सत्यमेव जयते

INTEGRATED PEST MANAGEMENT PACKAGE FOR MAIZE

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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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

Maize (*Zea mays* L.) occupies an important place in world agriculture. It is estimated that by the year 2020, demand for maize in developing countries will surpass demand for both wheat and rice. Maize in India ranks fifth in total area and third in total production and productivity. This level of production has to be substantially raised to meet growing demand of maize for human food, animal and poultry feed, as well as industrial processing by the wet and dry millers to produce value added products. Maize can be successfully grown in rainy (*kharif*), winter (*rabi*) and summer spring (*zaid*) crop seasons. Because of its divergent types, it is grown over a wide range of climatic conditions, ranging from near sea-level to several thousand meters above sea-level (2,700 m msl). Maize can be grown in tropical, subtropical and temperate climates, however tropical and sub-tropical occupy a higher percentage of corn production. It can also be grown in all types of soils ranging from sandy to heavy clay. Deep heavy soils are considered more suitable in view of their better water holding capacity. Saline and alkaline soils should be avoided since these adversely affect crop growth and development. The requirement of fertilizers depends upon the status of the soil, previous cropping history and duration of the variety to be grown. However, a balanced application of 60-120 kg N, 40-60 kg P and 40 kg K is recommended for various ecosystems. A population of 65,000-70,000 plants/ha is optimum for realizing high maximum yield.

Among the factors adversely affecting productivity, ubiquitous prevalence of diseases and insect pests in the pre harvest stage are prominent. The total economic loss of the crop in India due to insect pests and diseases has been estimated to be of the order of 13.2%. Since there is practically no possibility of increasing maize area, the productivity can only be raised by providing seed of improved cultivars, better agronomic practices and protection against diseases and pests. Hence, this document aimed to provide comprehensive integrated pest management practices to reduce crop losses caused by diseases and insect pests of maize.

2. Biotic Constraints

2.1 Major Insect Pests of National Significance

1. Maize stem borer (*Chilo partellus* Swinhoe)
2. Pink stem borer (*Sesamia inferens* Walker)
3. Shoot fly (*Atherigona* spp.)

2.2 Major Insect Pests of Regional Significance

1. White grub (*Holotrichia consanguinea* Blanch.)
2. Cut Worm (*Agrotis ipsilon* Hufnagal)
3. Hairy caterpillar (*Amsacta albistriga* Walker)
4. Aphid (*Rhopalosiphum maidis* Fitch.)
5. Army worm (*Mythimna separata* Walker)
6. Pyrilla *(Pyrilla perpusilla* Walker)
7. Thrips (*Anaphothrips sudanensis* Trybom)
8. Termites *(Microtermes obesi* Holmgren)
9. Chafer beetle (*Chiloloba acuta* Wiedmann)

2.3 Major Diseases of National Significance

1. Turcicum leaf blight (TLB): *Exserohilum turcicum* (Pass) leon. & Sugs.
2. Maydis leaf blight (MLB): *Drechslera maydis* Niskado Syn. *H. Maydis*
3. Post flowering stalk rots
   i. Fusarium stalk rot: *Fusarium moniliforme* Sheld.
   ii. Charcoal rot: *Macrophomina phaseolina* (Goid) Tassi
4. Banded leaf and sheath blight: *Rhizoctonia solani* f. sp. *sasakii* Exner
5. Common rust: *Puccinia sorghi* Schw.

2.4 Major Diseases of Regional Significance

1. Polysora rust *(Puccinia polysora* Underw) in Karnataka and Coastal areas of A.P.
2. Brown stripe downy mildew (*Sclerophthora rayssiae* var. *zeae* Payak and Renfro) in foothills of H. P. Uttarakhand and Punjab
3. Sorghum downy mildew (*Peronosclerospora sorghi* Weston & Uppal Shaw.) in Karnataka and Tamil Nadu
4. Rajasthan downy mildew (*Peronosclerospora hetropogoni* Siradhana et.al) in Rajasthan
5. Post flowering stalk rot (PFSR) - Late wilt (*Cephalosporium maydis* Samara, Sabeti & Hingorani) in Andhra Pradesh and Rajasthan

2.5 Major Nematodes of National and Regional Significance

1. Cyst nematode **(***Heterodera zeae* Koshy *et al.*,) in Himachal Pradesh, Rajasthan, Gujarat, Andhra Pradesh and Bihar

2.6 Major Weeds of National and Regional Significance

1. *Dactyloctenium aegyptium* (Willd.)
2. *Eleusine indica* (L.) Gaertn**.**
3. *Celosia argentea* L.
4. *Portulaca oleracea* L.
5. *Digera arvensis* Forsk.
6. *Euphorbia* sp.

2.7 Major Vertebrate Pests of National and Regional Significance

1. Rodent
2. Parrot

3. Integrated Pest Management Approach

There are over sixty seven (67) 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 as compatible a 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.

