सत्यमेव जयते

INTEGRATED PEST MANAGEMENT PACKAGE FOR GROUNDNUT

NCIPM

Government of India
Ministry of Agriculture, Department of Agriculture & Cooperation
Directorate of Plant Protection, Quarantine & Storage
CGO Complex, NH IV, Faridabad
Haryana- 121001

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Cover picture : Healthy crop of Groundnut

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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, pest replacement and pesticide residues. There is a growing awareness world over of the need for promoting environmentally sustainable agriculture practices.

Integrated Pest Management (IPM) is a globally accepted strategy for promoting sustainable agriculture. There is a conscious shift from the reliance on economic threshold level and chemical pesticides driven approaches in the past to more ecologically sustainable Agro-Eco System Analysis (AESA) based IPM strategies. These focus 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 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 AESA 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 these IPM packages will be relied upon by various 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

(Avinash K. Srivastava)

PREFACE

Pests are major biotic constraints to achieve self sufficiency in ensuring food security. Losses due to pest vary range 10-30% depending upon the genetic constituent of crop, its health and the governing environment. General national estimate of annual crop losses due to pest amounts to ₹ 260000 million per year. However, negligence of endemic areas can result in complete crop failures. In view of inefficacy of chemical pesticides and environmental problems thereof, Integrated Pest Management (IPM) has been accepted as a cardinal principle of Plant Protection in the overall Crop Protection Programme under the National Agricultural Policy of the Govt. of India. IPM being an eco-friendly approach, socially acceptable and economically viable has been widely accepted across the country. The IPM package encompasses various management strategies for pest and disease problems. Pest monitoring is also one of the important components of IPM to take proper decision to manage any pest problem. It can be done through Agro-Ecosystem Analysis (AESA), field scouting, light, pheromone, sticky/yellow pan traps. The economic threshold level (ETL) of important pests and diseases are also given in the package to activate appropriate control measures on standing crops.

The existing package and practices was developed way back in 2001-02 by DPPQ & S, Faridabad catering the need of extension personals in extending IPM tactics to farmers. Though these were useful, there is a need to update them in view of changing climate and its impact on pests and their protection measures.

A National Workshop on IPM for harmonization of Package of Practices was organized at the National Centre for Integrated Pest Management, New Delhi, during 25-26th Feb., 2013 with a view to provide technical knowledge to the extension functionaries and farmers in the States. The IPM package has been developed with the technical inputs from the experts from the PI (AICRIP), Indian Council of Agricultural Research (NCIPM), State Agricultural Universities, and DPPQ & S, Faridabad.

It will also be useful in reducing the pesticide residues in exportable agricultural commodities and would also help in the management of pests/diseases/weeds/nematodes, which may get inadvertently introduced in the country. These packages will be useful for the researchers, extension workers and farmers alike who are engaged in the agricultural practices.

Editors

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1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.), also known as peanut, is a legume that ranks 6th among the oilseed crops and 13th among the food crops of the world. Groundnut is the most important oilseed crop in India, covering nearly half of the area under oilseeds. The vegetable oil is rich in omega-3 fatty acid and extensively used for cooking purpose. In addition to providing high quality edible oil (48–50%), easily digestible protein (26–28%), and nearly half of the 13 essential vitamins and 7 of the 20 essential minerals necessary for normal human growth and maintenance, it produces high quality fodder for livestock. The major growing states are Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Rajasthan, and Maharashtra. These constituting and contributing around 80% of area and production. The total area under groundnut is about 8 million hectares and annual production is over 9 million tonnes of pods. Groundnut plays a significant role in the livelihoods of smallholder farmers of rainfed area. In India, groundnut is cultivated during *kharif*, *rabi* and *summer* season under various cropping systems. The national average production of rabi groundnut is higher (1600 kg/ha) than kharif (1000 kg/ha). Rain fed groundnut cultivation coupled with attack by a variety of insect pests and diseases are the major reason for lower productivity. As the crop and its pests are the major reason sensitive to extreme weather events, the crop productivity is determined by the interplay of weather and pests in a given season.

2. BIOTIC CONSTRAINTS

2.1. Major Insect Pests: National Significance

a. Aphid (*Aphis craccivora* Koch.)
b. Bruchids (*Caryedon serratus* Olivier)
c. Jassid (*Empoasca kerri* Pruthi)
d. Leaf miner (*Aproarema modicella* Deventer)
e. Termite (*Odontotermes* spp.)
f. Thrips (*Scirtothrips dorsalis* Hood, *Thrips palmi* Karny)
g. Tobacco caterpillar (*Spodoptera litura* Fabricius)
h. White grub *Lachnosterna* (*Holotrichia*) *serrata* Fab. and *Lachnosterna* (*Holotrichia*) *consanguinea* Blanchard)

2.2. Major Insect Pests: Regional Significance

a.	Bihar Hairy Caterpillar (*Spilosoma/Diacrisia obliqua* HL & *S. obliqua* Walk)	Punjab
b.	Gram Pod borer (*Helicoverpa armigera* Hubner)	Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat and Goa
c.	Jewel beetle (*Chrysochroa fulgidissima* Tamamushi)	Andhra Pradesh
d.	Red hairy caterpillar (*Amsecta albistriga* Walker & *A. moorei* Buttler)	Andhra Pradesh, Tamil Nadu and Karnataka
e.	Wire worms (*Hapatesus hirtus* Candeze)	Andhra Pradesh, Tamil Nadu and Gujarat

2.3. Major Diseases: National Importance

a. Alpha-root *(Aspergillus flavus* Link)
b. *Alternaria* blight (*Alternaria* spp. / *A. arachidis* Kul.) (rabi-summer groundnut)
c. Crown rot/Collar rot *(Aspergillus niger* Tiegh)
d. Dry root rot *(Rhizoctonia bataticola* Taub.*)*
e. Leaf spot *(Phaeoisariopsis personata* Berk. & Curt. and *Cercospora arachidicola* Hori.)
f. Peanut bud necrosis tospovirus disease *(*Peanut bud necrosis virus*)*
g. Rust *(Puccinia arachidis* Spegazzini*)*
h. Stem rot and Pod rot *(Sclerotium rolfsii* Sacc.*)*

2.4. Major Diseases: National Importance

Peanut stem necrosis disease (PBND)	Tobacco streak virus (vector-*Thrips* spp.)	Anantapur (A.P.)

2.5. Major Nematodes of National and Regional Importance

1.	Root knot nematode (*Meloidogyne arenaria* Chitwood and| *M. javanica* Treub)	Gujarat, Rajasthan, Bihar, Maharashtra, West Bengal and Punjab
2.	Kalahasthi malady (*Tylenchorhynchus brevilineatus* Williams)	Parts of Andhra Pradesh

2.6. Major Weeds of National and Regional Importance

Common name	**Botanical Name**
Indian mallow	*Abutilon indicum*
Pigweed	*Amaranthus viridis*
Mexican poppy	*Argemone mexicana*
Nut sedge	*Cyperus difformis*
Crow foot grass	*Dactyloctenium aegyptium*
Crab grass	*Digitaria arginata, D. sanguinalis*
White cock's comb	*Celosia argentina*
Bran Yard grass	*Echinochloa colonum*
Love grass	*Eragrostis pilosa*
Spurge	*Euphorbia hirta*
Jews mellow	*Corchorus olitorius*
Button plant	*Borreria articularis*
Common purslane	*Portulaca oleracea*
Gaint pigweed	*Trianthema portulacasturm*

2.7. Major Rodents of National and Regional Importance

House mouse	*Mus* spp.
Indian gerbil	*Tatera indica* Hardwicke
Smaller bandicoot	*Bandicota bengalensis* Gray
Soft furred field rat	*Millardia meltada* Gray

3.0. Integrated Pest Management Approach

There are over seventy two (72) definitions of IPM, issued by governments, research organizations, NGOs, and universities (Bajwa and Kogan, 2002). Some assume that IPM will eliminate the use of crop protection products, specially the chemical pesticides, which is most unlikely. Extreme views equating IPM with "pest free" farming will become increasingly marginalised and more balanced views will prevail. There is no reason not to support IPM as defined by the FAO International Code of Conduct on the Distribution and Use of Pesticides (Article 2): *Integrated Pest Management (IPM) means a pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in a compatible manner as possible and maintains the pest populations at levels below those causing economically unacceptable damage or loss* (FAO, 1967). Thus, IPM is the best combination of cultural, biological and chemical measures that provides the most cost-effective, environmentally sound and socially acceptable method of managing diseases, insects, weeds and other pests.

IPM is a knowledge-intensive sustainable approach for managing pests by combining compatible cultural, biological, chemical, and physical tools in a way that minimizes economic, health, and environmental risks with the help of pest scouts. IPM relies heavily on knowledge of pests and crop interaction to choose the best combination of locally available pest management tools (Fig. 1). Therefore, IPM is not a single product that can be stored on shelves like pesticide, and it does not rely on single method to solve all our pest problems. Pests also co-evolve and adapt very quickly to single control tactics through natural selection, and that multiple methods used simultaneously, or an "integrated" approach, is the most effective for long-term, sustainable management programs.

IPM is neither organic nor it rely solely on biological control to achieve the desired sustainable outcomes. It does often try to assist and augment the effectiveness of natural enemies by limiting the impact of pesticide on their populations and provide clean and safe niche. It seeks to conserve balance between the crop and the natural environment. The World Bank policy (OP 4.04 - Natural Habitats) also promotes the conservation of natural habitats, and enhancement of the environment for long-term sustainable development.

In the IPM concept, use of pesticides involves a trade-off between pest control and the risks of adverse effects on non-target organisms, such as natural enemies, pollinators, wildlife, and plants, contamination of soil and water.

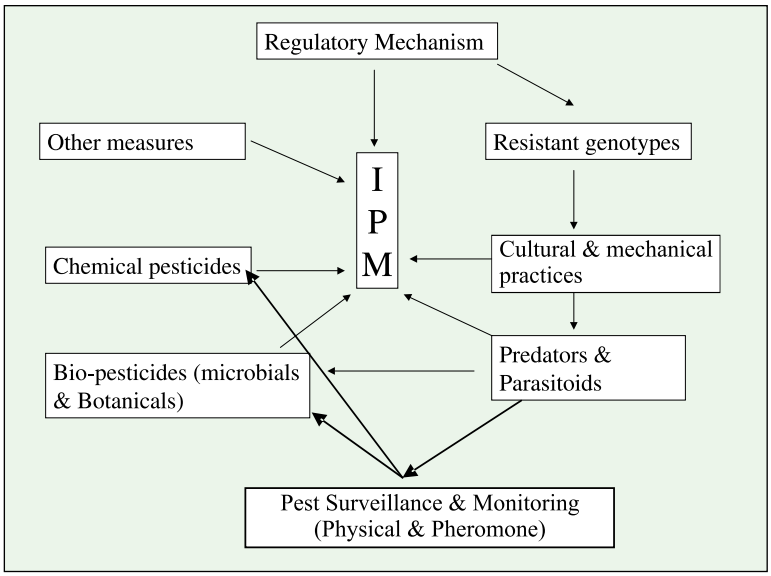


Fig 1. Diagrammatic representation of IPM components.

