ENEMIES OF STORED GRAIN

VOLUME II OF
SMALL FARM GRAIN STORAGE

BY

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AND

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TABLE OF CONTENTS

APPENDIX B: Bibliography: Reprint of Listings Prepared by the Tropical Products Institute, London

CONVERSION TABLES

PURPOSE OF THE MANUAL

Small Farm Grain Storage is a set of how-to manuals. Together these volumes provide a comprehensive overview of storage problems and considerations as they relate to the small farmer. The authors recommend the volumes be purchased as a set because the material forms an excellent and complete working and teaching tool for development workers in the field. This grain storage information can be adapted easily to meet on-the-job needs; it has already been used as the basis for a grain storage workshop and seminar in East Africa.

This set of publications retains the purpose of the original volume: to bring together and to communicate effectively to field personnel 1) the basic principles of grain storage and 2) the practical solutions currently being used and tested around the world to combat grain storage problems. Only the format has been changed to:

* **reduce printing and postage costs.**

* **permit updating and revising one volume at a time.**

* **provide smaller books that are easier to hold and use than the large, single volume.**

* make portions of the information available to the user who is especially interested in only one or another of the major aspects of small farm grain storage.

Of course, it is impossible to cover all storage situations in this manual. But farmers who understand the basic, unchanging principles of drying and storing grain are better able to adapt ideas, suggestions, and technologies from other parts of the world to their own needs. This material was prepared for use by those who work to facilitate such understanding.

OVERVIEW OF THE MANUAL

Volume I, "Preparing Grain for Storage," discusses grain storage problems as they are faced by small-scale farmers. This volume contains explanations of the structure of grain, the relationship between grain and moisture, the need for proper drying. One large section contains detailed, fully illustrated plans for constructing a variety of small-scale grain dryers.

Volume II, "Enemies of Stored Grain," is an in-depth study of two major enemies: insects and rodents. Each is discussed in detail with guidelines for 1) defining the size of the problem and 2) protecting grain by both chemical and non-chemical means. This volume includes dose and use information for a variety of pesticides, as well as suggestions for preparing materials to be used in audio-visual presentations.

Volume III, "Storage Methods," contains a survey of storage facilities from the most traditional basket-type granary to metal bins and cement silos. The emphasis in this volume is on improving existing facilities; for example, there are detailed construction procedures for an improved mud silo. Storage in underground pits and sacks also is discussed. There are guidelines for using insecticides in storage situations. The largest silo presented in detail is the 4.5 ton cement stave silo.

THE PEOPLE WHO PREPARED THIS MANUAL

Carl Lindblad served as a Peace Corps Volunteer in Dahomey (Benin) from 1972 to 1975. As a Volunteer, Lindblad worked in programs designed to introduce and popularize a variety of grain storage technologies. Upon his return to the United States, he began the task of pulling together this manual as a consultant to VITA and Peace Corps. At present, he serves as a consultant to a number of international organizations, specializing in appropriate technologies for grain storage -- in the areas of planning, extension and evaluation. He spends much of his time in the field.

Laurel Druben served as an International Voluntary Services, Inc. Volunteer in Laos from 1966 to 1968. While in Laos she was a curriculum planner and a teacher of English as a second language. Subsequently, she worked with a consulting firm evaluating government-funded research and development projects, ran a small education-oriented business, and was a free-lance consultant and proposal writer. Druben, who has worked and lived in India and Micronesia, as well as Southeast Asia, is Director of Communications for VITA.

Many thanks are due to the skilled and concerned people who worked to make this manual possible:

A number of VITA people provided technical review, artwork, and production skills:

Staff assistance -- John Goodell

Section 4, Vol. I materials -- Frederick Bueche

Technical review -- Douglas Barnes, Merle Esmay, Henry Highland, Larry Van Fossen, Harold Willson, Kenton Harris

Artwork -- George Clark, John Goodell, Kenneth Lloyd, Nicholas Reinhardt, Guy Welch

Thanks are extended to the following individuals and institutions that provided invaluable assistance in early stages of work on the manual:

Mary Ernsberger and Margot Aronson, Peace Corps Program and Training Journal, USA

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Siribonse Boon-Long, Ministry of Agriculture and Cooperation, Thailand

Asian Institute of Technology, Chulalongkorn University, Thailand
Merrick Lockwood, Bangladesh Agricultural Research Council
International Rice Research Institute (IRRI), Philippines
Dante de Padua, University of Los Banos, Philippines

THE SPONSORING ORGANIZATIONS

Small Farm Grain Storage is part of a series of publications combining Peace Corps practical field experience with VITA technical expertise in areas in which development workers have special difficulties finding useful resource materials.

ACTION/Peace Corps

Since 1961 Peace Corps Volunteers have worked at the grassroots level in countries around the world in program areas such as agriculture, public health, and education. Before beginning their two-year assignments, Volunteers are given training in cross-cultural, technical, and language skills. This training helps them to live and work closely with the people of their host countries. It helps them, too, to approach development problems with new ideas that make use of locally available resources and are appropriate to the local cultures.

Recently Peace Corps established an Information Collection and Exchange, so that these ideas developed during service in the field could be made available to the wide range of development workers who might find them useful. Materials from the field are now being collected, reviewed, and classified in the Information Collection and Exchange system. The most useful materials will be shared with the development world. The Information Collection and Exchange provides an important source of field-based research materials for the production of how-to manuals such as Small Farm Grain Storage.

VITA

VITA people are specialists who volunteer their free time to answer requests for technical assistance. Many VITA Volunteers have lived and worked in other countries, often as Peace Corps Volunteers. Most VITA people now work in the United States and other developed countries where they are engineers, doctors, scientists, farmers, architects, writers, artists, and so on. But they continue to work with people in other countries through VITA. VITA Volunteers have been providing technical assistance to the Third World for almost 20 years.

Requests for assistance come to VITA from many nations. Each request is handled by a Volunteer with the right skills. For example, a question about grain storage in Latin America might be handled by a professor of agriculture, and a request for an improved planting implement would go to an agricultural engineer. These VITA Volunteers, many of whom have lived and worked in Third World countries, are familiar with the special problems of these areas and are able to give useful, and appropriate, answers.

VITA makes the expertise of VITA people available to a wide audience through its publications program.

HOW TO USE THIS MANUAL

Development workers can use material from this manual in a number of ways:

* Discussions. The manual provides clear presentations of grain storage principles from which you can take material to lead discussions with farmers and village leaders.

* Demonstrations. There are suggestions for demonstrations and experiments which you might find helpful to illustrate grain storage principles to farmers.

* Leaflets. Some of the material has been prepared in the form of illustrated leaflets which can be used directly by you with a farmer. They may require little or no adaptation by you. But, if you prefer, you can use the structure of the leaflet and substitute photographs specific to your area. The material on rodent control in Volume II is a good example of this kind of leaflet.

* Construction Plans. Many of the construction plans have been simplified so that you will be able to work more closely with the farmer. Some of the plans are fully illustrated. You could add photographs of the work steps showing conditions in your area. It is likely that after you introduce the material, farmers can follow the instructions themselves. The plans are written so that they would be easy to translate into local languages. The Improved Maize Drying Crib in Volume I is a good example of a step-by-step, illustrated presentation.

* Checklists. Some of the material most likely to be useful for small-scale farmers has been simplified and prepared in checklist or hand-out form. This material would lend itself to illustrations or photographs, so it can better fit into the local situation. The checklists on controlling grain storage insect pests included in Volume II are in this category.

* Examples. The appendices contain examples of leaflets that have been prepared by development workers in several countries. These examples have been included to give you some idea of how the materials in this manual might be organized, illustrated, translated, and presented to reach farmers.

* Sources. Wherever possible, addresses are given so that you can write for more information on a subject.

* Further Information. Other appendices contain information on areas which, although important, cannot be covered fully within the scope of this manual, for example, storage program planning. A bibliography is provided at the end of each volume.

These are some of the aims of Small Farm Grain Storage. You will probably find added uses. While it is not possible to make this manual specific to the situations or culture of your particular area, the information is presented so that you can do this very easily by making additions or substitutions to the material.

Dimensions are given in metric units in the text and illustrations.

Conversion tables are provided at the end of each volume.

This manual will grow and change as its readers and users send in additional material, comments, and ideas for new approaches to grain storage problems and better ways to communicate with farmers. Your own ideas and conclusions are welcome. A form has been included for your comments. Please send us the results of your silo or dryer building. Let us know how you used the information and how it could be make even more useful to you. Tell us how you changed a plan to fit local needs.

Your experience will help us to produce manuals of growing usefulness to the world-wide development community.

REPLY FORM

For your convenience, a reply form has been inserted here. Please send it in and let us know how the manual has helped or can be made more helpful. If the reply form is missing from your book, just put your comments, suggestions, descriptions of problems, etc., on a piece of paper and send them to:

GRAIN STORAGE
3706 RHODE ISLAND AVENUE
MT. RAINIER, MD 20822
U.S.A.

ENEMIES OF STORED GRAIN

INTRODUCTION

In any given part of the world, grain can be attacked in a number of ways. For example, some farmers lose a lot of grain to birds and animals which are common to that area. Much of this loss occurs because local methods of grain drying and storage do not provide adequate protection.

It is not possible to provide a lot of detail here on all the enemies of stored grain simply because the list would have to be so long and would differ by area. But there are two major groups of stored grain enemies which are common to all parts of the world: insects and rodents. The material in this volume deals with controlling these pests.

The authors wish to make special note here of their intent to add a section to this volume which contains guidelines for non-chemical/organic control of stored grain pests. If you are experimenting with non-chemical and organic means of control, please let us know of your efforts.

1 Insects

This discussion of insects deals only with some of the insects that attack stored grain. It is designed to help you provide farmers with the information they need to control insect infestation in their stored grain. If you find insects in your area that are not discussed here, or if you require more information on insects in general, there are more detailed books which will help you name the pest and will give information on controlling the pest.

WHAT IS AN INSECT?

Adult insects have six legs. Farmers may see other insect-like creatures in or near their grain, but they are not insects if they have more or less than six legs. Spiders, mites, and scorpions have more than six legs, so they are not insects.

Most adult insects have two pairs of wings; some insects can fly and some cannot. All adult insects have three main parts to their bodies: head (front); thorax (middle); abdomen (behind). The legs and wings are attached to the thorax.

<FIGURE 1>

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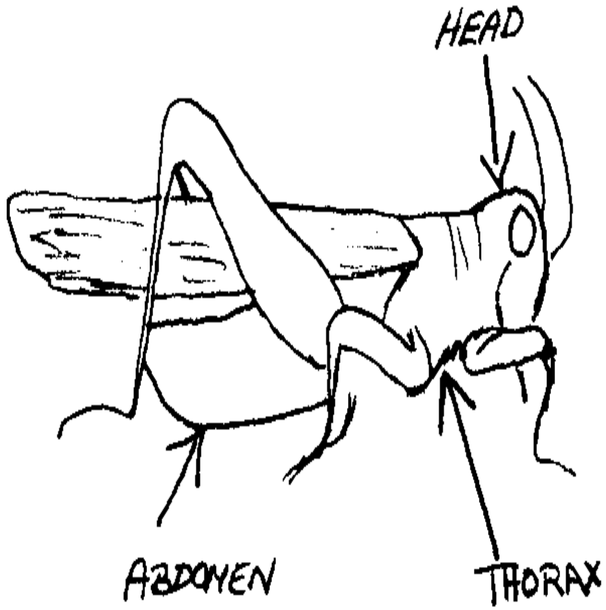

Some Other Facts About Insects:

*** Insects have no bones,and the soft inside parts are protected in a hard case called the exoskeleton.**

*** Insects bite off, scrape off, or chew food using their mandibles (jaws).**

*** Some insects are 25cm long. Most grain storage insects are only from 2 to 20mm long. The length of an insect is measured from the tip of the head to the end of the abdomen.**

INSECT LIFE CYCLE

<FIGURE 2>

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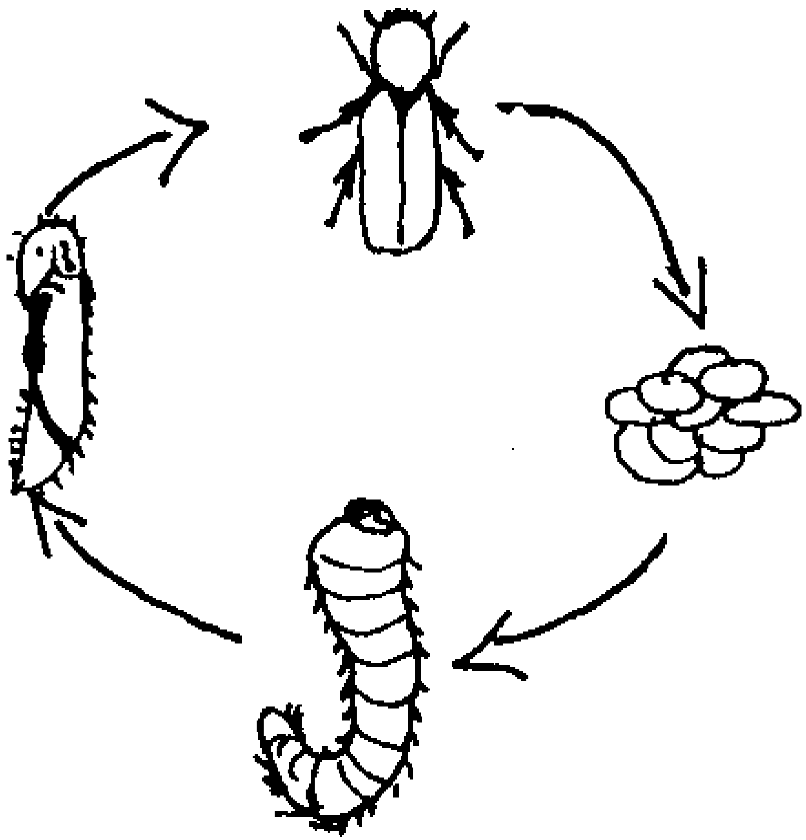

Humans grow from babies to children to adults. This is the human life cycle. Most grain insects grow from eggs to larvae to pupae to adults. These growth stages are the insects' life cycle.

It is not important for a farmer to know the names of the insects or the names of the stages in their life cycles. But it is important for him to be able to recognize insects at all these stages. Moreover, he must know how stored grain insects develop, so he will know where to look for signs of insects in his grain. Adult insects are easy to see, but larvae and eggs of insects often are not.

Eggs

Each female insect can lay many eggs. The number of eggs depends upon the kind of insect; some females lay hundreds of eggs. And each of these eggs could grow into a new adult. Some insects lay eggs on top of the grain; some insects lay eggs inside the grain. The eggs are laid in storage or in the field, depending upon the kind of insect.

Larvae

<FIGURE 3>

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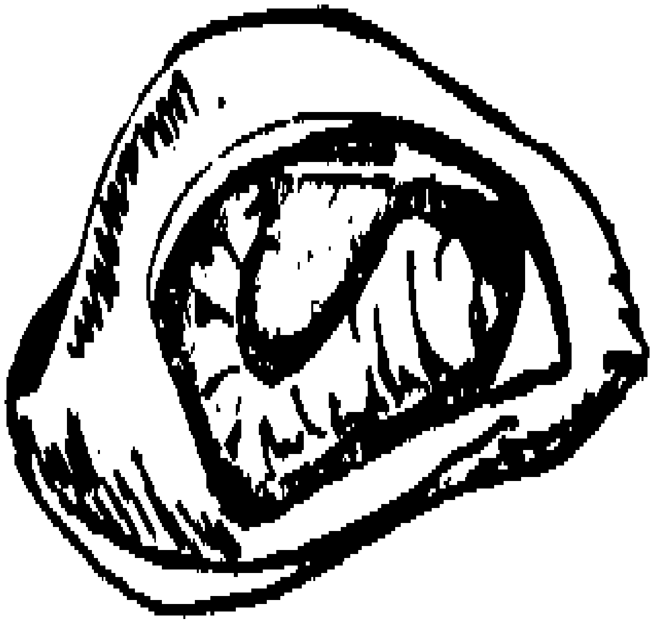

Eggs hatch into larvae. Larvae are often the big grain eaters. A larva growing inside a grain kernel eats out the inside of the kernel. Each larva is covered with a tough skin called the cuticle. The larva grows and the cuticle gets too small. The larva throws the cuticle away, keeps eating, and forms a new skin. This whole process might happen three or more times before the larva is full size and passes to the next stage.

Pupae

This is the transformation stage. Sometimes the larva forms a cocoon or other protective covering around itself as it goes into this stage. As a pupa, the growing insect needs no food and moves only in very small movements. It just slowly changes into an adult insect.

<FIGURE 4>

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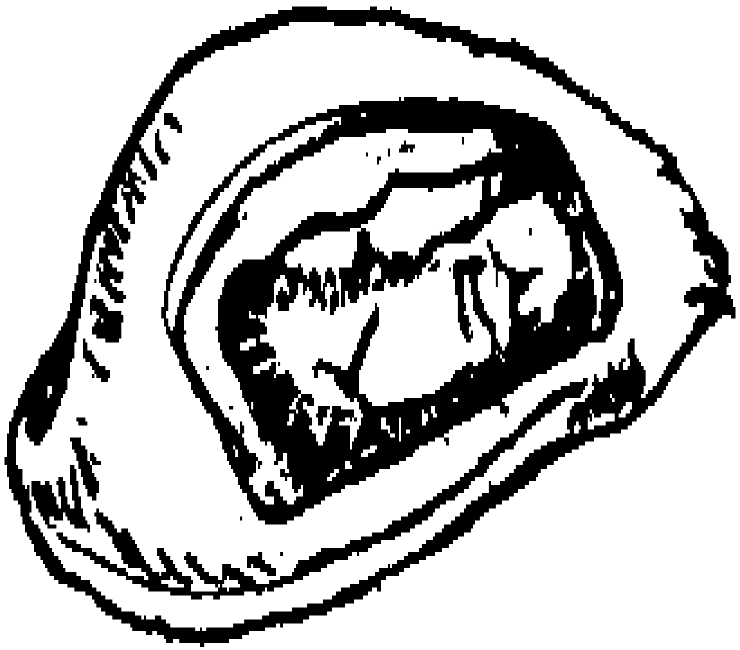

Adult

<FIGURE 5>

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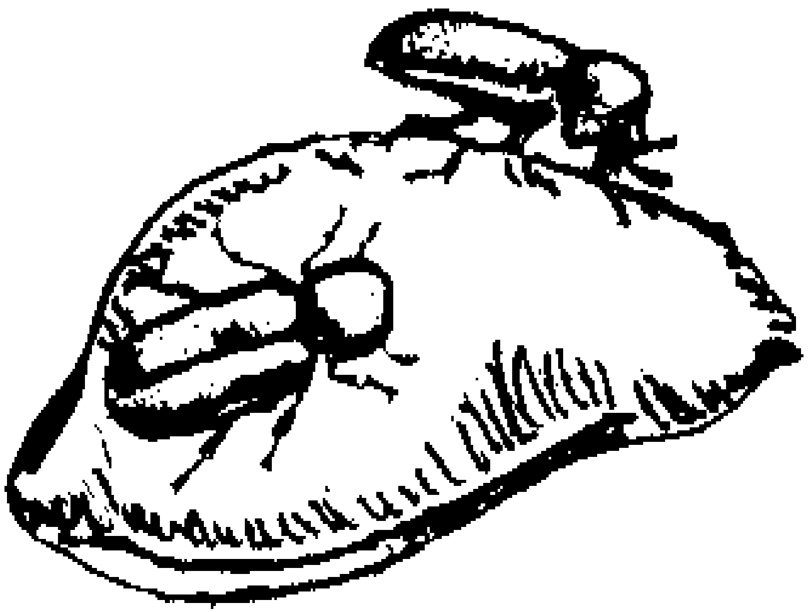
Adult



When all the adult characteristics are developed, the pupa throws off a last skin and the adult comes out. The new adult is pale and soft. It takes 2 - 72 hours for the cuticle of the adult to harden and take on adult coloring and markings.

HOW INSECTS GET INTO GRAIN

Insects get into grain in a number of ways, depending upon the kind of

insect:

*** Some insects infest the grain while it is still in the field -- before harvest and after (if the grain is being dried in the field).**

*** Some insects can fly from fields to stored grain and from stored grain to the fields. This type of insect is very dangerous because it can so easily get to the grain.**

<FIGURE 6>

51bp03c.gif (486x486)

* Farmers store grain year after year in the same sacks, containers, and buildings. Bins made of wood or woven grasses have cracks and spaces which fill up with dust, dirt, and broken grains. Insects live in these dirty places and infest the new grain right after it is put into the container.

* New grain is put into a storage building containing grain left

from the last harvest, grain already heavily infested.

* Grain goes from the field to the storage place in carts and wagons which were not cleaned after the last use.

WHY INSECTS INFEST GRAIN

Insects which infest grain also eat and live in other materials. Insects infest grain because grain provides food. Unfortunately, in too many cases, stored grain provides a perfect place for insects to live and grow because food, air, moisture, and heat are provided.

<FIGURE 7>

51bp04a.gif (600x600)

Food

Obviously, grain provides food. But grain provides food for insects in different ways. Some insects like certain kinds of grains better than others. Not all insects eat the same part of the grain kernel. How they eat the grain and the part of the grain they eat depends upon the type of insect.

Primary Pests. Some insects, such as the Angoumois Grain Moth, the lesser Grain Borer, and the Rice Weevil are primary pests. They attack the grain first. They are able to break down the hard seed coat of the whole grain. Their eggs are laid inside the kernel, and the growing larvae eat the inside of the kernel.

<FIGURE 8>

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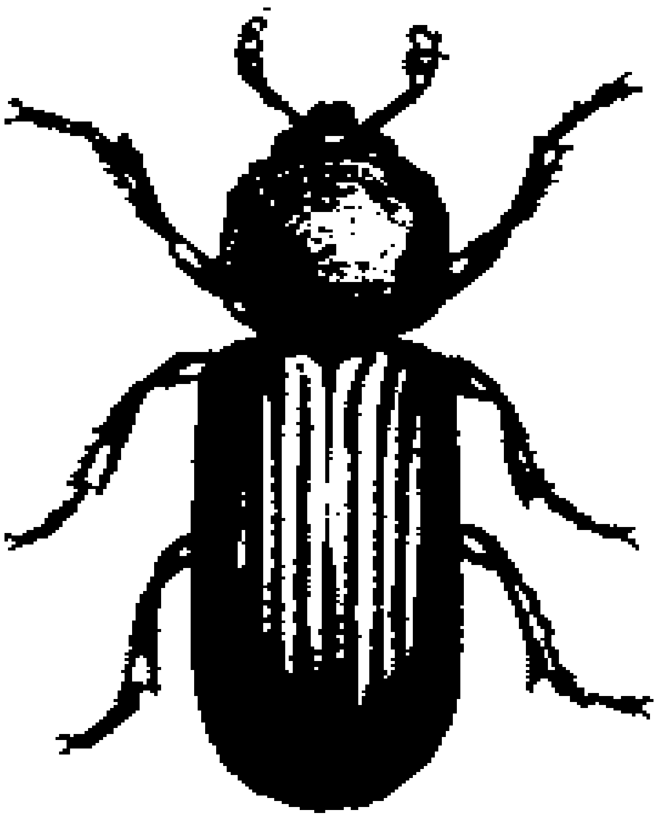

Secondary Pests. Other insects follow these first attackers. These are secondary pests. They feed on the grain that now has broken and cracked seed coats. The Rusty Grain Beetle is a good example of a secondary pest. This beetle will not attack healthy, undamaged grain, but it will attack spoiled grain. A farmer should know which beetles attack first and which do not. If a farmer sees a Rusty Grain Beetle in his stored grain, it is a sign that he should look for other, worse insect attackers.

<FIGURE 9>

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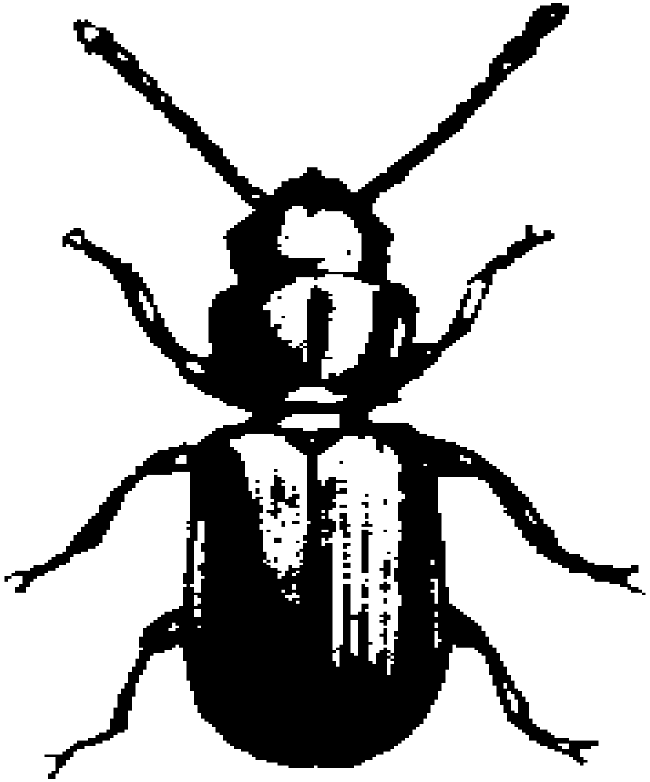

Tertiary Pests. There is even a third group of insects found in stored grain. These are the tertiary pests. They feed on

broken grains, grain dust, and powder left by the other groups. The Confused Flour Beetle is a tertiary pest of whole grains. Also, it is a primary pest of milled grains, such as flour.

<FIGURE 10>

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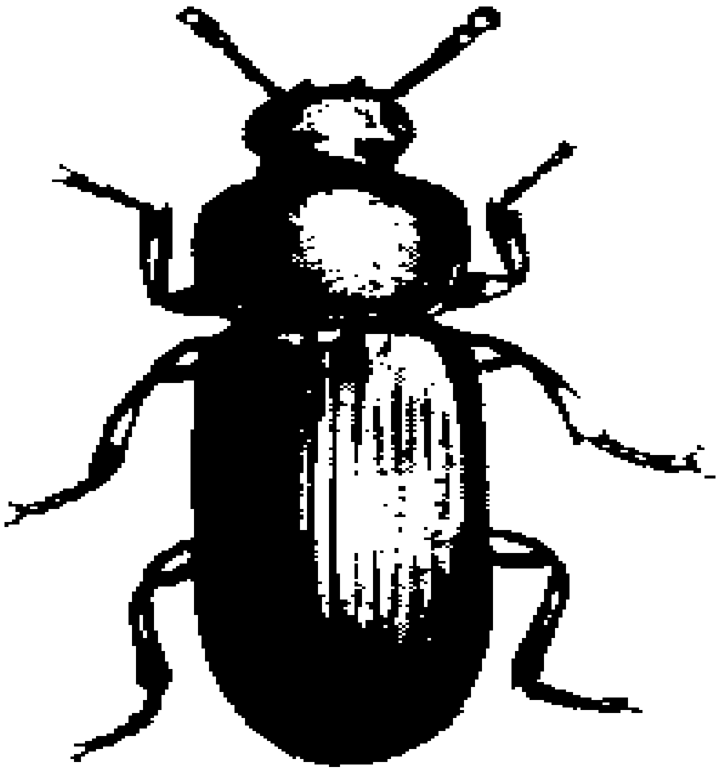

It is not important for a farmer to know the names of these insects, but he should know how the given insects eat and whether they attack grains already damaged. If he can read the signs left by the insects, he will be better able to find infestations before they become a major problem.

Air

Insects do require a certain amount of air containing oxygen to live. Storing grain in containers which keep out air is based on knowledge of this fact. Airtight storage will be discussed later. Briefly, in airtight storage, the respiration of the grain, and of insects in the grain, uses up the oxygen quickly; any insects present in the grain will die.

Moisture

Insects need some moisture to live, and they can get it from stored grain in several ways:

* Insects can take moisture from the air, just as grain can.

* Grain contains moisture which insects get when they eat it. The more moisture the grain contains, the better food it is for insects.

* Insects produce moisture and heat in the stored grain as they eat. The insect-infested grain then respires more quickly and produces more heat and more moisture. In a hot spot, where insects are active, grain releases a lot of moisture

into the grain mass. Insects can take this moisture into their bodies. When the hot spot becomes too hot, the insects will leave it and go to another part of the grain mass.

*** Insects can take moisture directly from the wet surfaces of the grain through special openings in their bodies.**

The fact that insects require a certain amount of moisture is important because it underlines the need for careful drying of grain before it goes into storage.

Heat

Insects live best within a certain temperature range. As the temperature in the grain gets lower, they become less active. At one point they stop reproducing. If the temperature goes below 5 [degrees] C they will die, depending on length of exposure and other conditions. As the temperature increases from 10-26 [degrees] C, depending upon the kind of insect, they become more and more active. They will reproduce very quickly in a grain hot spot, for example, until the grain gets too hot. Above 35 [degrees] C. they have a more difficult time living and die at 60 [degrees] C.

Try to keep stored grain as cool as possible.

COMMON GRAIN PESTS

There are many kinds of insects which can attack stored grain. But it is

a much smaller number of insects which cause the major insect problems in stored grain.

<FIGURE 11>

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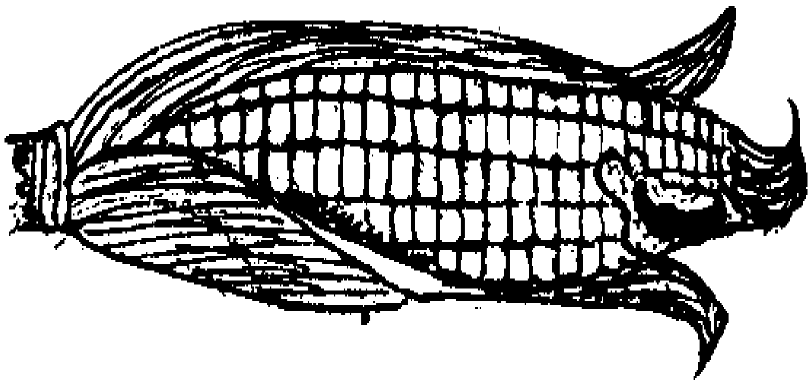

The following pages contain information on some major stored grain insect pests. Each insect is discussed on a separate page. This information should help farmers indentify the insects which are in their grain. Since the right control method often depends upon the kind of insect involved, and upon the characteristics of that insect's life cycle, each page gives a picture and description of the insect and other information on that insect's habits and life cycle.

GRANARY WEEVIL

Sitophilus granarius L.

<FIGURE 12>

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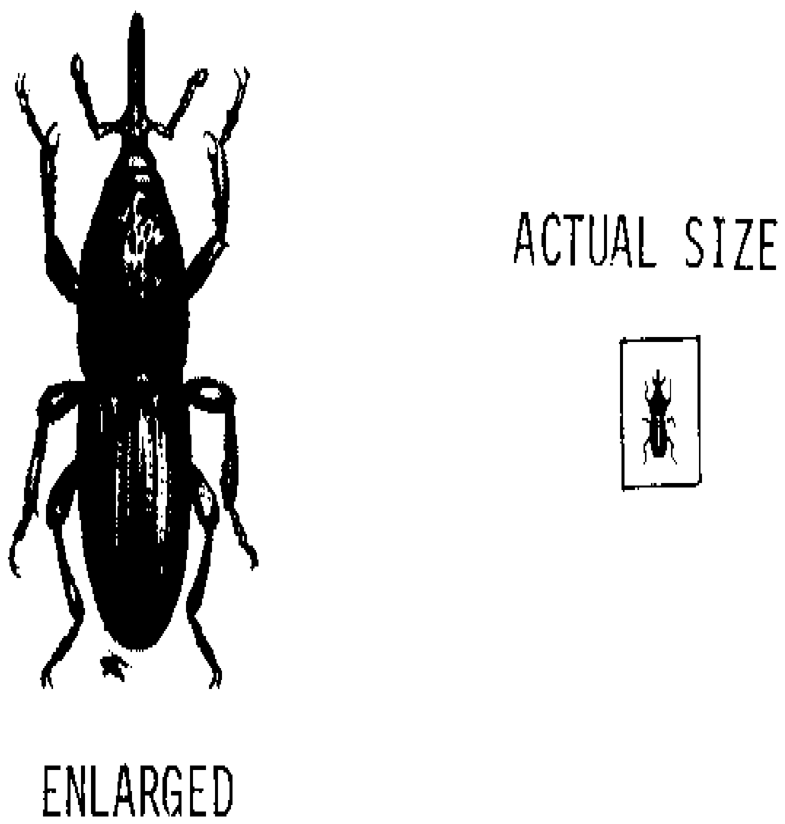

WHAT IT LOOKS LIKE

*** Brown or black**

*** Long, thin nose**

*** Strong jaws**

*** Long stripes on the body**

*** No wings**

*** 3.5mm long**

WHERE IT LIVES

*** In many kinds of grain**
*** In all parts of the world**

LIFE CYCLE

*** Develops from egg to adult in 4 weeks, in warm weather**

Eggs

*** Female lays 50 - 250 eggs inside the grain kernel after female makes hole with strong jaws**

<FIGURE 13>

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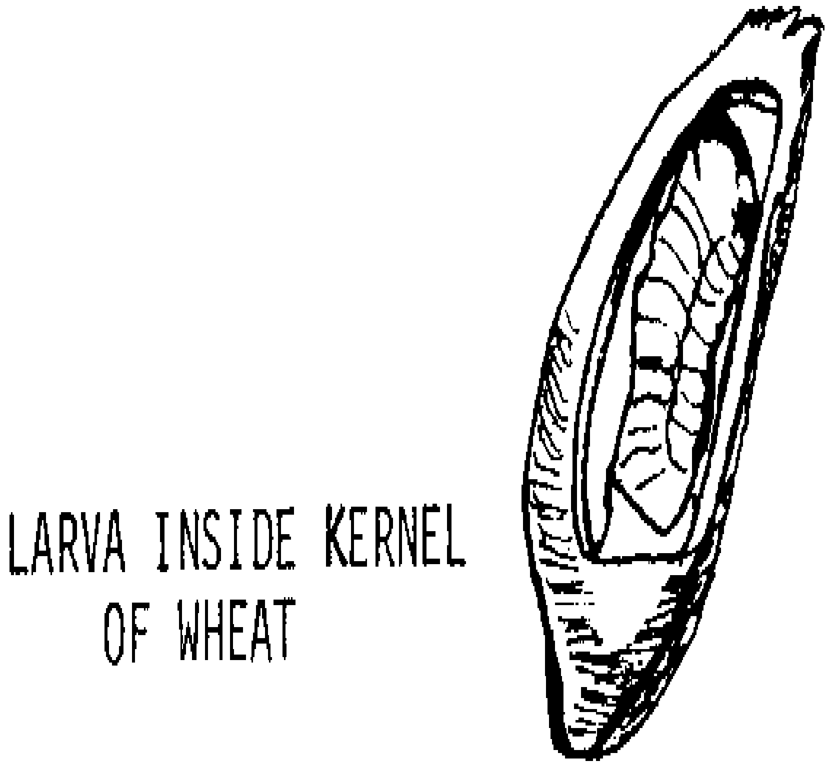

Larvae
*** Grow inside grain kernel**
*** See Picture**

<FIGURE 14>

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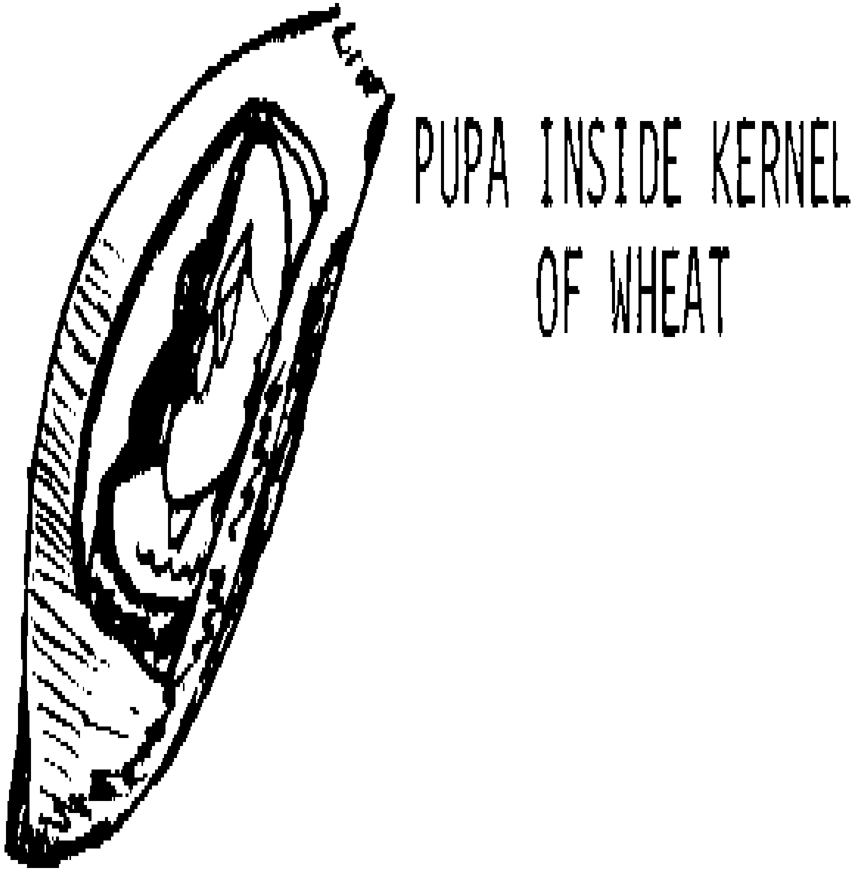

Pupae
*** See Picture**

<FIGURE 15>

51bp07d.gif (540x540)

ADULT EATING KERNEL OF WHEAT

Adults

*** Develop from egg to adult in 4 weeks, in warm weather**

*** Leave the seed and eats the**

kernel while getting ready to lay eggs
*** Adult lives 7-8 months**

NOTE: A Primary Pest. It looks a lot like the Rice Weevil. The Granary Weevil and the Rice Weevil are the only grain storage insects with long snouts (noses), so they are easy to see. The Granary Weevil cannot fly; the Rice Weevil can fly.

LESSER' GRAIN BORER
Rhyzopertha dominica F.

<FIGURE 16>

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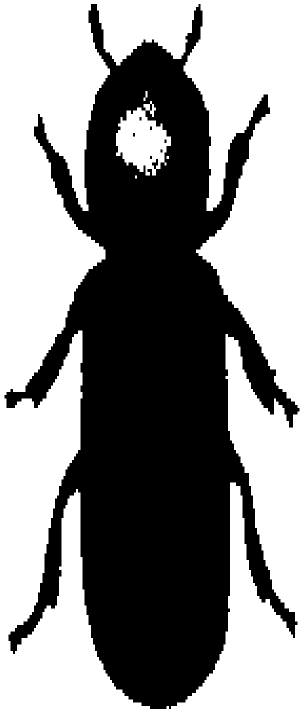
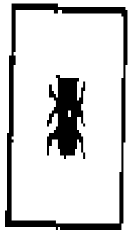


ADULT
ENLARGED

ACTUAL SIZE



WHAT IT LOOKS LIKE

*** Shiny, dark brown or black**

* Head turned down under body
* Strong jaws which cut wood
* 2.5 to 3mm long

WHERE IT LIVES
* In warm places all over world
* In many kinds of grain

LIFE CYCLE
* Life Cycle is completed in
about 5 weeks
* Each female lays from 300-500 eggs

Eggs
* Laid on the surface of the grain or
in spaces between grains
* Hatch in a few days

<FIGURE 17>

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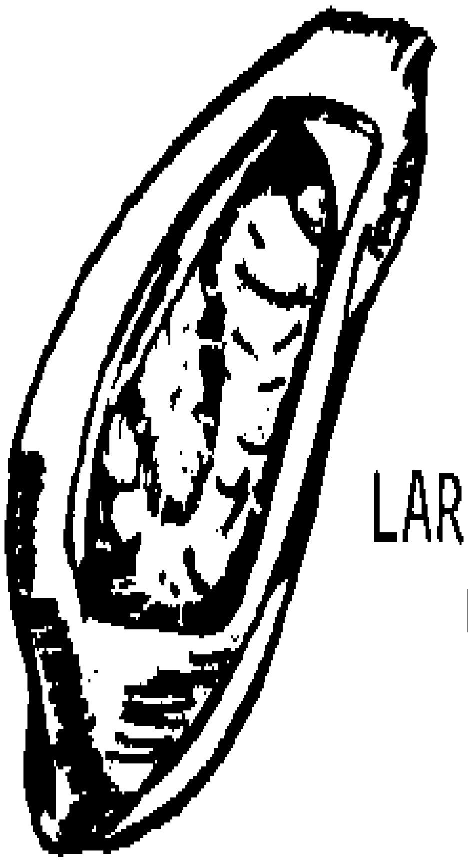


LARVA IN KERNEL OF WHEAT

Larvae

*** Crawl around grain eating flour left by the boring of adult beetles**

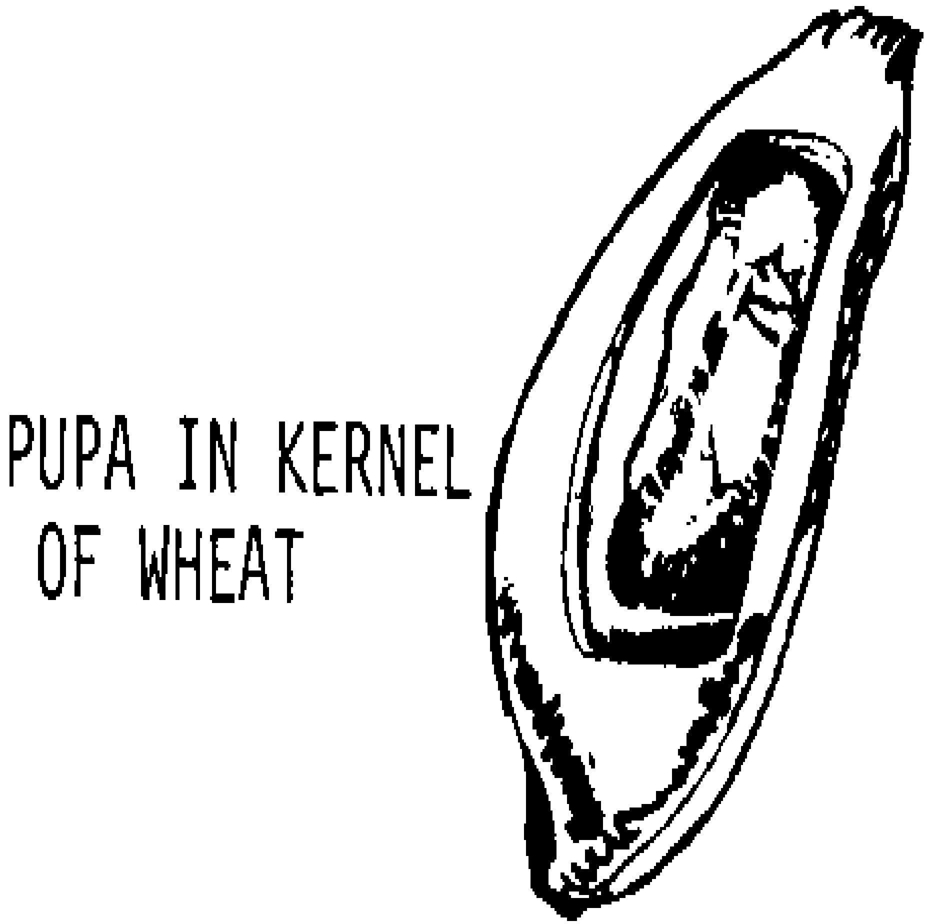
*** Bore holes in damaged grains**

*** Finish growing inside grain kernel**

*** Picture of larva inside kernel of wheat. See Picture**

<FIGURE 18>

51bp08c.gif (486x486)



Pupae
*** See Picture**

<FIGURE 19>

51bp08d.gif (486x486)

Adults
*** Cut their way out of the kerne**

* Feed on grain

NOTE: A Primary Pest, both the beetles and the larvae of the Lesser Grain Borer are very dangerous insect pests. They bore holes in the grain and leave behind a powder from the chewed-up grain. Here is a picture which shows kernel of wheat full of holes made by the boring and feeding of the adult and the larvae.

