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11. Integrated Pest Management in Cereal Crops

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Abstract:

Pests pose a significant threat to cereal crops, leading to substantial losses in yield and quality. Insect pests, diseases, and weeds can severely impact cereal crops, reducing their productivity and overall agricultural output. The economic impact of pest damage in cereal crops is significant, as it results in reduced agricultural productivity, increased production costs, and decreased profitability for farmers. Additionally, Pest-related losses in cereal crops can have detrimental effects on food security, impacting local and global food supplies. To mitigate these losses, integrated pest management (IPM) strategies are employed, which include cultural practices, biological control agents, pest-resistant crop varieties and judicious use of pesticides. Regular monitoring, timely pest detection, and appropriate management interventions are crucial to minimize losses and maintain the productivity and sustainability of cereal crop production. The damage symptoms of major insect pests and their management strategies are discussed in this chapter.

Key words:

Insect pests, Cereal crops, Integrated pest management

11.1 Introduction:

Cereals have an important part in agricultural area, productivity, and nutritional composition across the world. India is a significant contributor to global cereal production, ranking second position in the production of rice, wheat, and other cereal crops. Cereals constitute an important part of the worldwide human diet and India specifically ranks as the second-largest producer of the rice, wheat and other cereals. However, these vital cereal crops face challenges from various insect pests, and other abiotic stresses. The emergence of insect pest problems is often linked to factors such as global warming, abnormal weather patterns and human intervention, such as changes in cropping patterns. Insect pests alone account for approximately 15.70% of crop losses in cereals (Dhaliwal et al., 2015). The introduction of high yielding varieties, the expansion of irrigation systems, and the wide spread use of increased amounts of agrochemicals, such as fertilizers and pesticides, have been implemented to enhance crop productivity. However, these practices have inadvertently led to significant crop losses caused by insect pests in certain crops. The primary elements contributing to this situation include the elimination of natural enemies, the resurgence of pests, developing resistance to insecticides, and the outbreaks of secondary pests.

The disruption of natural ecological balances and reliance on chemical treatments, insect populations have thrived and caused significant harm to created agricultural crops. This chapter mainly focuses on the symptoms of damage of pests and the Integrated Pest Management (IPM) for significant cereal crop pests such as rice, wheat, maize, and other millets.

11.2 Rice:

Rice crop being infested with number of pests and cause significant damage among them the Major insect pests of the paddy crop includes Yellow Stem Borer (*Scirpophaga incertulas Walker*), Brown Plant Hopper (*Nilaparvatha lugens* Stal), White Backed Plant Hopper (*Sogatella furcifera* Horvath), Leaf Folder (*Cnaphalocrocis medinalis* Guenee), Gundhi Bug (*Leptocorisa acuta* Thunberg), Gall Midge (*Orseolia oryzae* Wood-Mason)

A. Yellow Stem Borer (*Scirpophaga Incertulas*):

Yellow stem borer (YSB) is the serious insect pest of the rice crop. The female insect lays eggs in clusters on the leaves of upper surface. After a period 5-10 days, the eggs hatch, and the white larvae bore into the leaf sheath, causing patches of yellowish-white discoloration. As they continue to grow, they move into stem, resulting in "Dead hearts" at vegetative stage and also causes "White ears" during panicle stage.

B. Rice Gall Midge (*Orseolia Oryzae)*:

The rice gall midge is a significant pest that primarily affects rice plants during the tillering stage. It is characterized by the attack of only maggots, which inject a toxin called cecidogen into the growing stems. This toxin causes hollow, tubular galls known as silver shoots or onion leaves. Infestation by maggots results in excessive tillering and stunted growth of the rice plant.

C. Brown Plant Hopper (*Nilaparvatha Lugens)*:

The Brown plant hopper is the most damaging pest mainly in rice the growing regions of India. The infestation of BPH typically increases from the tillering stage to the panicle initiation stage, leading to severe yield losses.

Excessive nitrogen fertilizer usage, narrow planting spacing, judicious pesticide use, extended submergence of fields, and high humidity (>90%) with temperatures ranging from 25 to 32˚C all variables that encourage the development of BPH. Both nymphs and adults of BPH congregate above the water level at the base of the rice plant and feed from sap of the stem and leaf sheath.

