Commercial Pesticide Applicator

SEED TREATMENT

Training Manual

LSU AgCenter Research & Extension

LOUISIANA STATE UNIVERSITY COOPERATIVE EXTENSION SERVICE

Commercial Pesticide Applicator

S E E D   T R E A T M E N T

Training Manual

COMPILED BY:

Dr. Randall Carver
Associate Specialist (Plant Pathology)

AND

Dr. John W. Impson
Associate Specialist (Pesticide Safety)

Louisiana Cooperative Extension Service

Louisiana State University

Baton Rouge, Louisiana

TABLE OF CONTENTS

NOTICE TO USERS OF THIS MANUAL

The Commercial Pesticide Applicators' Seed Treatment Training Manual has been prepared to give pesticide applicators essential information on pesticide laws, safety, labels, uses and application. Rules, regulations, safety facts, calibration and operation of application equipment and other basic information on pests and pesticides are stressed.

This manual does not give information or recommendations for the use of specific pesticides or equipment for specific pest control problems. Trade names and common names of specific pests, pesticides and application equipment are used where they are helpful in illustrating important information.

This manual will provide the essential information needed by applicators in studying for certification in Seed Treatment, as required by the Louisiana Pesticide Control Act.

Use of trade names in this publication does not imply endorsement of the products or machinery named nor criticism of similar ones not mentioned.

LAWS AFFECTING PESTICIDES IN LOUISIANA

In Louisiana pesticides are important in the production of food and fiber, as well as in the protection of man and his surroundings. Louisiana has had laws and regulations affecting pesticides for many years. These laws are based on the needs of the people, as well as concern for the protection of man and his environment.

Louisiana laws have been amended where necessary to comply with all requirements of the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as Amended. Congress passed laws in 1972 and 1975 which amended FIFRA and affected to a great extent the manufacture, application and uses of pesticides.

Federal Insecticide, Fungicide and Rodenticide Act

When Congress amended FIFRA in 1972, the Environmental Protection Agency (EPA) was designated to carry out the provisions of the Act. Some of the provisions are:

* Manufacturers must register all pesticides with EPA.
* EPA must then decide whether each use is a general or restricted use.
* Each manufacturer must register each establishment where pesticides are produced and EPA inspects these for compliance with the laws and regulations.

The portions of FIFRA that are of greatest concern to applicators, consultants and dealers are those which regulate registration and classification, certification, and establish violations and penalties.

Registration and Classification

Every pesticide must be registered by the manufacturer. It is then classified by its uses.

* Pesticides with the same active ingredients, but with a different formulation or different uses, must have a different label (make sure you check the label carefully).
* Each use must be classified as general or restricted use.
* General use pesticides should damage the environment very little or not at all when used according to the label and may be applied by anyone.
* Restricted use pesticides may damage the environment or be harmful to man even when used according to the label, and must be applied by a certified applicator or someone under his direct supervision.

Certification

To apply restricted use pesticides, an applicator must prove that he knows the safe and correct way to apply pesticides.

Federal regulations set forth standards for certification, including the naming of a head agency in each state--in Louisiana it is the Louisiana Department of Agriculture--to carry out the certification program. The Federal Standards include:

* The Private Applicator should possess: a practical knowledge of the pest problems and pest control paractices associated with his agricultural operations; proper storage, use, handling

and disposal of pesticides and containers; and his related legal responsibility.

* The Commercial Applicator must meet some General Standards, which are divided into eight areas of knowledge, and Specific Standards for each of the ten categories of applicators designated in the Federal Regulations.

The standards are detailed in a pamphlet, <u>Standards for Certification of Pesticide Applicators</u>, available from EPA, the Louisiana Department of Agriculture, or the Louisiana Cooperative Extension Service.

Violations and Penalties

Everyone involved with pesticides should be aware of acts that are violations of FIFRA and the penalties for these violations.

* Violations include such things as:

  1. Detaching, altering, defacing, destroying, in whole or in part, any labeling under this Act;
  2. Refusing to keep records;
  3. Making available for use, or to use, any registered pesticide classified for restricted use for some or all purposes other than as provided for in FIFRA or regulations thereunder;
  4. Using any registered pesticide in a manner inconsistent with its labeling;
  5. Disposing of any pesticide or its container except as the label or labeling directs.

* Penalties for violation are:

1. Civil penalties for private applicators up to $1,000.00;
2. Civil penalties for commercial applicators up to $5,000.00;
3. Criminal penalties for private applicators up to $1,000.00 and thirty (30) days in prison for each offense;
4. Criminal penalties for commercial applicators up to $25,000.00 and one (1) year in prison.

There are other Federal Laws that give Federal Agencies besides EPA authority over the regulation of pesticides. These are briefly outlined in a booklet entitled Apply Pesticides Correctly, designed for both commercial and private applicators.

Louisiana Laws and Regulations

In Louisiana pesticides are basically regulated by three laws: the Louisiana Pesticide Law, the Louisiana Pesticide Control Act and the Louisiana Structural Pest Control Act. Each of these laws covers some aspect of pesticides as required by Federal Law, and all are designed to meet the needs of the people in Louisiana.

Louisiana Pesticide Law

This law established the procedure for registering pesticides in Louisiana, as well as procedures for sampling pesticides for purity and proper labeling.

Louisiana Pesticide Control Act

The recommendation, sale, application and use of pesticides are important parts of this Act. These points are addressed in the provisions for Licensing and Certification of Pest Management Consultants, Pesticide Dealers and Pesticide Applicators.

* Licenses are required of all persons who are in the business of making recommendations as to the use of pesticides (Pest Management Consultants), selling restricted use pesticides (Pesticide Dealers) and applying pesticides (Custom Applicators).
* Certification is recognition by the State of Louisiana that a person has proven satisfactorily that he knows the safe and correct way to carry out his job in relation to recommendation, handling or use of pesticides. Pesticide Consultants, Pesticide Sales Supervisors, Commercial Applicators, as well as Private Applicators, must be certified.

Other provisions of this Act set up procedures for filing complaints regarding pesticides, collecting and analyzing pesticide samples, and enforcement action against persons violating sections of the Act.

Louisiana Structural Pest Control Act

This law regulates the persons in the business of applying pesticides in the category of Institutional, Structural and Health Related Pest Control. These persons are involved almost exclusively with control of household pests.

Details on these three laws are available from the Louisiana Department of Agriculture.

INSECTS AND RELATED INVERTEBRATES

What They Are

Insects make up about three-fourths of all the different kinds of animals on earth and live in all places on earth. There are beetles that spend their entire lives in the water. They breathe air, carrying it in little bubbles on their bodies. Larvae of some insects like the dragonfly spend all of their larval life in the water breathing by means of gills, whereas the adult lives outside of the water.

There are over a million different kinds of insects, and they differ from one another in many ways. In many instances, though, they are quite alike. Some are very small; aphids are as small as the head of a pin. Some, like walking sticks, are up to ten inches long. Some don't have any wings, and some are all wings, like the butterfly. They are in all different forms.

Not all insects develop in the same manner. In the case of the butterfly, the caterpillar doesn't at all resemble the adult. The caterpillar has three pairs of true legs as do all insects, plus abdominal legs. The abdominal legs on the caterpillar differ in number and formation and are used for identification purposes. Some have two pairs of legs; some have three pairs, and some four pairs. So, when you look at insects as a whole, they don't look at all like one another, but we will discuss some of the characteristics that make them similar and place them in the group called insects.

Parts of an Insect

Close inspection of an insect shows that the body is divided into three parts: head, thorax and abdomen.

Head--On the head are two antennae. The antennae are used primarily for sensing, as an organ for smell, and in some cases, for tasting. The antennae are very sensitive and are used by some for sensing or exploring the area. All insects have one pair of compound eyes. These eyes are made up of small units. Insects can't move the eyes or focus them. Some but not all insects have simple eyes. If they have them, they either have one or three. There is also a mouth that contains mouth parts for chewing and sucking.

Thorax--The thorax is made up of three segments with one pair of legs on each segment. All adult insects have three pairs of jointed legs. Most of the legs of insects are for running and and walking, and in some cases the hind legs are for jumping. Some insects have hind legs for swimming. There may also be special adaptations of the legs in some of the insects. Some have the front legs adapted for some special purpose; the praying mantis has its adapted for capturing its prey. In the case of the honey-bee, the pollen basket is located on its hind legs for collecting pollen. The thorax also contains wings. Most insects have two pairs. These are located on the second and third thoracic segments. Some insects have very hard front wings, as in the case of the beetle. The hind wings are used for flying; the front wings are just wing covers and protect the hind wings and soft abdomen.

Abdomen--The third part of the body is the abdomen. The abdomen contains all of the reproductive and digestive organs of the insect. At the tip of the abdomen there may be some special device like the ovipositor on the female insect. The ovipositor is used for laying eggs. The ovipositor differs with the various species of insects. In the case of the bees and wasps, the female insect has a sting. This is a specially developed ovipositor used as a defensive weapon for protecting the colony.

Insects have a skeleton, but it is an external skeleton which supports and protects the internal organs. Covering the skeleton is a waxy coating, which serves to conserve moisture. Insects must conserve as much moisture as they can inside their bodies. This waxy covering on the outside prevents water evaporation from the body of the insect.

Since the outside skeleton is very hard, it won't stretch. So as the young insect grows in size, it has to shed its skin. We call this "molting." When an insect sheds its skin, it is called a molt. Insects go through a series of these as they grow in size.

The insect also has a nervous system. It's a rather simple nervous system, but the series of nerves all connect with the brain in the head of the insect. The insect also has a digestive system. This digestive system is a rather complex tube running from the head of the insect to the tip of the abdomen for digestive purposes. Even though insects have blood, they are cold-blooded animals. The body temperature of the insect changes with the outside temperature. Each insect has a certain temperature at which it functions best. When this temperature drops below its mean temperature the insect activity may cease altogether.