3.1. Pest Monitoring

3.1.1. Survey/Field Scouting

The objective through roving surveys is to monitor the initial development of pests in endemic areas. Therefore, in the beginning of crop season survey routes based upon the endemic areas are required to be identified to undertake roving surveys. Based upon the results of the roving surveys, the state extension functionaries have to concentrate for greater efforts at block and village levels as well as through farmers to initiate field scouting. Therefore, for field scouting farmers should be mobilised to observe the insect pest and disease occurrence at the intervals as stipulated hereunder. The plant protection measures are required to be taken only when insect pests and diseases cross Economic Threshold Level (ETL) as per results of field scouting.

1. Roving survey: - Undertake roving survey at every 10 km distance at 7-10 days intervals (depending upon pest population). Everyday at least 20 spots should be observed.
2. Field scouting: - Field scouting for pests and bio-control fauna by extension agencies and farmers once in 3-5 days should be undertaken to workout ETL.

3.1.2. Pest monitoring through pheromones/light traps

Majority of insects population can be monitored by fixing and positioning of pheromones or light traps at appropriate stage of crop. Light trap is used to know the abundance and species composition of lepidopteran insect pests in the area to be managed. The light trap is most commonly used tool for obtaining this

information as well as killing of the pests. Use of pheromone traps for monitoring *Spodoptera*/*Helicoverpa* and leaf miner. Install pheromone traps at a distance of 50 m @ 5 traps per ha. Use specific lure for each pest species and change it after every 15-20 days. Trapped moths should be removed daily. Yellow sticky traps may be used for monitoring population of whiteflies and jassids.

The State Department of Agriculture can initiate this action at strategic locations at village level as per the following details:

1. **Pheromone trap-monitoring** - 5 traps per ha may be used to monitor moth population.
2. **Light trap** - light trap can be operated for two hours in the evening to observe photo-tropic insect pests.
3. **Sweep-nets** - water pans - Besides visual observations sweep-nets and water pans may also be used to assess the population of insect pests, and biocontrol agents to determine the type of pesticides to be recommended or used.

The objective of pest monitoring is to detect the initial development of pests and diseases and also the bio control potentials in the field situations.

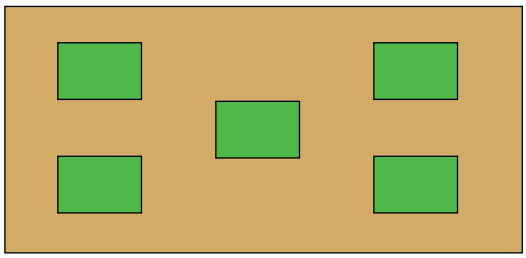
3.1.3. Agro Eco System Analysis (AESA)

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. In modern IPM (FAO, 2002) emphasis is given to Agro Eco System Analysis (AESA) where farmers take decisions based on larger range of field observations. The health of a plant is determined by its environment which includes physical factors (i.e. sun, rain, wind and soil nutrients) and biological factors (i.e. insect-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.

It is an approach, which can be gainfully employed by extension functionaries and farmers to analyse field situations with regard to pests, defenders, soil conditions, plant health, the influence of climatic factors and their interrelationship for growing healthy crop. Such a critical analysis of the field situations will help in taking appropriate decision on management practice. The basic components of AESA are:

1. Plant health at different stages.
2. Built-in-compensation abilities of the plants.
3. Pest and defender population dynamics.
4. Soil conditions.
5. Climatic factors.
6. Farmers past experience.

AESA Methodology



Field observations on insect pests and diseases are to be initiated 20 days after sowing. In each field select five spots randomly shown in the figure (four in the corner, at least 5 feet inside the border and one in the centre). At each spot select 10 plants randomly for recording observations.

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

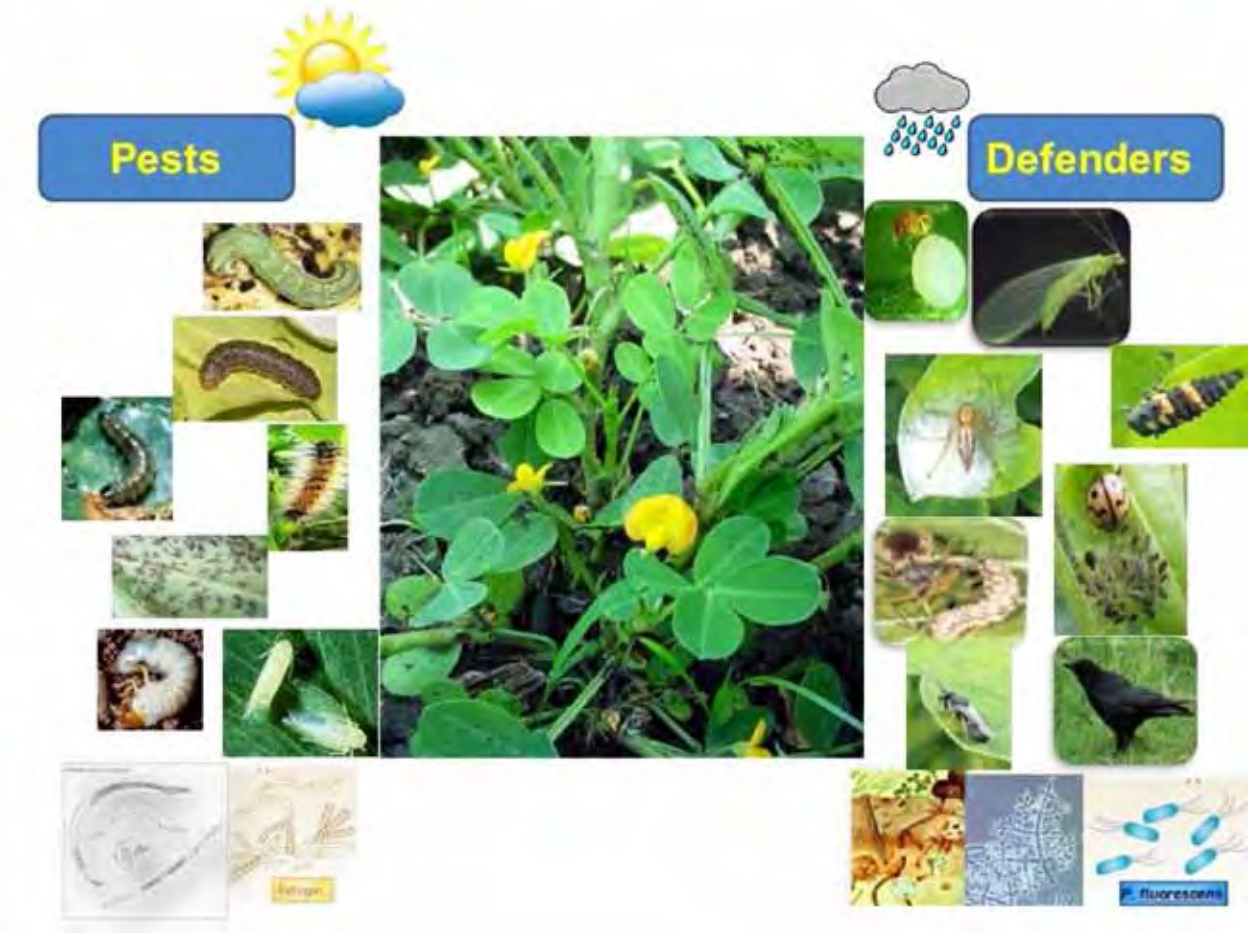
- Plant growth (weekly)
  - Number of plants
  - Plant height
  - Number of leaves
- Crop situation (e.g. for AESA)
  - Plant health: Observe the crop stage and deficiency symptoms etc.
  - Pests, diseases, weeds: Count insect pests at different places on the plant, and identify any visible disease symptoms and severity. Observe weeds in the field and their intensity. For rats, count number of plants affected by rats.
  - Natural enemies: Count parasitoids and predators
  - Soil condition
  - Irrigation
  - Weather conditions
- Input costs
  - Seeds
  - Fertilizer
  - Pesticides
  - Labour
- Harvest
  - Yield (kg/ha)
  - Price of produce (₹/kg)

Important instructions while taking observations

- 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 as shown in MODEL AESA CHART.
- 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.

Model agro-ecosystem analysis chart

Date: ..... Village:..... Farmer:.....



Courtesy : NIPHM, Hyderabad

Decision taken based on the analysis of field situation

Soil condition :

Weather condition :

Diseases types and severity :

Weeds types and intensity :

Rodent damage (if any) :

No. of insect pests :

No. of natural enemies :

Pest : Defender (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

For the success of Integrated Pest Management pest monitoring, prevention (Cultural and genetic) and timely intervention (Biological or chemical) are the key components.

3.1.4. Economic threshold levels (ETLs)

S. No.	Pest	Economic threshold levels (ETLs)
1.	Aphids	5–10 aphids/ terminal at seedling stage
2.	Defoliators	10% foliage damage
3.	Jassids	15-20 jassids/plant
4.	Leaf miner	2-3 larvae/plant
5.	Rodents	15 live burrows/ha
6.	*Spodoptera* / *Helicoverpa*	2 larvae/plant or 20-25% defoliation at 40 days
7.	Thrips	5 adults/terminal buds
8.	White grub	1 grub/m^2

3.2. Cultural practices

a. Deep ploughing in summer to expose soil - borne pathogens, white grubs, nematodes, hibernating defoliators and rhizomes of perennial weeds.

b. Soil application of castor cake/neem cake @ 250 kg/ha against stem rot, collar rot and termite.

c. Rotate the crop with sorghum or pearl millet or rice or maize after kharif crop may reduce the incidence of early leaf spot, late leaf spot, rust and PBND or with wheat/cotton/maize/onion/ garlic to reduce the incidence of soil borne pathogens.

d. Intercropping:

Groundnut + sorghum

Groundnut + pigeonpea

Groundnut + pearl millet

Groundnut + castor in 3-6 :1 ratio to reduce the thrips and PBND.

After groundnut crop is harvested, castor crop is allowed to remain in the field. This gives additional income to the farmers besides acting as a trap crop/ indicator crop for *Spodoptera* (Gujarat, M.P.).

To take care of pests on castor viz. semi looper, capsule borer and hairy caterpillar grow one row of pigeonpea after groundnut. After the harvest of groundnut, pigeonpea is allowed to remain in the fields. For management of *Helicoverpa armigera* use the following methods:

I. Set up pherornone traps @ 5/ha to monitor *Helicoverpa armigera / Spodoptera litura*

II. Conduct AESA weekly. If the pest population is in upward trend without corresponding increase in defender population, take decision on management practices on the basis of AESA as suggested below.

1. Apply *Ha*NPV @ 250 LE/ha or *Sl*NPV @ 250 LE/ha or *Bt.* 1 kg/ha or 5% NSKE when large number of eggs and early instar larvae are noticed.
2. If the above measures are not giving adequate control then apply only safe pesticide at recommended doses.

e. Timely sowing with pre-monsoon showers avoids damage due to white grub and bud necrosis (if protective irrigation is available).

f. Stray plant of cowpea or soybean act as trap crops for leaf miner; castor or sunflower as trap crop for *Spodoptera* hence they need to be removed.

g. In endemic areas, dense cropping (increased seed rate) is advised to reduce bud necrosis damage and weed population.

h. Two hand hoeing at 15-20 days and 30 to 45 days after sowing for effective weed control.

i. Rogue out the virus infected plant like PBNV, PSNV and peanut clump virus from the field.

j. Avoid prolonged drought (>20 days) during pod maturation stage (if irrigation is available) to prevent pre-harvest infection of *Aspergillus flavus* and subsequent aflatoxin contamination.

k. Harvest at optimum maturity stage to avoid pod infection by *A. flavus* (neither immature nor over-matured stage).

l. Dry the pods to optimum kernel moisture level of about 7 %.

m. Store in polythene-lined gunny bags on raised platform. The bag should not be sealed or stitched to avoid loss of germination.