SAW-TOOTHED GRAIN BEETLE
Oryzaephilus surinamensis L.

<FIGURE 20>

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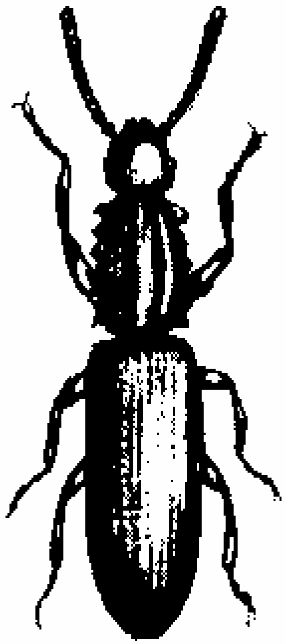
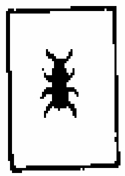


ADULT
ENLARGED

ACTUAL SIZE



WHAT IT LOOKS LIKE

*** Narrow, flat, small, dark brown**

*** 3.5 mm long**

WHERE IT LIVES

* In sorghum, maize, and other cereals and flour

HOW IT GROWS

* Grows from egg to adult in 3 to 4 weeks in warm weather
* Each female lays about 300 eggs

Eggs

* Laid among the grains
* Hatch in 3 to 5 days

<FIGURE 21>

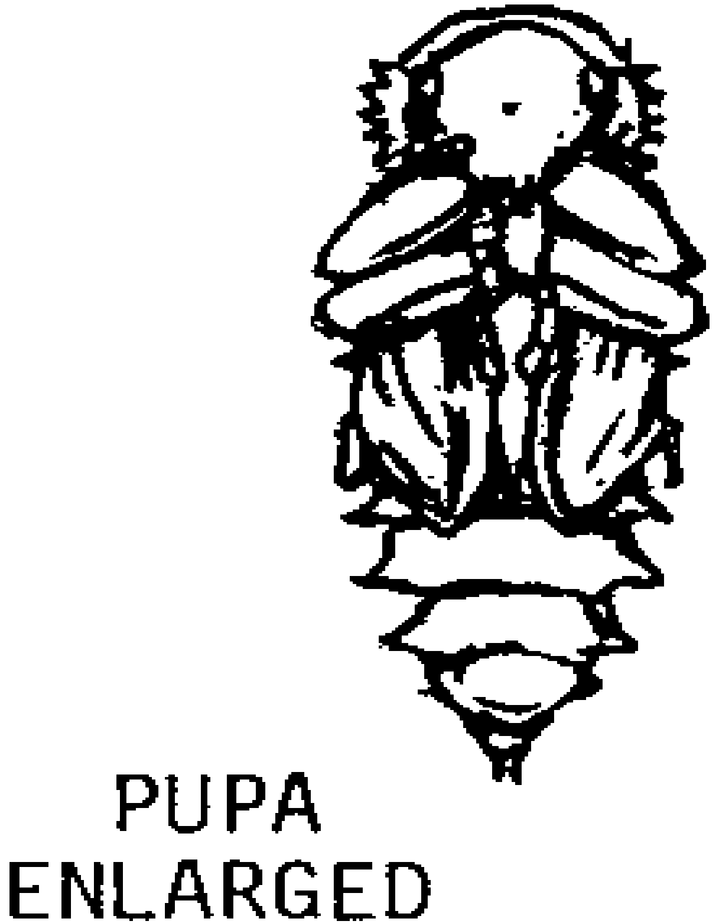
51bp09b.gif (486x486)

LARVA
ENLARGED

Larvae
*** Are straw colored**
*** Crawl among the grain eating broken kernels**
*** Grow in this stage about 4 weeks**

<FIGURE 22>

51bp09c.gif (486x486)



Pupae
*** Form in a cocoon**
*** See Picture**

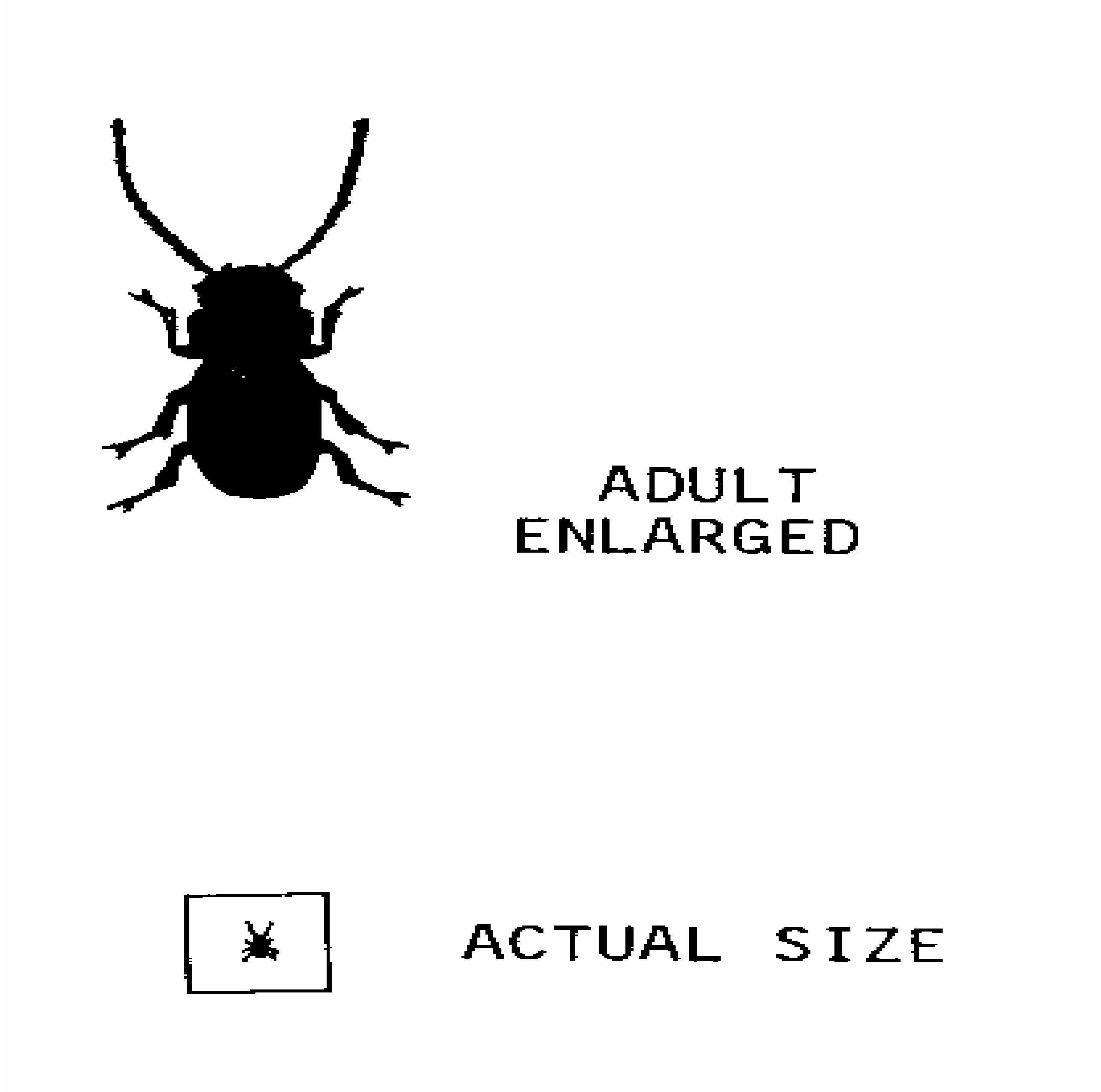
Adults

*** Adults live from 6 months to 3 years**

FLAT GRAIN BEETLE
Laemophloeus pusillus Schonherr

<FIGURE 23>

51bp10a.gif (600x600)



WHAT IT LOOKS LIKE

* **Long antennae (feelers)**

* Reddish-brown, flat
* 1 - 2mm long

WHERE IT LIVES

* In produce which is dusty, contains broken grain, or is already infested

HOW IT GROWS

* Grows from egg to adult in 5 weeks

Eggs

* Laid in cracks in grain or in spilled grain

<FIGURE 24>

51bp10b.gif (600x600)

Larvae
*** Yellowish-brown**

* Like to eat the germ of cereal grains
* May not eat any other part of grain
* Like to eat grain having mold on it

Pupae
* Transform in a cocoon

Adults
* Live from 6 - 12 months

NOTE: The flat Grain Beetle can be a primary pest. But if you find this beetle, you know that other, more dangerous insects are in the grain. Often you find the Flat Grain Beetle in grain already damaged by the Rice Weevil.

ANGOUMOIS GRAIN MOTH
Sitotroga cerealella Olivier

<FIGURE 25>

51bp11a.gif (600x600)

ENLARGED

ACTUAL SIZE

WHAT IT LOOKS LIKE

*** Light, yellow-brown**

* 8-10mm long
* 15mm from tip of wing to wingtip
* Fringe on back wings

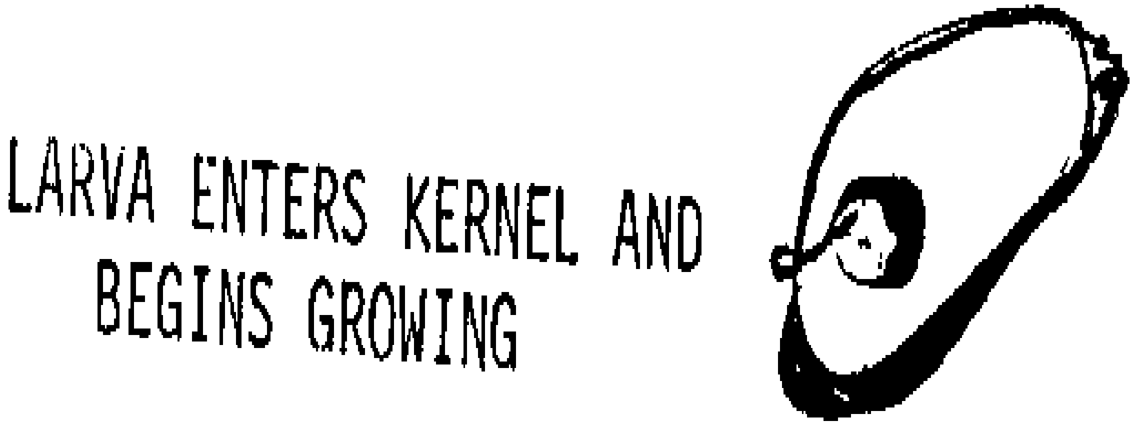
WHERE IT LIVES
* Attacks all grains in storage and in the field
* In all parts of the world

LIFE CYCLE
* Adults do not live long and do not eat
Each female adult lays 50-100 eggs

Eggs
* Laid on the surface of grain in the field or in storage

<FIGURE 26>

51bp11b.gif (300x600)



Larvae
*** Eat into kernel after hatching**
*** Grow inside kernel for 5 weeks**
*** Eat inside to the seed coat and they cut out part of a circle (door) in the seed coat**

<FIGURE 27>

51bp11c.gif (300x600)

Pupae
*** Form inside a cocoon near the door cut by the larvae**

<FIGURE 28>

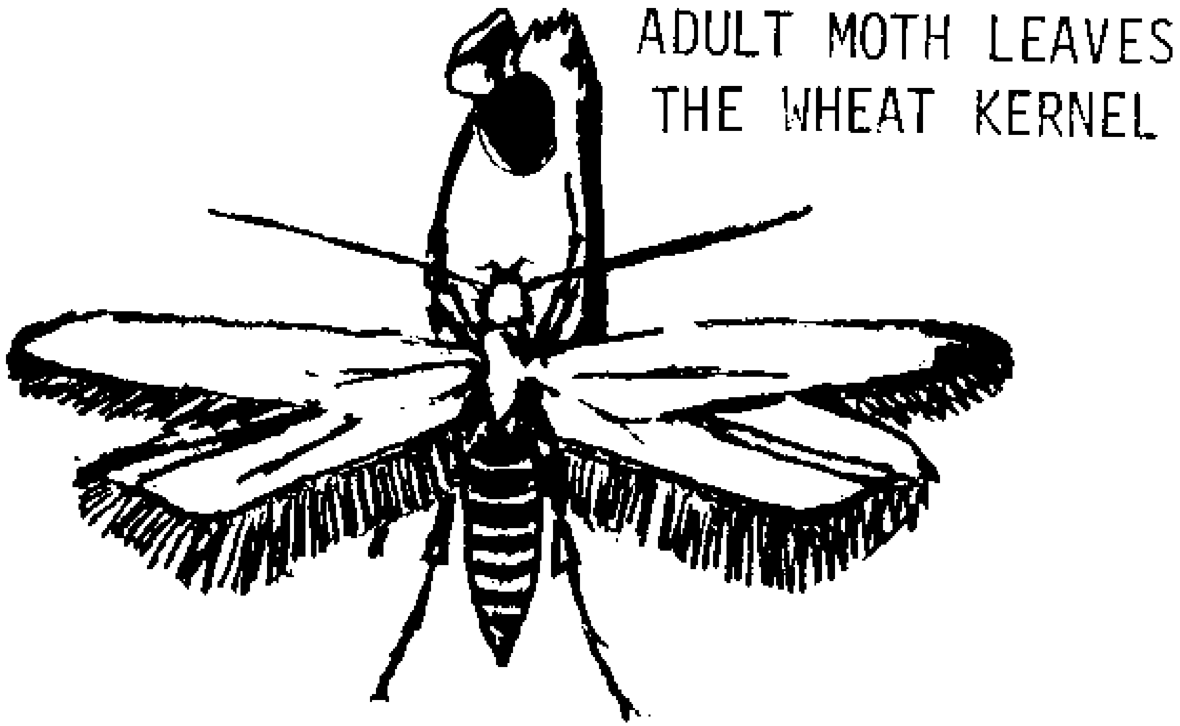
51bp11d.gif (300x600)

PUPA IN KERNEL OF WHEAT

Adults
*** Push out through the door prepared by larvae**
*** Lay eggs on the stored grain or fly to the fields and lay eggs on grain there**

<FIGURE 29>

51bp11e.gif (400x600)

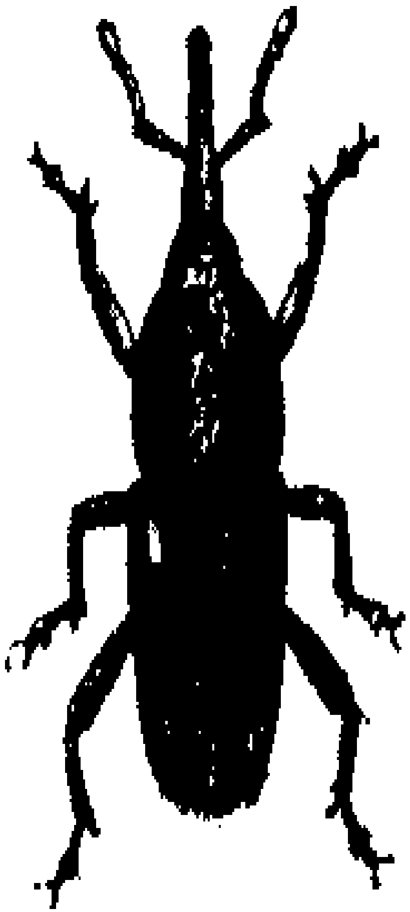


NOTE: PRIMARY PEST

RICE WEEVIL
Sitophilus oryzae L.

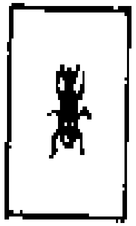
<FIGURE 30>

51bp12a.gif (600x600)



ADULT
ENLARGED

ACTUAL SIZE



WHAT IT LOOKS LIKE

*** Reddish-brown or black**

* May have 4 light spots on its back
* Long nose is easy to identify
* 2.5mm long

WHERE IT LIVES

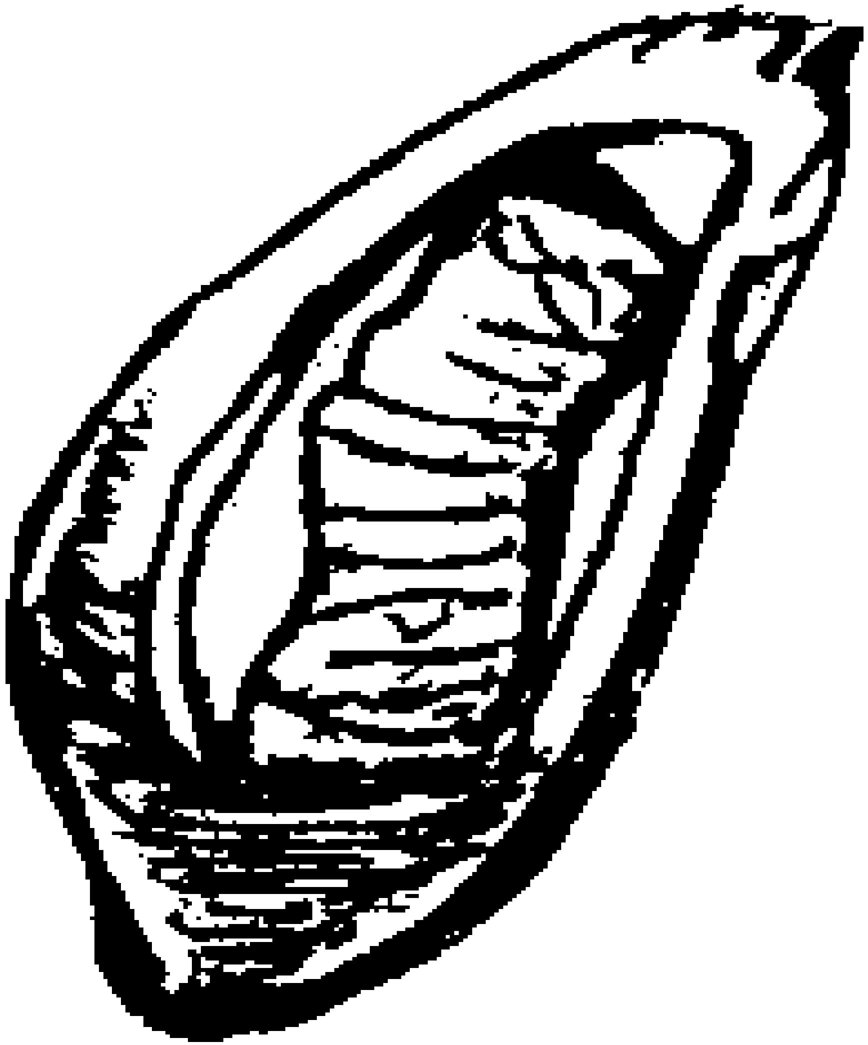
* In warm places
* In sorghum, maize, and other stored grain

HOW IT GROWS

* Female lays 300-400 eggs

<FIGURE 31>

51bp12b.gif (600x600)



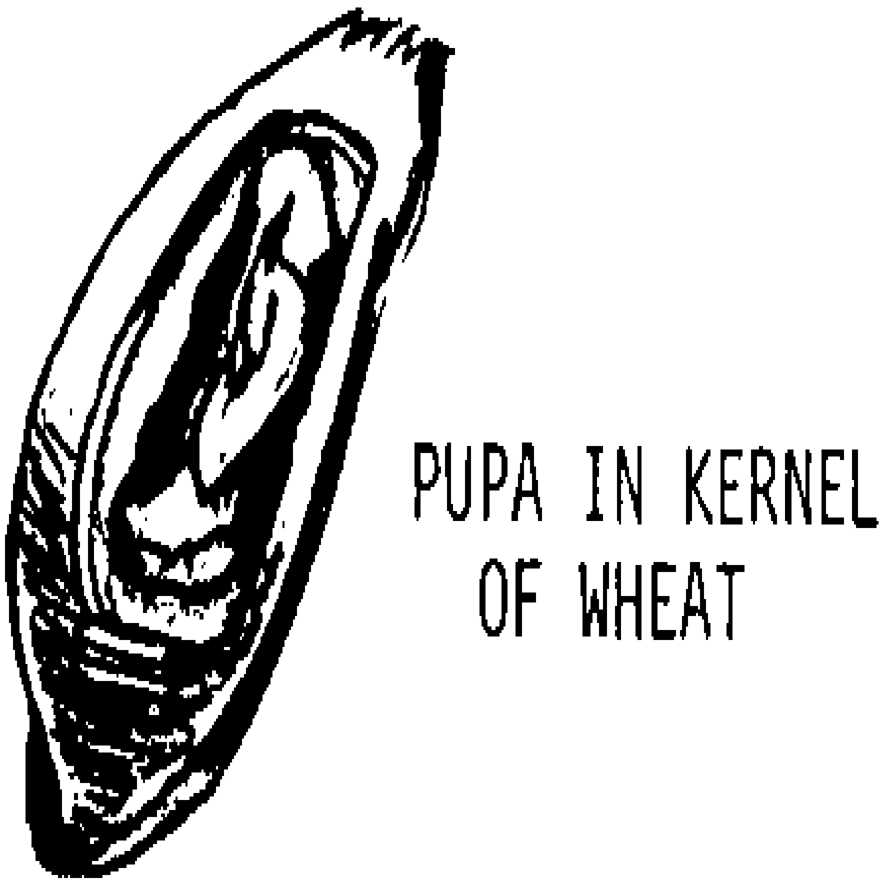
Eggs

*** Laid inside the grain kernel**

*** Sealed into the hole with secretion which makes them difficult to see**

<FIGURE 32>

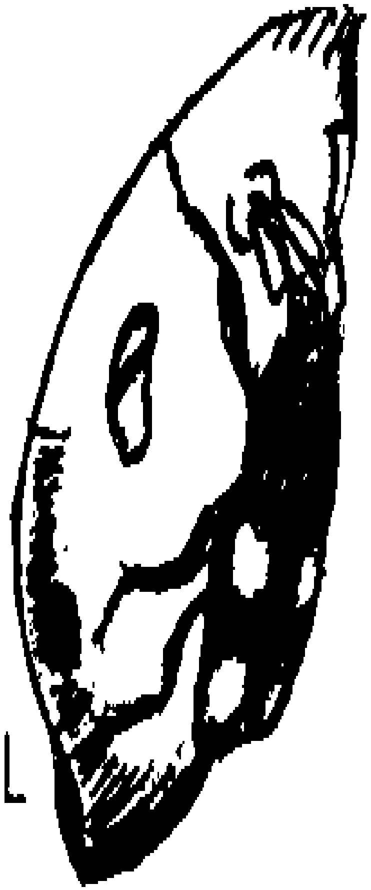
51bp12c.gif (486x486)



Larvae
*** Have no legs and are white**
*** Grow inside grain kernels and do most of the damage**
*** Stay in larval stage about 5 weeks**

<FIGURE 33>

51bp12d.gif (486x486)



ADULT EATING KERNEL OF WHEAT

Adults

*** Leave the kernels. Half kernel is eaten and other half is poor quality**

*** Feed on the seeds**

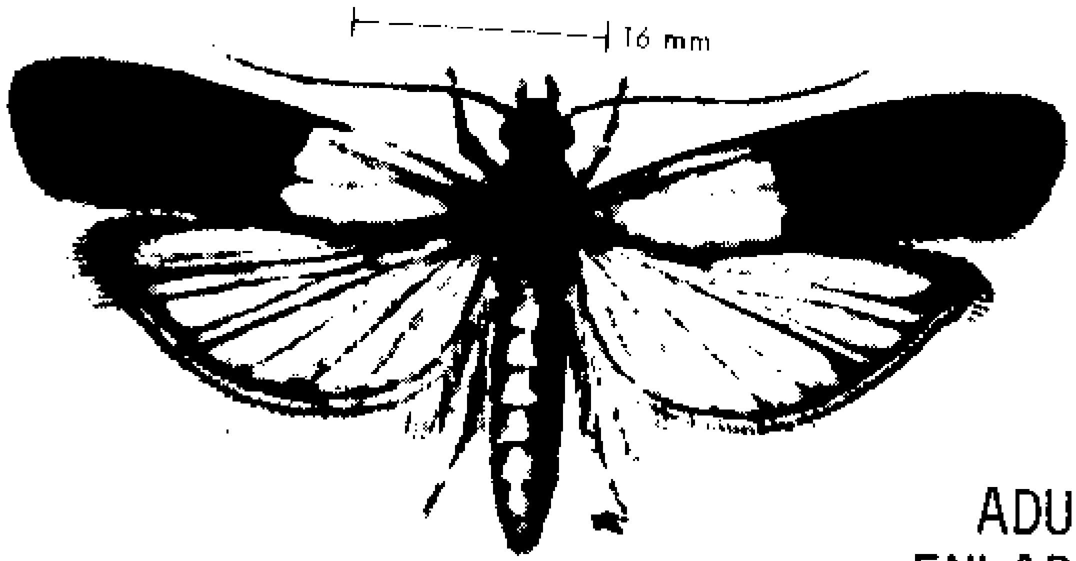
*** Looks like the Granary Weevil, but this weevil can fly**

NOTE: PRIMARY PEST. It can fly. It flies from grain storage places to the fields and back again. It can infest grain again and again.

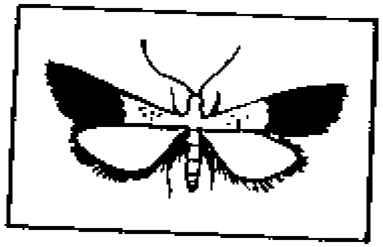
INDIAN-MEAL MOTH
Plodia interpunctella Hbn.

<FIGURE 34>

51bp13a.gif (600x600)



ADULT
ENLARGED



ACTUAL SIZE

WHAT IT LOOKS LIKE

*** Reddish-brown outer wings**

* Whitish-gray wings next to body
* 16mm from tip of one wing to
tip of the other
* Easy to see in grain

WHERE IT LIVES
* In broken grains and flour.
Also can attack whole gains
* In all parts of world

HOW IT GROWS
* Grows from egg to adult in
6-8 weeks
* Each female lays 200-300 eggs

Eggs
* Laid on food or grain
* Hatch into small, white larvae

<FIGURE 35>

51bp13b.gif (486x486)

Larvae
* Eat embryo or germ of grain
* Spin thread while they eat
* Dirty white color
* Sometimes look pink or green
* Spin a cocoon

Pupae

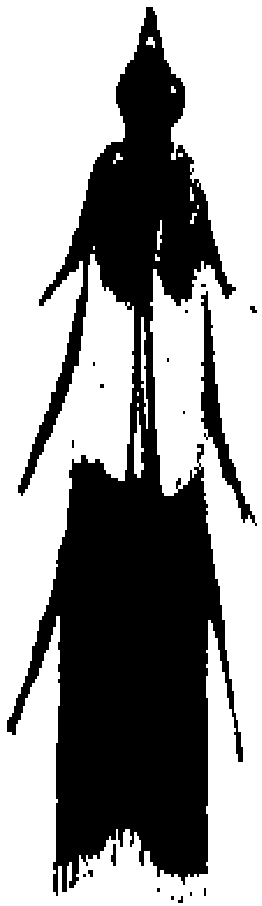
*** Light brown**

*** Develop in a cocoon**

<FIGURE 36>

51bp13c.gif (486x486)

ADULT WITH
WINGS FOLDED



Adults
*** Usually attack grain already attacked by other insects**
*** Live less than 14 days**

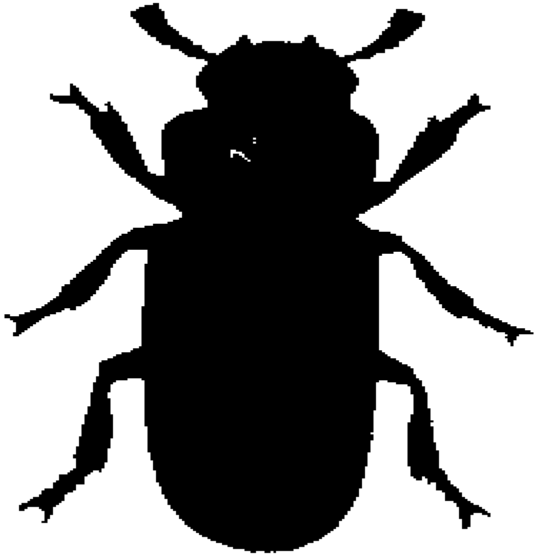
NOTE: Checking and moving grain from time to time is good protection against this insect. Also, the Indian-Meal Moth is attacked

by the parasite Bracon hebetor Say.

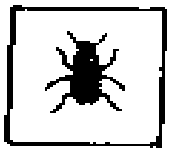
CONFUSED FLOUR BEETLE
Tribolium confusum J. du Val

<FIGURE 37>

51bp14a.gif (600x600)



ADULT
ENLARGED



ACTUAL SIZE

WHAT IT LOOKS LIKE

*** Shiny, reddish-brown, flat**

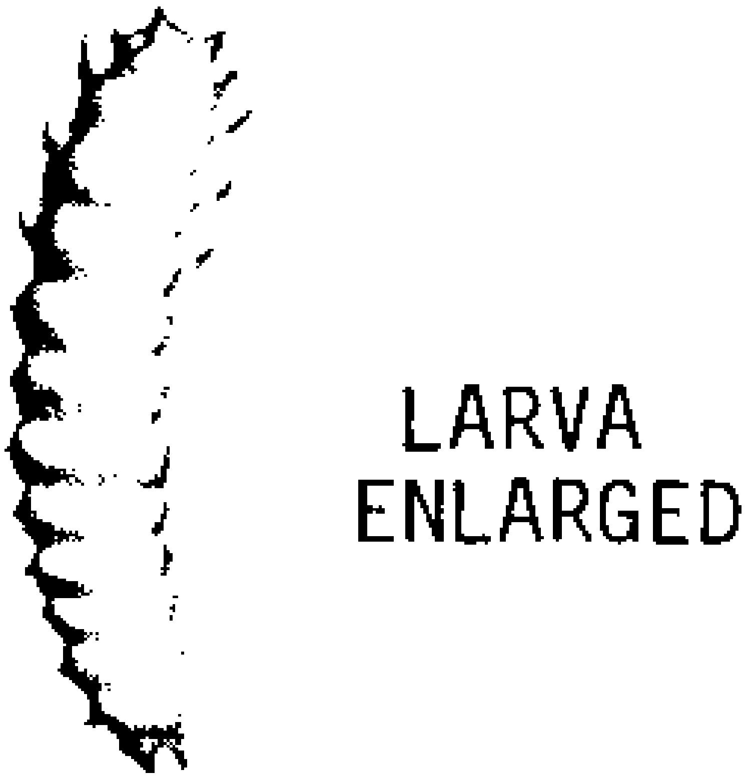
* 3-4mm long

WHERE IT LIVES
* In all parts of the world
* In storage places and flour mills

HOW IT GROWS
* Changes from egg to adult in 6 weeks in warm weather
* Female lays 450 eggs
* Eggs are sticky and stick to boxes, sacks, and storage containers

<FIGURE 38>

51bp14b.gif (486x486)



Larvae
*** Larvae eat flour, grain dust, and broken surfaces of grain kernels**

Pupae
*** First white, then change to**

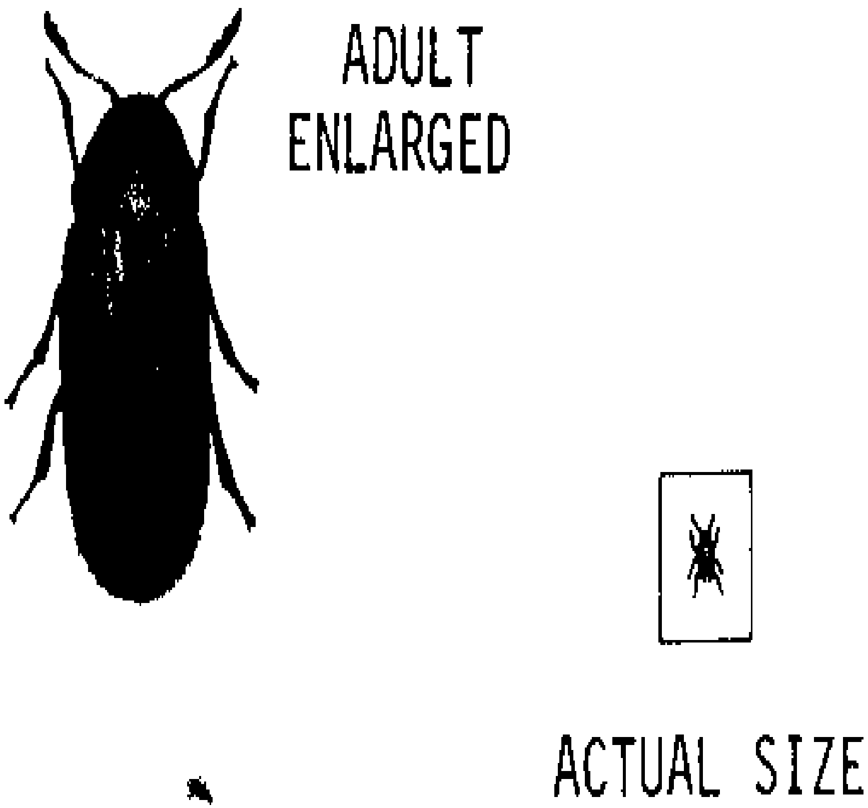
yellow and then to brown color

Adults
*** Live about 1 year**

DRUGSTORE BEETLE
Steaobium paniceum L.

<FIGURE 39>

51bp15a.gif (486x486)



WHAT IT LOOKS LIKE
* Small, fat, reddish colored
* Body covered with soft hairs

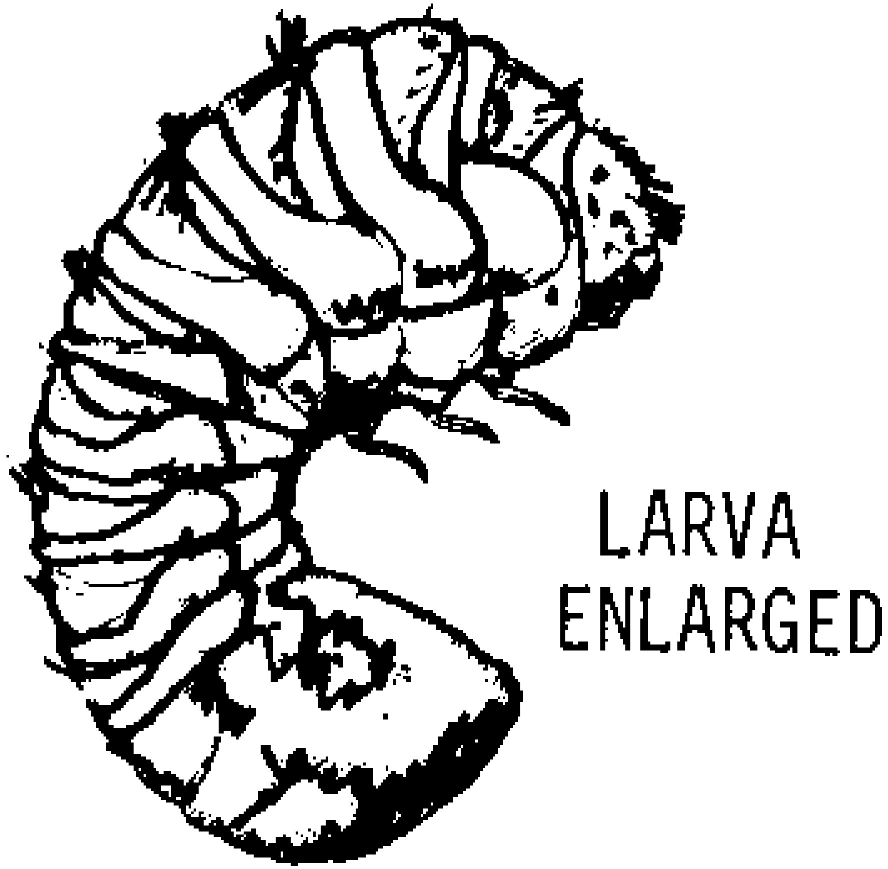
WHERE IT LIVES
* In many kinds of stored grain
* In all parts of the world

LIFE CYCLE
*** Develops from egg to adult in 6-8 weeks**
*** Each female lays about 100 eggs**

Eggs
*** Laid in any dry food substance**

<FIGURE 40>

51bp15b.gif (486x486)

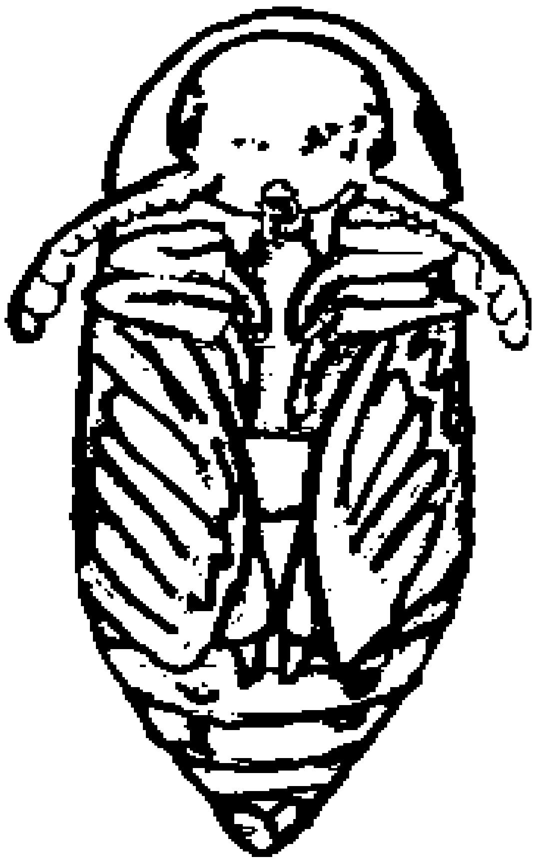


Larvae
*** Small and white**
*** Enlarged picture**

<FIGURE 41>

51bp15c.gif (486x486)

PUPA
ENLARGED



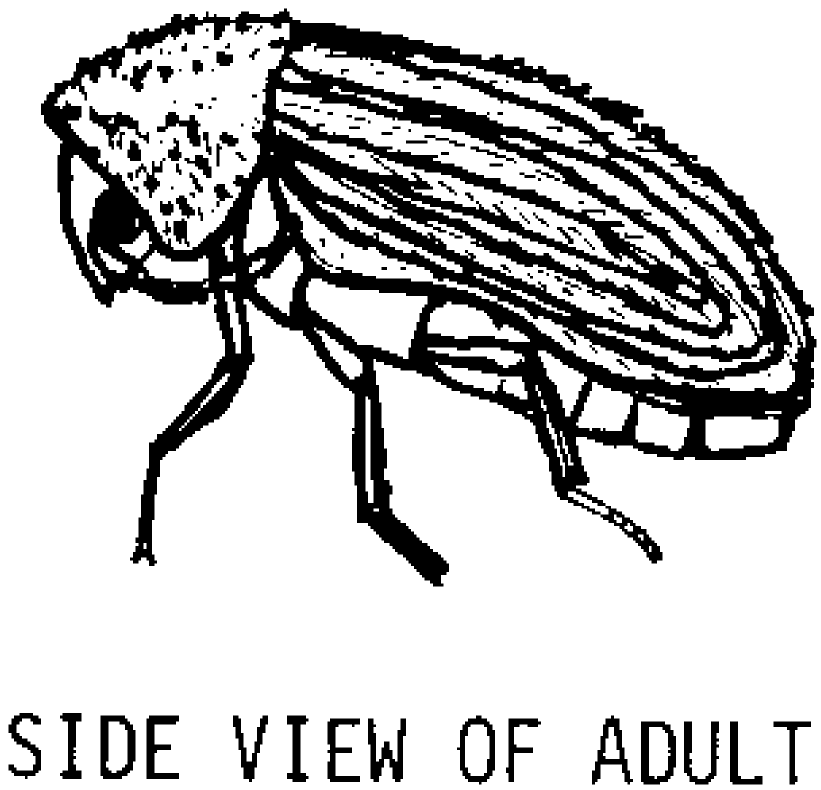
Adult
* Looks like cigarette Beetle
* Adults live only 2 to 4 weeks

NOTE: Protect grain from this beetle by checking the stored grain often. This beetle never attacks grain unless the grain

has been in storage for a long time without being checked or moved.

<FIGURE 42>

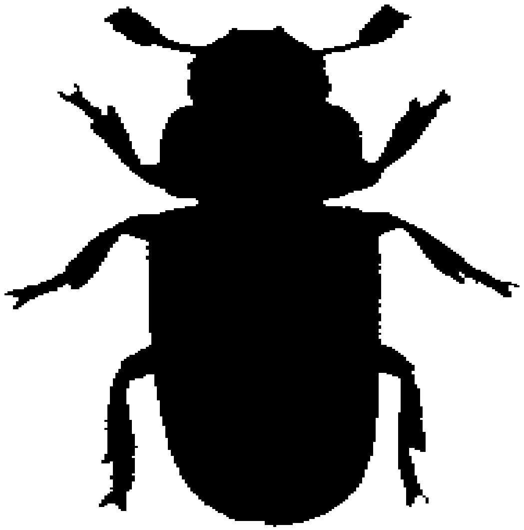
51bp15d.gif (486x486)



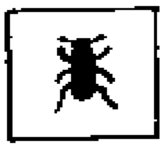
RED FLOUR BEETLE
Tribolium castaneum Hbst.

