PRACTICAL MANUAL

Pests of crops and stored grains and their management

(APE 322) 3(2+1)

For B.Sc. (Hons.) Agriculture V Semester

Dr. Maimom Soniya Devi
Dr. Usha
Dr. V.K. Mishra

2020

Department of Entomology
College of Agriculture
Rani Lakshmi Bai Central Agricultural University, Jhansi

Syllabus APE 322 3(2+1): Identification of different types of damage. Identification and study of life cycle and seasonal history of various insect pests attacking crops and their produce: (a) Field Crops; (b) Vegetable Crops; (c) Fruit Crops; (d) Plantation, gardens, Narcotics, spices & condiments. Identification of insect pests and Mites associated with stored grain. Determination of insect infestation by different methods. Assessment of losses due to insects. Calculations on the doses of insecticides application technique. Fumigation of grain store / godown. Identification of rodents and rodent control operations in godowns. Identification of birds and bird control operations in godowns. Determination of moisture content of grain. Methods of grain sampling under storage condition. Visit to Indian Storage Management and Research Institute, Hapur and Quality Laboratory, Department of Food., Delhi. Visit to nearest FCI godowns.

Name of Student .....

Roll No. .....

Batch .....

Session .....

Semester .....

Course Name : .....

Course No. : .....

Credit .....

Published: 2020
No. of copies: ……..
Price: Rs.

CERTIFICATE

This is to certify that Shri./Km. .....ID No.....
has completed the practical of course.....course No. ..... as per the syllabus of B.Sc. (Hons.) Agriculture/ Horticulture/ Forestry ..... semester in the year.....in the respective lab/field of College.

Date: Course Teacher

CONTENTS

EXPERIMENT NO. 1

Objective: To study damage done by phytophagous insect

Exercise: Observe and write the damaging symptoms of the given insect specimen.

OBSERVATIONS TO BE RECORDED:

Stem borer: ……...

……...

……...

Eg. ……..

Shoot borer: ……

……

……

.Eg. ……..

Defoliator: ……

……

……

Eg. ……..

Leaf miner: ……

……

……

Eg. ……..

Leaf webber: ……

……

……

Eg. ……..

Leaf folder: ……

……

……

Eg. ……..

Gall maker: ……

……

Eg. ……..

Pod/ capsule borers/ bollworm: ……

……

……

Eg. ……..

Root feeder: ……

……

……

Eg. ……..

Seed feeder (stored grain pests) ……

……

……

Eg. ……..

Sap feeder

a. From grain: ……

……

……

Eg. ……..

b. From tender plant parts: ……

……

……..

Eg. ……..

EXPERIMENT NO. 2

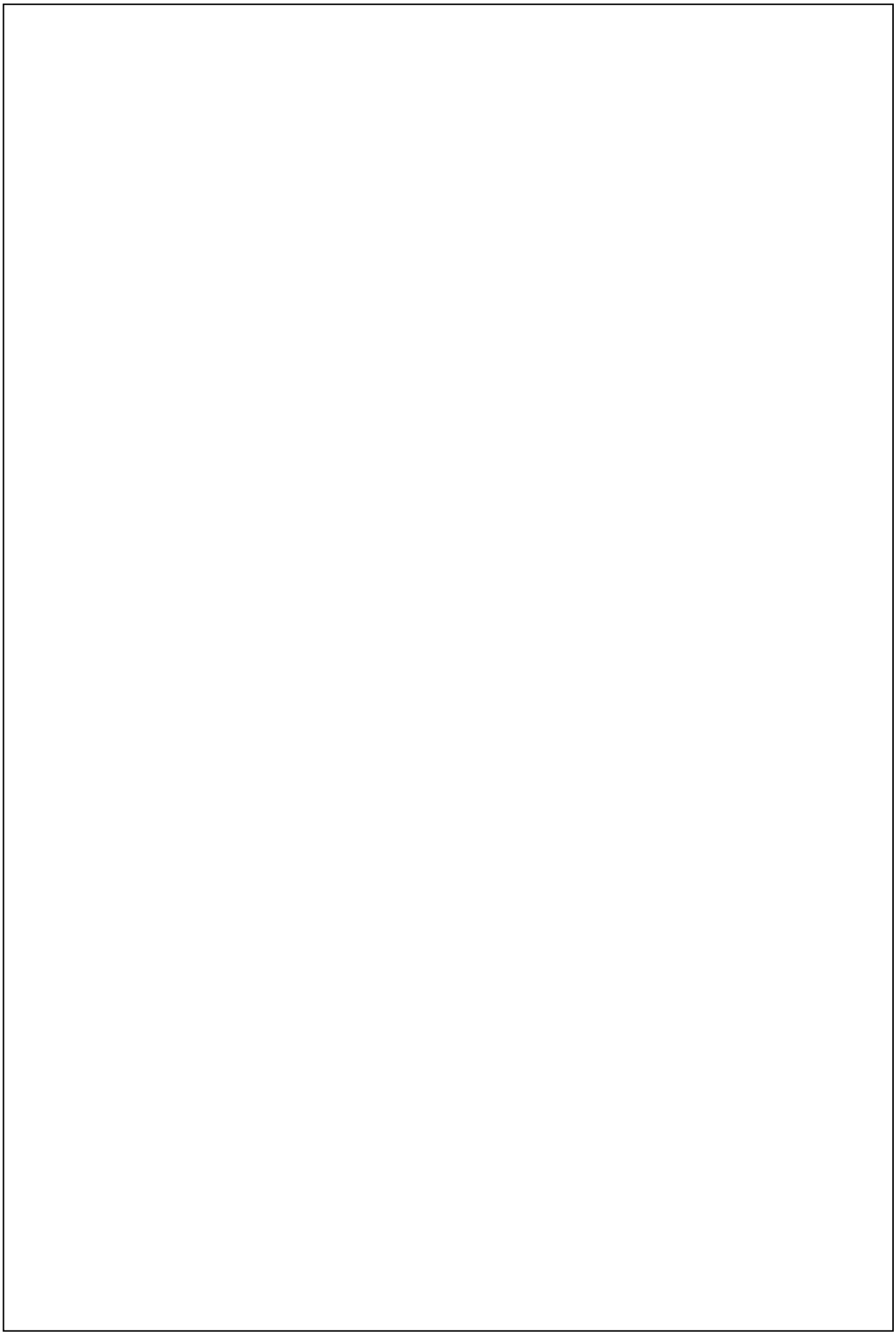
Objective: To identify insect pests attacking cereal crops

Exercise: Observe and enlist major pests attacking cereal crops. Draw a neat diagram of important pest of cereal crops.

Common name	Scientific name	Family & Order	Damaging symptoms
Rice			
Rice stem borer	…… ……	…… ……	…… …… …… ……
Gall midge	…… ……	…… ……	…… …… ……
Green leaf hopper	…… ……	…… ……	…… …… ……
Brown plant hopper	…… ……	…… ……	…… …… ……
Rice earhead bug	…… ……	…… ……	…… …… ……
Rice leaf folder	…… ……	…… ……	…… …… ……
Rice caseworm	…… ……	…… ……	…… …… ……
Rice grasshopper	…… ……	…… ……	…… …… …… ……

Wheat and Barley			
Wheat aphid	…… ……	…… ……	…… …… ……
Climbing cutworm /armyworm	…… ……	…… ……	…… …… ……
Ghujhia Weevil	…… ……	…… ……	…… …… ……
Termites	…… ……	…… ……	…… …… ……
Maize and Sorghum			
Stem borer	…… ……	…… ……	…… …… ……
Fall armyworm	…… ……	…… ……	…… …… ……
Shoot fly	…… ……	…… ……	…… …… ……
Shoot bug	…… ……	…… ……	…… …… ……
Sorghum midge	…… ……	…… ……	…… …… ……

Diagram of major pests of cereal crops



Draw the life cycle of rice stem borer

Diagram of damaging symptoms of *Chilo partellus*

EXPERIMENT NO. 3

Objective: To identify insect pests attacking pulse crops

Exercise: Observe and enlist major pests attacking pulse crops. Draw the different life stages of *Helicoverpa armigera.*

Common name	Scientific name	Family & Order	Damaging symptoms
Gram pod borer	…… ……	…… ……	…… …… ……
Plume moth	…… ……	…… ……	…… …… ……
Spotted pod borer	…… ……	…… ……	…… …… ……
Bean aphid	…… ……	…… ……	…… …… ……
Leaf hopper	…… ……	…… ……	…… …… ……
Thrips	…… ……	…… ……	…… …… ……
Pod bug	…… ……	…… ……	…… …… ……
Blister beetle	…… ……	…… ……	…… ……

Life stages of *Helicoverpa armigera*

Egg	**Larva**
Pupa	**Adult**

EXPERIMENT NO. 4

Objective: To identify insect pests attacking cash crops

Exercise: Observe and enlist major pests attacking cash crops. Write the integrated pest management of sugarcane.