Infested plants initially display yellowing leaves, which eventually turn brown as the plants dry up. This gives affected plants a burnt or scorch like appearance known as "hopper burn". The hoppers excrete honeydew, which causes a sooty mold to form at the base of the affected plant. These are the vectors of Grassy stunt and ragged stunt disease.

D. Green Leafhopper (*Nephotettix nigropictus and Nephotettix virescens*):

Green leaf hopper is a sap-sucking insect that infests rice plants from the seedling stage to the panicle initiation stage. The favorable factors for development of the pest population are excess use of nitrogen, insufficient rainfall along with high temperatures and staggered planting. Green leaf hopper infestation leads to gradual yellowing of leaves, starting from tip and progressing downwards. It acts like a vector for Rice Tungro virus, Rice yellow dwarf and transitory yellowing.

E. Gundhi Bug (*Leptocorisa acuta*):

They attack rice crop during the flowering stage and continue up to milky stage. Both the nymphs and the adults use their piercing and sucking mouthparts to collect sap milky grains. As a result, the damaged grains become shriveled and retain a chaffy appearance.

F. Rice Leaf Folder (*Cnaphalocrocis Medinalis*):

The larvae fold the leaves by joining their margins together using silken threads. It resides within the formed tubes or rolls and consumes the chlorophyll present inside the leaves. The larvae's feeding activity resulting in the production of whitish, membranous folded leaves, giving them a scorched appearance. Presence of longitudinal transparent whitish streaks is the major identification symptom.

G. Integrated Pest Management (IPM) for Rice:

- Selection of suitable resistant or moderately resistant varieties.
- Adoption of timely planting.
- Raising of healthy nursery.
- To minimize the overwintering population of insects, it is recommended to eliminate and disposing of rice stubbles during the initial ploughing after harvest.
- Removal of the alternate hosts and weed sps.
- Installation of pheromone traps for monitoring the pests.
- Before transplanting, clipping off the tips of seedlings can reduce the spread of the pests in main field.
- Alternate drying and wetting of crop and draining out of the standing water from field 2-3 times can reduce the BPH population.
- Formation of the alley ways at 2 meters' distance, which promotes adequate crop aeration.
- Late sowing should be avoided to keep the gall midge infestation under control
- Mechanically passing rope over the crop 2-3 times during the tillering stage is an effective method to remove the larvae of the leaf folder.
- Using of some of natural enemies like *Trichogramma japonicum* egg parasitiod of yellow stem borer, *Trichogramma chilonis* for leaf folder.
- Seedling root dip method for the control of the yellow stem borer, dip the roots of the seedling in the chlorpyriphos solution (0.02%) for 12-14 hrs.

- Spraying of acephate 75 SP @ 1.5 g or cartap hydrochloride 50 SP @ 2 g or chlorantraniliprole 18.5 SC @ 0.3 ml of water or apply carbofuran 3G @ 10 kg or cartap hydrochloride 4G @ 8 kg or chlorantraniliprole 0.4% G @ 4 kg/acre to control the attack of yellow stem borer.
- For the management of the BPH chemically apply acephate 75 SP @ 1.5 g or buprofezin 25 SC @ 1.6 ml or imidacloprid + ethiprole 80WDG @ 0.25 g or dinotefuran 20 SG @0.4 g or tryflumezopyrim 10SC @ 0.485 ml or pymetrozine 50WG @0.6 g/l of water.

11.3 Wheat:

Wheat is one of the significant cereal crops in the world, playing a crucial role in global food security. Insect pests pose a significant challenge to wheat production worldwide, acting as important biotic factors which limit crop yields. The pests that cause economic damage to this crop include Termites, Wheat aphid, Armyworm, American pod borer, Brown mite, pink stem borer, Shoot fly, Wheat thrips and Ghujia weevil. Among them the damage symptoms of some significant pests are discussed here.