<FIGURE 43>

51bp16a.gif (540x540)



ADULT
ENLARGED



ACTUAL SIZE

WHAT IT LOOKS LIKE
* 3-4mm long
* Looks like Confused Flour Beetle

WHERE IT LIVES

* In warm countries
* In grain dust and broken grains

HOW IT GROWS

* Female lays 400 - 500 eggs

Eggs

* Laid in dust, flour

<FIGURE 44>

51bp16b.gif (486x486)

LARVA
ENLARGED

Larvae
*** Stay in larval stage 5 weeks**
*** Feed on stored produce**
*** Whitish-yellow color**
*** Has two, dark, upturned, pointed projections at back end of body**

Adults

*** Eat and breed the same way as Confused Flour Beetle**

*** Give terrible smell and taste to grain in which they live**

KHAPRA BEETLE

Trogoderma granarium Everts

<FIGURE 45>

51bp17a.gif (540x540)

ADULT
ENLARGED

ACTUAL SIZE

WHAT IT LOOKS LIKE
*** Brown or black color**
*** Body has many fine, yellowish hairs all over**

* 1.5 - 3mm long

WHERE IT LIVES

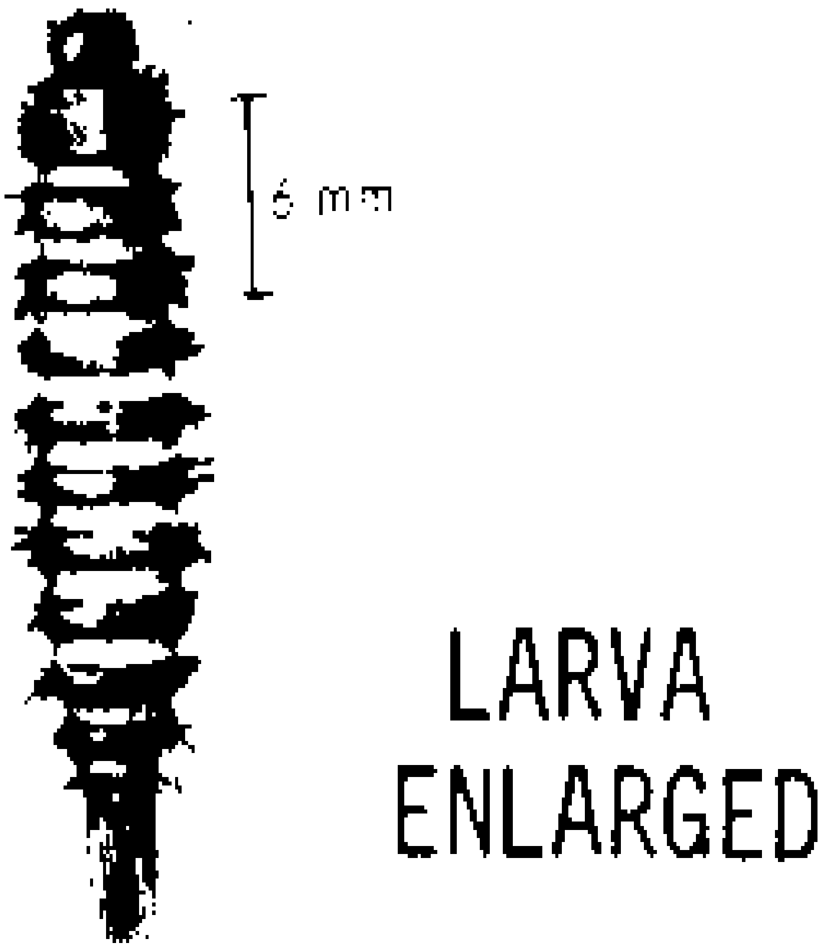
* In stored grain
* In all parts of the world, particularly warm places

HOW IT GROWS

* Grows from egg to beetle in 4 - 6 weeks in good growth conditions
* Female lays 40 - 70 eggs each

<FIGURE 46>

51bp17b.gif (540x540)



Larvae
* Can take up to a year to hatch
* Yellow-white and have many hairs
* Leave many hairs in the grain

* Grow to 6mm in the larval stage. Takes about 3 weeks
* Are able to live without food or water for long periods
* Appear on surface of stored grain
* Crawl into cracks of buildings and bins. Hard to reach even with insecticide

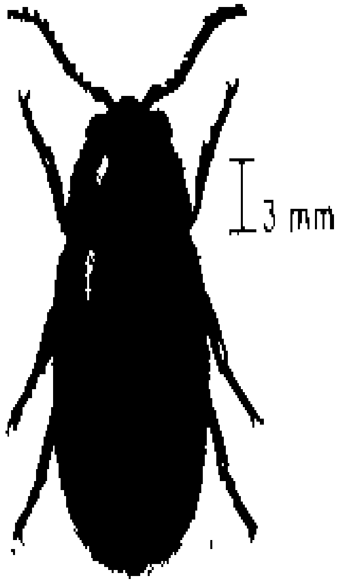
Adults
* Life cycle can take years while under poor conditions
* Breed quickly under good conditions
* Live only about 14 days

NOTE: Primary Pest. Grain damaged by the Khapra beetle looks like grain which has been attacked by the Lesser Grain Borer.

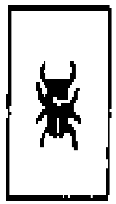
CIGARETTE BEETLE
Lasioderma serricorne F.

<FIGURE 47>

51bp18a.gif (540x540)



ADULT
ENLARGED



ACTUAL SIZE

WHAT IT LOOKS LIKE

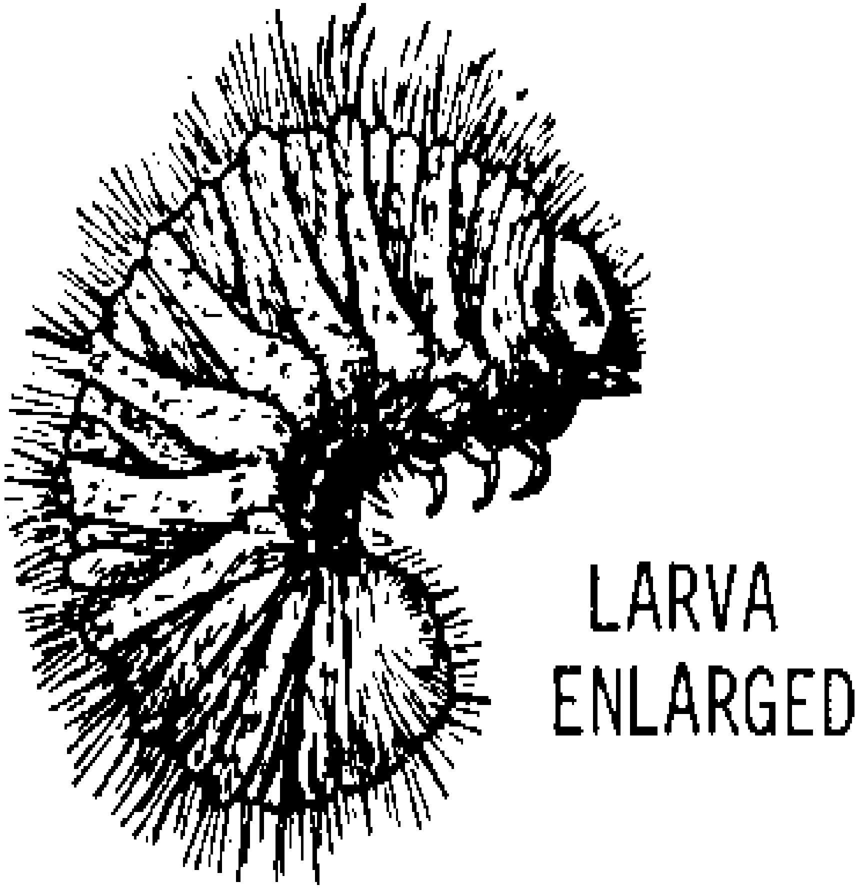
* Reddish-yellow or brown
* Head bent down toward body
* 3mm long

WHERE IT LIVES
*** In stored products all over the world**
*** In grain left too long in storage in the original sacks**

LIFE CYCLE
*** Develops from egg to adult in 6 to 8 weeks**
*** Female lays about 100 eggs**

<FIGURE 48>

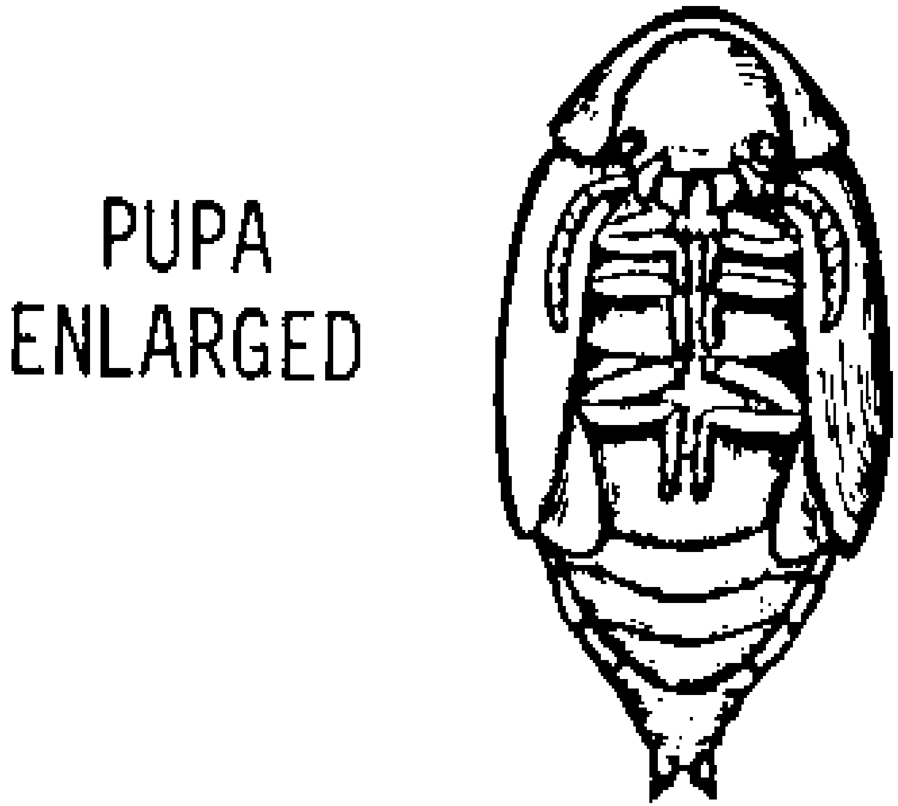
51bp18b.gif (486x486)



Larvae
*** See Picture**

<FIGURE 49>

51bp18c.gif (486x486)

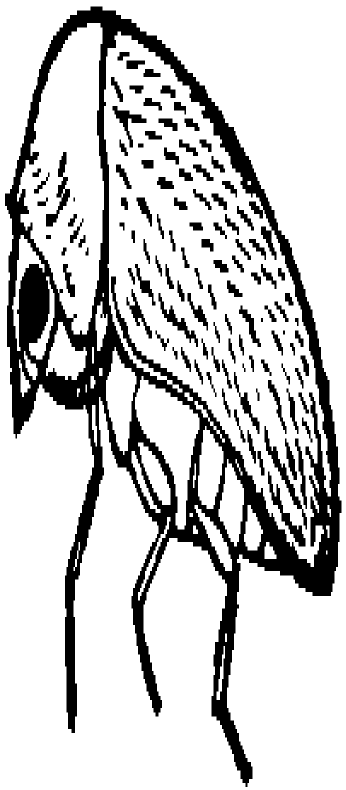


Pupae
*** See Picture**

<FIGURE 50>

51bp18d.gif (486x486)

SIDE VIEW OF ADULT

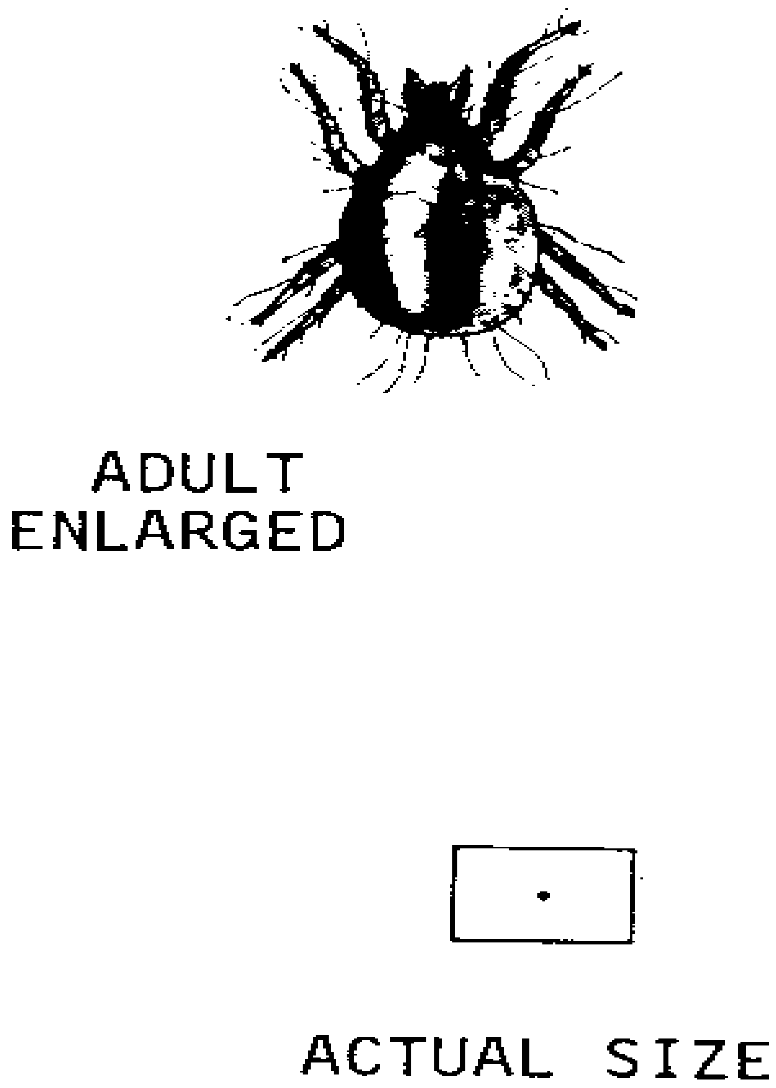


Adult
*** Looks like adult Drugstore Beetle**
*** Adults live from 2 to 4 weeks.**

FLOUR OR GRAIN MITE
Acarus siro L.

<FIGURE 51>

51bp19.gif (540x540)



WHAT IT LOOKS LIKE
* Pale, gray-white color
* Smooth bodies with lots of hairs
* Breed quickly
* Real size no bigger than the dot of an "i"

WHERE IT LIVES
* In warm, wet places
* In broken grain and flour

WHAT TO LOOK FOR
* Fluffy, light-brown masses on the floor around sacks of stored grain

These masses are the old skins and dead bodies of mites. If you see these masses, there are many, many mites in the grain

WHAT MITES DO TO GRAIN
* They do not eat much grain
* When there are many mites, the grain gets warmer and wetter
* When there are many mites, a bad smell develops in the grain
* Flour which has had large numbers of mites in it is no good for baking

WHAT TO DO ABOUT MITES
* Screen and fan the grain if you find mites.
* Dry grain very well before storing.

*** Dust sacks of flour or other milled cereal products with recommended insecticide. Place sacks so they do not rest directly on the floor.**

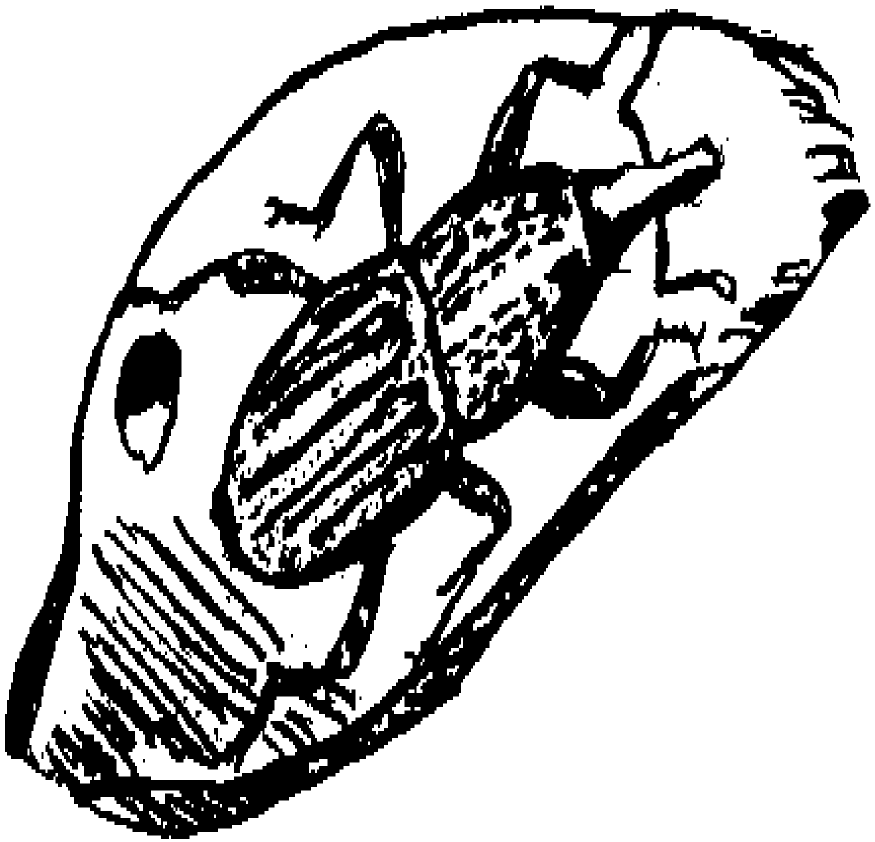
CONTROL OF INSECTS IN STORED GRAIN

INTRODUCTION

Adult insects are easy to see in grain. They live outside the grain, and they are darker in color. Often a farmer waits until he sees adults before he takes any steps to control insects or applies insecticide. This approach can be a mistake. When the farmer sees adults, it usually means the grain contains many more insects than the ones he is seeing.

<FIGURE 52>

51bp20.gif (486x486)



Insect control should begin before the harvest. And it must definitely begin before the grain is put into storage. There are many steps farmers can take to protect their grain from pests. Some of these steps involve insecticides, but all of them depend upon thorough cleaning of storage bins and containers.

The first step a farmer should take is to plan an insect control program.

His program should include, among other things:

* finding out which insects are damaging his grain.

* drying and cleaning his grain very well.

* asking an extension agent about insecticides.

* deciding if he has enough money to buy insecticides.

The second step a farmer should take is to follow some general guidelines for cleaning and storing his grain.

Whether the storage area is old or new, it must be clean. Most farmers can save many grain losses by careful cleaning of storage containers, bins, and buildings. And cleaning does not cost large amounts of money. For just a little time and effort, the farmer can get better returns on the effort he puts into growing and harvesting his crop.

All equipment which touches the grain should be clean. This includes tools for harvesting and threshing. It also means cleaning the carts and wagons used for carrying the grain.

Cleaning and repairing should include:

* sweeping out grain, grain dust, and dirt from storage bins, buildings, or areas in the home where grain is kept.

* repairing cracks in floors, walls, and ceilings where insects might get in or live.

* removing pieces of grain and dust from cracks, beams, ledges, and other parts of the building.

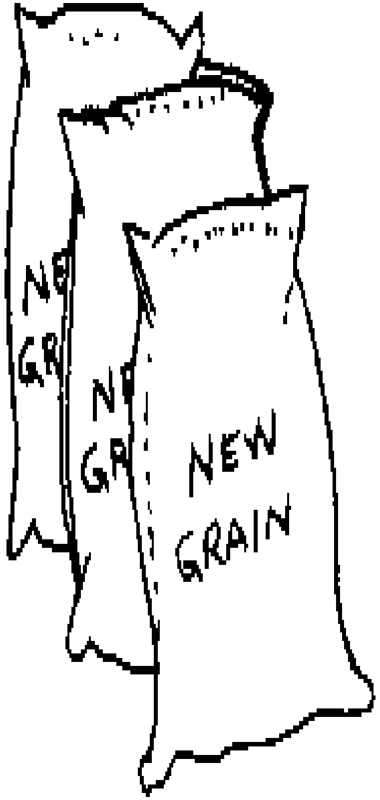
* patching any holes in the building and making sure it is watertight; moisture must not get into the storage area.

Concrete and metal bins are easier to clean than wooden bins and sacks. But all containers should be cleaned as carefully as possible.

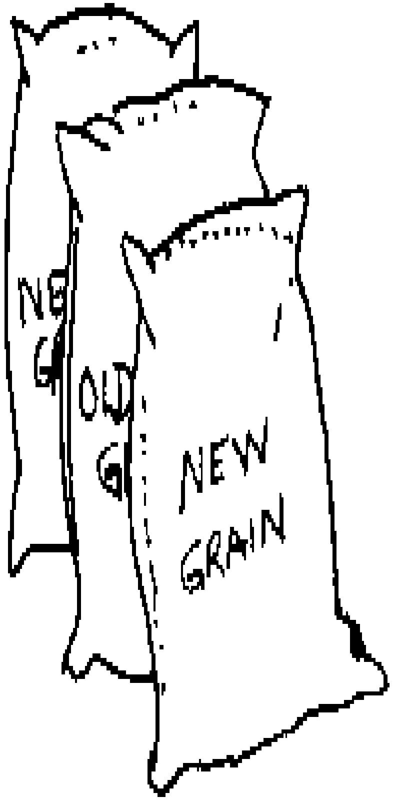
Many farmers make the mistake of storing grain from a new crop near grain from an older crop. If the grain from the old crop is full of insects (and it usually is), the insects will spread to the new grain quickly. Also, grain for eating and selling should never be put into storage with grain which will be used to feed the animals. Animal grain usually sits around for a long time and is full of insects.

<FIGURE 53>

51bp21.gif (486x486)



RIGHT



WRONG

Sometimes farmers cannot find or afford the correct insecticide. In these cases, careful cleaning will help the problem. In fact, insecticides will not work properly unless they are used under dry, clean conditions. So the following material presents information on steps the farmer can take to control insects -- both with and without the use of insecticides.

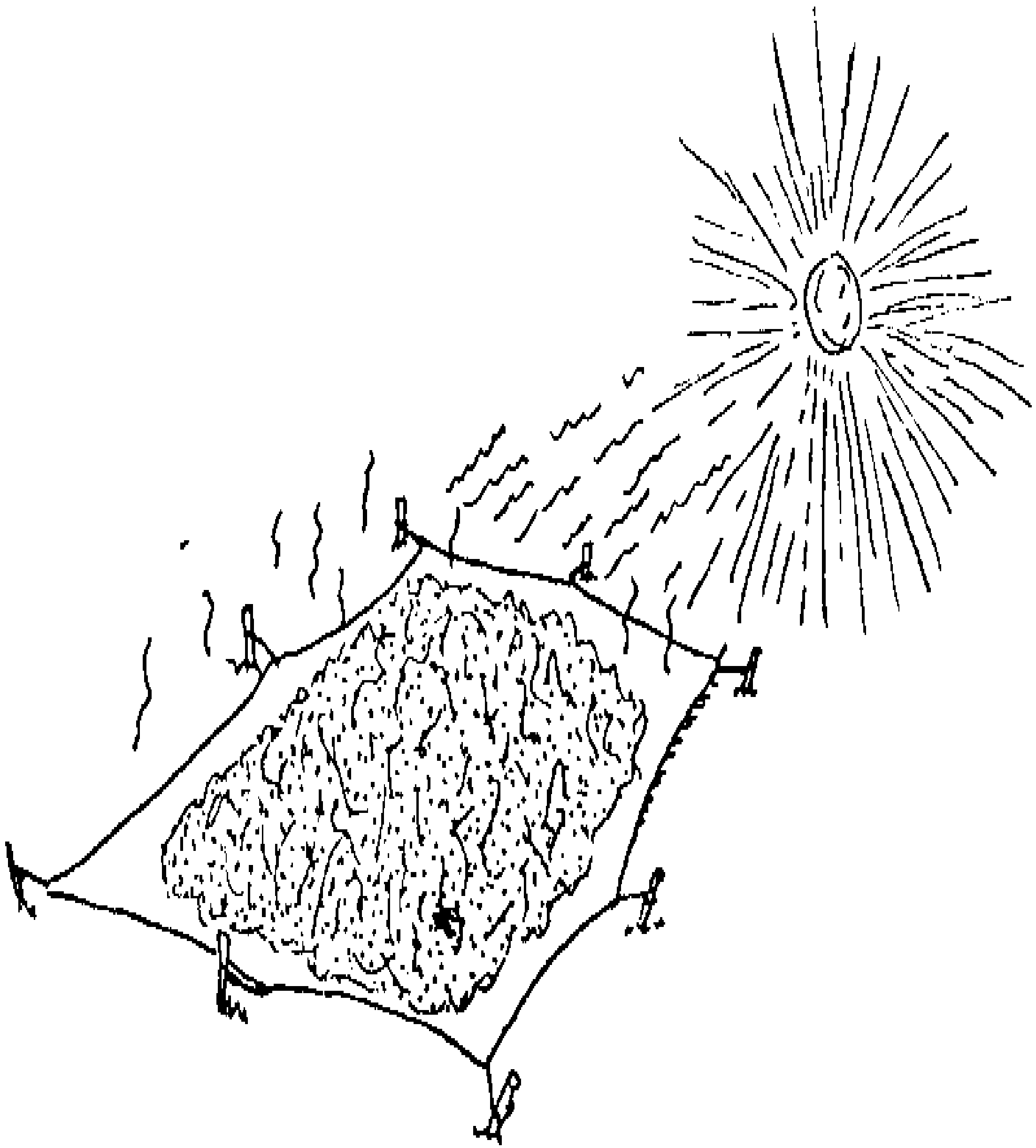
CONTROLLING INSECTS WITHOUT INSECTICIDES

Traditional Methods

Farmers have been fighting insects for hundreds of years. They accept the fact that insects are going to eat and destroy a certain amount of their grain. Here are some insect control methods farmers use:

<FIGURE 54>

51bp22.gif (600x600)



Sunning. Insects leave grain which is placed in

hot sunlight. They do not like heats higher than 40-44 [degrees] C. The sunning process, however, does not always kill eggs and larvae which are inside the kernels of grain.

Mixing Local Plants with Grain. In many areas, farmers mix local plants with grain. Information about which plants, and which parts of the plants, should be mixed with grain is passed on within the family; the plants differ from one part of the world to another. Such natural control methods, or methods which provide active control without insecticide, need to be looked at more closely. Future editions of this manual might include a chapter on using such plants and other natural control methods.

Mixing Sand or Wood-Ash with Grain. This is another natural-control method. Some farmers mix sand or wood-ash with threshed grain to keep insects from breeding. The sand scratches the covering or cuticle of the insect's body and the insect loses moisture through the scratches. If the grain is dry, insects will not be able to get enough moisture to replace the moisture lost though the scratches, and they will die.

Smoking. Some farmers store unthreshed grain on raised wooden platforms. They build small smoky fires under the platforms. Other farmers store harvested grain in the roof of the building or shelter used for cooking. Both of these methods use the smoke and heat of fires to kill and drive insects out of the grain. The heat from the fires also helps to keep the grain dry and protects the grain from new insect attacks.

Storing in Airtight Containers. This is the process of putting grain into a closed container so that no air can enter the grain. Insects in the grain then die because there is not enough air containing oxygen. In some areas, farmers store grain in very dry underground pits which can be made quite airtight. Other types of airtight storage containers can be more difficult to build and maintain. Airtight storage is talked about more completely in the section on storage methods.

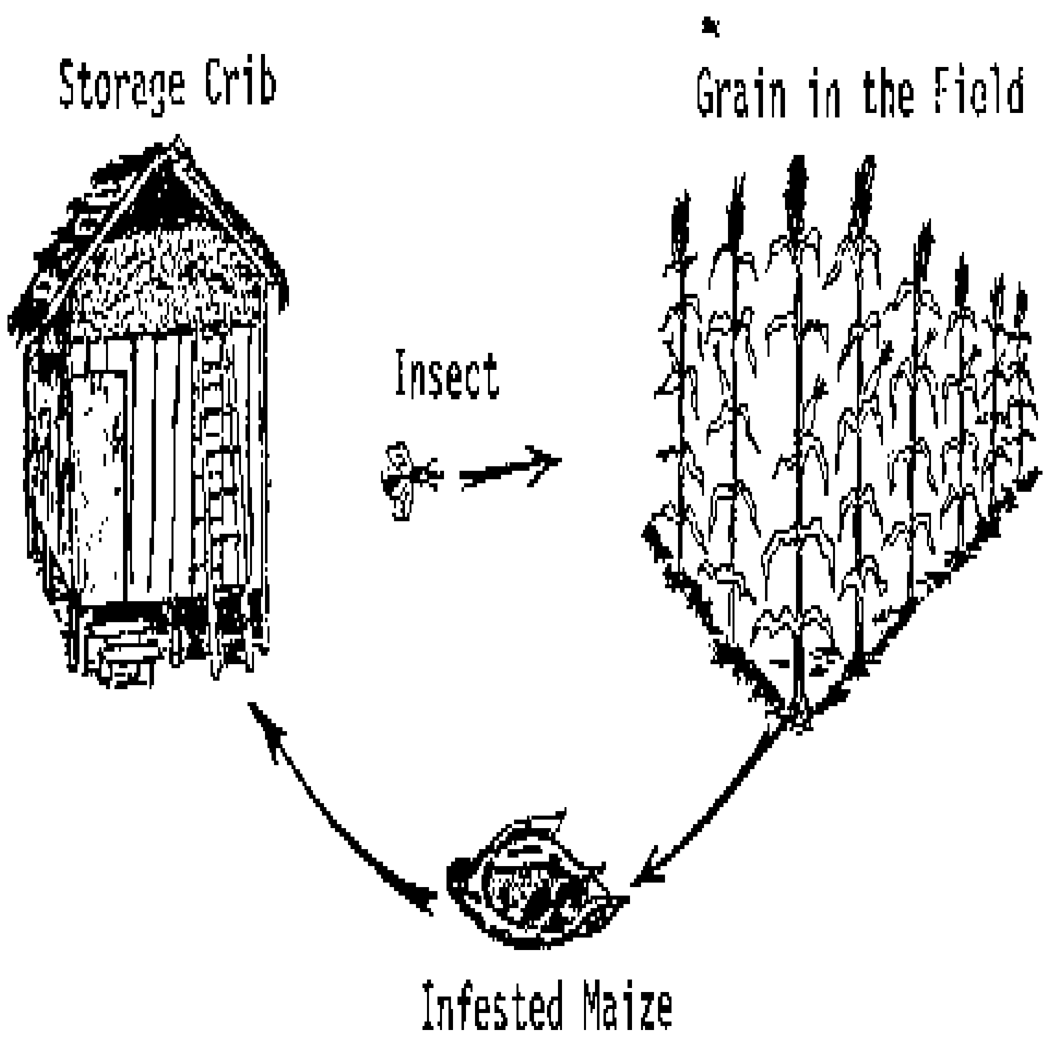
Storing Unthreshed Grain. The husk on maize and the hull of rice offer some protection from insect attack. If the rice hull is hard and dry, it is more difficult for insects to attack the grain kernels. Many farmers store their grain without threshing when they do not have insecticides.

Improvement in Traditional Methods

It is very important to have a clean and waterproof building for storing the grain. If the farmer is choosing a site for a new building, the buildings should he placed as far away as possible from grain standing in the fields. This helps protect against insects flying from the field to the storage area. The grain storage place should not be built near places where animals are kept: certain insects found near animals and their food also attack stored grains.

<FIGURE 55>

51bp23.gif (540x540)



Most farmers know that insects are a problem, and will not have to be convinced. Or perhaps it is better to say that some farmers may need to be shown how insects infest grain; they must be convinced that there is really something they can do about insects. For a farmer who has looked upon insects in his grain as a part of his life for years, the biggest forward step he will take is realizing that there is something he can do about the problem.

There are some easy ways to show how insects can be kept out of grain. You probably use them in your work. Here is one way:

* Take several small bags of grain, each of which is clean and free of insects.

-- Place one bag near the animal grain

-- Place one bag beside grain that has been in storage a long time

* Place one bag in a clean, cool, dry corner away from other grain. Make sure this bag is not placed directly on the floor and keep it away from the walls.

Insects will, of course, attack all these bags of grain. What will be interesting is how long it takes for the infestation to develop in each bag, and how much damage occurs in a given period of time. It should take longer for the infestation to develop in the clean grain stored away from other grains.

Also, if you want to use the same demonstration to show how an improved storage method protects against insects, place insect-free grain, equal to the amount in the other bags, in a small plastic bag. Seal the bag tightly and put it next to bags of grain which have been in storage for some time. All of the other bags will have insects in them; this one will not.

Following here is a checklist of steps which can be taken to control insects without using insecticides. In fact, these rules for cleaning and storing only dry grain should be followed even if insecticide is used. Insecticides will not provide protection unless they are given the right conditions in which to work. Perhaps you will be able to adapt this checklist to fit your situation and use it as you work with farmers.

CONTROLLING INSECTS WITHOUT INSECTICIDES

A CHECKLIST

Suggestions for Use: Pick out the points that will be most useful to farmers in your area. Translate and illustrate them as necessary.

* Store grain away from wet areas.

* Protect the stored grain from rain and run-off.

* Keep stored grain or grain containers out of strong sunlight. This will keep the grain cooler. Warm grain will breed more insects.

* Place stored grain containers or buildings where winds can help cool the containers.

* Keep the stored grain as far away from the fields as possible. This helps keep flying insect pests from flying to the stored grain from the fields.

* MAKE SURE THE STORAGE AREA IS CLEAN. SWEEP ThE WALLS, CEILINGS, AND FLOORS AND GET OUT ALL DIRT, OLD GRAIN, AND DUST BEFORE YOU PUT NEW GRAIN IN.

* Make sure the containers for the grain are very clean.

* Clean the grain well.

* Dry the grain well.

* Put only whole, healthy grains into storage. Do not store broken grains.

* If possible, place grain into special containers which you can seal tightly.

* Do not place sacks of grain near the walls. Make sure the sacks are not placed directly on the floor. Moisture from the ground will dampen the grain if the sacks are left on the floor.

* Check your grain often.

* Watch for flying beetles in the early morning or late afternoon.

* Watch for moths anytime of day.

* Hit a sack against the floor. Then let it rest out of direct sunlight for a while. Then check to see if there are any weevils on the outside of the sack.

* Dump part of the grain out or take some out from the middle of the storage container.

* Put the grain through a sieve.

* If a large number of insects is present, dump all the grain out on a tray or plastic sheet under a hot sun. Do not put the grain directly on the ground.

* Or put all the grain through a sieve and remove the insects. Burn the insects so they can not return to the grain.

* Mix grain with sand and ash when you put it into the storage containers. Sand and ash damage the insects' bodies, and they die.

* Store unthreshed grain on raised wooden platforms and build small smoky fires underneath. The heat and smoke from the fire help drive the insects away.

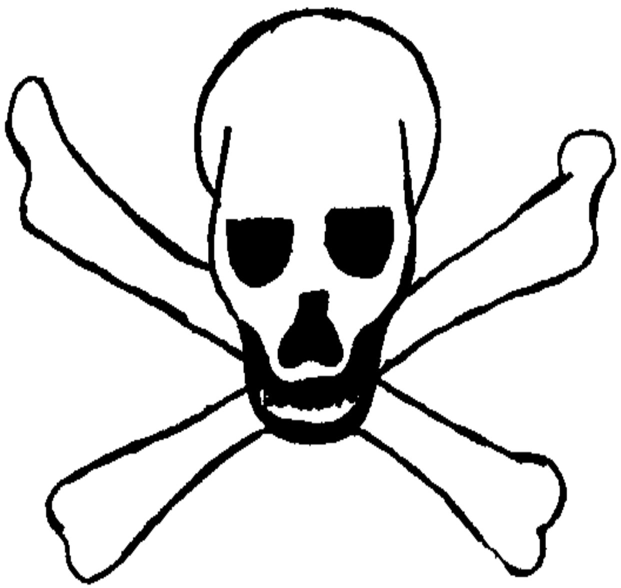
* Plan for storing the next crop. If you continue to

have trouble with insects, see if there is a storage method which might be better. Also, find someone who knows how to use insecticide and get advice on your problem.

INSECT CONTROL WITH INSECTICIDES

<FIGURE 56>

51bp26.gif (317x317)



Insecticides are poisons used for killing insects. But insecticides also can kill or hurt humans and animals if they are not used correctly. Use only recommended insecticides on clean, dry grain. Insecticides must always be used with care.

Most farmers know something about insecticides. But often they are not aware of exactly what insecticides should be used for or of the differences among insecticides.

Farmers may use insecticides without knowing how to apply the insecticide they are using or on what materials that insecticide can be used. Some insecticides are safer than others; some insecticides can poison grain as well as insects. The danger in insecticide use is that farmers do not have enough information about insecticides to use them correctly for their type of grain and their storage situation. For example, many farmers around the world call all insecticides, DDT. They are likely to go to market, pick up some DDT powder, and use in ways and places which can lead to sickness and even death.

This section of the manual presents information on insecticides in a form which should help you provide farmers in your area with the information they need to use insecticides appropriately and safely.

The use of insecticides cannot be separated from the kind of storage container and the purpose for which the grain will be used. Some insecticides can be used on grain for seed, but cannot be used on grain for food. Some insecticides can be used for treating both kinds of grain. The following is a basic discussion of types and kinds of insecticides used in grain storage work. These insecticides also are discussed in the section on storage methods.

TYPES OF INSECTICIDES

Many different poisons kill insects. But there is a much smaller number of poisons (insecticides) which are useful in grain storage work. Some insecticides are made from parts of plants. Pyrethrum is an example of this type. Some, such as Cyanide, are inorganic chemicals; others are man-made organic chemicals such as Malathion and BHC.

The insecticides available to farmers to use for grain storage purposes are of two major types -- contact chemicals and fumigant gases. These insecticides can be bought in a number of forms (formulations); they are applied differently depending upon the type of grain and the type of storage.
Contact Chemicals. These are the contact poisons: the insect must actually get these insecticides on its body. The contact chemicals are available in the following formulations:

Dusts

These contain a low concentration of insecticide mixed with powder. This makes them safer to handle than some of the other formulations available. Dusts also:

* are ready to use.

* must be kept dry or they will not mix evenly, and the insecticide will not work as long.

*

* may be mixed with grain at the time of storage. Use only those dusts, for example, Malathion and Lindane, recommended for this purpose.

Wettable Powders (Dispersible Powders)

These contain a high concentration of insecticide. Wettable powders:

* must be mixed with water before they can be used.

* require careful mixing.

* are used to spray outside surfaces of sacked grain, storage containers, or buildings.

* are never used directly on grain.

* can be applied with simple sprayers which can be purchased or made.

Emulsion Concentrates

These are liquid concentrates which:

* must be mixed with water before they can be used.

* contain a high amount of insecticide mixed with other ingredients.

* need special equipment to apply.

* are more difficult for farmers to use.

Emulsions of pyrethrum or Malathion are available, and the directions for mixing are usually given on the labels of the containers. But farmers should know of the need for special equipment to apply these, so that they do not spend their money on a formulation of insecticide which they will not be able to use.

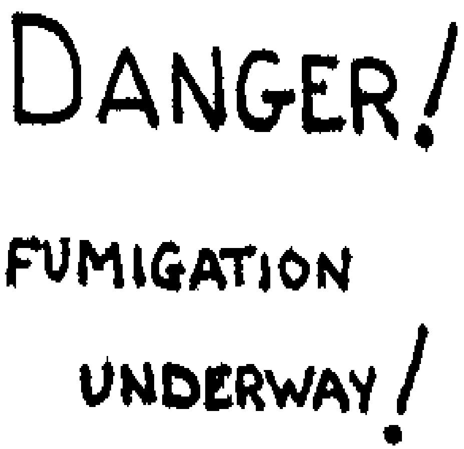
Other Forms. These are liquid concentrates and powders which must be used with special equipment. These formulations are used with fogging machines and smoke generators; they are not appropriate for use by most farmers.

REMEMBER: It is important for the farmer to know which formulations are available in his area, which of these formulations he can use, which he should not use, and how they should be applied.

Fumigants

<FIGURE 57>

51bp28.gif (285x285)



The second major category of insecticides is the fumigants. Fumigants are gases. Fumigants have several advantages as an insect control method:

*** Gas can enter all the cracks in storage buildings to kill insects hiding there.**

*** Gas can get between the tightly packed grains in storage and, in most cases, can kill larval stages within the kernels.**

*** Gas does not leave marks on the grain as some insecticides do.**

But farmers should also know that there are problems involved in using

fumigants:

* The choice of fumigant is very important. Fumigants are extremely dangerous to man, but some are easier and safer to use than others. A fumigant must be chosen which will not leave poison in the grain and which is relatively safe for the farmer to use.

MOST FUMIGANTS ARE SAFE ONLY WHEN USED BY A SKILLED OPERATOR

* Fumigants kill only insects which are already in the grain. They do not protect grain from new attacks.

* Fumigants must be used in airtight containers. If the farmer is storing his grain in jute sacks, he will have to find an oil drum, or some other container which can be made airtight before he can fumigate his grain. Or he must be able to cover his grain sacks with heavy plastic and fumigate in this way.

* Fumigation may hurt the ability of seeds to germinate.

Fumigants are available in the following forms:

Solid Fumigants[N]. These fumigants are in tablet or packet or pellet form. The active chemical is Aluminum Phosphide. The tablets release Phosphine gas when moisture touches them. Fortunately, the tablets take

about three hours to release enough poison gas to kill a person, so the person who follows the rules for fumigation carefully can use these tablets safely. The fumigant is sold under the trade names Phostoxin, Detia, and Celphos.

<FIGURE 58>

51bp29a.gif (486x486)

Liquid Fumigants and Low Boiling Point Gases. Some of these are Carbon Tetrachloride, Ethylene Dichloride, Ethylene Dibromide, and Methyl Bromide. They are all dangerous to apply and must be applied by trained people wearing full protective

clothing. Do not recommend these formulations to farmers for individual use. Warn very strongly against them. They can kill people, if used incorrectly.

The number of insecticides which can be used on stored grain products is really not large. Knowledge of these insecticides is important to the farmer. And he must have enough information about the insecticide and its use so that he can use it safely.

Information on using insecticides with stored grain is included in the storage section of this manual (Volume 3).

SOME CLOSING NOTES

In more and more places around the world, farmers are able to find and buy some of the newer formulations for insect control. Here are two examples of insecticides which may be useful to control flying insects in the home or farm shed, though they are of no value in stored grain.

<FIGURE 59>

51bp29b.gif (353x353)

* Vapona Pest Strip -- This strip is hung from the ceiling. It contains the insecticide Dichlorvos, which is released slowly into the air over a period of some weeks.

* BAYGON -- This is a trade name given to an aerosol spray formulation being seen in more and more places. This spray is handy to use and is effective for spraying storage buildings.

Although these formulations are not dangerous when used correctly, they can be harmful when used without proper directions. BAYGON, for example, must not be sprayed around food.

It is a good idea for you to know which formulations are available in your area and are likely to be picked up by farmers looking for insecticides. Often these formulations are brought in from other countries, and the containers are written in another language: even a farmer who can read his own language will not be able to read the instructions and warnings on the can. If you keep in touch with the insecticides that are available, you can prepare insecticide-use directions in your own language (s), or in picture language which would give uses and non-uses without words.

The following pages contain information on some of the more important grain storage insecticides. Each insecticide is listed on a separate page so that you can remove material on those most available in your area. Perhaps you can use the information to put together a short leaflet on insecticide use to hand out to farmers. This is a good way to introduce and encourage appropriate and safe use of insecticides.

Also included here are:

* Recommended dosages and insecticides for use with grain, in storage buildings, etc.

* A sample of methods for applying insecticide.

* A checklist on when to use insecticides and on how to use them safely.

* A list of steps to take if a person is poisoned by insecticide.

The appendices to this manual contain a selection of leaflets that have been used, or are being used, by development workers in various parts of the world. Perhaps they will give you ideas on how best to combine material from this manual with knowledge of your area and farmer need. Additional information about insecticides and their applications which is of interest to you, but not necessarily to the farmer, is included in Appendix A.

INSECTICIDE INFORMATION SHEET

MALATHION

OTHER NAMES: Malaphos, Malathon, Malphos, Cythion, Emmatos, Carbophos, Mercaptolhion

TYPE: Contact Chemical

FORMULATIONS: Emulsion Concentrate, Wettable Powder, Dust, Granules, Aerosol, Baits

WARNING: ONE OF THE SAFEST INSECTICIDES FOR MAN TO USE.
DO NOT USE OR PUT IN METAL CONTAINERS SUCH AS IRON.