Common name	Scientific name	Family & Order	Damaging symptoms
Pests of Sugarcane			
Early Shoot borer	…… ……	…… ……	…… …… …… ……
Internode borer	…… ……	…… ……	…… …… …… ……
Top borer	…… ……	…… ……	…… …… …… ……
White grub	…… ……	…… ……	…… …… …… ……
Termites	…… ……	…… ……	…… …… ……
Pyrilla	…… ……	…… ……	…… …… ……
Wooly aphid	…… ……	…… ……	…… …… …… ……

Pests of Cotton			
Aphids	…… ……	…… ……	…… …… ……
Whiteflies	…… ……	…… ……	…… …… ……
Thrips	…… ……	…… ……	…… …… ……
Red cotton bug	…… ……	…… ……	…… …… ……
American bollworm	…… ……	…… ……	…… …… ……
Pink boll worm	…… ……	…… ……	…… …… ……
Spiny boll worm	…… ……	…… ……	…… …… ……
Tobacco caterpillar	…… ……	…… ……	…… …… ……

Integrated pest management of sugarcane

……

……

……

……

EXPERIMENT NO. 5

Objective: To identify insect pests attacking vegetable crops

Exercise: Observe and enlist major pests attacking vegetable crops. Draw the diagram of the observed pests.

Common name	Scientific name	Family & Order	Damaging symptoms
Pests of Solanaceous crops			
Fruit borer	…… ……	…… ……	…… …… ……
Tobacco caterpillar	…… ……	…… ……	…… …… ……
White flies	…… ……	…… ……	…… …… ……
Thrips	…… ……	…… ……	…… …… ……
Pin worm	…… ……	…… ……	…… …… ……
Serpentine leaf miner	…… ……	…… ……	…… …… ……
Fruit sucking moth	…… ……	…… ……	…… …… ……
Brinjal shoot and fruit borer	…… ……	…… ……	…… …… ……

Epilachna beetle	…… ……	…… ……	…… …… ……
Chilli thrips	…… ……	…… ……	…… …… ……
Aphids	…… ……	…… ……	…… …… ……
Potato tuber moth	…… ……	…… ……	…… …… ……
Cut worms	…… ……	…… ……	…… …… ……
Potato GLH	…… ……	…… ……	…… …… ……
White grubs	…… ……	…… ……	…… …… ……
Pests of Okra			
Bhendi fruit and shoot borer	…… ……	…… ……	…… …… ……
Bhendi fruit borer	…… ……	…… ……	…… …… ……
White fly	…… ……	…… ……	…… …… ……

Aphid	…… ……	…… ……	…… …… ……
Jassids	…… ……	…… ……	…… …… ……
Red cotton bug	…… ……	…… ……	…… …… ……
Pest of Crucifers			
Diamond back moth	…… ……	…… ……	…… …… ……
Cabbage borer	…… ……	…… ……	…… …… …… ……
Cabbage green semilooper	…… ……	…… ……	…… …… ……
Cabbage butterfly	…… ……	…… ……	…… …… ……
Tobacco caterpillar	…… ……	…… ……	…… …… ……
Cabbage aphid	…… ……	…… ……	…… …… ……
Mustard aphid	…… ……	…… ……	…… …… ……

Pests of Cucurbits			
Fruit flies	…… ……	…… ……	…… …… ……
Pumpkin beetles	…… ……	…… ……	…… …… ……
Stem gall fly	…… ……	…… ……	…… …… ……
Pumpkin caterpillar	…… ……	…… ……	…… …… ……
Leaf miner	…… ……	…… ……	…… …… ……

Diagram of important pests of vegetable crops

Diamond back moth	**Whitefly**
Fruit fly	**Thrips**

EXPERIMENT NO. 6

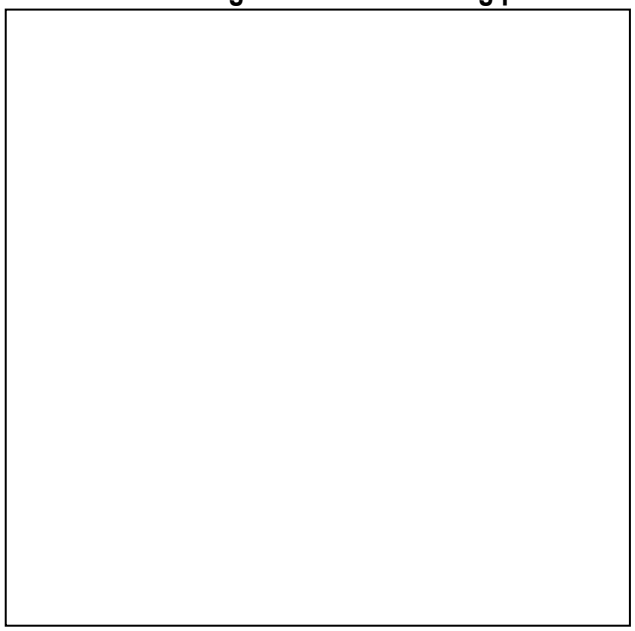
Objective: To identify insect pests attacking oilseed crops

Exercise: Observe and enlist major pests attacking oilseed crops.

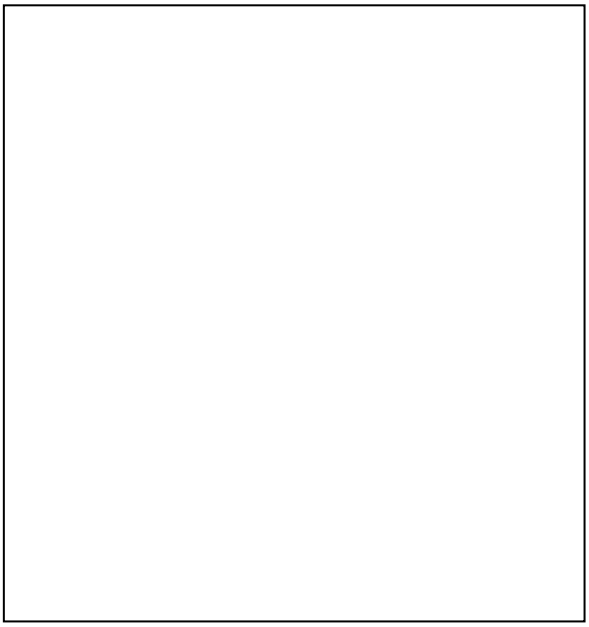
Common name	Scientific name	Family & Order	Damaging symptoms
Capitulum borer	…… ……	…… ……	…… …… ……
Bihar Hairy Caterpillar	…… ……	…… ……	…… …… ……
Tobacco caterpillar	…… ……	…… ……	…… …… ……
Red Hairy Caterpillar	…… ……	…… ……	…… …… ……
Ground nut leaf miner	…… ……	…… ……	…… …… ……
White grub	…… ……	…… ……	…… …… ……
Mustard aphid	…… ……	…… ……	…… …… ……
Mustard sawfly	…… ……	…… ……	…… …… ……
Sesame leaf hopper	…… ……	…… ……	…… …… ……

Sphingid	…… ……	…… ……	…… …… ……

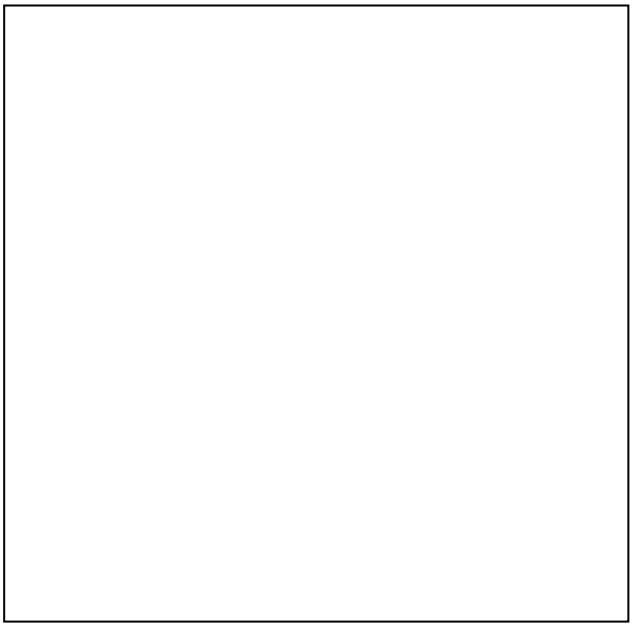
Draw the neat diagram of the following pests



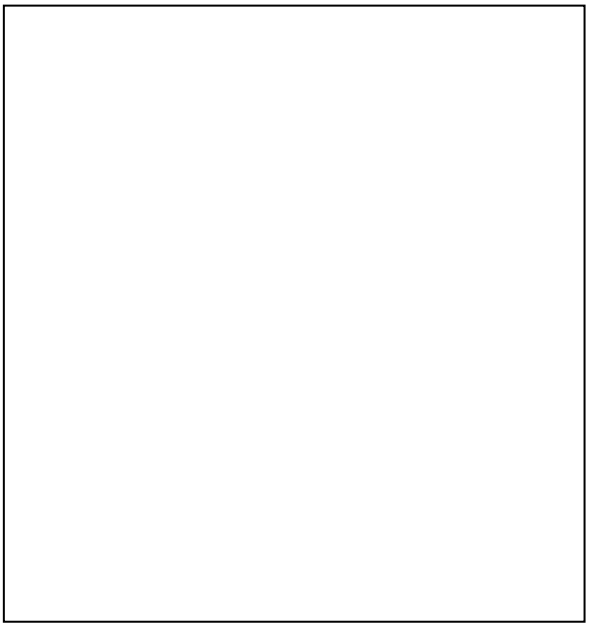
White grub



Aphid



Leaf miner symptoms



Sphingid

EXPERIMENT NO. 7

Objective: To identify insect pests attacking fruit crops

Exercise: Observe and enlist major pests attacking fruit crops.