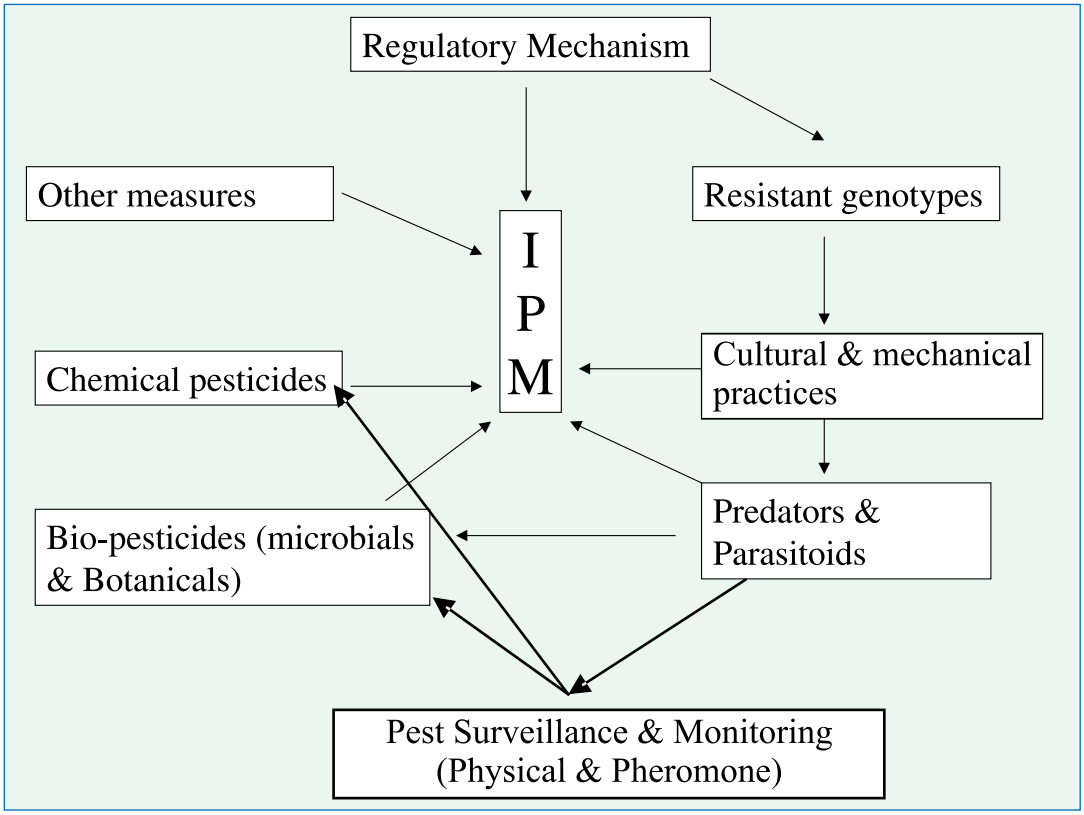


Fig. 1. Diagrammatic sketch of IPM systems.

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.

3.1 Monitoring

For sucking pests

- **For aphids, pyrilla**

  Count and record the number of both nymphs and adults on five randomly selected leaves per plant.

- **For 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).

- **For *Chilo* and *Sesamia***

  Total number of shoots and cobs damaged due to *Chilo* and *Sesamia* and number of larvae on individual plants should be counted and recorded.

Surveillance through pheromone trap catches for *Chilo* and *Sesamia*

Pheromone traps for two insects viz., *Chilo* and *Sesasia* @ 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 *Chilo* and *Sesamia*/trap/week should be recorded year round. The trapped moths should be destroyed and removed after each recording.

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.

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).

Economic Threshold Levels (ETL)

Pests	Economic Threshold Levels (ETL)
Armyworm	One larva per plant
White grub	One grub/m^2 area
Nematodes	One to two nematodes/g soil
Downy mildew	10% incidence
Leaf blight	10% incidence
Stalk rot	10% incidence
Rodent	15 live burrows/ha

3.1.1 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. 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.

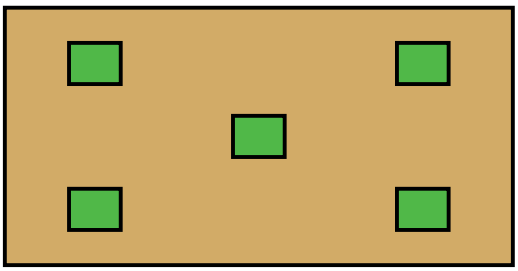
Principles of AESA based Integrated Pest Management (IPM)

Grow a healthy crop

- Select a variety resistant/tolerant to major pests
- Treat the seed with recommended pesticides especially biopesticides
- Select healthy seeds and seedlings
- Follow proper spacing
- Soil health improvement (mulching and green manuring)
- Nutrient management especially organic manures and biofertilizers based on the soil test results i.e. nitrogen supplying microorganisms such as *Azotobacter* and
- phosphorous supplying microorganism such as phosphate solubilizing microorganisms,
- arbuscular mycorrhizal fungi and potash mobilizing microorganisms as well as liquid microbial inoculants should be used. 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

AESA Methodology

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



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)**
  - Length of plant
  - Number of dead seedlings
  - Number of wilted plants
- **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^{-1})
  - Price of produce (₹ /kg)

Important instructions while taking observations

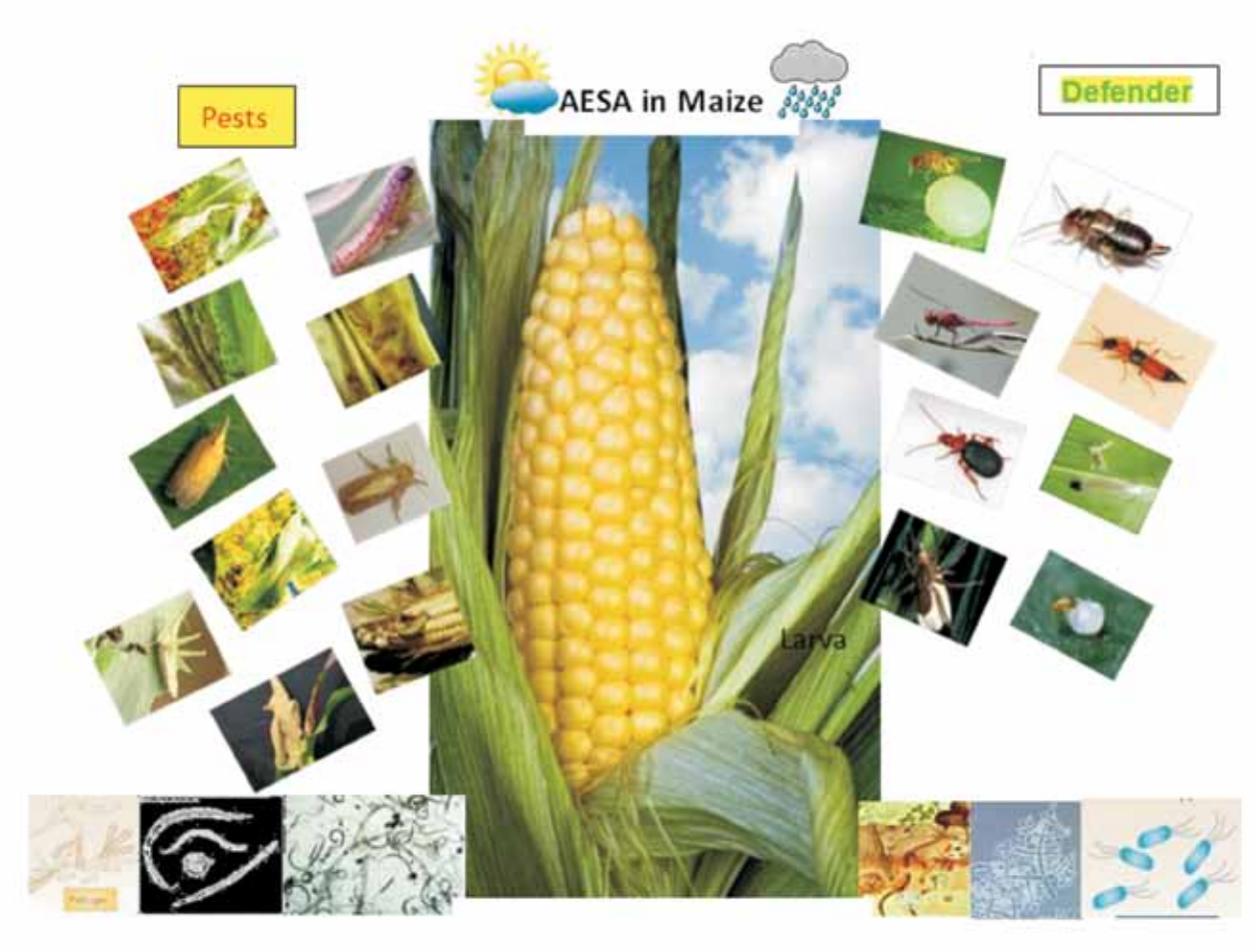
- While walking in the field, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if 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 act ivities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