Phylum Arthropoda

Insects are in the phylum Arthropoda. Included in this phylum are the related Arthropods like the ticks and mites, scorpions, millipedes and centipedes. Sometimes these are mistaken for insects. All of the Arthropods have segmented bodies and paired, jointed appendages. Their legs are arranged in pairs. In the case of the class Arachnida, which includes all of the spiders, ticks and mites, there are four pairs of legs, whereas insects have only three pairs of legs. The most important of all the Arachnids would be the spider mites, some of which are serious crop pests.

There is another group of Arthropods called the Crustacea. They may have from five to ten pairs of legs. Included in this group are the crab, lobster, shrimp and crayfish.

Two other groups are the millipedes and the centipedes. The millipedes have two pairs of legs to each body segment whereas the centipede has only one pair of legs to each body segment.

All the Arthropods have heavy outside skeletons. This protective covering protects the inside delicate parts of the insect. Some of them, like the crab, have a very hard covering, much harder than the others.

All insects have certain characteristics in common. They all have six legs. Their bodies are divided into three parts: the head, thorax and abdomen. Most of the adult insects have wings, usually two pairs of wings. They all have internal systems that perform functions such as digestion, respiration and reproduction. Also, there are similarities between the insects and their close relatives in the phylum Arthropoda.

Life Cycles of Insects

The development of insects is called metamorphosis. Metamorphosis means a change in form. All insects start life cycles as eggs. Some are laid in clusters such as those of some of the moths. There are other eggs that are laid singularly like those of the walking stick. The female will usually lay its eggs on a food plant that the larvae will eat. Most insects lay far more insect eggs than will hatch because this is the only way the species can be perpetuated.

Some also use various means to protect their eggs like in the case of the praying mantis. She covers the eggs with a frothy mass that will harden and protect them through the winter.

Types of Development

There are three main types of development of insects: complete metamorphosis, incomplete metamorphosis, and no metamorphosis.

Complete Metamorphosis--In complete metamorphosis there are four stages of development: from an egg to a larva to a pupa to an adult.

An example is the monarch butterfly. The female monarch glues the egg to the host food plant which is the milkweed. In three or four days the egg hatches into a tiny larva. The larva begins to feed and grow. As it grows, it sheds its skin. In the case of the monarch butterfly it will molt four times. This is not true of all insects with complete metamorphosis. Some of them will molt from four to twelve times. The caterpillar eats all the time as long as the food is there. All the senses it has now are taste and smell. When about three weeks old, it begins to prepare for the pupal or chrysalis stage. It spins a little button of silk and attaches itself to a twig and begins its final molt. As the old skin peels away, the chrysalis begins to appear. As it matures, the veins of the wings begin showing through the chrysalis. About two weeks later the monarch butterfly has completed its development inside the chrysalis and is ready to emerge. The butterfly presses itself against the outside of the chrysalis; it splits open and the butterfly crawls out. The wings are at first rather small and shriveled. The butterfly pumps body fluids into the wings to spread them out. Once the wings harden, the butterfly is able to fly. A moth undergoes the same type of metamorphosis. Instead of a chrysalis it forms a cocoon. Inside the cocoon is the pupa of the insect. When mature, the adult comes out of the cocoon and spreads its wings.

There are other insects that undergo complete metamorphosis, like the ants, bees, wasps and also the beetles. Of the 26 orders of insects, nine have complete metamorphosis. The group with complete metamorphosis makes up the largest group of all.

Incomplete Metamorphosis--The next type of metamorphosis or development of insects is incomplete metamorphosis. This is where the insect develops from an egg to a nymph to an adult. In incomplete metamorphosis, the young somewhat resemble the adults. When the eggs hatch, the little nymphs emerge. They look a great deal like the parents, except they don't have wings, they are not capable of reproduction and the heads are larger in proportion to the rest of the body. As the insect grows and molts, it sheds its skin, and it begins to look more and more like an adult each time it sheds its skin. After the last molt, it becomes a full-grown, sexually mature insect with wings.

There are many insects that undergo incomplete metamorphosis. The damselfly and the dragonfly are examples. Eggs are laid near the water. The egg hatches and the little nymph, naiad in this case, falls into the water and begins its development. It will spend at least three years in the water feeding and growing in size. As it grows, it sheds its skin. It may shed its skins as many as twenty times. After it completes its development as a naiad, it crawls out of the water and the adult crawls out of the old skin. It rests a while on the twig, its wings expand and harden, and it flies off. Cicadas also are in this group that have incomplete metamorphosis. The nymph of the cicadas may spend two to seventeen years feeding in the soil on roots of plants. It leaves the soil, its skin splits down the back, and the adult crawls out. It expands its wings; the wings harden, and it is ready to fly.

No Metamorphosis--The last type of development we are going to discuss is one that has no metamorphosis. The egg hatches and the young emerges, and it looks exactly like the adult except that it is smaller. There are only two groups of insects with this type of metamorphosis. These are the springtails and the silverfish.

Briefly, to review the three types of development of insects, there are those that have no metamorphosis, those with incomplete metamorphosis, and those with complete metamorphosis. It is important you know this if you are going to be working in control of insects. You should know something about the development of the animal you are to control.

There is some advantage to complete metamorphosis. Some of the insects have specialized adaptations for development. like in the case of caterpillars. Caterpillars have a voracious appetite and real good jaws for chewing food, so they grow very rapidly. Some of the other insects have other adaptations for dispersal, like wings. The biggest advantage of complete metamorphosis is that the adult and the larval stages do not compete for the same food. In the case of the caterpillar, it feeds on the foliage of a plant, whereas the adult will feed on the nectar of a plant.

The Different Kinds of Insects

There are over a million different kinds of insects. These are divided into 26 groups that we call orders. Each order has certain characteristics. Several of the more important orders of insects and the characteristics of each will be discussed. The orders are divided into three main groups. These are: no metamorphosis, incomplete metamorphosis, and complete metamorphosis. We'll study these by groups.

The first group has no metamorphosis. This includes the silverfish and springtails. The next group has incomplete metamorphosis, such as the grasshopper. And the last group has complete metamorphosis where the young doesn't look at all like the adult, and the wings develop on the inside of the body. This is the largest group.

Beetles

Now we will look at the orders in the most advanced group, which are those with complete metamorphosis. The beetles are the largest order of insects. There are over a quarter of a million different kinds of beetles. It is said that if you lined up all the different kinds of animals present on earth one behind the other, that every fifth one would be a beetle. There are just that many beetles on earth. The beetles have hardened front wings used to protect the delicate hind wings and soft abdomen. Beetles' wings meet in a straight line down the back. This is how to distinguish a beetle from other animals. No other order of insects has this type of front wing cover. Beetles come in all shapes and sizes. Some of them have special adaptations, like the firefly, which uses a light to attract its mate. Some have enormous jaws, such as the stag beetle. It's not really as ferocious as it appears; its jaws are not very effective as a diversive weapon.

Butterflies and Moths

The next largest order of insects contains the butterflies and moths. What differentiates this order of insects from all others is the very tiny scales on their wings. The moths and butterflies feed on the nectar if they feed at all. They feed by means of a coiled tube which they uncoil and insert into the bloom to get their food.

Flies

The next group is the pest insects, and these are the flies. In addition to flies, mosquitoes are in this group. All of the insects in this group have only one pair of wings. Remember, when they are two pairs, they are on the second and third thoracic segments. All mosquitoes and flies have only one pair of wings, and this pair is on the second thoracic segment. In place of the second pair of wings, they have a little, knob-like organ on the third thoracic segment. Although flies have only one pair of wings, they constitute some of the best of the flying insects.

Fleas

Another order is the fleas, a wingless insect. The fleas fall into the complete metamorphosis group because the larva doesn't look anything like the adult. The larva of the flea is a little caterpillar or worm-like animal. The larvae of butterflies and moths are called caterpillars. The larvae of flies are called maggots. And the larvae of beetles are called grubs. The larvae of fleas have no special name.

Wasps, Bees and Ants

Anorther very large order in this particular group of insects with complete metamorphosis are the wasps, bees and ants. They are probably the most interesting group of all the insects. They are very highly developed animals. The one characteristic that separates this order from many of the other orders is that they have a narrow waist between the abdomen and the thorax. All of these animals have mouth parts for chewing. In addition to chewing mouth parts, the lower lip of the honeybee is developed into a little organ for sucking nectar from flowers. The ants are also in this group. Most species live in the ground. Their tunneling helps in aerating the soil. The ants are very interesting little animals in that they live in a society where there is one queen and workers. These are called social insects. Many of our ants, bees and wasps are social insects. They depend on one an another for their existence. Some colonies of ants rear aphids for honeydew; some collect seed for feed; others raise fungi, like the town ant. In the honeybee colony is found a very well organized social group of insects. In fact, it is so well organized that some bees in the colony have assigned tasks. Some feed the young; some mold the wax; some haul water; some go out collecting nectar. In addition to this, bees are also very important as pollinators, especially for some of our fruit and legume crops. Another group of social insects is the paper wasps. They are different from ants and bees in that they don't survive the winter. The reproductive kings and queens go into hibernation. They come out the next spring, mate and begin a new colony.

Grasshoppers, Crickets and Roaches

The second group of insects are those with incomplete metamorphosis. The largest order in this group is the one to which the grasshoppers, crickets, katydids and roaches belong. The front wings of these insects are leathery and are not used much for flying. They mostly protect the hind wings. This is one of the characteristics used in differentiating this group of insects from the others. Many of the individuals in this order are good jumpers. They have their hind legs for jumping, like the crickets, katydids and grasshoppers. The crickets are known for the noise they make. They make this noise by rubbing their wings together.

True Bugs

A lot of people refer to all insects as bugs. There is only one order of insects that are true bugs. If you call one of these a bug, you are correct. All of the true bugs have the inner half of the front wings hard and the outer half membranous. If you've ever looked at the wings of a stinkbug, you've been able to see this. The mouth parts of these animals are adapted for piercing and sucking. They stick their beaks into the plant or animal and suck the juices or blood. Some of this group also have legs especially adapted for walking on water; an example of this is the water strider.

Cicadas, Aphids, Etc.