Common name	Scientific name	Family & Order	Damaging symptoms
Pests of Mango			
Mango hopper	…… ……	…… ……	…… …… ……
Stem borer	…… ……	…… ……	…… …… ……
Fruit fly	…… ……	…… ……	…… …… ……
Mango nut weevil	…… ……	…… ……	…… …… ……
Mango mealy bug	…… ……	…… ……	…… …… ……
Bark eating caterpillar	…… ……	…… ……	…… …… ……
Pest of Banana			
Rhizome weevil	…… ……	…… ……	…… …… ……
Pseudostem borer	…… ……	…… ……	…… …… ……
Banana aphid	…… ……	…… ……	…… ……

			……
Pest of apple, pear and plum			
Apple woolly aphid	…… ……	…… ……	…… …… ……
San Jose scale	…… ……	…… ……	…… …… ……
Cotton cushiony scale	…… ……	…… ……	…… …… ……
Codling moth	…… ……	…… ……	…… …… ……
Green peach aphid	…… ……	…… ……	…… …… ……
Pests of citrus			
Shoot psyllid	…… ……	…… ……	…… …… ……
Citrus leaf miner	…… ……	…… ……	…… …… ……
Citrus whitefly	…… ……	…… ……	…… …… ……
Fruit piercing moth	…… ……	…… ……	…… …… ……

Bark eating caterpillar	…… ……	…… ……	…… …… ……
Citrus butterfly	…… ……	…… ……	…… …… ……
Pests of guava			
Fruit borer complex	…… ……	…… ……	…… …… ……
Fruit flies	…… ……	…… ……	…… …… ……
Bark borer	…… ……	…… ……	…… …… ……
Tailed mealy bug	…… ……	…… ……	…… …… ……
Spiralling white fly	…… ……	…… ……	…… …… …… ……
Pests of pomegranate			
Anar butterfly	…… ……	…… ……	…… …… ……
Tailed mealy bug	…… ……	…… ……	…… …… ……

Aphids	…… ……	…… ……	…… …… ……
White fly	…… ……	…… ……	…… …… ……
Pests of grapevine			
Stem girdler	…… ……	…… ……	…… …… ……
Flea beetle	…… ……	…… ……	…… …… ……
Thrips	…… ……	…… ……	…… …… ……
Mealy bugs	…… ……	…… ……	…… …… ……

EXPERIMENT NO. 8

Objective: To identify insect pests attacking plantation crops

Exercise: Observe and enlist major pests attacking plantation crops. Write the management practices of rhinoceros beetle attacking coconut.

Common name	Scientific name	Family & Order	Damaging symptoms
Rhinoceros beetle	…… ……	…… ……	…… …… ……
Red palm weevil	…… ……	…… ……	…… …… ……
Spindle bug (oilpalm/ arecanut)	…… ……	…… ……	…… …… ……
Termites	…… ……	…… ……	…… …… ……
Root grubs	…… ……	…… ……	…… …… ……
Arecanut Inflorescence caterpillar	…… ……	…… ……	…… …… ……
Mites	…… ……	…… ……	…… …… ……
Coffee berry borer	…… ……	…… ……	…… …… ……

Mealy bugs	…… ……	…… ……	…… …… ……
Tea mosquito bug	…… ……	…… ……	…… …… ……
Tea mite complex	…… ……	…… ……	…… …… ……

Management of rhinoceros beetle: ……

…..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

……..……

EXPERIMENT NO. 9

Objective: To identify insect pests attacking spices, condiments and narcotics

Exercise: Observe and enlist major insect pests attacking spices, condiments and narcotics.

Common name	Scientific name	Family & Order	Damaging symptoms
Pests of spices and condiments			
Cardamom thrips	…… ……	…… ……	…… …… ……
Cardamom Aphid	…… ……	…… ……	…… …… ……
Cardamom capsule borer	…… ……	…… ……	…… …… ……
Cardamom hairy caterpillar	…… ……	…… ……	…… …… ……
Pepper pollu beetle	…… ……	…… ……	…… …… ……
Tailed mealy bug	…… ……	…… ……	…… …… ……
Ginger shoot borer	…… ……	…… ……	…… …… ……
Ginger Rhizome scale	…… ……	…… ……	…… …… ……
Thrips	…… ……	…… ……	…… …… ……

Pest of tobacco			
Tobacco caterpillar	…… ……	…… ……	…… …… ……
Tobacco stem borer	…… ……	…… ……	…… …… ……
Whitefly	…… ……	…… ……	…… …… ……
Aphid	…… ……	…… ……	…… …… ……

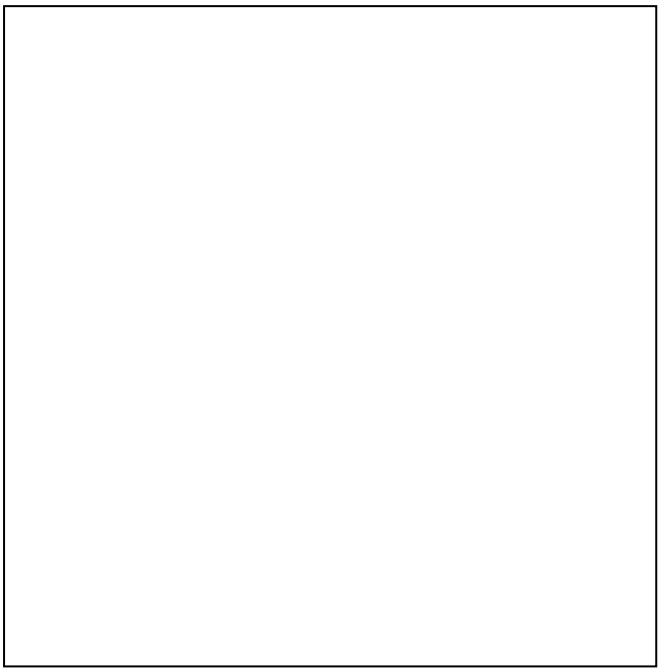
EXPERIMENT NO. 10

Objective: To identify insect pests attacking ornamental plants

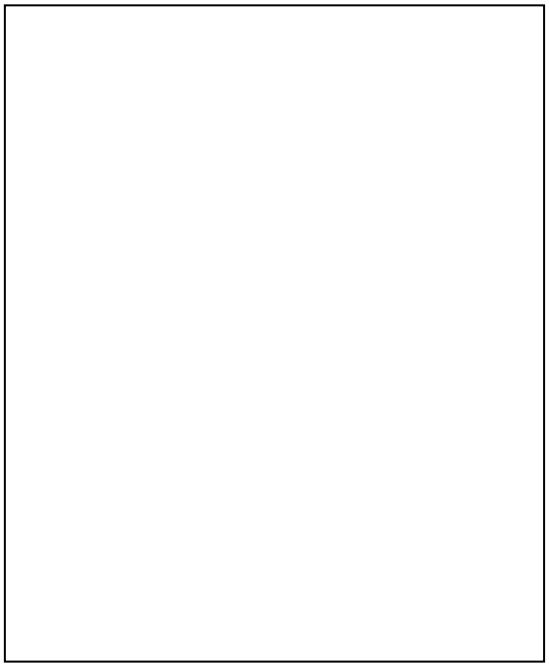
Exercise: Observe and enlist major insect pests attacking ornamental plants. Draw the different life stages of AK butterfly.

Common name	Scientific name	Family & Order	Damaging symptoms
Rose thrips	…… ……	…… ……	…… …… ……
Rose aphids	…… ……	…… ……	…… …… ……
Leaf cutter bee	…… ……	…… ……	…… …… ……
Dusky cotton bug	…… ……	…… ……	…… …… ……
Banded blister beetle	…… ……	…… ……	…… …… ……
Ak butterfly	…… ……	…… ……	…… …… ……
Lily moth	…… ……	…… ……	…… …… ……
Gerbera leaf miner	…… ……	…… ……	…… …… ……