CONTROLS: Aphids, mites, flies, leaf hoppers, mealy bugs, Japanese beetles, corn earworms, ants, spiders and many others. Some special grain storage notes about Malathion:

* works well against Saw-Toothed Grain Beetle, Rice and Granary Weevils.

* does not work against the Red Flour Beetle in some areas.

* does not control adult moths and mites as well as BHC.

USE TO: MIX WITH GRAIN. Apply as a dust to grain when it goes into storage. Use 125 grams of Premium Grade Malathion 1.0% Dust per 100kg. It should be used only with very dry grain. Malathion does not work well in wet or moldy grain.

SPRAY OR BRUSH ON BUILDINGS. It is unstable on cement or whitewashed walls.

DUST interior surfaces in contact with grain.

INSECTICIDE INFORMATION SHEET

PYRETHRUM

OTHER NAMES: Pyrethrum is used with piperonyl butoxide

TYPE: Contact Chemical

FORMULATIONS: Sprays and Dusts

WARNING: IT IS NOT DANGEROUS TO MAN, AND IT CAN BE USED NEAR FOOD. BUT IT CAN CAUSE ALLERGIES IN SOME PEOPLE.

CONTROLS: All grain storage insects. They are not resistant to it.

USE TO: SPRAY STORAGE AREAS. It is a good insect repellant, and controls moths.

MIX DUST DIRECTLY WITH GRAIN GOING INTO STORAGE.

NOTE: It costs a lot. Pyrethrum is a natural insecticide. It is made from the heads of a certain kind of flower. It repells insects, but its power does not last long and breaks down in oxygen, water, or light. This is why piperonyl butoxide or another stabilizer is added to the pyrethrum.

INSECTICIDE INFORMATION SHEET

LINDANE

OTHER NAMES: Gammexane, Isotox, Gamma, Renesan, OKO, BHC (extremely similar but not the same)

TYPE: Contact Chemical

FORMULATIONS: Dust, Wettable Powder

WARNING: NOT IMMEDIATELY DANGEROUS TO MAN, BUT, IF YOU TOUCH IT OFTEN, YOUR BODY KEEPS THE POISON INSIDE. IF YOUR BODY HOLDS TOO MUCH POISON, SICKNESS CAN RESULT. ALWAYS READ THE INSTRUCTIONS ON THE CONTAINER, AND USE LINDANE CORRECTLY.

REMEMBER:

*** DO NOT APPLY TO CROPS FOR FOOD WITHIN 30 DAYS AFTER HARVEST.**

*** IT IS POISON TO FISH AND HONEY BEES.**

*** DO NOT USE ON CHICKENS OR CHICKEN HOUSES.**

CONTROLS: Aphids, lygus bugs, grasshoppers, roaches, mange mites, termites. It is very good against weevils which have developed resistance to BHC and against the audlt stage of the Angoumois Grain Moth.

USE TO: TREAT YOUR SEED FOR PLANTING. Use 113g to 454g to treat the seed required to plant 25 acres. Store treated seed below 21 [degrees] C and use within three months of treatment. Dosage should not go above 2.5 ppm on cob maize and above 5 ppm on unthreshed sorghum.

DUST on unshelled groundnuts; unthreshed sorghum, bags

of maize, wheat, rice, maize in cribs.

SPRAY STORAGE AREAS.

INSECTICIDE INFORMATION SHEET

DICHLORVOS

OTHER NAMES: DDVP, Vapona

TYPE: Contact Chemical and Fumigant

FORMULATIONS: Spray, Pest Strip

WARNING: CAN BE DANGEROUS TO PEOPLE AND ANIMALS IF NOT HANDLED CORRECTLY.

HANDLE PEST STRIP WITH GLOVES.

DO NOT LET PEST STRIP TOUCH FOOD.

CONTROLS: Moths, beetles. It is very poisonous to flying moths in a tight building, but kills beetles more slowly.

USE TO: SPRAY STORAGE PLACES to kill flying insects. It does not last long.

Provide control of flying insects by hanging the VAPONA PEST STRIP. The strips give off poison for

about 3 months (depending upon climate).

INSECTICIDE INFORMATION SHEET

DDT

OTHER NAMES: Chlorophenothene, Accotox, Anofex, Neocid, Neocidol, Pentachlorin, Sillortox.

TYPE: Contact Chemical, long-lasting.

FORMULATIONS: Emulsion Concentrate, an aerosol, granules, dusts. It is also sold mixed with other pesticides.

WARNING: * DDT IS NOT IMMEDIATELY DANGEROUS TO MAN. BUT SINCE THIS POISON DOES STAY ON THINGS FOR A LONG TIME, THERE IS SOME CONCERN ABOUT WHETHER DDT CAN HURT PEOPLE WHO USE IT VERY OFTEN AND FOR A LONG TIME. USE IT CAREFULLY.

* DO NOT USE NEAR FOOD.

* DO NOT USE IN AREAS WHERE IT MAY POLLUTE THE WATER SUPPLY.

* DO NOT USE TO DUST SACKS OF STORED GRAIN.

* DO NOT USE WHEN THE TEMPERATURE IS OVER 90 [degrees] F.

*** DO NOT USE ON DAIRY ANIMALS OR IN DAIRY BUILDINGS OR AROUND POULTRY.**

*** DO NOT STORE IN IRON CONTAINERS.**

*** DO NOT USE TO DUST INSIDE OF GRAIN STORAGE CONTAINERS.**

CONTROLS: Codling moths, flea beetles, leaf hoppers, corn earworms, corn borers, thrips, flies, mosquitoes, leaf miners, Japanese beetles, spittle bugs, and others. It works well against beetles, in some areas, but in other places beetles have developed resistance.

USE TO: PROTECT YOUR STORAGE BUILDING against insect attack. Apply the DDT either by spraying or painting it on with a brush. Repeat the treatment every six to eight weeks.

NOTE: DDT no longer works against some insects.

INSECTICIDE INFORMATION SHEET

B H C

OTHER NAMES: Benzene Hexachloride, hch, hoch

TYPE: Contact Chemical, lasts a long time.

FORMULATIONS: Emulsion Concentrate, Wettable Powder, Dust and Smoke. Sometimes it is sold mixed with other pesticides.

WARNING: SAFE TO USE IN THE CORRECT DOSAGES. READ DIRECTIONS CAREFULLY. NEVER USE MORE THAN THE DIRECTIONS SAY TO USE.

*** DO NOT USE ON OR NEAR CATTLE OR PLACES WHERE CATTLE LIVE.**

*** DO NOT FEED TREATED FORAGE OR CROPS TO LIVESTOCK.**

*** DO NOT ALLOW IT TO POLLUTE WATER SUPPLY.**

*** DO NOT USE ON ROOT CROPS. IN MANY FRUITS AND VEGETABLES, BHC CAUSES A FUNNY TASTE TO DEVELOP. ROOT CROPS ABSORB AND HOLD THE FLAVOR. TOO MUCH BHC CAN HURT GERMINATION, AND SEED GROWTH.**

*** DO NOT STORE NEAR ANY PRODUCE THAT WILL ABSORB THE SMELL OF THE INSECTICIDE.**

*** IT IS POISON TO FISH AND HONEY BEES.**

CONTROLS: Grasshoppers, ticks, chiggers, aphids, lygusbugs, spittle bugs, thrips, fleabeetles, leafhoppers, armyworms, wire worms, flies, mosquitos, ants, termites, and others.

USE TO: SPRAY OR DUST THE INSIDE AND OUTSIDE OF GRAIN STORAGE BUILDINGS. Keep animals away while you are working with BHC.

MIX WITH SEED that is going to be used for planting.
INSECTICIDE INFORMATION SHEET

DIELDRIN

OTHER NAMES: HEOD

TYPE: Contact Insecticide.

FORMULATIONS: Emulsion Concentrate (EC), Wettable Powder (WP), Dust, and Granules.

WARNING: DO NOT TOUCH. IT CAN BE ABSORBED THROUGH THE SKIN. IT IS EXTREMELY DANGEROUS TO MAN IF NOT USED CORRECTLY.

*** DO NOT APPLY DIRECTLY TO ANIMALS OR LET ANIMALS EAT TREATED CROPS.**

*** DO NOT DUMP EXTRA SOLUTION INTO LAKES, STREAMS, OR PONDS. IT WILL KILL FISH. PEOPLE WHO EAT THESE FISH WILL GET VERY SICK.**

*** IT IS POISON TO BEES.**

*** DO NOT USE TO TREAT GRAIN OR ANY PRODUCT TO BE USED FOR FOOD, ANIMAL FEED, OR OIL PURPOSES.**

USE TO: Protect storage buildings against insect attack.

INSECTICIDE INFORMATION SHEET

PHOSTOXIN

OTHER NAMES: Celphos, Detia, Delicia, Phosphine

TYPE: Fumigant

FORMULATIONS: Pellets, tablets, or packets

WARNING: VERY DANGEROUS.

*** THESE TABLETS GIVE OFF A GAS WHICH CAN KILL A MAN IN A FEW MINUTES.**

*** THIS INSECTICIDE MUST ONLY BE USED IN AIRTIGHT SITUATION OR CONTAINERS.**

*** TALK TO SOMEONE WHO KNOWS HOW TO USE PHOSTOXIN IF YOU HAVE NOT USED THIS FUMIGANT BEFORE.**

CONTROLS: Weevils, grain beetles, grain borers, flour beetles, cadelle, flour moths, grain moths

and others.

USE TO: Fumigate grain in airtight conditions. Fumigation must continue for at least 72 hours. This poison kills the insects present in the grain, but does not protect the grain from attack again.

RECOMMENDED INSECTICIDES AND DOSAGES

FOR MIXING DIRECTLY WITH FOOD-GRAINS:

Malathion -- 120 grams of 1.0% Dust for each 200kgs of grain.

Lindane -- 120 grams of 0.1% Dust for each 200kgs of grain.

Pyrethrum -- 120 grams of 0.2% pyrethrins plus 1.0% piperonyl butoxide. Dust for each 200kg of grain.

FOR MIXING DIRECTLY WITH SEED-GRAINS:

It is possible to use more insecticide on grain to be used only for seed than can be used on grain for food. If there is any chance the grain will be used for food, use only the Malathion, Lindane, or Pyrethrum at the dosage recommended for food grain.

If the farmer is certain the grain will be used for seed, he can use:

Malathion, Lindane, or Pyrethrum -- 2 to 5 times more

Dust than can be used for food grain.

DDT -- 100 grams of 3 or 5% DDT Dust for each 100kg of grain.

IMPORTANT: There may be other insecticides available in your area which can be used for grain-storage work. Make sure you know what these insecticides are and how to use them.

FOR SPRAYING STORAGE BUILDINGS:

Note before spraying:

*** Always clean the building before spraying.**

*** Dispersible Powders (DP) are better than Emulsion Concentrates (EC) for spraying on cement, brick, stone, or whitewashed surfaces.**

Malathion -- Mix 400 grams of 25% DP or 200 milliliters of 50% EC in 5 liters of water.

Lindane ---- Mix 200 grams of 50% DP or 500 milliliters of 20% EC in 5 liters of water.

DDT -------- Is sometimes used to spray buildings. It must never be used directly on food.

Lindane/DDT- Mix 100 grams of Lindane 50% DP and 200 grams of DDT 50% DP in 5 liters of water.

OR

Mix 250cc of Lindane 20% EC and 400cc of DDT 25% EC in 5 liters of water.

All of these dosages will spray 100 sq.m. If a larger area must be sprayed, mix more insecticide. Reapply the spray as needed.

IMPORTANT: There may be other insecticides available in your area which can be used for grain-storage work. Make sure you know what these insecticides are and how to use them.

APPLYING INSECTICIDES

<FIGURE 60>

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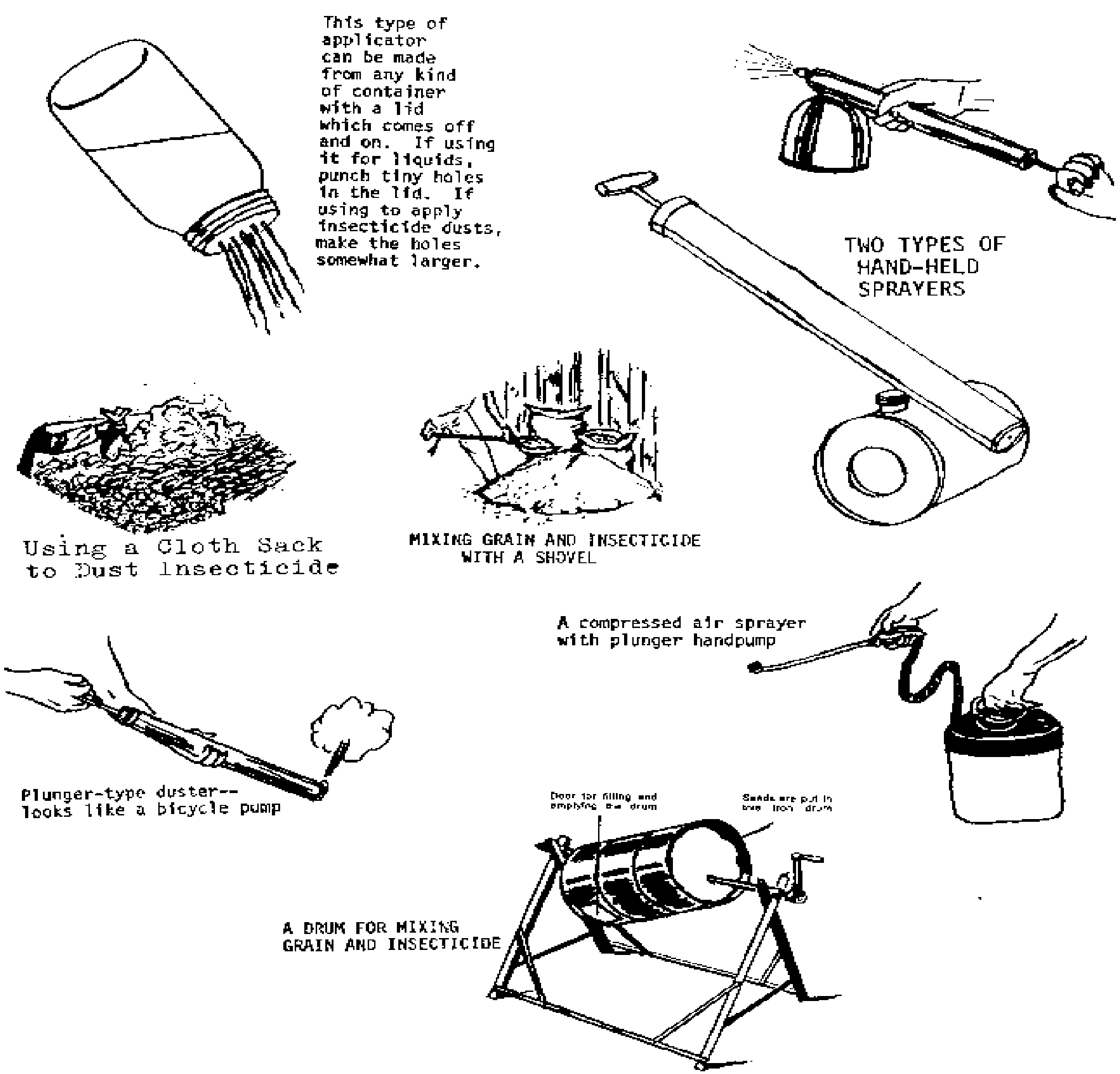
APPLYING INSECTICIDES



NOTE TO DEVELOPMENT WORKERS ON APPLYING INSECTICIDES

Many farmers in your area will have trouble following directions for measuring correct dosages of insecticides. This is true because the directions often require exact weight measures.

Therefore, it is a good idea for you to figure out a simple measure which farmers can use for their storage containers. For example:

* 1-1/2 matchboxes of insecticide for each standard-size area basket granary

* 1 empty sardine can of insecticide for each metal bin.

These are only examples, of course. You should figure out the dosage depending upon the kind of insecticide, the types of measures (matchboxes, tin cans, etc.) farmers are likely to have, and on the kinds of storage container most used in your area.

CONTROLLING INSECTS BY USING INSECTICIDE

A CHECKLIST

Suggestions for Use: Pick out the points that will be most useful to farmers in your area. Translate and illustrate them as necessary. Add the names and dosages of those insecticides most likely to be used by farmers in the area.

Insecticides are poisons used for killing insects. There are many types of insecticides. Some insecticides can be added directly to grain;

others may be sprayed around grain storage areas or on the outside of the containers, but should never be placed directly on the grain. Some insecticides are liquids; some insecticides are powders. Some insecticides are gases which you use by adding them to the grain, sealing the container up tight, and letting the fumes of the poison gas kill the insects in the grain.

Never use an insecticide until you are sure you know how it should be used and all the rules. for applying it.

Insecticides are not magic. They should be used with clean, dry grain in good storage conditions if they are to work well.

To use insecticides effectively for storage, you should:

* Find out which insecticide to use for each purpose.

* Know how to use and handle insecticides properly.

* Have good storage buildings and containers.

* Spray the walls of the storage building to kill insects hiding in cracks in the ceiling and floor.

* Dust the storage containers in and out with the appropriate insecticide.

* Mix insecticide into the grain before putting the grain into storage. To do this, you can put the grain in a

pile in a place protected from wind. Add the right insect poison from a tin can with holes punched in the top. Turn the grain over and over with a shovel to mix the poison with the grain. IMPORTANT: BE CAREFUL TO USE THE CORRECT INSECTICIDE. IF YOU ARE NOT CERTAIN IT IS CORRECT, ASK YOUR EXTENSION AGENT.

* Check the grain after it has been in storage for some time. You may have to add more insecticide. Poisons only remain dangerous to insects for a period of time.

To use insecticides safely you must:

* Read the directions on insecticide containers carefully. It will give you correct ways to use the insecticide and tell you what to do in case of an accident.

* Make sure the mixture is correct for its purpose. Using a wrong insecticide can poison the grain.

* Do not use more than the recommended dose.

* Wear rubber gloves when using insecticide.

* Wash your hands with a lot of running water after you use insecticide. Do this right away if your hands touch the poison.

* Take off any clothing that has touched the poison.

* Do not eat, drink, or smoke while you are using poison.

* Label poison containers so that you know what is inside.

* Keep containers away from children and animals.

* Bury or burn all empty insecticide containers. If you bur them, be sure they will not pollute underground water sources.

HELPING SOMEONE WHO HAS BEEN POISONED BY

INSECTICIDE

1. HEADACHE WEAKNESS
NAUSEA SWEATING
DIZZINESS VOMITING

These are signs of poisoning.

2. IF: The person feels sick while using an insecticide or soon afterward

THEN: Get the poisoned person to the doctor as soon as possible.

Find the insecticide container or label so the doctor will know which insecticide poisoned the person.

3. IF: The person swallowed a poison

and if

he is awake

and

he can't see a doctor right away

THEN: Mix a tablespoonful of salt in a glass of warm water and make the victim vomit. Or stick your finger down the person's throat. Make him vomit!

Make the victim lie down. Keep him warm, and do not let him move until you can get him to the doctor.

4. IF: The person spilled an insecticide concentrate or oil solution on his skin or clothing, get the clothing off and wash the skin with soap and plenty of water.

THEN: Get him to the doctor as soon as possible.

5. IF: The person is overcome by breathing the gases of a fumigant.

THEN: ACT QUICKLY!

*** Get the victim outdoors or to a room free of gas.**

* Lay victim on the ground.

* Give artificial respiration if needed.

Call a doctor as soon as you can. People using fumigants should have kits which contain treatment for poisoning by the fumigant which is being used.

IMPORTANT: ALWAYS TRY TO GET THE VICTIM TO A DOCTOR QUICKLY.

ALWAYS HAVE THE INSECTICIDE CONTAINER READY TO SHOW THE DOCTOR. TREATMENT OFTEN DEPENDS UPON THE TYPE OF INSECTICIDE THAT POISONED THE PERSON.

2 Rodents

Rodents in many countries are healthy enough to provide a meat source for humans. In many cases, this is because they feed so well on the farmers' grain.

Rodents damage crops in the fields and in storage. They can eat a lot of grain. They make the stored grain dirty while they are eating it. They damage buildings, storage containers, and many other things on the farm.

Rodents also carry diseases which people can catch from eating and handling grains the rodents have contaminated (made dirty).

There are many kinds of rodents, but rats and mice do the most damage to stored grain.

STORED GRAIN RODENTS

<FIGURE 61>

51bp47.gif (437x437)

The type of rat and mouse may differ depending upon the country or the area.

But, in many parts of the world, there are three important rodents which can be found moving from house to fields to storage looking for food, water, and good living conditions. These three are:

Rattus Norvegicus

Also called Sewer Rat, Norway Rat, Common Rat, or Brown Rat. This is the largest of the three. The adult rat weighs about 330 grams and is very strong. It actively looks for grain in the field and in storage. It also burrows into and near farm buildings. Called a brown rat, it may also be black. It has a blunt nose.

Rattus Rattus

Also called Roof Rat, Ship Rat, Black Rat, or Alexandrine Rat. This rat weighs about 250 grams when fully grown. It has a long tail and a pointed nose. These rats can be brown, grey, black, or light brown. These rats like to climb more than they like to dig. They can climb outer walls of concrete, perpendicular pipes, wires, and trees. In many areas, Rattus Rattus is the most dangerous stored grain rodent.

Mus Musculus

This is the well-known house mouse. It weighs only 16 grams. It has a long tail and pointed nose. Mice are usually brown-grey in color. Most farmers are so used to seeing mice around that they may not be aware of the damage mice can cause until the mice have multiplied into great numbers. Mice eat a lot of grain. Also, because they usually eat only part of the whole grain, mice ruin even more grain than they eat.

<FIGURE 62>

51bp48a.gif (437x437)

Rats and mice have big families. Most of the young rodents die before they are grown. But the adults reproduce so quickly that it does not take long for rats and mice to become a big problem for a farmer.

HABITS AND CHARACTERISTICS OF STORED GRAIN RODENTS

<FIGURE 63>

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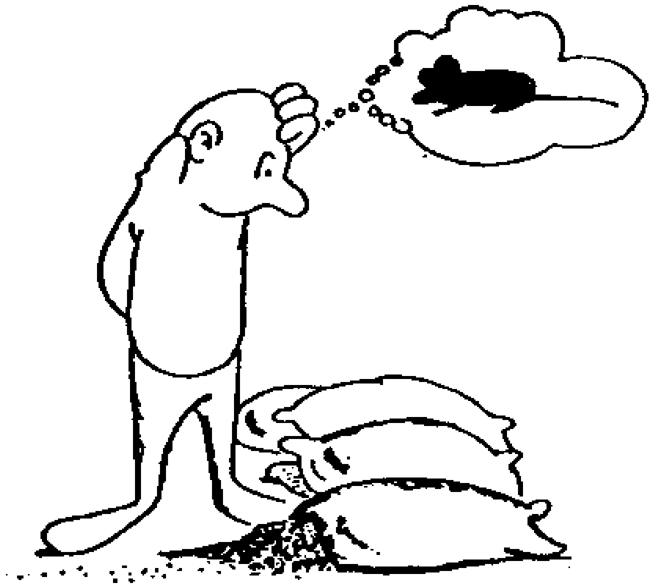

Fortunately, if the farmer understands how rats and mice live, and if he knows what rodents will and will not do, there are many things he can do to fight rodents. On the next page are some important things to know about rodents:

* Rats and mice usually do the same things every day at the same time. They are most active from sunset until about midnight. They also move around at certain other hours during the day and night. If grain is stored in a dark,

cool place, they will go in at any time of day.

* Rodents always go the same way. When a rodent is going from his nest to eat grain from storage, he always goes by the same path. He chooses his paths so that he will be running beside walls or stacks. He remains behind things (out of sight) as much as possible. If the food is out in an open space, the rodent runs out, grabs it, and runs back to his path.

* Rodents stay away from new things. If a farmer places food on a rodent path, some rodents will not eat it because it was not there before. After it has been there for some time, and the rodent is used to seeing it, he will eat it.

* Rodents can climb. Rats and mice can climb any straight up-and-down surface on which they can find places for their toenails. Vines, drainpipes, and wires are good runways for rats and mice. Rats can reach about 32cm up a wall and can do a standing jump of almost 60cm. They can do a running jump as high as 90cm. Even a mouse can do a running jump of 60cm.

* Rodents can swim. They are not afraid of water. They look for drains under water. Piping systems underground are often travelled by rats.

* Some rats can dig. Rats and mice live close to food and water. The roof rat likes to nest in ceilings, but the Norway rat digs

under the ground. Rats dig down along a wall. If something blocks the digging, they stop. They do not go around the thing which is in the way.

* Rodents must use their teeth. The front teeth grow until the rodent dies. The teeth will grow 10-12cm a year. Rats must gnaw things all the time to keep wearing their teeth down.

* Rodents like some foods more than others. Some of the foods they like are meat, grain, eggs, and potatoes.

* Rodents use their body hairs and whiskers to touch with. They do not see as well as humans do, and they cannot see colors. They hear very well. They can smell other rats; they can recognize certain rats by smelling the pathways and burrows.

* Rats and mice always can be found near man. There have been large programs to kill rats and get them out of certain areas. But the rats always return. It is not likely that a farmer will be able to free his farm of rats completely. But he can and should control the numbers of rats and mice that live on his farm and eat his grain.

FINDING RODENTS ON THE FARM

A farmer must know where rats are before he can fight them. And there are things a farmer can look for which will tell him where rodents are living and show him their pathways and homes.

Holes, Nests, and Burrows

Rodent holes are usually found outside houses and buildings. These holes also appear inside in soft foundations or earth floors. To see if a hole is being used all the time, the farmer can block it lightly with a piece of earth. If the earth has been moved, the farmer will know the hole is being used. Holes in use are free of dust and spider webs. They look used.

Mouse holes (2.5cm in diameter) are smaller than rat holes (7.5cm) and also are found inside and outside.

Rodent nests also can be found outside and inside. Outside, nexts are often made of grass or leaves and are located near garbage and rubbish piles. Inside, nests are made of paper, dry hay, straw, shredded cloth, and so on.

Norway rats like to live in the ground. Their burrows (underground nests) can be found along the outside walls of buildings and in dirt basements. Some of the burrows are away from buildings in brush, bushes, and piles of dirt. Often these burrows are joined under the ground.

Runways and Smears

Rodents use the same paths. So, after a number of days of using the same path outside, rats make trails in the grass. Search for these paths in areas where the running rat would feel most protected. On dirt, the runway may appear as a clean-swept bath 5.7.5cm wide.

Sometimes a runway which is used often is marked by a greasy smear from the oil and the dirt that rats and mice have on their bodies. Check for these smears around gnawed holes, along pipes, on edges of stairs, along walls or other places a rodent might run.

Mouse runways are harder to find because they are smaller.

Footprints and Tail Marks

These are found when rodents have been running over dusty or wet places. Some farmers will find tracks on the surface of grain sacks. Rat tracks are large: the back foot of the Norway rat can leave a print 37mm long. Mouse footprints are much smaller and harder to find.

Droppings

<FIGURE 64>

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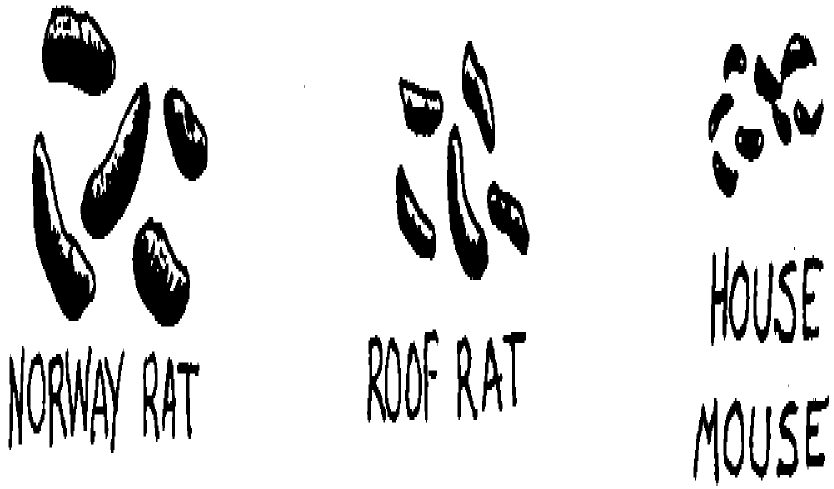
Droppings



Each kind of rodent drops a different shape of feces from his body. The farmer should check for droppings near runways, holes, corners, food, and other places he feels rodents would go.

New droppings often are shiny and wet-looking. The color is usually black, but changes depending upon what the animal eats. The number of the droppings can give some idea of how many rodents are eating the grain. It is wise for the farmer to think in terms of more rodents than droppings. Some droppings may be eaten by insects, and some rodents will run by without leaving droppings.

Damage and Gnaw Marks

<FIGURE 65>

51bp51b.gif (437x437)

Rats and mice must use their teeth all the time.

The farmer should check for gnaw marks on his buildings and produce. Also, if he stores in sacks, he must check the center of his sacked storage.

Smell

Rats and mice leave a smell in the room and in the grain. It is a very obvious sign that rodents are present.

CONTROLLING RODENTS WITHOUT USING POISON

Rats and mice need food, water, and places to hide. Rodents usually choose to live where these things are available close together. They do not like to travel far from home to find food and water. They like to live beneath wooden floors near chicken houses, barns, granaries, corn-cribs. They live in piles of wood, lumber, and trash, and in straw hay. Rodents need room to grow undisturbed.

Farmers who use their knowledge of rodents' habits and characteristics can fight rodents by not giving them food, water, and places to live. Keeping cats and dogs to chase and kill rodents will help, but not enough.

<FIGURE 66>

51bp52a.gif (437x437)

The three most important things farmers can do to control rats and mice without using poison are to keep the stored grain area clean; to rodent-proof houses, storage bins, and sheds so that rodents cannot get into them; and to set out traps.

Keep the Farm and Storage Area as Clean as Possible

<FIGURE 67>

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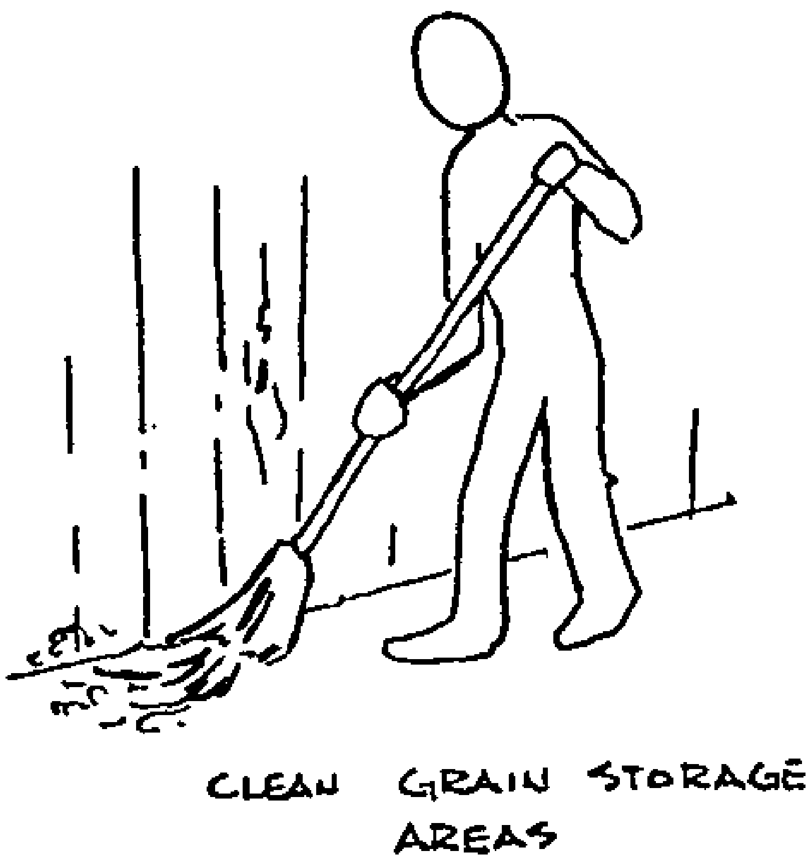

* Do not pile food or trash around the outside or inside of farm buildings.

* Bury or burn all garbage and old food away from the house or storage place.

* Place all food items in covered containers.

* Store grain sacks off the floor.

* Sweep out all dirt, dust, straw, old cloth that rodents might nest and hide in.

* Cover dirt floors with a thin layer of mortar, if possible. This keeps rats from digging up through the floors.

* Keep the grass cut short around all farm buildings. Rodents like to hide in tall grasses.

* Cut any tree limbs which touch windows to keep rats from climbing the trees and jumping in through the windows.

Rodent-Proofing

This simply means the farmer must store his grain so that the rats and mice either cannot get in or have to work very hard to do so.

* Construct granaries of mud. Farmers in some areas have found these are not attacked by rodents too much, especially when they are built off the ground. In other words, storing grain above the ground helps keep rodents away.
Place cribs for grain storage, such as the

one described in this manual, at least 75cm above the ground -- because rats can jump. Put barriers on the legs of the cribs so that the rodents can not climb the legs. These barriers are called rat baffles or rat guards. Baffles can be made from tin cans. The instructions for making these baffles are on a separate page at the end of this section.

<FIGURE 68>

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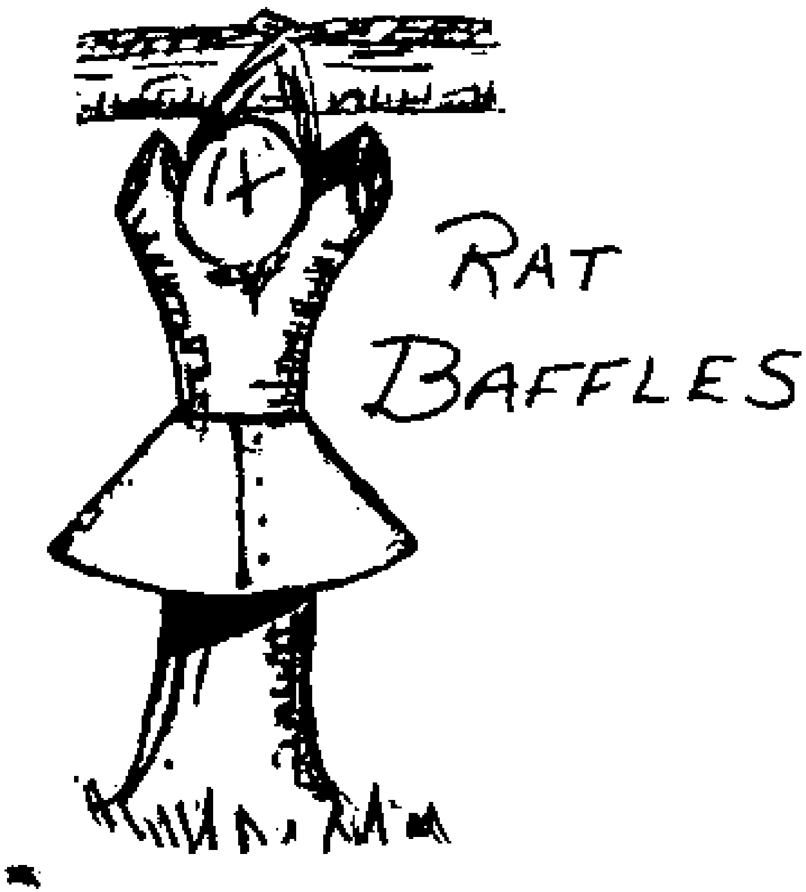

* Never place a bicycle or other piece of equipment against storage places. Rodents use such items as ladders to climb into the stored grain.

<FIGURE 69>

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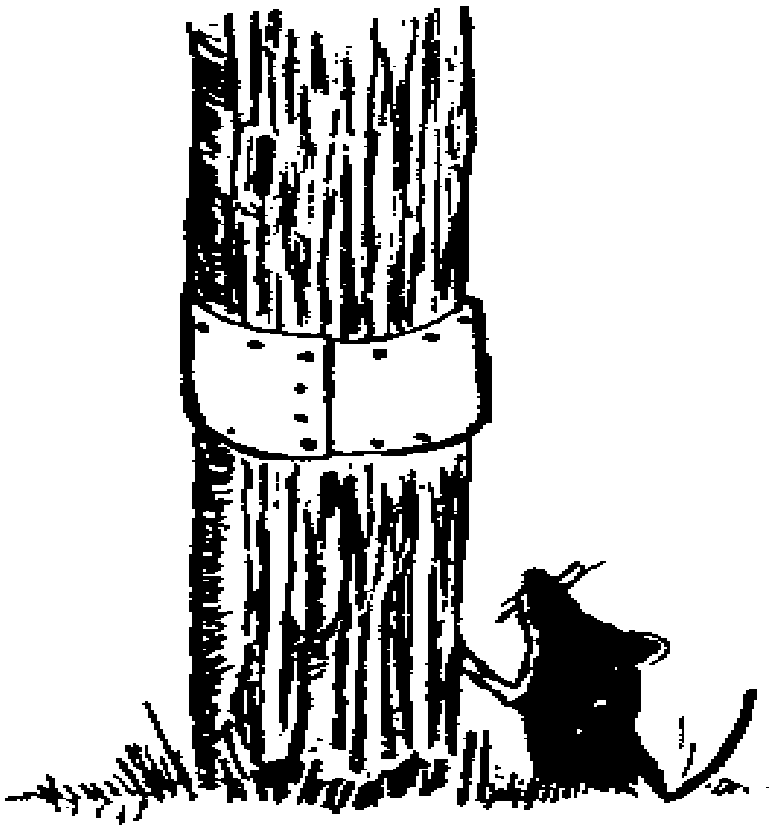


* Build storage buildings or containers on a concrete base at least 50cm high. The floor should be concrete. If the bin is made of tin sheet, the sheet should be fixed in concrete. Farmers should place sheet metal bands around mud or cement silos to prevent rodents from climbing. Some mudblock constructions use fired bricks at the bottom levels because

rodents cannot gnaw through them.

* Make sure doors and grain chutes fit tightly. A wooden door should have a thick metal sheet along the bottom to stop rodents from eating through. Grain chutes sometimes are packed with mud.

* Cover all windows and large openings with heavy wire netting. Wire netting with an 8mm mesh is a good size. Holes in a roof made of corrugated tin should be filled with cement mortar.

* Cover the ends of any pipes which enter the building where grain is stored with wire netting.

Setting Traps for Rats and Mice

Traps can be very effective if correctly placed and used. They need to be regularly maintained. They may be used where poison is hard to get. Also, traps are much safer to use very near stored grains in houses and storage buildings. Rodents run out, get food, and carry it back to where they are going to eat it. They walk over the poison and pick it up on their feet and bodies. Then they walk over grain or food and so put poison on it. So, for a small farmer whose grain is not well-covered, traps may be a better way to fight rodents.

Farmers in many parts of the world already use traps of different kinds. One method is to hang a maize cob over a five-gallon tin of water. The maize cob swings freely. When the rat reaches for it, he loses his balance, falls into the water and drowns.

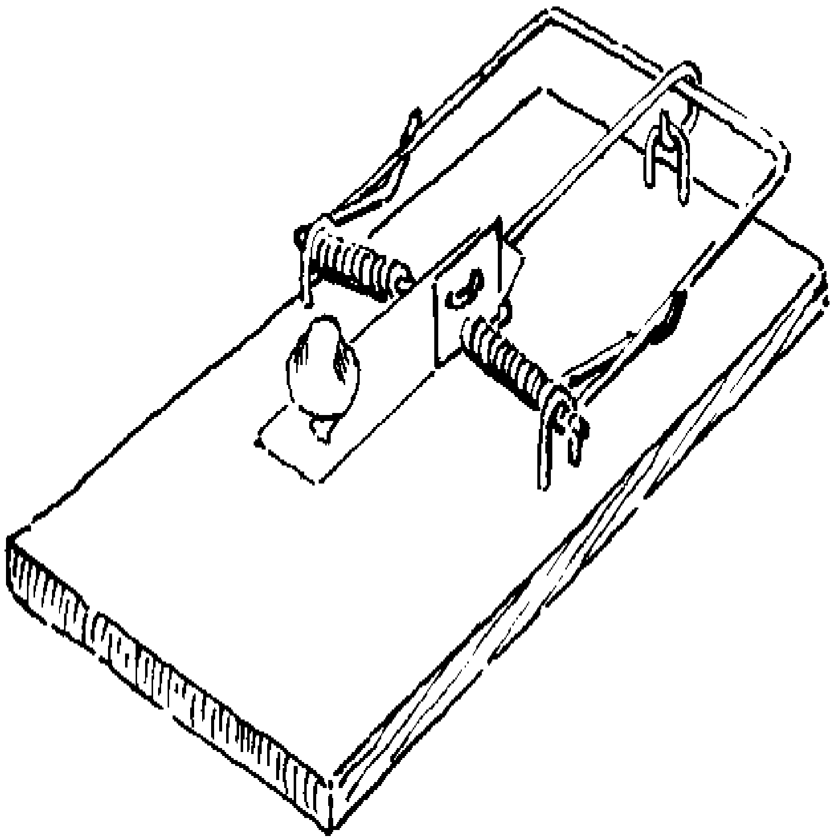
This trap works if the number of rodents is not too great. A small-scale farmer can easily put several water traps around his storage area.
The best traps consist of a base, a spring and trigger and heavy wire. The heavy wire is bent back and held by a spring. The spring is released when a rodent steps on the trigger. The wire snaps down on the rodent. These traps can be made, but it usually requires too much time to make enough traps.

On the other hand, traps can be expensive if a farmer needs many of them. The number of traps he needs depends upon whether he is seeking to control rodents in his grain fields, in his storage area, in his home, or in all these places. He can protect his grain best by controlling rodents at all these points. So a farmer has to figure the number and kind of traps he needs. There are a number of kinds available:

Snap Traps (Also Called Wood Traps or Breakback Traps). These have a flat wooden base. They kill with a heavy wire which is pulled back by a spring. When a rat or mouse touches the trigger, the wire comes down over the rat, breaking its back,

<FIGURE 70>

51bp54.gif (437x437)



Snap traps come in a number of sizes. The trap for a rat should be about 9 x 22cm. The traps for mice need to be only 5 x 10cm. Some farmers place pieces of food (bait) in these traps to attract mice and rats.

Putting food in the traps is not necessary if the farmer places the trap in a rat runway.

Steel Traps. These traps have a base with a trigger and two steel jaws. When a rat steps on the platform and releases the trigger, the jaws snap

together. A steel trap with 9cm jaws is good for rats. The problem with steel traps is that rats usually do not die, but are caught. This means the farmer must kill the rat himself.

<FIGURE 71>

51bp55.gif (437x437)

Tunnel, Box, and Cage Traps. These do not use bait. They are placed in runways and other places where the rats and mice go. Only rats and mice can enter these traps. And they cannot get out.

After the farmer has an idea of how many of which traps he needs, he must figure the cost of traps. Points he should consider:

* Buying the traps requires money. How much would it cost to buy all the traps?

* Traps can be used over again.

* Traps can be repaired and do not have to be replaced often.

* It takes time to bait, set, empty, and re-set traps. And this must be done often, especially if the trap has food in it. Rodents do not like old or moldy food. Doing all this takes a lot of time.

* How much would it cost to put poison out instead of traps? Are the right poisons available? Putting out poison requires making special boxes to hold the poison, buying the poison, setting it out, etc. Would it be cheaper to use poison? Would it be easier?

