toothed, tapering into the petiole, apex subacute. Flowers small, white, borne in drooping, umbellate 3-8 flowered cymes. Fruits berries globose, 5-8 mm in diameter, red, yellow or purplish-black. when ripened, fruits having numerous, disc-shaped, 1.5 mm in diameter, yellow, minutely pitted seeds.

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

An annual glabrous herb with prostrate and succulent stem. Leaves spatulate, flattened, apex round nearly truncate. Flowers 3-10 mm diameter and yellow. Fruits capsules ovoid, 4-9 mm diameter. Seeds black or dark brown, orbiculate or elongate, flattened, 0.6-1.1 mm; surface cells sooth, granular, or stellate, with rounded tubercles.

10) False amaranth: *Digera arvensis* Forssk. (Amaranthaceae)

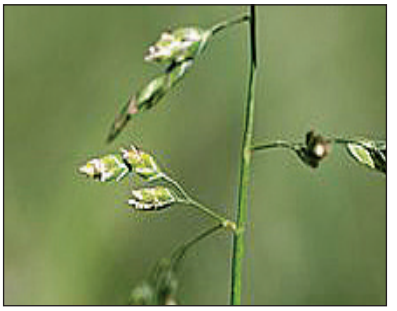
An annual herb, 30-60 cm height with spreading branches. Leaves variable, 2-7.5 cm long and 1.3-4.5 cm wide, ovate or elliptic, acute or rounded at the apex, sometimes with reddish margins, glabrous. Flowers pink, borne in threes axillary, pedunculate spikes, 2.5-12.5 cm long. Fruits globose, approximately 0.3 cm in diameter having yellowish-brown.

11) Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)

It is one of the worlds' worst weeds mostly found in uncultivated lands but now a - days it can be seen invading cropped fields. It is a short-lived annual herb with an extensive root system and erect shoot upto 2 m height. Upper half of the main stem becomes highly-branched at flowering with strips due to longitudinal grooves or ribs and they become woody with age. Leaves are pale green, deeply lobed and covered with finesoft hairs. Flowers are creamy-white occurring at the tips of the stems. Clusters of male and female florets are grouped as five-lobed flowers on the terminal branches of the flower stem and measure 4–6 mm in diameter. Seeds are achene small (1–2 mm), flattened, triangular and dark brown–black with two thin, white, spoon-shaped appendages.

Grasses

12) Bluegrass: *Poa annua* L. (Poaceae)



Annual cool-season grass grows 6 to 8 inches height when left unmowed. It has light green flattened stems that are bent at the base and often rooted at the lower stem joint. Leaf blades are often crinkled part way down and vary from 1 to 3 inches long with typical *Poa* boat-shaped leaf tips- a key characteristic of annual bluegrass. Inflorescence is branched with three to eight flattened florets in each spikelet.

13) Rabbit / crow foot grass: *Dactyloctenium aegyptium* (L.) Willd (Poaceae)

Annual, very variable, grass, 10-44 cm height. Stem erect or creeping culms, rooting from the profusely branched nodes. Leaves are linear, tapering to a fine point, 2-10 cm long and 0.2-0.4 cm wide, flat, glaucous, glabrous or hispid; leaf sheaths striate, the lower whitish; ligules membranous, very short. Inflorescence comprised of 2-6 digitate spikes, 0.5-4 cm long, olive-grey; spikelets 2-5 flowered, spreading at right angles, pendulous, strongly striate. Grain 0.5-1 mm long, subglobose, reddish, very rugose.

14) Crabgrass: *Digiteria sanguinalis* (L.) Scop. (Poaceae)

A prostrate or ascending annual grass with spreading, branched stem having rooting at nodes. Leaves are 3-20 cm long, 3-10 mm wide, with hairs on both the surfaces. Stem sheaths hairy and closed. Leaves and sheaths may turn dark red or maroon with age. Seed head composed of 4-6 branches (spikes) at the top of the stems, each approximately 3-15 cm long. Fruit caryopsis shiny, yellowish-brown, 2-3 mm long.

15) Barnyard grass: *Echinochloa crusgalli* (L.) Beauv. (Poaceae)

Robust, tufted annual grass, erect or at the base decumbent and rooting at the nodes, 20-150 cm tall. Culms cylindrical, glabrous, filled with white spongy pith. Leaf sheaths glabrous and 9-13 cm long. Leaf blades merging into the sheath, linear, with a broad, rounded base and acute top; rough margined, glabrous or at the base with a few long hairs, smooth or the upper surface minutely bristly. Inflorescence is an apical panicle of 5-40 spikes like racemes. Fruit are caryopsis ovoid to obovoid, compressed, 1.5-2 mm long.

Sedges

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

A perennial sedge, hard, fragrant, globose-ovoid tubers, up to 1.2 cm long and 0.3-0.7 cm in diameter; culms solitary or few together, sparsely tufted, erect, 10-75 cm tall, 3-angled at top. Leaves narrowly linear, sometimes longer than stem, 0.4-0.8 cm wide, dark green above, pale beneath. Inflorescence is a simple or compound umbel, rays 2-8, each up to 7.5 cm long, bearing short spikes of 3-10 spreading, red-brown spikelets. Nuts oblong to ovate-oblong, 3-sided, 1.3-1.5 mm long and 0.5-0.7 mm wide, maturing brown.

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

Annual sedge, sometimes behaving as a perennial with 8 to 60 cm height. The culms are tufted, triangular, smooth, green and 0.6-3.0 mm thick. The roots are numerous, short and yellowish-red. Leaves are linear-lanceolate, usually all shorter than the culm, 1-8 mm wide, flat, and rough on the margin and major ribs; leaf sheaths are green to reddish-brown, membraneous and envelope the culm at the base. Inflorescence is simple or compound, usually open, 1-20 cm long and 1-20 cm wide, with groups of spikes which are either attached directly to stem or on 0.5-15.0 cm long peduncles (rays). Spikelets are erect-spreading, crowded, 6-24-flowered, golden to yellowish green. Nutlet, 1.0-1.5 mm long, 0.6-0.7 mm wide, obovate, triangular in cross section, dark-brown to almost black; the surface is almost smooth.

Parasitic weed

18) Broomrape: *Orobanche aegyptiaca* L. (Orobanchaceae)

Broomrape is an annual root parasites lacking chlorophyll, upto 1 m tall. Usually parasitize solanaceae and fabaceae hosts reducing crop yield severely. Seeds germinate in response to host root exudates and the seedlings must come in contact with host root immediately after germination. Some species may produce flowers within a week of emergence from the soil. Seeds of orobanche are irregular wedge shaped oblong, tiny dust like 0.2 to 0.5 mm long black to brown coloured.

VIII. DESCRIPTION OF INSECT AND NEMATODE PESTS

1) Gram pod borer/bud worm/capsule borer:

Biology:

It is a polyphagous.