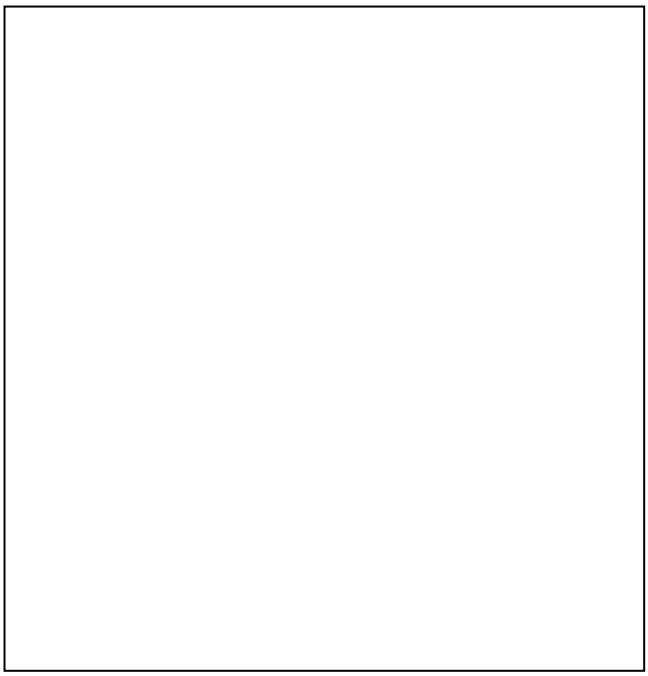
Life stages of AK butterfly



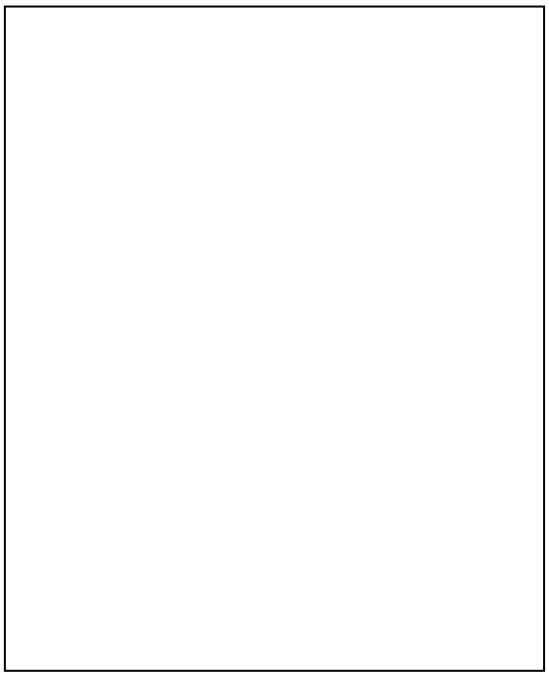
Egg



Larva



Pupa



Adult

EXPERIMENT NO. 11

Objective: To identify insect pests and Mites associated with stored grain

Exercise: Observe and enlist the insect pests and mites attacking stored grain

Common name	Scientific name	Family & Order	Damaging symptoms
Rice weevil	…… ……	…… ……	…… …… ……
Angoumois grain moth	…… ……	…… ……	…… …… ……
Cigarette beetle	…… ……	…… ……	…… …… ……
Red flour beetle	…… ……	…… ……	…… …… ……
Rice moth	…… ……	…… ……	…… …… ……
Khapra beetle	…… ……	…… ……	…… …… ……
Saw toothed grain beetle	…… ……	…… ……	…… …… ……
Long headed flour beetle	…… ……	…… ……	…… …… ……
Grain mite	…… ……	…… ……	…… …… ……

EXPERIMENT NO. 12

Objective: To determine insect infestation

Exercise: Explain various methods for determination of insect

Grain Probe Traps: ……

……

……

……

……

……

Sticky Traps: ……

……

……

……

……

……

Refuse Trap Method: ……

……

……

……

……

……

……

……

Light Trap Method ……

……

……

……

……

……

……

Use of Pheromone ……

……

……

……

……

……

Visual Lures: ……

……

……

……

……

……

……

……

……

Acoustical Methods: ……

……

……

……

……

……

……

……

Electrical Conductance: ……

……

……

……

……

Berlese Funnel Method: ……

……

……

……

X-Ray Imaging: ……

……

……

……

……

EXPERIMENT NO. 13

Objective: To assess losses due to insects

Exercise: Visit to field and asses the losses caused by the insect

Basic needs: ……

……

……

……

……

……

Assessment of Losses due to Insect Pests

EXPERIMENT NO. 14

Objective: To calculate doses of insecticides application technique

Exercise: Calculate the quantity of dimethoate 30 EC required to spray 2 hectares of citrus crop infested with sucking pests when applied @ 0.06 per cent solution. Volume of spray solution required is 500 litres per ha.

EXPERIMENT NO. 15

Objective: To study techniques of fumigation for stored grains

Exercise: Elaborate the various techniques of fumigation for stored grains

1. Direct mixing ……

……

……

……

……

……

……

……

……

……

……

……

……

……

2. Surface application :……

……

……

……

……

……

……

……

……

a. Large bulk fumigation:……

……

……

……

……

……

……

……

……

3. Surface infestation:……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

4. Hot spot fumigation:……

……

……

……

……

……

……

……

……

5. Tent fumigation: ……

……

……

……

……

……

……

……..

6. Vacuum fumigation:……..

……

……

……

……

……

……

……

……

……

……

……

7. Fumigation for rodent control:……

……

……

……

……

……

……

……

……

……

……

……

……

EXPERIMENT NO. 16

Objective: To study non-insect pests in field/godown

Exercise: Identify the non- insect pests attacking in field/ godown and write their management

Observation:

1. Giant African snail:……

……..

……

2. Millipedes: …….

…….

……

3. Mites: ……

…….

……

4. Snails and slugs: …….

…….

……

5. Nematodes: …….

…….

……

6. Rodents: …….

…….

……

7. Aves……..

…….

…….

Others: ……..

…….

……

…….

……..

Management:

EXPERIMENT NO. 17

Objective: To determine moisture content of grain

Exercise: Calculate the moisture content of the given sample

Principle: ……

……

……

……

……

……

……

……

……

……

……

……

……

Requirement: ……

……

Procedure: ……. ….

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

Observations

S.No.	Item	Sample no.	weight
1	Initial weight of sample	1	
		2	
		3	
2	Fresh weight of sample	1	
		2	
		3	
3	Container weight without sample	1	
		2	
		3	

Results: Tabulate the results as follows:

S. No.	Moisture measurement method	Sample No. (wet basis)	Moisture content (dry basis)	Moisture content
1	Air oven method	1		
		2		
		3		
2	Universal moisture meter method	1		
		2		
		3		
3	Brown dual fractional distillation method	1		
		2		
		3		

EXPERIMENT NO. 18

Objective: To study methods of grain sampling under storage condition

Exercise: Write the procedures for sampling of grain under storage condition

Equipment Needed for Sampling: ……..

……

……

Procedure :……

……

……

……

……

……

……

……

……

……

……

……

……

……

Safety Precaution: ……..

……

……

……

……

……

……

……

……

……

……

EXPERIMENT NO. 19

Objective: To visit to Indian Storage Management and Research Institute, Hapur and Quality Laboratory, Department of Food., Delhi and nearby FCI godowns.

Exercise: Make a report of the visit.

Report: ……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

APPENDICES

GENERAL SYMPTOMS OF DAMAGE CAUSED BY DIFFERENT PESTS ON CROP PLANTS

Entomologist classified the plant feeding insect into two categories such as generalist and specialist according to the mode of host plant use by them. Generalist insect can be defined those insect which use wide range of plant species as their host, whereas the specialist insect using a specified range of host plants in their life stages. Again phytophagous insects are differentiated into three categories such as *monophagous, oligophagous* and *polyphagous*. The insect species which feed on plants under single genus termed as monophagous. The oligophagous type consumed wide range of plants of different genera but in a single plant family. Whereas a polyphagous insect refers that they are feeding wide range of plant under different plant families. Most of the phytophagous insects are specialized for choosing their host plant.

Root feeding insects: Insect larvae feed on roots, root nodules; nymphs and adults suck sap from roots, resulting in stunted growth, poor tillering, drying of plants in isolated patches e.g: White grubs, grubs of rhinoceros beetles, termites, rice root weevil and ragi root aphid

Stem borers: Larvae enter into the shoot of main stem, tillers and feed on the central growing point. As a result, nutrient supply from the main plant beyond the infested part is affected leading to withering, wilting and drying up exhibiting symptoms such as dead heart / white ear / over growths of bunchy top e.g, Stem borers of paddy, millets, sugarcane, brinjal, bhendi, cotton etc.

Shoot borers: Larvae attack tender shoots and bore inside during the vegetative stage of crop growth and cause wilting, dropping of terminal plant part which later dries up e.g., Shoot fly of sorghum, early stem borer in sugarcane, stem fly in black gram/French bean, soybean, shoot borers of brinjal, bhendi, cotton, castor etc.

Tree borers: Larvae bore deep into the tree trunk, tunnels in zigzag manner and feed on inner tissues, affecting nutrient and translocation of sap to upper portions of branches / tree exhibiting symptoms such as withering of leaves, drying of twigs or complete dying of tree. Presence of fresh powdered material, ooze of gummy exudations etc. from the affected portion on the tree trunk is also seen in some cases e.g., Tree borers of mango, cashew; coconut red palm weevil etc.

Bark borers: Larvae enter into the bark and tunnel into the branches. The larvae remain hiding in the galleries formed from floss / fecal matter and silken saliva on the stem and continue to scrape the bark. Larval feeding results in drying of branches and breaking of affected portion with wind or gale e.g., Bark eating caterpillars of citrus, mango, guava, casuarinas, jack etc.

Gall formers: Larvae/nymphs feeding inside the stem! tiller /leaf/ flower bud affect the tissue by nibbling the meristematic tissues and secretion of auxins that results in excessive growth of cells at the affected portion leading to distorted growth and malformation of plant parts known as 'Gall' e.g., Paddy gall midge, chilly midge, gingelly midge, cucurbit stem borer, mango malformations, tobacco stem borer, cotton stem weevil, mango inflorescence midge, chilli midge etc.