Another order of insects that belong in this group with incomplete metamorphosis are the cicadas, aphids, leafhoppers, scale insects, whiteflies and mealy bugs. All of these have front and hind wings a little different from their close relatives, the stinkbugs or the true bugs. Instead of having their front wings with a hard covering on the inner half, the front and hind wings are practically the same. Among the different species of aphids, some have wings and some do not. Also, within the same species, some may have wings and some may not.

Termites

Another order of insects in this group is the termites. Termites are one of the oldest insects on earth. They have been here for at least three hundred million years. They too are social insects. There are the ones that the average person refers to as white ants. They are really not ants; they are not in any way related to ants. The thing they are best noted for is that they feed on wood.

Other Orders

The next order of insects with incomplete metamorphosis is the one with the dragonflies and the damselflies. Another order is the mayflies. Mayflies are interesting in that the larvae may stay in the water for several years, emerge, and live as an adult for just a few hours. It doesn't feed in the adult stage. at all.

DISEASES

Diseased plants are sick plants and do not function as well as healthy ones. These plants may eventually die. In the process of being diseased, plants lose their normal functions, in part or entirely.

Examples are:

1. Leaf spots cause photosynthesis to be stopped or reduced.
2. Bacterial wilt--stems become plugged so that water and nutrients cannot move up nor down, growth slows down and the plant becomes stunted and wilted.
3. Root rots and nematodes--the water and nutrients cannot be taken in and later translocated, resulting again in the plant becoming stunted or yellowed or slow to mature or die. Yields are reduced or nonexistent.

All of these effects are the result of the disease and its causal agent.

Plant diseases may be dynamic or may be static. When pathogens such as fungi, bacteria and viruses are involved it usually taken 10-14 days for the plant to show symptoms after initial infection.

Plant diseases may be divided into two broad groups based on their causes. These two groups are nonparasitic and parasitic.

Some of the nonparasitic disorders are:

1. Nutrient deficiency
2. Extreme cold or heat (frost or fire)

3. Toxic chemicals (air pollutants, weed killers, fertilizer excesses)
4. Mechanical damage
5. Lack or excess of water

These nonparasitic diseases cannot be passed from one plant to another. Breeding has given the grower a few varieties capable of withstanding disease induced by nonparasitic problems. Some of these are cold tolerances in crops such as alfalfa and thickness of watermelon rinds.

The parasitic diseases are caused by living things which live and feed on or in plants. The most common of these are:

1. Fungi
2. Bacteria
3. Viruses
4. Nematodes
5. Parasitic seed plants

Fungi are plants that lack green color (chlorophyll). Fungi cannot make their own food. There are more than 100,000 kinds of fungi of many types and sizes. Not all are harmful, and many are helpful to man. Most fungi reproduce by spores, which work about the same way as seeds. Many fungi are capable of penetrating plant tissue directly. Examples of diseases caused by fungi are smut on corn, downy mildew on soybeans and red rot of sugarcane.

Bacteria are microscopic and single celled organisms. They usually reproduce by simply dividing in half. Each half becomes a fully developed bacterium. Bacteria can build up very rapidly under ideal conditions. Some divide every 30 minutes. Bacteria must enter plant tissue either through natural openings or through wounded tissue. Fire blight of pears and scab of potatoes are caused by bacteria.

Viruses are so small that they cannot be seen with the unaided eye or even with an ordinary microscope. They are generally found and studied by their effects on plants. Identifications are usually made by the electronmicroscope or by using indicator plants.

Many virus diseases are carried by insects, usually aphids and leafhoppers. Viruses are easily carried along in bulbs, roots and cuttings. They are seldom seedborne. Some viruses are transmitted by rubbing leaves of healthy plants with juice from diseased plants. A few are trandmitted by pollen and nematodes. Examples of virus diseases are sugarcane mosaic virus and tomato mosaic virus.

Nematodes are small, usually microscopic worms. They have no antennae, legs or other appendages. Only a small percentage of the nematodes are pathogenic. They may attack the roots, leaves or stems. Nematodes usually do not kill plants but reduce growth and plant health. This lowers production and yield.

All nematodes that are parasites on plants have a hollow spear or stylet. This is used to puncture plant cells and feed on the cell contents.

The life cycle includes an egg, four larval stages and an adult. The female of some, such as root knot and cyst nematodes, are the ones that parasitize plants. The male only lives through mating and does not parasitize plant parts. Examples of parasitic nematodes are root knot of tomatoes and soybean cyst.

Parasitic seed plants usually attach themselves to the host and deprive the host of nutrients and water. Mistletoe can manufacture its own food after it obtains the raw materials from the host. Mosses and dodders are other examples of parasitic seed plants.

When a pathogen is the causal agent, there are three minimal requirements for disease to occur. First, the pathogenic agent must be present and of the correct pathogenic form, race, or strain; second, the environmental conditions must be favorable for the agent to develop and enter the plant and cause disease; and third, there must be a susceptible host. No one of these three is considered more important than any other. They make up a triangle. If any one of these points of the triangle is absent, or in any way "weakened," then disease is likely to be correspondingly lessened or even absent. This is the basis for plant disease control. Examples of this are resistant varieties, chemical sprays and choosing the proper planting time.

Having an influence on the development of disease are one or more so-called conditioning or predisposing factors. When we think about a disease, we usually think first of the causal agent, the varietal susceptibility of the plant and then of its conditioning factors such as moisture, temperature and light. Susceptibility, age, vigor and other inherent characters or qualities of the host are as important conditioning factors as are those of the plant's environment.

There are four basic stages of disease development. These are penetration, infection, incubation and development followed by symptoms. Penetration refers to initial invasion of the host by an organism. Infection implies the establishment of the pathogen within the host following penetration. Incubation period is the period between infection and appearance of the disease. Symptoms are the actual expressions or responses of the host to successful pathogen penetration, infection and incubation.

There are three main ways in which a plant or host responds to pathogen invasion. These are:

1. Hyperplasia--overdevelopment of tissue such as galls, swellings and leaf curls.
2. Hypoplasia--underdevelopment of tissue such as stunting, lack of chlorophyl and incomplete development of organs.
3. Necrosis--death of tissue, such as blights, leaf spots, wilting and cankers.

The control of plant diseases involves breaking the disease cycle. There are several methods that can be employed. Many times several methods will be required. There are six broad areas or methods of plant disease control or disease pest management. These are:

1. Exclusion--not allowing disease pathogens to enter the crop production area. Examples:

   A. Quarantine--potatoes are checked for late blight and ring rot.

   B. Vector control--white tip of rice.

   C. Seedbed sterilization--keeps pathogens out of the field.

2. Eradication--removal of disease pathogen after it has entered the crop production area. <u>Inoculum</u> <u>reduction</u> is perhaps a better description of this control method since only one disease has ever completely been eradicated from the United States. Examples:

   A. Removal of diseased twigs--fireblight.

   B. Deep plowing to bury diseased plant debris--southern blight.

   C. Soil fumigation for nematode control.

   D. Dormant sprays to keep down primary disease infection--pecan, etc.

3. Therapy--destruction of a disease that has become established. Examples:

   A. Seed treatment--hot water treatment for cabbage black rot control.

   B. Heat treatment--ratoon stunting disease of sugarcane.

   C. Chemical therapeutants--kill established diseases; some systemic fungicides.

4. Resistant varieties--use of resistant varieties is understood by most producers. We should keep in mind that resistance does not imply immunity. Examples:

A. Tomatoes--Pelican--fusarium wilt resistance.

B. Soybeans--Pickett--reniform nematode resistance.

5. Escape--avoidance of the disease by following practices that do not favor the disease development. Examples:

   A. Soil rot of potatoes--planting in pH below 5.2.

   B. Blossom end rot of tomatoes--avoid water fluctuations and maintain proper calcium levels in the soil.

   C. Planting time--damping off usually worse under cool moist conditions.

6. Protection--usually implies the use of protective chemical which prevents the pathogen from attacking the host plant. Examples:

   A. Surface protection--fungicidal sprays.

   B. Seed treatment--chemicals designed to protect seed from root rot diseases.

PESTICIDE TOXICOLOGY

Insecticides

Properties of a Good Insecticide

1. It must kill insects; otherwise it cannot be considered an insecticide. When a new chemical is discovered, it is screened for general pesticide action. Normally, certain groups of insects such as adult Colorado potato beetles, at least one caterpillar (an immature of a moth or butterfly), and usually one group of sucking type insects such as aphids or scales serve as test species.

2. Is nontoxic to mammals--this is particularly true for most wildlife species, but also includes most other mammals as well as birds, fish and other forms of wildlife. Both chronic and acute dosages must be determined. Also, oral and dermal lethal dosages must be known initially before it can be tested to any large extent in the field.

3. Is nontoxic to plants--although phytotoxicity is not usually a problem to people using an insecticide, it is often a limiting factor in the early stages of developing a new insecticide. Many times it may not be the chemical itself causing the phytotoxicity, but may be the carrier or some other ingredient of the compound. An example of a widely used compound in Louisiana that can be phytotoxic is Kelthane used at a high rate. If the calibration is off just a little (example--a double rate) burn may occur on several plants. Also, Methomyl at present has a label for only two applications on cotton due to phytotoxicity.

4. Has low production cost--this is almost a thing of the past. The cost of producing pesticides has increased at a much higher rate than the cost of most other things in the country. For example, the price of food has increased by 50 or 60% in the last 10 years; the cost of the production of pesticides has increased by some 200 to 1,000% in the same period of time.

5. Is easily formulated--this is one of the things that can cause the cost of a pesticide to be high. For example, Sevin is a chemical that the company has tried to formulate as an emulsifiable concentrate but has not been sucessful. It is formulated as a slurry type, but the price is usually higher than the wettable powder.

6. Is compatible with other pesticides--in the insecticide group this in general has not been as big a problem as it has been with some of the fungicides, particularly the coppers. Sometimes highly alkaline water can contribute to a serious mixing problem. This has been observed on several occasions with parathion.