Habitat management

Ecological 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.

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.

Habitat management for pest – 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., 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.

Habitat management for pest – 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 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 biofertilizers
- Apply mychorrhiza and PGPR
- Applying *Trichoderma* as seed treatment 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 predatory 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 horne grasshoppers, *Chrysoperla, Earwigs*, etc.

Flowering plants that attract natural enemies/repel pests

S.No.	Insect pest	Natural enemies	Attractant Plants
1	Leaf miner	**Parasitoids:** *Chelonus blackburni* (egg-larval), *Bracon* spp. (larval), *Brchymeria* spp. (larval), *Apanteles* spp., *Goniozus* spp., *Elasmus* spp., *Stenomesius*, *Sympiesis* and *Tetrastichus* etc. **Predators:** *Odynerus punctum, Cheilomenes sexmaculata, Coccinella septempunctata, Chrysoperla carnea, Rhynocoris marginatus*	**Repellent plants:** Basil **Attractant plants:** Carrot family, sunflower family, buck wheat, alfalfa, corn, shrubs (minute pirate bug and lacewing) Nectar rich plants with small flowers i.e. anise, caraway, dill, parsley, mustard, sunflower, buck wheat and cowpea (wasp)
2.	Red hairy caterpillar	**Parasitoids:** *Bracon hebetor*, *Helonus* spp. *Apanteles* sp. *Telenomus* sp, Larval-pupal parasite : *Exorista* spp. **Predators:** *Coccinella* spp. *Minochilus sexmaculata, Cantheconidia furcellata. Anthia* sp. Ground beetles: *Scarinus subterranious*. Nematode : *Steinernema* sp. Fungus : *Aspergillus flavus.*	**Repellent plants:** Basil **Attractant plants:** Carrot family, sunflower family, buck wheat, alfalfa, corn, shrubs (minute pirate bug and lacewing) **Nectar rich plants with small flowers:** Anise, caraway, dill, parsley, mustard, sunflower, buck wheat and cowpea (wasp)
3.	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 carnea*, coccinellids, King crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants, big eyed bugs (*Geocoris* sp.), pentatomid bug (*Eocanthecona furcellata*),	**Repellent plants:** Basil **Attractant plants:** Carrot family, sunflower family, buck wheat, alfalfa, corn, shrubs (minute pirate bug and lacewing) **Nectar rich plants with small flowers:** Anise, caraway, dill, parsley, mustard, sunflower, buck wheat and cowpea (wasp)
4.	Tobacco Caterpillar	**Parasitoids:** *Trichogramma chilonis* (egg), *Tetrastichus* spp. (egg), *Telenomus* spp. (egg), *Chelonus blackburni* (egg-larval), *Carcelia* spp. (larval-pupal), *Campoletis chlorideae* (larval), *Eriborus argentiopilosus* (larval), *Microplitis* sp. (larval) etc. **Predators:** *Chrysoperla carnea*, coccinellids, King crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants, big eyed bugs (*Geocoris* sp.), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc. *Ovomermis albicans*, a nematode	**Repellent plants:** Basil **Attractant plants:** Carrot family, sunflower family, Malvaceae family, buck wheat, alfalfa, corn, shrubs (minute pirate bug and lacewing) **Nectar rich plants with small flowers:** anise, caraway, dill, parsley, mustard, sunflower, buck wheat and cowpea (wasp)

5.	Jassids	**Parasitoids:** *Lymaenon empoascae (egg), Anagrus flaveolus, Stethynium triclavatum* **Predators:** Lady beetle, ants *Distina albino, Chrysoperla* spp., mirid bug *(Dicyphus hesperus)*, big-eyed bug, *(Geocoris* sp.*) etc.*	Sunflower family, alfalfa (damsel bug & minute pirate bug) Carrot family, buck wheat, alfalfa, corn, shrubs (minute pirate bug)
6.	Aphids	**Parasitoids:** *Aphidius colemani*, *Diaeretiella* spp., *Aphelinus* spp. etc. **Predators:** Anthocorid bugs/pirate bugs (*Orius* spp.), mirid bugs, syrphid/hover flies, green lacewings (*Mallada basalis* and *Chrysoperla carnea*), predatory coccinellids (*Stethorus punctillum*), staphylinid beetle (*Oligota* spp.), predatory cecidomyiid fly (*Aphidoletis aphidimyza*) and predatory gall midge, (*Feltiella minuta*), earwigs, ground beetles, rove beetles, spiders, wasps etc.	Carrot family, sunflower family, marigold, buckwheat, spear mint (syrphid fly, lace wing, minute pirate bug, damsel fly and lady beetle), French bean (predatory thrips), Strips of Rye grains, cover crops and mulch beds (rove beetle) Mustard, sweet clove, dill (aphid midge, *Aphidoletes aphidimyza*) Nectar rich plants with small flowers i.e. anise, caraway, dill, parsley, mustard (aphid parasite and braconid wasp), Sunflower, buckwheat and cowpea (braconid wasp)
7.	White grubs	**Prasitoids:** Braconids, Trichogrammatids, **Predators:** dragon flies, Viral & Fungal pathogens NPV, green muscardine fungus.	**Repellent plants:** Basil **Attractant plants:** Carrot family, sunflower family, buck wheat, alfalfa, corn, shrubs (minute pirate bug and lacewing) **Nectar rich plants with small flowers:** Anise, caraway, dill, parsley, mustard, sunflower, buck wheat and cowpea (wasp)

3.3. Genetic management

Use of varieties with resistance to insect pest and diseases are given below:

Resistance to rust and late leaf spot	ICG FDRS 10, ICGV86590, R8808, R9201
Field tolerant to Bud Necrosis under Rabi/ Summer situation	ICGS 11(ICGV 87123), ICGS 44
Nematode tolerance (Kalahasthi malady)	Tirupati 2, Tirupati 4
Pest resistance	Gimar1 (Jassid), ICGV87160 (Aphids), Kadiri 3, BG 2 (*Spodoptera*)

State wise location specific list of promising groundnut varieties

S.No.	Insect pest
Andhra Pradesh	Kadiri 6, Kadiri 7, Kadiri 8, Narayani, ICGV 91114, Kadiri 9, GPBD 4, Abhaya, Prasuna, Greeshma, Ajeya, Vijetha, Kadiri Harithandra, ICGV 00350
Andhra Pradesh	GG 2, GG 20, TG 37A, GG 5, GG 6, GG 7, JL 501, GJG 9, GJG 31, TPG 41, Dh 86
Andhra Pradesh	BAU 13, Girnar 3, GPBD 5, Vijetha, Dh 86, Dh 101, TG 38B, TG 51
Karnataka	GPBD 4, TGLPS 3, Ajeya, Vijetha, VRI (Gn) 6, ICGV 91114, TAG 24, Kadiri Harithandra
Madhya Pradesh	JGN 3, JGN 23, AK 159, GG 8
Maharashtra	AK 159, JL 220, JL 286, JL 501, AK 303, AK 265, Ratneshwar, TLG 45, TAG 24, Dh 86, Kadiri Harithandra
NEH region	BAU 13, ICGS 76, ICGV 86590, GPBD 5, TAG 24, Dh 86, Dh 101, TG 38B, TG 51, TG 37A
Orissa	OG 52−1, ICGV 91114, Girnar 3, TAG 24, TG 38B, TG 51, TG 37A, Dh 86, Dh 101
Punjab	M 548, Girnar 2, HNG 10, TG 37A, Prakash, Amber, Utkarsh, GG 14, GG 21, HNG 69, HNG 123, Raj Mungphali-1, SG 99
Rajasthan	HNG 10, Girnar-2, TG 37A, Prakash, Amber, Utkarsh, GG 14, GG 21, HNG 69, HNG 123, Raj Mungphali-1, TBG 39, Pratap Mugphali-1, Pratap Mugphali-2, JL 501
Tamil Nadu	VRI 2, VRI (Gn) 6, TMV (Gn) 13, Co (Gn) 5, Co 6, ALR 2, VRI (Gn) 7, GPBD 4, ICGV 00348, ICGV 00350
Uttar Pradesh	Prakash, Amber, Utkarsh, HNG 10, Girnar-2, GG 14, GG 21, TG 37A, HNG 69, HNG 123, Raj Mungphali-1, Dh 86
Uttarakhand	VL Mungphali-1
West Bengal	Girnar 3, TAG 24, TG 37A, TG 51, Dh 86, Dh 101, TG 38B

(Source: Dr B B Singh, ADG (OP), ICAR, Krishi Bhawan, New Delhi-12)

State wise location specific list of promising groundnut varieties

S. No.	Name of variety/ hybrid	Year of release/ notification	Recommended niche	Salient feature	
				Plant type, Maturity group*, seed size	Biotic and Abiotic Stress
1	GG 2 (Gujarat Groundnut 2)	1983	Summer	Erect, early (105 days), small seed	High water use efficiency
2	VRI 2	1989	*Kharif* and *rabi*-summer	Erect, early (105 days), medium seed	Tolerant of ELS, LLS and rust
3	ICGS 76 (ICGV 87141)	1989	*Kharif*	Semi-spreading , medium (118-122 days), medium bold seed	Resistant to ELS and LLS
4	TAG 24	1991	*Kharif* and *rabi*-summer	Erect, semi-dwarf, early (102 days), small seed	High Harvest Index (>50%) and high water use efficiency
5	ICGV 86590 (ICGS 86)	1991	*Kharif*	Erect, maturity (108 days), small seed	Multiple diseases (rust, LLS, PBND, stem and pod rots); and insect pest (*Spodoptera litura*) resistant
6	GG 20 (Gujarat groundnut 20)	1992	Kharif	Semi-spreading , medium (120 days), large seed, Suitable for confectionery	-
7	CSMG 84-1 (Ambar)	1992	Kharif	Spreading , late (125-130 days), medium seed	Tolerant of high temperature, and resistant to ELS and LLS
8	Birsa Bold (BAU 13)	1993	Kharif	Spreading , medium (122 days), large seed	Tolerant of collar rot and PBND
9	ALR 2 (ALG 56)	1994	Kharif	Erect, early (105 days), medium seed	Resistant to rust and LLS
10	Smruti (OG 52-1)	1995	*Kharif* and *rabi*-summer	Erect, medium (110 days), medium seed	Resistant to collar rot , stem rot, rust and leaf spots
11	JGN 3 (Jawahar roundnut 3)	1997	*Kharif*	Erect, early (104), small seed	Drought tolerant
12	HNG 10	1998	*Kharif*	Semi-spreading , late (125-30), medium seed	-
13	GG 5	1999	*Kharif*	Erect, medium (110 days), medium seed	Drought tolerant
14	CSMG 884 (Prakash)	1999	*Kharif*	Semi-spreading, medium (115-125), large seed	Tolerant of leaf spots and PBND
15	Phule Vyas (JL 220)	2000	*Kharif*	Erect, extra early (90-95 days), medium seed	-
16	GG 7 (J-38)	2001	*Kharif*	Erect, early (100 days), medium seed	Tolerant of LLS
17	AK 159	2002	*Kharif*	Erect, early (106 days), small seed	-
18	GG 6	2003	*Rabi*-summer	Erect, early (100 days), medium seed	-