Leaf folders: Larvae fasten the margins of individual leaves from margins / fold longitudinally or roll leaves into bell shape and feeds within by scrapping the chlorophyll e.g., Rice/ maize/leaf folder, cotton leaf roller, red gram/ black gram leaf folder.

Leaf miners: Larvae fasten the leaves /leaflets by means of silken threads (derived from saliva) and scrape the chlorophyll content by remaining within the web. Fecal pellets / frass remains present in the web e.g., Leaf webbers on groundnut / gingelly, Webbers of mango / sapota /Cashew.

Leaf webbers: Larvae fasten the leaves /leaflets by means of silken threads (derived from saliva) and scrape the chlorophyll content by remaining within the web. Fecal pellets / frass remains present in the web e.g., Leaf webbers on groundnut / gingelly, Webbers of mango / sapota /Cashew.

Defoliators / Skeletonizers: Larvae feed on the leaves completely leaving only midrib / veins or scrape the chlorophyll content of leaves or cause numerous holes e.g., Castor semilooper, red hairy caterpillar, Bihar hairy caterpillar, snakegourd semilooper, ash weevils, tobacco caterpillar, brinjal epilachna beetle.

Pod / Capsule borers: During the reproductive stage of crop, larvae bore into the flowers, pods, capsules and fasten the adolescent plant parts with silken threads, frass and excreta and feed on the internal contents within the web e.g., Spotted pod borer in legumes, capsule borers of castor / gingelly ; pod borer complex in pulses, gram caterpillar, pink bollworm, tobacco caterpillar , chilly pod borer etc.

Fruit borers / Bollworms: Larvae enter into the tender fruit's bolls and feed on internal content /pulp and plug the larval burrow with excreta e.g., Fruit borer of brinjal /bhendi /tomato, mango fruit borer, fruit fly, mango stone weevil, cashew apple and nut borer, anar/ guava fruit borer, Cotton bollworm etc.

Seed feeding insects / stored grain pests: Larvae feed on stored seeds either as internal/ external feeders / by webbing the food particles e.g., Rice weevil, lesser grain borer, red rust flour beetle, rice moth, cigarette beetle, saw toothed beetle.

Sap sucking insects / feeders:

From tender plant parts: Nymphs and adults suck sap from the base of the plant/leaves / tender terminal plant parts and affect the vigor and growth of the plants. Different insects exhibit different symptoms. Most of the sap suckers suck sap in excess of their requirement and excrete honey dew, which is rich in sugars, a source for sooty mold development e.g., Aphids, leafhoppers (jassids), plant hoppers, white flies etc. on important crops.

From grains: Nymphs and adults suck juice from developing ovaries/milky grains resulting in the formation of shriveled /chaffy grains e.g., Rice gundhy bug, sorghum ear-head bug, sorghum midge.

Symptoms of sucking pest damage:

• Hopper burn (drying of margins), complete drying of plants in patches - paddy brown plant hopper, cotton leafhoppers
• Scorch appearance of leaves - paddy leafhopper
• Upward curling of leaves - Chilli thrips
• Downward curling of leaves and elongation of petioles of older leaves-Chilli white mites
• Leaf drying from tip down wards - Onion thrips
• Yellowing /crinkling of leaves - Thrips on groundnut, pulses
• White / yellow blotches on upper surface of leaves - Thrips in castor, Cotton mites, Brinjal mites
• Red streaks on leaves - Sorghum/Maize mites
• Reduced vigour /sooty mold /yellowing / - Aphids / whiteflies on cotton/brinjal
• Corky out growths on fruits - tea mosquito bug in guava
• Rotting of fruits - fruit sucking moth in citrus fruit flies in mango
• Die back symptoms - tea mosquito bug in cashew

MAJOR INSECT PESTS ATTACKING CEREAL CROPS

Common name	Scientific name	Family	Order
Paddy			
Rice yellow stem borer	*Scirpophaga incertulas*	Pyraustidae	Lepidoptera
Gall midge	*Orseolia oryzae*	Cecidomyiidae	Diptera
Green leaf hopper	*Nephotettix virescens*, *N. nigropictus; N. cincticeps*	Cicadellidae	Hemiptera
Brown plant hopper	*Nilaparvata lugens*	Delphacidae	Hemiptera
Rice earhead bug	*Leptocorisa acuta*	Alydidae	Hemiptera
Rice leaf folder	*Cnaphalocrocis medinalis*	Pyralidae	Lepidoptera
Rice caseworm	*Nymphula depunctalis*	Pyraustidae	Lepidoptera
Rice grasshopper	*Hieroglyphus banian*	Acrididae	Orthoptera
Wheat			
Wheat aphid	*Macrosiphum miscanthi*	Aphididae	Hemiptera
Climbing cutworm /armyworm	*Mythimna separata*	Noctuidae	Lepidoptera
Ghujhia Weevil	*Tanymecus indicus*	Curculionidae	Coleoptera
Termites	*Odontotermes obesus/ Microtermes obesi*	Termitidae	Isoptera
Maize and Sorghum			
Stem borer	*Chilo partellus*	Crambidae	Lepidoptera
Fall armyworm	Spodoptera frugiperda	Noctuidae	Lepidoptera
Shoot fly	*Atherigona soccata; Atherigona orientalis*	Muscidae	Diptera
Shoot bug	*Peregrinus maidis*	Delphacidae	Hemiptera
Sorghum midge	*Contarinia sorghicola*	Cecidomyiidae	Diptera

Rice stem borer

Green leaf hopper

Rice leaf folder

Termites

Fall armyworm larva

Shootfly

INSECT PESTS ATTACKING PULSE CROPS

Common name	Scientific name	Family	Order
Gram pod borer	*Helicoverpa armigera*	Noctuidae	Lepidoptera
Plume moth	*Exelastis atomosa*	Pterophoridae	Lepidoptera
Spotted pod borer	*Maruca testulalis*	Pyraustidae	Lepidoptera
Bean aphid	*Aphis craccivora*	Aphididae	Hemiptera
Leaf hopper	*Empoasca kerri*, *E. binotata*, *E. flavescens*	Cicadellidae	Hemiptera
Thrips	*Ayyaria chaetophora*, *Caliothrips indicus*, *Megalurothrips distalis*	Thripidae	Thysanoptera
Pod bug	*Riptortus pedestris*	Coreidae	Hemiptera
Blister beetle	*Mylabris pustulata*	Meloidae	Coleoptera

Life stages of *Helicoverpa armigera*

Damaging stage of blister beetle

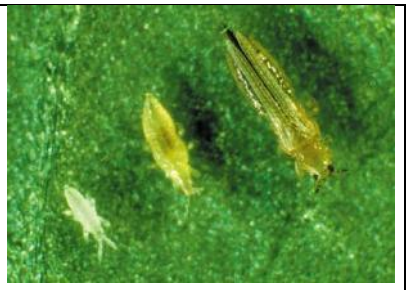
INSECT PESTS ATTACKING CASH CROPS

Common name	Scientific name	Family	Order
Sugarcane			
Early Shoot borer	*Chilo infuscatellus*	Crambidae	Lepidoptera
Internode borer	*Chilo sacchariphagus indicus*	Crambidae	Lepidoptera
Top borer	*Scirpophaga excerptalis*	Pyralidae	Lepidoptera
White grub	*Holotrichia consanguinea*	Melolonthidae	Coleoptera
Termites	*Odontotermes obesus*	Termitidae	Isoptera
Pyrilla	*Pyrilla perpusilla*	Lophopidae	Hemiptera
Wooly aphid	*Ceratovacuna lanigera*	Aphididae	Hemiptera
Cotton			
Aphids	*Aphis gossypii*	Aphididae	Hemiptera
Whiteflies	*Bemisia tabaci*	Aleyrodidae	Hemiptera
Thrips	*Thrips tabaci*	Thripidae	Thysanoptera
Red cotton bug	*Dysdercus cingulatus*	Pyrrhocoridae	Hemiptera
American bollworm	*Helicoverpa armigera*	Noctuidae	Lepidoptera
Pink boll worm	*Pectinophora gossypiella*	Gelechiidae	Lepidoptera
Spotted boll worm	*Earias vittella* & *E. insulana*	Noctuidae	Lepidoptera