7. Has low toxicity to beneficial insects--this is one of the areas that EPA has stressed. That is, to have a chemical that is toxic to one group of insects and not toxic to another. Of course, from a farmer's standpoint, this may or may not be particularly good. As of now, there are very few insecticides that are for specific groups of insects. Dipterex at low rates is pretty specific to flies. Dimethoate at low rates is pretty much specific to sucking type insects such as aphids, scales, etc.

But in general, most insecticides in use today kill several different groups of insects including pests as well as beneficial insects.

8. Produces no off taste--this problem must be solved before the pesticide can be labeled. BHC will at times cause an off taste on some vegetables such as peas. Chlordane will in some instances give a little bit of off flavor to Irish potatoes. However, Chlordane has not been a problem in Louisiana.

9. Has an optimal residue persistence--in the past an insecticide that had a long residual effect on insects was considered ideal. Today it is a different story. With the persistence problems experienced with most of the older insecticides such as DDT, EPA is not likely to permit registration of a pesticide that is persistent in the environment. Some of the materials registered today might have up to a two-day residual effect. But these chemicals must biodegrade rapidly and the metabolites must be nontoxic. The metabolites must be identified, and it must be shown that they are not harmful. This was probably the biggest problem with DDT. DDT breaks down to a material called DDE, and tends to be rather persistent in this stage. Although the DDE is relatively nontoxic in general, this persistence was the thing that was really objectionable. Most of the insecticides that are being registered today have a residual effect of something like 2 to 48 hours. Most of the phosphates and carbamates fall into this category. However, when used in the soil, mocap,

for example, will be effective on soilborne insects on sweet potatoes from 70 to 90 days. Di-syston is also a pretty good soil insecticide. However, most chemicals tend to break down withing 2 to 3 days after they are sprayed or dusted on the foliage of plants.

Finding and Developing a Pesticide

This procedure may not necessarily come in this particular order listed:

1. Analysis of the market--the company must decide whether they have a market for a particular pesticide or not, and if so, determine the full extent of that market.

2. Synthesis--this is the discovery of the chemical. Many times the chemical may be discovered before a market is developed. The synthesis of a compound will usually include the original and all of its analogues. When a compound is labeled today, the company will attempt to label all related compounds. Many times the original compound may not be the most widely used chemical.

3. The preliminary screening--most insecticide companies have a particular set group of insects they use for screening. These will usually include a beetle, a fly, a caterpillar and one of the sucking insects.

4. Extensive screening--if it works fairly well on any one of these insects, then they go further with the screening of that material in an attempt to find out all the insects which that chemical might be used against.

5. Pilot plant--this is for the production of a relatively small amount of the chemical so that it can be further tested. The company is not trying to get on the market yet. This compound will still be 2 to 4 years away from the first label.

6. Formulation--at this stage, the solvents and emulsifiers that can be used to produce a usable formulation are tested. This is a very important step. Many good potential insecticides fall by the wayside here.

7. Small plot field tests--the pilot plant produces the material used in this step.

8. Chronic mammalian toxicity studies--this used to be a minor part of developing a pesticide, but today this is where a tremendous amount of cost built into developing a pesticide comes from. Today this procedure usually takes three years; 20 years ago it seldom took more than 90 days.

9. The metabolism studies--this is the breakdown of the chemical; that is, what happens to it when it is put into the environment; what breaks it down? Is it sunlight, or water, or bacteria, etc.?

10. Registration--this is the time when the label is issued by EPA and a right to market the chemical is obtained.

11. Large scale production--this is where the chemical is formulated for use by farmers, etc. The company normally sets up a big plant to make the material on a large scale basis. Usually, a production plant is made specifically for this purpose.

Sometimes a company will have a plant that can be used for more than one chemical.

12. Promotion.

All of this is going to cost somewhere in the neighborhood of 8 to 15 million dollars. Just five or six years ago, this cost was running about 1 to 2 million dollars. Usually a patent is good for 17 years. This means that only the company with the patent can produce that particular chemical during that time without competition from other companies.

Tolerances

Before any chemical can be labeled for use, it must have a tolerance established. There are two things that must be demonstrated. The first is that a given level or amount of insecticide will have no harmful effects on a mammal. For example, if a tolerance of one part per million is established the company must demonstrate that one part per million will not have any effects on the animal or on the plant for which the tolerance is established. Most of the time there will be about a two- to tenfold safety factor here. If they find, for example, that two parts per million has an effect on the animal or plant, but one part does not, the tolerance will usually be set at something considerably less than one. So then instead of establishing a one part per million where it was proven safe, the tolerance would probably be set at .1 part or possibly .5 part. That way EPA can be assured that the chemical will not be of any harm even if an overdose is used, nor will there be an excessive residue.

The second thing that must be demonstrated is that a given treatment procedure will result in no more than the above determined level of the insecticide. That is essentially saying that if the label says that one pound per acre of the material can be used, and there is a tolerance of one part per million, when one pound per acre is applied, it will not have above one part per million residue. Most of the insecticides, even on the use, the safety hazards, and everything else, have a pretty good safety factor built into them. Usually it will be at least five- to tenfold, pretty close to the same that they have on the tolerance level. All plants, whether they are food or fiber, must have a tolerance established.

LD_{50}-LD_{90}

This is simply a measurement of the amount of toxicant that it takes to kill 50% of a given population. This is usually measured in milligrams of toxicant per kilogram of body weight; sometimes it will be given in milligrams of an insecticide per insect. The latter is the measurement we've done on the tobacco budworm, for example. The LD_{90} is the amount of toxicant it takes to kill 90% of an insect population. The LD_{90} will change quicker than the LD_{50} in determining insect resistance to a particular insecticide. In determining resistance the LD_{50} or LD_{90} must be known for a susceptible population. Then, if resistance has occurred, it will take a higher dosage to kill 50% of that population. For example, if the LD_{50} for a susceptible population of tobacco budworms to DDT is 2 milligrams per worm and 20 milligrams per worm in another population of the same species, then resistance is evident.

Another way is to get a level established before any resistance occurs. Again, this is what we did in the case of the bollworm and the tobacco budworm. We have data going back for 12 to 15 years using the same technique and the same insecticide to establish this LD_{50}. When an increase in dosage occurs, for example 6 to 8 folds in the lab, then resistance has occurred.

So you cannot always take laboratory data and corrolate it to the field. Methyl Parathion is an example here. In the laboratory, methyl parathion looks good. But in the field, it was never an outstanding material on bollworms and tobacco budworms. However, on other caterpillars such as armyworms, it gives outstanding control.

<u>General Types of Insecticides</u>

All insecticides kill through contact or through ingestion. DDT is an example of the contact insecticides; the arsenicals have to be eaten. A contact insecticide can kill as a residual effect, or as a fumigant. A systemic such as Di-syston could kill from residual effect, or from the insect sucking the juice from the plant. Any way that the insects come in contact with the residual film should kill them, whether it gets on their legs, body or stomach. This is what we consider a good insecticide, one that does have a little residual.

There are not many of the stomach poisons. They have a lot to be desired in that they kill only through the stomach, and that means they must be eaten. The most common one again would be the arsenicals, but we have got some new ones coming on the market. One of these is the Bacillus Thurengensis; it must be injested by the caterpillar. It would be considered strictly a stomach poison.

1. Arsenicals--these are pretty much out of the picture as far as insects are concerned. There were two common ones; one of them was calcium arsenate, and the other one was lead arsenate. One of the major problems with the insecticide arsenicals was persistence. Once they are applied they remain there. Also, as mentioned above, being a stomach poison only was not ideal. However, there have been very few insects that ever developed resistance to arsenicals.

2. Dinitrophenols--again, there are very few of these still in use as insecticides. These were used earlier as dormant sprays. Usually, they were used in conjunction with some of the oils for scale and in some cases, mites.

3. Rotenone--several could be listed here since these are derivative of plants. This is a group that the organic gardeners can use. The organic gardener does not want to use one of the so-called synthetic insecticides. Rotenone is made from a plant called the Derris plant. This insecticide was real common at one time and it still has a place, particularly where it is used for

killing fish in a pond. It does a good job, and it is the most common one used in ponds where people want to clean up a pond and start over.

4. Pyrethrum--this is a very important group, and it has a lot of excellent properties. It has what is commonly called flushing action. Very few of the synthetic insecticides have this flushing action. When a house is sprayed with Diazinon and Pyrethrum, it has a flushing action, and the roaches start moving. This is very beneficial in that it makes the insects move and come in contact with the insecticide quicker and while the chemical is still wet. It also has some other advantages. It is extremely good on wasps and honeybees. It has a quick knockdown. Many people have probably used it at one time or another. This is the material in the bombs for wasps, etc. There will usually be a low percentage of this chemical such as .02% Pyrethrum. It takes a very small amount of this material to have an effect on insects. Another good advantage of it is that it is very safe to mammals. In fact it is almost nontoxic to mammals, particularly at those low doses. Also it does not have much of a residual. So, from this standpoint, it has been a real good one in the past and still has a place.

There is a new group of insecticides called synthetic pyrethroids. They may be on the market by 1977. They look extremely good in most of the tests against caterpillars and, in fact, a large group of insects. The caterpillars are generally the hardest group of insects to kill. The beetles are normally relatively easy to kill in the adult stage, and the caterpillars and the grub stages are hardest to kill.

5. Organochlorine insecticides--this is the most important group of insecticides that has been discovered to date. They were also the first. The ironic thing about DDT was that this material was discovered way back in 1874 by a man by the name of Zeigler. He discovered the compound, but it was a fellow by the name of Muller who discovered what it would do as far as insecticidal activity back in 1939, and of course he won a Nobel Prize for it. This was the first one of the synthetic pesticides, and this is the group referred to as the chlorinated hydrocarbons. This is the group that has received most of the bad publicity; most of them are persistent type insecticides. Persistence is one thing that is not desirable. A good residual is desirable, but not necessarily a real long persistence. Most of this group has been banned.

Also, the other more common hydrocarbons are endrin, chlordane, heptachlor, telodrin, thiodan, dieldrin, and aldrin. Then there's a group sometimes referred to as off-type hydrocarbons: toxaphene, strobane, mirex, and kepone. All of these are in the same group and somewhat related. The chemical formulas of toxaphene and strobane have never been worked out. They are both made from pine stumps, and at the time of their discovery many of the requirements of today were not necessary. And with the patent having run out on it, the company has felt like it was not worth the cost of working out the chemical structure of it.