A. Termite (*Odontotermes obesus, Microtermes obesi*):

They cause damage to crops from the early sowing stage to nearly the maturity stage. The infestation of termites is more prevalent in un-irrigated fields. These pests feed on the roots, stems and even the dead tissues of wheat plants. Infested plants eventually dry up entirely and are easily uprooted.

B. Wheat Aphid (*Sitobian avenae, S. miscanthi*):

Both nymphs and adult aphids extract sap from the delicate portions of the plants by sucking. They typically target young leaves and ears, particularly during cold and cloudy weather conditions.

C. Pink Stem Borer (*Sesamia inferens*):

The Pink stem borer inflicts severe damage to crops by breaking the stem. Initially, larvae feed mostly on unfolding leaves, creating rows of oblong holes. The larvae penetrate into central shoot, causing the growing point to wither and resulting in the development of dead core in the young plants. Affected plants also exhibit the development of white ears. Dark circular ring-like cuts can also be observed on the lower most part of internodes of stem because of the feeding activity of the larvae.

D. Ghujia Weevil (*Tanymecus indicus*):

The pest is known to cause significant damage, particularly during the months of October and November. The adults of Ghujia weevil primarily consume tender leaves and shoots of wheat plants. It exhibits a preference for cutting germinating seedlings at ground level, often leading to the need for reshowing of affected areas. The grubs destroy the roots. Severe infestation is seen at the seeding stage.

E. Integrated Pest Management (IPM) for Wheat:

- Implementing summer ploughing is recommended to expose and eliminate the pupae of Ghujia weevil through sunlight exposure
- To protect wheat crop from damage caused by aphids, armyworm, shoot fly, *Helicoverpa*, it is advisable to avoid late sowing.
- Higher levels of nitrogen can attract larger populations of these pests, it is important to use the recommended dosage of nitrogenous fertilizers.
- Targeted spraying of the field borders can help to reduce the attack of aphids and minimize its damage inflicted to crop.
- To prevent damage caused by termites, it is advisable to consistently use well-rotted FYM.
- Mechanically destroy the termitaria.
- Installation of pheromone traps to monitor the presence of pink stem borers.
- Installation of the bird perches in the field@ 10 per acre can help facilitate the visits of predatory birds.
- Grow 4 rows of a barrier crops like sorghum or maize or pearl millet around the field.
- Treatment of seeds with chlorpyriphos @ 3-4 ml/kg of seed, use chlorpyriphos 50 EC @ 10 ml/l as a soil drench at sowing time in termite prone soils.

11.4 Maize:

In India maize holds the position of the third most significant cereal crop, following rice and wheat, both in terms of cultivation area and production. Presence of biotic and abiotic stress that hinder optimal yield potential. The three major insect pests of the maize include spotted stem borer (*Chilo partellus* swinhoe), Pink stem borer (*Sesamia inferens* walker) and Shoot fly (*Atherigona* spp) were previously the main concerns. However, since the report of invasive fall armyworm (*Spodoptera frugiperda* J.E. Smith) has raised concerns about maize production in the country, posing a significant challenge.

A. Spotted Stem Borer (*Chilo partellus*):

The larvae of the stem borer primarily consume the soft surface of the leaves before entering into stem through the whorl, where they consume the pith of the stem. They also feed on folded tender leaves causing characteristic symptoms resembling “shot holes”.

The infested plants exhibit stunted growth and may develop a condition known as “dead heart”. The larvae have the ability to migrate from other plants and enters the stem through lower nodes by creating bore holes.

B. Pink Stem Borer (*Sesamia inferens*):

During their early stages, the immature larvae of the *S.inferens* feeds on epidermal layer of the first three leaf sheaths. As they continue to grow, they drill into the central shoot of the plant, causing the drying up of the growing point. This results in a condition known as “dead heart” in young plants.

The presence of tiny punctures or elongated openings on the leaves indicates the visible signs of damage caused by the larvae. Additionally, exit holes can be observed on the stem, and the tunnels created by the larvae are filled with their excreta.

C. Shoot Fly (*Atherigona* spp):

The larvae of the shoot fly are commonly known as maggots, target seedlings that are 2 days to 3 weeks old. They bore into the shoot of the maize plant while feeding, resulting in the gradual destruction of the growing point. This leads to the withering of the central shoot, which is referred to as "dead heart". The formation of dead heart typically occurs within 2 weeks of germination.