19	GG 14 (JSP 28)	2003	*Kharif*	Spreading , medium (123 days), medium seed	Tolerant of thrips, *Spodoptera litura* and leaf miner
20	TPG 41	2004	*Rabi*-summer	Erect, late (122 days), large seed	-
21	TG 37A	2004	*Kharif* and *rabi*-summer	Erect, late (122 days), small seed	Possesses fresh seed dormancy up to 1 week
22	Vikas (GPBD 4)	2004	*Kharif*	Erect, early (107 days), small seed	Resistant to LLS and rust
23	TLG 45	2004	*Kharif*	Erect, medium (114 days), large seed	-
24	SG 99	2004	Summer	Erect, early (102 days), medium seed	Tolerant of PBND
25	Phule Unap (JL 286)	2004	*Rabi*-summer	Erect, extra early (93-95 days), small seed	-
26	Prutha (Dh 86)	2005	*Rabi*-summer	Erect, late (125-127 days), small seed	Tolerant of tikka and sucking pests
27	Kadiri 6 (K 1240)	2005	*Rabi*-summer	Erect, early (100-105 days), small seed	Tolerant of leaf spots
28	Pratap Mugphali 2 (ICUG 92195)	2005	Kharif	Erect, early (105 days), small seed	Tolerant of ELS, LLS, PBND, *Spodoptera litura*, leaf miner and thrips
29	Pratap Mugphali 1 (ICUG 92035)	2005	*Kharif*	Erect, early (108 days), small seed	Tolerant of ELS, LLS, PBND, *Spodoptera litura*, leaf miner and thrips
30	Ratneshwar (LGN 1)	2005	*Kharif*	Erect, early (105 days), small seed	Tolerant of stem rot
31	Co(GN) 5	2005	*Kharif*	Semi-spreading , late (125 days), medium seed	Tolerant of rust, PBND, leaf miner and *Spodoptera litura*
32	Utkarsh (CSMG 9510)	2005	*Kharif*	Spreading , late (125), large seed	-
33	GG 21 (JSSP 15)	2005	Kharif	Semi-spreading, late (123 days), large seed	-
34	GG 8 (J 53)	2006	*Kharif*	Erect, early (104-107 days), small seed	Tolerant of PBND and collar rot
35	TG 38B (TG 38)	2006	*Rabi*-summer	Erect, late (115-125 days), medium seed	Tolerant of stem rot
36	Prasuna (TCGS 341)	2006	*Kharif* and *rabi*-summer	Erect, medium (110 days), medium seed	Tolerant of Kalahasti malady
37	Abhaya (TPT 25)	2006	*Kharif* and *rabi*-summer	Erect, early (106 days), small seed	Tolerant of early-and-mid season moisture deficit stress
38	TMV (Gn)13	2006	*Kharif*	Erect, early (105-110 days), medium seed	Tolerant of early-and mid- season moisture stress conditions
39	Vasundhara (Dh 101)	2007	*Rabi*-summer	Erect, late (120-135 days), small seed	Tolerant of stem rot, PBND, thrips and *Spodoptera litura*
40	ICGV 91114	2007	*Kharif*	Erect, extra early (90-95 days), medium seed	Tolerant of drought , LLS and rust

41	Narayani (TCGS 29)	2007	*Kharif* and *rabi*-summer	Erect, early (100 days), medium seed	Tolerant of mid-season moisture deficit stress
42	AK 265	2007	*Kharif*	Semi-spreading, medium (120 days), medium seed	Resistant to rust and LLS diseases
43	M 548	2007	*Kharif*	Spreading , medium (123 days), large seed	-
44	TBG 39 (TG 39)	2007	*Kharif*	Semi-spreading, medium (118 days), large seed	-
45	AK 303	2007	*Kharif*	Semi-spreading , late (125 days), large seed	-
46	TG 51	2008	*Rabi*-summer	Erect, late (124 days), small seed	Tolerant of stem rot and root rot
47	Ajeya (R 2001-3)	2008	*Kharif*	Erect, medium (106 days), small seed	Drought tolerant
48	VL- Moong phali-1	2008	*Kharif*	Erect, late (125-130 days), medium seed	Resistant to LLS and root rot
49	Girnar 2 (PBS-24030)	2008	*Kharif*	Semi-spreading, late (130 days), large seed	Tolerant of rust and LLS
50	ICGV 00348	2008	*Kharif*	Semi-spreading, late (124 days), medium seed	Tolerant of leaf spots and rust
51	VRI (Gn) 7	2008	*Kharif*	Semi-spreading, late (120-125 days), medium seed	Tolerant of leaf miner, LLS and rust
52	VRI (Gn) 6 (VG 9816)	2009	*Kharif*	Erect, early (100-106 days), small seed	Tolerant of LLS, rust, PBND
53	Jawahar Groundnut 23 (JGN 23)	2009	*Kharif*	Erect, early (104 days), small seed	Tolerant of ELS and LLS
54	Kadiri 7	2009	*Kharif*	Semi-spreading, late (120-125), large seed	Tolerant of sucking pest and leaf spots
55	Kadiri 8	2009	Kharif	Semi-spreading, late (120-125), large seed	Tolerant of sucking pest and leaf spots
56	Kadiri 9	2009	*Kharif*	Erect, early (105-110 days), small seed	Tolerant of early-and end-of-season drought
57	Greeshma	2009	*Kharif* and *rabi*-summer	Erect, early (90-100 days), medium seed	Tolerant of LLS
58	TGLPS 3 (TDG-39)	2009	*Kharif*	Semi-spreading, medium (115-120), large seed	-
59	JL 501	2010	*Kharif*	Erect, early (102 days), medium seed	-
60	Vijetha (R 2001-2)	2010	*Kharif*	Erect, medium (105-115 days), small seed	Resistant to PBND
61	Girnar 3 (PBS 12160)	2010	*Kharif*	Erect, early (104-111 days), small seed	Tolerant of leaf miner and thrips

62	Kadiri Haritan dhra (K 1319)	2010	*Rabi*-summer	Erect, late (122 days), medium seed	-
63	GPBD-5	2010	*Kharif*	Erect, early (105-110 days), small seed	Resistant to LLS and rust
64	HNG 69	2010	*Kharif*	Semi-spreading , late (131 days), large seed	Tolerant of collar rot, stem rot and ELS
65	ICGV 00350	2012	*Rabi*-summer	Erect, medium (114 days), small seed	Resistant to LLS, rust and tolerant of stem rot
66	HNG 123	2012	*Kharif*	Semi-spreading , late (124 days), large seed	Tolerant to collar rot, stem rot and ELS
67	Raj Mungfali-1 (RG 510)	2012	*Kharif*	Spreading , late (112-138 days), large seed	Tolerant of collar rot
68	CO 6	2012	*Kharif*	Semi-spreading, late (125-130 days), medium seed	Resistant to LLS and rust
69	GJG 31 (J 71)	2012	*Kharif*	Erect, early (103 days), small seed	Tolerant of stem rot
70	GJG 9 (J 69)	2012	Summer	Erect, medium (117 days), medium seed	-

(Source: Dr B B Singh, ADG (OP), ICAR, Krishi Bhawan, New Delhi-12)

*Maturity group: early=less than110 days; medium=111 to 120 days; late= more than 120 days

ELS= Early Leaf Spot; LLS= Late Leaf Spot and virus; PBND= Peanut Bud Necrosis Disease

Small seed= less than 35g/100 seed; medium seed= more than 35 to 45g/100 seed; large seed= more than 45g/100 seed

3.4. Mechanical Practices

a. Installation of 12 light traps/ha or bonfire against red hairy caterpillar (RHC) in endemic areas.

b. Collection and destruction of egg masses and early instar larva of *S. litura*, RHC and Bihar hairy caterpillar

c. Collection and destruction of white grub beetles from jujube or neem trees around the field, immediately after the early rains.

d. Installation of pheromone traps @ 5/ha for monitoring and trapping of *S. litura* and *H. armigera*

e. Trenching and destruction of migrating larvae of hairy caterpillar.

f. Remove the collateral host during the season.

g. Use of aggregating pheromones on the preferred host of white grub beetle on community basis.

3.5. Biological control of insects/diseases

a. Seed treatment with *Trichoderma viride* @ 10 g/kg seed for controlling of soil borne diseases like collar rot, root rot and stem rot.

b. Soil application of *Trichoderma viride* @ 10 kg/ha multiplied in 250 kg FYM, 15 days prior to its application and applied at the time of sowing.

c. Release of *Telenomus remus* @ 50000/ha in 4 times (7-10 days interval) against defoliators (tobacco caterpillar) based on pheromone trap catching.

d. Use *S. litura* NPV @ 250 LE (6 x 10^9/LE)/ha or Bt @ 1 kg/ ha when large number of egg masses and early instar larva are noticed.

e. Use 5% neem seed kernel extract against *S. litura*, leaf miner and foliar diseases on need basis.

f. Augment the release of *Cheilomenes sexmaculata* (Fabricius), @ 1250/ha against *Aphis craccivora*.

g. Release of *Bracon hebetor* @ 5000/ha in 2 times at 7- 10 days interval against leaf miner and defoliators.

h. Release of larval parasitoid *Apanteles african* @ 5000/ha.

i. Conserve the natural bio control population of anthocorids, damsel bugs, assassin bug, predatory pentatomid bugs, lady bird beetles, ground beetles, rove beetles, hover flies, robber flies, preying mantids, green and brown lacewings, spiders, vespidae , damsel flies, dragon flies, tachnid flies, Ichneumonid wasps, Braconid wasps, Trichogrammatid wasps and beneficial pathogen like Nuclear Polyhedrosis Virus by use of less toxic pesticides.

j. EPN can be recommended @ one billion per acre for the management of white grub (*Holotrichia serrata*).

k. Apply entomopathogenic nematodes (EPNs) @ 20-120 crore infective juveniles of *Steinernema* feltiai/acre for the management of red hairy caterpillar (*Amsacta* sp.)