Pyrilla

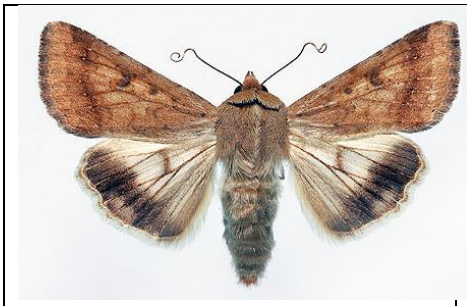
White grub

Wooly aphid

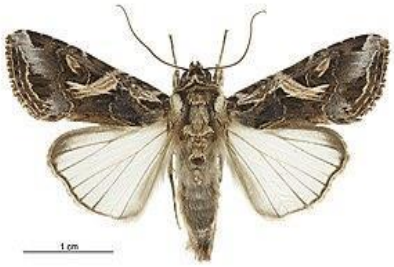
		
Whitefly	**Red cotton bug**	**Thrips**

INSECT PESTS ATTACKING VEGETABLE CROPS

Common name	Scientific name	Family	Order
Solanaceous crops			
Fruit borer	*Helicoverpa armigera*	Noctuidae	Lepidoptera
Tobacco caterpillar	*Spodoptera litura*	Noctuidae	Lepidoptera
White flies	*Bemisia tabaci*	Aleyrodidae	Hemiptera
Thrips	*T. tabaci*,*F. schultzi*	Thripidae	Thysanoptera
Pin worm	*Tuta absoluta*	Gelechiidae	Lepidoptera
Serpentine leaf miner	*Liriomyza trifolii*	Agromyzidae	Diptera
Fruit sucking moth	*Othreis fullonica*, *O. materna*, *O. ancilla*	Noctuidae	Lepidoptera
Brinjal shoot and fruit borer	*Leucinodes orbonalis*	Pyraustidae	Lepidoptera
Epilachna beetle	*Henosepilachna dodecastigma, H. vigintioctopunctata*, *H. demurille*, *H.* implicata	Coccinellidae	Coleoptera
Chilli thrips	*Scirtothrips dorsalis*	Thripidae	Thysanoptera
Aphids	*Myzus persicae*	Aphididae	Hemiptera
Potato tuber moth	*Phthorim aea operculella*	Gelechiidae	Lepidoptera
Cut worms	*Agrotis ipsilon, A. segetum, Xestia C. nigrum and Peridroma saucia*	Noctuidae	Lepidoptera
Potato GLH	*Empoasca kerri*	Cicadellidae	Hemiptera
White grubs	*Holotrichia excisa, H. repetita, H. notaticollis, Anomala communis, A. nathani*	Melolonthidae	Coleoptera
Okra			
Bhendi shoot and fruit borer	*Earias vitella*, *E. insulana*	Noctuidae	Lepidoptera
Bhendi fruit borer	*Helicoverpa armigera*	Noctuidae	Lepidoptera
White fly	*Bemisia tabaci*	Aleyrodidae	Hemiptera
Aphid	*Aphis gossypii*	Aphididae	Hemiptera
Jassids	*Amrasca bigutula bigutula*	Cicadellidae	Hemiptera
Red cotton bug	*Dysdercus koenigii*	Pyrrhocoridae	Hemiptera
Crucifers			
Diamond back moth	*Plutella xylostella*	Plutellidae	Lepidoptera
Cabbage borer	*Hellula undalis*	Pyraustidae	Lepidoptera
Cabbage green semilooper	*Tircihoplusia ni*	Noctuidae	Lepidoptera
Cabbage butterfly	*Pieris brassicae*	Pieridae	Lepidoptera
Tobacco caterpillar	*Spodoptera litura*	Noctuidae	Lepidoptera
Cabbage aphid	*Brevicoryne brassicae*	Aphididae	Hemiptera
Mustard aphid	Lipaphis erysimi	Aphdidae	Hemiptera
Cucurbits			
Fruit flies	*Bactrocera cucurbitae*	Tephritidae	Diptera
Pumpkin beetles	*Aulacophora foveicollis, A. cincta, A.intermedia*	Galerucidae	Coleoptera
Stem gall fly	*Neolasoiptera falcate*	Cecidomyiidae	Diptera
Pumpkin caterpillar	*Plusia peponis. P.signata, P.orichalcea*	Noctuidae	Lepidoptera
Leaf miner	*Liriomyza trifolii*	Agromyzidae	Diptera



H. armigera



S. litura

Fruit sucking moth

Diamond back moth

Cabbage butterfly

Cucurbit fruit fly

Pumpkin beetle

Leaf miner

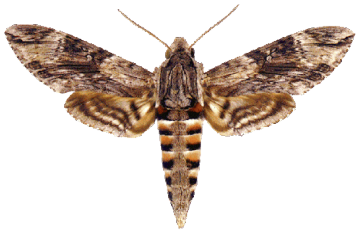
Cabbage aphid

INSECT PESTS ATTACKING OILSEED CROPS

Common name	Scientific name	Family	Order
Capitulum borer	*Helicoverpa armigera*	Noctuidae	Lepidoptera
Bihar Hairy Caterpillar	*Spilosoma obliqua*	Arctiidae	Lepidoptera
Tobacco caterpillar	*Spodoptera litura*	Noctuidae	Lepidoptera
Red Hairy Caterpillar	*Amsacta albistriga*	Arctiidae	Lepidoptera
Groundnut leaf miner	*Aproaerema modicella*	Gelechiidae	Lepidoptera
White grub	*Holotrichia consanguinea*	Melolonthidae	Coleoptera
Mustard aphid	*Lipaphis erysimi*	Aphididae	Hemiptera
Mustard sawfly	*Athalia lugens*	Tenthredinidae	Hymenoptera
Sesame leaf hopper	*Orosius albicinctus*	Cicadallidae	Hemiptera
Sphingid	*Acherontia styx*	Sphingidae	Lepidoptera

Mustard sawfly larva

Mustard sawfly adult



Sphingid

PESTS ATTACKING FRUIT CROPS

Common name	Scientific name	Family	Order
Mango			
Mango hopper	*Idioscopus niveosparsus, I. clypealis,Amritodus atkinsoni*	Cicadellidae	Hemiptera
Stem borer	*Batocera rufomaculata*	Cerambycidae	Coleoptera
Fruit fly	*Bactrocera dorsalis*	Tephritidae	Diptera
Mango nut weevil	*Sternochaetus mangiferae*	Curculionidae	Coleoptera
Mango mealy bug	*Drosicha mangiferae*	Margarodidae	Hemiptera
Bark eating caterpillar	*Indarbela tetraonis, I. quadrinotata*	Metarbelidae	Lepidoptera
Banana			
Rhizome weevil	*Cosmopolites sordidus*	Curculionidae	Coleoptera
Pseudostem borer	*Odoiporus longicollis*	Curculionidae	Coleoptera
Banana aphid	*Pentalonia nigronervosa*	Aphididae	Hemiptera
Apple, pear and plum			
Apple woolly aphid	*Eriosoma lanigerum*	Pemphigidae	Hemiptera
San Jose scale	*Quadraspidiotus perniciosus*	Diaspididae	Hemiptera
Cotton cushiony scale	*Icerya purchase*	Margarodidae	Hemiptera
Codling moth	*Cydia pomonella*	Tortricidae	Lepidoptera
Green peach aphid	*Myzus persicae*	Aphididae	Hemiptera
Citrus			
Shoot psyllid	*Diaphorina citri*	Psyllidae	Hemiptera
Citrus leaf miner	*Phyllocnistis citrella*	Gracillaridae	Lepidoptera
Citrus whitefly	*Dialeurodes citri*	Aleyrodidae	Hemiptera
Fruit piercing moth	*Othreis materna*, *O. fullonica*, *O. ancilla*	Noctuidae	Lepidoptera
Bark eating caterpillar	*Indarbela tetraonis*	Metarbelidae	Lepidoptera
Citrus butterfly	*Papilio demoleus*, *P. polytes*	Papilionidae	Lepidoptera
Guava			
Fruit borer	*Virachola* (*Duodorix*) *isocrates*	Lycaenidae	Lepidoptera
Fruit flies	*Bactrocera (Dacus) diversus*	Tephritidae	Diptera
Bark borer	*Indarbela tetraonis*	Metarbelidae	Lepidoptera
Tailed mealy bug	*Ferrisia virgata, Maconellicoccus hirsutus*	Pseudococcidae	Hemiptera
Spiralling white fly	*Aleurodicus disperses*	Aleyrodidae	Hemiptera
Pomegranate			
Anar butterfly	*Duodorix Isocrates*	Lycaenidae	Lepidoptera
Tailed mealy bug	*Ferrisia virgata, Maconellicoccus hirsutus*	Pseudococcidae	Hemiptera
Aphids	*Aphis punicae*	Aphididae	Hemiptera
White fly	*Aleurodicus disperses*	Aleyrodidae	Hemiptera
Grapevine			
Stem girdler	*Sthenias grisator*	Cerambycidae	Coleoptera
Flea beetle	*Scelodonta strigicollis*	Eumolpidae	Coleoptera
Thrips	*Rhipiphorothrips cruentatus*	Thripidae	Thysanoptera
Mealy bugs	*Maconellicoccus hirsutus*	Pseudococcidae	Hemiptera

Mango hopper

Mango stem borer

Mango nut weevil

Leaf mining symptoms

Citrus butterfly

Stem girdler

Banana Pseudostem weevil symptoms

INSECT PESTS ATTACKING PLANTATION CROPS

Common name	Scientific name	Family	Order
Rhinoceros beetle	*Oryctes rhinoceros*	Scarabaeidae	Coleoptera
Red palm weevil	*Rhynchophorus ferrugineus*	Curculionidae	Coleoptera
Spindle bug	*Carvalhoia arecae*	Miridae	Hemiptera
Termites	*Odontotermus obesus*	Termitidae	Isoptera
Root grubs	*Leucopholis burmeisteri*	Melolonthidae	Coleoptera
Inflorescence caterpillar	*Tirathaba mundella*	Pyralidae	Lepidoptera
Mites	*Oligonychus indicus*	Tetranychidae	Acari
Coffee berry borer	*Hypothenemus hampei*	Scolytidae	Coleoptera
Mealy bugs	*Ferrisia virgata , Planococcus, lilacinus, P. citri*	Pseudococcidae	Hemiptera
Tea mosquito bug	*Helopeltis theivora*	Miridae:	Hemiptera
Red spider mite	*Oligonychus coffeae*	Tetranychidae	Acari
Pink mite	*Acaphylla theae*	Eriophyidae	Acari
Yellow mite	*Polyphagotarsonemus latus*	Tarsonemidae	Acari