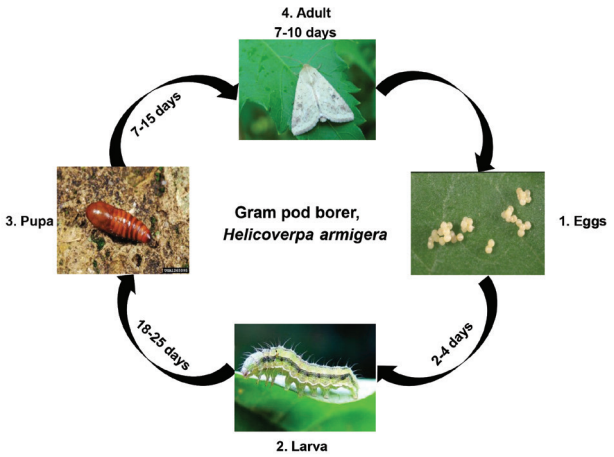
Egg: The spherical, yellowish eggs are laid singly on tender parts and buds of plants. The egg period lasts for 2-4 days.

Larva: Caterpillars are of varying colour, initially brown and later turn greenish with darker brown lines along the side of the body. The larval period lasts for 18-25 days. Body covered with radiating hairs. When full grown, they measure 3.7 to 5 cm in length. The full grown caterpillar pupates in the soil in an earthen cell and emerges in 16-21 days.

Pupa: Pupation takes place inside the soil, pupal stage lasts 7-15 days.

Adult: Moth is stout, medium sized with brownish/greyish forewings with a dark cross band near outer margin and dark spots near costal margins, with a wing expanse of 3.7 cm.

Life cycle:



1. http://www7.inra.fr/hyppz/RAVAGEUR/6helarm.htm
2. http://www.infonet-biovision.org/default/ct/120/crops
3. http://www.invasive.org/browse/subinfo.cfm?sub=9408
4. http://en.wikipedia.org/wiki/Helicoverpa_armigera

Damage symptoms:

- During the vegetative phase larvae feed on bud leaves and surrounding leaves. During flowering/ capsule formation stage larvae feed on flower buds, flowers and capsules Seeds are eaten severely and completely hollowed out. While feeding the caterpillar thrust its head inside leaving the rest of the body outside.
- Bored capsules with round holes.
- Damaged bud leaves, shoots and buds.
- The activity of *Helicoverpa* starts on green gram, summer vegetables and maize and continues their generation by Oct-Nov months synchronizing with main crop.

https://www.google.co.in/search?q=damage+symptoms+of+tobacco+by+helicoverpa+armigera

Parasitoids of gram pod borer:

Egg parasitoid

1.*Trichogramma* sp

Larval parasitoids

2. *Bracon* sp

3. *Campoletis* sp

4. *Carcelia* sp

Pupal parasitoid

5. *Ichneumon* sp

3. http://www.nbaii.res.in/Featured%20insects/Campoletis.htm; 4. http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398;
5. http://www.organicgardeninfo.com/ichneumon-wasp.html

Predators of gram pod borer:

1. Lacewing

2. Ladybird beetle

3. Spider

4. Praying mantis

5. Reduviid bug

6. Dragonfly

7. Robber fly

8. Wasp

4. http://spirit-animals.com/praying-mantis/; 6. http://en.wikipedia.org/wiki/Dragonfly; 7. http://www.warpedphotosblog.com/robber-fly-and-prey
8. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/; 9. http://somethingscrawlinginmyhair.com/2011/09/17/yellowjacket-with-prey/

* For management refer to page number 18.

2) Tobacco caterpillar:

Biology:

It is found throughout the tropical and sub tropical parts of the world, wide spread in India. Besides tobacco, it feeds on cotton, castor, groundnut, tomato, cabbage and various other cruciferous crops.

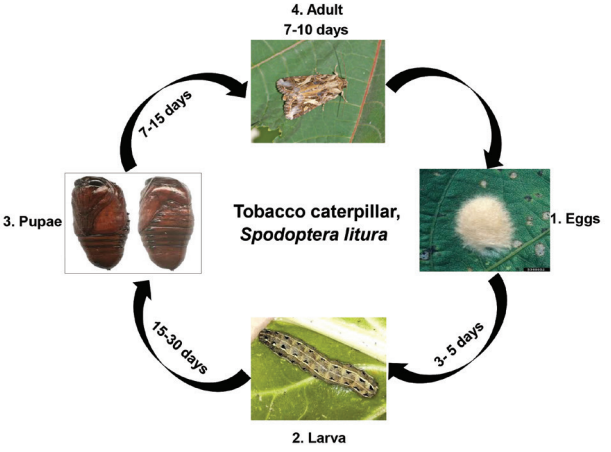
Egg: Female lays about 300 eggs in clusters. The eggs are covered over by brown hairs and they hatch in about 3-5 days.

Larva: Caterpillar measures 35-40 mm in length, when full grown. It is velvety, black with yellowish – green dorsal stripes and lateral white bands with incomplete ring – like dark band on anterior and posterior end of the body. It passes through 6 instars.Larval stage lasts 15-30 days

Pupa: Pupation takes place inside the soil, pupal stage lasts 7-15 days.

Adult: Moth is medium sized and stout bodied with forewings pale grey to dark brown in colour having wavy white crisscross markings. Hind wings are whitish with brown patches along the margin of wing. Pest breeds throughout the year. Moths are active at night. Adults live for 7-10 days. Total life cycle takes 32-60 days. There are eight generations in a year.

Life cycle:



1. http://m.animal.memozee.com/m.view.php?q=%EB%8B%B4%EB%B0%B0%EA%B0%80%EB%A3%A8%EC%9D%B4&p=3
2. http://www.forestryimages.org/browse/detail.cfm?imgnum=2511050
3. http://www.fera.defra.gov.uk/plants/publications/documents/factsheets/bemisia.pdf
4. http://www.entomology.umn.edu/cues/inter/inmine/Whitefg.html

Damage symptoms:

- In early stages, the caterpillars are gregarious and scrape the chlorophyll content of leaf lamina giving it a papery white appearance. Later they become voracious feeders making irregular holes on the leaves.
- Irregular holes on leaves initially and later skeletonisation leaving only veins and petioles
- Heavy defoliation.


https://www.google.co.in/search?q=damage+symptoms+of+tobacco+by+spodoptera+litura&espv=210&es_sm=122&source=lnms&tbm=isch&sa=X&ei=C88BU_C3CsOMrQewgYH

Parasitoids of tobacco caterpillar:

Egg parasitoid

1.*Trichogramma* sp

Larval parasitoids

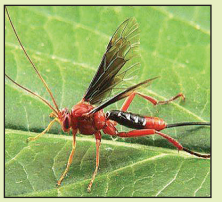
2. *Bracon* sp

3. *Campoletis* sp

4. *Carcelia* sp

Pupal parasitoid

5. *Ichneumon* sp



3. http://www.nbaii.res.in/Featured%20insects/Campoletis.htm; 4. http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398;
5. http://www.organicgardeninfo.com/ichneumon-wasp.html

Predators of tobacco caterpillar:

1. Lacewing

2. Ladybird beetle

3. Spider

4. Praying mantis

5. Reduviid bug

6. Dragonfly

7. Robber fly

8. Wasp

4. http://spirit-animals.com/praying-mantis/; 6. http://en.wikipedia.org/wiki/Dragonfly; 7. http://www.warpedphotosblog.com/robber-fly-and-prey
8. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/; 9. http://somethingscrawlinginmyhair.com/2011/09/17/yellowjacket-with-prey/

* For management refer to page number 16.