* If there are a lot of rodents to control, would it be cheaper for the farmer to use a combination of traps and poison? Traps could be placed in areas, such as the house, where poisons are not a good idea. Poison could be used

in the fields and other areas where rodents are appearing in great numbers. After many rats are poisoned, traps can be set to provide continuing control.

If traps are to be part of the farmer's rodent control program, there are certain things he must know about traps:

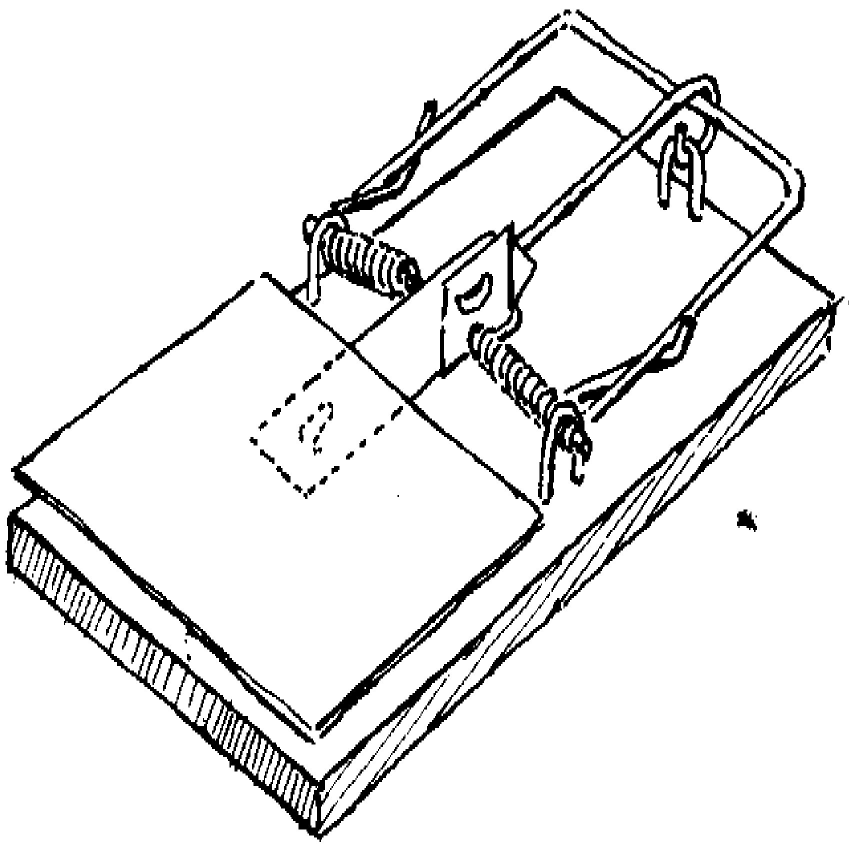
Size and Condition of the Trap

*** Mice can take the food from a rat trap without getting caught. It is important to place mouse-size traps where there are signs of mice and rat-size traps where rats are running.**

Snap traps can be used without bait if the platform or base is made larger so that the rat releases the trigger by simply stepping on the platform.

<FIGURE 72>

51bp56a.gif (437x437)



Make the trap bigger by fastening a 4cm-square piece of thin metal, screen, or cardboard to the trigger of the bait holder.

* Traps should be kept clean, so they will work well.

* If a lot of bait is being taken, and rats and mice are not being caught, the trap probably needs fixing. Check for bent or rusted triggers, weak springs, or

loose wires.

Baiting the Traps

Snap traps often are used with bait to encourage the rat to come to the trap.

* Bait may be any food rats like to eat.

* Use a piece of food about the size of the end of a man's finger.

* Make sure the bait is fastened down very well. If the bait is not held down well, the rat will steal the bait and run away.

* Food baits should be changed every three days. Rats do not like old food. Change from one kind of bait to another.

Placing the Traps

<FIGURE 73>

51bp56b.gif (437x437)

Here is where the knowledge of rodent habits becomes very useful. Farmers will usually catch most rodents the first night. Therefore, put out enough traps. Not every trap will catch a rat; the farmer should expect this. The farmer should:

* Place baited traps very near the rodent runways he has found.

* Place traps near the walls at right angles to the wall. The trigger end should be nearest the wall so that the

trap will attract a rodent running from either direction.

*** Cover the traps with straw, dust,or other material which hides all of the trap except for the bait. This is done only when there is no danger that people and animals will step on the trap.**

*** Set the base of the trap right into the floor if the floor is dirt.**

*** Place baited traps near holes, nests, and burrows. If the area is one where people or animals are likely to go, the farmer should put a cover over the trap so that it will be available to nothing but rats and mice.**

*** Place unbaited traps or expanded-trigger traps right in the rodent runways. Boards or boxes can be placed beside and behind the traps to guide rodents into them. Traps are also placed in burrows, hole openings, and corners. For roof rats and mice, also place traps on shelves, beams, pipes, and other high places**

Many farmers will decide that the best control program for them will use all of the methods discussed above, plus poison, to kill the rodents.

<FIGURE 74>

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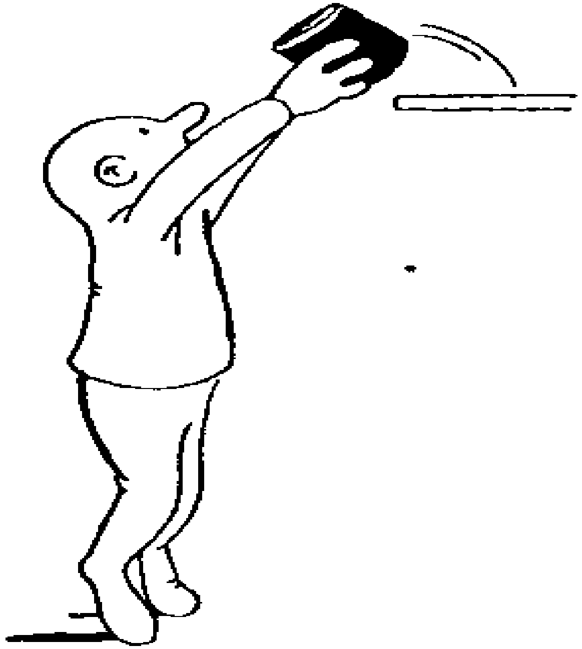


CONTROLLING RATS WITH POISON

Using poisons to control rodents is cheap, in most places, and effective.

BUT RODENTICIDES (POISONS WHICH KILL RATS AND MICE) CAN POISON HUMANS AND OTHER ANIMALS AS WELL. IT IS VERY IMPORTANTS THEREFORE, THAT FARMERS KNOW WHICH POISONS TO USE AND HOW TO USE THEM.

There are two kinds of poison used for killing rodents: acute poisons and anticoagulant poisons.

Acute Poisons

These are also called single-dose poisons. Rodents need to eat only a few mouthfuls of this poison. Death occurs quickly -- usually within a half hour.

The most common of the acute poisons are zinc phosphide, arsenious oxide, and sodium fluoroacetate (also called 1080). Some tropical countries are also using thallium sulphate, yellow phosphorous, aluminum phosphide, calcium cyanide, strychnine, Norbomide, Eastrix, and Antu. Some of these are only good for mice, some for rats. This manual discusses only some of the most common poisons effective against grain storage rodents. If one of the other poisons mentioned is being made available to farmers in your area, you might prepare information sheets on the proper use of that poison -- such as the ones attached to the end of this section.

Anticoagulant Poisons

These poisons must be eaten by rodents for a number of days before death occurs. They are used at a low dosage. In other words, there is only a little mixed in with the food each day. These poisons cause rodents to bleed inside their bodies and die.

<FIGURE 75>

51bp58.gif (437x437)

The best known anticoagulant poison is Warfarin. Others are Coumatetralyl (Racumin), Chlorophacinone, Pival, Fumarin, PMP, Diphacinone, Rodafarin (India).

Choosing a Poison

The kind of rodent is important when choosing a poison. What kills one

kind of rat may not kill another kind. The farmer should be able to recognize which types of rodent are attacking his stored grain. There are some poisons which can kill a number of types. Each of the major ones mentioned in this manual will control Norway rats, roof rats, and mice.

The farmer has to decide whether to use an acute poison or an anticoagulant. Acute poisons kill more rodents and kill them quickly. But many of the rodents will not feed. And these rodents will not eat the poison bait that killed the other rodents if the bait is left in the same places. Acute poisons are also more dangerous for farmers to use.

<FIGURE 76>

51bp59a.gif (393x393)

Anticoagulants are added to food and the rat must eat the food for about 5 days at a time. These poisons have no taste and no smell. The rodents do not know they are being poisoned, and this is an advantage. They continue to eat the poisoned food. It takes a lot of poison, a lot of bait, and a lot of time to use anticoagulants well. This may be a disadvantage for some farmers. But anticoagulants are much safer for farmers to use. And safety is an important factor to weigh when using poison.

Preparing Bait

Poison is mixed with foods rodents like (bait).

The bait and poison mixture must look good to rodents so that they will eat the poisoned bait instead of the stored grain.

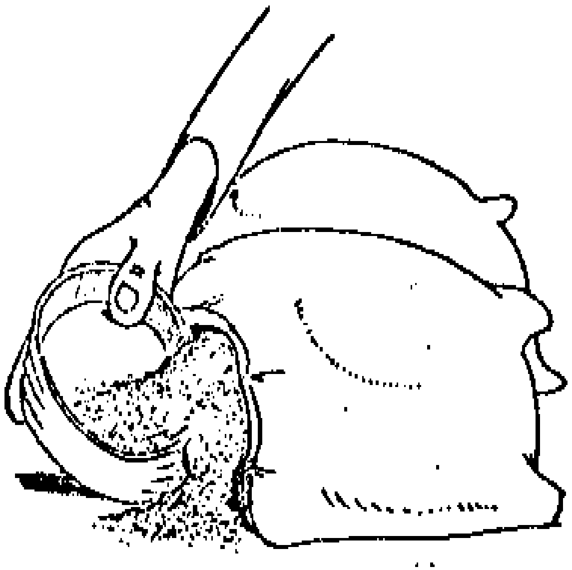
<FIGURE 77>

51bp59b.gif (317x317)

A cereal bait often is used. Cereals for bait must be kept free of insects. The cereal should be in fine- or medium-size pieces. Warfarin is usually used at 0.005% to 0.05% (the amount of Warfarin contained in the bait mixture). Above 0.05% the rats can taste the poison and will not eat the bait.

<FIGURE 78>

51bp59c.gif (317x317)



Anticoagulant poisons are often sold in master mix form. This master mix includes an ingredient which helps the poison mix in better with the bait.

Here are directions for mixing baits:

Dry Anticoagulant Baits. To make 10kgs of Warfarin or Coumatetralyl ready-to-use bait:

*** Mix 9.5kg of dry ground meal (19 parts by weight) of oats,**

wheat, or any cereal grain with 0.5kg of master mix (1 part by weight).

Oily Anticoagulant Baits. These baits are used instead of dry baits in wet places, add in places where the bait will stay for some time. The cereal does not have to be as fine as for dry bait. Rats like the bait when it has sugar, molasses, or some sweet food in it.

* Mix (by weight): 17 parts cereal
1 part sugar
1 part Warfarin Master Mix

* Stir well, so all dry ingredients are mixed.

* Add one part (by weight) oil -- liquid paraffin or white oil.

* Stir until the bait is evenly mixed.

* This makes a total mixture of 19 parts of bait (cereal, sugar, and oil) to 1 part of poison. If rodents still prefer to eat the stored grain, change from oily bait to damp bait.

Damp Bait. Rodents like damp baits, but these baits dry out quickly. amp baits are usually used with acute poisons. There are several ways of making damp bait:

1. [/I]Wet Cereal. Soak cereal grains overnight (wheat, sorghum,

etc.) in water. Drain the water off just before use. Add correct amount of poison. The directions for the amount of poison are given on the containers. IF THERE ARE NO DIRECTIONS FOR USE, DO NOT USE THE POISON.

2. [/I]Damp, Coarse Cereal. Soak (by weight) 2 parts cereal in 1 part water for 1 hour. Stir several times. Add poison and use.

3. [/I]Bread Mash. Soak old bread in water. Drain off extra water. Pound wet bread to a paste. Mix in poison and use.

Liquid Bait. These are useful in dry situations. Rats living in stored grain areas have to go looking for water. Other sources of water should be removed as much as possible. Liquid baits then are placed as drinking

<FIGURE 79>

51bp60a.gif (393x393)

Liquid baits are simply poisons dissolved in water. They may be acute or anticoagulant types of poison. Sodium fluoroacetate, Warfarin, and Pival all are used in making liquid baits.

Liquid baits, however, lose their power in two or three days i n warm weather.

Placing Baits

<FIGURE 80>

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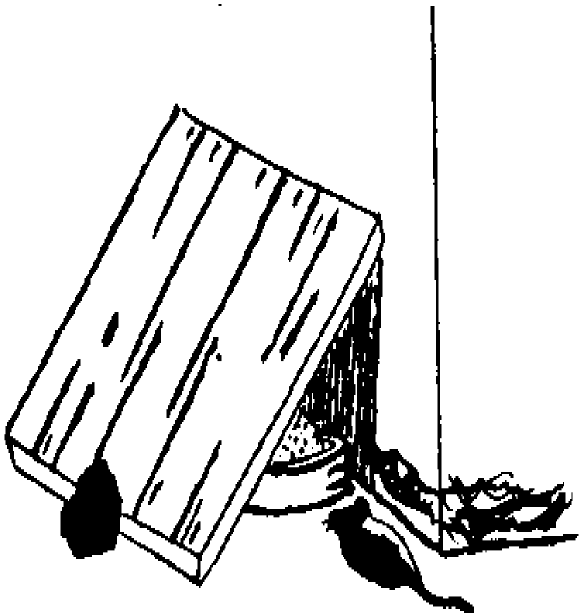


There must be plenty of bait stations
Bait must be placed in runways, near holes, burrows, and nests. Farmers should remember when placing bait that rodents stay close to home. Rats usually travel in an area of About [45m.sup.2]and mice stay within a [9m.sup.2] area.

Placing Acute Poisons. Here is one method:

* Prepare 10cm x 10cm square papers, banana leaves, or like

material.

* Place poisoned food in the middle at one end.

* Roll up the paper and twist the ends.

* One pound of bait makes 80 or 90 doses.

* Throw the paper packets into places where it is impossible to place traps -- into holes and burrows, between walls, etc.

NEVER PLACE THESE PACKETS WHERE CHILDREN AND PETS CAN GET THEM.

Another method of placing bait:

* Cover the floor with small pieces or teaspoonsful of bait containing an acute poison.

* Collect and destroy the bait after 24 hours. Do not recommend this method to farmers who do not have separate grain storage buildings: it is far too dangerous to leave poison bait sitting around on the floors and grounds belonging to a small farmer.

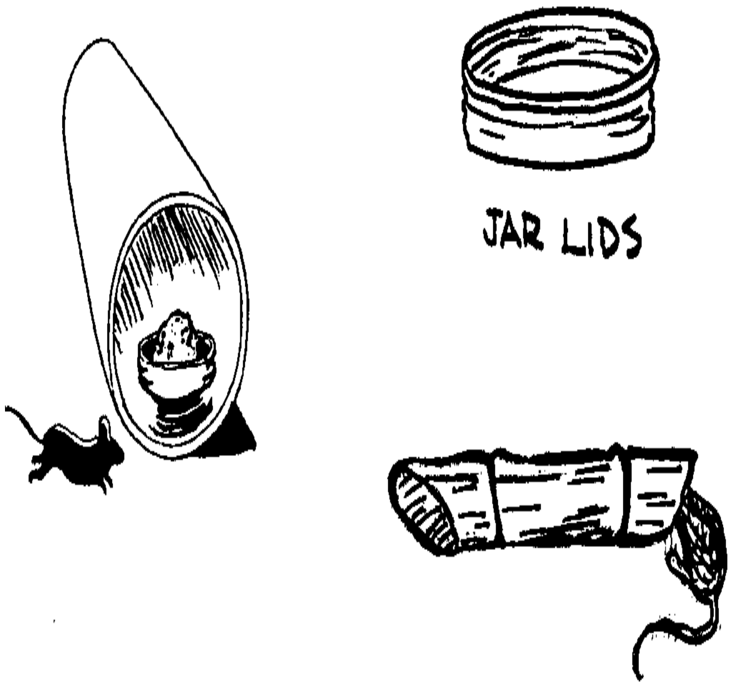
Placing Anticoagulant Poisons. These poisons are probably the best ones for you to recommend to farmers. They must be used carefully. But they are relatively easy to use.

It is important to keep enough bait out for a long enough period of time. Keep bait out at least two weeks. Each pile of bait should be 200-250cm, and each should be laid in the places where signs of rodents have been found.

Place the bait in empty shallow tins, on ends cut off from tin cans, in pipes and pieces of bamboo. The bait can be placed directly on the ground, but it may get wet and moldy.

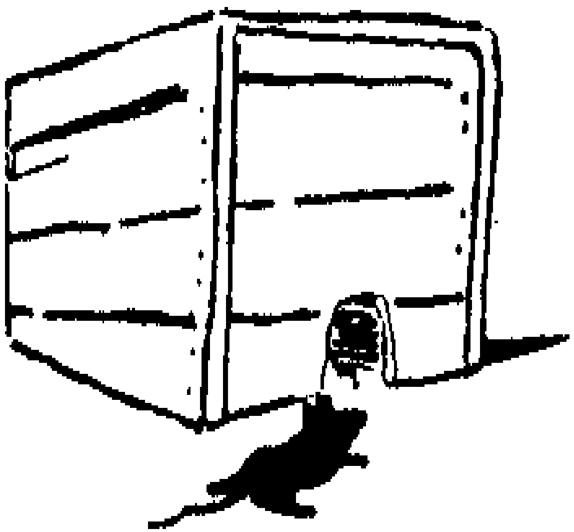
<FIGURE 81>

51bp61.gif (353x353)



<FIGURE 82>

51bp62a.gif (317x317)



*** Construct bait boxes and use them and boards, pipes, or cans in certain places to hide the bait from other animals to keep baits from getting wet.**

*** Put the bait in places where signs of rodents have been found.**

* Check the bait stations every day to make sure there is enough bait.

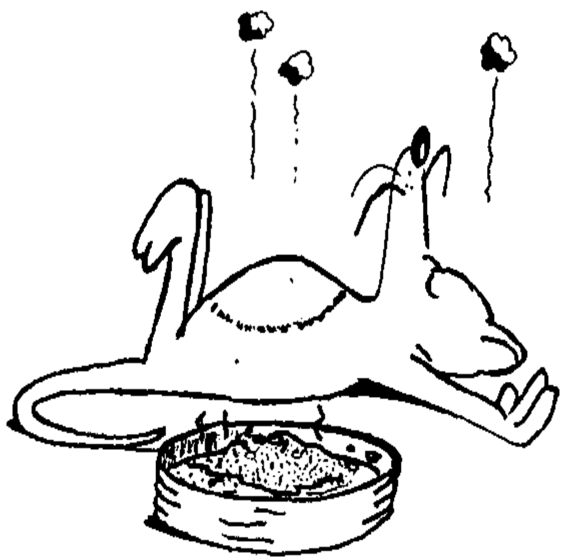
* Smooth the bait so that next time he checks he will be able to see signs of feeding.

* Change moldy or insect-infested baits for new ones.

* Move the bait station to another place if the bait is not being eaten.

<FIGURE 83>

51bp62b.gif (285x285)



Other materials on rodent control follow:

*** Information sheets on major rodent poisons. Use these as guides to preparing materials for use with rodenticides available in your area.**

*** Instruction sheet for making rat baffles.**

*** Scripts for a series of illustrated leaflets on rat control, including an example of how an artist can turn these scripts into very effective information through use of illustrations.**

WARFARIN

<FIGURE 84>

51bp63.gif (317x317)

TYPE: Anticoagulant rat poison.

FORMULATIONS: * Ready-to-use bait.

*** Powder concentrate. The Total of Warfarin in the concentrate is only 0.5% of the whole. Mix 1 part of the powder concentrate to 19 parts of bait. This gives a bait which contains 0.025% Warfarin.**

*** Powders to dissolve in water. This makes a liquid for use as poisoned drinking water or making wet bait.**

* Dusts. These contain 1% Warfarin. This can be sprinkled on surfaces where rats run.

* Wax rat blocks. These are blocks of wheat held together by wax. The poison is mixed in the wheat. The block is placed where rats will nibble at it.

These formulations are easy to use. But they should be used with great care.

WARNING: ALL POISONS ARE DANGEROUS!!

* Follow directions for use given on the poison container.

* Do not eat, drink, or smoke when using poison. Wash your hands very well after using poison.

* Put poison containers away out of the reach of children.

NOTE: If someone swallows Warfarin, make him vomit. To make someone vomit--stick your fingers down his throat or make him drink warm water with salt in it. Vomiting empties the stomach. Get the poisoned person to a doctor as soon as you can.

COUMATETRALYL

OTHER NAMES: Racumin

TYPE: Anticoagulant rat poison.

FORMULATION: * Ready-to-use bait (0.05%).

*** Mix containing 0.75. Dilute 1 part mix to 19 parts of bait. Final concentrate 0.37%.**

*** Dust (0.75%). Place on surfaces where rats run.**

USES: Uses as you would use Warfarin.

WARNING: ALL POISONS ARE DANGEROUS.

*** If you are not sure which poison to use, ask someone who knows how to use poisons correctly.**

*** Read all direction carefully.**

*** Do not eat, drink, or smoke when handling poison.**

<FIGURE 85>

51bp64a.gif (353x353)

<FIGURE 86>

51bp64b.gif (285x285)

WASH YOUR HANDS

CHLOROPHACINONE

OTHER NAMES:

TYPE: Anticoagulant poison.

FORMULATION: * Ready-to-use bait (0.005%).

*** Mix in oil (0.25%). Dilute 1 part to 49 parts to 19 of bait. Concentrate should be (0.005%).**

*** Dusts. These contain 2% Chlorophacinone. These can be sprinkled into holes and runways used by rats. Dusts should be sprinkled for 20 days.**

WARNING: ALL POISONS ARE DANGEROUS.

*** If you are not sure which poison to use, ask someone who knows how to use poisons correctly.**

*** Read all directions carefully.**

*** Do not eat, drink, or smoke while using poisons.**

*** Never use these formulations near food.**

KEEP AWAY FROM CHILDREN WASH YOUR HANDS AFTER USING POISON

SODIUM MONOFLUOROACETATE

OTHER NAMES: Compound 1080

TYPE: Acute Rat Poison

FORMULATIONS: Must be used as a liquid. When using the liquid,, you must obey all the safety rules for handling poison.

WARNING: VERY DANGEROUS TO MAN. THERE IS NO ANTIDOTE TO THIS POISON.

* Men and animals can be killed or made sick by eating rats that have eaten this poison. The powder form causes immediate death in humans who breathe it. NEVER EVEN OPEN A CONTAINER OF THE POWDER.

* Do not get the poison on your clothes or your body. If you do, wash with a lot of running water.

* Keep it away from other people and animals.

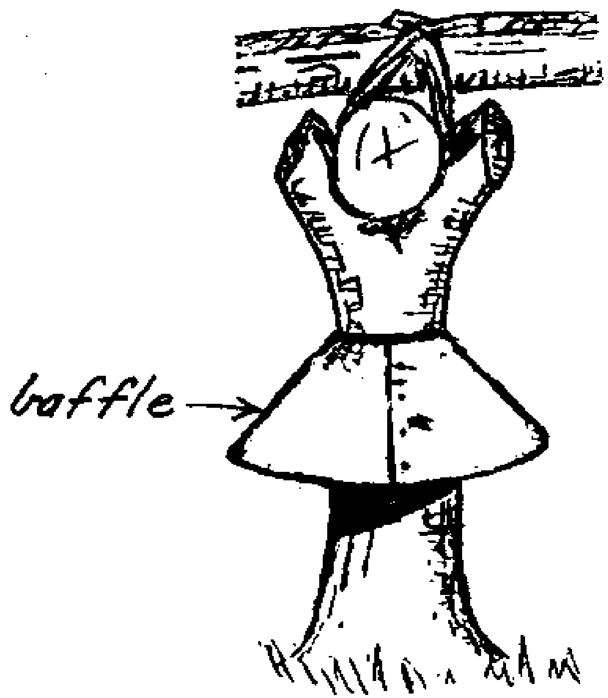
* Burn or bury all the tools and containers used to mix and hold the poison. If buried, keep away from underground water sources.

* USE RUBBER GLOVES AND WASH YOUR HANDS CAREFULLY AFTER MIXING THE POISON.

RAT BAFFLES

<FIGURE 87>

51bp67.gif (353x353)



Materials and Equipment

* 1 flat tin sheet (30 gauge, 0.9 x 2m)

1 pair tin shears or sharp chisel

1 hammer

Chalk, charcoal, or large nail for drawing baffles on tin sheet

25, 4-6cm nails (You will need 5 nails for each baffle)

Baffles should be about 50cm in diameter at the narrow end. The size will vary with the size of the leg which the baffle must fit.

* Mark out baffles on tin sheet with chalk or charcoal before cutting them out.

* Cut out along the outside edges. Do not cut the middle yet.

* Start with the thinnest leg first. Cut out the hole in the middle of the baffle little by little. The baffle must fit tightly to keep even the smallest rodent from climbing between the baffle and the leg. If the hole in the baffle gets too big for this leg, use it on a fatter leg.

* Nail the baffle tightly to a wooden leg. Use cement mortar to fasten the baffle to a concrete leg.

* Cut out and fit all the baffles in the same way.

* Make wooden legs round, if they are not round already. Cut the middle hole of the baffle to fit a concrete leg which is not round.

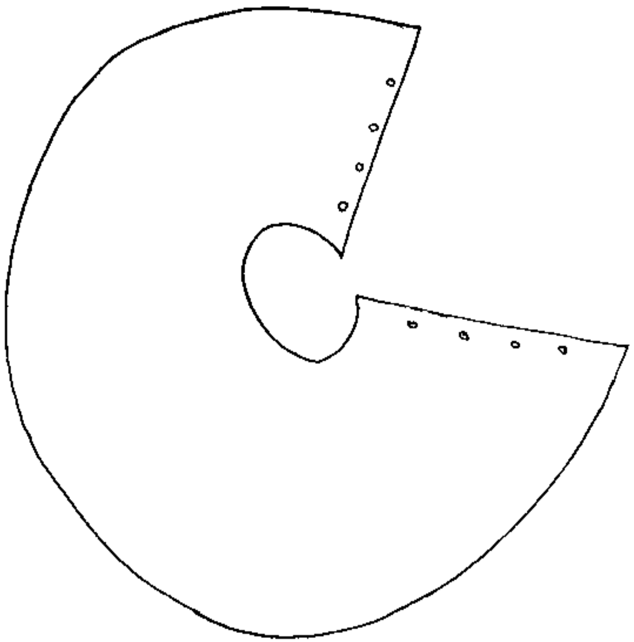
NOTE: You can use whatever thin metal is available. Old tin cans can be cut and flattened.

Below is a pattern for a rat guard to be cut from a piece of tin or a flattened tin can. This piece is cut out and bent to form a cone with a hole in the center. It is fastened around the leg of the crib or

storage building and attached to the leg with nails or wire.

<FIGURE 88>

51bp68.gif (317x317)



RAT CONTROL SERIES

SUGGESTED USES: This series of scripts is a short version of the material in the rodent section. The scripts could be used as part of a campaign to alert farmers to the damage rodents do, and to the steps which can be taken to control rodents.

The scripts have been prepared in some detail; you can choose the points

which best fit the situation in your area. The points can be translated and pictured quite easily. The illustrated material which follows these scripts shows how VITA artist Kenneth Lloyd has used pictures to explain many facts about rodents.

SCRIPT # 1

RODENTS ARE EVERYWHERE

* **Rats live in your houses.**

* **Rats live in your fields.**

* **Rats eat holes in your buildings.**

* **Rats eat food in your houses.**

* **Rats eat grain in your storage places.**

* **Rats make your food and grain dirty. They put droppings from their bodies on the grain while they are eating it.**

* **Rats bring sickness. They can bring diseases which make people die. They can even kill sleeping babies.**

* **Rats like to live in storage places.**

* **Rats eat a lot of your grain everyday. There is less grain for you to sell and eat.**

* You must keep rats out of your fields. You must keep rats out of your house. You must keep rats out of your stored grain.

* Your extension worker can tell you how to keep rats away from your farm.

* Remember: Rats bring sickness to you and your family.
Rats steal food and grain.
Rats make your grain dirty.

SCRIPT # 2

KNOW ABOUT RATS

* You must know what rats can do before you can fight them.

* Rats move fast. They are fast and quiet.

* Rats have sharp teeth. They can make holes in wooden walls and trees.

* Rats can climb and jump.

* Rats can crawl on ropes and wires.

* Rat can swim. They are not afraid of water.

* Rats are smart. They can stay away from traps.

* Rats have large families. One pair of rats can make a family of more

than 1,000 rats in a year.

* Rats build nests in quiet, dark places. They make nests using straw, feathers, paper, and other pieces of trash.

* Rats hide around homes and storage places. Rats like to live near food.

* Some rats live under the ground. They like to live near grain growing in the field.

* Rats like to eat at night. Rats move around at night.

* Rats use the same road every time they make a trip.

* Rats find many places to hide on a farm. You must look carefully to find them.

* Look for nests.

* Look for trails. Rats pack down the plants in places because they always use the same road.

* Look for droppings. New droppings are shiny and black. Old droppings are gray.

* Look for chewed holes in wooden walls.

* Look for dirty, greasy marks at the bottom of walls and doors.

* Listen at night. Sometimes you can hear rats moving in the roof, cooking place, or grain storage place.

* Now you know where the rats are. Now you can get the rats away.

* Your extension worker can give you information on how to get rats away from your farm.

SCRIPT # 3

FIGHTING RATS WITHOUT POISON

* Rats must have food and water to live.

* Rats like dirty places.

* Keep your home and grain storage places CLEAN.

* Make sure rats do not get food.

* Put old food into a covered container if you want to use it later. Do not leave food on tables or shelves.

* Feed old food to the pigs and chickens right away.

* Bury garbage. Or burn garbage. Or compost garbage.

* Clean around the outside of buildings. Do not leave piles of garbage,

rags, paper, leaves, and cans. Rats like to hide in these things.

*** Keep grass cut short.**

*** Cut tree branches that grow near your home and grain storage area. Remember rats can jump. They can jump from the tree to the building.**

*** Make sure rats cannot get under the door of your home or storage area.**

*** Put strips of metal along the bottom of doors. Rats cannot bite through metal.**

*** Close all holes in wooden buildings with metal sheets or flattened tin cans.**

*** Fill holes in plaster, brick, or mud walls.**

*** Use rock or concrete floors. Rats can come up through the ground into the storage area.**

*** Store grain in covered containers. Place containers off the ground.**

*** Put metal bands around the bottom or legs of grain containers. This keeps rats from climbing up to the top.**

*** Keep a cat or dog. Train the animal to chase and kill rats.**

*** You may have to use rat poison also. Contact your extension worker. Do not use poison before you talk to the extension worker. POISON**

IS DANGEROUS.

SCRIPT # 4

FIGHTING RATS WITH POISON

* Clean your grain storage areas.

* Close and rat-proof all holes in buildings.

* Protect the storage containers and building with metal. This stops new rats from coming in.

* Use poison and traps to kill any rats that are left.

* Talk to your extension worker before you use poison. The extension agent will know which poison to use. He will know how to use the poison. He will know where you can get the poison.

* Remember that some rat poisons can kill other animals and people.

* One poison kills rats quickly. You can kill many rats at one time.

* Soon rats will not eat this poison. They know this poison kills.

* Then you can use another kind of poison. Rats must eat this poison for 3 days or so before they die. Rats do not know they are dying. So they will keep eating the poison.

* Some poison is already mixed with food rats like to eat.

* Food that rats like to eat is called bait. Bait can be rice, corn meal, bread.

* You can mix this bait with poison yourself. Ask your extension worker how much poison to mix with the bait.

* Add some corn oil, coconut oil, sugar or molasses to the bait and poison. Rats like the taste very much.

* Try not to touch the poison. Wash your hands when you finish mixing.

* Now make boxes and containers to put the bait in. These boxes and containers let the rats in. Other animals and children can not get into these boxes and containers.

* There are different kinds of bait boxes and containers.

* You can put bait in pipes made of bamboo or metal.

* Put bait in tin cans.

* Put bait in small dishes made out of bamboo or tin cans. Put dishes inside the bait boxes or bait containers.

* Put bait containers close to walls and doorways in your storage area.

* Put poison containers near places where rats run.

* Make bait containers to put in your fields.

* Put these containers near trails and rat holes.

* Poison field rats before the grain is ready. Rats will not eat poison if they can eat grain.

* Check all bait containers very often. The poison bait must not get too old. Rats will not eat old bait.

* Remember: Check with your extension agent for help with poison.
Read the words on the poison box or jar.
Wash your hands after you mix the bait with poison.
Keep all poison away from food, animals, and people.

SCRIPT # 5

FIGHTING RATS WITH TRAPS

* Your extension worker can tell you which traps to use. He can tell you how to use them.

* It is good to use traps in places where children might go. Poison is too dangerous.

* Show your family where you are putting the traps.

* Show your family how the traps work. Traps can hurt people.

* You must put food that rats like in the trap. Try different kinds until you find a good bait. Try pieces of meat, dried fish, bread.

* Put traps near food places. Put traps on top of stored grain. Do not use rat poison in these places.

* Tie the traps down. Sometimes rats run away with traps. The traps just catch the rats' noses.

* Put traps near rat trails, rat footprints, rat holes.

* Move the traps around every few days.

* Check the traps every day. Make sure the bait is still there.

* Do not touch dead rats. Rats carry disease and sickness.

* Use a stick or shovel to get the rat out of the trap.

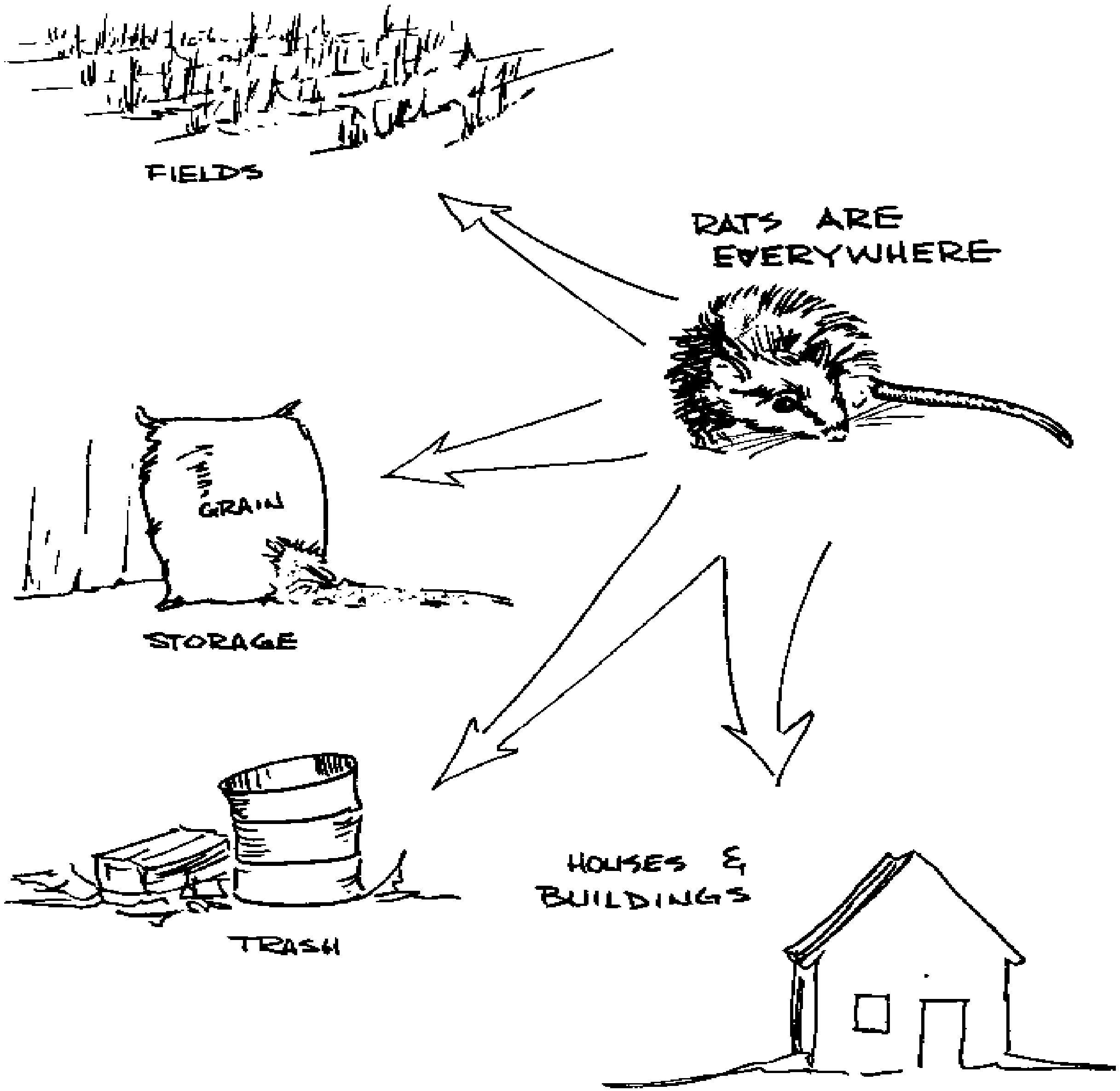
* Burn dead rats.

* Wash traps before using them again. Wash your hands.

* Remember: Ask your extension worker about traps and how to use them.
Traps can hurt people and animals. Use them carefully.
Do not let children play with traps.
Use traps near food and grain. Never use poison in these places.

