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AESA BASED IPM PACKAGE

AESA based IPM – Pomegranate

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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.

A K Srivastava

Date: 6.3.2014

(Avinash K. Srivastava)

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FOREWORD

IPM is a holistic approach of crop protection based on the integration of multiple strategies viz., cultural, physical, mechanical, biological, botanicals 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, though 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 since shown 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)

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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 a 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, though 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)

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AESA BASED IPM PACKAGE FOR POMEGRANATE

Pomegranate plant description:

Pomegranate is a small tree, measuring less than 4 m when cultivated, although it can reach 7 m in the wild. Some trees may live longer than 100 years. The root is knotty, consistent and reddish, well developed and extremely absorbent in saline soils. Numerous suckers grow beside the trunk and have to be eliminated occasionally. The bark, known as pomegranate bark, has traditionally been used for the alkaloids it contains although the trunk and bark of the branches contain similar quantities of the same. The trunk is more or lessround, erect, ramified, with alternate open branches, sometimes prickly at the apex. The ageing bark shows cracks and takes on a greyish colour. It appears knotted ant twisted. The tree itself varies in appearance from drooping to erect.

Leaves: The leaves in vegetative or mixed clusters measure about 2 to 9 cm in length and 1 to 3 in width. They are entire, smooth, opposed, with no stipule, sometimes verticillate**,** hairless, oblong, deciduous and with short petioles

Flowers: The flowers appear singly or in small clusters generally of 2-7 flowers, occasionally at the end of the branch but sometimes on the auxiliary buds. They are spectacular, with a pear shaped thallus, concave and fleshy, almost seated, single or in groups of 2-7, with bell-shaped calyx. The petals, 5-9, are wrinkled, alternating with and longer than the sepals and scarlet. The shorter sepals (5-9) alternate with the petals and form a continuous fleshy red crenelation.

Fruit: The fruit is a fleshy berry denominated balausta, thick-skinned, complex, enclosed by the thallus, with various polyspermal cavities separated by tenuous membranous partitions (carpelar membranes). The interior is filled with many fleshy seeds, prismatic in shape, with pulpy testa and woody tegmen, very juicy. The ripe fruit is greenish yellow or brown with reddish areas which may occasionally occupy the whole surface of the fruit.

I. PESTS

A. Pests of National Significance:

1. Insect pests

1.1. Anar butterfly: *Deudorix* (*Virachola*) *isocrates* Fabricus (Lepidoptera: Lycanidae)

1.2. Stem borer: *Coelosterna spinator* Febricius (Coleoptera: Cerambycidae)

1.3. Whitefly: *Siphorinus phillyreae* Haliday (Hemiptera: Aleyrodidae)

1.4. Shot hole borer: *Xyleborus perforans* Wollastan (Coleoptera: Scolytidae)

1.5 Thrips: *Scirtothrips dorsalis* Hood or *Rhiphiphorothrips cruentatus* Hood (Thysanoptera: Thripidae)

1.6. Fruit borers: *Conogethes punctiferalis,* (Lepidoptera: Pyralidae)

2. Diseases

2.1 Bacterial leaf and fruit spot: *Xanthomonas axonopodies* pv. *punicae* (Hingorani and Singh) Vauterin et al.

2.2 Leaf and fruit spot: *Pseudocercospora punicae* (Hennings) Deighton

2.3 Anthracnose: *Colletotrichum gloeosporioides* (Penz.) Sacc.

2.4 Wilt: *Fusarium oxysporum* Schlecht.

B. Pests of Regional Significance:

1. Insect pests

1.1 Pomegranate aphid: *Aphis punicae* Passerini (Homoptera: Aphididae)

1.2 Mealy bugs: *Ferrisia virgata* Cockerell (Homoptera: Coccidae)

1.3 Fruit borer: *Spodoptera litura* (Lepidoptera: Noctuidae)

1.4 Fruit sucking moth: *Eudocima* spp. (Lepidoptera: Noctuidae)

2. Diseases

2.1 Fruit scab: *Speciloma* sp.

2.2 Leaf spot: *Alternaria* sp. and *Cercospora* sp.

2.3 Fruit rot: *Phytophthora* spp., *Aspergillus foetidus* Thom & Raper

3. Animal and rodent pests

In some areas, rodents damage the pomegranate crop by making burrows in the pomegranate fields. Sometimes, monkeys, buffaloes, wild boar and other grazing animals also destroy the pomegranate cultivation by grazing or trampling over it.

II AGRO-ECOSYSTEM ANALYSIS (AESA) BASED INTEGRATED PESTS 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 forces 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 material
- Treat the seed/seedlings/planting material with recommended pesticides especially biopesticides
- Follow proper spacing
- Soil health improvement (mulching and green manuring whenever applicable)
- Nutrient management especially organic manures and biofertilizers based on the soil test results. If the dosage of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dosage is too low, the crop growth is retarded. So, the farmers should apply an adequate for best results. The phosphatic fertilizers should not be applied each and every season as the residual phosphate of the previous season will be available for the current season also.
- Proper irrigation

- Crop rotation

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.)

http://4.bp.blogspot.com/-3S7jTfQfmiw/TxF9yz51rFI/AAAAAAAAEuU/YiRVblq2ln4/s410/piantagione_di_melograni_cultivar_Wonderful.jpg

Plant compensation ability

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

Understand and conserve defenders

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

Insect zoo

In field various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in crop field. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial and harmful insects. In this method, unfamiliar/unknown predators are collected in plastic containers with brush from the field and brought to a place for

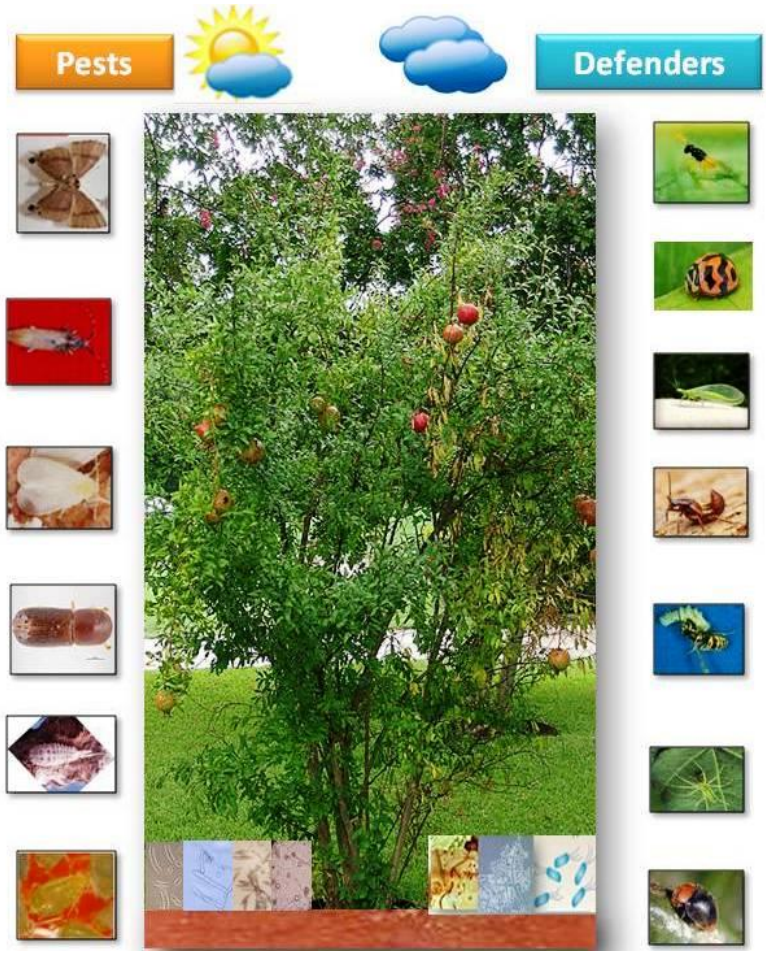
study. Each predator is placed inside a plastic bottle together with parts of the plant and some known insect pests. Insects in the bottle are observed for certain time and determined whether the test insect is a pest (feeds on plant) or a predator (feeds on other insects).