D. Fall Armyworm (*Spodoptera frugiperda*):

The first and second instar larvae of the fall army worm can be found on outermost part of the leaves, where they scrape the epidermis, resulting in elongated papery windows appearing on surface of leaves wholly. As the larvae reach the third instar and beyond, they settle in the whorl of the plant, and their feeding activity creates a series of holes in the unfurling leaves, accompanied by the presence of their faecal matter. As the larvae grow, their feeding rate increased, leading to larger holes and an increased amount of faecal matter. During the sixth instar stage, the larvae cause significant defoliation and leave a substantial amount of faecal matter in the plant whorl. Additionally, the larvae have the potential to attack the tassel and developing ears of the maize plant.

E. Integrated Pest Management (IPM) for Maize:

- Implementing deep summer ploughing and fallowing techniques can be beneficial in exposing the resting stage of pests. This helps in reduction of their population and controlling their damage.
- Inter-cropping maize with legumes, such as soybean, cowpea, or green gram, can help reduce the incidence of borers. These intercropping combinations are effective in managing pest populations.
- using well decomposed farmyard manure (FYM) can help reduce termite attack on maize crops. FYM incorporation enhances soil nutrient content and structure, making it less favourable for termites.
- Destruction of crop and removal of debris after harvesting the crop. Eradication of alternate host plants.
- Installation of pheromone traps for monitoring the incidence of pests in case of Fall Armyworm.
- Physically removing the neonates and egg masses helps in reduction of the pest population and protects from further damage to the maize plants.
- Remove dead hearts manually and destroy.
- Release of *Trichogramma chilonis* @ 1,60,000/ha on 7- and 15-days old crop and subsequently if needed.
- *Trichogramma pretiosum* or *Telenomus remus* (egg parasitoid) and *Completes chlorideae* (larval parasitiod) can be released to control Fall armyworm.

- Application of entomopathogenic fungi such as *Metarhizium anisopliae*, *Nomuraea rileyi*, *Beauveria bassiana* and *Verticillium lecanii*. Additionally use of bacteria like *Bacillus thuringiensis* var.kurstaki formulations are found effective for management of fall armyworm.
- When the damage reaches a level of 5% it is recommended to spray a solution of 5% NSKE (Neem seed kernel extract) or Azadirachtin at a concentration of 1500ppm.This solution should be mixed with 5 ml of water and applied during the seedling to early whorl stage.
- To control 2nd and 3rd instar of fall armyworm larvae, it is advised to spray specific insecticides during the mid-whorl to late whorl stage of the crop when foliar damage reaches around 10% Spinetoram 11.7% SC or Chlorantraniliprole 18.5% SC or Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC.

11.5 Sorghum:

Sorghum also known as jowar in India, cultivated globally, is a valuable source of fodder and fiber. *Sorghum bicolor*, originally from Africa, but now cultivated in various forms is a significant global crop with diverse applications. It is utilized for food consumption as grain and in production of sorghum syrup or "sorghum molasses". It is commonly known as Great millet and faces threats from several pests including stem borer, shoot fly, midge and white grub which can cause damage to crop. It faces threats from several insect pests such as stem borer, shoot fly, midge.

A. Shoot Fly (*Atherigona Soccata*):

Sorghum plants are damaged during the seedling stage which occurs between 5 to 30 days after emergence and they will exhibit characteristic symptom known as dead heart. During this stage, larva migrates towards upper side of leaf and moves within the leaf whorl until it reaches the growing point. At this point the larvae sever the growing point, causing the central leaf to wither and resulting in formation of dead heart. The dead hearts are easy to pull out and emits a foul odour due to rotting.

B. Stem borer (*Chilo partellus*):

The stem borer initiates its attack on the crop when it is around one month old, and continues till the appearance of ear heads. The borer's attack leads to the withering of central shoot, resulting in the manifestation of symptoms known as dead heart. Signs of infestation include the presence of bore holes near the nodes, minute holes on the delicate folded leaves resembling gunshot wounds and internal tunneling with stem.