3) Whitefly:

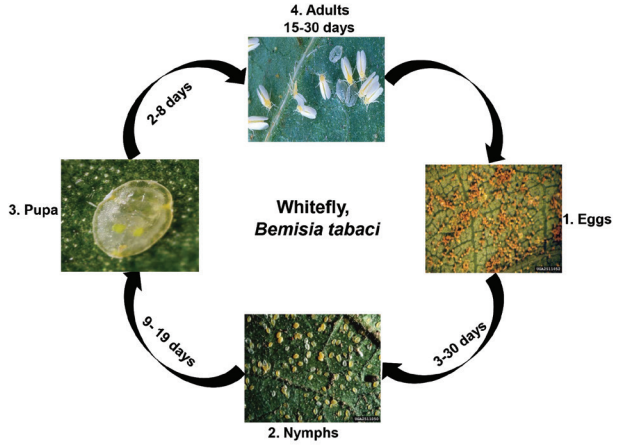
Biology:

Egg: Pear shaped, light yellowish.

Nymph: On hatching - Oval, scale-like, greenish white.

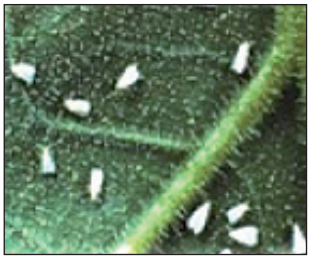
Adult: White, tiny, scale-like adult.

Life Cycle:



Damage symptoms:

- Chlorotic, spotting veins and leaf yellowing, blotching and mosaic of leaves together with leaf curling.
- Vector of tobacco leaf curl disease.



https://www.google.co.in/search?q=damage+symptoms+of+tobacco+by+whitefly&espv=210&essm=122&source=lnms&tbm=isch&sa=X&ei=RM8BU5O2GMG4rAeClIHYCA&ved=0CAcQ_AUoAQ&biw=

1. http://m.animal.memozee.com/m.view.php?q=%EB%8B%B4%EB%B0%B0%EA%B0%80%EB%A3%A8%EC%9D%B4&p=3
2. http://www.forestryimages.org/browse/detail.cfm?imgnum=2511050
3. http://www.fera.defra.gov.uk/plants/publications/documents/factsheets/bemisia.pdf
4. http://www.entomology.umn.edu/cues/inter/inmine/Whitefg.html

Parasitoids of whitefly:

Pupal parasitoids:

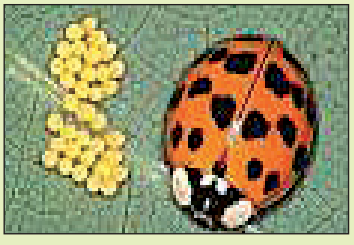
1. *Encarsia formosa*

2. *Eretmocerus* sp

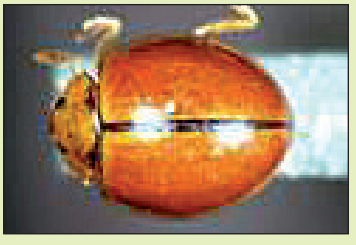
1. http://www.buglogical.com/whitefly-control/encarsia-formosa/; 2. http://www.dongbufarmceres.com/main/mboard.asp?strBoardID=c_product01_en

Predators of whitefly:

1. *Harmonia octomaculata*



2. *Verania discolor*



3. *Coccinella septumpunctata*

1. https://www.google.co.in/search?q=Harmonia+octomaculata&espv=210&; 2. https://www.google.co.in/search?q=Verania+discolor&btnG=
3. http://lladybug.blogspot.in/; 4. http://commons.wikimedia.org/wiki/File:Geocoris_punctipes.jpg

* For management refer to page number 16.

4) Stem borer:

Biology:

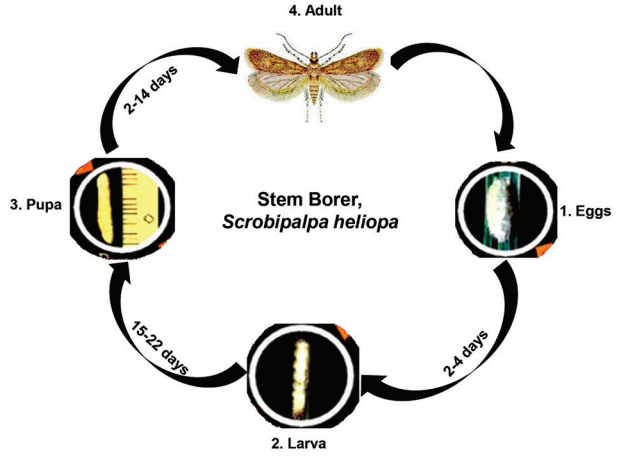
Egg: A female, on an average, lays 50- 80 cylindrical eggs singly more on the upper surface.

Larva: In 4th days, eggs hatch and the tiny caterpillars mine along the leaf stalk into the stem and feed on the internal tissues. The full grown larva is pale white in colour, with head and thorax dark brown.

Pupa: Pupation occur after 15-22 days. The tunnel is prepared before pupation for exit of adult. Pupation period 2-14 days.

Adult: Adults are copper red in colour with wing span of 1 cm.

Life Cycle:



1,2,3,4; http://upload.wikimedia.org/wikipedia/commons/thumb/e/eb/Scrobipalpa_aptatella_(ento-

Damage symptom:

- Larvae bore inside the stem to form a swelling. It causes stunting and unusual branching of the seedlings.

https://www.google.co.in/search?q=damage+of+tobacco+caused+by+Scrobipalpa+heliopa&espv=210&es_sm=122&source=lnms&tbm=isch&sa=X&ei=cc8BU46RI8qCrge8g4DQAw&ve

Parasitoids of stem borer:

Larval parasitoid:

***Chelonus* sp**

http://www.nbaii.res.in/Featured%20insects/chelonus.htm

* For management refer to page number 16.

5) Tobacco aphid:

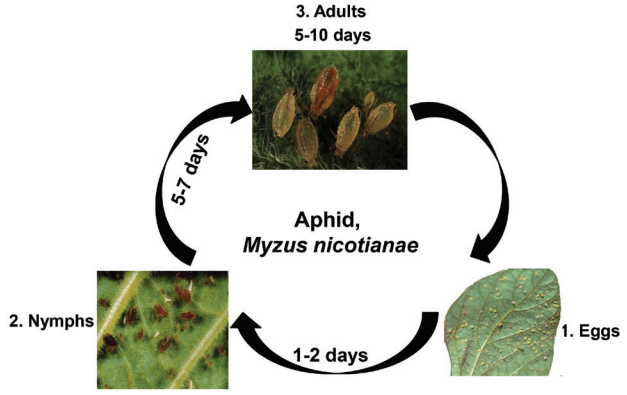
Biology:

Egg: Eggs are brownish in colour and laid along the veins of leaves.

Nymph: There are four nymphal stages (instars). The general appearance of each stage is similar except for increase in size during subsequent instars. The first, second, third and fourth nymphal stages last 1-2, 2, 2, and 3 days respectively.