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 pomegranate pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens. The important natural enemies in pomegranate are given in ecological engineering table on page …..

Model agro-ecosystem analysis chart

Date:
Village:
Farmer:



Decision taken based on the analysis of field situations

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

No. of natural enemies :
P: D ratio :

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

Decision making

Farmers become experts in crop management

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

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

AESA methodology

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

    - Plant: Observe the plant health, 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.
    - Rats: Count number of plants affected by rats.
    - Weeds: Observe weeds in the field and their intensity.
    - Water: Observe the water situation of the field.
    - Weather: Observe the weather condition.

- While walking in the field, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the field situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be

drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.

- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on 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

- Keep records of what has happened
- Help us making an analysis and draw conclusions

Data to be recorded

- **Plant growth (weekly):** General plant vigour
- **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.

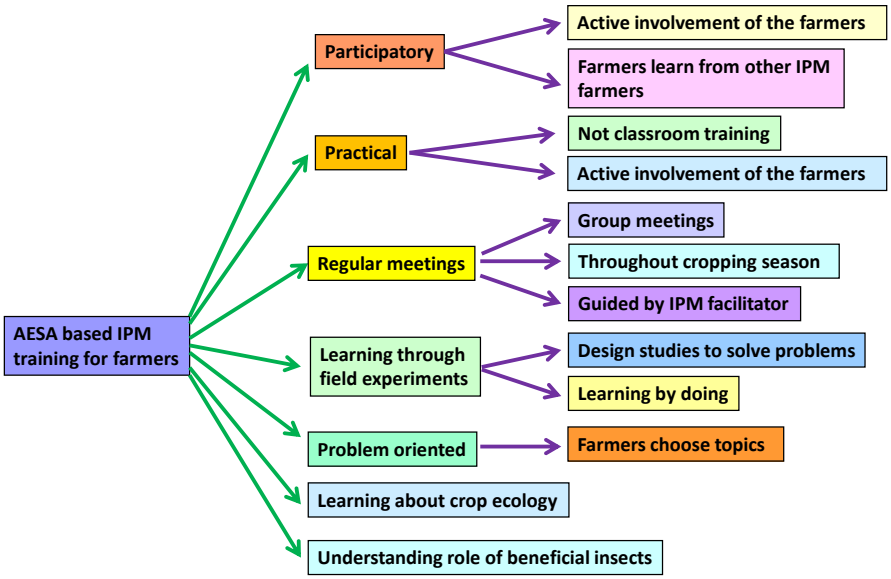
AESA and farmer field school (FFS)

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

For sucking pests:
Aphids, whitefly: Count and record the number of both nymphs and adults on five randomly selected leaves per plant.
Thrips: Count and record the number of nymphs and adults of thrips present on five terminal leaves per plant (tapping method also can be used to count thrips).
*Anar butterflySpodoptera***:** Total number of fruits, damaged fruits 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). Always check plants that appear unhealthy. It is often necessary to wash the roots with water to examine them properly. If the roots are well developed, cut into them to examine the roots for internal infections (discolouration & signs). Count the total number of pseudostem damaged/infested/infected due to rot should be counted and incidence should be recorded.

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

Stem, flower and fruit sampling: Carefully examine the stems, flower and fruits of plants for signs of fungal or bacterial diseases or lesions. The stems, pods and fruits and heads should be split or taken apart and examined for discoloration caused by fungi and bacteria. Count the number of plant, fruit, pod infected due to disease and incidence should be recorded.

C. Surveillance through pheromone trap catches for *Spodoptera* *and* *anar butterfly*:

Pheromone traps for *Spodoptera litura and anar butterfly etc* @ 2/fixed field have to be installed. Install the traps for each species separated by a distance of >75 feet in the vicinity of the selected fixed 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). During each week of surveillance, the number of moths/trap should be counted and entered.

Procedure for observation: Total number of moths of *anar butterfly and Spodoptera litura*/trap/week should be recorded year round. The trapped moths should be destroyed and removed after each recording.

D. Yellow pan water trap/sticky traps

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

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).

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. Shelters such as overwintering sites, moderate microclimate, etc are needed.
3. Natural enemies may also require alternate host when primary host are not present.

Ecological engineering for pest management – Above ground:

- Raising 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
- Growing 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 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.
- Keeping soils covered year-round with living vegetation and/or crop residue.
- Adding organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance below ground biodiversity.
- Reducing tillage intensity so that hibernating natural enemies can be saved.
- Applying balanced dose of nutrients using biobiofertilizers.
- Apply mycorrhiza and plant growth promoting rhizobacteria (PGPR)
- Apply *Trichoderma* and *Pseudomonas fluorescens* as seed, 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, lady bird beetles, long horned grasshoppers, *Chrysoperla,* earwigs, etc.

Ecological Engineering Plants

Attractant plants

Cowpea

Carrot

Sunflower

Buckwheat

Alfalfa

Mustard

Cosmos

Anise

Caraway

Dill

Parsely

Marigold

Repellent plants

***Ocimum* sp**

Peppermint

Spear mint

Border plants

Sorghum

Maize

Pearl Millet

Intercrops

French bean

Blackgram

Greengram

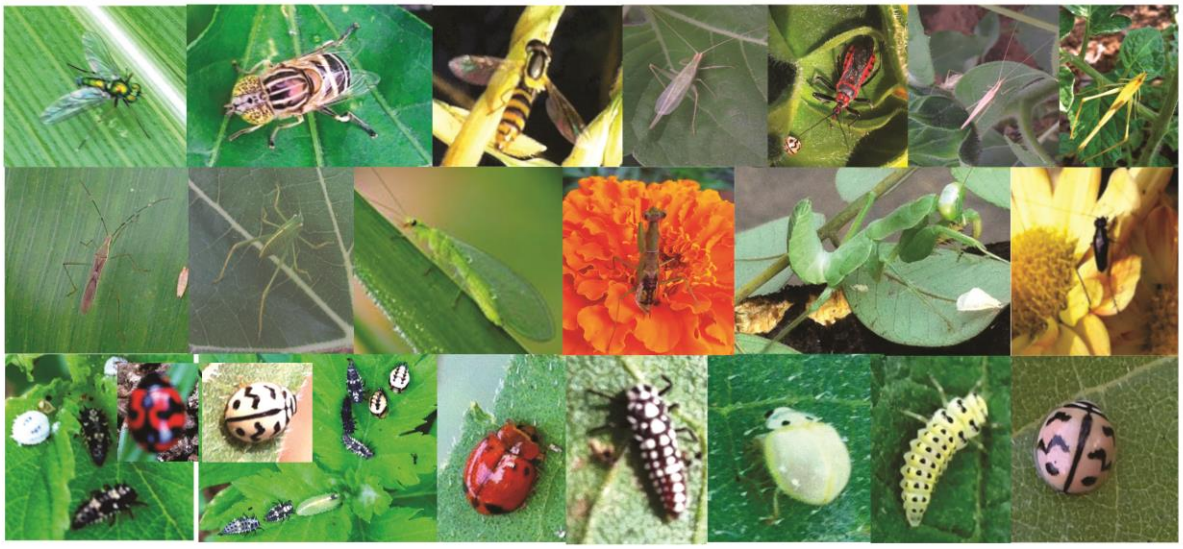
Groundnut

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

Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders

IV. CROP STAGE-WISE IPM

Management	Activity
Pre planting*	
	<u>Common cultural practices:</u> • Timely planting should be done. • Field sanitation, rogueing • Destroy the alternate host plants • Apply manures and fertilizers as per soil test recommendations • Sow the ecological engineering plants • Sow the intercrops as per the season. • Sow/plant sorghum/maize/pearl millet in 4 rows all around the crops as a guard/barrier crop. •
Nutrients	• Pits are dug 60-75 cm3 before the onset of monsoon. The pits are filled with 20-25 kg of FYM or Compost, 1 kg of super phosphate. The plants are planted usually in square or hexagonal system. • The distance of planting in case of many improved varieties is 5.0 X 4.0 m. • For higher yields during the first 4-5 years after planting, a distance of 5 X 2 m may be adopted and alternate plants may be removed afterwards maintaining a planting distance of 5 X 4 m.
Weeds	• Weeds should be removed from the field to avoid further spread of weed seeds
Soil-borne pathogens, and resting stages of insects	**<u>Cultural control:</u>** • Deep summer ploughing of fields to exposes dormant stages (pupa and larva) and subsequently reduces their initial population build up • **Soil solarization:** Cover the beds with polythene sheet of 45 gauge (0.45 mm) thickness for three weeks before planting for soil solarization which will help in reducing the soil-borne pests including weeds. • Ploughing in inter- space.
Bacterial leaf spot	**<u>Cultural control:</u>** • Proper plant & row spacing • Selection of disease free seedlings for fresh planting • Use of plenty of organics + micronutrients + recommended NPK
Planting*	
	<u>Common cultural practices:</u> • Use resistant/tolerant planting material/seedlings • Use healthy, certified and weed free planting material. • Follow proper plant spacing
Nutrients	• One year old plants should be applied about 10 kg of FYM and