C. Midge (*Stenodiplosis sorghicola*):

The midge is an insect that sucks the sap of cultivated sorghum and wild species, causing damage by feeding on the evolving grains and pupating with them. Infected plants display symptoms such as shedding of pollen, appearance of white pupal cases emerging from the grains and the grains with hole have chaffy appearance.

D. Integrated Pest Management (IPM) for Sorghum:

- To manage the infestation of stem borers, it is recommended to plant a single row of intercrop (lab lab or Dolichos) alongside four rows of sorghum.
- Perform thorough ploughing to bring the larval and pupal stages that reside in the stubbles to the uppermost layer.
- In the areas heavily infested by the *Atherigonia soccata* infestation, apply carbofuran 3G to the soil at the rate of 8kg per acre within the seed furrows.
- Remove and eliminate dead hearts dead hearts caused by stem borer infestation.
- Utilize pest-resistant or pest-tolerant varieties to combat pest infestations.
- Eradicate alternate hosts.
- For late sown crops affected by shoot fly infestation, use high seed rate of 4-5 kg/acre and subsequently thin out the affected and excess plants four weeks after sowing.
- Introduce biocontrol agents such as *Trichogramma chilonis, Bracon chinensis* and *Apanteles flaviceps* into the crop as a means of controlling the stem borer population.
- Seed treatment by using Imidacloprid at a rate of 7ml per kg of seed in combination with Thiomethoxam at a rate of 3 grams per kg of seed for shoot fly.
- To control the incidence of shoot fly, spray Thiodicarb at a concentration of one gram per litre or Lamdacyhalothrin at a concentration of 2 milliliters per litre at 7 and 14 days after the emergence of the crop.

11.6 Pearl Millet:

Pearl millet is the pre dominant variety of millet cultivated on large scale. It is a sustainable grain renowned for its abundant minerals and vitamins, making it a valuable source of nutrition. Pearl millet crop faces infestations from various pests with cut worms and white grubs being of national significance whereas grasshoppers, termites, stem borers, grey weevils, ear head bugs, ear head worms, blister beetles and chaffer beetles are considered insects of regional importance.

A. Cutworms (*Agrotis ipsilon*):

Cutworms are predominantly active during night time and have a tendency to feed on various agricultural and horticultural crops, especially during the seedling stage. During the initial larval stages, they create small irregular holes on leaves, while more mature larva cut the stalks of plants. Infested plants exhibit symptoms of wilting and, in some cases may die entirely.

The larva has tendency to cut plants beneath soil clods. In instances of high infestation, cutworms can result in significant crop losses, estimated at approximately 75 percent.

B. White Grubs (*Holotrichia consanguinea*):

White grubs are highly damaging insect pests for Pearl millet and they are most active during rainy season. These grubs primarily feed on underground roots of the crop, while beetles consume the foliage part during night time.

Affected plants display symptoms such as yellowing and wilting of leaves, as well as drying of entire crown. It becomes effortless to uproot the plants that have been affected.

C. Integrated Pest Management (IPM) for Pearl Millet:

- Adopting favorable cultural practices such as thorough summer ploughing, use of well decomposed farmyard manure, early sowing and crop rotation is recommended.
- To address the issue of cutworm infestation in the field, it is recommended to implement flood irrigation, conduct summer ploughing and manually remove the larvae during morning and evening hours.
- For managing cutworm infestation, it is advisable to install light traps at a density of 1per hectare and pheromone traps at a density of 12 per hectare to attract male moths. Additionally, applying neem oil at a concentration of 3% or chlorpyriphos 20 EC at a rate of 1 litre per hectare is recommended for spray treatment.
- Prior to sowing it is advised to mix in either 25 kg of Phorate 10G or 33kg of carbofuran 3G per hectare for grub control.
- Apply imidacloprid 17.8 SL at a rate of 2ml or chlorpyriphos 20EC at a rate of 6.5-12 ml per kilogram of seed as a seed treatment for grub control.
- To control white grubs, it is recommended to apply a drenching treatment within the root zone using chlorpyriphos 20 EC at a rate of 4 litres per hectare, three weeks after the emergence of adult grubs.

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