Rhinoceros beetle | **Red palm weevil** | **Coffee berry borer**

INSECT PESTS ATTACKING SPICES, CONDIMENTS AND NARCOTICS

Common name	Scientific name	Family	Order
Spices and condiments			
Cardamom thrips	*Sciothrips cardamom*	Thripidae	Thysanoptera
Cardamom Aphid	*Pentalonia nigronervosa*	Aphididae	Hemiptera
Cardamom capsule borer	*Dichocrocis punctiferalis*	Pyraustidae	Lepidoptera
Cardamom hairy caterpillar	*Eupterote cardamomi*	Bombycidae	Lepidoptera
Pepper pollu beetle	*Longitarsus nigripennis*	Alticidae	Coleoptera
Ginger shoot borer	*Conogethes punctiferalis*	Pyraustidae	Lepidoptera
Rhizome scale	*Aspidiotus hartii*	Diaspididae	Hemiptera
Thrips	*Panchaetothrips indicus*	Thripidae	Thysanoptera
Tobacco			
Tobacco caterpillar	*Spodoptera litura*	Noctuidae	Lepidoptera
Stem borer	*Scrobipalpa heliopa*	Gelechiidae	Lepidoptera
Whitefly	*Bemisia tabaci*	Aleyrodidae	Hemiptera
Aphid	*Myzus nicotianae*, *Myzus persicae*	Aphididae	Hemiptera

INSECT PESTS ATTACKING ORNAMENTAL PLANTS

Common name	Scientific name	Family	Order
Rose thrips	*Rhipiphorothrips cruentatus*	Thripidae	Thysanoptera
Rose aphids	*Macrosiphum rosaeformis, M. rosae*	Aphididae	Hemiptera
Leaf cutter bee	*Megachile anthracina*	Megachilidae	Hymenoptera
Dusky cotton bug	*Oxycarenus laetus*	Lygaeidae	Hemiptera
Banded blister beetle	*Mylabris phalerata*	Meloidae	Coleoptera
Ak butterfly	*Danais chrysippus*	Nymphalidae	Lepidoptera
Lily moth	*Polytela gloriosae*	Noctuidae	Lepidoptera
Gerbera leaf miner	*Liriomyza trifolii*	Agromyzidae	Diptera

***Danais chrysippus* (Larva)**

***Danais chrysippus* (Adult)**

Leaf cutter bee

INSECT PESTS AND MITES ASSOCIATED WITH STORED GRAIN

Common name	Scientific name	Family	Order
Rice weevil	*Sitophilus oryzae,*	Curculionidae	Coleoptera
Angoumois grain moth	*Sitotroga cerealella*	Gelechiidae	Lepidoptera
Cigarette beetle	*Lasioderma sericorne*	Anobiidae	Coleoptera
Red flour beetle	*Tribolium castaneum, T. confusum*	Tenebrionidae	Coleoptera
Rice moth	*Corcyra cephalonica*	Galleriidae	Lepidoptera
Khapra beetle	*Trogoderma granarium*	Dermestidae	Coleoptera
Saw toothed grain beetle	*Oryzaephillis surinamensis*	Silvanidae	Coleoptera
Long headed flour beetle	*Latheticus oryzae*	Tenebrionidae	Coleoptera
Grain mite	*Acarus siro*	Acaridae	Sarcoptiformes

Rice weevil

Angoumois grain moth

Red flour beetle

Khapra beetle

Saw toothed grain beetle

Rice moth

DETERMINATION OF INSECT INFESTATION BY DIFFERENT METHODS

Grain Probe Traps: Grain probe traps are cylindrical tubes with perforations in the upper section through which insects drop into the trap and are unable to escape because of the shape of the receptacle. They are labour intensive, limits temporal availability of data, restricts placement of probe traps in easily accessible locations and difficult to interpret.

Sticky Traps: Any surface coated with a sticky substance (such as petroleum jelly or polybutene gel usually sold as bird repellant) that prevents insects from leaving after landing on it. They should be suspended from the store roof, to hang above or between stacks or heaps of stored grains. They have a short effective life since their surfaces are easily covered with dust.

Refuse Trap Method: These are made from waste material such as cardboard packaging. They provide a refuge for insects such as moth larvae which habitually leave the food source to pupate in sacking or crevices in the storage structure.
Light Trap Method: Most efficient at detecting moth infestations since the adults are attracted to light when they leave the produce in order to fly and mate. Ultraviolet (300-400nm) and green light (500-550nm) are the most attractive wavelengths to storage pests.
Use of Pheromone: For use in monitoring, chemical attractants are impregnated or encased in a rubber, paper or plastic lure that slowly releases the active components over a period of several days/weeks. Environmental factors affect catches: temperature, rainfall, wind speed and direction influence attractant release from lures and insect flight.
Visual Lures: Similar to light traps, visual lures are either lights that attract insects from the dark/dimly lit surroundings (usually fluorescent, incandescent and ultraviolet lights) or they are colored objects that are attractive because of their specific reflectance and shapes that stand out against a contrasting background. Electrical cutters are placed in dimly lit areas where their light is not visible outdoors such that it does not lure insects into the building.
Acoustical Methods: Use sound (insect feeding sounds) to automatically monitor both internal/external grain feeding insects. Affected by background noise, insect behaviour, insect inactivity, unfavorable environment, intensity/duration/ spectral characteristics of the sound at source, distance of the receiver and receiver's spectral sensitivity.
Electrical Conductance: Conductance is monitored by measuring the voltage across the kernel (the kernel acts as one resistor in a two-resistor and voltage-divider circuit of the single kernel characterization system. This method requires skilled person.
Berlese Funnel Method: Works on the principle that insects move away from heat. It takes 5-6hrs to determine the presence of insects in 1Kg grain samples though proved 59% efficient in recovering Stephens adults in wheat. It is slow and inaccurate in detecting infestations; by this time, the grain would have been loaded into ships/bins.
Near-Infrared Reflectance Spectroscopy: Based on the absorption of electromagnetic wavelengths in the range of 780-2500nm to determine the concentrations of constituents like water, proteins, fats and carbohydrates using classical absorption spectroscopy. It has proved in several Coleopteran species and external and internal infestations in wheat, with up to 1000 kernels scan per second.
Machine Vision: Individual grain kernels are compared with the photographic print of the representative sample. It consists of high speed integrated machine vision software used with a monochrome CCD camera and a personal computer. It has a limited rate of sample throughout put
X-Ray Imaging: A soft X-ray system consisting of a fluoroscope operated at 15KV potential and 65µ A, produces the real time non-destructive, highly accurate images. It can detect both internal and external insects, and able to detect both live and dead insects inside the grain kernels, except it can't detect insect eggs.

ASSESSMENT OF LOSSES DUE TO INSECTS

Basic Needs

- To determine the economic status of a given pest species.
- For establishing the economic threshold levels and economic injury levels of the pest.
- To estimate the effectiveness of control measures.
- For evaluating the crop or a variety for its reaction to the pests.
- Helping in deciding the allocations for research and extension in plant protection.
- Helping in assigning the priorities on the bases of relative importance of different pests.

Assessment of Losses due to Insect Pests

Stem borer: Based on eggs and larval damage: Presence of yellowish-brown egg mass near the leaftip/presence of dead heart (vegetative stage) or white ear (reproductive stage).

a. Eggs in the nursery: Number of egg masses/m2 (ETL: 2)
b. Larval damage: Count the total tillers and affected tillers in a unit area and arrive at a percentage

$$\% \text{ drying branches} = \frac{\text{Number of drying branches}}{\text{Total number of branches}} \times 100 \text{ (ETL: 10\%)}$$

Inflorescence midge:

$$\% \text{ Infected shoot} = \frac{\text{Number of infected bud}}{\text{Total number of bud}} \times 100 \text{ (ETL 10\%)}$$

Leaf Webber: Based on damage - folded and scrapped leaves

$$\% \text{ leaf damage} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves}} \times 100$$

(ETL: 10% at vegetative stage or 5% at flowering stage) (in 10 randomly selected plants)

Whorl maggot: Based on damage - marginal blotching and yellow patches on the leaves

$$\% \text{ leaf damage} = \frac{\text{Number of Damage Leaf}}{\text{Total number of leaves}} \times 100$$

(in 10 randomly selected plants)

$$\% \text{ Avoidable yield losses} = \frac{\text{Yield in protected crop - Yield in unprotected crop}}{\text{Yield in protected crop}} \times 100$$

PESTICIDE DOSAGE CALCULATION

The following formulas are useful in quantifying insecticides for field application.

1. For spraying

Preparation of spray solution is V 1 S 1 =V 2 S 2

Where V 1 = volume of insecticide required.
S 1 = strength of the commercial formulation
V 2 = volume of spray fluid required.
S 2 = strength of the spray fluid.