The next one, Kelthane, is still used quite a bit for mites. This is a case where it is used for mites only. It is one of the few that has good selectivity. That is, it kills only a small group of pests.

The biggest thing that heptachlor had against it was the fact that it formed a material called heptachlorepoxide, which is extremely persistent, very much like DDE, except much more toxic. Once it formed the epoxide this material pretty well stayed in the environment for many years. Also the epoxide is more toxic than the original heptachlor.

Aldrin and dieldrin are somewhat unique in that aldrin breaks down to dieldrin. Once an animal eats aldrin, it changes to dieldrin. Dieldrin is really the toxic form. It was rather interesting to note that all of this group--aldrin, dieldrin, endrin, heptachlor and chlordane--were developed by one man.

The last two are not as well known, but are hydrocarbons--mirex and kepone. These are relatively safe materials, and of course, most of this group (with the exception of endrin) are considered safe as far as mammals are concerned.

Some of the symptoms of poisoning of the hydrocarbons are hyperexcitability, tremors, convulsions, paralysis, and finally death, if something is not done. This entire group affects primarily the nervous system. The most common and best antidotes are the barbituates. These must be given by an M.D.

6. Nicotine--as mentioned earlier, nicotine is a plant derivative from tobacco. The reason that this insecticide is not used much is it is a lot more toxic to man than it is to insects. Nicotine was never an outstanding control of many insects.

7. Organophosphorus insecticides--many of these are outgrowths of the war gases that were developed by the Germans during World War II. This is the case of methyl parathion and ethyl parathion, which were two of the first. Phosdrin and some of the others came on pretty shortly after that. Of all the phosphates on the market today, phosdrin still ranks as one of the most toxic to mammals, and I suspect that there have been more people poisoned with phosdrin than any other pesticide on the market. We have had several people in Louisiana poisoned with it. However, there have not been any deaths. Some of the more common phosphates are parathion, malathion, guthion, di-syston, thimet, bidrin, azodrin, EPN, diazinon and dipterex. The first one, Tepp, has been used quite extensively in vegetable production, and it is still probably one of the two most toxic materials on the market today. Malathion is one of the really safe ones. Diazinon has an LD_{50} orally of 150 mg/kg which is quite safe, and dermally it is also one of the least toxic at 4000 mg/kg. This is one of the reasons that it makes a real good insecticide for homeowners to use because they will not get poisoned.

Axodrin's biggest fault is that it has adverse effects on birds. That is, it is very toxic on birds; it is a pretty good pesticide other than that. It also has one other thing that makes it a little unique; it is water soluble. That is not necessarily good. If you get rain soon after application, it breaks down very rapidly. Parathion, on the other hand, is not water soluble. Put methyl parathion in water and it tends not to break down and may remain there for many days. Again, methyl parathion and parathion were the first two developed. EPN is a very similar material to methyl parathion. It has some very similar biological activities. It is one of the phosphates that does a fair job of controlling some otherwise difficult to control insects.

DDVP is the one that is used in the strips that hang from the ceiling. It does a pretty good job and is relatively non-toxic in this form. It has an LD_{50} of about 80 mg/kg orally and about 107 mg/kg dermally. This is another one of the pesticides where there was very little difference between the oral and dermal toxicities. Some of them penetrate very readily. Parathion is another one that penetrates the skin very readily whereas methyl parathion is not quite as toxic dermally. This is one of the reasons that methyl parathion has been used a lot more than parathion. It is less toxic dermally than parathion.

The organic phosphate insecticides are, in most cases, highly toxic to warm blooded animals. They are acetylcholinesterase inhibitors. The phosphates and the carbamates have the same antidotes, either atropine sulphate or a combination of atropine sulphate plus 2-PAM. 2-PAM relieves the poisoning symptoms, but not the cause. Therefore, it should never be used alone

Again, this is one of the reasons for keeping the label on the pesticide; if somebody drinks it, you cannot tell what kind of pesticide poisoning they have by looking at their activity because many of the pesticide poisoning symptoms are the same; that is hyperexcitability, tremors, convulsions, paralysis and death. The carbamates do essentially the same as far as actions on mammals.

8. Carbamates--this is a relatively new group. Sevin (carbaryl) was one of the first discovered and is still one of the most widely used insecticides on the market today. Although carbaryl is very safe, many of the other carbamates are very toxic to mammals. The carbamate sevin is somewhat like malathion of the phosphate group. It is one of the few that is safe. Temik and methomyl are two that are dangerous. The one that is used commonly now is methomyl. Many times when there is resistance to the phosphates, there will also be resistance to the carbamates and vice versa. Certainly, in most of the other cases where there is resistance to the phosphates, there is also resistance to some of the carbamates. Cross resistance is very common between these two groups.

9. Biological agents--certainly this is the day and time you cannot say anything about an insecticide without saying something about biological agents. Right now there is only one major one on the market, and it is Bacillus Thuringensis. There are a number of others that should be on the market in the next four

or five years including some viruses that will control many of the caterpillars. There are a number of others; for example, there are some nematodes that are effective for controlling mosquitoes.

Fungicides and Nematocides

Chemicals for the prevention of plant disease losses in major agricultural crops have been recognized as one of the essential weapons in our arsenal of defense against microscopic pathogens which include bacteria, fungi, viruses and nematodes. While food production is our major concern, we also are constantly reminded of the value of trees and ornamental plants to the home owner.

Crop producers and homeowners are primarily interested in three phases of plant disease control: (1) identification, (2) control practices and (3) economics. The principal emphasis of this section is to discuss chemical controls. Although chemical fungicides and nematocides are useful in combating diseases, let's not think of them as the only way to control disease problems.

Disease Control Chemicals

Chemicals are used as pesticides because they are toxic to various pests. Many are toxic to non-target organisms, including man. Safe and proper use depends in part on a knowledge of toxic properties and a respect for the potential hazards associated with their use.

A compound's toxicity is its inherent ability to injure living organisms. Criteria for cataloging pesticides by toxicity established in the Federal Insecticide, Fungicide and Rodenticide Act are as follows:

Highly Toxic LD_{50} - 50 mg/kg or less
Moderately Toxic LD_{50} - 50 to 500 mg/kg
Low Order Toxicity LD_{50} - 500 to 5000 mg/kg
Comparatively free from danger LD_{50} - 5000 + mg/kg

LD_{50} refers to the dosage level which killed 50% of the test animals when administered under controlled conditions. Normally, for comparison purposes, LD_{50} refers to a dosage administered orally to a group of 10 or more white laboratory rats. The probable lethal oral dose for man in each of the four classes of pesticides is:

Highly toxic - Pinch
Moderately Toxic - Teaspoon to 2 tablespoons
Low Order Toxicity - 1 ounce to 1 pint
Nontoxic - 1 pint to 1 quart

Foliar, Fruit and Flower Protectants

By far the greatest volume of chemicals used for plant disease control are protectants applied as sprays or dusts to leaves, flowers or fruit. Most protective fungicides are solids which are either incorporated with inert materials as dusts, or are treated with conditioning agents as wettable powders and applied in sprays. Only a few fungicides are liquids.

One of the major limiting factors in the use of dusts for disease prevention is the difficulty with which adequate protective residues are maintained under varying weather conditions. For this reason, dusts often have to be reapplied at frequent intervals due to their poor weathering properties. The active ingredient in dusts is usually lower (5-20%) than in wettable powders, thus requiring more pounds of chemical to achieve the same level of protection.

Wettable powders often require the use of spreader stickers on "hard to wet" surfaces. Waxy coatings or fuzzy coatings, such as on peaches, may be difficult to coat with fungicides unless these additives are used.

Invariably, failure to control diseases by the use of protective fungicides is a consequence of improper application rather than the inability of the chemical to prevent disease establishment. Most protective fungicides will inhibit disease-inciting fungi but will not control a disease that is already established. Unlike insect pests, fungicide applications cannot be delayed until disease symptoms are visible. They should be applied prior to infection to provide a uniform blanket of protection.

A number of useful surface protectant chemicals are available to the farmer or homeowner.

Inorganics

1. Bordeaux Mixture is a mixture of copper sulfate (bluestone) and calcium hydroxide (lime). It can be bought premixed or can be mixed at time of application. Once placed in water, the compound should be used immediately. Bordeaux is used on a variety of crops, including ornamentals and many fruits. Bordeaux is incompatible with most other pesticides and is corrosive to equipment.

2. Fixed Copper--a number of non-phytotoxic copper containing compounds are available for disease control. The term "fixed" copper is derived from the fact that they have low water solubility and thus have low phytotoxicity. Some of the more available

fixed coppers include Copper hydroxide (Kocide 101), Tribasic Copper Sulfate, and C.O.C.S. (Copper Oxychloride Sulfate). Fixed coppers are useful not only as fungicides but are moderately toxic to bacteria, as well.

3. Sulfur has been used for many years as a fungicide, as well as a miticide. It is available as a dust or as a wettable sulfur (30 to 90% active). Sulfur is nontoxic and has no time limits, but it may injure plants if applied when the temperature is above 80°F. Sulfur should not be combined with oil sprays. The wettable sulfurs are the safest on young plants.

Metal Organics

The main organic fungicide with a heavy metal as a toxic element is Du-Ter. Du-Ter or Fentin Hydroxide contains tin as a toxic element. The principal use of this compound is in pecan disease control, but it is registered on potatoes and peanuts also.

Antibiotics

Antibiotics are chemicals produced by one organism which inhibit another organism.

1. Streptomycin is produced by an organism with the same name and is used as a bactericide. It is sold under various trade names including agristrep and Agrimycin. It is currently limited to use in the plant bed on tomatoes and peppers and to certain ornamental bacterial diseases.

2. Cycloheximide or Acti-Dione is a toxic antibiotic and is often formulated with other fungicides. It has the ability

to eradicate established fungal diseases. It is used principally on turf diseases and powdery mildew of ornamental shrubs.