Adult: Aphids are small, soft-bodied, pearl-shaped insects that have a pair of cornicles (wax-secreting tubes) projecting out from the fifth or sixth abdominal segment. Aphids are pinkish to brown or green colour. Both apterous (wingless) and alatae (winged) forms pass through 4-5 nymphal instars in their development and the nymphal period ranges from 5-7 days. Both the forms mate within a day or two after the final moult and start reproducing young ones. The apterous forms produce significantly more number of young ones than alatae but their life-period is shorter than that of alatae. In the field generally viviparous apterous forms are observed in large number.

Life Cycle:



1,2,3; https://www.google.co.in/search?q=damage+of+tobacco+by+aphid &espv=210&es_sm=122&source=lnms&tbm=isch&sa=X&ei=mc8BU_ yMCNGsrAeb5YHIDA&ved=0CAcQ_AUoAQ&b

Damage symptoms:

- By constantly sucking the sap from leaves they make the plant pale and sickly and thereby retard the growth. They secrete sugary juice known as `honey dew' on the leaves due to which sooty mould develops rendering the leaves unfit for curing.

https://www.google.co.in/search?q=damage+of+tobacco+by+aphid &espv=210&es_sm=122&source=lnms&tbm=isch&sa=X&ei=mc8BU_yMCNGsrAeb5YHIDA&ved=0CAcQ_AUoAQ&b

Predators of tobacco aphid:

1. Lacewing

2. Ladybird beetle

3. Syrphid fly

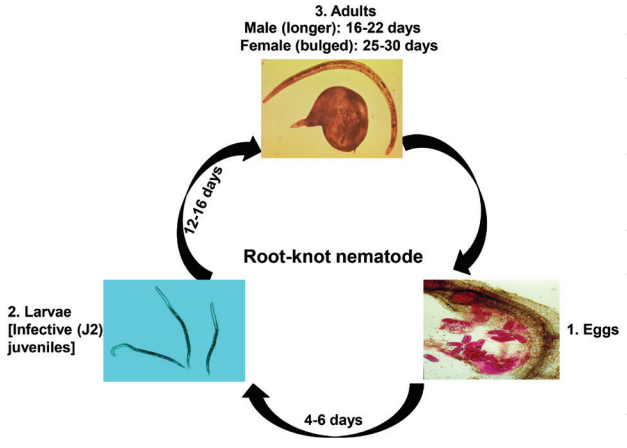
* For management refer to page number 17-18.

6) Root knot nematode:

Biology:

- Most species of plant parasitic nematodes have a relatively simple life cycle consisting of the egg, four larval stages and the adult male and female.
- Development of the first stage larvae occurs within the egg where the first molt occurs. Second stage larvae hatch from eggs to find and infect plant roots or in some cases foliar tissues.
- Under suitable environmental conditions, the eggs hatch and new larvae emerge to complete the life cycle within 4 to 8 weeks depending on temperature.
- Nematode development is generally most rapid within an optimal soil temperature range of 70 to 80°F.

Life cycle:



1.http://keys.lucidcentral.org/keys/sweetpotato/key/Sweetpotato%20Diagnotes/Media/Html/TheProblems/Nematodes/RootKnotNematode/Root-knot.htm
2. http://nematology.umd.edu/rootknot.html
3. http://www.cals.ncsu.edu/pgg/dan_webpage/Introduction/Images/pyroform.htm

Damage symptoms:

- Infected plants in patches in the field
- Formation of galls on host root system is the primary symptom
- Roots branch profusely starting from the gall tissue causing a 'beard root' symptom
- Infected roots become knobby and knotty
- In severely infected plants the root system is reduced and the rootlets are almost completely absent. The roots are seriously hampered in their function of uptake and transport of water and nutrients
- Plants wilt during the hot part of day, especially under dry conditions and are often stunted
- Nematode infection predisposes plants to fungal and bacterial root pathogens

Survival and spread:

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

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

Favourable conditions:

Loamy light soils.

https://www.google.co.in/search?q=damage+symptoms+of+tobacco+by+nematode&espv=210&es_sm=122&source=lnms&tbm=isch&sa=X&ei=xs8BU9DHGoOJ

* For management refer to page number 16.

IX. DESCRIPTION OF DISEASES

1) Damping off:

Disease symptoms:

- Damping off of tobacco occurs in two stages, i.e. the pre-emergence and the post-emergence phase.
- In the pre-emergence the phase the seedlings are killed just before they reach the soil surface.
- The young radical and the plumule are killed and there is complete rotting of the seedlings.
- The post-emergence phase is characterized by the infection of the young, juvenile tissues of the collar at the ground level.
- The infected tissues become soft and water soaked. The seedlings topple over or collapse.



https://www.google.co.in/search?q=damping+off+of+tobacco&esp\

Survival and spread:

- The fungus survives in soil. Primary infection occurs by soil and secondary by conidia through rain or wind.

Favourable conditions:

- High humidity, high soil moisture, cloudiness and low temperatures below 24°C for few days are ideal for infection and development of disease.
- Crowded seedlings, dampness due to high rainfall, poor drainage and excess of soil solutes hamper plant growth and increase the pathogenic damping-off.

* For management refer to page number 15.

2) Frog eye leaf spot:

Disease symptoms:

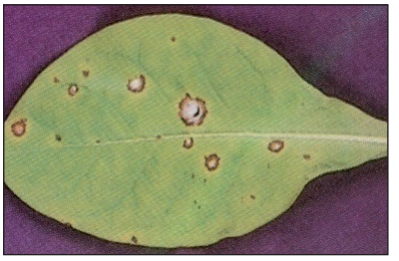
- Disease appears both in nursery and field.
- Several small, round brown lesions with 2-10 mm diameter on lower and mature leaves occur.
- Typical lesion with white parchment centre surrounded by brown or tan colored margin resembling eye of frog.
- Different spots coalesce causing drying of leaves which wither prematurely.

Survival and spread:

- The fungus survives in soil debris which is cause of primary infection. Secondary infection occurs by conidia through rain splash or wind.

Favourable conditions:

- High humidity and warm weather conditions responsible for the disease.

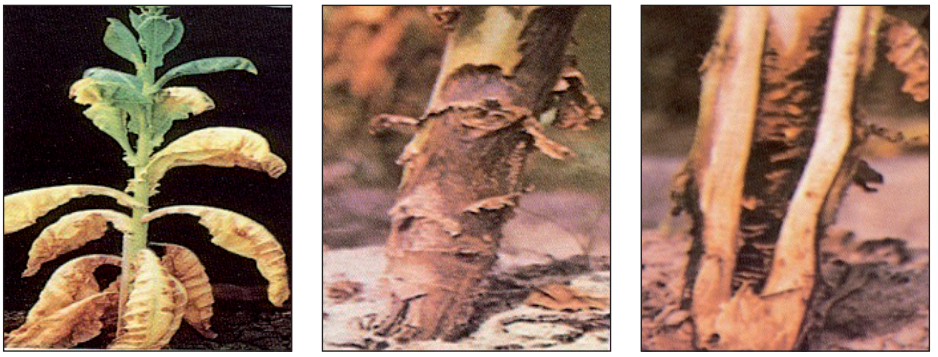
https://www.google.co.in/search?q=frog+eye+spot+of+tobacco&espv=210

* For management refer to page number 15.