	150 to 200 grams of Ammonium sulphate. This amount is increased every year, so that a five year old plant gets 50 kg FYM and 1 Kg of Ammonium sulphate.The adult bearing trees are applied with 675g of Nitrogen, 250g each of Phosphorous and Potash.
Weeds	• Remove weeds before planting.
Soil-borne pathogens, and resting stages of insects	**Cultural control:** • **Clean cultivation:** For healthy growth keep basin clean. • **Soil health:** Avoid water logging, keep soil raked and aerated, to reduce invasion of shot hole borer. • **Detection of pest:** The infestation should be detected periodically by looking out for drying branches. • Moderate to heavy pruning to remove disease affected, broken, crisscross branches, water sprouts, suckers and opening canopy to improve light penetration. **Mechanical control:** • **Uproot infested trees:** Infested young plants should be uprooted and burnt.
***** Apply *Trichoderma viride/ harzianum* and *Pseudomonas fluorescens* as seed/seedling/planting material, 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).	
Vegetative stages	
	Common cultural practices: • Collect and destroy crop debris • Provide irrigation at the critical stages of the crop • Avoid water logging • Avoid water stress during flowering stage • Follow judicious use of fertilizers • Enhance parasitic activity by avoiding chemical pesticide spray, when 1-2 larval parasitoids are observed in the crops field. **Common mechanical practices:** • Collect and destroy disease infected and insect infested plant parts • Collect and destroy eggs and early stage larvae • Handpick the older larvae during early stages • Use yellow sticky traps @ 4-5 trap/acre • Use light trap @ 1/acre and operate between 6 pm and 10 pm • Install pheromone traps @ 4-5/acre for monitoring adult moths activity (replace the lures with fresh lures after every 2-3 weeks) • Erecting of bird perches @ 20/acre for encouraging predatory birds such as King crow, common mynah etc. • Set up bonfire during evening hours at 7-8 pm. • **Common biological practices:** • Conserve natural enemies through ecological engineering

	• Augmentative release of natural enemies
Nutrients	• Irrigation interval may vary from 1-3 days depending upon weather condition, age of plant, crop stage, soil type etc. • Provide less irrigation during new leaf emergence and flower development stages as excess water during these Stages may lead poor flowering. • Apply NPK@ 170-40-40g/tree and FYM@ 10kg/tree if the crop age is 3years, NPK@ 170-40-85g/tree and FYM @ 15kg/tree crop age is 4years, NPK@ 210-85-85 g/tree and FYM @ 20kg/tree crop age is above 5years. • Along with recommended dosage of NPK and FYM apply Neem cake 0.5kg + vermicompost 1.5kg + calcium ammonium nitrate 50g/tree in circular trench (15-20 cm wide of 8-10cm depth) at 45-60cm apart from the stem, cover the trenches properly with soil and start irrigation.
Weeds	• Remove weeds before flowering.
Shot hole borer	**Cultural control:** • Avoid water logging and rake the soil **Mechanical control:** • Infested young plants should be uprooted and burnt.
Stem boring beetle	**Cultural control:** • Detect early infestation periodically looking out for drying branches.
Pomegranate butterfly	**Cultural control:** • Clean cultivation and maintenance of health and vigour of the tree should be followed. • The fruits if screened with polythene or paper bags may escape infestation. • Removal and destruction of all the affected fruits. **Mechanical control:** • Remove weeds of compositae family • Detect early infestation by periodically looking for drying branches. **Biological control:** • Release of *Trichogramma chilonis* @ 1.0 lakhs/ acre four times at 10 days interval
Flowering and Fruiting	
	Common cultural practices • Same as in vegetative stage

Nutrients	• Collect & burn fallen leaves /debris from the orchard • Harrowing in interspaces. • Apply full dose of well rotten FYM and P, 1/3rd N&K fertilizers @ 330-85-85g/tree and FYM @ 20kg/tree for 3year old plant, NPK@ 330-85-165 g/tree and FYM @ 25 kg/tree crop age is 4yrars, NPK @415-165-165 g/tree and FYM @ 30 kg/tree crop age is above 5 years along with micronutrients (ZnSO4, FeSO4, MnSO4 each 25g and10g Borax (Boron) /tree)+ Neem Cake 1-1.5 kg /tree + Vermicompost 2 kg/tree in shallow trench or ring (15-20 cm wide of 8-10cm depth) at 45-60cm apart from the stem, cover the trenches properly with soil and give light irrigation immediately after fertilizer application. • There should not be moisture stress at fruit setting, fruit maturation and fruit ripening.
Weeds	• Remove weeds and suckers • Remove suckers & take up timely weeding
Butterfly/fruit sucking moth	**Cultural control:** • Remove eggs from calyx. • Collect and destroy damaged fruits • Follow clean cultivation as weed plants serve as alternate hosts **Mechanical control:** • Prune the affected parts of the plant and destroy. • Detect early infestation by periodically looking for drying branches. • Use light trap @ 1/ acre to monitor the activity of adults **Biological control:** • Release *Trichogramma chilonis* at one lacs/acre.
Shot hole borer	**Mechanical control:** • Infested trees should be uprooted and brunt, especially the root zone. • Prune the affected fruits and buds of the plant and destroy. • Detect early infestation by periodically looking for drying branches
Thrips	**Cultural control:** • Keep basin clean. • Maintain adequate aeration by proper training and pruning **Mechanical control:** • Prune the affected parts of the plant and destroy. • Detect early infestation by periodical monitoring for drying branches. • Use of blue sticky traps @ 4-10 traps/acre **Biological control:** • Conservation and release of defenders like Syrphids and Coccinellids should be done to suppress sucking pests.
Mealy bugs	**Cultural control:**

	• Collect and destroy the infested plant parts • Remove alternate hosts **Biological control:** • Conservation and release of defenders like Syrphids and coccinellids should be conserved to suppress sucking pests. • Release *Cryptolaemus montrouzieri* near the site of mealy bug @ 10/tree.
Aphid	**Cultural control:** • Collect and destroy the damaged plant parts • Maintain adequate aeration by proper training and pruning • Use yellow sticky traps @ 4-10 traps /acre **Biological control:** • Release first instar larva of *Chrysoperla zastrowi sillemi* @ 15 / flowering branch (four times) at 10 days interval from flower initiation during April.
Whitefly	**Cultural control:** • Field sanitation • Removal of host plants • Maintain adequate aeration by proper training and pruning • Install yellow sticky traps @ 4-10 traps /acre **Biological control:** • Release of predators *viz.*, Coccinellid predator, *Cryptolaemus montrouzieri* and lacewing, • Release of parasitoids *viz*., *Encarsia haitierrsis* and *E. guadeloupae*
Bacterial leaf and fruit spot	**Cultural control:** • Clean cultivation and strict sanitation in orchard • Prune and burn affected branches and fruits should be done regularly • Collect and burn fallen infected leaves and fruits
Leaf and fruit spot	**Cultural control:** • The diseased fruits and twigs should be pruned and destroyed. • . • 10% garlic and onion bulb extracts is effective in controlling the disease. **Chemical control:** • Apply Propineb 70% WP @ 0.30% or 120g in 80 l of water as required depending upon size of the tree and plant protection equipment used
Anthracnose	**Cultural control:** • Select Haste or Ambe bahar • Wider plant spacing, yearly pruning of trees. • Proper disposal of diseased leaves, twigs and fruits. **Chemical control:** • Apply Kitazin 48% EC @ 0.20% or 80ml in 80 l of water as require depending upon crop stage and plant protection equipment used

Fruit rot & scab**	**<u>Cultural control:</u>** • Select Haste or Ambe bahar • Wider plant spacing, yearly pruning of trees. • Proper disposal of diseased leaves, twigs and fruits.
Post harvest	
Pest & diseases	**<u>Cultural methods:</u>** **<u>Mechanical control:</u>** • Remove and destroy all the affected fruits to reduce, the incidence of Anar butterfly. • Cover the fruit with paper bags when the fruits are sized up to 5 cm.