Carbamates

1. Ferbam is a carbamate fungicide used as a foliage protectant. It is non-phytotoxic but may leave a black residue on the crop after spraying. The basic toxic element is iron. Ferbam can be used on a variety of fruits, vegetables and ornamental crops.

2. Maneb (Manganous Ethylene Bisdithiocarbamate) is used primarily as a foliage protectant. Manganese is the basic toxic element in the compound. Maneb is used on many crops, especially vegetables. Some confusion has developed with the variety of trade names listed for this product. Dithane M-22 and Manzate are original Maneb formulations. A small amount of zinc was added to this product to give an improved range of plant protection. Maneb + Zn is sold as Dithane M-22 Special or Manzate D. Maneb and Maneb + Zn are very similar chemically and are registered for the same crop use. A third compound, Dithane M-45, Manzate 200 or Fore consists of manganese and Zinc ions in a coordination carbamate product. Crop uses are more restricted for this product. Maneb has some phytotoxic effects on tender tomato leaves and on some apple and cucurbit varieties.

3. Zineb is the zinc ion equivalent of Maneb and also has a wide use range. Zineb may be phytotoxic to certain zinc-sensitive crops such as cucurbits and tobacco.

Miscellaneous Organic Fungicides

1. Benomyl (Benlate) is a systemic fungicide that can be applied to the soil or directly on the plant. It is formulated as a 50% wettable powder and can be used as a preventive and eradicant fungicide. It also acts as a mite ovacide. It has good residual action and is usually applied at intervals of 10-21 days. Principal uses are on ornamentals, certain fruits, cucurbit vegetables and on soybeans.

2. Captafol (Difolatan) is formulated as 80% WP, 60-65% dusts and in a 4 lb/gallon flowable. Current usage is primarily on certain vegetables and fruits. May be phytotoxic to grapes, apples, and citrus.

3. Captan (Orthocide) has a wide crop and application use. Captan can be used for seed treatment, soil treatment, postharvest spray and foliage spray. Captan is not compatible with oil and does not have a long shelf life after exposure to the atmosphere.

4. Chlorothalonil is sold under several trade names, including Bravo, Daconil 2787 and Termil. It has a wide range of uses on vegetables, turf and ornamentals. Termil is a smoke generator used in the greenhouse. This product is one of the better vegetable fungicides.

5. Folpet (Phaltan) is formulated as dust, 50 and 75% wettable powders and 39% flowable suspensions. Primary use is on fruits, ornamentals and certain vegetables. Do not mix with oil sprays or use following an oil spray.

6. Dinocap (Karathane) is used primarily against powdery mildew on certain fruits, vegetables and ornamentals. Do not apply to crop within 30 days of an oil spray.

<u>Seed Treatment Fungicides</u>

Chemical seed treatments are used to protect the seed and young seedling plant from fungus attack. Many disease organisms are carried on the seed and can be controlled with these chemicals. Protective fungicides also form a zone of inhibition and repel the attacks of many soilborne fungi. A few chemicals have been found to be good seed protectants. They are usually mixed with water to form a slurry and are evenly applied to the seed as it is turned on some type of drum.

1. Thiram (Arasan) is used to treat many vegetables, corn, cotton, rice, soybeans and wheat. It helps prevent damping off, seed decay and seedling blights. Several turf diseases can be controlled using foliage applications.

2. Captan (discussed previously) can be used to treat seed of a variety of vegetables, corn, cotton, soybeans and wheat.

3. Carboxin (Vitavax) is a seed treatment chemical used on corn, cotton, oats and wheat.

4. Chloronil can be used on corn, cotton, otas, rice, sorghum and many vegetable seeds.

5. Dichlone, Dexon and Maneb are used as seed treatment chemicals on certain vegetable and agronomic crops.

Soil Treatment Fungicides

Soil treatment fungicides, like seed treatment, are designed to stop attacks by soilborne organisms. Soil fungicide treatments may be broadcast or applied in bands. Some soil fungicides are formulated as granules for easy application.

1. PCNB (Terraclor) can be used as a soil treatment preplant or at planting time to control southern blight, sclerotial blight and other seedling diseases in a number of vegetables including beans, broccoli, cabbage, cauliflower, peppers and tomatoes.

2. Captan can be used as a preplant soil treatment on beans, broccoli, cabbage, cauliflower, cantaloupe, corn, eggplants, onions, peas, peppers and tomatoes.

Soil Fumigants

Soil fumigants usually are liquid formulations that become gaseous when exposed to the atmosphere. Some are very volatile and must be sealed by plastic tarps. Others diffuse slowly and can be sealed in the soil with a drag or with water. Fumigants often kill all life in the soil including weeds, fungi and nematodes.

1. Methyl bromide (Dowfume MC-2) is one of the most widely used fumigants. It is sold in a pressurized can and must be covered and sealed by a plastic tarp on application. Methyl bromide is a highly toxic gas, but is safe if used properly. Plant beds, ornamental beds, commercial tomato fields, orchard sites and strawberry fields can be treated with methyl bromide. A 7- to 10-day waiting period is required.

2. Vapam (SMDC) is easier to use by the average homeowner and is registered on all ornamental and vegetable crops in the field. It can be applied by hose proportioner, sprinkled in front of a tiller, injected into the soil or used with a tarp. A water seal is required if a tarp is not used. A waiting period of two to three weeks is required before planting.

<u>Nematocides</u>

Nematodes are perhaps the most underestimated pest that attacks our crops. Their destruction is often overlooked, and their injury attributed to other causes. It should be recognized by everyone that all nematodes do not cause galls or knots on plant roots. A number of useful nematocides are available to combat these worms. Granular nematocides are some of our most toxic agricultural chemicals.

1. Temik can be fatal by skin contact or by breathing the dust. Temik is usually applied in the furrow or as a band treatment. Temik is registered for use on potatoes, sweet potatoes, peanuts, sugarcane and ornamental bulbs.

2. Dasnit is available in 10 and 15% granules as well as a 63% emulsifiable concentrate. It kills nematodes by contact and must therefore be mixed with the soil for maximum control. It is registered for use only by commercial applicators and nurserymen.

3. Mocap is formulated in 10 and 15% granules for use only by commercial or professional personnel. In Louisiana, it can be used on sweet corn, sweet potatoes, peanuts, soybeans and sugarcane.

4. Chloronated Hydrocarbons are the largest and oldest group of nematocides. These include methyl bromide, D-D mixture (1,2-Dichloropropane and 1,3-Dichloropropane), EDB (Ethylene Dibromide), Formaldehyde, DBCP (Dibromochloropropane), Telone (1,3-Dirchloropropane and Chloropicrin.

Most of these nematocides can be applied to the soil with chisels set 4-8" deep and sealed with some type of drag. Formaldehyde, Chloropicrin and Methyl bromide should be sealed with a tarp. Most of these chemicals require one to three weeks aeriation time. DBCP is the only nematocide that can be used directly on established plants. It is sold under various trade names including Nemagon, Fumazone, Nema-Killer and Nema-X. It is the safest material for homeowner use.

SEED TREATMENT

General Information

Seed treatment, as defined by the Federal Seed Act, means: "...given an application of a substance or subjected to a process designed to reduce, control or repel disease organisms, insects, or other pests that attack seeds or seedlings." It includes control of pests while the seed is in storage and after it has been planted.

A person treating seeds should know:

(1) The kinds of seeds to be treated

(2) Why they should be treated

(3) The correct use of seed treatment pesticides

Since there is no one seed treatment method or material that can be recommended as a universal preventive for problems that attack seeds, the different kinds and methods of seed treatment will vary according to locality. Some seed treatments may be ineffective or harmful to some crops and very beneficial to others. Some seed treatments may not be harmful to animals; however, care must be exercised when handling all seed treatment materials. Even though some seed treatment chemicals may not be actually poisonous, most of them, like house dust, can be irritating to the eyes and nose.

Maintaining seed quality prior to and after treatment is dependent upon several factors, including (1) moisture, (2) temperature, (3) humidity and (4) storage conditions.

Even if these factors are properly taken care of, all seed contain certain seedborne diseases and are subject to damage or destruction by insects or other pests. Research has indicated that treating seed with one or more pesticides is an economical and efficient way to protect seed from some of these pests.

Seed Commonly Treated

The kinds of seed that are normally treated with one or more pesticides are corn, peanuts, cotton, sorghum, wheat, oats, rye, barley, millet, soybeans, pine tree seed and most vegetable seed.

Diseases and Insect Seed Pests

Seed pests fall into three basic categories. These are: (A) Fungi and Bacteria, (B) Soil Insects, (C) Storage Insects.

(A) Fungi and Bacteria

Fungi and bacteria may attack and result in the following conditions or symptoms:

(1) Seed rot--rotting of seed before germination.

(2) Damping off and seedling blight--soft rot of stem tissue near ground level and water soaking of seedling tissues.

(3) Seedling wilt--gray discoloration starting at the leaf tips and extending rapidly to the entire leaf, causing complete collapse of the seedling.

(4) Root rot--water soaking, browning and sloughing of rootlets.

Several disease organisms may be responsible for these disease symptoms. These are *Pythium*, *Fusarium*, *Diplodia*, *Penicillium*, *Helminthosporium*, *Ustilago* and *Rhizoctonia*.

(B) Soil Insects

(C) Storage Insects

Control of Seed Pests

Although most seed protection is done with chemicals, there are some nonchemical means that may be used in certain instances. These include the development of plant and crop varieties whose seeds are resistant to pests, the use of low humidity and low temperature in storage areas to inhibit the growth of bacteria, mold and mildew and to slow the growth of insect pests, and the use of good sanitation practices (such as removing waste seed and seed particles from the storage area) to reduce food and shelter for pests.

For chemical control there are three basic types of chemical control for seed diseases and insects. These are:

(1) Seed surface disinfestation. This refers to a complete covering of the seed with a pesticide which kills spores and other disease agents on the surface of the seed.

(2) Seed protection. This refers to a pesticide that is applied to the seed to protect the seed and young seedling from disease agents or insects in the soil or in storage.