Potential natural enemies of groundnut insect pests

Name of the Predator/ Parasitoid/Pathogens	Pest	Stage attacked
Ants	Soft bodied insects	Eggs and larvae
Braconids / Ichneumonid wasps	Lepidoptera	Larval and pupal stage
Damsel flies / Dragon flies	All insects including Jassids, *H. armigera* and *S. litura*	Larval and adult stage
Earwig (Carcinophorids)	Lepidoptera	Larval stage
Flower bugs (Anthocorids)	Thrips Mites Lepidoptera Aphids	Eggs and young larvae of lepidopteron pests. Adults and nymph of aphids, mites & thrips.
Green lace wing (Chrysopids) Pest	Soft bodied insects (including small larvae)	Eggs and larvae
Green muscardine fungus (*Metarrhizium anisopliae*).	Lepidoptera, Jassids and Coleoptera	Larval stage
Ground beetle (Carabids)	Aphids, Mealy Bugs, Jassids, Thrips	Nymph and adult stages
Hover flies (Syrphids)	Aphids	All stages
Lady bird beetles (Coccinellids)	Lepidoptera Bugs	Nymph and adult stages
Nuclear Polyhydrosis Virus	Lepidoptera	Larval stage
Preying mantids	All insects (including grasshopper)	All stages
Rober fly	*Helicoverpa, Spodoptera* and Grasshopper	Larvae and adult stages
Rove beetle (Staphilinids)	Soft bodied insects	Nymph and adult stages
Shield bugs (Predatory Pentatomid)	Lepidoptera Aphids	Immature and adults stage
Spiders	All insects	All stages preferably moving stages
Trichogrammatids	Lepidoptera	Eggs stage

Feeding/egg laying potential of different parasitoids/predators

Predators/ Parasitoids	Feeding potential/ Egg laying Capacity
Lady bird beetle	Predatory rate of adult coccinellid on aphids is 50 aphids per day
Green Lace wing	Each larva can consume 100 aphids, 329 pupa of whitefly and 288 nymphs of jassids.
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
Spider	5 big larvae/day
Telenomus spp.	Egg parasitoid on *Spodoptera litura*
Bracon hebetor	Egg laying capacity is 100-200 eggs/female. 1-8 eggs/larva
Trichogramma sp.	Egg laying capacity is 20-200eggs/female

3.6. Chemical control

a. Seed treatment with Chlorpyrifos 20% EC @ 2.5 to 12.5 ml/kg seed in endemic areas against white grub.

b. Two spray of Difenaconazole 25% @ 100 g/100 lit. of water or Propiconazole 25% EC @ 500g/750 lit. of water or Hexaconazole 5% EC @ 1500 ml/500 lit. of water at 15 days interval after appearance of diseases for leaf spots and rust.

c. Use 0.005% Bromadiolone cake as a bait for rodent control.

d. Soil application of phorate 10% CG @ 15-25 kg/ha for aphids, leaf miner and white grub or Carbofuran 3% CG @ 33.3 kg/ha against white grub and other soil borne insect pest.

e. Need based application of Dimethoate 0.05% or Monocrotophos 0.05%, or Imidacloprid 0.008% or Dichlorovos 76% SC for managing sucking pests of groundnut.

f. Spray Quinolphos 25% EC 0.05% or Chlorpyrifos 20% EC for managing defoliators like *Spodoptera* and *Helicoverpa.*

3.7. Weed management

3.7.1. Cultural and mechanical practices

a. Summer deep ploughing of fields for destroying the underground vegetative parts of perennial weeds.

b. Two mechanical weeding each at 15-20 days and 30-45 days after sowing to keep the crop weed free for 6 weeks.

3.7.2. Chemical control

a. Apply Oxyflourfen 23.5% EC @ 425-850 g/500 lit. of water or Alachlor 50% EC @ 1.5 -2.5 kg/250-500 lit. of water or Alachlor 10% GR @15-25 kg/ha after sowing but before emergence of weeds.

b. Use of post- emergence weedicides like Imazethapyr 10% SL @ 1.0-1.5 lit/500-700 lit. of water or Quizalofop ethyl 5% EC @ 750-1000 g/500 lit. of water for grass and broad leaf weeds.

3.8. Managements of nematode pests

Major species Root knot nematodes (*Meloidogyne arenaria, M. javanica*) and Kalahasthi Malady (*Tylenchorhynchus brevilineatus*)

Minor species Lesion nematodes (*Pratylenchus* spp.)

3.8.1. Cultural and mechanical practices

a. Deep summer ploughing: Plough the soil down to a depth of minimum 20 cm. in the hot summer months to expose the soil to solar radiation. The nematodes die due to desiccation. This practice can be coupled with summer fallow to make it more effective.

b. Use of resistant varieties

Nematode		Variety
i.	Kalahasthi malady	Kadiri-3, Tirupati 2 and Tirupati 3
ii.	*M. javanica*	G 201, CGC 4018, Japtin 220 -15, Ambali
iii.	*Pratylenchus* sp.	P – 1295233, P- 1290606.

3.8.2. Management of Kalahasthi malady

a. Crop rotation with paddy or other cereal crops like sorghum and maize. Rotation with paddy is very effective in reducing the population of Kalahasthi nematode. Rotation with maize or sorghum reduces root knot nematode population.

b. Green manuring and incorporation of organic manure to the soil can help in minimizing the Kalahasthi and root knot nematodes.

c. Quarantine regulations need to be strictly monitored to check the entry of *Aphelenchoides arachidis* and *Belonolaimus longicaudatus*.

3.8.3. Management of root knot nematode

a. Deep summer ploughing in states having hot and dry summers help in reducing infestation of plant parasitic nematodes.

b. Soil amendments with neem cake or castor cakes @ 1 tonne/ha preferably seven days prior to sowing has been found to reduce nematode population.

c. Farmers of south Saurashtra region of Gujarat are advised to sow groundnut with castor as an intercrop (2:1 ratio) along with soil application of Carbofuron @ 1kg a.i/ha to reduce the population of root-knot nematodes infecting groundnut.

d. EPN recommendation for management of insect pests in ground nut.

3.9. Management of rodents

Lesser bandicoot: *Bandicota bengalensis* (Gray) (throughout India)

Field mouse: *Mus booduga* (Gray) (throughout India)

Soft furred field rat: *Millardia meltada* (Gray) (throughout India)

Indian Gerbil: *Tatera indica* (Hardwicke) (throughout India)

Brown spiny mouse: *Mus platythrix* (Bennett)

Rodent damage in groundnut

- Rodents cause damage to germinating seeds by nibbling
- Maximum damage is found during the pod formation and maturity.
- Rodents will make the burrow near the plant base, cut the roots and pods and eat the seeds from developed pods. Fat content in the seeds attract the rats and leads to losses. Due to root damage sometimes plants also withers.

Management practices

- Plough the fields to demolish the rodent habitat and maintain weed free fields to reduce alternate source of food and habitat
- Practice burrow smoking using natural smoking materials in ANGRAU/ NIPHM burrow fumigator for 2-3 min. for each burrow
- Application of 0.005% bromadiolone in ready to use form (wax blocks) or loose bait in packets near rodent burrows
- Apply 2% Zinc phosphide poison baits when the rodent infestation is very high.

4.0. Crop stage/pest *vis.-a-vis.* IPM practices

Crop Stage/Pest	IPM Component	IPM Practices
1.Pre-Sowing		
White grubs, Nematodes, Bud necrosis, Red hairy caterpillar Soil borne pathogens (stem rot, collar rot, dry rot, *Aspergillus flavus*)	Cultural practices	Partial or complete lopping of host plants and retaining of a few most preferred host trees in the area for congregation of white grub adults. Deep summer ploughing to expose soil borne pathogens, white grubs, nematodes and hibernating defoliators and underground bulbs and rhizomes of perennial weeds. Crop rotation with wheat, maize, sorghum, pearl millet, cotton or onion/garlic. Early sowing to avoid damage due to insect pests and bud necrosis (if irrigation facility is available) except pest endemic area. Removal of volunteers or previous crop residue.
	Mechanical practices	Collection and destruction of white grub adults. Installation of 12 light traps/ha or bonfire against Red hairy caterpillar (RHC) in endemic areas.
2. Seed & Seedling		
Weeds	Cultural practices	Two hand hoeing at 20 days and 35-45 days after sowing for effective weed control.
Aphids, Leaf miner, Tobacco caterpillar	- do -	Stray planting of Cowpea (aphids), Soybean (for leaf miner), Castor and Sunflower for *S. litura* as trap crops.
Bud necrosis	- do -	Dense cropping (increased seed rate) to reduce bud necrosis damage and weed population.
Collar rot, Stem rot, White grubs and Termites	- do -	Soil application of castor or neem cake @ 250 kg/ha
Red hairy caterpillar (RHC) and Tobacco caterpillar	Mechanical practices	Continue with light trap or bonfire against RHC. Collection and destruction of egg masses of RHC in the fields around light-trap areas

Seed rots/ collar rots and root rot	Biological control	Seed treatment with *Trichoderma viride* @ 10 g/ kg seed. Soil application *Trichoderma viride* @ 10 kg/ ha multiplied in 250 kg FYM 15 days prior to its application and applied at the time of sowing.
Weeds	Chemical control	Apply Oxyflourfen 23.5% EC @ 425-850 g/500 lit. of water or Alachlor 50% EC @ 1.5-2.5 kg/250-500 lit. of water or Alachlor 10% GR @15-25 kg/ha after sowing but before emergence of weeds . Use of post- emergence of weedicides like Imazethapyr 10% SL @ 1.0-1.5 lit./500-700 lit. of water or Quizalofop ethyl 5% EC @ 750-1000 g/500 lit.of water for grass and broad leaf weeds.
Seed rots / collar rots and root rot	Chemical control	Two spray of Difenaconazole 25% EC @ 100 ml/100lit.of water or Propiconazole 25% EC @ 500 g/750 lit. of water or Hexaconazole 5% EC @ 1500 ml/500 lit. of water at 15 days interval after appearance of diseases.
White grubs	- do -	Spraying white grubs harbouring host trees with Chloropyrifos 1.0-1.25 lit./500-1000 lit. of water. Seed treatment with Chlorpyriphos 20% EC @ 2.5 to 12.5 ml/kg seed in endemic areas against white grub. Soil application of phorate 10% CG @ 15-25 kg/ha for white grub or Carbofuran 3% CG @ 33.3 kg/ha against white grub.
Sucking Pests & Termites	- do -	Seed treatments with Imidacloprid 17.8% SL @ 2ml/kg seed or spraying the Imidacloprid 17.8 % SL @ 100-125 ml/500 lit. of water. Soil application of Phorate 10% CG @ 15-25 kg/ha for aphids and jassid or Carbofuran 3% CG @33.3 kg/ha against termites and others soil borne insect pest. Need based application of Dimethoate 0.05% or Monocrotophos 0.05%, or Imidacloprid 0.008% or Dichlorovos 76% SC for managing sucking pests of groundnut
3. Vegetative Phase		
Leaf spot, Rust, Stem rot, Bud necrosis clump (Regional) Sucking pests, Tobacco caterpillar Red hairy caterpillar, Bihar hairy caterpillar, Leaf miner	Cultural practices	Rouge out bud necrosis affected and clump infected plants.
	Mechanical practices	Continue with light trap or bonfire, mechanical collection of *S. litura*, RHC, BHC, egg mass, larva and install 5 pheromone traps/ha for monitoring or 25 traps/ha for mass trapping of *Spodoptera*. Collection and destruction of White grub adults from Jujube or neem trees around the field. Two hand or mechanical weeding at 15-20 days after sowing.

	Biological control	Release egg parasite of *Telenomus remus* @ 50000/ ha, 4 times (7-10 days interval) against *S. litura.* Spray *S. litura* NPV @ 250 LE (6 x 10^9 /LE.)/ ha. or *Bacillus thuringiensis* (B.t.) @ 1 kg/ha for controlling defoliators like *Spodoptera* and *Chilomenus sexmaculata* @ 1250/ha twice against sucking pests.
	Chemical control	Two spray of Difenaconazole 25% EC @ 100 ml/100lit.of water or Propiconazole 25% EC @ 500 g/750 lit. of water or Hexaconazole 5% EC @1500 ml/500 lit. of water at 15 days interval after appearance of diseases. Spray Quinalphos 1.5% DP @ 2300-2500 g/ha or Quinalphos 25% EC @1400 ml/ha or Dichlorovas 76 % EC @ 470-940 ml/ha or Chlorpyriphos 20% EC @1lit./ha to control full grown hairy caterpillar. Two spray of Difenaconazole 25% EC @ 100 ml/100 lit. of water or Propiconazole 25% EC @ 500 g/750 lit. of water or Hexaconazole 5% EC @ 1500 ml/500 lit. of water at 15 days interval after appearance of diseases for leaf spots and rust. Need based application of Dimethoate 0.05% or Monocrotophos 0.05%, or Imidacloprid 0.008% or Dichlorovos 76% SC for managing sucking pests of groundnut. Spray Quinolphos 25 EC 0.05% or Chlorpyrifos 20 % EC for managing defoliators like *Spodoptera* and *Helicoverpa*
4. Flowering		
Leaf miner, Spodoptera Rust & Tikka disease	Mechanical practices	Collection and destruction of white grub beetle immediately after the early rains. Installation of 12 light traps/ha or bonfire against Red hairy caterpillar (RHC) in endemic areas. Installation of pheromone trap @ 5/ha for monitoring or 25/ha for mass trapping of *S.litura.* Spray of neem based formulation @ 2%.
	Biological control	Release of *Trichogramma chilonis* (50000/ha) twice against leaf miner and other defoliators. Spray 5% neem seed kernel extract against *Spodoptera.* Spray 5% neem seed kernel extract against *Spodoptera.* Spray SlNPV @ 250 LE. /ha or B.t. 1 kg/ha on need basis.