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. DESCRIPTION OF INSECT-PESTS

1. Anar butterfly/ Pomegranate fruit borer

Biology:

Eggs: Laid singly on tender leaves, stalks and flower buds.
Larvae - Bark brown, short and stout, covered with short hairs, larval period lasts for 18-47 days.
Pupation: Occurs either inside the damaged fruits or on the stalk holding it.
Pupal period lasts for 7-34 days. Total life cycle is completed in 1 to 2 months**.**
Adult - Bluish brown butterfly.

Damage symptoms:

- Caterpillar bores into young fruits.
- Feeds on internal contents (pulp and seeds)
- Fruit rotting and dropping may occur

Holes on fruit **Fruit get rot and Drop down**

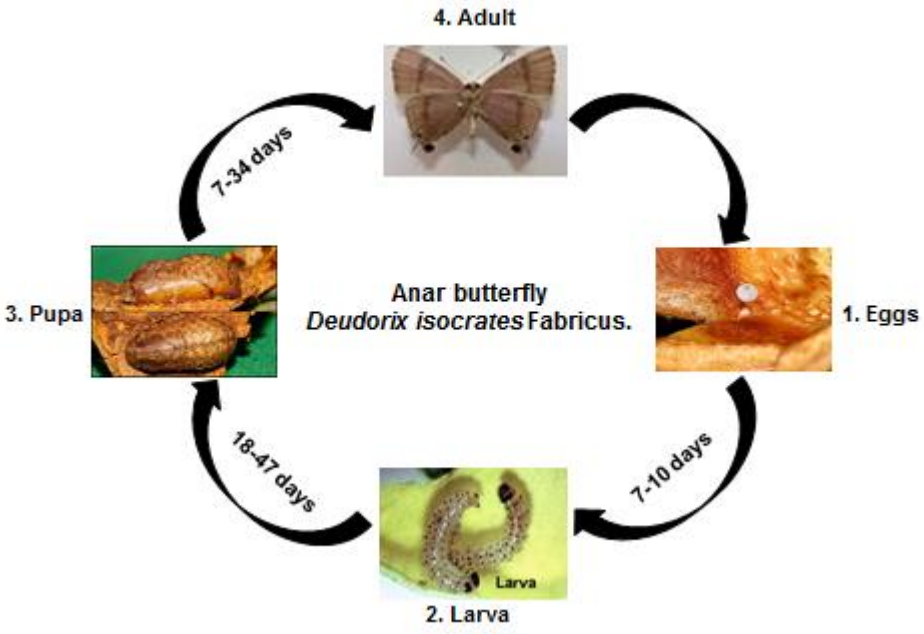


http://agropedia.iitk.ac.in/content/pomegranate-fruit-borer

Favourable conditions:

- It is mostly prevalent during the 'mrig' bahar.
- Fruit injury revealed at the age of 30—50 days.

Life cycle:



http://flickrhivemind.net/Tags/isocrates/Interesting

*For management refer to page number----------

2. Stem borer

Biology:

Egg: Eggs are laid in young living plants in stems and is deposited under the bark. The number of eggs laid by female is 20-40

Grub: Newly emerged larva is about 1/4 of an inch long the mature larva is about 2.1/2 inches long. On hatching the larva feeds on the soft tissues around the oviposition cavity and then bores into the stem and roots. The length of the larval period is about nine or ten month.

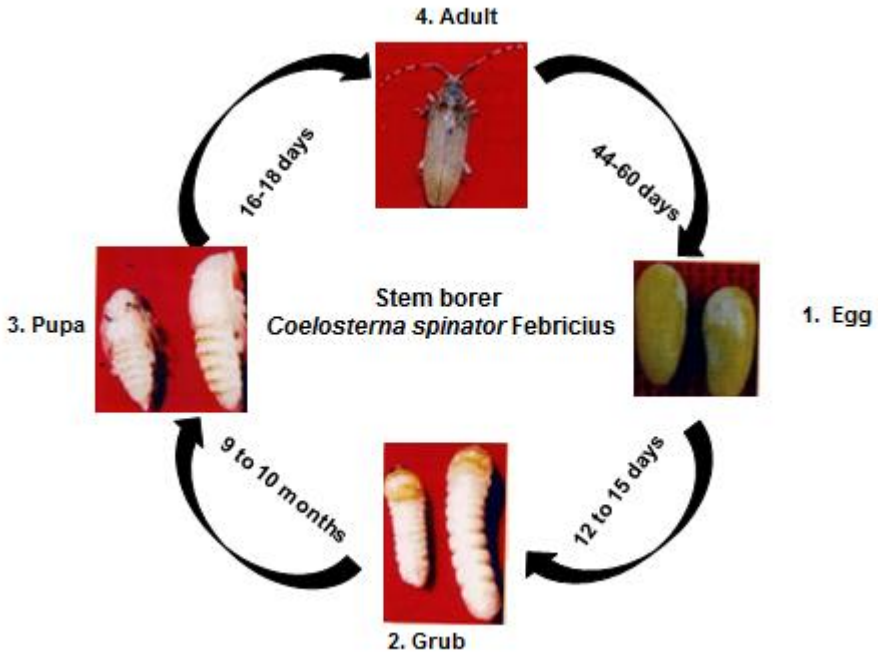
Pupal: Period is16 to 18 days. There is only one generation per year and longevity of beetles is 45 to 60 days.

Adult: Pale yellowish-brown body with light grey elytra and are 30 to 35 mm long. The beetle emerges by eating a circular hole through the bark. Adult beetles are 1.1/4 to 1.1/2 inches long, dull, yellowish-brown, the sides of the body and legs bluish, elytra yellowish-grey with a large number of black spots varying in size from a pin's head to minute specks.

Damage symptoms:

- The grubs bore inside the trunk and feed on sapwood.
- Adult beetles are active by the day and feed by gnawing the green bark of shoots.
- Holes on bark of main stems, excreta and dry powdered material are usually seen near the base of plants.
-

Life cycle:



http://uasr.agropedia.in/content/pomegranate-stem-borer
http://www.icfre.org:8080/woodsci/Insectdetails.jsp?id=301

Natural enemies of stem borer:

Predators: Damsel bugs, elm leaf beetle, spiders, tachinid flies, big eyed bugs (*Geocoris* sp.), braconid wasp