(3) Systemic Treatment. This is a treatment where the applied pesticide penetrates the seed and/or extends into the plant as it grows. A systemic treatment repels or kills certain types of fungi or insects and keeps them from causing damage.

Seed Treatment Formulations

There are two components to a seed treatment pesticide. These are the active ingredients and the inert ingredients. Active ingredient refers to the actual chemical that is effective against the target pests.

The inert ingredients are used in addition to the active ingredients to improve appearance, increase coverage and adherence, prevent dusting and provide hazard recognition. Inert ingredients have little or no effect on seed germination and do not have to be listed individually on the label.

The seed treatment formulations or materials are usually applied to seed as dust, slurries (a mixture of wettable powder in water) and liquids.

Based on composition, seed treatment fungicides may be organic or inorganic, metallic or non-metallic and, until recently, mercurial or non-mercurial. Before the cancellation of the volatile mercurials, fungicides for treating seeds were generally classified as volatile or non-volatile. With the elimination of the volatile mercurials, most fungicides now approved for use on seed are classified as non-volatile materials; complete coverage of the seed is necessary to obtain effective control.

Some of the systemics, a fairly new class of pesticides, may now be used as seed treatment materials. The systemics would move inside the seed or plant and control the pest prior to or after entry into the seed. Such a material is called a systemic.

Cotton Insects

Thrips

Seedling cotton is attacked by several species of thrips. These slender insects are about one-sixteenth of an inch long and have feathery wings. Their mouthparts are rasping-sucking and they damage the terminal buds and young leaves by rupturing the cells and sucking up the sap. This causes the distorted leaf surface and the silvery appearance of severely damaged leaves. Stunted growth results when plants are heavily infested with thrips. Both larvae and adults damage plants.

The eggs are laid in tender plant tissue and they pass through larval and pupal stages before becoming winged adults. From two to three weeks are required to complete the life cycle. They overwinter as adults on weeds. Thrips adults frequently migrate from winter small grains to cotton when the grain is harvested in the spring. They also migrate from older cotton to fields of young cotton.

Research conducted in Louisiana does not show any significant increase in cotton yields from controlling thrips. Predator insects are attracted to and increase their numbers in fields which have some thrips present.

Cotton Aphid

Aphids damage cotton by adults and nymphs sucking sap from the plants and excreting a sugary waste product called "honeydew." They usually feed on the lower surface of the leaves, but when they are present in large numbers they can be found all over the plants. A typical symptom of their damage is the downward cupping of the leaves on which they feed. Another sign of their presence is the "honeydew" on the upper surface of the leaves.

Aphids are soft-bodied, about one-eights of an inch long and range in color from green to light yellow. The adults are usually without wings in Louisiana and they usually give birth to living young without mating. They mature and start reproducing in 7 to 10 days, depending on the temperature. Aphids are called plant lice by some growers.

Low populations of aphids on cotton provide an excellent food source to attract predator insects. After the predators are in the field they will reproduce and increase in numbers as long as this food source remains. This predator insect population is of tremendous value in keeping bollworm and tobacco budworm populations under control.

<u>Spidermites</u>

Several species of red spidermites and the green, two-spotted spidermite are known to attack and damage seedling cotton. They feed on the lower surface of the leaves and remove the green chlorophyl from the leaves. The damage appears as yellow spots on the upper leaf surface. Severe infestations will completely defoliate the plants. Premature plant defoliation will reduce cotton yields. Spidermite infestations are more severe in hot, dry weather.

Adult spidermites are about one-sixteenth of an inch long and are almost round in shape. They have four pairs of legs like their relatives, the spiders. Their color is green or reddish, depending on which species it is. They spin a fine web on the lower leaf surface and their eggs are on the lower leaf surface, too. The eggs hatch into small nymphs that mature into adults in about one week. The adults have no wings but are spread over the field on equipment or on man and animals that walk through the field. Infestations start on field margins and are spread over the field from there.

Insecticides Used on Cotton Seed

Three organo-phosphorous type insecticides are used to some extent as a seed treatment for cotton seed. They are Di-Syston, Phorate and Azodrin. These insecticides are systemic and are absorbed through the plant roots and translocated through the plant sap into the foliage. They control thrips, aphids and spidermites for three to four weeks. The plants have usually grown to the 4- to 6-leaf stage by that time.

These insecticides should be applied only to cotton seed of high quality that have the seed coats intact. Cracked seed are damaged by these insecticides. Treatment might cause phytotoxicity under some conditions to the extent that stands are damaged and early growth retarded. Phytotoxicity might be greater where certain pre-emergence herbicides are used or where certain fungicide combinations are used as planter-box treatments.

Dosage rates of these insecticides per 100 pounds of seed should not be greater than one-half pound technical Di-Syston, 1.45 pounds technical Phorate or 1.25 pounds technical Azodrin. This should be applied to the seed only by custom operators who are equipped to treat the seed uniformly and adequately without hazard to the operator. These insecticides are highly toxic to man and animals and should be handled with extreme care.

Cotton seed treated with these insecticides should not be carried over for planting the next growing season. The germination of the seed might be reduced by the insecticide treatment. The degree of insect control received is likely to be reduced also.

Seed which has had an insecticide applied on it is often called "triple-treated" seed. The seed is normally treated with two different fungicides and the insecticide is the third chemical treatment on the seed.

Insecticide treated cotton seed must be properly labeled to indicate it is treated. This label must include such information as the chemical with which it is treated, a statement that the seed is not for human or animal consumption and that the seed is not to be processed for feed or oil, insects controlled by the treatment, planting directions, appropriate warnings and precautions, including the precautions for handling, the hazard posed to wildlife and the environment and the antidote.

Grain Insects

There are several insects which attack seed and stored grain. The rice weevil, Sitophilus oryzae, and the lesser grain borer, Rhizopertha dominica, are the primary beetles in Louisiana which will bore into the whole kernel of the grain. Other beetles that are pests of stored seed in Louisiana are the confused flour beetle, Tribolium confusum; the saw-toothed grain beetle, Oryzaephilus surinamensis; the cigarette beetle, Lasioderma serricorne; the red flour beetle, Tribolium castaneum; the flat grain beetle, Laemophloeus fusillas; and several others. This group of beetles is often referred to as bran beetles. They do not normally feed on the whole grain kernel, but feed on small broken grain particles.

There are also three species of moth larvae that attack grain and other seed. They are the Indian meal moth, Plodia interpunctella; the angoumois grain moth, Sitotroga cerealella; and the Mediterranean flour moth, Ephestia Kuetiniella. All three of these can be serious pests in stored grain, attacking the whole kernel as well as grain particles.

Figure 1. RICE WEEVIL:
This weevil is found in all grains and is the most common and most destructive of stored grain insects. It is a small-snout beetle that often infests grain in the field before harvest. The larva burrows into the heart of the kernel where it feeds and passes through the pupa stage. It emerges as an adult, cutting a small hole through the kernel ("weevil exit hole").

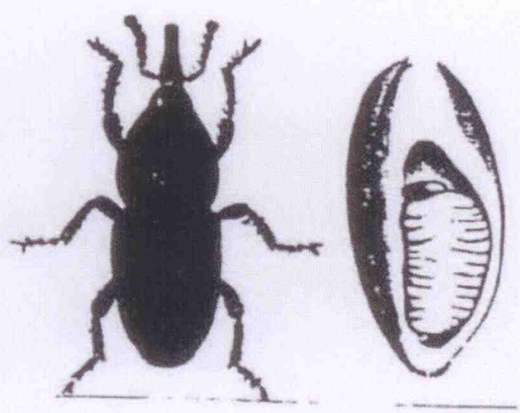


Figure 2. LESSER GRAIN BORER: This is a small beetle, dark brown to black, with its head turned down under the front part of its body. It is a strong flier and can live under much drier conditions than most of the other stored grain insects. It also attacks the whole kernel similar to the rice weevil.

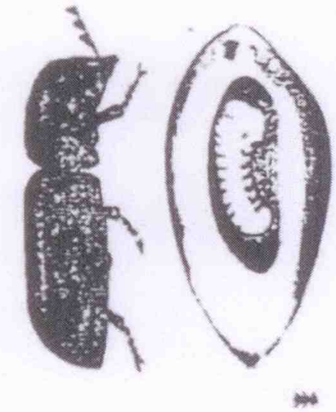


Figure 3. SAW-TOOTHED GRAIN BEETLE: This is a reddish-brown to black insect which has six saw-toothed projections on each side of the front part of the body, visible under microscope. This beetle is one of the bran beetles.

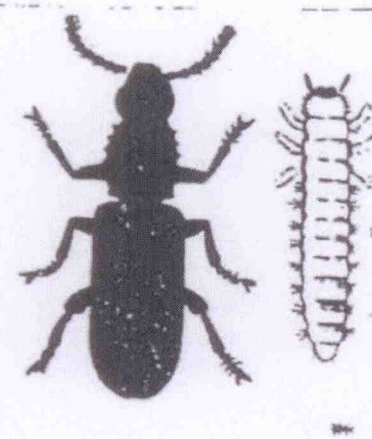


Figure 4. CONFUSED FLOUR BEETLE: The confused flour beetle, saw-toothed grain beetle and flat beetle are commonly referred to as "bran beetles." The confused flour beetle is reddish-brown and is one of the most common storage insects both in elevators and mills.

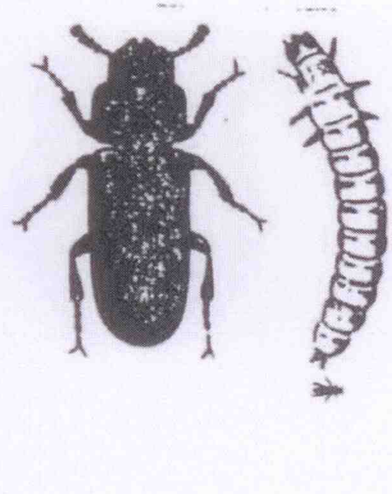


Figure 5. FLAT GRAIN BEETLE:
This is one of the smallest stored grain beetles. It is flattened, oblong, and reddish brown with antennae about 2/3 as long as the body.