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 P: D ratios for yellow stem borer are given below. The natural enemies of maize pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens.

Model AESA Chart

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



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 :

3.2. Management practices for insect pests

3.2.1 Cultural Practices

1. Deep summer ploughing followed by fallowing helps in exposing resting stage of pests.
2. Inter-cropping with legume reduces borer incidence. Maize-Soybean/Maize-Cowpea/ Maize-Green gram are some of the good examples.
3. Use of well decomposed farm yard manure (FYM) reduces termite attack.
4. Plant spacing 75 cm x 18 cm in Kharif and 60 cm x 18 cm in Rabi is recommended.
5. Balanced use of fertilizers (NPK 120:60:40) kg/ha and supplement of micronutrient.
6. Proper water management practices to avoid foot rot.

3.2.2 Genetic Management

Use certified seeds of recommended verities having built-in mechanisms for resistance of local pest problems as given below:

Insect resistant / tolerant varieties

Insect	Resistant/tolerant varieties
Maize Stem Borer (*Chilo partellus* Swinhoe/ *Sesamia inferens* Walker)	HQPM 1, DHM 117, HM4, HM5, Vivek hybrid 5, HMM 1, PEHM 1, Pusa Composite 3, Pusa Composite 4, Amar, Azad Kamal

3.2.3 Mechanical Practices

1. Removal of dead hearts will help to reduce second generation infestation.
2. Use of bird scarer prevents seed damage.
3. Manual collection and destruction of white grub and chaffer beetle during adult emergence period reduces the pest population.

3.2.4 Biopesticides

1. Soil application of neem cake for control of nematode and chaffer beetle

3.2.5 Biological control

1. Conservation of naturally occurring biocontrol agents such as *Trichogramma chilonis* Ishii., *Cotesia flavipes* Cameron, Carabids, Coccinellids, *Chrysoperla*, spiders and wasps, etc. and by reducing chemical pesticides.
2. Release of *Trichogramma chilonis* @ 1,60,000 /ha. on 7 and 15 days old crop and subsequently if required.

Description of parasitoids and predators in maize ecosystem

S.No	Natural enemy	Pest	Stage attacked
A. Parasitoids			
1	*Trichogramma chilonis*	*Chilo partellus, Plutella xylostella,*	egg
2	*T. dendrolimi*	tissue borer	egg
3	*T. evanescens*	tissue borer	egg
4	*T. mwanzai*	*Helicoverpa armigera*	egg
5	*Trichogrammatoidea armigera*	*Helicoverpa armigera*	egg
6	*Cotesia flavipes*	Stem borer	larva
7	*Bracon chinensis*	Stem borer	larva
8	*Xanthopimpla punctata*	Stem borer	Pupa
9	*Tetrastichus ayyari*	Stem borer	Pupa
B. Predators			
10	*Cryptolaemus montrouzieri*	Mealy bugs	Adult
11	*Brumoides suturalis*	Aphids and whiteflies	Adult
12	*Coccinella septempunctata*	Aphids	Adult
13	*Adonia variegate*	Aphids	Adult
14	*Cheilomenes sexmaculata*	Aphids	Adult
15	*Oenopia luteopustulata*	Aphids	Adult
16	*Leis dimidiate*	Aphids	Adult
17	*Coelophora sexareata*	Aphids	Adult
18	*Chllocorus bijugus*	Aphids	Adult
19	*Leis decimaculata*	Aphids	Adult
20	*Blaptostethus pallescens*	Aphids	Adult
21	*Reduviolus* sp.	*Calocoris angustatus*	Nymph, adult
22	*Lygaeid bug*	*Calocoris angustatus*	Nymph, adult
23	*Geocoris tricolor*	*Calocoris angustatus*	Nymph, adult
24	*Eocanthecona furcellata*	leaf worm, spotted bollworm American bollworm	Larva
25	*Harpactor costalis*	Red cotton bug	Nymph, adult

Egg parasitoid

Trichogramma chilonis

T. chilonis parasitizes eggs of the Lepidopteran pests such as stem borer. Adults have small body with short antennae and red eyes. Wings with hairs along the margin, 3-segmented tarsi. Each female may lay 40 eggs.

Larval and pupal parasitoids

Cotesia flavipes

C. flavipes parasitizes the larval stage of Lepidopteran pests such as stem borer. Black small wasps but stout with clear wings and short antennae. Base of the hind leg is brown yellow to red. Female lays 1-20 eggs in each host larva. Immature parasites feed inside the host. Parasite larvae emerge from sides of the dead host and develop white overlapping cocoons near or below the host.

Sturmiopsis parasitica

Host: *Sturmiopsis parasitica* is a larval and pupal parasitoid. It parasitizes maize stem borers and other Lepidopterans such as *Eldana saccharina*, *Busseola fusca*, *Sesamia* sp., and *Chilo partellus*. The highest rates of parasitism are 15% of *B. fusca* and *C. partellus*, respectively.