*For management refer to page number----------

3. Whitefly

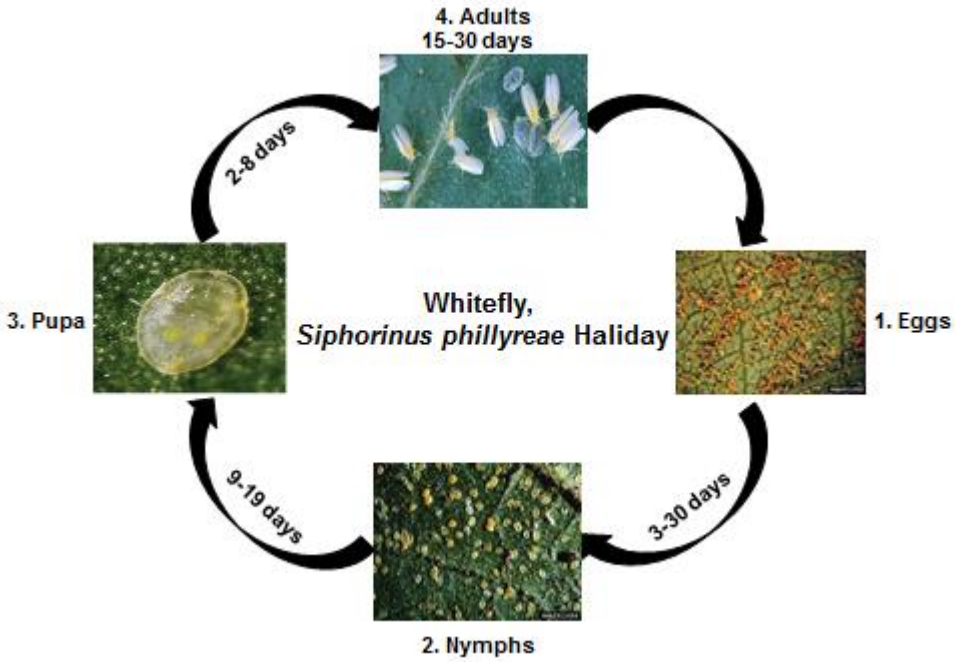
Biology:

- **Eggs:** Eggs are laid in a circle on the underside of leaves.
- **Nymph:** short glass like rods of wax along the sides of the body
- **Adult:** Powdery white, active during early morning hours.

Damage symptoms:

- Nymphs and adults suck the sap from leaves
- Honey dew - development of sooty mould fungus
- Yellowing of leaves.
- Dropping of affected leaves.

Life cycle:



http://entnemdept.ufl.edu/creatures/orn/ash_whitefly.htm
http://www.ces.ncsu.edu/depts/ent/notes/O&T/trees/note113/note113.html

Natural enemies of whitefly:
Parasitoid : *Encarsia inaron*

Predators: *Cryptolaenus montrouzieri, Chrysopa*sp., ladybird beetles

*For management refer to page number----------

4. **Shot hole borer**

Biology:

- **Eggs** are oval or round, shiny and iridescent white.
- **Larvae** are white and legless, and can be up to 4 mm long.
- **Adult** is about 2-3 mm long, black to reddish-brown, and cigar shaped. They have a short, stubbed head capsule, with chewing mouthparts. Male adults do not fly. Two generations per year.

Damage symptoms:

- Adult females bore into the basal part of the stem and roots.
  Causes Small shot holes on roots, main trunk, wilting and finally leads to death of the tree **.**

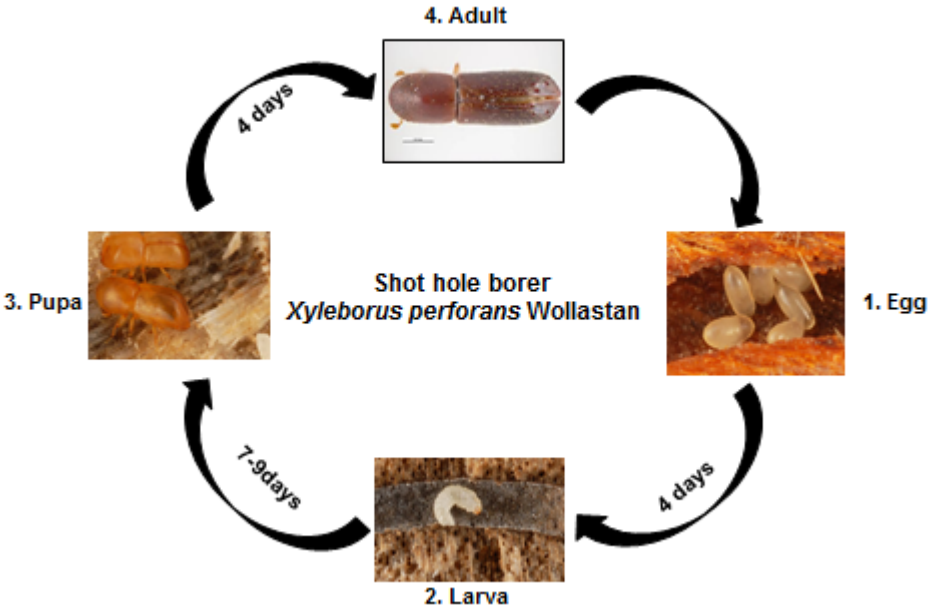
Shot hole borer damage

http://www.insectimages.org/browse/detail.cfm?imgnum=5460860

Favourable conditions:

- They survive in temperatures ranging from -26 to 15°C. The flight activity is greatest late afternoon or early evening and the beetles usually fly at or below 15 ft .

Life cycle:



http://entnemdept.ufl.edu/creatures/trees/beetles/redbay_ambrosia_beetle.htm
http://www.cabi.org/isc/datasheet/57169

Natural enemies of shot hole borer:

Parasitoids: *Trichogramma, Tetrastichus* spp., *Telenomus* spp., *Chelonus blackburni, Carcelia* spp. *Campoletis chlorideae, Bracon* spp.

Predators: *Chrysoperla* sp. rove beetles, spiders, parasitic wasp, coccinellids, robber fly, dragonfly, Beduviid bug (*Geocoris* sp.), praying mantis, fire ants, pentatomid bug (*Eocanthecona fucellata*), earwigs, ground beetles, common mynah, king crow,

*For management refer to page number----------

5. **Thrips**

Biology:

- The adults are minute, slender, soft bodied insects with heavily fringed wings, blackish brown with yellowish wings and measure 1.4 mm long. *Scirtothrips dorsalis* adult is straw yellow in colour. The nymphs are minute yellowish brown in colour.
- Female lays on an average 50 dirty white bean-shaped eggs on the under surface of leaves.
- The incubation period is 3-8 days. Newly hatched nymphs are reddish and turn yellowish brown as they grow.
- Pupal period lasts 2-5 days

Damage symptoms:

- Both nymphs and adults feed on the underside of the leaves by rasping the surface and sucking the oozing cell-sap.
- Leaf tip turn brown and get curled**,** drying and shedding of flowers and **scab on fruits** which will reduce the market value.

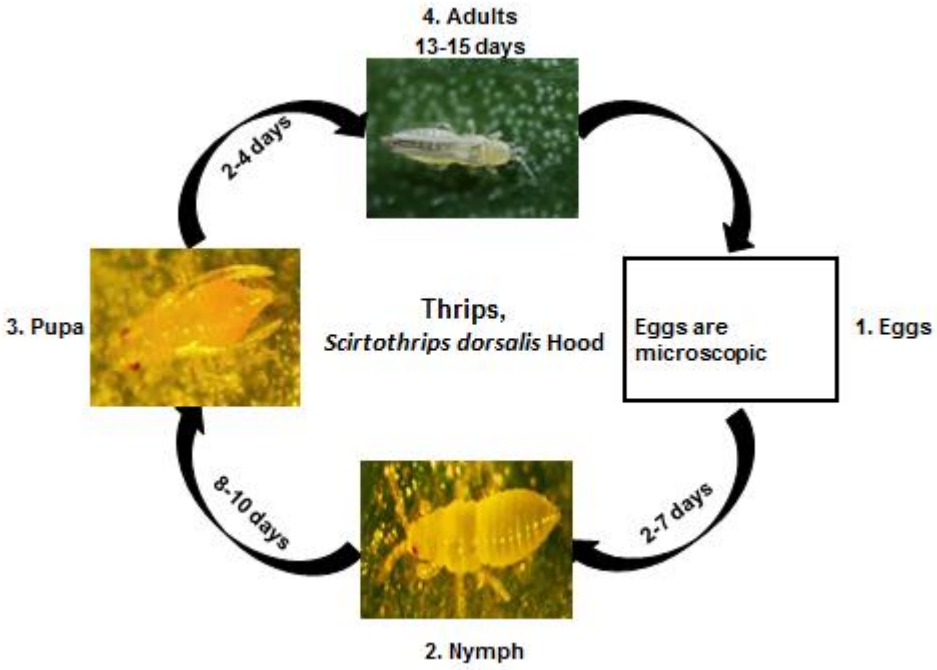
Thrips damage on flower buds **Thrips damage on fruits**

http://agropedia.iitk.ac.in/content/pomegranate-thrip

Favourable condition:

- The incidence of this pest is mainly seen from July to October with the peak period in September.