<FIGURE 89>

51bp75.gif (600x600)



- Illustrations by VITA Volunteer Ken Lloyd

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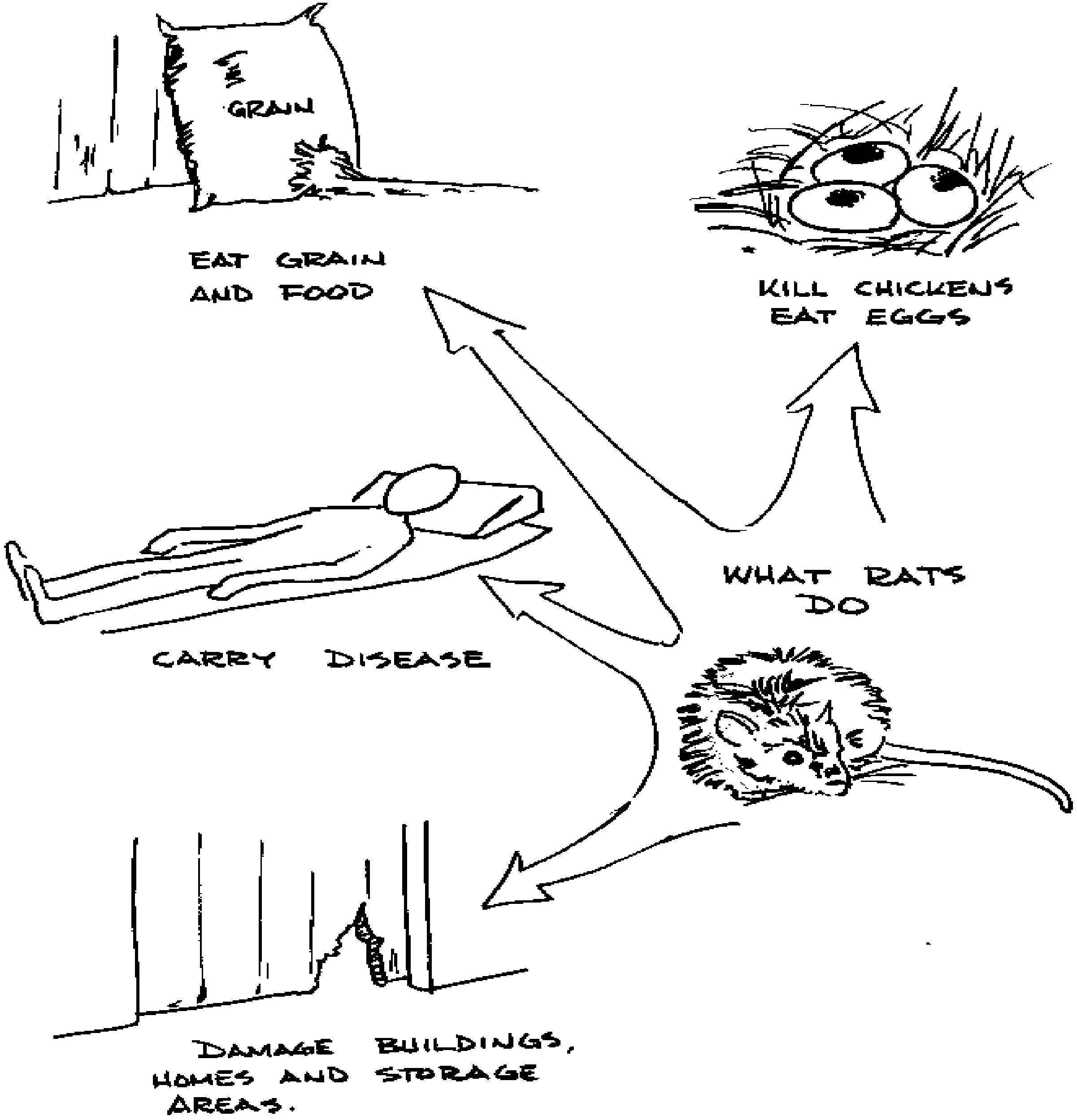

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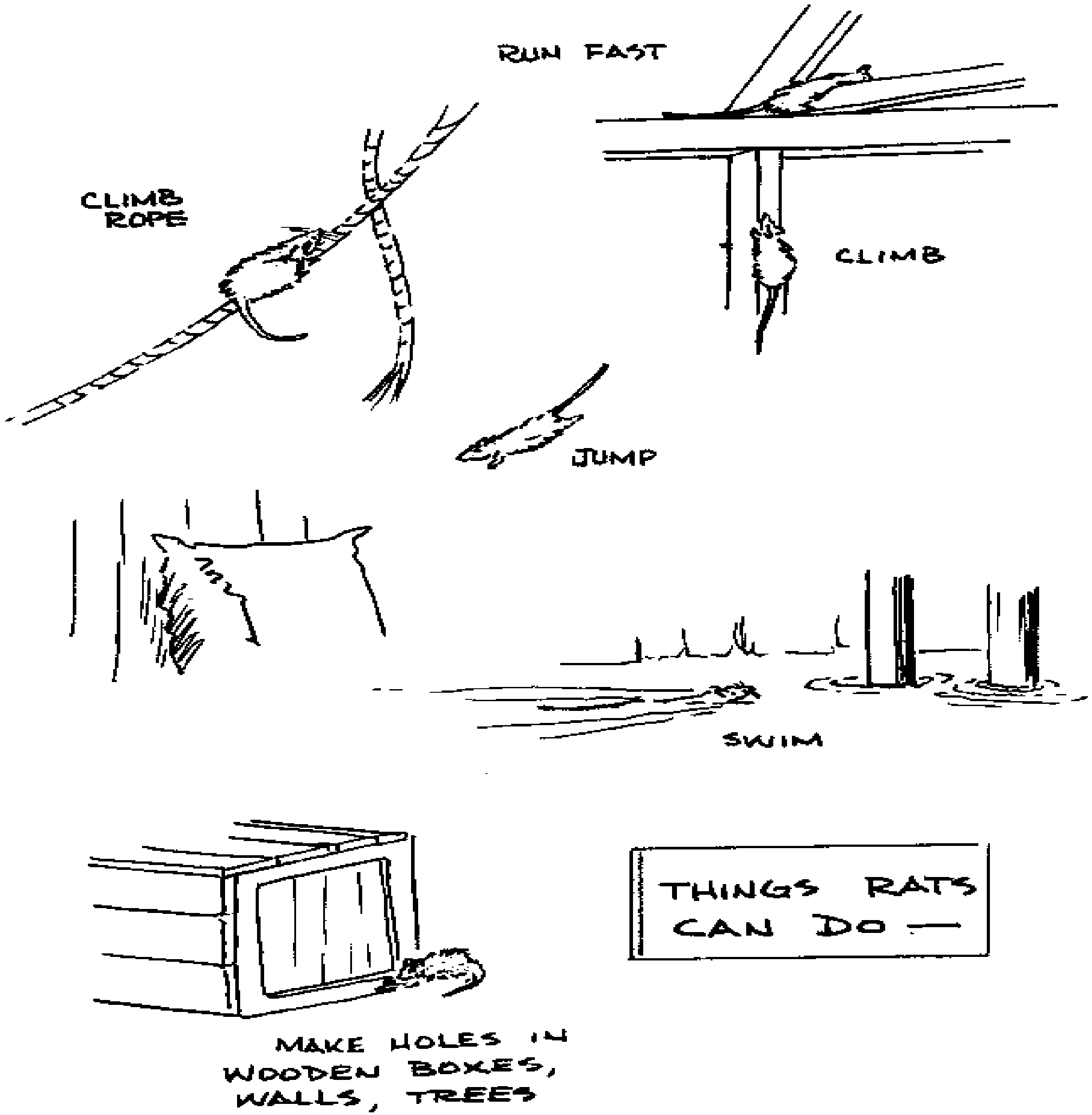

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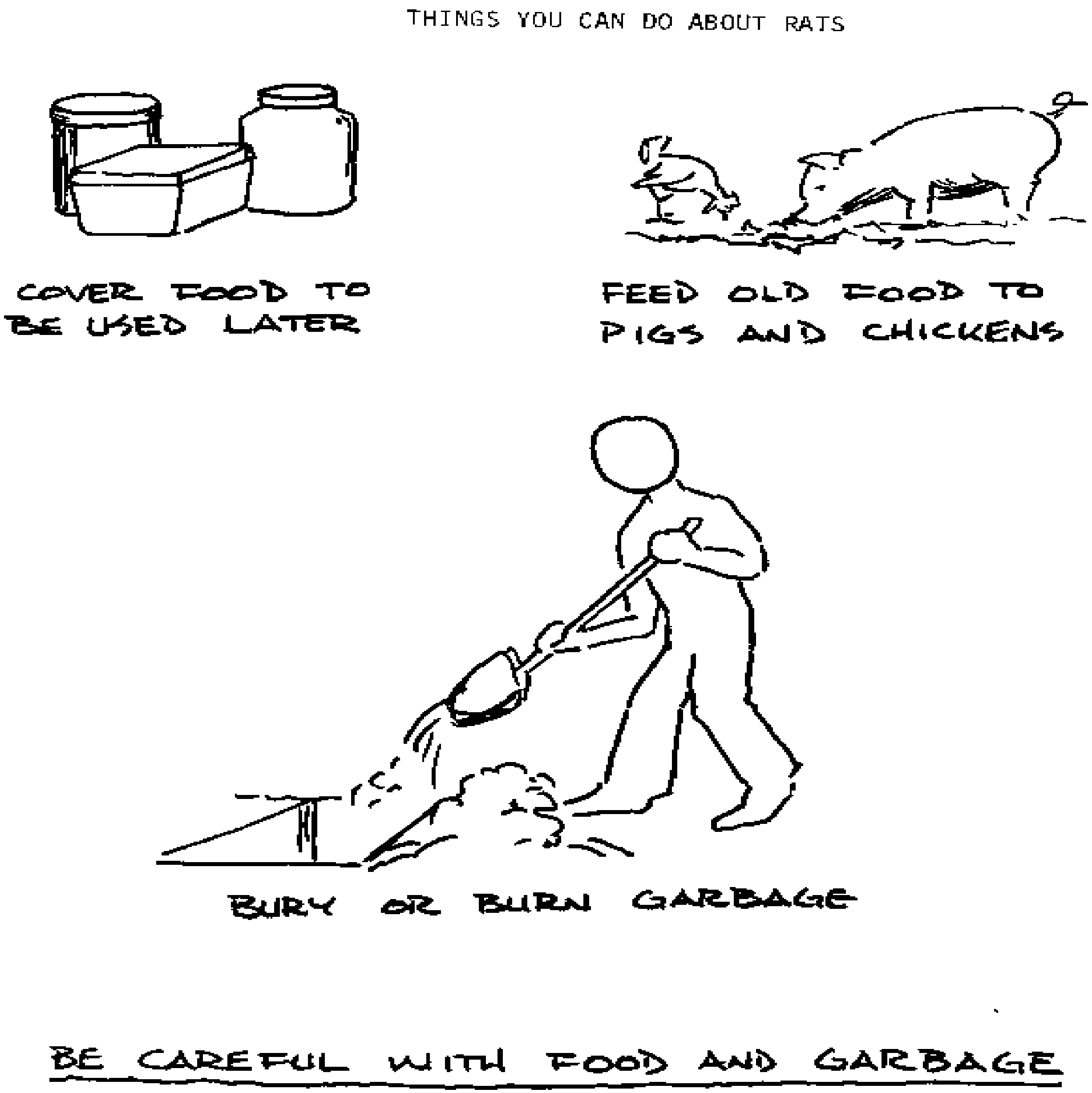

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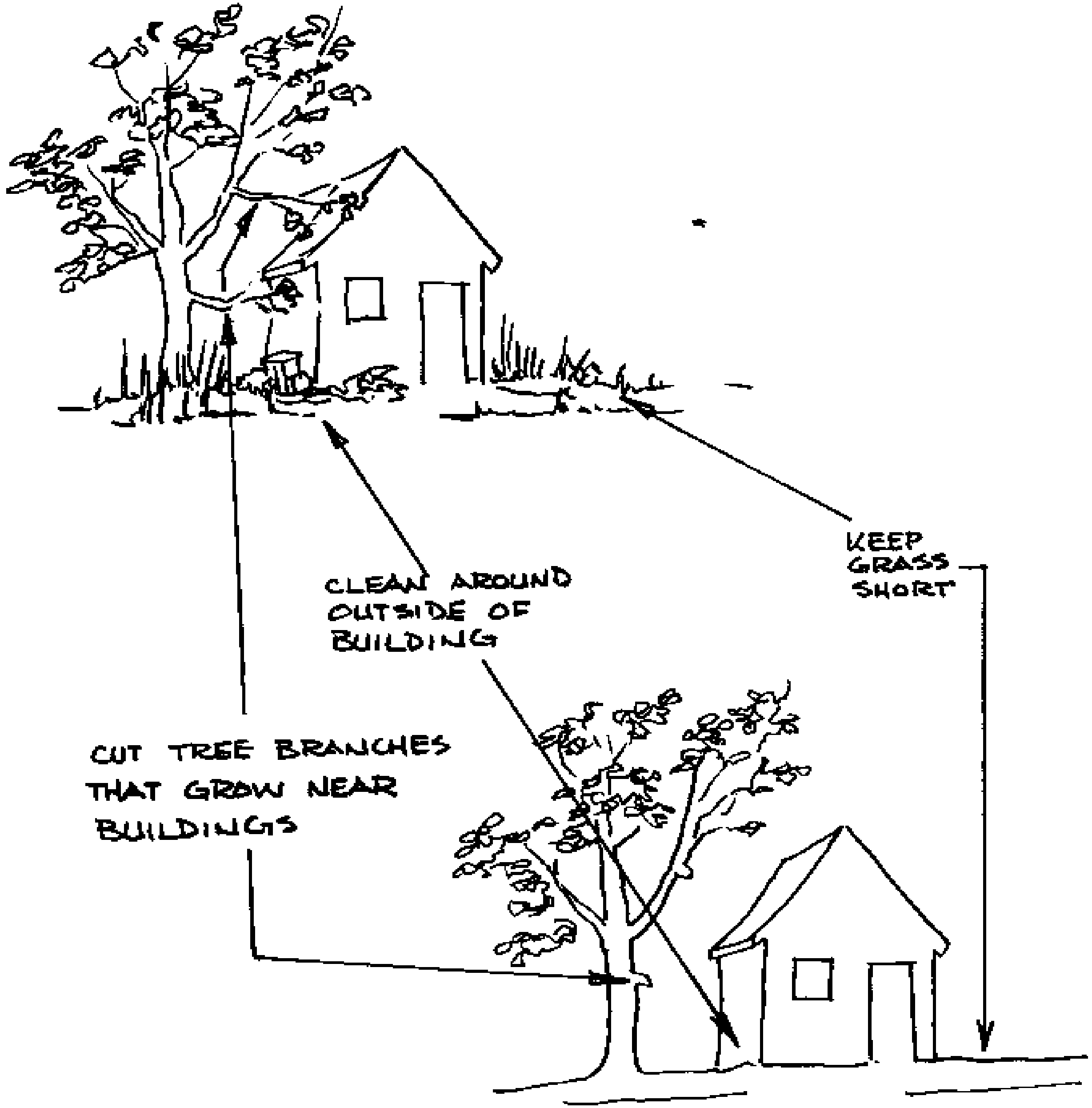

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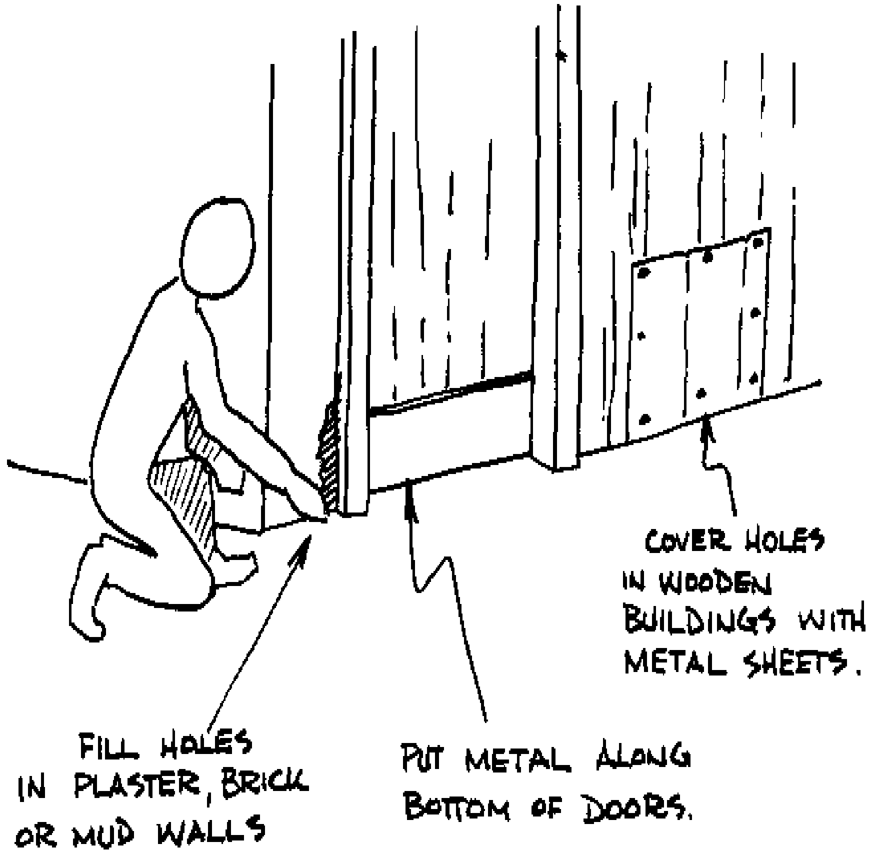

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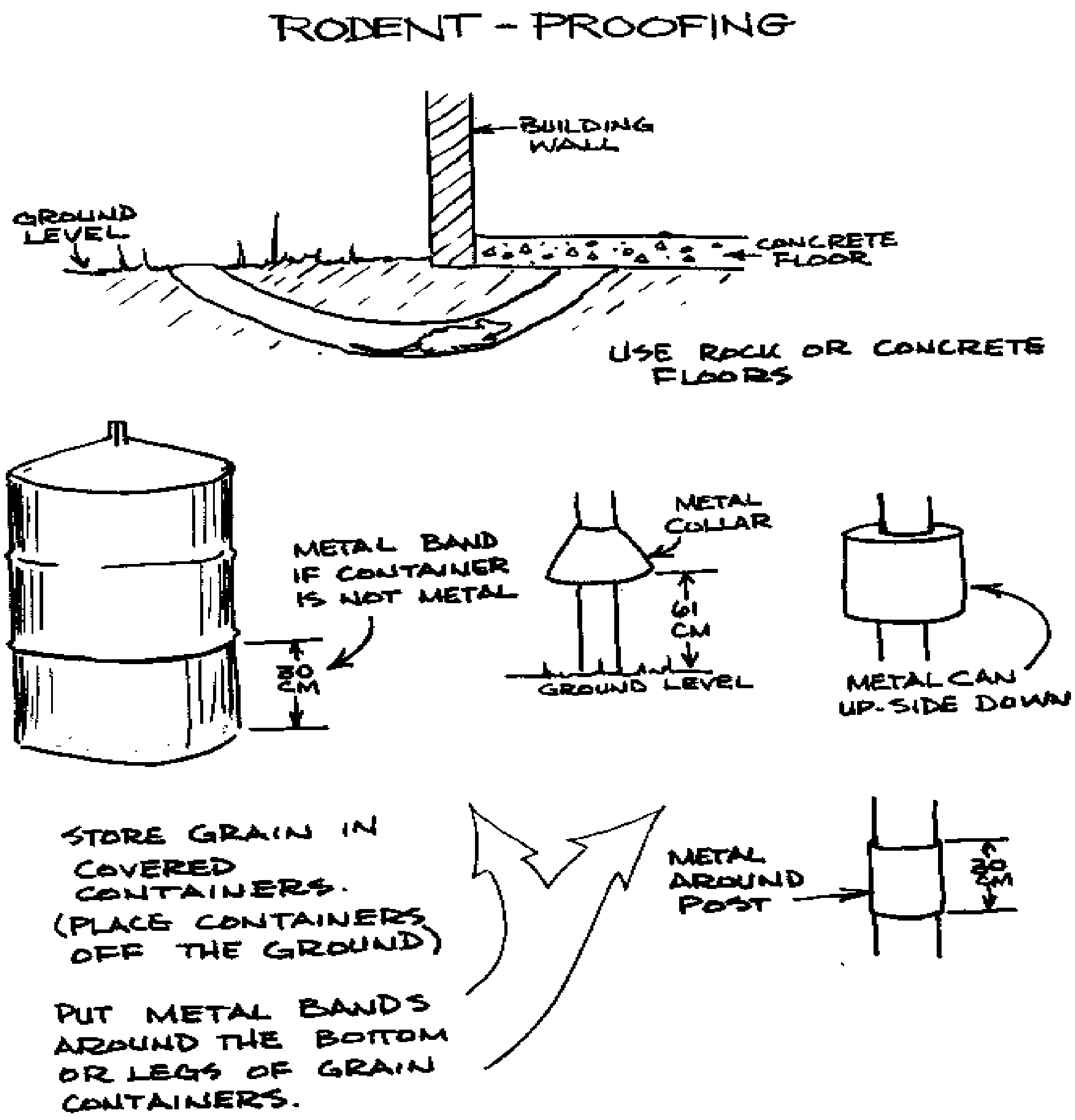
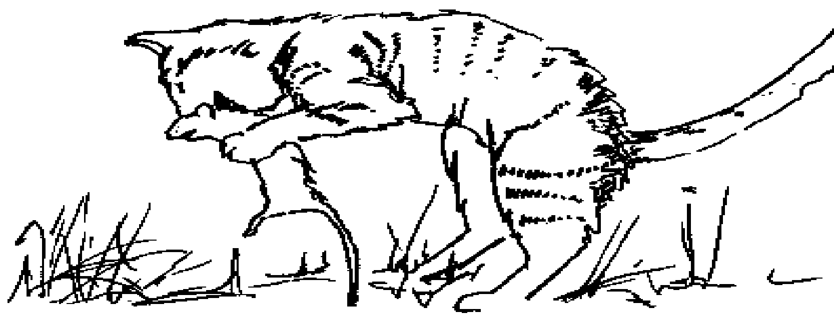


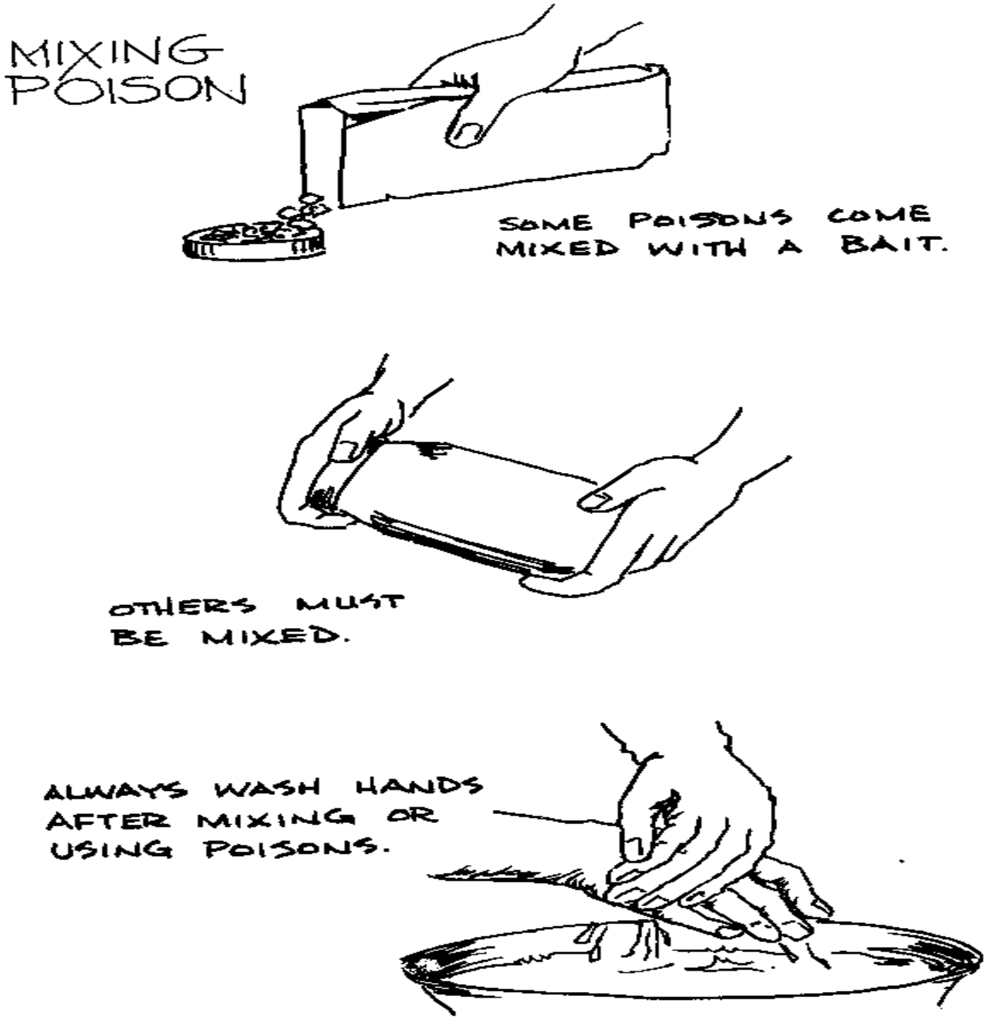
51bp82.gif (486x486)



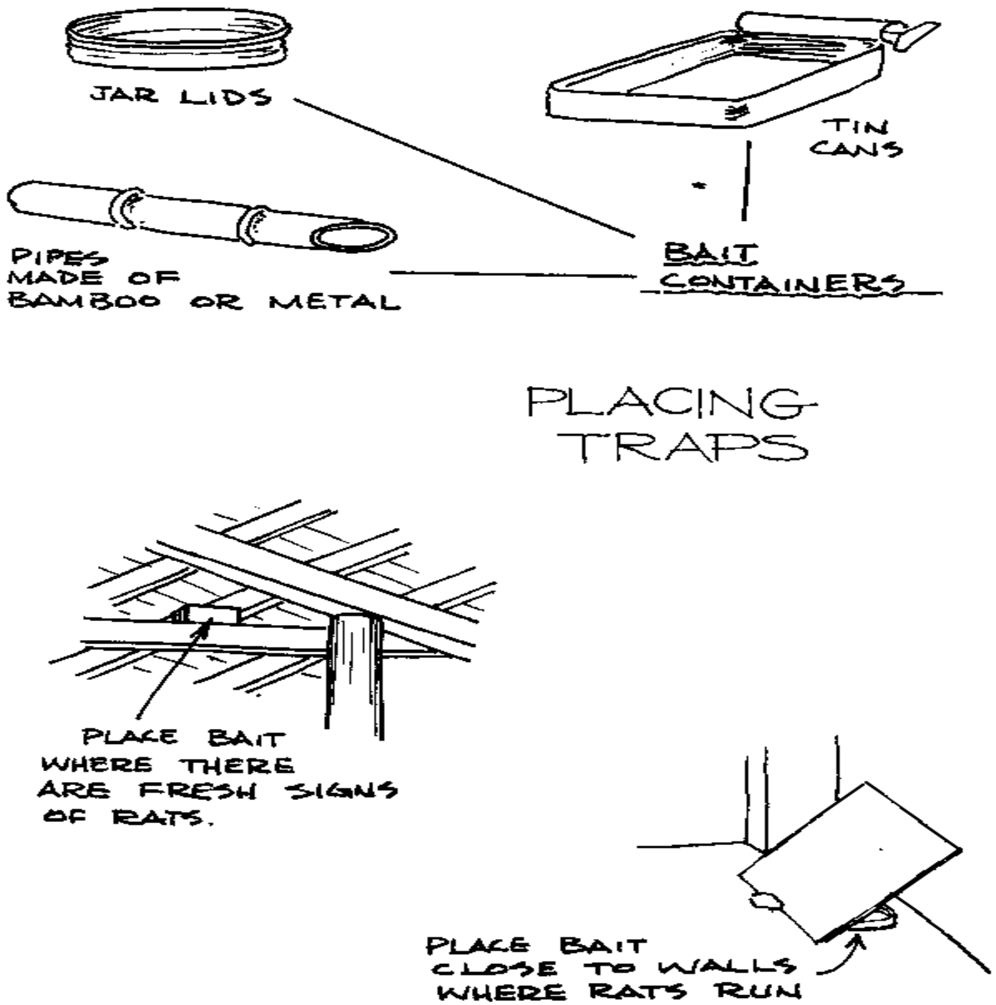
KEEP A CAT OR DOG.

CLEAN GRAIN STORAGE AREAS

51bp83.gif (486x486)



51bp84.gif (486x486)



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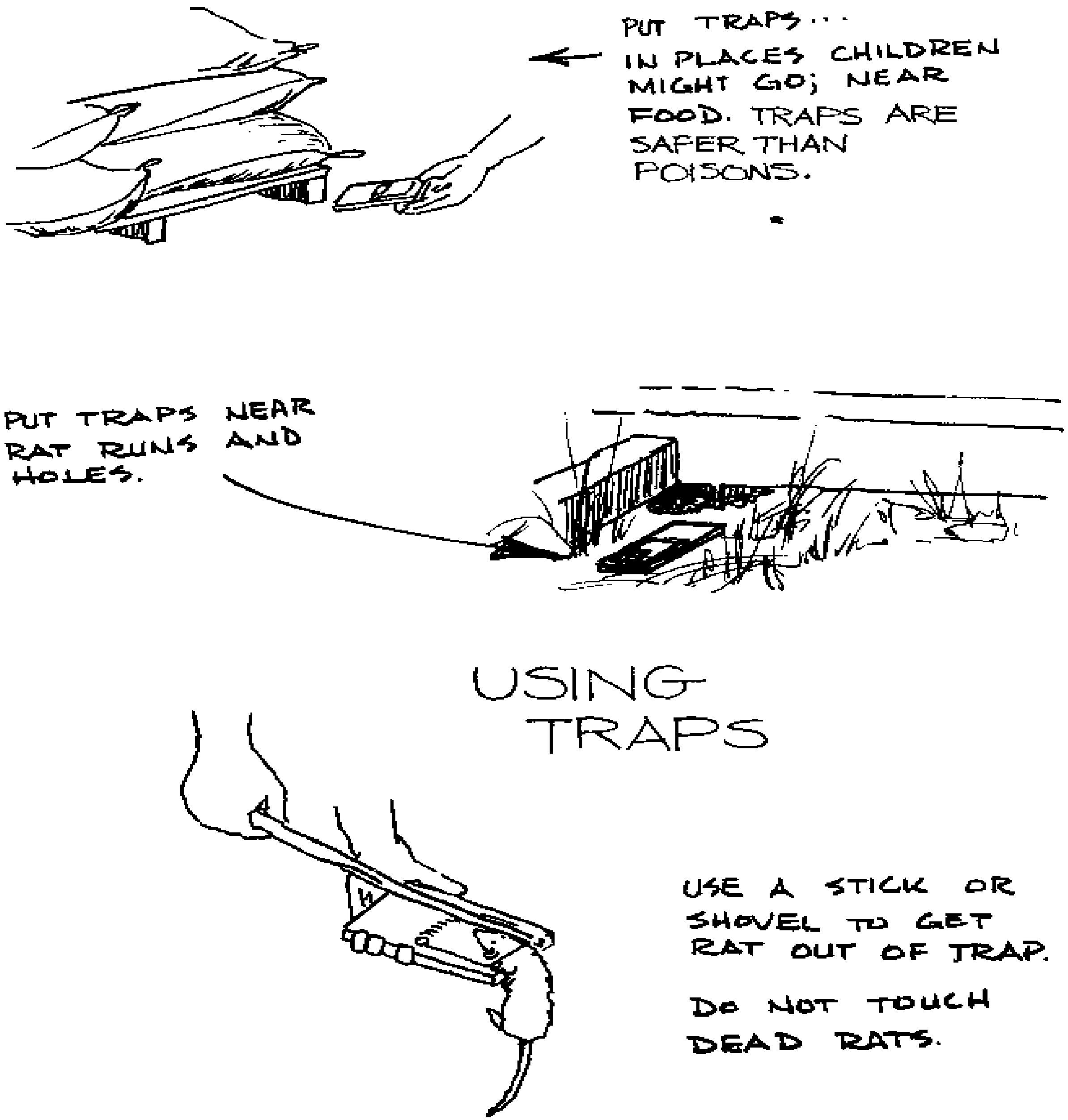

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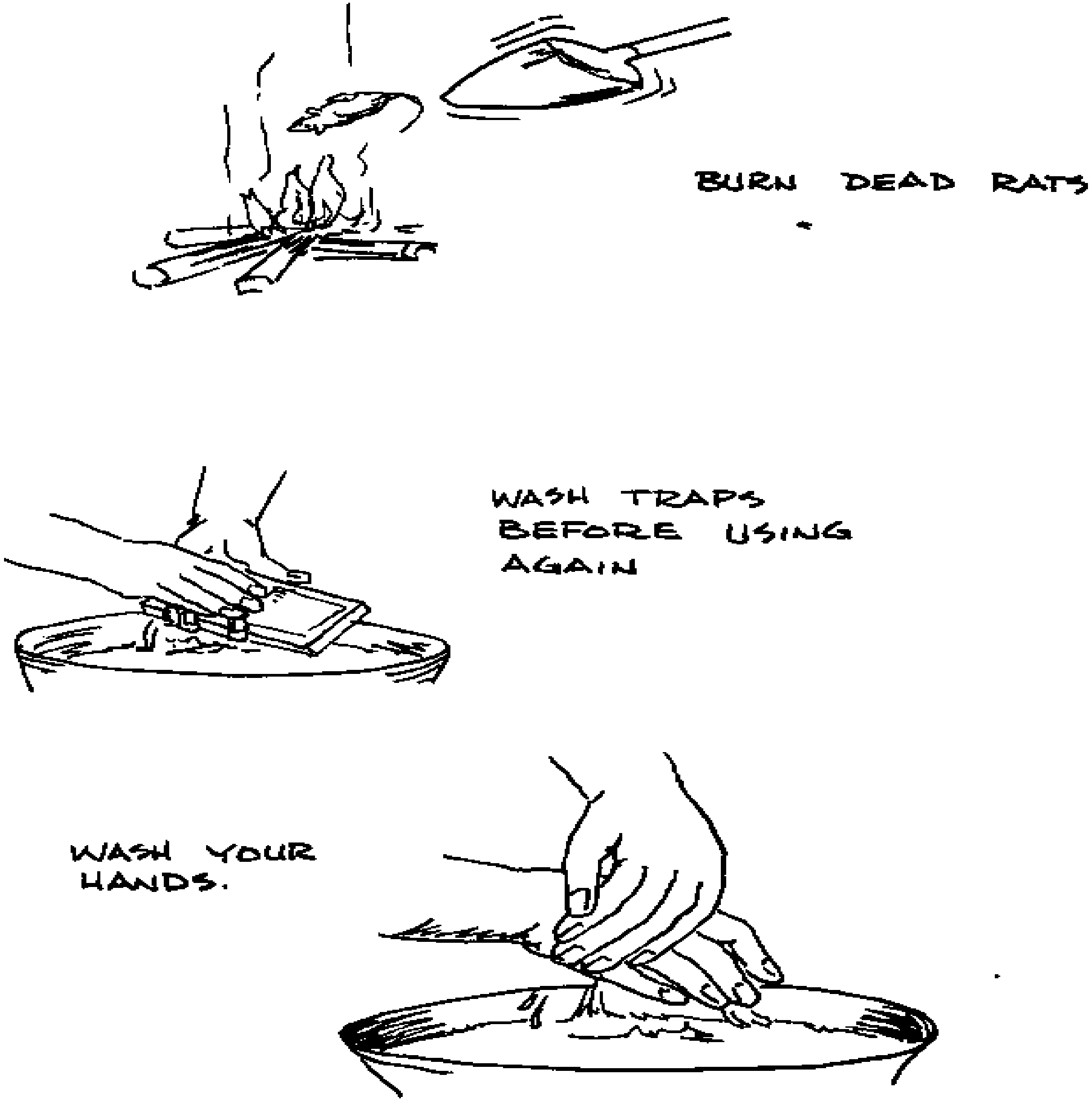
BURN DEAD RATS
WASH TRAPS BEFORE USING AGAIN
WASH YOUR HANDS.

<FIGURE 90>

<FIGURE 91>

<FIGURE 92>

<FIGURE 93>

<FIGURE 94>

<FIGURE 95>

<FIGURE 96>

<FIGURE 97>

<FIGURE 98>

<FIGURE 99>

<FIGURE 100>

Appendix A

The following material is taken from Guidelines for the Use of Insectidides, published by the

Agricultural Research Services
and Forest Service of the
United States Department of Agriculture

The section of the Guidelines included here contains information on

applying insectidides with sprayers and power dusters, safety precautions, and protection of wildlife from insecticides. The section of this book pertaining to insecticide dosages, formulations, and applications for use with stored grain is included in its entirety. This information is included because it is often hard for development workers to get such complete information.

The entire publication includes insect control for crops, livestock, households, forests, and forest products.

OTHER MEANS OF INSECT CONTROL

In addition to the use of insecticides, there are a number of other ways to control or to help control injurious insects. Natural controls, such as parasites, predators, diseases, and adverse weather conditions, are continually at work. Often they reduce populations of injurious insects and keep them at levels that are not economically damaging. Also, good sanitation and housekeeping are essential for the effective control of house flies, stable flies,
cockroaches, fleas and stored-product insects, even when these practices are supplemented by chemical controls. Cultural practices and mechanical devices aid materially in the control of the pink bollworm, boll weevil, tobacco hornworm, white pine weevil, and certain bark beetles. Crop varieties resistant to insects have been developed and are available to avoid or reduce damage by such insects as the hessian fly, wheat stem sawfly, spotted alfalfa aphid, and the European corn borer.

When harvested products are subjected to heat or extreme cold in storage, insect infestations are often destroyed or inhibited. Insect-free commodities can be protected by insect-resistant packaging and sanitation in storage and in marketing channels.

More satisfactory control of insect pests may frequently be obtained by carefully integrating the use of insecticides or fumigants with biological control agents and other nonchemical measures. This approach to insect control is most effective when the total population of the insect is attacked on a continuous basis (compared with treatment of seasonal infestations in individual fields). Often when such integrated control is practiced, insecticides
are needed only to supplement the other control measures. However,
for this method, all means of control of a pest insect must be considered to coordinate them to the greatest advantage and with the least harmful effect on other living organisms in the environment. Consult your State agricultural experiment station for the latest information. Do not use insecticides or fumigants unless they are needed.

APPLICATION OF INSECTICIDES

The key to effective use of an insecticide without injury to the treated plant, animal, or agricultural product is to follow directions on the label. Do not use any insecticide preparation for any purpose for which it is not specified. Most oil sprays prepared for application to walls of buildings will injure living plants or animals. Insecticide concentrates prepared for application
to plants may injure or kill treated animals or result in illegal residues in animal tissues or byproducts.

Only general information can be given here on the effective application of insecticides since much depends on the habits of the insect pest, the kind of damage that it causes, the nature and condition of the infested plants, animals, or commodities to be treated, weather conditions, and application equipment, as well as the type and formulation of the insecticide to be applied. For information to meet special needs, consult your State agricultural experiment station.

Weather Conditions

Wind, rain, and sun play an important part in the control you get from outdoor use of insecticides. Keep an eye on the weather. Local weather reports may be helpful in planning insecticide applications. Before you start to treat, watch the tops of trees or use other means to determine the direction and the amount of wind. Some air movement is helpful. Winds, however, can cause an insecticide dust or spray to be unevenly distributed on the plants and to drift away from target areas.

If rain is predicted, postpone treatment, if possible. Rain falling soon after you treat may reduce the effectiveness of an insecticide deposit. Cold weather may have the same effect. Some insecticides must be applied at temperatures above 50 [degrees] F. to be effective.

Extremes in weather during or following the spraying of fruit trees may lead to fruit or foliage injury. Russeting of fruit may be increased by pesticide
sprays if they are applied at night or during cool, rainy, or humid weather. Emulsifiable materials are more likely to cause injury than are wettable powders.

High wind and low temperature make control of insects by fumigation difficult. High winds may reduce gas concentration even in well-sealed warehouses. Insects are difficult to kill by fumigation at temperatures below 60 [degrees] F.

PRECAUTIONS

The following safeguards are to protect handlers of insecticides and treated objects, consumers of treated crops and animals, honey bees, fish, wildlife, domestic animals, fish pools, bird baths, creeks, feeding dishes of animals, and our basic natural resources--water, soil, and air.

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key-out of the reach of children and animals-and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

When spraying near dwellings, be sure you have left no puddles of spray on hard soil surfaces. Also check children's playthings such as mud pie dishes or other containers that may retain the spray solution and endanger small children who may enter the area later.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from
equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

Protection of Persons Using Insecticides

In handling any insecticide, avoid repeated or prolonged contact with skin and prolonged inhalation of dusts, mists, and vapors. Wear clean, dry clothing, and wash hands and face before eating or smoking. Launder clothing daily.

Avoid spilling the insecticide on the skin and keep it out of the eyes, nose, and mouth. If you spill any on your skin or clothing, remove contaminated clothing immediately and wash the skin thoroughly with soap and water. Launder clothing before wearing it again. If the insecticide gets in the eyes,

flush with plenty of water for 5 minutes and get medical attention.

The following insecticides can be used without special protective clothing or devices. In all cases, follow the label precautions.

Abate ovex
Bacillus thuringiensis paradichlorobenzene
calcium arsenate paris green
carbaryl Perthane
chlorobenzilate piperonyl butoxide
cryolite pyrethrins
dicofol ronnel
diphenylamine rotenone
Kepone ryania
lead arsenate sabadilla
lime sulfur Strobane
malathion sulfur
metaldehyde TDE
methoxychlor tetradifon
mirex trichlorfon
naphthalene zineb
oxythioquinox

The following insecticides can be absorbed directly through the skin in harmful quantities. When working with these insecticides in any form, take extra care not to let them come in contact with the skin. Wear protective clothing and respiratory devices as directed on the label.

benzene hexachloride ethion

binapacryl fenthion
chlordane heptachlor
chlorpyrifos Imidan
coumaphos lindane
crotoxyphos naled
crufomate Nemacide
diazinon phosalone
dichlorvos propargite
dimethoate propoxor
dioxathion toxaphene
endosulfan

The following insecticides are highly toxic and may be fatal if swallowed, inhaled, or absorbed through the skin. These materials should be applied only by a person who is thoroughly familiar with their hazards and who will assume full responsibility for proper use and comply with all the precautions on the labels.

aldicarb endrin
aldrin EPN
Bux famphur
azinphosmethyl methomyl
carbofuran methyl parathion
carbophenothion Methyl Trithion
compound 4072 mevinphos
Dasanit mexacarbate
demeton monocrotophos
dichloropropane-dichloropropene nicotine sulfate
mixture parathion

dicrotophos phorate
dieldrin phosphamidon
disulfoton Telone
DN-111 tepp
Dyfonate

The following insecticides are used in closed spaces as fumigants. Because of their volatility and toxicity, they are considered to be hazardous when inhaled. In closed spaces these fumigants should be used only by a licensed pest control operator or by a qualified person who is thoroughly familiar with their hazards, who will assume full responsibility for their proper use, and who knows he must comply with all precautions on the labels. The value given in parentheses after each material is the maximum average atmospheric concentration (threshold limit) of the insecticide, by volume, to which workers may be exposed for an 8-hour day without injury to health. These threshold limit values were adopted at the 30th Annual Meeting of the American Conference of Governmental industrial Hygienists, May 1968.

acrylonitrile (20 p.p.m.) ethyl formate (100 p.p.m.)
aluminum phosphide ethylene dibromide [(25 p.p.m.).sup.3]
(as phosphine 0.3 p.p.m.) ethylene dicfdoride (200 p.p.m)
calcium cyanide [(5 mg. dust per ethylene oxide (50 p.p.m.)
cubic meter).sup.2] hydrogen cyanide 10 p.p.m.)
carbon disulfide (20 p.p.m.) methyl bromide [(20 p.p.m.).sup.3]
carbon tetrachloride (10 p.p.m.) methyl formate (100 p.p.m.)
chloroform [(50 p.p.m.).sup.3] propylene oxide (100 p.p.m.)
chloropicrin (0.1 p.p.m.) sulfuryl fluoride (5 p.p.m.)

Reduce the danger of skin exposure to insecticides by wearing protective clothing and equipment as specified on the label. If specified, wear a respirator or mask designed for protection against the particular insecticide being used. Directions for use or illustrative material must contain the names of the pesticide being used. Fullface masks should always be worn by persons applying fumigants in buildings or warehouses. They should also be worn by persons applying the type of insecticide aerosols used in commercial greenhouses and warehouses. In many cases masks or respirators are needed by persons loading insecticides into aircraft or applying them by aircraft.

The gas methyl chloride used as a propellent in greenhouse aerosols and the liquid fumigants carbon disulfide, ethyl formate, ethylene oxide, methyl formate, and propylene oxide are flammable and explosive. Never use them near heat or fire in any form. Never open containers of these chemicals where there is little air in circulation without wearing an adequate fullface mask. Do not transfer any liquid fumigant from one container to another in a closed room; do not breathe the fumes.

(2) Not from list of threshold limit values.
(3) Ceiling limit not to be exceeded.

Protection of Persons Handling Treated Plants or Objects

If you must transplant or otherwise handle plants within 5 days after treatment with azinphosmethyl, demeton, disulfoton, endrin, or parathion or within 1 day after treatment with methyl parathion or mevinphos, protect your skin by wearing clean, dry cotton gloves. If gloves become wet, thoroughly wash the hands and put on clean joves. If you must work in close contact with tieated crops, as in thinning or harvesting, you should also wear dry, clean, tightly woven clothing.

If concentrated pesticide is spilled on the ground, remove or bury the contaminated soil. This is especially important in areas where small children play.

Treatment for Poisoning

If a person is poisoned by an insecticide, call a physician and give first aid immediately. If breathing has stopped, give artificial respiration. If two persons are present, one should give first aid while the other obtains the insecticide container and calls the physician. Tell him the name of the insecticide and obtain instructions.

In general it is advisable to induce vomiting if the victim has swallowed a high toxic insecticide and is not in an unconscious state and a physician will not be available within 30 minutes. A tablespoonful of salt or baking soda in a glass of warm water will help induce vomiting. Have the victim lie down and keep him quiet until you get advice from a physician. Keep the victim warm.

If a concentrate or oil solution has been spilled on the skin or clothing, remove contaminated clothing and wash skin with soap and water. If a person feels sick while using an insecticide or shortly afterward, call a physician immediately. In all cases make available the insecticide container and any attached labeling. Information provided by them is extremely valuable to the physician. Inform him of recent contacts with insecticides. The one most obvious to you may not be the one to blame.

If a person is overcome by the vapor of a fumigant, prompt, on-the-spot action is essential. Carry the victim outdoors or to a room free of gas and lay him down. Remove contaminated clothing and keep him warm. Administer first aid treatment immediately. If breathing has stopped, give artificial respiration. Call a physicial immediately. Fumigators should have kits properly equipped with antidotes required for first aid treatment of a victim of the specific fumigant being used and instructions on treatments that are to be administered only by a physician.

Protection of Fish and Wildlife

No chemical control of insects should be undertaken unless the expected benefits outweigh possible hazards to other animals. To minimize damage to fish and wildlife, do not use persistent chlorinated hydrocarbon insecticides when alternative insecticides of lesser hazard are available. Select insecticides
and methods of application that are least hazardous and apply them at minimum effective dosages.

Avoid drift of insecticides as much as possible and limit applications of insecticides to the target area. To prevent damage to fish, birds, and other animals, be careful not to contaminate streams, lakes, marshes, and grazing or browsing areas by improper application or excessive drift of insecticides. Where drift is difficult to control, use sprays or granules instead of dusts, and
ground applications instead of air applications.

Aircraft spraying in forest areas should be kept under aerial and ground surveillance at all times to insure precise application. Operations should be suspended any time the deposit pattern is not right. Monitor spray projects before, during, and after spraying to evaluate the effects of the insecticide on

fish, wildlife, livestock, beneficial insects, water, soil, and plants. Pilots should fly spray planes at least 500 feet high when going back and forth between the airstrip and spray block. They should carefully choose a route parallel to but not over streams and avoid flights over lakes, ponds, farm buildings, or pastures. They should check frequently to be sure that calibration is correct and all components are in good operating condition.

Field borders, hedgerows, ditchbanks, stream margins, and wood edges are prime wildlife habitat. Insofar as feasible, avoid treating them. "Dressing the field margins" can be very hard on desirable animal life. Be careful to avoid leaving treated seed or insecticide granules on the surface; this is especially necessary at turnrows. Overlapping swaths of insecticides are dangerous in doubling or tripling the danger to wildlife. This danger is greatest near aerial turning points, where several swaths may overlap, if care is not taken to prevent it.

Do not clean spray equipment or dump excess spray materials in or near streams or other water areas where drainage could contaminate water.