Larval period is 12–14 days, prepupal period is 12 h, and the pupal period is 12–19 days. Females produce 500–900 maggots after a gestation period of 18–19 days.

Campoletis chlorideae

Campoletis chlorideae is an important early larval endoparasitoid of many noctuid species, and has been widely reported as a potential biological control agent for *H. armigera*. It completes 8–10 generations per year. *Campoletis chlorideae* oviposits in early instars of *H. armigera*, but prefers second and third instars. On an average *C. chlorideae* parasitizes 23.7% early instar larvae of *H. armigera*.

Pediobius furvus

The life-cycle is completed in 18–20 days at 30°C, and up to several hundred adults may emerge from a single host pupa, the most suitable pupae being 2–3 days old at the time of oviposition. Longevity is improved when sucrose is provided as food. Host pupae outside the stem are parasitized. Pupae formed inside cocoons are not attacked.

Predators

Coccinellids (*Cryptolaemus montrouzieri*)

Cryptolaemus montrouzieri is a small (about 3-4 mm long), dark brown lady beetle with a tan to orange head and posterior. The larvae grow up to 1.3 cm in length and have woolly appendages of wax (their true legs are barely visible underneath) which makes them resemble mealy bugs, although they are about twice as large as the adult female citrus mealybug. *C. montrouzieri* eggs are yellow. *C. montrouzieri* adult eating mealybugs.

Eocanthecona furcellata

Host: preying on larvae of Lepidoptera; the female lays eggs ranging from 70 to 100; the total life cycle is 25 days. The total predatory period from the second nymphal instar to death of adult is 45.23 days. Adult predatory capacity is higher than the nymphal stages. The adults and the nymphs (except the first instar nymphs) are predaceous, sucking the body fluids of the larval prey.

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 lacewing	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
Predatory mite	Predatory rate of adult is 20-35 phytophagous mites/female/day
Bracon hebetor	Egg laying capacity is 100-200 eggs/female. 1-8 eggs/larva.
Trichogramma sp	Egg laying capacity is 20-200 eggs/female

Some of Good Insectory Plants

Cosmos

Sunflower

Okra

Hibiscus

Marigold

Fennel

Carrot

Coriander

Chrysanthemum

Mustard

Radish

Fagopyrum sp.

Ageratum sp.

Tridax

Alfalfa

Good insectary plants belonging to Compositae, Malvaceae, Umbelliferae, Brassicae and Asteraceae etc families.

Flowering plants that attract natural enemies/repel pests

Insect	Natural enemies	Flowering plants that attract natural enemies/ repel pests
Maize stem borer	**Parasitoids:** *Trichogramma chilonis* (egg), *Cotesia flavipes* (larval) **Predators:** *Chrysoperla carnea*, coccinellids, king crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, preying mantids, fire ants, big eyed bugs (*Geocoris* sp), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc. *Ovomermis albicans*, a nematode	• Attractant plants: Carrot family, sunflower family, buck wheat, alfalfa, corn, shrubs, okra, *Hibiscus* (Malvaceae family) (minute pirate bug and lacewing) • Nectar rich plants with small flowers i.e. anise, caraway, dill, parsely, mustard sunflower, buck wheat and cowpea (wasp)

Insect	Natural enemies	Flowering plants that attract natural enemies/ repel pests
Shootfly	**Parasitoids:** *Trichogramma chilonis* (egg), *Trichogrammatoidea simmondsi* (egg), *Neotrichoporoides nyemitawus* (larva) **Predators:** *Chrysoperla carnea*, coccinellids, king crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, preying mantids, fire ants, big eyed bugs (*Geocoris* sp), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc.	• 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, parsely, mustard, sunflower, buck wheat and cowpea (wasp)
White grub	**Parasitoids:** *Tiphia rufo- femorata* (grub) etc. **Predators:** Spider, robber fly, preying mantids, fire ants, big eyed bugs (*Geocoris* sp), crock beetle *(Autocrates aenens),* Indian mynah, jungle crow etc.	• 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, parsely, mustard, sunflower, buck wheat and cowpea (wasp)
Pyrilla	**Parasitoids:** *Epiricania melanoleuca* **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 (*Aphidoletes aphidimyza*) and predatory gall midge, (*Feltiella minuta*), earwigs, ground beetles, rove beetles, spiders, wasps etc.	• 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, parsely, mustar, sunflower, buck wheat and cowpea (wasp)
Aphid	**Parasitoids:** *Aphidius colemani* (adults and nymphs), *Diaeretiella* spp. (adults and nymphs), *Aphelinus* spp. (adults and nymphs) 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 (*Aphidoletes aphidimyza*) and predatory gall midge, (*Feltiella minuta*), earwigs, ground beetles, rove beetles, spiders, wasps etc.	• Attractant plants Carrot family, sunflower family, marigold, buckwheat, spearmint (syrphid fly, lacewing, minute pirate bug, damsel bug and lady bird beetle) • Cosmos (praying mantis). • 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, parsely, mustard (aphid parasitoid and braconid wasp). • Sunflower, buckwheat and cowpea (braconid wasp)
Thrips	Predatory mite (*Amblyseius swirskii*), predatory thrips (*Aeolothirps* spp.), insidious flower bugs (*Orius insidiosus*) etc.	• Attractant plant: French bean (predatory thrips)

3.2.6 Chemical control

Need based and judicious application of pesticides is an important components of IPM.

1. Granular application of Carbofuran 3% CG @33.3kg/ha in whorls of infested plants to control stem borer, shoot fly and thrips
2. Spray of Carbaryl 85% WP @ 1764 g/l against borer at 15-18 days after germination
3. Spray Monocrotophos 36% SL @ 625 ml/ha or Dimethoate 30% EC @ 1155 ml/ha or Oxydemeton – methyl 25% EC @ 1000 ml/ha or Phorate 10% CG @ 30 Kg/ha for the management of shoot fly

3.3 Management Practices for diseases

3.3.1 Cultural Practices

1. Select field with good drainage
2. Sanitation and removal of previous crop debris/wheat straw
3. Deep ploughing 2 to 3 times at 10 to 15 days interval to destroy crop debris & weeds
4. Proper seed bed preparation, planting seed in warm, fairly moist soil (above 12.8°C)
5. Use certified seeds and eliminate light weight, chaffy, injured seeds
6. Adoption of crop rotation
7. Use balanced soil fertility, avoid high level of N and low level of K
8. Avoidance of moisture stress at the time of flowering to grain filling stage