	Chemical control	Spray of Dimethoate 30% EC @ 470-940 g/500-1000 lit. of water for controlling the leaf miner Spray Quinolphos 25 EC 0.05% or Chlorpyrifos 20 EC for managing *Spodoptera.* Two spray of Difenaconazole 25% @ 100 ml/100lit. of water or Propiconazole 25% EC @ 500 g/750 lit. of water or Hexaconazole 5% EC @1500 ml/500 lit. of water at 15 days interval after appearance of diseases for leaf spots and rust.
5. Peg & Pod formation		
Spodoptera, Leaf miner, Rust, Leaf spot, Stem rot	Mechanical practice	Collect egg masses and early instar larvae of *S. litura.* Spray of neem based formulations @ 2%.
	Biological control	Spray SlNPV @ 250 LE. /ha or B.t. 1 kg/ha on need basis.
	Chemical control	Spray of Dimethoate 30% EC @ 470-940 g/500-1000 lit. of water for controlling the leaf miner. Spray Quinolphos 25 EC 0.05% or Chlorpyrifos 20 EC for managing *Spodoptera*. Two spray of Difenaconazole 25% EC @ 100 ml/100lit.of water or Propiconazole 25% EC @ 500 g/750 lit. of water or Hexaconazole 5% EC @ 1500 ml/500 lit. of water at 15 days interval after appearance of diseases for leaf spots and rust.
6. Maturity stage		
Pod rot, Leaf spots, Rust, Pod borers Termites, Rodents, Aflatoxins	Chemical control	No chemical control Measures are suggested as this action may leave pesticides residues in the harvested produce. Use 0.005% Bromadiolone cake.
7. Harvest & Storage		
	Cultural practices	Store in polythene - lined gunny bags on raised platform. The bag should not be sealed or stitched to avoid loss of germination. Dry the pods to optimum kernel moisture level to optimum level of about 7 %. Harvest at optimum maturity state to avoid pod infection by *A. flavus* (neither immature nor over-matured)
	Chemical control	In case of Bruchids infection, fumigates with Aluminium phosphide one tablet (3g)/30 kg bag under air tight condition.

5.0. Safety parameters

Annexure deals with the safety parameters inter-alia classification of toxicity as per Insecticides Rules, 1971, WHO Classification of hazards, colour of toxicity triangle, first aid measures, symptoms of poisoning and treatment of poisoning, the extension functionaries of the State Department of Agriculture have to make use of this information as under:

I. Basic precautions which are required to be taken as per classification of toxicity as well as hazard criteria by WHO.

II. The extension functionaries are to educate the farmers on safety use of pesticides with the help of colour toxicity triangle as the farming community can follow the colour and corresponding safety precautions.

III. The symptom of poisoning must be known to the extension functionaries to enable them to extend first aid measures to affected persons to the extent possible.

IV. Basically, the information on first aid measures and treatment of poisoning is required to be passed on by the extension functionaries to the doctors at Primary Health Centres as well as to the Private Doctors in the vicinity of spraying of pesticides.

V. Extension functionaries must ensure that names of common pesticides during plant protection measures along with a copy of the leaflet which is an integral part of a pesticide container must be made available to the doctors in the vicinity of plant protection operations.

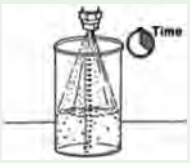
VI. Extension functionaries are to request the doctors to intervene in procurement of antidotes for different pesticides as cited under “Treatment of poisoning”.

Protocol for Pesticide application techniques, equipments and nozzle specifications

Category A: Stationary, crawling pest/ disease		
Vegetative stage 1. For crawling and soil borne pests 2. For small sucking leaf borne pests	Insecticides and fungicides	• Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min Or • Motorized knapsack sprayer or • mist blower (Droplets of small size) • Air blast nozzle • Operating speed: 2/3rd throttle
Reproductive stage	Insecticides and fungicides	• Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min

Category B: Field Flying pest/airborne pest		
Vegetative stage	Insecticides and fungicides	• Motorized knapsack sprayer or mist blower (Droplets of small size) • Air blast nozzle • Operating speed: 2/3rd throttle or • Battery operated low volume sprayer • (Droplets of small size) spinning disc nozzle
Reproductive stage (Field Pests)		
Category C: Weeds		
Post-emergence application	Weedicide	• Lever operated knapsack sprayer (Droplets of big size) • Flat fan or flood jet nozzle @ 15 to 20 psi • Lever operating speed = 7 to 10 strokes/min
Pre-emergence		• Trolley mounted low volume sprayer (Droplets of small size) • Battery operated low volume sprayer (Droplets of small size)

Operational, calibration and maintenance guidelines

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.	 Do not spray dust into the wind
6.	Operator shouldmaintain normal walking speed while undertaking application.	
7.	Operator shouldmaintain normal walking speed while undertaking application.	 

8.	Operator shouldtake 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.	

Do's and don'ts in groundnut IPM

Sl. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the month of May and June. The field should be kept exposed to sun light at least for 2-3 weeks	Do not plank 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.	Grow only recommended varieties	Do not grow varieties not suitable for the season or the region.
3.	Prefer to sow the crop from Mid-April to May for North Zone and up to June end for South and Central Zones.	Avoid late sowing as this may lead to reduced yield and incidence of white grubs and diseases.
4.	Always treat the seeds with approved chemicals/ bio products for the control of seed borne diseases/ pests.	Do not use seeds without seed treatment with biocides/chemicals.
5.	Sow in rows at optimum depths under proper moisture conditions for better establishment	Do not sow seeds beyond 5-7 cm depth.
6.	Pre-emergence herbicides should be applied immediately after sowing before the emergence of weeds and crop.	Pre-emergence herbicides should not be applied after emergence of crop and/or weeds they cannot control the germinated weeds as well as they may cause phytotoxicity to the crop.
7.	Herbicides like Oxyflurofen/Alachlor should be incorporated into the soil immediately after spraying, to avoid its photo- degradation.	Soil application of Oxyflurofen/Alachlor should not be delayed or avoided for achieving effective weed control.
8.	Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with fan or flat jet nozzles.	Pre-emergence as well as soil incorporation of herbicides should not be done in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
9.	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 stage growth stages.
10.	Use NPK fertilisers as per the soil test recommendations.	Avoid imbalanced use of fertilisers
11.	Use micronutrient mixture after sowing as top dressing separately.	Do not mix micronutrients with fertilisers and incorporate into the soil.
12.	Conduct AESA weekly in the morning preferably before 9 am. Take decision on management practice based on AESA, ETL, and P : D ratio only.	Do not apply chemical pesticides on calendar basis.

13.	Install pheromone traps on 20-30 DAS for *Spodoptera* and leaf miner. Replace lures in 15-20 days.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
14.	Release parasites only after noticing adults' moth catches in the pheromone trap or as per field observation.	Do not apply chemical pesticides within 7 days of release of parasites.
15.	Apply S. litura NPV 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 use the same sprayer for application of chemical pesticides and biocides.
16.	In case of pests which are active during night like *Spodoptera* spray recommended biocides chemicals at the time of their appearance during dusky hours.	Do not apply pesticides/biocides when it is not absolutely required.

Method for calculation of pesticides for application

(i) **Solid formulations** such as dust, wettable powder or granules, the active ingredient is mixed with inert material. The concentration is expressed as -

Active ingredient (%) in the total weight of commercial product

$$\text{Active ingredient (\%) in dust, WP or granules} = \frac{\text{Weight of a.i. x 100}}{\text{Total weight of WP , dust, etc.}}$$

Example. Carbendazim 50% WP means there are 50 g of carbendazim in every 100 g of commercial WP (5 0 % a.i.).

Calculations when recommendation is in kg a.i. ha^{-1}. For WP, dust, granules, etc.

Specification required:

1) Area to be sprayed
2) Concentration of a.i in formulation
3) Recommended rate as kg a.i. ha^{-1}.

$$\text{Formula: kg of WP/dust/granules} = \frac{\text{Recommended rate x spray area (sq.m)}}{\text{a.i (\%) in W P x 100}}$$

Example: If Carbendazim 50% WP is used at the rate of 2 kg a.i ha^{-1}, then amount of Carbendazim 50% WP required for 1 ha (10000 m^2) is:

$$\text{kg of Carbendazim 50\% WP required} = \frac{2 \times 10000}{50 \times 100} = 4 \text{ kg/ha}$$

(ii) Liquid formulation: Here the a.i. is dissolved in a solvent with an emulsifying agent. It is expressed as in emulsifiable concentrate (EC). The concentration can be expressed in two ways.

a) $$\text{Active ingredient (\%) in EC} = \frac{\text{Weight of a.i. x 100}}{\text{Volume of EC}}$$

b) Grams L^{-1}

Example: Hexaconazole 5% EC means, 100 ml of commercial product has 5 ml of pure Hexaconazole

For emulsiflable concentrates

Specification required:

i) Area to be treated
ii) Recommended rate as kg a.i. ha^{-1}
iii) Concentration of commercial EC as a.i (%) or kg L^{-1}

When concentration of EC is in a.i. (%)

Formula:

$$\text{kg of EC required} = \frac{\text{Recommended rate x area } (m^2)}{\text{a.i (\%) in commercial EC x 100}}$$

$$= \frac{\text{Recommended rate x area (ha)}}{\text{a.i. (\%) in commercial EC x 100}}$$

Example: Hexaconazole 5% EC to be sprayed at the rate of 2 kg a.i. ha^{-1} for 10000 m^2 and Hexaconazole 5% EC has 5 % a.i. How much liters of Hexaconazole is required?

$$\text{Liters of 5 \% Hexaconazole required} = \frac{2 \times 10000}{5 \times 100} = 40 \text{ L}$$

When concentration expressed is in kg a.i. L^{-1}

Formula:

$$= \frac{\text{Recommended rate in kg a.i. } ha^{-1} \text{ x area (ha)}}{\text{Concentration of a.i. in product (kg } L^{-1})}$$

Example: Acetamprid (0.01 kg a.i. L^{-1}) is to be applied at the rate of 0.05 kg a.i. ha^{-1} How much will be required for 3 ha?

$$\text{Liters of Acetamprid required} = \frac{0.05 \times 3.0}{0.01} = 15 \text{ liters}$$

When recommendation is based on a.i (%) in the spray fluid

i) Wettable powders (when diluted with water)

Specifications required:

1 Spray volume as L ha^{-1}
2 Concentration desired as a.i. (%) in spray
3 Concentration of commercial product as a.i. (%)

Formula :

$$WP = \frac{\text{a.i. (\%) desired x spray volume}}{\text{a.i. (\%) in commercial WP}}$$

Example: To control *Spodoptera* in a plot. 2000L of 2% Methyl Parathion DP is to be prepared. The commercial product to be used is Methyl parathion 50% EC. How much Methyl parathion is required?

$$\text{Litre of Methyl parathion required} = \frac{2 \times 2000}{50} = 80 \text{ liters}$$

ii) Emulsifiable concentrates (EC)

Specification required:

1) Spray volume as L ha^{-1}
2) Concentration as percentage of a.i desired.