3) Leaf blight / black shank:

Disease symptoms:

- The disease is characterized by scattered, rapidly enlarging, irregular, brown, water-soaked lesions with characteristic gray-green borders.
- Symptom development occurs particularly during and immediately following periods of heavy rains and high relative humidity.



https://www.google.co.in/search?q=black+shank+disease+tobacco&oq=black+shank+disease

Survival and spread:

- Primary infection occurs by inoculum present in plant debris in soil and secondary by means of sporangia through air and water.

Favourable conditions:

- High soil moisture and moist weather conditions with intermittent showers are responsible for the development of disease.

* For management refer to page number 15.

4) Anthracnose:

Disease symptoms:

- Symptom appears as small water soaked spots with sunken center on leaves.
- Spots become white with brown margin.
- Lesions occur also on midribs, petioles and lateral veins causing distortion and ragged.
- Lesions on stem weaken the stem.

https://www.google.co.in/search?q=anthracnose+of+tobacco&espv=210&es_sm=93&source=lnms

Survival and spread:

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

Favourable conditions:

- Rain and high humidity are favourable for the development of disease.

* For management refer to page number 15.

5) Sore shin:

Disease symptoms:

- *Rhizoctonia solani* causes two types of diseases on tobacco seedlings in greenhouses:

1. Target spot. Symptoms on leaves begin as small, round, water-soaked spots about 2-3 mm in diameter.

- Under favorable conditions these lesions enlarge rapidly, becoming light green, almost transparent, with irregular margins and chlorotic halos.
- In infested areas, lower leaves turn brown and stick to the surface of the tray and the presence of brown spider-like webs (mycelium) may be observed attached to leaves and stems.

2. Damping-off. This disease is usually observed at early stages of seedling growth.

- The first symptom is a small water soaked lesion on the stem close to the soil line that rapidly becomes brown and sunken.
- Under favourable conditions lesions become very constricted and the stems break-off. The lesions continue to grow throughout the stem and leaves causing them to turn brown and die.

https://www.google.co.in/search?q=shore+shin+of+tobacco&oq=shore+&aqs=chrome.

Survival and spread:

- The primary source of inoculum for *Rhizoctonia* diseases are infested trays. Resting structures (sclerotia) of *R. solani* are formed in trays where the disease developed the previous season.

Favourable conditions:

- High humidity and high temperature favours the development of diseases.

* For management refer to page number 15.

6) *Fusarium* wilt:

Disease symptoms:

- The first symptom appears as chlorosis of the leaves.
- Wilting of leaves from bottom to top occur.
- Brown vascular discolouration inside infected stem or root leads to the death of plants.

Survival and spread:

The disease is soil borne and primary infection occurs through inoculum present in the soil.

Favourable conditions:

- Relatively high soil moisture and soil temperature are favourable for the infection.

* For management refer to page number 15.

https://www.google.co.in/search?q=fusarium+wilt+of+tobacco&espv=210&es_sm=93&source=

7) Brown spot:

Disease symptoms:

- Initially it appears on lower and older leaves as small brown, concentric circular lesions, which spread, to upper leaves, petioles, stalks and capsules even.
- In warm weather under high humidity, the leaf spots enlarge, 1-3 cm in diameter, centers are necroses and turn brown with characteristic marking giving target board appearance with a definite outline.
- In severe infection spots enlarge, coalesce and damage large areas making leaf dark-brown, ragged and worthless.

https://www.google.co.in/search?q=brown+spot+of+tobacco&espv=210&essm=93&source=lnms

Survival and spread:

- The pathogen survives through spores (conidia) or mycelium in diseased plant debris or weed.

Favourable conditions:

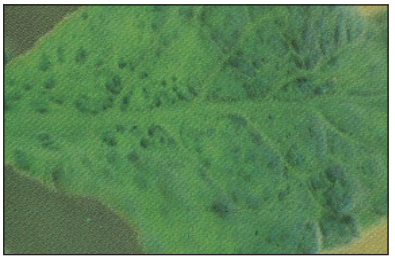
- Warm weather with high humidity.

* For management refer to page number 19.

8) Tobacco mosaic disease:

Disease symptoms:

- Affected plants show leaves with mottling or mosaic pattern of light green and dark-green areas.
- Primary symptoms appear on newly formed young leaves as vein clearing, greenish yellow mottling.
- Infection on young plants results in stunted growth, malformation, distortion and puckering of leaves. Dark-green blisters and sometime enations (leafy growth) appear on the dorsal side of the leaf.



https://www.google.co.in/search?q=tobacco+mosaic+disease&espv=210&es_sm=93&source=lnm

Transmission and favourable conditions:

- TMV is highly contagious and transmitted by sap. It is easily transmitted by mere contact of a diseased plant with a healthy one.
- Air-dried tobacco is a common source of new infection. Workers who chew or smoke natural leaf tobacco during nursery operations may spread the virus into the seedlings.
- Old stems and leaf trash of affected plants buried in the soil are the other sources of infection and spread.
- In the nurseries, seedlings may get affected due to the presence of susceptible weed hosts.

* For management refer to page number 19

9) Tobacco ring spot disease:

Disease symptoms:

- Infected leaves show mottling veins show shortened internodes with small, distorted leaves.
- In later growth of plant stunted and limited to basal suckers, and the vine eventually dies.
- Dead and dying vines are usually present in a roughly circular pattern in the vineyard. The viruses are introduced into vineyards with infected planting stock or by dispersal of seed from infected weeds. The virus is then spread by dagger nematodes feeding on roots of infected plants.

https://www.google.co.in/search?q=tobacco+ring+spot+disease&espv=210&es_sm=93&source

Transmission and favourable conditions:

- Mode of transmission and favourable conditions are not well studied in this plant. The nematodes can retain the virus for long periods. The virus is transmitted on the other host through nematode *Xiphinema americanum,* another vector *Thrips tabaci* help in the transmission of disease.

* For management refer to page number 19.

10) Cucumber mosaic disease:

Disease symptoms:

- Disease plants show leaves with mottling or mosaic pattern of light green and dark-green areas.
- Vein clearing, greenish yellow mottling occur as primary symptoms on newly formed young leaves.
- Infection on young plants results in stunted growth, malformation, distortion and puckering of leaves. Dark-green blisters and sometime enations (leafy growth) appear on the dorsal side of the leaf.

https://www.google.co.in/search?q=cucumber+mosaic+virus+of+tobacco&espv=210&es_sm

Transmission and favourable Conditions:

- The disease is transmitted by Aphid.
- CMV is shown to develop symptoms more readily in temperatures between 79 and 89 degrees Fahrenheit.
- Aphids are more active in warm summer conditions and increased their population as well as spread the viruses more.

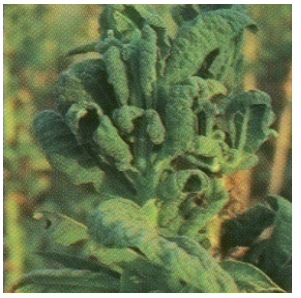
* For management refer to page number 19.