3.3.2 Genetic Management

1. Use certified seeds of recommended varieties having built-in mechanisms for resistance of local pest problems

Disease resistant / tolerant varieties

Disease	Resistant/tolerant varieties
Turcicum Leaf Blight *(Exserohilum turcicum (Pass) Leon. & Sugs.)*	PEMH-5, VIVEK 21, VIVEK 23, VIVEK 25, PRATAP KANCHAN 2, NITHYASHREE for Karnataka & Andhra regions
Maydis Leaf Blight *(Drechslera maydis (Niskado & Miyake)* Syn. *H. Maydis)*	HM 10, PAU 352, MALVIYA HYBRID MAKKA 2, PEMH 1, HQPM 7, HQPM 5, HQPM1, SHAKTIMAN 3, SHAKTIMAN 4, PEMH 5, HQPM4 and HSC 1
Common rust (*Puccinia sorghi* Schw.)	BULAND, SHEETAL, HHM 1, HHM 2, HQPM 1 and NITHYASHREE
Polysora Rust (*Puccinia polysora* Underw.)	NITYASHREE for A.P. and Karnataka
Brown Stripe Downy Mildew (*Sclerophthora rayssiae* var. *zeae* Payak and Renfro.)	PAU 352, PRATAP MAKKA 3, GUJARAT MAKKA 4, SHALIMAR KG 1, SHALIMAR KG 2, PEMH 5, BIO 9636, NECH – X 1280
Sorghum Downy Mildew (*Peronosclerospora sorghi* (Weston & Uppal) Shaw)	DMH 1, NAC 6002, COH (M) 4, COH (M) 5, NITYASHREE

Disease	Resistant/tolerant varieties
Brown Spot (*Physoderma maydis* Miyake)	JH 10655, FH 3113
Banded Leaf and Sheath Blight (*Rhizoctonia solani* f. sp. *sasakii* Exner)	PRATAP KANCHAN 2, PRATAP MAKKA 3, PRATAP MAKKA 5, SHAKTIMAN 1 and SHAKTIMAN 3
Pre-flowering Stalk Rots or Pythium Stalk Rot (*Pythium aphanidermatum* (Eds) Fitz)	PEMH 1, X 1280 and HQPM 4
Bacterial Stalk Rot (*Erwinia chrysanthemi* p.v. *zeae* (Sabet) Victoria, Arboleda & Munoz.)	PAU 352, PEMH 5, DKI 9202, DKI 9304
Post – flowering Stalk Rot (*Fusarium moniliforme* Sheld.)	PEMH 1, PEMH 2, PRATAP KANCHAN 2,PRATAP MAKKA 3, PRATAP MAKKA 5, SHEETAL, JH 6805, X 1280
Charcoal Rot (*Macrophomina phaseolina* (Goid) Tassi)	JHMH 1701, JH 6805 and BIO 9639
Cyst nematode (*Heterodera zeae* Koshy *et al.*,)	AGET-71

3.3.3 Mechanical Practices

1. Stripping of 2 lower leaves along with leaf sheath
2. Rogue and destroy infected plants & alternate host
3. Use bird scarer to prevent seed damage

3.3.4 Biological control

1. Add *Trichoderma harzianum* formulation 2.0% WP in furrows at the time of sowing prior mixing with FYM @ 10 g/kg FYM & incubated for 10 days in moist condition for Charcoal rot (Post flowering stalk rot)
2. Seed treatment with *Trichoderma harzianum* 2.0% WP @ 20 g/kg of seeds for control of *Rhizoctonia solani* f. sp. *sasakii* (Banded leaf & sheath blight)
3. Combined application of mustard & tobacco dust @ 2.5q/ha (ETL – 2 cyst/g of soil) for cyst nematode
4. Application of *Trichogramma chilonis* @ 1,60,000/ha. on 7 and 15 days old crop onwards at weekly interval for various pathogens.

3.3.5 Chemical control

Need based and judicious application of fungicides are most important component of integrated pest management.

1. Seed treatment with Thiram 75% WS @ 25 to 30 g/kg seed.
2. Seed treatment with fungicide Metalaxyl-M 31.8% ES @ 2.4 ml/kg of seed in the endemic areas of downy mildews.
3. Foliar Spray at first appearance of leaf blight with Mancozeb 75% WP @ 1.5 to 2 kg/l of water followed by 2 to 4 applications at 10 days interval if needed.

4. Spray of Mancozeb 75% WP @ 1.5 to 2 kg/l of water or Zineb 75% WP @ 1.5-2 kg/ha at first appearance of pustule of Polysora rust or Common rust and three sprays of fungicide at 15 days interval are recommended if needed.
5. Foliar spray of Mancozeb 75% WP @ 1.5 to 2 kg/l at very first appearance of symptoms of downy mildews
6. Soil drenching of bleaching powder containing 33% chlorine @ 10 kg/ha as at pre- flowering stage if symptoms of bacterial rot appears (Pre flowering)

4. Weed Management Practices

1. Summer ploughing for destroying stubles and perennial weeds.
2. Timely sowing of crop to minimise crop weed competition.
3. Proper spacing to facilitate interweeding operation.
4. Two manual weeding 2-3 & 6 weeks after sowing.
5. Pre-emergence application of Atrazine 50% WP @ 1-2 kg/ha or Alachlor 50% EC @ 5 l/ha or 2,4-D Ethyl Ester 38 % EC @ 2.65 l/ha or Paraquat dichloride 24% SL @ 0.8-2 l/ha or Diuron 80% WP @ 1 kg/ha followed by one manual weeding for controlling grassy and broad leaved weeds.

5. Rodent Management Practices

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

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

Damage

- At vegetative stage, plant stem (cane) may damaged by rodents due to its sweet juice or mucilage secretions and smooth structures
- Rodent problem appears generally at milky stage and seed maturity stage
- Mice and rats may make nest or reside on plant with help of corn silk (horborage)

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 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. Practice pre-baiting in case of ZNP poison baiting. Don't apply ZNP poisons more than one time in a crop season as rodents develop bait shyness to this poison.