Concentration of commercial EC as a.i. (%).

Formula:

$$\text{Liter of EC} = \frac{\text{a . i . (\%) desired x spray volume}}{\text{a.i. (\%) in commercial EC}}$$

Example: 2000 L of 2 % Quinalphos 25% EC spray is to be prepared. How much commercial 25 % EC is required?

$$\text{Liters of Methyl Parathion} = \frac{2 \times 2000}{25} = 160 \text{ L}$$

Annexure-I

List of recommended pesticides having label claim for groundnut

Herbicides	Insecticides	Fungicides
Alachlor 10% GR	Bromadiolone 0.005% RB	Benomyl 50 % WP
Alachlor 50% EC	Bromadiolone 0.25% CB	Bitertanol 25% WP
Imazethapyr 10% SL	Carbofuran 3% CG	Carbendazim 12% + Mancozeb 63% WP
Oxyflourfen 23.5% EC	Chlorpyrifos 20% EC	Carbendazim 25%+ Mancozeb 50% WS
Quizalofop-ethyl 5% EC	Deltamethrin 2.8% EC	Carbendazim 50% WP
	Dichlorvos 76% EC	Carboxin 37.5% + Thiram 37.5% DS
	Diflubenzuron 25% WP	Chlorothalonil 75% WP
	Dimethoate 30% EC	Copper hydroxide 77% WP
	Imidacloprid 17.8% SL	Difenoconazole 25% EC
	Lambda-Cyhalothrin 5% EC	Hexaconazole 5% EC
	Malathion 50% EC	Mancozeb 75% WP
	Methomyl 40% SP	Metriam 70% WG
	Methyl Parathion 2% DP	Propiconazole 25% EC
	Oxydemeton methyl 25% EC	Sulphur 40% WP
	Phenthoate 50% EC	Sulphur 80% WP
	Phorate 10% CG	Sulphur 85% DP
	Phosalone 35% EC	Tebuconazole 2% DS
	Phosalone 4% DP	Tebuconazole 25.9% m/m EC
	Quinalphos 1.5% DP	Tebuconazole 25%WG
	Quinalphos 20% AF	Thiram 75% WS
	Quinalphos 25% EC	
	Trichlorofon 5% Dust	
	Trichlorofon 5% Gr	
	Trichlorofon 50% EC	

Source: www.cibrc.nic.in (15.10.2013)

Annexure-II

Commonly Available Formulations of Pesticides for Agricultural Use

Class	Type	Abbreviation	Description
Dry	Dust	D	• Ready to use, off shelf available • Low percentage of active ingredients, • Very fine dry inert carrier made from tale, chalk, clay, or ash • Prone to high level of pesticide drift
	Granule	G	• Granule particles are larger and heavier • Used for soil treatment and broadcasting to manage nematodes, weeds and insect pests
	Wettable	WP	• Finely grounded power
	Powder	W	• Finely grounded power
	Micro encapsulated	M	• Mixed with water for spray application
Liquid	Emulsifiable concentrate	EC	• Particles of active ingredients (liquid or dry) surrounded by a plastic coating
	Concentrate solution	C LC	• Liquid active ingredients, dissolved in petroleum based solvents • Easily absorbed through skin
		ULV	• Diluted with a liquid solvent before being applied
		F L	• Very high percentage of active ingredient • Used before dilution or diluted with small quantities of solvent
Fumigants	Pellets		• Finely grounded solid active ingredients suspended in the liquid with inert materials
liquids			• Solid or liquid that releases/vaporized into toxic gasses

Annexure-III

Pesticides and their Mode of Action

Type of pesticide	Mode of action	How it works
Insecticides and nematicides	Contact	Act through cuticle
	Ingestion	Act upon digestive track
	Systemic	Absorbed and translocated to affected portions
	Fumigants	Penetrates as a into cryptic parts
Herbicide	Contact	Act through cuticle and translocation
	Systemic	Absorbed through soil and translocated to different parts
Fungicide	Superficial protectants	Contact pathogen reproductive propagules
	Systemic	Absorbed through roots from soil, leaf and translocated to different parts

Annexure-IV

Mechanisms of Actions of Major Pesticides

Type of pesticide	Target tissue or organ	Mechanism
Insecticide	Central nervous	Interfere with electron system of nervous system Inhibit acetyl cholinesterase the enzyme responsible for the regulating biological activity
	Cuticle	Inhibit growth and prevent cuticle formulations
	Endocrine system	Disrupts hormonal metabolic system
Herbicide	Seed	Disrupts protein synthesis and inhibits germination
	Leaf, stem,	Prevent photosynthesis
	Leaf, stem, root	Interferes with the mitosis process
	Leaf, stem, root	Affects cell respiration and ATP synthesis
Fungicide	Seed, leaf, stem	Inhibits liquid synthesis affecting cell wall and membrane
	Root	Inhibits synthesis of essential ribosomal proteins Inhibits mitosis, osmoregulation and mitochondrial respiration

Annexure-V

General Guidelines for Management of Resistance

The general guidelines if adopted can prevent development of resistance by various pests in most of the agricultural situations. The general approaches to avoid them are as follows:

Insecticides

- Maintain good plant health,
- Delay the spray of insecticide as far as possible.
- Monitor populations and use economic thresholds
- Use all available tactics for management of a particular arthropod (insect or mite)
- Limit selection pressure throughout the season and remember spraying for one pest may influences another
- Limit use of one chemical molecule at a time and rotate chemical molecule and/or modes of action, and
- Use appropriate rates

Fungicides

- Avoid growing large areas of highly susceptible varieties in endemic areas. Resistant varieties should be used to reduce reliance on chemical pesticides.
- Make full use of non-fungicidal control measures e.g., dispose of crop debris and control collateral and alternate host, which harbor disease.
- Monitor crops regularly for disease and treat before the infection becomes established.
- Use fungicides only in the unavoidable situations where the risk of disease warrants treatment. Make full use of effective fungicides with different modes of action as alternate sprays. Mixtures of eradicant fungicides with protectants materials offer the most flexibility as well as reducing resistance risk.
- While formulating spray programmes, take into account any earlier use of fungicides groups as seed treatment.
- Do not exceed the maximum recommended numbers of applications to each crop for any particular fungicide group. Avoid repeated applications of very low doses.

Annexure-VI

Pesticides / formulations banned in India (As on 1st Jan, 2014)

A.	**Pesticides Banned for manufacture, import and use**	
	1.	Aldicarb
	2.	Aldrin
	3.	Benzene Hexachloride
	4.	Calcium Cyanide
	5.	Chlorbenzilate
	6.	Chlordane
	7.	Chlorofenvinphos
	8.	Copper Acetoarsenite
	9.	Dibromochloropropane
	10.	Dieldrin
	11.	Endrin
	12.	Ethyl Mercury Chloride
	13.	Ethyl Parathion
	14.	Ethylene Dibromide
	15.	Heptachlor
	16.	Lindane (Gamma-HCH) (Banned vide Gazette Notification No S.O. 637(E) Dated 25/03/2011)-Banned for Manufecture,Import or Formulate w.e.f. 25th March,2011 and banned for use w.e.f. 25th March,2013.
	17.	Maleic Hydrazide
	18.	Menazon
	19.	Metoxuron
	20.	Nitrofen
	21.	Paraquat Dimethyl Sulphate
	22.	Pentachloro Nitrobenzene
	23.	Pentachlorophenol
	24.	Phenyl Mercury Acetate
	25.	Sodium Methane Arsonate
	26.	TCA (Trichloro acetic acid)
	27.	Tetradifon
	28.	Toxaphene(Camphechlor)
B.	**Pesticide formulations banned for import, manufacture and use**	
	1.	Carbofuron 50% SP
	2.	Methomyl 12.5% L
	3.	Methomyl 24% formulation
	4.	Phosphamidon 85% SL
C.	**Pesticide / Pesticide formulations banned for use but continued to manufacture for export**	
	1.	Captafol 80% Powder
	2.	Nicotin Sulfate
D.	**Pesticides Withdrawn**	
		(Withdrawal may become inoperative as soon as required complete data as per the guidelines is generated and submitted by the Pesticides Industry to the Government and accepted by the Registration Committee. (S.O 915(E) dated 15th Jun,2006)
	1.	Dalapon
	2.	Ferbam
	3.	Formothion
	4.	Nickel Chloride
	5.	Paradichlorobenzene (PDCB)
	6.	Simazine
	7.	Warfarin

Source: www.cibrc.nic.in

Annexure-VII

Pesticides Restricted for Use in the Country (As on 1st Jan, 2014)

S.No.	Name of Pesticides	Details of Restrictions
1.	Aluminium Phosphide	The Pest Control Operations with Aluminium Phosphide may be undertaken only by Govt./Govt. undertakings / Govt. Organizations / pest control operators under the strict supervision of Govt. Experts or experts whose expertise is approved by the Plant Protection Advisor to Govt. of India except 1. Aluminium Phosphide 15 % 12 g tablet and 2. Aluminum Phosphide 6 % tablet.
2.	Captafol	The use of Captafol as foliar spray is banned. Captafol shall be used only as seed dresser. The manufacture of Captafol 80 % powder for dry seed treatment (DS) is banned for use in the country except manufacture for export. (S.O.679 (E) dated 17thJuly, 2001)
3.	Cypermethrin	Cypermethrin 3 % Smoke Generator, is to be used only through Pest Control Operators and not allowed to be used by the General Public.
4.	Dazomet	The use of Dazomet is not permitted on Tea.
5.	Diazinon	Diazinon is banned for use in agriculture except for household use.
6.	Dichloro Diphenyl Trichloroethane (DDT)	The use of DDT for the domestic Public Health Programme is restricted up to 10,000 Metric Tonnes per annum, except in case of any major outbreak of epidemic. M/s Hindustan Insecticides Ltd., the sole manufacturer of DDT in the country may manufacture DDT for export to other countries for use in vector control for public health purpose. The export of DDT to Parties and State non-Parties shall be strictly in accordance with the paragraph 2(b) article 3 of the Stockholm Convention on Persistent Organic Pollutants (POPs).
7.	Fenitrothion	The use of Fenitrothion is banned in Agriculture except for locust control in scheduled desert area and public health.
8.	Fenthion	The use of Fenthion is banned in Agriculture except for locust control, household and public health.
9.	Methoxy Ethyl Mercuric Chloride (MEMC)	The use of MEMC is banned completely except for seed treatment of potato and sugarcane.
10.	Methyl Bromide	Methyl Bromide may be used only by Govt./Govt. undertakings/Govt. Organizations / Pest control operators under the strict supervision of Govt. Experts or Experts whose expertise is approved by the Plant Protection Advisor to Govt. of India.
11.	Methyl Parathion	Methyl Parathion 50 % EC and 2% DP formulations are banned for use on fruits and vegetables.
12.	Monocrotophos	Monocrotophos is banned for use on vegetables.
13.	Sodium Cyanide	The use of Sodium Cyanide shall be restricted for Fumigation of Cotton bales under expert supervision approved by the Plant Protection Advisor to Govt. of India. (S.O.569(E) dated 25thJuly, 1989)

Source: www.cibrc.nic.in

Annexure –VIII

Basic Precautions in Pesticide Usage

A. Purchase

1. Purchase only JUST required quantity e.g. 100, 250, 500 or 1000 g/ml for single application in specified area.
2. Do not purchase leaking containers, loose, unsealed or torn bags.
3. Do not purchase pesticides without proper/approved LABELS.