11) Tobacco leaf curl disease:

Disease symptoms:

- Disease is characterized by downward curling & rolling of leaves; thickening; dark green in colour with vein clearing effect; brittle; enation (cup like or frill like outgrowth), reduction in size.
- Infected plants become stunted due to shortening of internodes and formation of more lateral branches.
- Flowers are deformed; partly or completely sterile.





https://www.google.co.in/search?q=tobacco+leaf+curl+virus&espv=210&es_sm=93&source=lnms

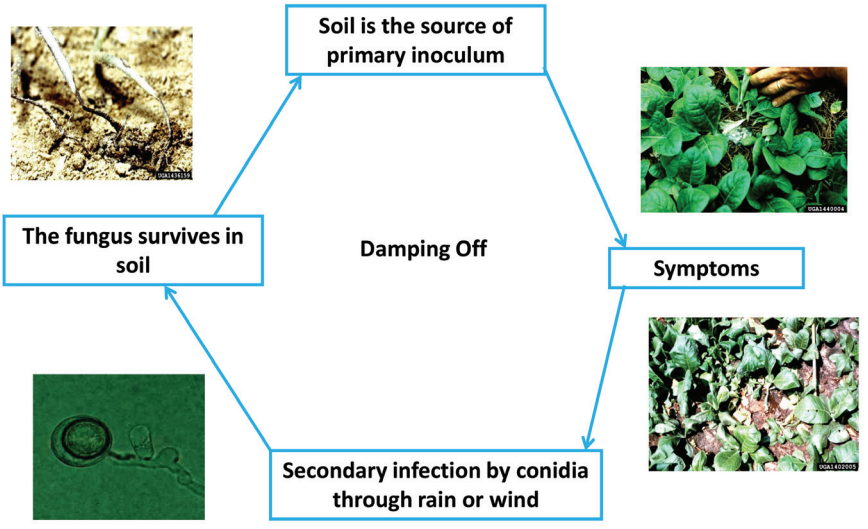
Transmissions and favourable conditions:

- White fly is the vector for transmitting of leaf curl virus.
- White flies become more active in dry periods after monsoon showers. Leaf-curl is therefore, noticed more during this period.
- Tobacco plants become more resistant to Tobacco leaf curl virus as they grow older.

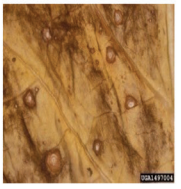
* For management refer to page number 19.

Disease cycles:

1) Damping off:



2) Frog eye leaf spot:

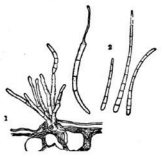


Primary infection occurs by spores present in the soil

The fungus survives in soil and plant debris

Frog eye leaf spot

Symptoms



Secondary infection by conidia through rain or wind

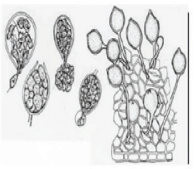
3) Leaf blight/black shank:

Primary infection occurs by spores present in the soil or infected plant debris

The fungus survives in soil and plant debris

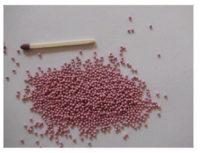
Leaf bight/ Black shank

Symptoms



Secondary by conidia through rain or wind

4) Anthracnose:



Primary infection occurs by sowing infected seeds

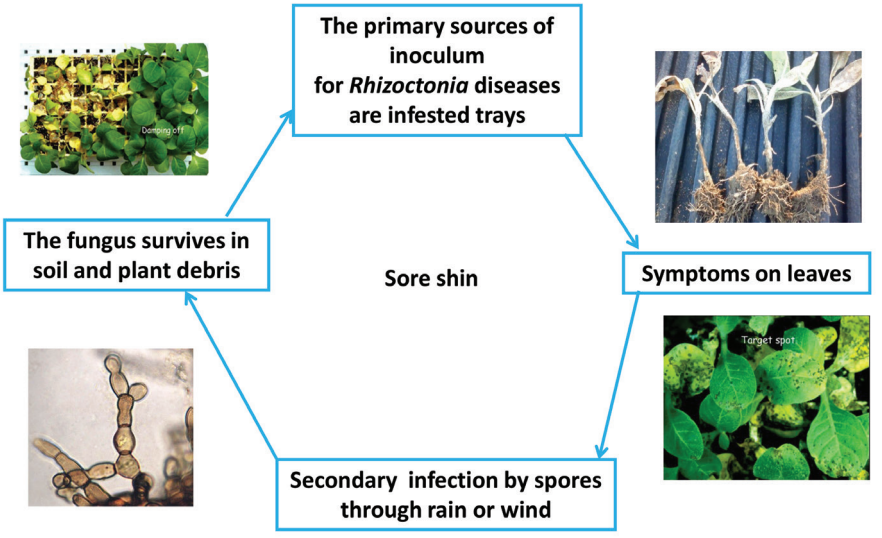
The fungus survives in seeds and plant debris

Anthracnose

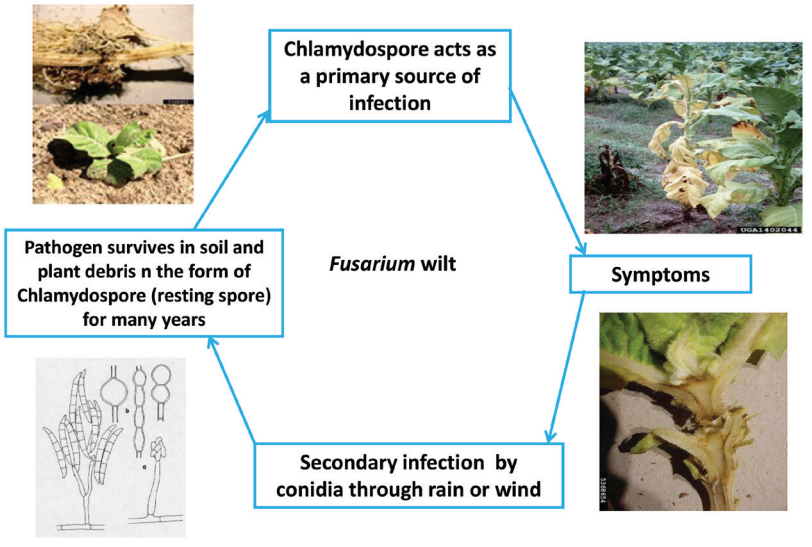
Symptoms on leaves

Secondary infection by conidia through rain or wind

5) Sore shin:



6) *Fusarium* wilt:



X. SAFETY MEASURES

A. At the time of harvest:

Tobacco is harvested in one of two ways. The oldest known method in use is simply cutting off the stalk at the ground using a curved knife. The other way to harvest tobacco leaves originated in the nineteenth century. They started to harvest the tobacco plant by pulling individual leaves off the stalk as they ripened, tobacco leaves ripen from the ground upward, so tobacco plant may be pulled several different times before the tobacco plant is entirely harvested. This is also known as "Cropping" or "Priming". These are terms used for pulling leaves off tobacco. The first crop at the very bottom of the stalks are called "sand lugs" as they are often against the ground and are coated with dirt splashed up when it rains.