6. Crop Stage wise Integrated Pest Management Practices

Stage	Name of pests	Pests/Pathogens	Practices
Pre sowing	Resting stage of insect, fungi, mycelia, conidia, thick walled sporangia & other resting spores	Many pathogens are involved like species of *Fusarium, Rhizoctonia, Penicillium, Aspergillus, Pythium, Acremonium, Cephalosporium, Helminthosporium,* white grub etc.	1. Adoption of crop rotation 2. Clean plow down of crop debris 3. Destruction of crop residue 4. Selection of tolerant varieties 5. Collection and destruction of white grub stages 6. Deep summer ploughing followed by fallowing
Seed & Seedling	Seed & Seedling blight	A variety of pathogens are associated like - *Pythium, Fusarium, Acremonium, Penicillum, Rhizoctonia, Macrophomina, Sclerotium* etc.	1. Eliminate light weight, chaffy, injured seeds 2. Use certified seeds 3. Proper seed bed preparation, planting seed in warm, fairly moist soil (above 12.8°C) 4. Treat seed with Thiram 75% WS @ 25-30 g/kg seed
Vegetative & foliar pest and diseases	Stem borers, Aphids, Thrips, Termites, Turcicum leaf blight (TLB), Maydis leaf blight (MLB), Common rust, Polysora rust, Brown spot, Curvularia leaf spot, etc.	A variety of pathogens are a ssociated like – *Helminthosporium, Puccinia, Curvularia & Physoderma* etc.	1. Removal and destruction of dead hearts 2. Release of *Trichogramma chilonis* @ 1,60,000/ha. on 7 and 15 days old crop onwards at weekly interval 3. Granular application of Carbofuran 3% CG on infested plant only for borer, Shoot fly and Thrips on 10-15 days after germination 4.. Spray Carbaryl 85 % WP @ 1764 g/l against borer at 15-18 days after germination 5. Ter followed by 2 to 4 applications at 10 days interval if needed 6. Resistant varieties/hybrids (PEMH–5, Vivek 21, Vivek 23, Vivek 25, Nithyashree) for Karnataka & Andhra regions
	Banded leaf & sheath blight	*Rhizoctonia solani* f. sp. *sasakii* Exner	1. Stripping of 2 lower leaves along with leaf sheath 2. Seed treatment with *Trichoderma harzianum* 2.0% WP @ 20 g/kg of seeds
	Common rust, Polysora rust	*Puccinia* sp.	1. Spray of Mancozeb 75% WP @ 1.5 to 2 kg/l of water at first appearance of pustule 2. Three sprays of fungicide at 15 days interval are recommended if needed

Stage	Name of pests	Pests/Pathogens	Practices
Downy mildews			
	Brown stripe downy mildew	*Sclerophthora rayssiae* var. *zeae* Payak and Renfro	1. Planting before rainy season begins. 2. Resistant varieties PEMH 5, Bio 9636, NECH- X 1280 etc. 3. Seed treatment with fungicide Metalaxyl 35% WS @ 0.75 to 1.0/100 kg of seed in the endemic areas
	Sorghum downy mildew	*Peronosclerospora sorghi* Weston & Uppal Shaw.	1. Avoid maize-sorghum crop rotation in field and sowing of maize adjacent to a field of sorghum to avoid the spread of secondary infection 2. Resistant varieties – DMH 1, NAC 6002, COH (M) 4, COH (M) 5, Nithyashree 3. Seed treatment with fungicide Metalaxyl 35% WS @ 0.75 to 1.0/100 kg of seed in the endemic areas
	Rajasthan downy mildew	*Peronosclerospora hetropogoni* Siradhana *et.al*	1. Rogue and destroy infected plants & alternate host (*Hetropogon* grass) 2. Resistant varieties PEMH 5, Bio 9636, NECH- X 1280, etc. 3. Seed treatment with fungicide Metalaxyl 35% WS @ 0.75 to 1.0/100 kg of seed in the endemic areas
Stalk Rots			
Pre stalk rots	*Pythium* stalk rot	*Pythium aphanidermatum* (Eds) Fitz.	1. Plant population should not to exceed 50,000 ha^{-1} 2. Good field drainage 3. Removal of previous crop debris/wheat straw 4. Seed treatment with fungicide Metalaxyl-M 31.8% ES @ 2.4 ml/kg of seed
	Bacterial stalk rot	*Erwinia chrysanthemi* p.v. *zeae* (Sabet) Victoria, Arboleda & Munoz.	1. Avoidance of water logging 2. Field should have proper drainage 3. Planting of the crop on ridges rather than flat soil 4. Avoid use of sewage water for irrigation 5. Soil drenching of bleaching powder containing 33% chlorine @ 10 kg/ha as at pre-flowering stage
Post flowering stalk rot	Fusaium stalk rot	*Fusarium moniliforme* Sheld.	1. Sanitation and removal of previous crop debris 2. Lower plant population 3. Balanced soil fertility, avoid high level of N and low level of K 4. Use crop rotation with non host crop like soybean

Stage	Name of pests	Pests/Pathogens	Practices
	Charcoal rot	*Macrophomina phaseolina* (Goid) Tassi.	1. Sanitation and removal of previous crop debris 2. Deep ploughing 3. Avoiding water stress at flowering time reduces disease incidence 4. Balanced soil fertility, avoid high level of N and low level of K 5. Add *Trichoderma harzianum* formulation 2.0% WP in furrows at the time of sowing prior mixing with FYM @ 10 g/kg FYM & incubated for10 days in moist condition for Charcoal rot
	Late wilt	*Cephalosporium maydis* Samara, Sabeti & Hingorani	1. Avoidance of moisture stress and balanced potash application reduce the incidence of the disease 2. Seed from infected areas should not be planted 3. Rotation with other crops
Cyst nematode		*Heterodera zeae* Koshy *et al.*	1. Deep summer ploughing 2-3 times at the interval of 10 to 15 days between April and May and summer fallowing with destruction of weeds 2. Use of non-cereal crops like vegetables, oilseeds and pulses etc., (When there are 3 cysts/g of soil) 3. Use of moderately resistant varieties like Ageti-71 4. Organic amendments like combined application of mustard cake and tobacco dust @ 2.5 q ha^{-1} 5. Soil application of Carbofuran 3% CG @ 2.0 kg a.i ha^{-1} (4 cysts/g of soil) 6. Apply Neem cake @ 50 kg/ha.