Life cycle:



Natural enemies of thrips:

Parasitoids: *Ceranisus menes*

Predators: Syrphid fly, minute pirate bug, praying mantis, predatory thrips, damsel bug, lace wing, coccinellid, spider etc.

*For management refer to page number----------

6. Tailed mealy bug

Biology:

- The female laid eggs in groups which lay beneath the body in a loose ovisac of waxy fibers.
- Fecundity (egg number) ranged from 109 to 185 per generation.
- The oviposition period lasted 20-29 days.
- The incubation period lasted about 3-4 hours.

- Female and male nymphs molted 3 and 4 times, respectively, and the development period varied from 26-47 and 31-57 days, respectively.
- Longevity of the adult female was 36-53 days and for the male, 1-3 days.

Damage symptoms:

- Premature dropping of fruit.

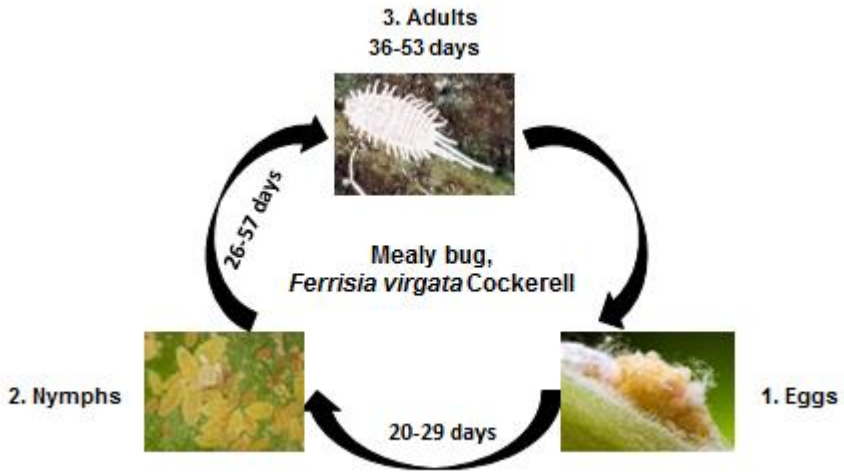
Mealy bug infested fruits

http://www.docstoc.com/docs/135953712/ppt-on-pest-management

Favourable conditions:

- Moist and warm conditions are favourable.

Life cycle:



http://www.cabi.org/isc/datasheet/23981

Natural enemies of mealy bug:

Predators: *Menochilus sexmaculatus,Rodolia fumida, Cryptolaemus montrozieri*

*For management refer to page number----------

7. Aphid

Biology:

Eggs: Eggs hatch after one or two days. Young aphids, called nymphs.
Nymph: Oval or slightly elongated, reddish brown with six segmented antennae
Adult: Small yellowish green typically colonizing the upper sides of mature leaves of pomegranate, concentrated along the midribs and around the leaf margins; also found on flowers and, rarely, fruits.. Aphids reproduce in two ways: by laying eggs and laying live young, which birth process is depends on environmental conditions and the availability of food. When food is plentiful, aphids give birth to live young.

Populations develop quickly as this pest has many young, a short life span and pre-adult insects can also give birth.

Damage symptoms:

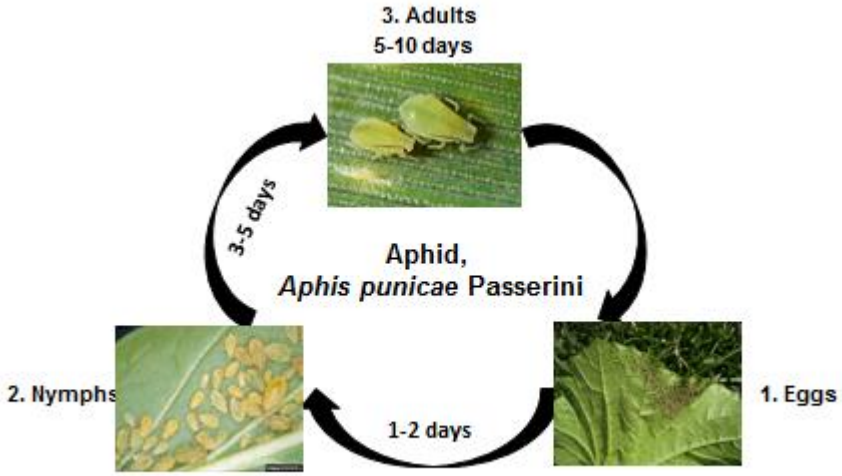
- Nymphs and adults suck the sap from leaves, shoots and fruits
- Yellowing of leaves
- Wilting of terminal shoots.

Aphids on fruits and flower of pomegranate

http://www.agdynamics.com.au/images/gallery/Agribusiness/11_Pomegranate_with_Aphids.jpg

Life cycle:

Predators :



1.

Natural enemies of aphids:

Predators: Parasitic wasp, *Chrysoperla* sp., ladybird beetle, predatory mite, syrphid fly etc.

*For management refer to page number----------

Natural Enemies of Pomegranate Insect Pests

Parasitoids

Egg Parasitoid:

1. ***Trichogramma***

Nymphal Parasitoid:

2. *Ceranisus menes* 3. *Encarsia inaron*

Larval Parasitoids:

***4. Tetrastichus* spp. 5. *Telenomus* spp. 6. *Chelonus blackburni* 7. *Carcelia* spp.**

***8. Campoletis chlorideae* 9. *Bracon* spp. 10. Braconid wasp 11. Tachinid flies**

Larval/ pupal parasitoids

12. Parasitic wasp

1. http://www.nbaii.res.in/Introductions/images/Tjapon2.jpg
2. http://biocontrol.ucr.edu/hoddle/avocadothrips.html
3. *https://cisr.ucr.edu/ash_whitefly.html*
4.http://www.nrs.fs.fed.us/disturbance/invasive_species/eab/control_management/biological_control/
5. http://www.nbaii.res.in/Featured%20insects/chelonus7.jpg
6. http://www.nbaii.res.in/Featured%20insects/chelonus7.jpg
7. http://www.meloidae.com/en/pictures/29944/?s=1
8. http://www.agripests.cn/showimg5_1.asp?id=33
9. http://www.gipsa.usda.gov/VRI/Images/Insects/IN-BRACON-HEBETER-(PARASITOID).jpg
10. http://www.forestryimages.org/browse/detail.cfm?imgnum=1323021
11. http://www.organicgardeninfo.com/images/tachinid-fly.jpg
12. http://www.shutterpoint.com/Photos-ViewPhoto.cfm?id=94159

Predators:

1. Menochilus sexmaculatus 2. Rodolia fumida 3. Cryptolaemus montrozieri 4. Fire ant

5. Ground beetles 6. Rove beetles 7. Spiders 8. Predatory mite

9. Beduviid bug 10. Big eyed bugs 11. Pentatomid bug 12. Minute Pirate Bug

13. Damsel bug 14. Predatory thrips 15. Earwigs 16. Robber fly




17. Dragonfly **18. Syrphid fly** **19. *Chrysoperla*** **20. Praying mantis**


21. King crow **22. Common mynah**

1. http://cyy4993.blogspot.in/2012/11/beetle-coccinellidae-coccinella.html
2. http://www.nbaii.res.in/Featured_insects/Rodolia-fumida.php
3. https://uribotanicalgardens.wordpress.com/tag/biocontrol/
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6. http://www.brisbaneinsects.com/brisbane_beetles/Staphylinidae.htm
8. http://www.eduwebs.org/bugs/predmite.gif
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20. http://en.wikipedia.org/wiki/File:Praying_mantis_india.jpg
21. http://jangalindia.blogspot.in/
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VIII. DESCRIPTION OF DISEASES

1. Bacterial leaf and fruit spot:

Disease symptoms:

- Appearance of one to several small water soaked, dark colored irregular spots on leaves resulting in premature defoliation under severe cases.
- The pathogen also infects stem and branches causing girdling and cracking symptoms.
- Spots on fruits were dark brown irregular slightly raised with oily appearance, which split open with L-shaped cracks under severe cases.