B. During post harvest:

Flue-cured virginia tobacco

The aim should be for the production of uniform, well-matured crop and only such ripe leaves should be harvested. Ripe leaves have greenish-yellow colour, have a velvety feel and have lost much of their stickiness. They have a tendency to lie horizontally or bend slightly down the plant and the leaf-tips are slightly dry. As a general rule, the leaves are harvested from the bottom primings slightly on the green side, the middle leaves when they are ripe and the top leaves when they are fully ripe. On an average, not more than three leaves should be harvested at a time. Harvesting must be done on a clear weather day. Immediately after rains or irrigation the crop should not be harvested and it is to be delayed by 2 - 3 days in such cases. Under normal condition, priming is once in a week. The leaves should be pluck against the direction of the sun for better judgment of matured leaf colour. While picking, the midribs should not be bent down, but they have to be bent side-ways. A well-matured leaf will snap crisply with a characteristic sound. The leaves are to be carried carefully without pressing to one end of the field and placed carefully in a wide basket with tips upward. The basket has to be taken to the tying shed as early as possible to minimise wilting in the field.

Depending on the type of the tobacco, four principal methods of curing can be distinguished, namely, i) flue-curing, ii) air-curing, iii) fire-curing and iv) sun-curing.

Details of the improved curing method are given below:

1. Yellowing:

    Temperature - 85-105°F,

    Time - 36-48 h.

2. Fixing colour:

    Temperature: 105-120°F

    Time: 5-10 h

    Progressive total time: 39-47 h.

3. Leaf drying:

    Temperature: 120 to 145°F

    Time : 36-48 h

4. Midrib drying:

    Temperature - 145 to 160°F

    Time : 24-36 h

    Progressive total time: 88 to 101 h.

Lanka tobacco

The crop gets ready for harvest 90-100 days after planting. Harvesting in the evening hours by cutting the plants close to the ground when the tips of leaves begin to dry and show considerable thickening and puckering. The plants are left over night in the field to wilt. The plants are brought nearer to curing-shed in the early hours of next day and then the leaves are separated along with a big slice of the stem. The 10-15 wilted leaves are stitched to the agave fibre with the help of tobacco needle (a long iron needle). These are called 'Thoranam' or 'Chekka'.

Cigar Wrapper tobacco

Harvesting of wrapper tobacco takes about 120-140 days from the date of planting till it gets ready for final harvest. Matured leaves of yellowish-green colour, with light brown spots (spangles) are harvested by "priming" (Removing 4 or 5 leaves at each priming in four or five installments). Cigar wrapper is an air-cured tobacco. Harvested leaves are placed in katcha curing barn, on racks made of bamboos after stringing the leaves with the help of sutli. The leaves are cured under atmospheric temperature and 70 - 80% relative humidity. The process takes 5-6 weeks for completion. After this it is sent for curing to the respective companies.

Chewing and hookah tobacco

Crop is harvested at full maturity stage by stack cut method with the help of a sickle or khurpi close to the ground level. After harvesting crop should be left in the field for sun-drying for 4 to 6 days. After 2-3 days drying, plants are turned upside down for drying of remaining portion. After 5-6 days of sun drying harvested crop is brought to the curing yard i.e. clean grassy patch and after two days of drying it is turned upside down in the morning.

Bidi tobacco

Harvesting of bidi tobacco normally should be carried out in December-February. Harvesting of bidi tobacco is done at an advanced stage of maturity. The maturity is judged by pronounced development of brown spots called 'spangles'. The leaves are ripe for harvest about 75 days after topping. Bright sunny days are ideal for harvesting. Prevalence of cloudy weather affects the quality adversely.

XI. 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 monocropping.
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/seedlings/ planting materials with approved bio products/chemicals for the control of seed borne diseases/pests. 	Do not use seedlings 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 planting based test recommendations.	Do not apply any micronutrient mixture after planting 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 SINPV 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.	In case of pests which are active during night like *Spodoptera* spray recommended biopesticides/ chemicals at the time of their appearance during evening time.	Do not spray pesticides at midday since, most of the insects are not active during this period.
16.	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for whiteflies, *Spodoptera* etc. 	Do not spray pesticides only on the upper surface of leaves.
17.	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
18.	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.

XII. SAFETY PARAMETERS IN PESTICIDE USAGE

S. No.	Pesticide	Classification as per insecticide rules	Colour of toxicity triangle	WHO classification of hazard	First Aid measures	Symptoms poisoning	Treatment of poisoning	Waiting period from last application to harvest (days)
Insecticides								
1.	Oxydemeton-methyl	Highly toxic		Class Ib-Moderately hazardous-	Atrophine sulphate	Severe – diarrhoea, pinpoint and non - reactive pupils, respiratory difficulty, pulmonary edema, cyanosis, loss of sphincter control, convulsions, coma and heart block.	For ingestion lavage stomach with 5 % sodium bicarbonate, if not vomiting. For skin contact, wash with soap and water (eyes – wash with isotonic saline). Wear rubber gloves while washing contact areas. In addition to atropine give 2 – PAM (2 – pyridine aldoximemethiodide). 1 g and 0.25g for infants intravenously at slow rate over a period of 5 minutes and administer again periodically as indicated. More than one injection may be required. Avoid morphine, theophylline, aminophylln, barbiturates Phenothiaznines	20
Fungicides								
2.	Captan	Moderately toxic		Class III slightly hazardous		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose,throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic	1
3.	Copper oxychloride	do	do	do		do	do	--
4.	Metalaxyl + Mancozeb	do	do	do		do	do	Not less than 7 weeks
5.	Sulphur	Slightly toxic		Unlikely to present acute hazard in normal use		do	do	--

XIII. 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. Equipment

1. Select right kind of equipment.
2. **Do not** use leaky and defective equipment.
3. Select right kind of nozzles.
4. **Do not** 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** just before the rains and after the rains; **Do not** 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 sprayer.
7. Avoid tank mixing of different pesticides.

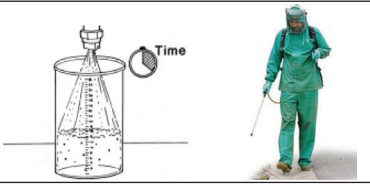
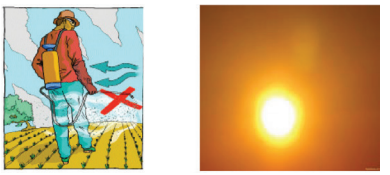
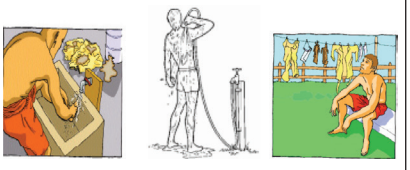
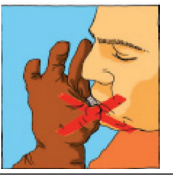
G. Disposal

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.