Annexure-I

List of recommended pesticides for maize

Herbicides	Alachlor 50% EC Alachlor 10% GR Atrazine 50% WP 2,4-D Dimethyl Amine salt 58% SL 2,4-D Sodium salt (having 2,4-D acid 80 % w/w) 2,4-D Ethyl Ester 38 % EC (having 2,4-D acid 34 % w/w) Diuron 80% WP Paraquat dichloride 24% SL
Insecticides	Carbaryl 4% G.R. Carbaryl 50% WP Carbaryl 85% WP Carbofuran 3% CG Dimethoate 30% EC Endosulfan 35%EC Endosulfan 4%DP Monocrotophos 36% SL Oxydemeton-Methyl 25%EC Phorate 10%CG
Fungicides	Mancozeb 75% WP Metalaxyl 35% WS Metalaxyl-M 31.8% ES Thiram 40 FS Thiram 75% WS Zineb 75% WP
Biopesticides	*Trichoderma harzianum* 2.0% WP

Source: CIBRC, Faridabad, India (As on 15-10-2013)

Annexure-II

Basic information about pesticides

A. 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 talc, 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	• Mixed with water for spray application
	Micro encapsulated	M	• Particles of active ingredients (liquid or dry) surrounded by a plastic coating
Liquid	Emulsifiable concentrate	EC	• Liquid active ingredients, dissolved in petroleum based solvents • Easily absorbed through skin
	Concentrate solution	CLC	• Diluted with a liquid solvent before being applied
		ULV	• Very high percentage of active ingredient • Used before dilution or diluted with small quantities of solvent
		F L	• Finely grounded solid active ingredients suspended in the liquid with inert materials
Fumigants	Pellets liquids		• Solid or liquid that releases/vaporized into toxic gasses

B. 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

C. 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, etc.	Prevent photosynthesis
	Leaf, stem, root, etc.	Interferes with the mitosis process
	Leaf, stem, root, etc.	Affects cell respiration and ATP synthesis
Fungicide	Seed, leaf, stem, etc.	Inhibits liquid synthesis affecting cell wall and membrane
	Root	Inhibits synthesis of essential ribosomal proteins Inhibits mitosis, osmoregulation and mitochondrial respiration

Annexure-III

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-IV

SAFETY PARAMETERS IN PESTICIDES USAGE

Safety parameters interalia 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 may be seen as per Annexure – IX.

(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 symptoms 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 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	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
2. For small sucking leaf borne pests		
Reproductive stage	Insecticides and fungicides	• Lev er 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)

Annexure-V

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

Annexure-VI

Do's and don't's 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 fter ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of erennial 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.	Sow early in the season	Avoid late sowing as this may lead to reduced yields and incidence of white grubs and diseases.
5.	Always treat the seeds with approved chemicals/ bio products for the control of seed borne diseases/ pests.	Do not use seeds without seed treatment with biocides/chemicals.
6.	Sow in rows at optimum depths under proper moisture conditions for better establishment.	Do not sow seeds beyond 5-7 cm depth.
7.	Apply only recommended herbicides at recommended dose, proper time as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
8.	Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition	Crops should not be exposed to moisture deficit stress at their critical growth stages.
9	Use the NPK fertilizers as per the soil test	Avoid imbalanced use of fertilizers.
10	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
11	Conduct AESA weekly in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.	Do not take any management decision without considering AESA and P: D ratio
12	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
13	Release egg parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per field observation	Do not apply chemical pesticides within seven days of release of parasitoids.
14	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, whiteflies, *Spodoptera* etc.	Do not spray pesticides only on the upper surface of leaves.
15	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
16	Follow the recommended procedure of trap crop technology.	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural

Annexure-VII

Operational, calibration and maintenance guidelines in brief

S. No.	Do's	Don'ts
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 commencementof spraying under guidance of trained person.	
3.	Clean and wash the machines and nozzles and store in dry place after use.	
4.	It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides. Do not apply pesticides without protective clothing and wash clothes immediately after spray application.	
5.	Do not apply in hot or windy conditions.	
6.	Operatorshould maintain normal walking speed while undertaking application.	
7.	Do not smoke, chew or eat while undertaking the spraying operation	

S. No.	Do's	Don'ts
8.	Operatorshould take properbath with soap after completing spraying	
9	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

Annexure-VIII

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 (50% a.i.).

Calculations when recommendation is in kg a.i. per ha.

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}.

Formula.

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

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 an emulsifiable concentrate (EC). The concentration can be ex pressed 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:

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

$$= \frac{\text{Recommended rate x area (ha)}}{\text{a.i. (\%) in commercial EC x100}}$$

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:

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

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) Concentratio n desired as a.i. (%) in spray

(3) Concentration of commercial product as a.i. (%)

Formula :

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

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

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

(ii) Emulsifiable concentrates (EC)

Specification required:

(1) Spray volume as L ha^{-1}

(2) Concentration as percentage ot a.i desired.

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

Formula:

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

Example: 2000 L of 2% Methyl parathion spray is to be prepared. How much commercial 50% EC is required?

$$\text{Liters of Methyl parathion} = \frac{2 \times 2000}{50} = 80 \text{ L}$$

Annexure-IX

Symptoms of poisoning and the treatment of poisoning for different pesticides

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 INSECTICIDES							
1.	Quinalphos	Highly toxic	Yellow	Class II Moderately 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) Indigestion – 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	Nausea, vomiting, restlessness, tremor, apprehension, convulsions, coma, respiratory failure and death Mild – anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity. Moderate- nausea, salivation, lacrimation, abdominal cramp, vomiting, sweating, slow pulse, muscular tremors, miosis. Severe – diarrhea, pinpoint and non-reactive pupils, respiratory difficulty, pulmonary edema, cyanosis, loss of sphincter control, convulsions, coma and heart block.	- Gastric lavage with 2-4 L. tap water. Catharsis with 30 gm (10 oz) sodium sulphate in the cup of water - Barbiturates in appropriate dosages repeated as necessary for restlessness or convulsions. - Watch breathing closely, aspirate oxygen and/or artificial respiration, if needed. - Avoid oils, oil laxatives and epinephrine (Adrenalin) – do not give stimulants. - Give calcium gluconate (19% in 10 ml Ampules) intravenously every four hours. For extreme symptoms of O.P poisoning, injection of atropine (2-4 mg, for adults, 0/5-1.0 mg for children) is recommended, repeated at 5-10 minute intervals until signs of atropinization occur. Speed is imperative - Atropine injection – 1 to 4 mg. Repeat 2 mg, when toxic symptoms begin to recur (15-16 minute intervals), Excessive salivation good sign, more atropine ed. - Keep airways open, Aspirate, use oxygen, insert endotracheal tube. Do tracheotomy and give artificial respiration as needed. - For ingestion lavage stomach with 5% sodium bicarbonate if not vomiting. For skin contact, wash with soap and water (eye wash with isotonic saline). Wear rubber gloves while washing contact areas.
2.	Monocrotophos	Extremely toxic	Bright red	Class I b Highly hazardous			
3.	Acephate	Moderately toxic	Blue	Class III Slightly Hazardous			
4.	Chlorpyriphos	Highly toxic	Yellow	Class II Moderately Hazardous			
5.	Ediphenphos	Highly toxic	Yellow	Class I b -Highly hazardous			
6.	Phorate	Extremely toxic	Red	Class Ia- Extremely hazardous			