B. Storage

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

C. Handling

1. Never carry/transport pesticides along with food materials.
2. Avoid carrying bulk - pesticides (dusts / 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 polyethylene bags as hand gloves, handkerchiefs or piece of clean cloth as mask and a cap or towel to cover the head (Do not use polyethylene bag contaminated with pesticides).
5. Read the label on the container before preparing spray solution.
6. Prepare spray solution as per requirement.
7. Do not mix granules with water.
8. Concentrated pesticides must not fall on hands etc. while opening sealed containers. Do not smell the sprayer tank.
9. Avoid spilling of pesticide solution while filling the sprayer tank.
10. Do not eat, drink, smoke or chew while preparing solution.
11. The operator should protect his bare feet and hands with polyethylene bags.

E. Equipments

1. Select right kind of equipment.
2. Do not use leaky, defective equipment.
3. Select right kind of nozzle.

4. Don't blow/clean clogged- nozzle with mouth. Use old tooth- brushes 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.
3. Do not apply just before the rains and also after the rains.
4. Do not apply against the wind direction.
5. Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer.
6. Wash the sprayer and bucket etc with soap water after spraying.
7. Containers, buckets etc. used for mixing pesticides should not be used for domestic purposes.
8. Avoid entry of animals and workers in the fields immediately after the spraying.

G. Disposal

1. Left over spray solution should not be drained in ponds or water lines etc. Throw it in barren isolated area, if possible.
2. The used/empty containers should be crushed with a stone / stick and burned deep into soil away from water source.
3. Never re-use empty pesticide container for any purpose.

Safe use of Pesticides
कीटनाशकों का सुरक्षित इस्तेमाल


कीटनाशकों को पदार्थों के साथ यहाँ–वहाँ न ले जाएं


ताला चाबी लगा कर रखें


बच्चों की पहुच से दूर रखें


मूल पैकिंग वाले कीटनाशक ही खरीदे


इस्तेमाल से पहले लेबल और पुस्तिका पढे


सुरक्षात्मक कपड़े पहने।


सुझाई गई मात्रा को सही–सही प्रमाण में इस्तेमाल करे।


लकड़ी या पैडल से पानी को अच्छी तरह मिलाए


कुप्पी का इस्तेमाल करते हुए बिना गिराए भरे।


खाद्य पदार्थों या पानी के संग्रह के लिए कीटनाशक के डिब्बें का इस्तेमाल न करे।


हवा की दिशा में ही छिड़काव करें


नौजल को साफ करने के लिए मुंह से हवा भीतर न डालें


छिड़काव करते समय कुछ खाए–पीएं नहीं तथा न ही धुम्रपान करें


रिसाव वाले स्प्रेयर व डस्टर का प्रयोग न करें


यदि गलती से कपड़े व शरीर पर लग जाए तो दूषित कपड़े व शरीर के हिस्से को अच्छी तरह धो डालें


बच्चों को छिड़काव न करने दें


इस्तेमाल किए जाने वाले स्थान पर खाद्य वस्तु न रखें


खाने–पीने या धुम्रपान करने के पहले हाथ व मुंह को धो लें।


विषैला असर दिखाई देने पर प्राथमिक उपचार व डॉक्टर को बुलाए।


डॉक्टर को डिब्बा व पुस्तिका बताएं


तुरंत विशेष चिकित्सा प्राप्त करें


खाली डिब्बें को तोड़–फोड़ कर नष्ट कर दें तथा गाड़ दे


इस्तेमाल के बाद स्नान करे व कपड़े धो लें


वातावरण को दूषित न होने दें


उपचार किए गए खेतों में चेतावनी सूचना लगा दें

कीटनाशकों की विषाक्तता की श्रेणियों के पहचान-चिह्न

अत्यंत विषैला

अत्यधिक विषैला

सामान्य रूप से विषैला

थोड़ा से विषैला

भारत सरकार
कृषि मंत्रालय
कृषि एवं सहकारिता विभाग
वनस्पति संरक्षण, संगरोध एवं संग्रह निदेशालय
केंद्रीय एकीकृत नाशीजीव प्रबंधन केंद्र
एन. एच. – 4, फरीदाबाद – 121001 हरियाणा

Classification of pestiside with sympton of poising and treatment

S. No	Name of pesticide	Classification as per Insecticides Rules. 1971	Colour of Toxicity Triangle	WHO classification by hazard	First aid measures	Symptoms of poisoning	Treatment of poisoning
INSECTICIDES ORGANOPHOSPHATE PESTICIDES							
1	Phorate	Extremely toxic	Red	Class Ia- Extremely hazardous	Remove the person from the contaminated environment. In case of (a) Skin contact- Remove all contaminated clothings and immediately wash with lot of water and soap; (b) Eye Contamination – Wash the eyes with plenty of cool and clean water; (c) Inhalation- Carry the person to the open fresh air, loosen the clothings around neck and chest, and (d) Ingestion – if the victim is fully conscious, induce vomiting by tickling back of the throat. Do not administer milk, alcohol and fatty substances. In case the person is unconscious make sure the breathing passage is kept clear without any obstruction. Victim's head should be little lowered and face should be turned to one side in the lying down position. In case of breathing difficulty, give mouth to mouth or mouth to nose breathing. Medical aid: Take the patient to the doctor / primary health centre immediately along with the original container, leaflet and label.	Mild – Anorexia, Head ache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, im-pairment of visual acurity.	For extreme symptoms of O.P.poisoning , injection of atropine (2-4 mg for adult, 0.5-1.0 mg for children) is recommended, repeat at 5-10 minute intervals until signs of atropinisation occurs. Speed is imperative - Atropine injection- 1-4mg, repeat 2mg when toxic symptoms begin to recur (15-16 minute intervals), Excessive salvation - good sign, more atropine needed; Keep airways open, Aspirate, use oxygen, insert endotracheal tube. Do tracheotomy and give artificial respiration as needed.
							-For ingestion of 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-PMA (2-pyridine aldoxime meth iodine), 1 g and 0.25 g for infants intravenously at a slow rate over a period of 5 minutes and administer again periodically as indicated. More than one injection may be required.

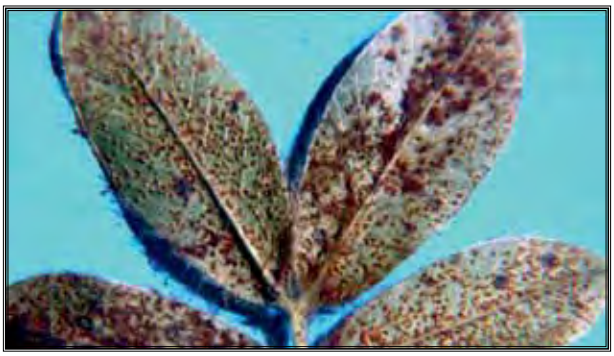
2.	Chloropy-riphos	Highly toxic	Yellow	Class Ib- Moderately hazardous		Moderate-Nausea, salivation, lacrimation, abdominal cramp, vomiting, sweating, slow pulse, muscular tremors, miosis. Severe- Diarrhoea, pin-point and non-recep-tive pupils, respiratory difficulties, pulmonary oedema, cyanosis, loss of sphincter control, convulsions, coma and heart block.	
3.	Q u i n a l - phos	Highly toxic	Yellow	Class Ib- Highly hazardous			Avoid morphine, theo-phylline, aminophylline, barbiturates or phenothiazines. Do not give atropine to a cyanotic pat-ent. Give artificial respiration first then administer atropine.
CARBAMATES							
	Carbaryl Carbo-furan Carbosul-fan	Highly/ Moderately toxic	Yellow/ Blue	Class Ib/II Highly/ Moderately hazardous		Constriction of pu-pils, salvation, profuse sweating, lassitude, muscle incoordination, nausea, vomiting, diar-rhoea, epigastria pain, tightness in chest.	-Atropine injection 1 to 4 mg, repeat 2 mg when toxic symptoms begin to recue (15-60 minute intervals). Excessive salvation- good sign, more atropine needed. Keep airway open. Atropine, use oxygen, inserts endotracheal tube. Do tracheotomy and give artificial respiration as needed. -For ingestion, lavage stomach with 5% sodium bicarbonate, if not vomiting. For skin contact was with soap and water (eye- wash with isotonic saline), wear rubber gloves while washing contact area. -Oxygen - Morphine, if needed. Avoid theophylline and aminophylline or barbiturates. 2PAM and other oximes are not harmful and in fact contra indicated for routine usage Do not give atropine to a cyanotic patient, give artificial respiration first then administer atropine.

FUNGICIDES							
5.	Difena-conazole	Slightly toxic	Green	Table5-unlikely to present acute hazard in normal use.		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eye and skin etc.	No specific antidote, Treatment is essentially symptomatic.
6.	Propi-conazole	- do -	- do -	- do -			
7.	Hexacon-azole	- do -	- do -	- do -			
HERBICIDES							
8.	Alachlor	Moderately toxic	Blue	Class III- slightly hazardous		Headache, palpitation, nausea,vomiting, flushed face, irritation of nose, throat, eye and skin, etc.	No specific antidote. Treatment is essentially symptomatic
9.	Quizalo-fop- ethyl	Slightly toxic	Green	Class IV			
10.	Oxyflour-fen	Slightly toxic	Green	Class IV	Table5-unlikely to present acute hazard in normal use.		
11.	Im-azethapry	Slightly toxic	Green	Class IV			
RODENTICIDES							
	Bromodi-olone	Extremely toxic	Red	Class I a Extremely hazardous		Bleeding from nose, gums and into conjunctiva, urine, stool and coma Possible polar and petechial rash, late-massive ecchymosis or hematoma of skin, joints, brain haemorrhage	Give vitamin K1 15-25 mg for adults; 5-10 mg for children orally; Transfuse with fresh blood if, bleeding if severe or until anaemia is corrected. Iron (ferrous sulphate) by mouth for correction of secondary anaemia, 0.3 hg t.i.d.

Seed rot

Collar rot

Alpha root



Rust-brown colour pustule

Early leaf spot

Late leaf spot

Stem rot (white mycelia)

Stem rot (brown sclerotia)

Plate I : Important diseases and their field symptoms

Aphids on leaves

Jassid adults

Yellowing and V shaped necrosis caused by Jassid

Larvae of *Spodoptera*

Damage caused by leaf miner

Larvae of red hairy caterpillar

Symptoms due to red haiy caterpillar

Symptoms of thrips damage

Plate II : Key insect pests and their field symptoms

Symptoms caused by root knot nematode

Grub of Coccinellid beetle

Adult Coccinellid beetle feeding on aphids

Spider

Adult parasitoid

Bacteria infected larvae

Fungus infected larvae

Plate III : Natural enemies of groundnut pest

NOTES

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