In forest spraying by aircraft, lay out spray blocks and flight lines to minimize drift into water, marshes, grazing, and other sensitive areas. Spray as near treetop levels as safety permits to minimize drift. Leave a nonspray strip along critical streams, lakes, ponds, and any other areas that may be adversely affected. Spray only when the wind velocity is less than 6 miles per hour and the temperature is less than 68 [degrees] F. Early morning or late evening hours are usually best for air operations. In aerial spraying of nonforest areas, take similar precautions.

Protection of Insect Parasites and Predators

A program of crop or forest pest control should be designed to take maximum advantage of any biological control factors that may be present. Whenever possible, the insecticide should be selective against the pest species concerned and of minimum danger to beneficial insects. If parasites or predators are abundant, it may be advantageous to defer or omit insecticide treatments.

Protection of Honey Bees and Other Insect Pollinators

More than half the crops listed in this handbook are dependent on insect pollination. An insecticide applied to these crops is of doubtful value if it destroys the pollinators while destroying the harmful insects. Most of this pollination is performed by honey bees. Protect them. Much of the damage to bees by insecticides can be prevented if you do not treat crops in bloom while bees are visiting the field. Treatment at night is safest. Other steps that will reduce bee losses are:

* Use pesticides only when needed.
* Use the lowest effective dosage and make a minimum number of applications.
* Use a material that is least hazardous to bees but will control the insect pest, if applications must be made while bees are actively visiting the area.
* Use granules or dilute sprays instead of dusts. They are usually less hazardous. Application with ground equipment is less hazardous to bees than application with aerial equipment.
* Avoid drift of insecticides into bee yards and adjacent crop or wild

plants in bloom.

* Do not apply insecticides if apiaries are near enough to be unavoidably affected; notify the beekeeper so he can move the hives in time.

The following lists indicate which insecticides are hazardous to honey bees, as determined by laboratory and field tests. These materials are hazardous to bees when applied as foliar treatments to agricultural and ornamental plants (including home garden applications), mosquito abatement treatments (except granular products) and foliage treatment to forests or shade trees. The materials are not hazardous when used as soil applications or dormant applications. For further information consult the pesticide container label. For information applicable to local conditions, consult your State agricultural experiment station.

Hazardous. -The following materials are highly toxic to bees exposed to direct treatment or residues. Do not apply these materials while plants are in bloom.

aldicarb Bux
aldrin calcium arsenate
azinphosmethyl carbaryl
benzene hexachloride carbofuran
chloropyrifos lead arsenate
crotoxyphos lindane
Dasanit malathion (as ULV or dust)
diazinon methyl parathion
dichlorovos Methyl Trithion
dicrotophos mevinphos

dieldrin mexacarbate
dimethoate monocrotophos
dyfonate naled
EPN parathion
famphur phosphamidon
fenthion propoxur
heptachlor tepp
imidan (Trichlorfon as a dust)

The following materials are toxic to bees and should not be applied when bees are actively visiting the area:

carbophenothion mirex
chlordane naled as E.C.
coumaphos perthane
crotoxyphos phorate
demeton phosalone
disulfoton propoxur
endosulfan ronnel
endrin TDE
malathion as E.C.

Avoiding Harmful Residues in or on Food and Feed

Residues in excess of the established legal tolerances can be avoided by applying only those insecticides specified for use on the crop or livestock and by following indicated schedules. Do not exceed recommended dosages. Observe carefully the safety restrictions, especially the required interval between the last application and harvest or feeding, and between the last application and slaughter of animals.

Avoid drift of insecticide sprays or dust to nearby crops or livestock, especially from applications by aircraft and other power equipment. Do not allow poultry, dairy animals, or meat animals to feed on plants or drink water contaminated by drift of insecticides.

Certain root crops, such as sugarbeets, peanuts, carrots, and parsnips, are susceptible to contamination from residues of certain organochlorine insecticides
in the soil. Do not apply aldrin, chlordane, dieldrin, endrin, heptachlor, or toxaphene to soils where the crop rotation includes one of these crops unless a finite tolerance has been established for the insecticide.

Byproducts from a number of crops treated with insecticides may be
safely fed to livestock or poultry if the crops are harvested or fed after the specified waiting period. However, when byproducts from some crops treated with certain insecticides are fed to livestock, insecticide residues in excess of
established tolerances may appear in meat, milk, or eggs. Before using an insecticide, read carefully the safety restrictions in the last column of the tables beginning on page 1.1 of this handbook to determine if such byproducts as sweet corn husks, citrus pulp, bagasse, alfalfa threshings, apple pomace, bean and pea vines, sugarbeet tops, cull potatoes, trimmings from leafy vegetables, and gin waste from cotton are safe for feeding to dairy animals, poultry, or animals being finished for slaughter.

In storage areas apply only those insecticides registered for the purpose. A commodity that comes in contact with floors or walls treated with an insecticide not registered for use in storage areas may become contaminated and be liable to confiscation. Repeated applications of some fumigants will cause residues to build up in the commodities. Be sure to follow the instructions on the registered label. Such a label will include an Environmental Protection Agency (EPA) Registration Number.

Safe Disposal of Empty Insecticide Containers and Surplus Insecticides

The careful disposal of empty insecticide containers and surplus insecticides is an important part of safe insecticide use. When possible, growers should carry their empty insecticide containers to a sanitary land-fill and have them buried. Do not abandon them on the land-fill. Inform the operator of the nature of the residues in the containers. Warn him of any danger of poisonous vapors if burned. Crush or puncture containers to prevent reuse.

If a suitable land-fill is not available, break or crush glass and metal containers (except pressurized cans) and bury them in an isolated place where they will not contaminate water supplies. Pour excess insecticides into a hole at least 18 inches deep, dug in level ground in an isolated place where they will not contaminate water supplies. Cover with dirt. If you have trash collection service, wrap small empty containers in several layers of newspapers before placing them in trash cans.

Sell large drums that contained insecticides to a firm dealing in used drums or barrels. The firm should have equipment to neutralize the toxicity of the adhering insecticides. Do not attempt to use the drums where they could become a source of contamination to feed or water. Old pesticide drums used as floats corrode and thus cause serious fish kills.

Do not dump containers or leftover chemicals in gullies, ditches, streams, woods, or trash heaps.

For more specific information on the safe use of insecticides, consult your State agricultural experiment station or one of the following U.S. Department of Agriculture publications:

Program Aid 622, "Farmers' Checklist for Pesticide Safety"

Program Aid 589, "Safe Use of Pesticides in the Home-in the Garden"

ARS 33-76-2, "Respiratory Devices for Protection Against Certain Insecticides"

Program Aid 727, "Use Chemicals Safely in the Production of Beef Cattle, Swine, and Sheep."

TOXICITY OF INSECTICIDES

All insecticides must be considered potentially toxic to man and animals. However, the degree of toxicity is one of several factors in the use of insecticides that determine the hazard to man. The primary hazard lies in failure to follow the precautions and directions for use indicated on the insecticide label and summarized in this handbook. These precautions and directions depend not only on the degree of toxicity and the nature of toxicity of the insecticide but also on its stability. Some highly toxic insecticides that must be handled with great caution dissipate so rapidly upon exposure on plants or animals or in the soil that they create no serious residue problems. On the contrary, some insecticides of low toxicity persist in the soil, on plants, and in meat and fat of animals that feed on these plants and may thus create critical residue problems.

In general, arsenical insecticides are very stable and may accumulate in the soil in quantities sufficient to injure plants. Small quantities are taken up by plants, which in time are eaten by animals.

Some organochlorine insecticides may also persist in the soil for years. Certain crops grown in such soils may pick up enough insecticide through contamination or translocation to exceed tolerances, even though the insecticide was not applied to them but to previous crops in the rotation. For example, enough aldrin or chlordane may persist in soil from year to year to contaminate such sensitive root crops as sugarbeets or carrots.

Organophosphorus insecticides generally are more toxic to animals than organochlorines. However, the organophosphorus insecticides usually do not leave highly persistent residues on treated plants or animals and are less likely
to accumulate in animal tissues. Diazinon and parathion applied to the soil become ineffective within 2 or 3 months and are not problems in rotation of crops. The persistence of insecticides is reflected in the waiting periods required between application and harvest. The toxicity of insecticides is a major factor in determining the tolerances set. The tolerance is set at a safe level as determined by data obtained in animal feeding studies. An adequate safety factor is used in translating animal data to man. However, a tolerance is not established at a level higher than required for the purpose in accordance

with good agricultural practice even if the toxicity of the pesticide is so low that a higher tolerance would be safe. Many factors must be considered in selecting an insecticide for a specific purpose. Whenever possible, preference should always be given to insecticides that have low toxicity, persist only a short time, and do not accumulate in animal tissues.

The following two tables provide information on the acute toxicity of various insecticides. In the first table, acute oral and dermal [LD.sub.50] (lethal dosage) values are given for most of the compounds included in this handbook. An [LD.sub.50] value is a statistical estimate of the dosage necessary to kill 50 percent of a population of white rats or other test animals within a specified period under standardized conditions in the laboratory. The toxicity of a chemical to such animals may vary, however, with species, age, sex, and nutritional state, and with the formulation of the insecticide and the manner of administration. Also the [LD.sub.50] values are usually expressed in terms of a single dosage, which provides little or no information on possible cumulative effects of repeated dosages of the compound.

In the second table are given the acute [LC.sub.50] values (lethal concentration) of some of the common insecticides for two fresh water fishes-rainbow trout and bluegills.

[LD.sub.50] or [LC.sub.50] values are useful in comparing different chemical compounds. However, they have certain limitations, and caution must be used in interpreting them in relation to actual use hazards. Since the values are obtained for other animals or fish, they can be applied to man only with reservations. Under comparable conditions and dosages, highly toxic substances are more hazardous than less toxic substances. However, such factors as dosage, frequency of application, and characteristics with respect to accumulation and persistence in animal tissues must be considered. For example, a highly toxic material applied at a low dosage may be less hazardous than a much less toxic one applied at a high dosage.

Acute Oral and Dermal [LD.sub.50] Values of Insecticides for Test Animals

(Data assembled by the Atlanta Toxicology Branch, Division of Pesticides, Bureau of Science, Food and Drug Administration, Consumer Protection and Environmental Health Service, Public Health Service, U.S. Department of Health, Education, and Welfare. Most of the values are based on standardized tests by the Atlanta Toxicology Laboratory of the Division of Pesticides; a few are based on publications from other laboratories. All values are for white rats unless otherwise indicated.)

Oral [LD.sub.50] (mg./kg.) Dermal [LD.sub.50] (mg./kg.)

Insecticide Males Females Males Females

Organochlorine Insecticides

aldrin 39 60 98 98
benzene hexachloride (1)1,250 .. .. ..
chlordane 335 430 840 690

chlorobenzilate 1,040 1,220 .. >5,000
dichloropropane-
dichloropropene (1)140 .. (1,2)2,100 ..
dicoful 1,100 1,000 1,230 1,000
dieldrin 46 46 90 60
endosulfan 43 18 130 74

See footnotes at end of table.

Acute Oral and Dermal [LD.sub.50] Values of Insecticides for Test Animals-Continued

Oral [LD.sub.50] (mg./kg.) Dermal [LD.sub.50] (mg./kg.)

Insecticide Males Females Males Females

Organochlorine Insecticides-Continued

endrin 17.8 7.5 18 15
ethylene dichloride (1)770 .. (1,2)3,890 ..
heptachlor 100 162 195 250
Kepone 125 125 >2,000 >2,000
lindane 88 91 1,000 900
methoxychlor 5,000 5,000 .. >6,000
mirex 740 600 >2,000 >2,000
paradichlorobenzene 3,850 3,900 .. ..
Perthane >4,000 >4,000 .. ..

Strobane (1)200 .. (1,2)>5,000 ..
TDE >4,000 >4,000 (1,2)>4,000 ..
Telone (1)250-500 .. .. ..
tetradifon (1)>14,700 .. (1,2)>10, 000 ..
toxaphene 90 80 1,075 780

Organophosphorus Insecticides

Abate 8,600 13,000 >4,000 >4,000
azinphosmethyl 13 11 220 220
carbophenothion 30 10 54 27
chloropyrifos 155 82 202 ..
coumaphos 41 15.5 860 ..
crotoxyphos 110 74 375 202
crufomate 635 460 .. ..
Dasanit 4.1 1.8 19 4.1
demeton 6.2 2.5 14 8.2
diazinon 108 76 900 455

See footnotes at end of table.

Acute Oral and Dermal [LD.sub.50] Values of Insecticides
for Test Animals-Continued

Oral [LD.sub.50] (mg./kg.) Dermal [LD.sub.50] (mg./kg.)

Insecticide Males Females Males Females

Organophosphorus Insecticides-Continued

dichlorvos 80 56 107 75
dicrotophos 21 16 43 42
dimethoate 215 245 610 610
dioxathion 43 23 235 63
disulfoton 6.8 2.3 15 6
Dyfonate (1)>16.5 .. (1,2)>150 ..
EPN 36 7.7 230 25
ethion 65 27 245 62
famphur (1)>35 .. (1,2)>1,460 ..
fenthion 215 245 330 330
Imidan 113 160 >2,000 1,550
malathion 1,375 1,000 >4,444 >4,444
methyl parathion 14 24 67 67
Methyl Trithion 98 120 215 190
mevinphos 6.1 3.7 4.7 4.2
monocrotophos 17.5 20 126 112
naled 250 .. 800 ..
Nemacide 270 .. .. ..
parathion 13 3.6 21 6.8
phorate 2.3 1.1 6.2 2.5
phosalone 120 135-170 1,390 ..
phosphamidon 23.5 23.5 143 107
ronnel 1,250 2,630 .. >5,000
tepp 1.05 .. 2.4 ..
tetrapopyl

thiopyrophosphate (1)1,450 .. 2,100 1,800
trichlorfon 630 560 >2,000 >2,000

See footnotes at end of table.

Acute Oral and Dermal [LD.sub.50] Values of Insecticides for Test Animals-Continued

Oral [LD.sub.50] (mg./kg.) Dermal [LD.sub.50] (mg./kg.)

Insecticide Males Females Males Females

Carbamate Insecticides

aldicarb 0.8 0.65 3 2.5
Bux 95 63 242 156
carbaryl 850 500 >4,000 >4,000
carbofuran 8.7 8.0 >1,000 >1,000
mexacarbate 19 34 >2,000
zineb >5,000 >5,000 >2,500 >2,500

Other Insecticides

binapacryl 63 58 810 720
calcium arsenate .. 298 .. >2,400
cryolite (1)200 .. .. ..

DN-111 (1)330 .. (1,4)>1,000 ..
ethylene dibromide 146 117 (1,2,3)300 ..
lead arsenate .. 1,050 .. >2,400
metaldehyde (1,5)ca. 1,000 .. ..
napthalene 2,200 2,400 >2,500 >2,500
nicotine sulfate .. 83 .. 285
ovex (1)2,050 .. .. ..
oxythioquinox 1,800 1,100 >2,000 >2,000
paris green .. 100 .. >2,400
propoxur 83 86 >2,400 >2,400
pyrethrins 470 263 (1,2)>1,880 ..
rotenone (1)50-75 .. (1,2)>940 ..
ryania 1,200 .. (1,2)>4,000 ..
Uniroyal DO14 1,480 1,480 250 680

(1) Sex not indicated. (4) Value for guinea pigs.
(2) Value for rabbits. (5) Value for dogs.
(3) Approximate [LD.sub.50].

Acute 24-Hour [LC.sub.50] Values of Insecticides for
Rainbow Trout and Bluegills

(Data provided by Fish-Pesticide Research Laboratory, U.S. Department
of the Interior, Columbia, Mo. Rainbow trout were tested at 55 [degrees] F. and
bluegills at 65 [degrees] or 75 [degrees]. Certain persistent insecticides
exhibit cumulative
toxicity for fish and shellfish at levels lower than shown in this study.)

[LC.sub.50] for rainbow [LC.sub.50] for bluegills
Insecticide trout (p.p.b.) (p.p.b.)

Abate 8,200 -
aldrin 14 22
azinphosmethyl 14 22
benzene hexachloride 76 560
binapacryl 42 41
carbaryl 3,500 3,400
carbophenothion - 24
chlordane 22 54
chlorobenzilate 750 -
chlorpyrifos 32.6 3.4
crotoxyphos 140 760
cryolite 160,000 400,000
cube extract formulation 32 24
(4.85 percent rotenone)
demeton - 195
diazinon 380 54
dichlorvos 500 1,000
dichrotophos 15,000 38,000
dicofol 110 960
dieldrin 6 14
dimethoate 20,000 28,000
dioxathion 130 16
disulfoton 2,450 65
endosulfan 1.8 2.2
endrin .7 .8
EPN 210 370
ethion 1,300 700
fenthion 840 1,800

Acute 24-Hour [LC.sub.50] Values of Insecticides for Rainbow Trout and Bluegills-Continued

[LC.sub.50] for rainbow [LC.sub.50] for bluegills
Insecticide trout (p.p.b.) (p.p.b.)

heptachlor 15 35
Kepone 66 260
lime sulfur 10 48
lindane 30 61
malathion 100 120
methoxychlor 20 31
methyl parathion 7,000 8,500
Methyl Trithion 1,800 1,200
mevinphos 34 41
mexacarbate 7,000 -
mirex 126,000 >100,000
monochrotophos 12,000 23,000
oxythioquinox 1,550 110
naled 250 2,200
Nemacide 1,600 4,300
ovex 860 870
parathion 2,000 56
Perthane 9 21
phorate 25 10
phosalone 11,000 5,100
phosphamidon 4,500 26,000

piperonyl butoxide - 8,800
pyrethrins extract(1) 56 78
ryania - 24,000
Strobane 12 15
TDE 30 56
tetradifon 3,700 1,100
toxaphene 7.6 7.2
trichlorfon 27,500 5,600

(1) Synergized formulation containing 4.85 percent of pyrethrins.

CHEMICALS REFERRED TO IN THIS HANDBOOK

[Common names for pesticides approved by the American National Standards Institute are indicated by an asterisk. Chemical names conform to those used in "Acceptable Common Names and Chemical Names for the ingredients Statement on Pesticide Labels," 2d ed., 1972. Pesticides Regulations Division, Environmental Protection Agency.]

Name Used Identity

Abate [R] O,O,O',O'-tetramethyl O,O'-thiodi-p-phenylene phosphorothioate
acrylonitrile acrylonitrile
aldicarb (Temik [R]) 2-methyl-2-(methythio)propionaldehyde O-(methylcarbamoyl)oxime
(*)aldrin hexachlorohexahydro-endo, exo-dimethanonaphthalene 95% and related

compounds 5%
aluminum phosphide aluminum phosphide
azinphosmethyl O,O-dimethyl S-[(4-oxo-1,2,3-benzo triazin-3(4H)-yl)methyl] phosphorodithioate
benzene hexachloride 1,2,3,4,5,6-hexachlorocyclohexane, consisting of several isomers and containing a specified percentage of gamma isomer
(*)binapacryl 2-sec-butyl-4,6-dinitrophenyl 3-methyl-2-butenoate
borox sodium tetraborate decahydrate
boric acid boric acid
Bux [R] a mixture of 3 parts m-(1- methylbutyl)phenyl methylcarbamate and 1 part m(1-ethylpropyl)-phenyl methylcarbamate
calcium arsenate calcium arsenate
calcium cyanide calcium cyanide
(*)carbaryl 1-naphthyl methylcarbamate
(*)carbofuran (Furadan [R]) 2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate
carbon disulfide carbon disulfide
carbon tetrachloride carbon tetrachloride
(*)carbophenothion S-[[(p-chlorophenyl)thio]methyl] O,O-diethyl phosphorodithioate

Name Used Identity

chlordane, technical octachloro-4,7-methanotetrahydroindan 60% and related compounds 40%
chlorobenzilate ethyl 4,4'-dichlorobenzilate

chloroform chloroform
chloropicrin trichloronitromethane
(*)chlorphyrifos(Dursban [R]) O,O-diethyl O-(3,5,6-trichloro-2-pyridyl) phosphorothioate
Compound 4072 2-chloro-1-(2,4-dichlorophenyl)vinyl diethyl phosphate
coumaphos O,O-diethyl O-(3-chloro-4-methyl-2-oxo-2H-1-benzopyran-7-yl) phosphorothioate.
crotoxyphos dimethyl phosphate of alpha-methylbenzyl 3-hydroxy-cis-crotonate
(*)crufomate (Ruelene [R]) 4-tert-butyl-2-chlorophenyl methyl methylphosphoramidate
cryolite sodium hexafluoroaluminate
Dasanit [R] O,O-diethyl O-[p-(methylsulfinyl)phenyl] phosphorothioate
demeton O,O-diethyl O-[2-(ethylthio) ethyl] phosphorothioate and O,O-diethyl S-[2-ethylthio) ethyl] phosphorothioate
diazinon O,O-diethyl O-(2-isoprohyl-6-methyl-4-pyrimidinyl) phosphorodithioate.
dichloropropane- dichloropropane-dichloropropene mixture dichloropropene.
dichlorovos, technical 93 percent 2,2-dichlorovinyl dimethyl phosphate and 7 percent related compounds
dicofol 1,1-bis(p-chlorophenyl)-2,2,2-trichloroethanol
dicrotophos dimethyl phosphate ester with 3-hydroxy-N,N-dimethyl-cis-crotonamide
dieldrin hexachloroepoxyoctahydro-endo,exo-dimethanonaphthalene 85% and related

compounds 15%
(*)dimethoate O,O-dimethyl S-(N-methylcarbamoyl methyl phosphorodithioate
(*)dioxathion 2,3,-p-dioxanedithiol S,S-bis(O,O-diethyl phosphorodithioate)

Name Used Identity

diphenylamine diphenylamine
disulfoton O,O-diethyl S-[2-(ethylthio)ethyl] phosphoro-dithioate
DN-111 [R] 4,6,-dinitro-o-cyclohexylphenol, dicyclohexylamine salt
dormant oil a formulation of petroleum oil phytotoxic to foliage prepared for sprays on dormant plants, usually an emulsifiable concentrate of high oil content
Dyfonate [R] O-ethyl S-phenyl ethylphosphonodithioate
(*)endosulfan 6,7,8,9,10,10-hexachloro-1,5,5a,6,9,-9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin 3-oxide
endrin hexachloroepoxyoctahydro-endo-endo-dimethanonaphthalene
EPN O-ethyl O-(p-nitrophenyl) phenylphosphonothioate
(*)ethion O,O,O',O'-tetraethyl S,S'-methylenebisphosphorodithioate
ethylene dibromide 1,2,-dibromoethane
ethylene dichloride 1,2,-dichloroethane

ethylene oxide ethylene oxide
ethyl formate ethyl formate
famphur O,O,-dimethyl O-[p-(dimethyl-
sulfamoyl)phenyl] phosphorothioate
fenthion O,O-dimethyl O-[4-(methylthio)-
m-tolyl] phosphorothioate
Flit MLO [R] Mosquito larvicide oil (99% mineral oil)
heptachlor heptachlorotetrahydro-4.7- methanoindene and
related compounds
hydrogen cyanide hydrocyanic acid
Imidan [R] N-(mercaptomethyl) phthalimide
S-O,O-dimethyl phosphorodithioate
Kepone [R] decachlorooctahydro-1,3,4-metheno-
2H-cyclobuta [cd] pentalen-2-one
lead arsenate lead arsenate

Name Used Identity

lime sulfur 30% calcium polysulfide and various small
amount of calcium thiosulfate plus water and
free sulfur
lindane 1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer
of not less than 99% purity
malathion O,O-dimethyl dithiophosphate of dimethyl
mercaptosuccinate
mataldehyde metaldehyde
(*)methomyl S-methyl N-[(methylcarbamoyl)oxy)-
thioacetimidate
methoxychlor, technical 1,1,1-trichloro-2,2-bis(p-methoxy-

phenyl)ethane 88% and related compounds
12%
methyl bromide bromomethane
methyl chloride chloromethane
methyl formate methyl formate
methyl parathion O,O-dimethyl O-(p-nitrophenyl) phosphorothioate
Methyl Trithion [R] S-[[(p-chlorophenyl)thio]methyl] O,O-dimethyl
phosphorodithioate
mevinphos, technical 2-carbonethoxy-1-methylvinyl dimethyl phosphate
alpha isomer and related compounds
(*)mexacarbate (Zectran [R]) 4-(dimethylamino)-3,5-xylyl methylcarbamate
mirex dodecachlorooctahydro-1,3,4-metheno-1H-
cyclobuta[cd]pentalene
monocrotophos dimethyl phosphate of 3-hydroxy-
N,N-dimethyl-cis-crotonamide
(*)naled 1,2,-dibromo-2,2-dichloroethyl dimethyl phosphate
naphthalene naphthalene
Nemacide O-(2,4-dichlorophenyl) O,O-diethyl phosphorothioate
(*)ovex p-chlorophenyl p-chlorobenzenesulfonate
oxythioquinox 6-methyl-2,3-quinoxalinedithiol cyclic S,S-
dithiocarbonate
paradichlorobenzene p-dichlorobenzene
parathion O,O-diethyl O(p-nitrophenyl) phosphorothioate
paris green copper acetoarsenite
Perthane [R] diethyldiphenyldichloroethane and related
compounds

Name Used Identity

(*)phorate O,O-diethyl S-[(ethylthio)methyl] phosphorodioate
(*)phosalone O,O-diethyl S-[(6-chloro-2-oxobenzoxazolin-3-yl)methyl] phosphorodithioate
(*)phosphamidon 2-chloro-2-diethylcarbamoyl-1-methylvinyl dimethyl phosphate
piperonyl butoxide, (butylcarbityl) 6-propylpiperonyl) ether 80% and technical. related compounds 20%
(*)propargite 2-(p-tert-butylphenoxy)cyclohexyl 2-propynyl sulfide
propoxur o-isopropoxyphenyl methylcarbamate
propylene oxide propylene oxide
pyrethrins the active insecticidal constituents of pyrethrum
(*)ronnel O,O-dimethyl O-(2,4,5-trichlorophenyl) phosphorothioate
rotenone the primary active compound of derris and cube roots
ryania (ryanodine) powdered stemwood of Ryania speciosa
sabadilla ground seeds of sabadilla containing veratrine, a complex mixture of alkaloids
Strobane [R] terpene polychlorinates (65 percent chlorine)
sulfur sulfur
sulfuryl fluoride sulfuryl fluoride
summer oil a formulation of petroleum oil prepared for use in sprays to plant foliage, usually an emulsifiable concentrate of high oil content
tartar emetic antimony potassium tartrate
TDE dichlorodiphenyidichloreoethane
Telone [R] mixed dichloropropenes
tepp tetraethyl pyrophosphate

(*)tetradifon 4-chlorophenyl 2,4,5-trichlorophenyl sulfone
tetrapropyl O,O,O,O-tetrapropyl dithiopyrophosphate thiopyrophosphate (Aspon [R]).
toxaphene chlorinated camphene containing 67-69 percent chlorine
trichlorfon dimethyl (2,2,2,-trichloro-1-hydroxyethyl)-phosphonate
zineb zinc ethylenebis[dithiocarbamate]

EXPLANATION OF TABLES THAT FOLLOW

The tables that follow list the insecticides to use in the control of the major insect pests and give the formulations to purchase, dosages to use, and brief instructions on where and when to apply these insecticides. The tables also include the legal tolerances for insecticide residues permitted on food or feed products and the minimum time that must be allowed after applying the suggested dosages of insecticides in order to meet these tolerances. Other safety restrictions on the specific use of certain insecticides are given in the last column of the same page as the insecticide. Always read these safety restrictions to see if any of them apply to the insecticide that you plan to use and then observe those that are appropriate. For general precautions in the use of insecticides, see page.

With a few exceptions, the crops, insects, and insecticides are listed alphabetically. See page for the identification of the insecticides.

The insecticides listed for each insect are alternatives and are to be used

separately unless mixtures of two or more materials are indicated by plus (+) signs.

"Formulation" refers to the form of the insecticide, usually as purchased. Dusts, baits, fumigants, aerosols, and granules are generally applied at the strength purchased. Emulsifiable concentrates, wettable powders, suspension concentrates, and powders are to be diluted with water unless otherwise indicated. The amount of water to use will depend on the output of the equipment.

A single entry in a box applies to all the insecticides and formulations opposite that box, except as specified.

A dash in any column indicates that there is no appropriate entry.

The word "extended" in the tolerance column means that the registration for this particular use of the insecticide has been extended to allow time for the establishment of a finite tolerance. It will be withdrawn when the extension expires. Therefore, the insecticide must not be used on the indicated crop or animal without determining whether the registration is still in effect. Check with your county agricultural agent or with your State agricultural experiment station.

The term "nonfood use" in the tolerance column means that a tolerance is not needed. The Pesticides Regulation Division has determined that based on consideration of the pattern of use and the nature of the chemical, there is no reasonable expectation of any residue reaching and being retained in or on food or feed.

The word "safe" in the tolerance column means that the insecticide is "generally recognized as safe GRAS" under the provisions of 21 CFR 120.2 of the Federal Food, Drug, and Cosmetic Act as amended. A tolerance is not needed for such insecticides. Also, when "exempt" appears in this column, it means that under the provisions of this act, the insecticide used in this specific way has been exempted from the requirement for establishment of a tolerance.

The following abbreviations are used:
Bait B
Dust D
Emulsifiable concentrate EC
Fumigant F
Granules G
Solution soln.
Spray S
Ultra low volume concentrate ULV
Wettable powder WP

The insecticide dosages given in this handbook are the maximums suggested for mature plants and animals. Often they may be reduced for immature plants or animals without loss in effectiveness. Effective dosages may also be reduced by careful attention to application under favorable weather conditions. However, be careful not to exceed the suggested dosages except as indicated on the registered insecticide label. Dosages larger than those suggested in these tables may leave illegal residues on the harvested product unless more time is allowed between the last application and harvest than is suggested in the table.

The principles followed in the commercial use of insecticides on crops, livestock, or stored products should also be followed in their use in the home and the home garden. However, untrained persons should not use any insecticide labeled POISON and illustrated with the drawing of the skull and crossbones.

Trade names are used in this handbook solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture.

<TABLE 1>

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN--Barley (See GRAIN--Corn, shelled)	Control measures for insects in stored barley are the same as in GRAIN--Corn, shelled					
GRAIN--Corn, ear						Fumigants should be applied only by a trained operator. Do not fumigate with hydrogen cyanide (HCN) at temperatures below 60° F. Aerate for 24 hours after treatment. Aerate after fumigation with methyl bromide.
In bags in warehouse Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Hydrogen cyanide	100	F	3 lb.	Space fumigation.	
	Methyl bromide	50 (inorganic bromide)	F	2 lb.	Space fumigation. 24 hours at 60° F. or above.	
				4 lb.	Space fumigation. 24 hours at 50° - 59° F.	

Issued October 1972

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN—Corn, ear (con.)						
In perforated steel crib bins Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Methyl bromide	50 (inorganic bromide)	F	2 lb.	Cover crib with gastight tarpaulin. 24 hours at 60° F. or above.	
In wooden crib bins Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Carbon tetrachloride + carbon disulfide (80:20 mixture)	Exempt	F	6 gal./1,000 bu.	Distribute fumigant evenly over surface. Cover crib with gastight tarpaulin.	
	Ethylene dichloride + carbon tetrachloride (75:25 mixture)	Exempt	F	6 gal./1,000 bu.	Distribute fumigant evenly over surface. Cover crib with gastight tarpaulin.	
GRAIN—Corn, shelled or ear						Fumigants should be applied only by a trained operator. Do not release aerosol near an open flame.
In bulk Indian meal moth	Chloropicrin	Exempt	F	1.5 lb./1,000 cu. ft. of space above grain.	Apply as fine spray or vapor into space over top of grain to control moths in surface layer. 70° F. or above.	
				2 lb./1,000 cu. ft. of space above grain.	Apply as fine spray or vapor into space over top of grain to control moths in surface layer. Below 70° F.	Mineral oil to meet specification established by Food and Drug Administration.
	Mineral oil	200	S	2 qt./100 sq. ft. of surface or 5 qt./3,200 bu./bin.	Protective treatment with oil spray on surface. In South—First application after grain is fumigated; second in July or August. In North—First application after harvest following fumigation; second in April or May of next year.	

Issued October 1972

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN--Corn, shelled or ear (con.)						
Flying insects	Pyrethrins + piperonyl butoxide	3 + 20*	Oil soln. % by wt. Pyrethrins 0.2 + piperonyl butoxide 2.0 + tetrachloroethylene 50.0 + deodorized kerosene 47.8	0.006 + 0.06 lb./ 1,000 cu. ft. of airspace.	Apply with thermal aerosol generator.	
In warehouses Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Malathion (premium grade)	8	EC	0.63 lb./1,000 bu.	Spray into grain stream as it goes into storage. Mix with water—3 - 5 gal./ 1,000 bu.	Soft insect-susceptible varieties are difficult to protect. The dust will cause downgrading of market grain. Fumigants should be applied only by a trained operator. Do not recirculate phosphine from aluminum phosphide. Under no conditions shall any processed food or animal feed come in contact with any aluminum phosphide nor with aluminum phosphide residues.
				0.32 lb. in 1 to 2 gal. water/1,000 sq. ft.	Surface spray. Will not control insects established beneath the surface.	
	Pyrethrins + piperonyl butoxide	3 + 20*	EC or oil soln.	0.06 + 0.6 lb./ 1,000 bu.	Spray into grain stream as it goes into storage. Mix with water— 3 - 5 gal./ 1,000 bu.	
			D	0.05 + 0.8 lb./ 1,000 bu.	Protectant dust. Before corn is infested, when moisture content is 12% or less.	
GRAIN—Corn, shelled (also Barley and Oats)						
In concrete or metal upright bins, 3,200 bu. metal bins, or farm-type metal bins Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Aluminum phosphide	0.1** (phosphine)	F	3 tablets/ton or 90 tablets/1,000 bu.	Add to grain stream. Fumigate for 5 days at 54° - 59° F., 4 days at 60° - 68° F., or 3 days at 69° F. or above.	
				10 pellets/ton or 300 pellets/1,000 bu.	Add to grain stream. Fumigate for 4 days at 54° - 59° F., 3 days at 60° - 68° F., or 2 days at 69° F. or above.	

*Tolerance for pyrethrins and piperonyl butoxide on oats is 1 + 8 p.p.m.
**The tolerance for phosphine on processed commodities is 0.01 p.p.m. and on raw products, 0.1 p.p.m.

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STORED PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN—Corn, shelled (also Barley and Oats) (con.)						
In concrete or metal upright bins, 3,200-bu. metal bins, or farm-type metal bins Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Ethylene dibromide + methyl bromide (70:30 mixture)	50 (inorganic bromide)	F	24 - 36 oz./1,000 bu.*	Gravity-distribution fumigation. Surface application or layering method. 70° F. or above in farm-type bins.	Fumigants should be applied only by a trained operator. Aerate after fumigation. Do not fumigate with hydrogen cyanide (HCN) at temperatures below 60° F. Aerate for 24 hours after treatment. Do not recirculate phosphine from aluminum phosphide.
				30 - 36 oz./1,000 bu.	Probe fumigant into hotspot.	
	Ethylene dibromide + methyl bromide (30:70 mixture)	50 (inorganic bromide)	F	1.125 - 1.5 lb.*	Forced-distribution fumigation. Closed-recirculation or single-pass. 70° F. or above.	
				2 - 3 lb.*	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 70° F.	
	Ethylene dichloride + carbon tetrachloride (75:25 mixture)	Exempt	F	4.5 gal./1,000 bu.*	Gravity-distribution fumigation. Surface application or layering method. 70° F. or above.	
				2.5 gal.*	Forced-distribution fumigation. Closed-recirculation or single-pass. 70° F. or above.	
				3.5 gal.*	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 70° F.	
	Ethylene dibromide + ethylene dichloride + carbon tetrachloride (5: 35: 60 mixture)	50 (inorganic bromide) Others exempt	F	4 - 5 gal./1,000 bu.*	Gravity-distribution fumigation. Surface application or layering method. 70° F. or above.	
	Hydrogen cyanide	100	F	3 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass.	
	Methyl bromide	50 (inorganic bromide)	F	2 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. 24 hours at 60° F. or above.	
				3 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. 24 hours at below 60° F.	
In flat storage Beetles and moths	Aluminum phosphide	0.1** (phosphine)	F	3 tablets/ton or 90 tablets/1,000 bu.	Probe tablets into corn. Fumigate for 5 days at 54° - 59° F., 4 days at 60° - 68° F., or 3 days at 69° F. or above.	

*Double the dosage if used in wooden bins.
**The tolerance for phosphine on processed commodities is 0.01 p.p.m. and on raw products, 0.1 p.p.m.

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN--Corn, shelled (also Barley and Oats) (con.)						
In flat storage Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Calcium cyanide	25 (hydrogen cyanide)	F	15 - 20 lb./ 1,000 bu.	Mix into grain as it is being placed in storage.	
	Carbon tetrachloride + carbon disulfide (80:20 mixture)	Exempt	F	4.5 gal.	Gravity-distribution fumigation. Surface application or layering method. 70° F. or above.	Aerate after fumigation.
				2 gal.	Forced-distribution fumigation. Closed-recirculation or single-pass. 60° F. or above.	Fumigants should be applied only by a trained operator.
				2.25 gal.	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 60° F.	
	Chloroform + carbon disulfide + ethylene dibromide (71.25: 23.75: 5.0 mixture)	60 (inorganic bromide) Others exempt	F	3.75 gal./1,000 bu.	Gravity-distribution fumigation. 70° F. or above.	
				4.26 gal./1,000 bu.	Gravity-distribution fumigation. Below 70° F.	
	Chloropicrin + methyl chloride (85:15 mixture)	Exempt	F	2 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. 70° F. or above.	
				3 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 70° F.	
	Ethylene dibromide + methyl bromide (30:70 mixture)	50 (inorganic bromide)	F	1.5 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. 70° F. or above.	
				2.5 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 70° F.	
	Ethylene dibromide + methyl bromide (70:30 mixture)	50 (inorganic bromide)	F	30 - 36 oz./1,000 bu.	Probe fumigant into hotspot.	

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN–Corn, shelled (also Barley and Oats) (con.)						
In flat storage Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Ethylene dichloride + carbon tetrachloride (75:25 mixture)	Exempt	F	6 gal./1,000 bu.	Gravity-distribution fumigation. 70° F. or above.	Fumigants should be applied only by a trained operator. Aerate after fumigation.
				2.75 gal.	Forced-distribution fumigation. Closed-recirculation or single-pass. 70° F. or above.	
				3.75 gal.	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 70° F.	Do not fumigate with hydrogen cyanide (HCN) at temperatures below 60° F. Aerate for 24 hours after treatment.
	Ethylene dibromide + ethylene dichloride + carbon tetrachloride (5: 35: 60 mixture)	50 (inorganic bromide) Others exempt	F	4.25 gal./1,000 bu.	Gravity-distribution fumigation. 70° F. or above.	
	Hydrogen cyanide	100	F	3 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass.	
	Methyl bromide	50 (inorganic bromide)	F	2 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. 24 hours at 60° F. or above.	
				4 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. 24 hours at below 60° F.	
	Malathion (premium grade)	8	EC	0.63 lb./1,000 bu.	Mix with water 3 - 5 gal./1,000 bu. Spray on grain stream as it goes into storage.	Fumigants should be applied only by a trained operator.
				0.32 lb./1,000 sq. ft. of surface area.	Surface spray. Will not control insects already established beneath the surface.	Repeated surface sprays with malathion may cause excessive residues.
			D	0.6 lb./1,000 bu.	Mix dust into wheat before storing.	

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE *(p. p. m.)*	FORMULATION	DOSAGE *(active ingredient per 1,000 cu. ft. unless otherwise stated)*	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN—Corn, shelled (also Barley and Oats) (con.)						
In flat storage Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Pyrethrins + piperonyl butoxide	3 + 20*	EC or oil soln.	0.06 + 0.6 lb./ 1,000 bu.	Mix with water 3 - 5 gal./1,000 bu. Apply as protective spray to grain before it is stored.	Fumigants should be applied only by a trained operator. Repeated surface sprays with malathion may cause excessive residues.
			D	0.06 + 0.83 lb./ 1,000 bu.	Mix dust into wheat before storing.	
In bulk, in freight cars Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Ethylene dibromide + ethylene dichloride + carbon tetrachloride (5: 35: 60 mixture)	50 (inorganic bromide) Others exempt	F	5.75 gal./1,000 bu.	Apply from outside of car using hand or power sprayer.	
In bulk, in freight cars and van trucks Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Chloropicrin	Exempt	F	3 lb.	Recirculation fumigation. 70° F. or above.	
				4 lb.	Recirculation fumigation. Below 70° F.	
Storage bin Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Malathion (premium grade)	8 on grain	EC	0.45 lb./1,000 sq. ft.	Mix with water. At least 2 - 4 weeks before grain is binned, spray inside walls and floor of bin at rate of 2 gal./ 1,000 sq. ft.	
	Methoxychlor	2 on grain	WP, EC	0.4 lb./1,000 sq. ft.		
	Pyrethrins + piperonyl butoxide	3 + 20	Soln.	0.013 - 0.13 lb./ 1,000 sq. ft.	Mix with water and apply to walls and floor of empty storage at the rate of 2 gal /1,000 sq. ft.	

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN–Oats (See GRAIN–Corn, shelled)	Control measures for insects in stored oats are the same as in GRAIN–Corn, shelled, page 14.24.					
GRAIN–Popcorn						
In bags in freight cars Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Methyl bromide	240 (inorganic bromide)	F	15 lb. in refrigerator car.	Fumigate for 24 hr.	Fumigants should be applied only by a trained operator. Do not fumigate with hydrogen cyanide (HCN) at temperatures below 60° F. Aerate for 24 hours after treatment. Aerated after fumigation.
				14 lb. in wooden car.		
				10 lb. in steel car.		
In bags in ware houses, in fumigation chambers, or under tarpaulins Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Hydrogen cyanide	100	F	1 lb.	Perforated steel cribs should be covered with tarpaulins. Fumigate 24 hr. at 70° F. or above.	
	Methyl bromide	240 (inorganic bromide)	F	1.5 lb.		
In bulk, in packer bins with circulation systems Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Methyl bromide	240 (inorganic bromide)	F	1.5 lb.	Recirculation fumigation, 24 hr. at 70° F. or above.	
				2 lb.	Recirculation fumigation; 24 hr. at 60° – 69° F.	
				2.5 lb.	Recirculation fumigation. 24 hr. at 50° – 59° F.	
				3 lb.	Recirculation fumigation. 24 hr. at 40° – 49° F.	
In perforated steel crib bins Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Methyl bromide	240 (inorganic bromide)	F	2 lb.	Cover crib with gastight tarpaulin. 24 hr. at 60° F. or above.	

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p.p.m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN—Oats (See GRAIN—Corn, shelled)	Control measures for insects in stored oats are the same as in GRAIN—Corn, shelled, page 14.24.					
GRAIN—Popcorn						
In bags in freight cars: Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Methyl bromide	240 (inorganic bromide)	F	15 lb. in refrigerator car.	Fumigate for 24 hr.	Fumigants should be applied only by a trained operator. Do not fumigate with hydrogen cyanide (HCN) at temperatures below 60° F. Aerate for 24 hours after treatment. Aerated after fumigation.
				14 lb. in wooden car.		
				10 lb. in steel car		
In bags in warehouses, in fumigation chambers, or under tarpaulins: Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Hydrogen cyanide	100	F	1 lb.	Perforated steel cribs should be covered with tarpaulins. Fumigate 24 hr. at 70° F. or above.	
	Methyl bromide	240 (inorganic bromide)	F	1.5 lb		
In bulk, in packer bins with circulating systems: Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Methyl bromide	240 (inorganic bromide)	F	1.5 lb.	Recirculation fumigation, 24 hr. at 70° F. or above.	
				2 lb.	Recirculation fumigation, 24 hr. at 60° - 69° F.	
				2.5 lb.	Recirculation fumigation, 24 hr. at 50° - 59° F.	
				3 lb.	Recirculation fumigation, 24 hr. at 40° - 49° F.	
In perforated steel crib bins: Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Methyl bromide	240 (inorganic bromide)	F	2 lb.	Cover crib with gastight tarpaulin. 24 hr. at 80° F. or above.	