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
CARBAMATES							
7.	Carbofuran	Extremely toxic	Red	Class I b Highly hazardous		Constriction of pupils, salivation, profuse sweating, lassitude, muscle incoordination, nausea, vomiting, diarrhea, epigastric pain, tightness in chest.	- Atropine injection 1 to 4 mg, Repeat 2 mg when toxic symptoms begin to occur (15-60 minute intervals). Excessive salivation good sign, more atropine needed. - Keep airway open. Aspirate use oxygen, insert endotracheal tube. DO tracheotomy and give artificial respiration as needed. - For ingestion, larvae stomach ith 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. - Oxygen - Morphine, if needed. Avoid theophyllin and aminophyllin or barbituarates. 2-PAM 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.
8.	Carbaryl	Highly toxic	Yellow	Class II Moderately Hazardous			
9.	Cartap	Highly toxic	Yellow	Class II Moderately Hazardous Class II Moderately Hazardous			
FUNGICIDES							
10.	Mancozeb	Slightly toxic	Green	Table 5 – Unlikely to present acute hazard in normal use		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	No specific antidote, Treatment is essentially symptomatic.
11.	Hexaconazole	Slightly toxic	Green	do-			
12.	Propiconazole	Moderately toxic	Blue	Class III Slightly Hazardous			
13	Validamycin	Slightly toxic	Green	Table 5 – Unlikely to present acute hazard in normal use			
14.	Tricyclazole	Highly toxic	Yellow	Class II Moderately Hazardous			
15.	Iprobenphos	Moderately toxic	Blue	Class III Slightly Hazardous			
16.	Thiophanate methyl	Slightly toxic	Green	Table 5 – Unlikely to present acute hazard in normal use			
17.	Carbendazim	do-	do-	do-			
18.	Kasugamycin	do-	do-	do-			

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
HERBICIDES							
19.	Cyhalofop butyl	Slightly toxic	Green	Table 5 – Unlikely to present acute hazard in normal use		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	No specific antidote, Treatment is essentially symptomatic.
20.	Butachlor	Moderately toxic	Blue	-do-			
21.	Pretilachlor	Slightly toxic	Green	Table 5 – Unlikely to present acute hazard in norma l use			
22.	Chlorymuronethyl	Moderately toxic	Blue	-do-			
OTHER							
23.	Fipronil	Highly toxic	Yellow	Class II Moderately Hazardous		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	No specific antidote, Treatment is essentially symptomatic.
24.	Imidacloprid	-do-	do-	-do-			

Annexure-X

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.	Chlorfenvinphos
	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-XI

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. (S.O.569 (E) dated 25thJuly, 1989) 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. (S.O.3006 (E) dated 31st Dec, 2008)
5.	Diazinon	Diazinon is banned for use in agriculture except for household use. (S.O.45 (E) dated 08th Jan, 2008)
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. (S.O.706 (E) dated 03rdMay, 2007)
8.	Fenthion	The use of Fenthion is banned in Agriculture except for locust control, household and public hea lth. (S.O.46 (E) dated 08th Jan, 2008)
9.	Methoxy Ethyl Mercuric Chloride (MEMC)	The use of MEMC is banned completely except for seed treatment of potato and sugarcane.(S.O.681 (E) dated 17thJuly, 2001)
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. [G.S.R.371 (E) dated 20thMay, 1999 and earlier RC decision]
11.	Methyl Parathion	Methyl Parathion 50 % EC and 2% DP formulations are banned for use on fruits and vegetables. (S.O.680 (E) dated 17thJuly, 2001) The use of Methyl Parathion is permitted only on those crops approved by the Registration Committee where honeybees are not acting as a pollinators. (S.O.658 (E) dated 04th Sep., 1992.)
12.	Monocrotophos	Monocrotophos is banned for use on vegetables. (S.O.1482 (E) dated 10thOct, 2005)
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)

Plate I. Insect Pests of Maize

Maize Stem Borer – *Chilo partellus* swinhoe

Pink stem borer – *Sesamia inferens* Walker

Com Earworm - *Helicoverpa Zea* Boddie

Termite – *Microtermes obesi* Holmgren

Aphid - *Rhopalosiphum maidis* Fitch.

Pyrilla - *Pyrilla perpusilla* Walker

Grasshopper

Source: Dr. P. Kumar, DMR, New Delhi

Plate II. Diseases of Maize

Common rust: *Puccinia sorghi* Schw. The arrow indicates Uredinal pustules on leaf

Maydis Leaf blight (MLB): *Drechslera maydis* Niskado Syn. *H. maydis*

Turcicum leaf blight (TLB) : Exserohilum turcicum (Pass) leon. & Sugs

Polysora Rust: *Puccinia polysora* Underw

Sorghum Downy Mildew*: Peronosclerospora sorghi* Weston & Uppal Shaw.

Rajasthan Downy Mildew: *Peronosclerospora heteropogoni* Siradhana et.al.

Late Wilt: *Cephalosporium maydis* Samara, Sabeti & Hingorani

Fusaium Stalk Rot: *Fusarium moniliforme* Sheld.

Charcoal Rot : *Macrophomina phaseolina* (Goid) Tassi

Source: Major diseases of Maize in India, Second Edition, 2012 (Revised), DMR, New Delhi.

Plate III. Cyst Nematode of Maize

Cyst Nematode - *Heterodera Zeae* Koshy. Swarup and Sethi

Source: : Dr Mukesh Sehgal, NCIPM, New Delhi

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