Initial symptoms on leaves **symptoms on fruis**


http://www.sjournals.com/index.php/SJMS/article/view/629

Survival and spread:

- Primary source of inoculum is Infected cuttings
- Secondary source of inoculum spreads through Wind splashed rains.

Favourable conditions:

- The increase in day temperature (38.6°C) and afternoon relative humidity of 30.4% along with cloudy weather and intermittent rainfall favored the disease initiation and further spread of the disease.

*For management refer to page number----------

2. Leaf and fruit spot

Disease symptoms:

- Leaf spots are minute, brown with yellow halo.
- Spots are scattered, circular or irregular and become dark brown with age.
- Spots on lower side are sunken with clusters of spore bearing structures hence greyish in colour.
- Minute, circular, black spots appear on sepals of the flower.
- Fruit spots are black, minute and circular on rind.
- When grow old, become large, irregularly circular and depressed presenting an ugly look to the fruits.

Disease symptoms on leaves, flower and fruits

1.http://uasr.agropedia.in/content/cercospora-leaf-spot-pomegranate
2.http://agritech.tnau.ac.in/crop_protection/crop_prot_crop%20diseases_fruits_pomegranate.html
3. http://www.angrau.ac.in/media/7456/path372.pdf

Favourable conditions:

- Optimum temperature is 25-32°C with night temperatures above 16°C, and a relative humidity of 90-95%.

Survival and spread:

- Primary spread : Diseased plant debris
- Secondary spread : Wind borne conidia

3. Anthracnose

Symptoms:

- Small, regular to irregular black spots on leaves, calyx region and fruits which turn later on as dark brown depressed spots.
- Infected leaves turn yellow and drop off.

Brown spots on leaves **Dark brown depressed spots on fruits**

Survival and spread:

- **Primary source of inoculum:** Infected leaves
- **Secondary source of inoculum:** windborne conidia.

Favourable conditions:

- The disease is severe during August-September when there is high humidity, and the temperature

between 20-27ºC.

*For management refer to page number----------

4. Fusarium wilt

Disease symptoms:

- Affected plants show yellowing of leaves in some twigs or branches, followed by drooping and drying of leaves.
- The entire tree dies in few months or a year.
- When affected tree is cut open lengthwise or cross-section dark grayish-brown discolouration of wood is seen.


http://uasr.agropedia.in/sites/default/files/Symptoms_7.pdf

Favourable conditions:

- Relatively high soil moisture and soil temperature

Survival and spread

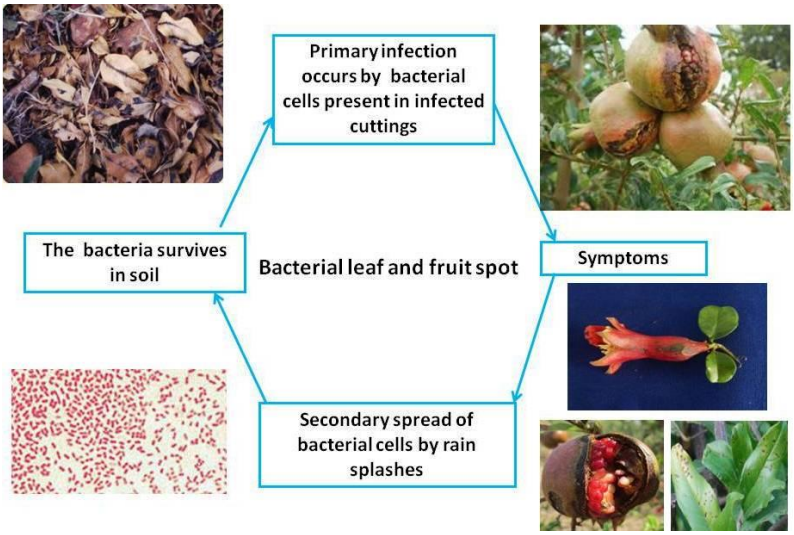
- **Primary source of inoculum:** Soil, Chlamydospores
- **Secondary source of inoculum:** Conidia, water
- Disease is more in heavy soil and increases with soil moisture.

http://agropedia.iitk.ac.in/content/pomegranate-wilt-0

*For management refer to page number----------

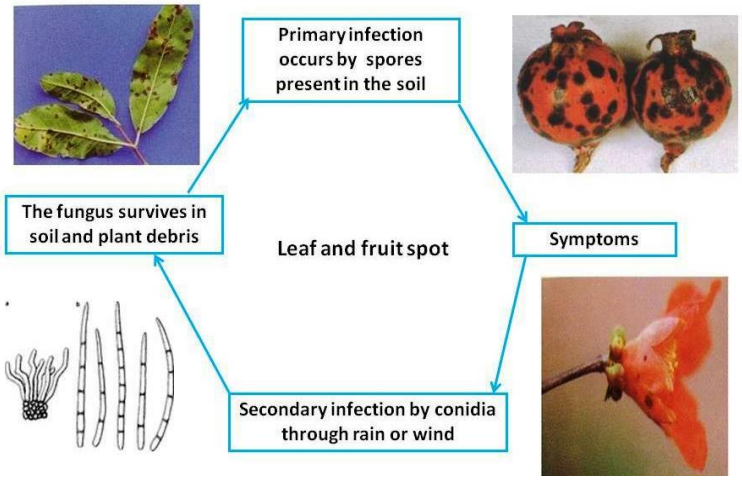
Disease cycles:

1. **Bacterial leaf and fruit spots**



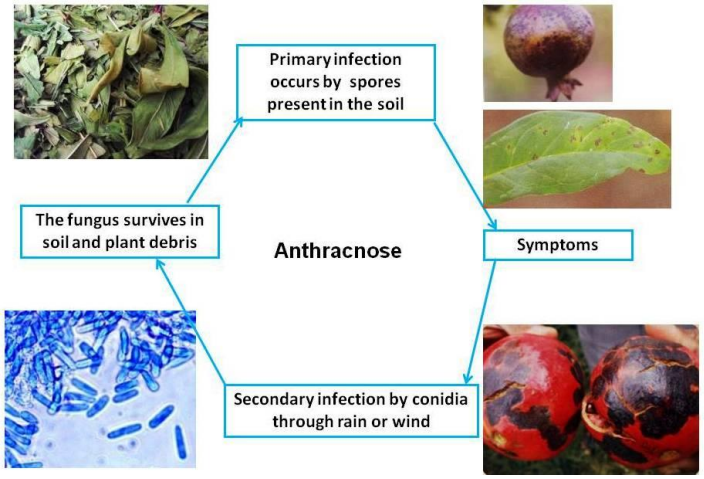
http://uasr.agropedia.in/content/pomegranate-bacterial-leaf-blight
http://www.nmpdr.org/FIG/wiki/pub/FIG/GramStain/300px-Gram_Stain_Anthrax.jpg

2. **Leaf and fruit spot:**



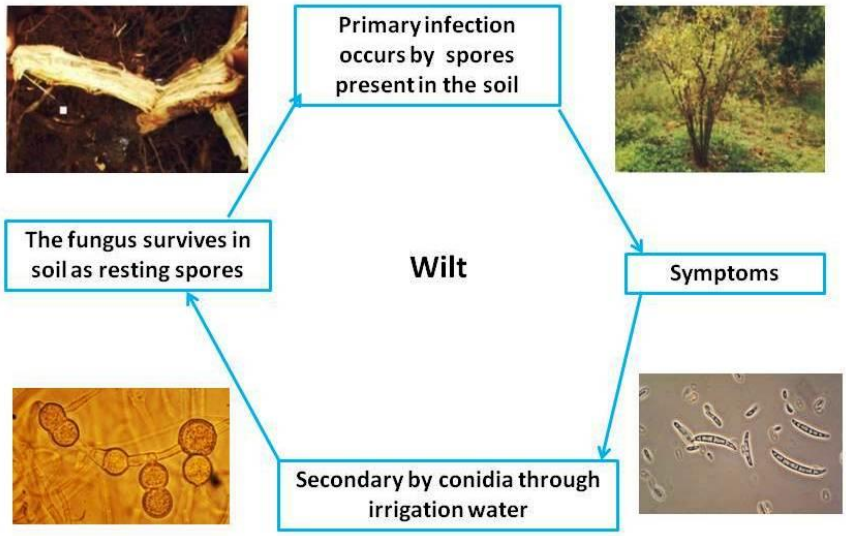
http://uasr.agropedia.in/content/pomegranate-bacterial-leaf-blight

3. **Anthracnose:**



http://www.forestryimages.org/images/768x512/2171049.jpg

4. **Fusarium wilt:**



XII. SAFETY MEASURES

A. At the time of harvest

Pomegranates in general do not have a synchronized single spring bloom and can have shoot flushes that bear flowers throughout the warmer parts of the year. Early cultivars will begin to ripen near the end of August, and will continue through to October or early November for the late-maturing cultivars. Except for intensive production where once-over harvesting is occasionally practiced, plan harvesting two to four times per season.