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN–Rice, enriched (con.)						
In packages Saw-toothed grain beetle, flour beetles, Indian meal moth	Methyl bromide	125 (inorganic bromide)	F	1.5 oz./1,000 lb. 1.75 lb.	4 hr. at 70° F. or above in atmospheric chamber.	Fumigants should be applied only by a trained operator. Aerate after fumigation with methyl bromide. Under no conditions shall any processed food or animal feed come in contact with any aluminum phosphide nor with aluminum phosphide residues. Aerate products 48 hours before offering to consumer. Repellent pyrethrins + piperonyl butoxide treatment not to be used on bags of less than 50-lb. size.
				1 oz./1,000 lb. 1.5 lb.	6 hr. at 70° F. or above in atmospheric chamber.	
				0.5 oz./1,000 lb. 0.75 lb.	12 hr. at 70° F. or above in atmospheric chamber.	
				1.5 oz./1,000 lb. 3 lb.	2 hr. at 65° F. or above in vacuum chamber.	
				0.75 oz./1,000 lb. 2 lb.	3 hr. at 65° F. or above in vacuum chamber.	
In bags Saw-toothed grain beetle, flour beetles, Indian meal moth	Pyrethrins + piperonyl butoxide + insect-tight kraft bags.	1 + 10	WP	5 ± 1 mg. pyrethrins + 50 ± 10 mg. piperonyl butoxide /sq. ft. of bag surface.	The insect-repellent treatment is to be applied on the paper used as the outer ply of multiwall bags having insect-tight construction as in specifications available from ARS.	
GRAIN–Rice milled						
In bags or cartons in fumigation chambers Saw-toothed grain beetle, flour beetles, Indian meal moth	Aluminum phosphide	0.01* (phosphine)	F		In tarpaulin fumigation, place tablets or pellets in trays at each corner of stack.	
				45 tablets	Fumigate for 5 days at 54° - 59° F., 4 days at 60° - 68° F., or 3 days at 69° F. or above.	
				165 pellets	Fumigate for 4 days at 54° - 59° F., 3 days at 60° - 68° F., or 2 days at 69° F. or above.	

*The tolerance for phosphine on processed commodities is 0.01 p.p.m. and on raw products, 0.1 p.p.m.

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 sq. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN–Rice, milled (con.)						
In bags in fumigation chambers Saw-toothed grain beetle, flour beetles, Indian meal moth	Methyl bromide	125 (inorganic bromide)	F	1.5 oz./1,000 lb. 1.75 lb.	4 hr. at 70° F. or above in atmospheric chamber.	Fumigants should be applied only by a trained operator. Aerate after fumigation with methyl bromide.
				1 oz./1,000 lb. 1.5 lb.	6 hr. at 70° F. or above in atmospheric chamber.	
				0.5 oz./1,000 lb. 0.75 lb.	12 hr. at 70° F. or above in atmospheric chamber.	
				1.5 oz./1,000 lb. 3 lb.	2 hr. at 65° F. or above in vacuum chamber.	
				0.75 oz./1,000 lb. 2 lb.	3 hr. at 65° F. or above in vacuum chamber.	
In bins Saw-toothed grain beetle, flour beetles, Indian meal moth	Methyl bromide	125 (inorganic bromide)	F	1 lb.	Fumigate in packer bins for 15 hr.	Aerate after fumigation with methyl bromide.
Storage bin Saw-toothed grain beetle, flour beetles, Indian meal moth	Malathion (premium grade)	8	EC	0.45 lb./1,000 sq. ft.	Mix EC or WP with water. Spray inside walls and floor of bin at rate of 2 gal./1,000 sq. ft. at least 2 weeks before grain is binned.	
	Methoxychlor	2	WP, EC	0.4 lb./1,000 sq. ft.		
	Pyrethrins + piperonyl butoxide	3 + 20	Oil soln.	0.013 - 0.13 lb./1,000 sq. ft.		

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN–Rice milled (con.)						
In cartons in fumigation chambers Saw-toothed grain beetle, flour beetles, Indian meal moth	Methyl bromide	125 (inorganic bromide)	F	1.25 oz./1,000 lb. 1.75 lb.	15 hr. at 70° F. or above in atmospheric chamber.	Fumigants should be applied only by a trained operator. Aerate after fumigation with methyl bromide.
				2 oz./1,000 lb. 4.25 lb.	2 hr. at 65° F. or above in vacuum chamber.	
				1.5 oz./1,000 lb. 3 lb.	3 hr. at 65° F. or above in vacuum chamber.	
				1.25 oz./1,000 lb. 2.5 lb.	12 hr. at 85° F. or above in vacuum chamber.	
Mill equipment Saw-toothed grain beetle, flour beetles, Indian meal moth	Carbon tetrachloride + ethylene dichloride + ethylene dibromide (21:64: 15 mixture) Ethylene dibromide + methyl bromide (70:30 mixture) Ethylene dichloride + carbon tetrachloride (75:25 mixture)	125 (inorganic bromide) Others exempt	F	0.5 - 1.5 pt. in area to be treated.	Spot fumigation of machinery every 2 weeks.	

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN–Rice, milled (con.)						
In packages in the home Saw-toothed grain beetle, flour beetles, Indian meal moth	Freezing	--	--		Whenever infestation is suspected, hold in freezer at 0° F. for 4 days. Store in insect-proof containers such as glass jars.	Fumigants should be applied only by a trained operator.
	Heating	--	--		Whenever infestation is suspected, heat to 120° F. in oven. Hold for 0.5 hr. Store in insect-proof containers such as glass jars.	Aerate after fumigation.
GRAIN–Rice, rough						Do not recirculate aluminum phosphide.
In bags in warehouse Rice weevil, Angoumois grain moth, lesser grain borer, grain beetles	Methyl bromide	50 (inorganic bromide)	F	1.25 lb.	Expose for 16 - 24 hr.	
In bags under tarpaulins Rice weevil, Angoumois grain moth, lesser grain borer, grain beetles	Aluminum phosphide	0.1* (phosphine)	F		Place tablets or pellets on metal trays at each corner of stack under tarpaulin.	
				45 tablets	Fumigate for 5 days at 54° - 59° F., 4 days at 60° - 68° F., or 3 days at 69° F. or above.	
				165 pellets	Fumigate for 4 days at 54° - 59° F., 3 days at 60° - 68° F., or 2 days at 69° F. or above.	

*The tolerance for phosphine on processed commodities is 0.01 p.p.m. and on raw products, 0.1 p.p.m.

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN—Rice, rough (con.)						
In bags under tarpaulins Rice weevil, Angoumois grain moth, lesser grain borer, grain beetles	Methyl bromide	50 (inorganic bromide)	F	1.5 lb.	Expose for 24 hr. at 70° F. or above.	Fumigants should be applied only by a trained operator. Aerate after fumigation with methyl bromide.
In flat storage, concrete or metal upright bins, or farm-type metal bins Rice weevil, Angoumois grain moth, lesser grain borer, grain beetles	Aluminum phosphide	0.1* (phosphine)	F	3 tablets/ton or 90 tablets/440 cwt.	Feed tablets into grain stream or insert into grain mass. Fumigate for 5 days at 54° - 59° F., 4 days at 60° - 68° F., or 3 days at 69° F. or above.	
				10 pellets/ton or 300 pellets/440 cwt.	Add to grain stream. Fumigate for 4 days at 54° - 59° F., 3 days at 60° - 68° F., or 2 days at 69° F. or above.	Do not recirculate aluminum phosphide. Do not use aluminum phosphide on rice stored on the farm.
	Calcium cyanide	25 (hydrogen cyanide)	F	12 lb./440 cwt.**	Mix into grain. Do not use in flat storage.	
	Carbon tetrachloride + carbon disulfide (80:20 mixture)	Exempt	F	3 gal./440 cwt.**	Gravity-distribution fumigation. At 75° F. or above.	
				4 - 5 gal./440 cwt.	Probe fumigant into hotspot.	
	Ethylene dichloride + carbon tetrachloride (75:25 mixture)	Exempt	F	3 gal./440 cwt.**	Gravity distribution fumigation. At 75° F. or above.	

*The tolerance for phosphine on processed commodities is 0.01 p.p.m. and on raw products, 0.1 p.p.m.
**Double the dosage if used in wooden bins.

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN—Rice, rough (con.)						
In flat storage, concrete or metal upright bins, or farm-type metal bins Rice weevil, Angoumois grain moth, lesser grain borer, grain beetles	Malathion (premium grade)	8	EC	0.63 lb./440 cwt.	Treat as rice is being placed in storage.	Fumigants should be applied only by a trained operator. Aerate after fumigation with methyl bromide. Do not release aerosol near open flames. Aerosols may be used against exposed insects only.
	Pyrethrins + piperonyl butoxide	3 + 20	EC	0.2 + 2.0 lb./440 cwt.	Treat as rice is being placed in storage.	
	Methyl bromide	50 (inorganic bromide)	F	1.5 - 2 lb.	Forced-distribution fumigation in flat storage. Expose for 24 - 36 hours.	
In flat storage, concrete or metal upright bins, or farm-type metal bins Moths, surface infestation	Malathion (premium grade)	8	EC	0.02 lb./100 sq. ft. of surface area.	Surface spray will not control insects already established beneath surface.	
	Methyl bromide	50 (inorganic bromide)	F	1 lb.	Expose for 16 to 24 hr. at 60° F. or above. Dosage calculated for overhead space only.	
	Pyrethrins + piperonyl butoxide	3 + 20	Oil soln. % by wt. Pyrethrins 0.2 + piperonyl butoxide 2.0 + tetrachloroethylene 50.0 + deodorized kerosene 47.8	0.006 + 0.06 lb./1,000 cu. ft. of airspace over the load.	Apply with thermal aerosol generator.	
			Pyrethrins 0.5 + piperonyl butoxide 5.0 + tetrachloroethylene 50.0 + deodorized kerosene 44.5	0.006 + 0.06 lb./1,000 cu. ft. of airspace over the load.	Apply with mechanical aerosol generator or as a mist spray.	
In freight cars Rice weevil, Angoumois grain moth, lesser grain borer, grain beetles	Methyl bromide	50 (inorganic bromide)	F	10 - 12 lb./car.	Bags or bulk in steel freight car.	Fumigants should be applied only by a trained operator.
				12 - 15 lb./car.	Bags or bulk in wooden freight car.	

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN–Rice, rough (con.)						
Storage bin Rice weevil, Angoumois grain moth, lesser grain borer, grain beetles	Malathion (premium grade)	8 on grain	EC	0.45 lb./1,000 sq. ft.	Mix with water. At least 2 - 4 weeks before grain is binned, spray inside walls and floor of bin at rate of 2 gal./ 1,000 sq. ft.	Aerate after fumigation with methyl bromide.
	Methoxychlor	2 on grain	WP, EC	0.4 lb./1,000 sq. ft.		
	Pyrethrins + piperonyl butoxide	3 + 20	Soln.	0.013 - 0.13 lb./ 1,000 sq. ft.	Mix with water and apply to walls and floor of empty storage at the rate of 2 gal./1,000 sq. ft.	
GRAIN–Rye (See GRAIN–Wheat)	Control measures for insects in stored rye are the same as in GRAIN – Wheat, page 14.51.					
GRAIN–Sorghum						
In bags in warehouse Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Aluminum phosphide	0.1* (phosphine)	F		In tarpaulin fumigation place tablets or pellets in trays at each corner of stack,	Fumigants should be applied only by a trained operator.
				45 tablets	Fumigate for 5 days at 54° - 59° F., 4 days at 60° - 68° F., or 3 days at 69° F. or above.	
				165 pellets	Fumigate for 4 days at 54° - 59° F., 3 days at 60° - 68° F., or 2 days at 69° F. or above.	Under no conditions shall any processed food or animal feed come in contact with any aluminum phosphide nor with aluminum phosphide residues.
	Methyl bromide	50 (inorganic bromide)	F	4 lb.	Space fumigation, 60° F. or above.	Fumigants should be applied only by a trained operator.
				6 lb.	Space fumigation. Below 60° F.	

*The tolerance for phosphine on processed commodities is 0.01 p.p.m. and on raw products, 0.1 p.p.m.

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN—Sorghum (con.)						
In bulk Moths, surface infestation	Chloropicrin	Exempt	F	1.5 lb./1,000 cu. ft. of space above grain.	Apply as fine spray or vapor into space over top of grain to control moths in surface layer. 70° F. or above.	Aerate after fumigation with methyl bromide.
				2 lb./1,000 cu. ft. of space above grain.	Apply as fine spray or vapor into space over top of grain to control moths in surface layer. Below 70° F.	Repeated surface sprays with malathion will cause excessive residues.
In bulk Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Malathion (premium grade)	8	EC	0.63 lb./1,000 bu.	Mix with water 3 - 5 gal./1,000 bu. Spray on grain stream as it goes into storage.	
				0.32 lb./1,000 sq. ft. of surface area.	Surface spray. Will not control insects already established beneath the surface.	
			D	0.6 lb./1,000 bu.	Mix dust into grain before storing.	
In bulk, in concrete or metal elevator bins, 3,200-bu. metal bins, or farm-type metal bins Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Aluminum phosphide	0.1* (phosphine)	F	3 tablets/ton or 90 tablets/1,000 bu.	Add to grain stream. Fumigate for 5 days at 54° - 59° F., 4 days at 60° - 68° F., or 3 days at 69° F. or above.	Fumigants should be applied only by a trained operator. Do not recirculate aluminum phosphide. Do not apply calcium cyanide in wooden bins.
				10 pellets/ton or 300 pellets/1,000 bu.	Add to grain stream. Fumigate for 4 days at 54° - 59° F., 3 days at 60° - 68° F., or 2 days at 69° F. or above.	
	Calcium cyanide	25 (hydrogen cyanide)	F	15 - 20 lb./1,000 bu.	Mix into grain as it is being binned.	

*The tolerance for phosphine on processed commodities is 0.01 p.p.m. and on raw products, 0.1 p.p.m.

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN–Sorghum (con.)						
In bulk, in concrete or metal elevator bins, 3,200-bu. metal bins, or farm-type metal bins. Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Carbon tetrachloride + carbon disulfide (80:20 mixture)	Exempt	F	4 gal./1,000 bu.*	Gravity-distribution fumigation. Surface application or layering method. 60° F. or above.	
				2.25 gal.	Forced-distribution fumigation. Closed-recirculation or single-pass. 60° F. or above.	
				3.5 gal.	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 60° F.	
	Chloroform + carbon disulfide + ethylene dibromide (71.25: 23.75: 5.0 mixture)	50 (inorganic bromide) Others exempt	F	3.5 gal./1,000 bu.*	Gravity-distribution fumigation. 70° F. or above.	Fumigants should be applied only by a trained operator.
				4.5 gal./1,000 bu.*	Gravity-distribution fumigation. Below 70° F.	Aerate after fumigation.
	Chloropicrin	Exempt	F	4 lb./1,000 bu.**	Gravity-distribution fumigation. 70° F. or above.	
				5 lb./1,000 bu.**	Gravity-distribution fumigation. Below 70° F.	
	Chloropicrin + methyl chloride (85:15 mixture)	Exempt	F	4 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. 70° F. or above.	
				5 lb.	Forced distribution fumigation. Closed-recirculation or single-pass. Below 70° F.	
	Ethylene dibromide + ethylene dichloride + carbon tetrachloride (5: 35: 60 mixture)	50 (inorganic bromide) Others exempt	F	4 gal./1,000 bu.**	Gravity-distribution fumigation. [1] Surface application or layering method. 70° F. or above.	

*Double the dosage if used in wooden bin.
**Double the dosage if used in wooden bin. Maximum chloropicrin dosage to be 6 lb./1,000 bu.

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p.p.m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN–Sorghum (con.)						
In bulk, in concrete or metal elevator bins, 3,200 bu. metal bins, or farm-type metal bins Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Ethylene dibromide + methyl bromide (70:30 mixture)	50 (inorganic bromide)	F	48 - 60 oz./ 1,000 bu.	Probe fumigant into hotspot.	
	Ethylene dichloride + carbon tetrachloride (75:25 mixture)	Exempt	F	5 gal./1,000 bu.*	Gravity-distribution fumigation. Surface application or layering method. 70° F. or above.	
	Ethylene dichloride + carbon tetrachloride (75:25 mixture)	Exempt	F	3.25 gal.	Forced-distribution fumigation. Closed-recirculation or single-pass. 70° F. or above.	Fumigants should be applied only by a trained operator.
				4.75 gal.	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 70° F.	
	Ethylene dibromide + methyl bromide (30:70 mixture)	50 (inorganic bromide)	F	2.25 - 3 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. 60° F. or above.	Aerate after fumigation.
				4 lb.	Forced distribution fumigation. Closed-recirculation or single-pass. Below 60° F.	
In bulk, in concrete or metal bins Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Methyl bromide	50 (inorganic bromide)	F	3 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. 60° F. or above.	
				5 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 60° F.	
In bulk, in freight cars and van trucks Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Chloropicrin	Exempt	F	4 lb.	Recirculation fumigation. 70° F. or above.	
				6 lb.	Recirculation fumigation. Below 70° F.	

*Double the dosage if used in wooden bins.

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN—Sorghum (con.)						
In bulk, in freight cars and van trucks Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth (con.)	Methyl bromide	60 (inorganic bromide)	F	4 lb.	Recirculation fumigation. 70° F. or above.	Fumigants should be applied only by a trained operator. Aerate after fumigation.
				6 lb.	Recirculation fumigation. Below 70° F.	
	Ethylene dibromide + ethylene dichloride + carbon tetrachloride (5: 35: 60 mixture)	50 (inorganic bromide) Others exempt	F	7.25 gal./1,000 bu.	Apply from outside of car using hand or power sprayer.	
In flat storage Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Aluminum phosphide	0.1* (phosphine)	F	3 tablets/ton or 90 tablets/1,000 bu.	Gravity-distribution fumigation. Fumigate for 5 days at 54° - 59° F., 4 days at 60° - 68° F., or 3 days at 69° F. or above.	Do not recirculate aluminum phosphide.
	Calcium cyanide	25 (hydrogen cyanide)	F	15 - 20 lb./1,000 bu.	Mix into grain as it is being placed in storage.	
	Carbon tetrachloride + carbon disulfide (80:20 mixture)	Exempt	F	6 gal./1,000 bu.	Gravity-distribution fumigation. 60° F. or above.	
				2.75 gal.	Forced-distribution fumigation. Closed-recirculation or single-pass. 60° F. or above.	
				4 gal.	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 60° F.	

*The tolerance for phosphine on processed commodities is 0.01 p.p.m. and on raw products, 0.1 p.p.m.

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN-Sorghum (con.)						
In flat storage Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth (con.)	Chloroform + carbon disulfide + ethylene dibromide* (71.25: 23.75: 5.0 mixture)	50 (inorganic bromide) Others exempt	F	5.5 gal./1,000 bu.	Gravity-distribution fumigation. 70° F. or above.	Fumigants should be applied only by a trained operator.
				6.5 gal./1,000 bu.	Gravity-distribution fumigation. Below 70° F.	Aerate after fumigation.
	Ethylene dibromide + ethylene dichloride + carbon tetrachloride (5:35:60 mixture)	50 (inorganic bromide) Others exempt	F	6 gal./1,000 bu.	Gravity-distribution fumigation. 70° F, or above.	
	Chloropicrin + methyl chloride (85:15 mixture)	Exempt	F	4 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. 70° F, or above.	
				5 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 70° F.	
	Ethylene dibromide + methyl bromide (30:70 mixture)	50 (inorganic bromide)	F	2.25 - 3 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. 70° F, or above.	
				4 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 70° F.	
	Ethylene dibromide + methyl bromide (70:30 mixture)	50 (inorganic bromide)	F	48 oz./1,000 bu.	Probe fumigant into hotspot.	

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN—Sorghum (con.)						
In flat storage Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth (con.)	Ethylene dichloride + carbon tetrachloride (75:25 mixture)	Exempt	F	7.5 gal./1,000 bu.	Gravity-distribution fumigation. 70° F. or above.	Fumigants should be applied only by a trained operator.
				3.75 gal.	Forced-distribution fumigation. Closed-recirculation or single-pass. 70° F. or above.	
				6.25 gal.	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 70° F.	Aerate after fumigation.
	Methyl bromide	50 (Inorganic bromide)	F	4 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. 60° F. or above.	
				5 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 60° F.	
Storage bin Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Malathion (premium grade)	8 on grain	EC	0.45 lb./1,000 sq. ft.	Mix with water. At least 2 - 4 weeks before grain is binned, spray inside walls and floor of bin at rate of 2 gal./1,000 sq. ft.	
	Methoxychlor	2 on grain	WP, EC	0.4 lb./1,000 sq. ft.		
	Pyrethrins + piperonyl butoxide	3 + 20	Soln.	0.013 - 0.13 lb./1,000 sq. ft.	Mix with water and apply to walls and floor of empty storage at the rate of 2 gal./1,000 sq. ft.	

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN—Wheat and Rye						
In bags in warehouse Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Methyl bromide	50 (Inorganic bromide)	F	2 lb.	Space fumigation, 60° F. or above.	Fumigants should be applied only by a trained operator.
				4 lb.	Space fumigation. Below 60° F.	
In bulk Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Malathion (premuim grade)	8	EC	0.63 lb./1,000 bu.	Mix with water 3 - 5 gal./1,000 bu. Spray on grain stream as it goes into storage.	
				0.32 lb./1,000 sq. ft. of surface area.	Surface spray. Will not control insects already established beneath the surface.	Do not release aerosol near an open flame. Aerate after fumigation with methyl bromide or chloropicrin.
			D	0.6 lb./1,000 bu.	Mix dust into grain before storing.	
	Pyrethrins + piperonyl butoxide	3 + 20	EC or oil soln.	0.06 + 0.6 lb./1,000 bu.	Mix with water, 3 - 5 gal./1,000 bu. Apply as protective spray to grain before it is stored.	
			D	0.06 + 0.83 lb./1,000 bu.	Mix dust into grain before storing.	
Moths, surface infestation	Chloropicrin	Exempt	F	1.5 lb./1,000 cu. ft. of space above grain.	Apply as fine spray or vapor into space over top of grain to control moths in surface layer. 70° F. or above.	
				2 lb./1,000 cu. ft. of space above grain.	Apply as fine spray or vapor into space over top of grain to control moths in surface layer. Below 70° F.	
In bulk or in bags Flying insects	Pyrethrins + piperonyl butoxide	3 + 20	Oil soln. % by wt. Pyrethrins 0.2 + piperonyl butoxide 2.0 + tetrachloroethylene 50.0 + deodorized kerosene 47.8	0.006 + 0.06 lb./1,000 cu. ft. of airspace.	Apply with thermal aerosol generator.	

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN—Wheat and Rye (con.)						
In bulk, in concrete or metal bins, farm-type metal bins, or large steel tanks Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Aluminum phosphide	0.1* (phosphine)	F	3 tablets/ton or 90 tablets/1,000 bu.**	Add to grain stream. Fumigate for 5 days at 54° - 59° F., 4 days at 60° - 68° F., or 3 days at 69° F. or above.	Fumigants should be applied only by a trained operator.
				10 pellets/ton or 300 pellets/1,000 bu.	Add to grain stream. Fumigate for 4 days at 54° - 59° F., 3 days at 60 - 68° F., or 2 days at 69° F. or above.	Do not recirculate aluminum phosphide.
	Calcium cyanide	25 (hydrogen cyanide)	F	12 - 15 lb./1,000 bu.	Mix into grain.	
				20 lb./1,000 bu.	Mix into grain. In 3,200-bu. metal bins.	
	Carbon tetrachloride + carbon disulfide (80:20 mixture)	Exempt	F	2.5 gal./1,000 bu.**	Gravity-distribution fumigation. 60° F. or above.	
				1.5 gal.**	Forced-distribution fumigation. Closed-recirculation or single-pass. 60° F. or above.	
				1.75 gal.**	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 60° F.	
	Chloroform + carbon disulfide + ethylene dibromide (71.25: 23.75: 5.0 mixture)	50 (inorganic bromide) Others exempt	F	1.75 gal./1,000 bu.**	Gravity-distribution fumigation. 70° F. or above.	
				2.75 gal./1,000 bu.**	Gravity-distribution fumigation. Below 70° F.	

*The tolerance for phosphine on processed commodities is 0.01 p.p.m. and on raw products 0.1 p.p.m.
**Double the dosage if used in wooden bins.

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN—Wheat and Rye (con.)						
In bulk, in concrete or metal bins, farm-type metal bins, or large steel tanks Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth (con.)	Chloropicrin	Exempt	F	2 lb./1,000 bu.*	Gravity-distribution fumigation. 70° F. or above.	Fumigants should be applied only by a trained operator. Do not fumigate with hydrogen cyanide (HCN) at temperatures below 60° F. Aerate for 24 hours after treatment.
				3 lb./1,000 bu.*	Gravity-distribution fumigation. Below 70° F.	
	Chloropicrin + methyl chloride (85:15 mixture)	Exempt	F	2 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. 70° F. or above.	
				3 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 70° F.	
	Ethylene dibromide + ethylene dichloride + carbon tetrachloride (5: 35: 60 mixture)	50 (inorganic bromide) Others exempt	F	2.25 gal./1,000 bu.*	Gravity-distribution fumigation. Surface application or layering method. 70° F. or above.	
	Ethylene dichloride + carbon tetrachloride (75:25 mixture)	Exempt	F	3 gal./1,000 bu.*	Gravity-distribution fumigation. 70° F. or above.	
				1.75 gal.	Forced-distribution fumigation. Closed-recirculation or single-pass. 70° F. or above.	
				2.75 gal.	Forced-distribution fumigation. Closed-recirculation or single-pass. Below 70° F.	

*Double the dosage if used in wooden bins.

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN—Wheat and Rye (con.)						
In bulk, in concrete or metal bins, farm-type metal bins, or large steel tanks Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth (con.)	Methyl bromide	50 (inorganic bromide)	F	2 lb.	Forced-distribution fumigation. Closed-recirculation or single-pass. 60° F. or above.	Fumigants should be applied only by a trained operator.
				3 lb.	Forced distribution fumigation. Closed-recirculation or single-pass. Below 60° F.	
	Ethylene dibromide + methyl bromide (30:70 mixture)	50 (inorganic bromide)	F	1.5 lb.	Forced-distribution fumigation. 70° F. or above.	Aerate after fumigation.
				2.5 lb.	Forced distribution fumigation. Below 70° F.	
	Ethylene dibromide + methyl bromide (70:30 mixture)	50 (inorganic bromide)	F	30 - 36 oz./1,000 bu.	Probe fumigant into hotspot.	
In bulk, in freight cars and van trucks Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Aluminum phosphide	0.1	F	3 tablets/ton or 90 tablets/1,000 bu.	Fumigate for 5 days at 54° - 59° F., 4 days at 60° - 68° F., or 3 days at 69° F. or above.	
	Chloropicrin	Exempt	F	2 lb.	Recirculation fumigation. 70° F. or above.	Do not recirculate aluminum phosphide.
				3 lb.	Recirculation fumigation. Below 70° F.	

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p.p.m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN—Wheat and Rye (con.)						
In bulk, in freight cars and van trucks Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth (con.)	Methyl bromide	50 (inorganic bromide)	F	2 lb.	Recirculation fumigation, 70° F. or above.	
				3 lb.	Recirculation fumigation, Below 70° F.	
	Ethylene dibromide + ethylene dichloride + carbon tetrachloride (5: 35: 60 mixture)	50 (inorganic bromide) Others exempt	F	5 gal./1,000 bu.	Apply from outside of car using hand or power sprayer.	Fumigants should be applied only by a trained operator.
In elevator machinery Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Ethylene dibromide + methyl bromide (70:30 mixture)	50 (inorganic bromide)	F	1.5 - 2 oz./boot or leg.	Apply as often as necessary to prevent infestation from becoming established.	Do not recirculate aluminum phosphide.
	Ethylene dichloride + carbon tetrachloride (75:25 mixture)	Exempt	F	1.5 pt. in small boots.	Apply as often as necessary to prevent infestation from becoming established.	
				0.5 gal. in large boots.		
				4 oz./ft. in screw conveyors.		
In elevator tunnels, gallery floor, and headhouse Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Methoxychlor	2	EC or WP	0.4 lb./1,000 sq. ft.	Apply as residual spray about 3 times during the summer. Clean area thoroughly before spraying.	
	Pyrethrins + piperonyl butoxide	3 + 20	EC	0.013 - 0.13 lb./1,000 sq. ft.		
In flat storage Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Aluminum phosphide	0.1* (phosphine)	F	3 tablets/ton or 90 tablets/1,000 bu.	Place tablets in grain mass. Fumigate for 5 days at 54° - 59° F., 4 days at 60° - 68° F., or 3 days at 69° F. or above.	
	Calcium cyanide	25 (hydrogen cyanide)	F	15 - 20 lb./1,000 bu.	Mix into grain.	

*The tolerance for phosphine on processed commodities is 0.01 p.p.m. and on raw products, 0.1 p.p.m.

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STORED-PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN—Wheat and Rye (con.)						
In flat storage Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth (con.)	Carbon tetrachloride + carbon disulfide (80:20 mixture)	Exempt	F	4 gal./1,000 bu.	Gravity-distribution fumigation. 60° F. or above.	Fumigants should be applied only by a trained operator.
				1.75 gal.	Forced-distribution fumigation. 60° F. or above.	
				2 gal.	Forced-distribution fumigation. Below 60° F.	
	Chloroform + carbon disulfide + ethylene dibromide (71.25: 23.75: 5.0 mixture)	50 (inorganic bromide) Others exempt	F	3.25 gal./1,000 bu.	Gravity-distribution fumigation. 70° F. or above.	
				3.75 gal./1,000 bu.	Gravity-distribution fumigation. Below 70° F.	
	Chloropicrin + methyl chloride (85::15 mixture)	Exempt	F	2 lb.	Forced-distribution fumigation. 70° F. or above.	
				3 lb.	Forced-distribution fumigation. Below 70° F.	
	Ethylene dibromide + ethylene dichloride + carbon tetrachloride (5: 35: 60 mixture)	50 (inorganic bromide) Others exempt	F	3.75 gal./1,000 bu.	Gravity-distribution fumigation. 70° F. or above.	
	Ethylene dibromide + methyl bromide (30:70 mixture)	50 (inorganic bromide)	F	1.125 - 1.5 lb.	Forced-distribution fumigation. 70° F. or above.	
				2 - 3 lb.	Forced-distribution fumigation. Below 70° F.	
	Ethylene dibromide + methyl bromide (70:30 mixture)	50 (inorganic bromide)	F	30 - 36 oz./1,000 bu.	Probe fumigant into hotspot.	Aerate after fumigation.

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STORED PRODUCT INSECTS

COMMODITY, STORAGE, AND INSECT	INSECTICIDE OR TREATMENT	TOLERANCE (p. p. m.)	FORMULATION	DOSAGE (active ingredient per 1,000 cu. ft. unless otherwise stated)	HOW, WHERE, AND WHEN TO APPLY	SAFETY RESTRICTIONS
GRAIN—Wheat and Rye (con.)						
In flat storage Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth (con.)	Ethylene dichloride + carbon tetrachloride (75:25 mixture)	Exempt	F	4.5 gal./1,000 bu.	Gravity-distribution fumigation. 70° F. or above.	Fumigants should be applied only by a trained operator.
				2 gal.	Forced-distribution fumigation. 70° F. or above.	
				3 gal.	Forced distribution fumigation. Below 70° F.	
	Methyl bromide	50 (inorganic bromide)	F	2 lb.	Forced-distribution fumigation. Recirculation or single-pass. 60° F. or above.	Aerate after fumigation.
				3 lb.	Forced distribution fumigation. Recirculation or single-pass. Below 60° F.	
Storage bin or ship's hold Grain weevils, lesser grain borer, grain beetles, Angoumois grain moth, Indian meal moth	Malathion (premium grade)	8 on grain	EC	0.45 lb./1,000 sq. ft.	Mix with water. At least 2 - 4 weeks before grain is binned, spray inside walls and floor of bin at rate of 2 gal./1,000 sq. ft.	
	Methoxychlor	2 on grain	WP, EC	0.4 lb./1,000 sq. ft.		
	Pyrethrins + piperonyl butoxide	3 + 20	Soln.	0.013 - 0.13 lb./1,000 sq. ft.	Mix with water and apply to walls and floor of empty storage at the rate of 2 gal./1,000 sq. ft.	

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Appendix B

BIBLIOGRAPHY

The information in this manual is not and can not be complete. The information presented here cannot be immediately applicable or appropriate

to all regions or to every storage need. You may well require further technical assistance in adapting these materials and others to your grain storage situation. Some of that help can come from books; much, from organizations and people.

The Tropical Products Institute (TPI) may already be a familiar name to you. This agency does a great deal to gather and distribute information worldwide on grain and grain storage problems. Materials from the TPI library have been of great value in the preparation of this manual.

Peace Corps and VITA are grateful to TPI for its permission to reprint that agency's bibliography of materials on the various aspects of farm-level grain storage.

Tropical Products Institute

G64 Crop storage bibliography
(with particular reference to
the storage of durable
agricultural produce in tropical
and sub-tropical countries)

Mrs. S.M. Blatchford and A.J. Wye

This bibliography has been produced by the Tropical Products Institute, a British
Government organization which helps developing countries to derive greater benefits

from their renewable resources.

Requests for further information on this subject should be addressed to:

Tropical Stored Products Centre
(Tropical Products Institute)
London Road
Slough SL3 7HL
Bucks.

Contents

N O T E S

This bibliography attempts to bring together a selection of the more important publications
dealing with tropical crop storage; it clearly cannot be exhaustive.

Where possible, the prices (at time of publication) and addresses are given for obtaining
publications listed here, excluding scientific papers. A list of the most common addresses
appears below.

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Conversion Tables

Simple methods are given here for converting English and metric units of measurement. Following these is a series of useful conversion tables for units of area, volume, weight, pressure and power.

LENGTH CONVERSION

The chart in Figure 3 is useful for quick conversion from meters and centimeters to feet and inches, or vice versa. For more accurate results and for distances greater than 3 meters, Equations: use either the tables in Figure 2 or the equations. 1 inch = 2.54cm
1 foot = 30.48cm
The chart in Figure 3 has metric divisions = 0.3048m
of one centimeter to three meters, 1 yard = 91.44cm

and English units in inches and feet = 0.9144m
to ten feet. It is accurate to about 1 mile = 1.607km
plus or minus one centimeter. = 5280 feet
1cm = 0.3937 inches
Example: 1m = 39.37 inches
= 3.28 feet
An example will explain how to use 1km = 0.62137 miles
the tables. Suppose you wish to find = 1000 meters
how many inches are equal to 66cm. On
the "Centimeters into Inches" table look
down the leftmost column to 60cm and then
right to the column headed 6cm. This
gives the result, 25.984 inches.

FIGURE 2
Inches into centimeters
(1 in. = 2.539977 cm.)

inches	0	1	2	3	4	5	6	7	8	9
0	cm.	2.54	5.08	7.62	10.16	12.70	15.24	17.78	20.32	22.86
10	25.40	27.94	30.48	33.02	35.56	38.10	40.64	43.18	45.72	48.26
20	50.80	53.34	55.88	58.42	60.96	63.50	66.04	68.58	71.12	73.66
30	76.20	78.74	81.28	83.82	86.36	88.90	91.44	93.98	96.52	99.06
40	101.60	104.14	106.68	109.22	111.76	114.30	116.84	119.38	121.92	124.46
50	127.00	129.54	132.08	134.62	137.16	139.70	142.24	144.78	147.32	149.86
60	152.40	154.94	157.48	160.02	162.56	165.10	167.64	170.18	172.72	175.26
70	177.80	180.34	182.88	185.42	187.96	190.50	193.04	195.58	198.12	200.66
80	203.20	205.74	208.28	210.82	213.36	215.90	218.44	220.98	223.52	226.06

90	228.60	231.14	233.68	236.22	238.76	241.30	243.84	246.38	248.92	251.46

Centimeters into inches
(1 cm. = 0.3937 in.)

cm.	0	1	2	3	4	5	6	7	8	9
0	inches	0.394	0.787	1.181	1.575	1.969	2.362	2.756	3.150	3.543
10	3.937	4.331	4.724	5.118	5.512	5.906	6.299	6.693	7.087	7.480
20	7.874	8.268	8.661	9.055	9.449	9.843	10.236	10.630	11.024	11.417
30	11.811	12.205	12.598	12.992	13.386	13.780	14.567	14.567	14.961	15.354
40	15.748	16.142	16.535	16.929	17.323	17.717	18.110	18.504	18.898	19.291
50	19.685	20.079	20.472	20.866	21.260	21.654	22.047	22.441	22.835	23.228
60	23.622	24.016	24.409	24.803	25.197	25.591	25.984	26.378	26.772	27.165
70	27.559	27.953	28.346	28.740	29.134	29.528	29.921	30.315	30.709	31.102
80	31.496	31.890	32.283	32.677	33.071	33.465	33.858	34.252	34.646	35.039
90	35.433	35.827	36.220	36.614	37.008	37.402	37.795	38.189	38.583	38.976

<FIGURE 101>

WEIGHT CONVERSION

The chart in Figure 5 converts pounds and ounces to kilograms and grams or vice versa. For weights greater than ten pounds, or more accurate results, use the tables (Figure 4) or conversion equations. See "Length Conversion," Figure 2, for an example of the use of

the tables.

On the chart, notice that there are sixteen divisions for each pound to represent ounces. There are 100 divisions only in the first kilogram, and each division represents ten grams. The chart is accurate to about plus or minus twenty grams.

Equations:

1 ounce = 28.35 grams
1 pound = 0.4536 kilograms
1 gram = 0.03527 ounce
1 gram = 2.205 pounds

FIGURE 4
Kilograms into pounds
(1 kg. = 2.20463 lb.)

kg.	0	1	2	3	4	5	6	7	8	9
0	lb.	2.20	4.41	6.61	8.82	11.02	13.23	15.43	17.64	19.84
10	22.05	24.25	26.46	28.66	30.86	33.07	35.27	37.48	39.68	41.89
20	44.09	46.30	48.50	50.71	52.91	55.12	57.32	59.53	61.73	63.93
30	66.14	68.34	70.55	72.75	74.96	77.16	79.37	81.57	83.78	85.98
40	88.19	90.39	92.59	94.80	97.00	99.21	101.41	103.62	105.82	108.03
50	110.23	112.44	114.64	116.85	119.05	121.25	123.46	125.66	127.87	130.07

60	132.28	134.48	136.69	138.69	141.10	143.30	145.51	147.71	149.91	152.12
70	154.32	156.53	158.73	160.94	163.14	165.35	167.55	169.76	171.96	174.17
80	176.37	178.58	180.78	182.98	185.19	187.39	189.60	191.80	194.01	196.21
90	198.42	200.62	202.83	205.03	207.24	209.44	211.64	213.85	216.05	218.26

Pounds into kilograms
(1 lb. = 0.45359 kg.)

lb.	0	1	2	3	4	5	6	7	8	9
0	kg.	0.454	0.907	1.361	1.814	2.268	2.722	3.175	3.629	4.082
10	4.536	4.990	5.443	5.897	6.350	6.804	7.257	3.175	8.165	8.618
20	9.072	9.525	9.979	10.433	10.886	11.340	11.793	12.247	12.701	13.154
30	13.608	14.061	14.515	14.969	15.422	15.876	16.329	16.329	17.237	17.690
40	18.144	18.597	19.051	19.504	19.958	20.412	20.865	21.319	21.772	22.226
50	22.680	23.133	23.587	24.040	24.494	24.948	25.401	25.855	26.308	26.762
60	27.216	27.669	28.123	28.576	29.030	29.484	29.937	30.391	30.844	31.298
70	31.751	32.205	32.659	33.112	33.566	34.019	34.473	34.927	35.380	35.834
80	36.287	36.741	37.195	37.648	38.102	38.555	39.009	39.463	39.916	40.370
90	40.823	41.277	41.730	42.184	42.638	43.091	43.545	43.998	44.452	44.906

TEMPERATURE CONVERSION

The chart in Figure 1 is useful for quick conversion from degrees Celsius (Centigrade) to degrees Fahrenheit and vice versa. Although the chart is fast and handy, you must use the equations below if your answer must be accurate

to within one degree.

Equations:

Degrees Celsius = 5/9 x (Degrees Fahrenheit -32)

Degrees Fahrenheit = 1.8 x (Degrees Celsius) +32

Example:

This example may help to clarify the use of the equations; 72F equals how many degrees Celsius?

72F = 5/9 (Degrees F -32)

72F = 5/9 (72 -32)

72F = 5/9 (40)

72F = 22.2C

Notice that the chart reads 22C, an error of about 0.2C.

Conversion Tables

Units of Area

1 Square Mile = 640 Acres = 2.5899 Square Kilometers

1 Square Kilometer = 1,000,000 Square Meters = 0.3861 Square Mile

1 Acre = 43,560 Square Feet

1 Square Foot = 144 Square Inches = 0.0929 Square Meter

1 Square Inch = 6.452 Square Centimeters

1 Square Meter = 10.764 Square Feet

1 Square Centimeter = 0.155 Square Inch

Units of Volume

1.0 Cubic Foot = 1728 Cubic Inches = 7.48 U.S. Gallons

1.0 British Imperial Gallon = 1.2 U.S. Gallons

1.0 Cubic Meter = 35.314 Cubic Feet = 264.2 U.S. Gallons

1.0 Liter = 1000 Cubic Centimeters = 0.2642 U.S. Gallons

Units of Weight

1.0 Metric Ton = 1000 Kilograms = 2204.6 Pounds

1.0 Kilogram = 1000 Grams = 2.2046 Pounds

1.0 Short Ton = 2000 Pounds

Conversion Tables

Units of Pressure

1.0 Pound per square inch = 144 Pounds per square foot

1.0 Pound per square inch = 27.7 Inches of Water(*)

1.0 Pound per square inch = 2.31 Feet of Water(*)

1.0 Pound per square inch = 2.042 Inches of Mercury(*)

1.0 Atmosphere = 14.7 Pounds per square inch (PSI)

1.0 Atmosphere = 33.95 Feet of Water

1.0 Foot of Water = 0.433 PSI = 62.355 Pounds per square foot

1.0 Kilogram per square centimeter = 14.223 Pounds per square inch

1.0 Pound per square inch = 0.0703 Kilogram per square centimeter

(*) at 62 degrees Fahrenheit (16.6 degrees Celsius)

Units of Power

1.0 Horsepower (English) = 746 Watts = 0.746 Kilowatt (KW)

1.0 Horsepower (English) = 550 Foot Pounds per second

1.0 Horsepower (English) = 33,000 Foot Pounds per minute

1.0 Kilowatt (KW) = 1000 Watts = 1.34 Horsepower (HP) English

1.0 Horsepower (English) = 1.0139 Metric Horsepower (cheval-vapeur

1.0 Metric Horsepower = 75 Meters X Kilogram/Second

1.0 Metric Horsepower = 0.736 Kilowatt = 736 Watts

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