XIV. PESTICIDE APPLICATION TECHNIQUES

Equipment			
Category A: Stationary, crawling pest/disease			
Vegetative stage i) For crawling and soil 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	 
ii) For small sucking leaf borne pests			
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 Reproductive stage *(Field Pests)*	Insecticides and fungicides	• Motorized knapsack sprayer or mist blower (Droplets of small size) • 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)	 

XV. 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. Do not apply pesticides without protective clothing and wash clothes immediately after spray application.	
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.	

XVI. REFERENCES

- http://www7.inra.fr/hyppz/RAVAGEUR/6helarm.htm
- http://www.infonet-biovision.org/default/ct/120/crops
- http://www.invasive.org/browse/subinfo.cfm?sub=9408
- http://en.wikipedia.org/wiki/Helicoverpa_armigera
- http://commons.wikimedia.org/wiki/File:Spodoptera_litura_egg_mass.jpg
- http://lepidoptera.butterflyhouse.com.au/lynf/lynf.html
- http://www.ccs-hk.org/DM/butterfly/Noctuid/Spodoptera-litura.html
- http://www.nbaii.res.in/insectpests/images/Spodoptera-litura11.jpg
- http://m.animal.memozee.com/m.view.php?q=%EB%8B%B4%EB%B0%B0%EA%B0%80%EB%A3%A8%EC%9D%B4&p=3
- http://www.forestryimages.org/browse/detail.cfm?imgnum=2511050
- http://www.fera.defra.gov.uk/plants/publications/documents/factsheets/bemisia.pdf
- http://www.entomology.umn.edu/cues/inter/inmine/Whitefg.html
- http://keys.lucidcentral.org/keys/sweetpotato/key/ Sweetpotato%20Diagnotes/Media/Html/TheProblems/Nematodes/RootKnotNematode/Root-knot.htm
- http://nematology.umd.edu/rootknot.html
- http://www.cals.ncsu.edu/pgg/dan_webpage/Introduction/Images/pyroform.htm
- http://gsquaredbugs.com/?page_id=318
- http://www.nbaii.res.in/Featured%20insects/Campoletis.htm
- http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398
- http://www.organicgardeninfo.com/ichneumon-wasp.html
- http://baba-insects.blogspot.in/2012/02/telenomus.html
- http://www.nbaii.res.in/Featured%20insects/chelonus.htm
- http://m.animal.memozee.com/m.view.php?q=%EB%8B%B4%EB%B0%B0%EA%B0%80%EB%A3%A8%EC%9D%B4&p=3
- http://www.forestryimages.org/browse/detail.cfm?imgnum=25110
- http://www.fera.defra.gov.uk/plants/publications/documents/factsheets/bemisia.pdf
- http://www.entomology.umn.edu/cues/inter/inmine/Whitefg.html
- Directorate of Weed Science Research, (ICAR), Jabalpur. www.dwsr.icar.org.in
- http://www.agroatlas.ru/content/weeds/
- http://www.biolib.cz/IMG/GAL/166362.jpg
- http://www.rkmp.co.in/sites/default/files/eis_states/Cyperus%20iria_0.JPG
- http://upload.wikimedia.org/

- http://www.madosz.hu/fileok/Image/Dr%20gondola/szadorgondola.JPG
- http://www.madosz.hu/fileok/Image/Dr%20gondola/szadorgondola.JPG
- http://www.ipmimages.org/images
- http://www.ipmimages.org/images
- http://www.ipmimages.org/images/384x256/1440089.jpg
- https://www.google.co.in/search?q=damage+symptoms+of+tobacco+by+helicoverpa+armigera
- https://www.google.co.in/search?q=damage+symptoms+of+tobacco+by+spodoptera+litura &espv=210&es_sm=122&source=lnms&tbm=isch&sa=X&ei=C88BU_C3CsOMrQewgYH
- https://www.google.co.in/search?q=damage+symptoms+of+tobacco+by+whitefly&espv=210&es_ sm=122&source=lnms&tbm=isch&sa=X&ei=RM8BU5O2GMG4rAeClIHYCA&ved=0CAcQ_AUoAQ&biw
- https://www.google.co.in/search?q=damage+of+tobacco+caused+by+Scrobipalpa+heliopa &espv=210&es_sm=122&source=lnms&tbm=isch&sa=X&ei=cc8BU46RI8qCrge8g4DQAw&ve
- http://www.nbaii.res.in/Featured%20insects/chelonus.htm
- https://www.google.co.in/search?q=damage+of+tobacco+by+aphid&espv=210&es_ sm=122&source=lnms&tbm=isch&sa=X&ei=mc8BU_ yMCNGsrAeb5YHIDA&ved=0CAcQ_AUoAQ&b
- https://www.google.co.in/search?q=damage+of+tobacco+by+aphid&espv=210&es_ sm=122&source=lnms&tbm=isch&sa=X&ei=mc8BU_yMCNGsrAeb5YHIDA&ved=0CAcQ_AUoAQ&b
- https://www.google.co.in/search?q=damage+symptoms+of+tobacco+by+nematode&espv=210&es_ sm=122&source=lnms&tbm=isch&sa=X&ei=xs8BU9DHGoOJ
- https://www.google.co.in/search?q=damage+symptoms+of+tobacco+by+nematode&espv=210&es_ sm=122&source=lnms&tbm=isch&sa=X&ei=xs8BU9DHGoOJ
- https://www.google.co.in/search?q=damping+off+of+tobacco&esp\
- https://www.google.co.in/search?q=frog+eye+spot+of+tobacco&espv=210
- https://www.google.co.in/search?q=black+shank+disease+tobacco&oq=black+shank+disease
- https://www.google.co.in/search?q=anthracnose+of+tobacco&espv=210&es_sm=93&source=lnms
- https://www.google.co.in/search?q=shore+shin+of+tobacco&oq=shore+&aqs=chrome.1
- https://www.google.co.in/search?q=fusarium+wilt+of+tobacco&espv=210&es_sm=93&source=
- https://www.google.co.in/search?q=brown+spot+of+tobacco&espv=210&essm=93&source=lnm
- https://www.google.co.in/search?q=tobacco+mosaic+disease&espv=210&es_sm=93&source=lnm
- https://www.google.co.in/search?q=tobacco+ring+spot+disease&espv=210&es_sm=93&source
- https://www.google.co.in/search?q=cucumber+mosaic+virus+of+tobacco&espv=210&es_sm
- https://www.google.co.in/search?q=tobacco+leaf+curl+virus&espv=210&es_sm=93&source=lnms
- Gurr Men SD, Altieri MA (2004) Ecological Engineering for Pest Management Advances in Habitat Manipulation for Arthropods. CSIRO PUBLISHING, Collingwood, Australia.

Good insectary plants belonging to Compositae, Leguminaceae, Umbelliferae, Brassicaceae etc. families

Castor

Sunflower

Carrot

Marigold

Chrysanthemum

Mustard

Coriander

Alfalfa

French bean

Cowpea

Buckwheat

Maize

रा व स्वा प्र सं
N I P H M

National Institute of Plant Health Management
Rajendranagar, Hyderabad, Telangana

Directorate of Plant Protection Quarantine and Storage
N. H. IV, Faridabad, Haryana

NCIPM

National Centre for Integrated Pest Management
LBS Building, IARI Campus, New Delhi

Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India