Pomegranates are easy to harvest and require minimal ladder work (assuming proper pruning and training of the tree). Fruit are harvested by clipping them with shears. Cut as close to the fruit as possible to prevent a sharp point of wood from piercing and rubbing against other fruit in the bin. Fruit are placed either directly into bins located in the orchard, or into shoulder harness baskets (identical to those used in the apple industry) while working around the tree. Either way, fruit should be handled with care in order to minimize scuffing or cracking (a strong bump may cause the fruit to split open).

B. Post-harvest storage

After harvest, it is not necessary to pre-cool fruit, but fruit will benefit from being placed into cold storage as soon as possible after harvest. Fruit destined for the fresh market should be washed with chlorine, rinsed with water and sorted by culls, cracks, defects, colour, size and weight. A storage wax can also be applied to promote the visual quality of the fruit and increase its storage life by reducing moisture loss. Fruit destined for the fresh market can either be placed in storage bins (for later packaging) or packaged immediately into appropriate cartons for the desired market.

Grading: The fruits after harvesting are graded as per their colour, size and weight. The different grades are as follows

Grades	Fruit Characteristics
Super size	Fruits are attractive, very large, dark red in colour, without blemish weighing >750 g.
King size	Fruits are attractive, large without blemish and weighing between 500-750 g.
Queen size	Fruit are large, attractive without blemish and weighing between 400-500 g.
Prince	Fruits are attractive, blemish free and weighing between 300-400 g.
12-A	Fruits having 1-2 spots and weighing between 250-300 g.
12-B	Fruits weighing <250 g.

Fruit can be stored up to six weeks in open-air storage or five months using controlled atmosphere storage (CA). CA is also useful for controlling the incidence of storage scald (the browning of the red pigments in the rind of the fruit).

Packing: All the graded fruits are wrapped in paper and packed in corrugated fibreboard (CFB) boxes. Brown coloured 3 fold CFB boxes are used for local market while, white coloured 5 fold CFB boxes are used for distant markets. Paper shreds are used as padding material. For 'Super' and 'King' grades, boxes of size 32.5 x 22.5 x 10 cm are used. 'Queen' grade fruits are packed in 37.5 x 27.5 x 10 cm size boxes while 'Prince' and '12-A' grades are packed in 35 x 25 x 10 cm size boxes.

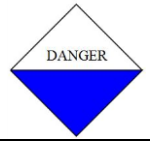
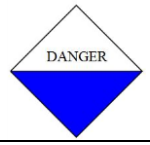
Storage: Fruits can be stored at 5°C with 90-95% relative humidity for 2 months. In case of storage beyond two months, temperature should be maintained at 10°C to avoid chilling injury. Pomegranates are very susceptible to water loss resulting in shriveling of the skins. Storing fruit in plastic liners and waxing can reduce water loss, especially under conditions of lower relative humidity.

XIII. 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 growing monocrop.
3.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
4	Plant early in the season (June-July & Sept-Oct.)	Avoid planting during summer
5	Use disease free seedling from certified agencies.	Do not use seedlings from disease infected areas/agencies
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-emergence 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 on soil test results.	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) and do not use expired pheromone septa.
13	Release parasitoids only after noticing adult moth catches in the pheromone trap or as	Do not apply chemical pesticides within seven days of release of

	pheromone trap or as per field observation	parasitoids.
14	In case of pests which are active during night, spray recommended biocides/ chemicals at the time of their appearance in the evening hours.	Do not spray pesticides at midday since, most of the insects are not active during this period.
15	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, thrips whiteflies, etc.	Do not spray pesticides only on the upper surface of leaves.
16	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
17	Follow the recommended procedure of trap or border crops technology.	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.

XIV. SAFETY PARAMETERS IN PESTICIDE USAGE

S. No.	Pesticide Classification as per insecticide rules 1971 Colour of toxicity triangle	WHO classification of hazard	Symptoms of poisoning	First aid measures and treatment of poisoning	Safety interval (days)
Fungicides					
1.	Propineb 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.	
2.	Kitazin 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.	

XV. 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; 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; expose to sunlight or rain water; 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; 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. Don’t blow/clean clogged nozzle with mouth. Use old tooth brush tied with the sprayer and clean with water.
5. Do not use same sprayer for weedicide and insecticide.

F. Precautions for applying pesticides

1. Apply only at recommended dose and dilution
2. Do not: apply on hot sunny day or strong windy condition; apply just before the rains and after the rains; apply against the windy direction.

3. Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer
4. Wash the sprayer and buckets etc. with soap water after spraying
5. Containers buckets etc. used for mixing pesticides should not be used for domestic purpose
6. Avoid entry of animals and workers in the orchard immediately after spraying
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.

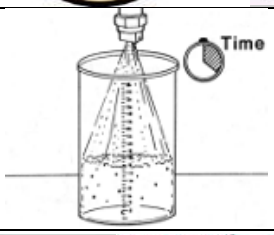
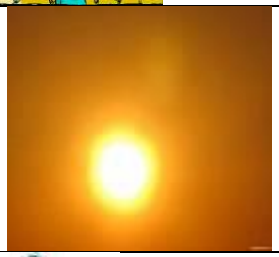
XVI. PESTICIDE APPLICATION TECHNIQUES

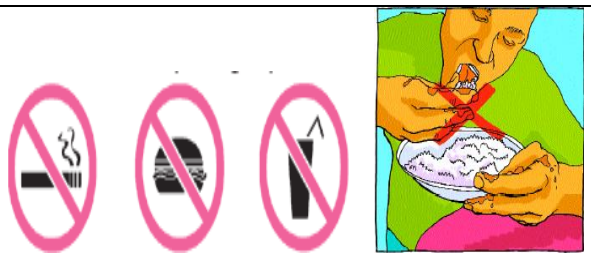
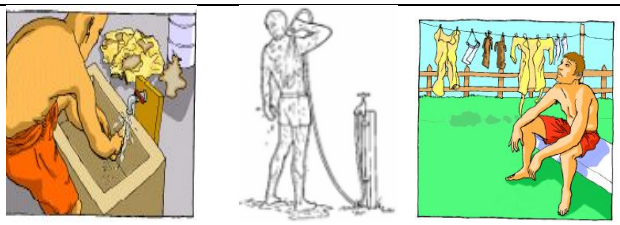
<table>
<tr><td colspan="4">Equipment</td></tr>
<tr><td colspan="4">Category A: Stationary, crawling pest/disease</td></tr>
<tr><td rowspan="2">Vegetative stage
i) for crawling and soil borne pests

ii) for small sucking leaf borne pests</td><td rowspan="2">Insecticides and fungicides</td><td rowspan="2">• 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</td><td>  </td></tr>
<tr><td>  </td></tr>
<tr><td>Reproductive stage</td><td>Insecticides and fungicides</td><td>• Lever operated knapsack sprayer (Droplets of big size)
• Hollow cone nozzle @ 35 to 40 psi
• Lever operating speed = 15 to 20 strokes/min</td><td>  </td></tr>
</table>

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)	  

XVII. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

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

		
8.	Operator should take proper bath with soap after completing spraying	
9.	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

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