2. For granular application

$$\text{Quantity of chemical needed} = \frac{\text{Recommended a.i./ha}}{\text{\% a.i in the formulation}} \text{ X } 100$$

TECHNIQUES OF FUMIGATION FOR STORED GRAINS

Precaution- In the application of fumigants to grain streams, care should be taken that fumes are not inhaled. Liquid-type fumigants are especially hazardous because vapours may be given off before the grain enters the storage.

Warning- When grain fumigants are atomized or sprayed into closely confined spaces, or into a shallow space above the grain surface, the concentration of fumigant may exceed 2 percent by volume in air. Canister-type respirators will afford no protection under these conditions. It is better for the fumigator to remain outside and to apply the fumigant through an opening. If it is absolutely necessary for operators to enter such a space during fumigations, air-line or self-contained respirators should be worn.

Dosage and Exposure: Dosages of fumigants recommended for the mixing-in-grain. Dosage in fumigation of grain by direct mixing is modified by the kind of grain treated and the gas tightness of the structure. Wind forces, thermal expansion of the internal gas and changes in atmospheric pressure can also influence gas loss from storage structures

Methods of fumigation in godown

Direct mixing (vertical storage): By this method, the fumigant is applied to the grain so that it is distributed as evenly as possible from the beginning of the treatment. Direct mixing is often employed when infestation is general throughout the mass and when there is access to the grain stream during filling or transfer from one bin to another. Only solid or liquid-type fumigants are used in this way. Aluminum phosphide tablets or pellets can be inserted in the grain stream by hand or with an automatic dispenser calibrated to deliver a dosage appropriate to the rate of loading in the bin and Calcium cyanide is usually discharged from an automatic applicator. Storage bins of the vertical type usually have manhole covers in the ceiling and these are usually closed immediately to prevent loss of fumigant

Surface application (flat storage): The surface application method has so far been used mainly with liquid type fumigants. The liquids are sprayed evenly over the top surface of the grain and the vapours slowly evolve and diffuse downward through the bulk. The carbon tetrachloride has given good distribution in grain in deep bins; carbon disulphide has been used in many countries.

Large bulk Fumigation: The liquid-type fumigants are usually applied to the surface of bulk grain by means of sprayers and the nozzles are removed to facilitate the rapid application of the liquid to the surface of the grain. A method for treatment of high vertical bins of grain by applying methyl bromide with carbon dioxide has been developed by Calderon and Carmi (1973). The carbon dioxide acts as a carrier and will take the methyl bromide down through the grain mass to the bottom of the bin. In flat storage units, in which the depth of the grain does not exceed 10 m (about 30 ft), tablets, pellets or sachets containing aluminium phosphide may be used. The fumigant is usually applied by probing into the grain

Surface infestation: With certain species of insects, such as the Indian meal moth, *Plodia interpunctella* infestation may be confined to the top of the grain. This problem cannot be solved by the usual method of surface application of fumigants because the vapours diffuse down through the grain. In silo bins or other storage units, which can be made air tight surface infestations can be treated with materials such as dichlorvos to obtain control. It should also be pointed out that incipient surface infestations of insects may be arrested by using pyrethrum, malathion or other approved materials applied as a fine mist in the space over grain. It should also be pointed out that incipient surface infestations of insects may be arrested by

using pyrethrum, malathion or other approved materials applied as a fine mist in the space over grain. It should also be pointed out that incipient surface infestations of insects may be arrested by using pyrethrum, malathion or other approved materials applied as a fine mist in the space over grain.

Hot spot fumigation: Treatment of localised areas in a grain mass is often a useful technique for dealing with incipient infestation. These spots are usually recognised and defined by local rise in temperature. Liquid type fumigants are applied through tubes. Aluminium phosphide tablets are the best materials in use. Enough fumigant is applied to maintain the required lethal concentration not only in the region of infestation, but also in the margins surrounding it for 1 or 2 m.

Tent fumigation: A tent (polythene or nylon impregnated with vinyl chloride) is constructed to cover sacks of grains**.** Tent can be conveniently stretched. The fumigant is introduced in to the tent through hoses connected to the preparing equipment. Most commonly HCN is used as fumigants

Vaccum fumigation: This is done in the case of cotton bales, imported products likely to be infested by insects, packaged food. The article to be fumigated is placed in a tight sealing steel chamber from which the air has been sucked out to produce a partial vacuum. A fumigant heated 120°F. Due to the partial vacuum the fumigant is able to penetrate the deeper layers of the bales. The reduction in the oxygen content due to partial vacuum forces the insects to breathe in toxic gas more readily. Today, the technique is used chiefly in plant quarantine work and for fumigating tobacco and other materials, such as compressed bales of jute bags and pressed dates which are difficult to penetrate at atmospheric pressure. Fumigants - Ethylene oxide/carbon dioxide mixture, Methyl bromide, Hydrogen cyanide.

Fumigation for rodent control: Most commonly employed chemical control measures include poison baits and fumigation. Initially poison baits are employed for control like Zinc phosphide (2%), Racumin bait, nor bromide etc. But to control the residual population of rodent's fumigation is necessary to kill more than 90% of population, otherwise they breed so fast that population reaches the same level within months. For this Fumigation with Aluminum phosphide tablets, 2 tablets of 0.6 g or half of 3g per burrow have been found effective. After introducing a tablet into live burrow, the opening is closed tight with soil. Soil moisture is essential to produce deadly phosphine gas.

NON- INSECT PESTS ATTACKING IN FIELD/ GODOWN

Giant African Snail

Slug

Red Spider Mite

Root Knot Nematode

Millipede

House mouse

Black Drongo

House sparrow

House rat

DETERMINATION OF MOISTURE CONTENT OF GRAINS

Principle: Removal of moisture from wet materials takes place by vaporization and it depends on the rate of heat and mass transfer which is related with two basic phenomenon namely vaporization of moisture from surface of material and movement of moisture from internal parts of materials to its surface. Movement of moisture takes place because of diffusion cell contraction and vapor pressure gradient.

Requirements: Electric balance, brown fuel moisture meter, stake moisture meter, indosaw universal moisture meter, oven, desiccators, moisture boxes

Procedure:

Oven drying method

1. Take the sample box and weigh with lid over it.
2. Put the sample in it (approximately 5-10 g)
3. Keep the sample in an oven at 105o C for 24 hrs
4. Take out the sample after 24 hrs and weigh it along with lid over it

Calculate the moisture content in percent with the following formula

Brown dual distillation method

$$\text{Moisture content (wet basis)} = \frac{\text{initial weight of sample} - \text{final weight of sample}}{\text{Initial weight of sample}}$$

$$\text{Moisture content (dry basis)} = \frac{\text{initial weight of sample} - \text{final weight of sample}}{\text{Dry weight of sample}}$$

Procedure

1. Arrange the instrument and settings
2. Take 100 g of material by weighing on the balance
3. Take 150 ml mineral oil (high bp) using jar
4. Take the grain and oil in a flask and keep it in the assembly
5. Supply the current and keep it for 30 minutes
6. Collect the condensed water in a graduated cylinder
7. Stop the supply when water collected in the cylinder is negligible
8. Take the cylinder and measure the reading which will give directly the wet basis moisture content

Universal moisture content

1. Arrange the instrument and set up
2. Take the sample and check the volume cup to be used from the mater
3. Fill the sample in the cup to top
4. Read out the pressure to be applied
5. Provide the compaction by means of racket handle
6. Press the button provided at the top such that the countdown starts from 10
7. After the end of the countdown moisture content is displayed to the screen which give the moisture content on weight basis
8. Repeat for three samples of same material

Precautions

1. The temperature and time for moisture removal is maintained properly
1. Clean and dry moisture boxes should be used for experimentation
2. Condensed water should be collected properly and weighed

METHODS OF GRAIN SAMPLING UNDER STORAGE CONDITION

Equipment Needed: Deep bin compartment probe, Deepcup probe, Grain sieve with 1/12- or 3/16-inch round holes, Sample vials, Bin inspection forms, Temperature probe

How to Sample: While standing on the grain mass surface, push the probe into the grain mass at a slight angle. The top of the cup will open as the probe is pulled up and out of the grain, allowing grain to fill the cup. It is best to divide the grain surface into quarters and take at least three probes per quarter section of grain mass. This will provide a good representative sample of the grain to allow inspection for the presence of insects, molds or excessively moist grain.

Sampling Difficulties: Overfilled grain bins are difficult to sample for insects or molds. Sometimes the only access points are through the bin wall, door or roof. Sample in the center of the grain mass as deeply as possible. Reach the bin wall if possible at two to three depths. Examining the Sample Place the grain sample in a specially designed weevil sieve (1½-inch diameter holes) if available and shake side to side at least 30 times to loosen any insects that may be in the grain. If a sieve is not available, place samples on a white piece of cloth for examination. Inspect the sample carefully for insects. It may be necessary to use a magnifying glass to see some of the smaller insects.

Safety Precautions: Bridged grain may result in a cave-in and subsequent suffocation of the workers. Bridged grain is caused when grain mats together, forming a false floor in the upper level of the grain mass. Persons falling through this bridged area are subject to suffocation.