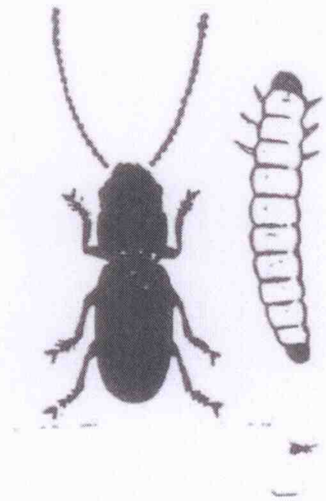


Figure 6. INDIAN MEAL MOTH
This moth has wings that are reddish-brown coppery luster on the outer two-thirds with the rest light gray. The larvae may completely web over the surface of the infected grain. Common in all stored grain and in packaged feed and meal, in stored grain this insect is usually found within the top two feed of the grain.

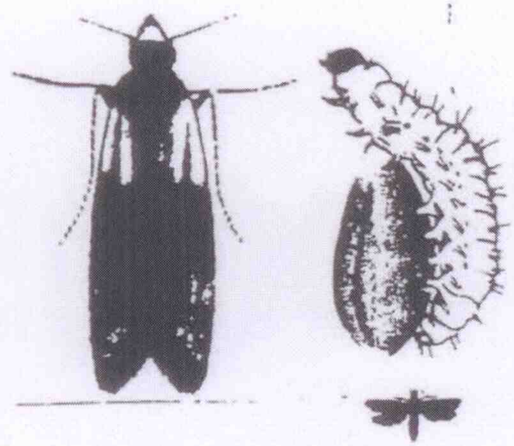
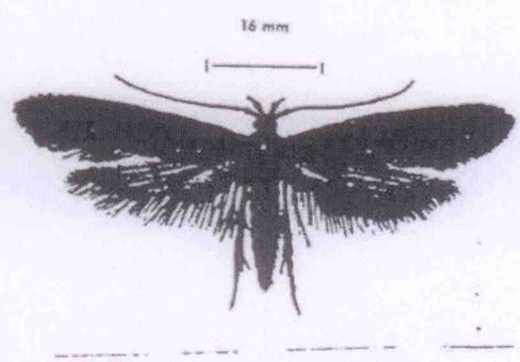


Figure 7. ANGOUMOIS GRAIN MOTH
The adult is a dull gray. The larvae bore into the kernel, pass through the pupa stage, and emerge through a small round hole cut in the outer layer of the kernel. This moth breeds on the surface of the grain.



Seed Treating Equipment

Commercial seed treaters are designed to apply accurately measured quantities of pesticides to a given weight of seed. Basically, there are three types of commercial seed treaters on the market: (1) Dust Treater, (2) Slurry Treater, and (3) Direct Treater. The Panogen and Mist-O-Matic treaters are examples of the direct treaters.

Operation

Controlling the Flow of Seed:

The amount of seed which flows into the weigh pan (which is just beneath the feed hopper on top of the treater) is controlled by opening or closing the gates of the feed hopper by means of the hand wheel on the side of the hopper. The scale on the hopper shows how far gates are open in inches. Gates should be open to whatever number of inches it takes to keep the weigh pan filled to the required number of pounds per dump as it tilts in either direction. The number of pounds per dump is adjusted by correctly setting the counterweight up or down on the counterweight arm.

Powder Application:

To ascertain that the correct amount of powder is being applied to the seed flow, a preliminary test must be made in which a given number of pounds of seed (such as 100 pounds) is run through the feeder. During this run the measuring cup provided with the feeder should be used to catch the powder as it comes off the vibrator. After the given amount of seed has run through, the powder should be weighed to determine how much is being applied to that amount of seed. The vibrator speed can then be adjusted accordingly. Then another or more tests should be run until proper setting of the vibrator speed is determined for correct coverage.

	Approximate Setting		
No. Dumps	Powder Scale Opening	Syntron Setting	Oz. Produced/ 100 lbs.
25	1/2	60	2
25	3/4	60	5
25	3/4	70	6
25	3/4	80	7
25	1	60	10

Number 4 on counterweight arm gives five pounds per dump.

Slurry Seed Treater:

The slurry treatment principle involves suspension of wettable powder treatment material in water. The treatment material applied as a slurry is accurately metered through a simple mechanism composed of a slurry cup and seed dump pan. The cup introduces a given amount of slurry with each dump of seed into a mixing chamber where they are blended.

While operation of slurry treater is relatively simple, the various operation procedures must be thoroughly understood.

1. The metering principle is the same in direct, ready-mix or fully automatic treaters, i.e., the introduction of a fixed amount of slurry to a given weight of seed.
2. To obtain a given dump weight, slurry treaters are equipped with a seed gate that controls seed flow to the dump pan.

With the proper seed gate setting a constant dump weight for a given seed can be obtained.

3. The amount of treatment material applied is adjusted by the slurry concentration and the size of the slurry cup or bucket. As the dump pan fills, a point is reached where it over-balances the counterweight and dumps into the mixing chamber. This brings the alternate weighing pan in position to receive the inflow of seed and activates a mechanism to add a cup of slurry to the mixing chamber. Thus one cup of slurry is added with each dump of seed.

4. The mixing chamber is fitted with an auger type agitator that mixes and moves seed to the bagging end of the chamber. The speed of the auger is important because at slow speeds more uniform distribution is obtained.

Slurry tanks have 15- to 35-gallon capacities depending upon the size of the treater. They are equipped with agitators that mix the slurry in the tank and keep it suspended during operation. It is important that the powder be thoroughly suspended in water before treating. If the treater has been idle for any period of time, sediment in the bottom of the slurry cups must be cleaned out.

The proper size slurry cup must be used. Most machines now have cups with ports and rubber plugs for 15 cc., 23 cc. and 46 cc. quantities. Some users prefer to mix the slurry in an auxiliary tank and then transfer to the slurry chamber as needed.

Direct Treaters:

Direct treaters are the most recent development and include the Panogen and Mist-O-Matic treaters. These two were initially designed to apply undiluted liquid treatment. Instead of applying 23 cc of material per 10 pounds of wheat, as in slurry treaters, they apply 14 to 21 cc (1/2 to 3/4 ounces) per bushel of wheat. This small quantity of material is suitable only with liquid materials which are somewhat volatile and do not require complete, uniform coverage for effective action.

Panogen Seed Treater:

The operation of the Panogen treater is relatively simple. A small treatment cup, operating from a rocker arm directly off the seed dump pan and out of a small reservoir, meters out one cup of treatment with each dump of the seed pan. Fungicide flows through a tube to the head of the revolving drum seed mixing chamber. It flows in with seed from the dumping pan and is distributed over the seed by the rubbing action of the seed passing through the revolving drum.

The desired treating rate is obtained by the size of the treatment cup and adjusting the seed dump weight. Treatment cup sizes are designated by treating rate in ounces and not by actual size, e.g., the 3/4 ounce cup applies 3/4 ounce (22.5 cc) of treatment per bushel with six dumps per bushel. Actual size of this cup is approximately 3.75 cc.

Later modifications for treaters include dual tanks that permit simultaneous addition of a fungicide and an insecticide, and adaptations for the application of slurries. The metering device in both treaters is similar to that of the slurry treater, since it is attained through synchronization of a treatment cup and seed dump. Otherwise, they differ decidedly from the slurry treater and from each other. Both of these direct treaters have an adjustable dump pan counterweight to adjust the weight of the seed dump. This is not practical with slurry treaters.

Mist-O-Matic Seed Treater:

The "Mist-O-Matic" treater applies treatment as a mist directly to the seed. The metering operation of the treatment cups and seed dump is similar to that of the Panogen treater. Cup sizes are designated by the number of cc's they actually deliver; e.g., 2 1/2, 5, 10, 15, 20, and 40. The treater is equipped with a large treatment tank, a pump and a return that maintains the level in the small reservoir from which the treatment cups are fed. After metering, the treatment material flows to a rapidly revolving fluted disc mounted under a seed spreading cone. The disc breaks drops of the treatment into a fine mist and sprays it outward to coat seed falling over the cone through the treating chamber. Just below the seed dump are two adjustable retarders designed to give a continuous flow of seed over the cone between seed dumps. This is important since there is a continuous misting of material from the revolving disc. The desired treating rate is obtained through selection of treatment cup size and proper adjustment of the seed dump weight.

Calibrating a Slurry or Liquid Seed Treater for the Correct Dosage

1. Determine how much liquid your treater's metering cup or bucket will dump into the seed each time the weighted seed pan trips. Record for future use.

2. Run seed slowly into the treater until the weighted seed pan dumps seed into the treater. Shut off the feed to the treater immediately. Weigh the amount of seed dumped into the treater. Record the setting of the weight on the weight balance arm and the weight of the grain dumped for future use.

3. Determine the number of dumps per bushel by dividing the weight per dump into the bushel weight of your seed. For example, a treater dumps 6 pounds of wheat each time the seed pan trips. Dividing 60 pounds per bushel by 6 gives 10 dumps per bushel.

4. Determine how much of the liquid or slurry you are applying per bushel of seed. To do this multiply (1 above) the amount of chemical your metering cup dumps into the seed by (3 above) the number of dumps per bushel. Since most metering cup capacities are measured in cc's, while the chemical recommendations are in ounces per bushel, divide the result by 29.57 to give the liquid ounces per bushel applied.

   $$\frac{\text{Metering cup capacity in cc}}{29.57\text{ cc}} \times \text{Number of dumps per bushel} =$$

   Ounces of liquid applied per bushel.

   FOR EXAMPLE:

   $$\frac{46\text{ cc} \times 10\text{ dumps}}{29.57} = \frac{460}{29.57} = 15.6\text{ oz. liquid per bushel.}$$

5. To determine the correct amount of powdered chemical to add to one gallon of water for a slurry mixture, divide 128 by the number of ounces of liquid applied per bushel and multiply the result by the ounces of the chemical you want to apply to one bushel.

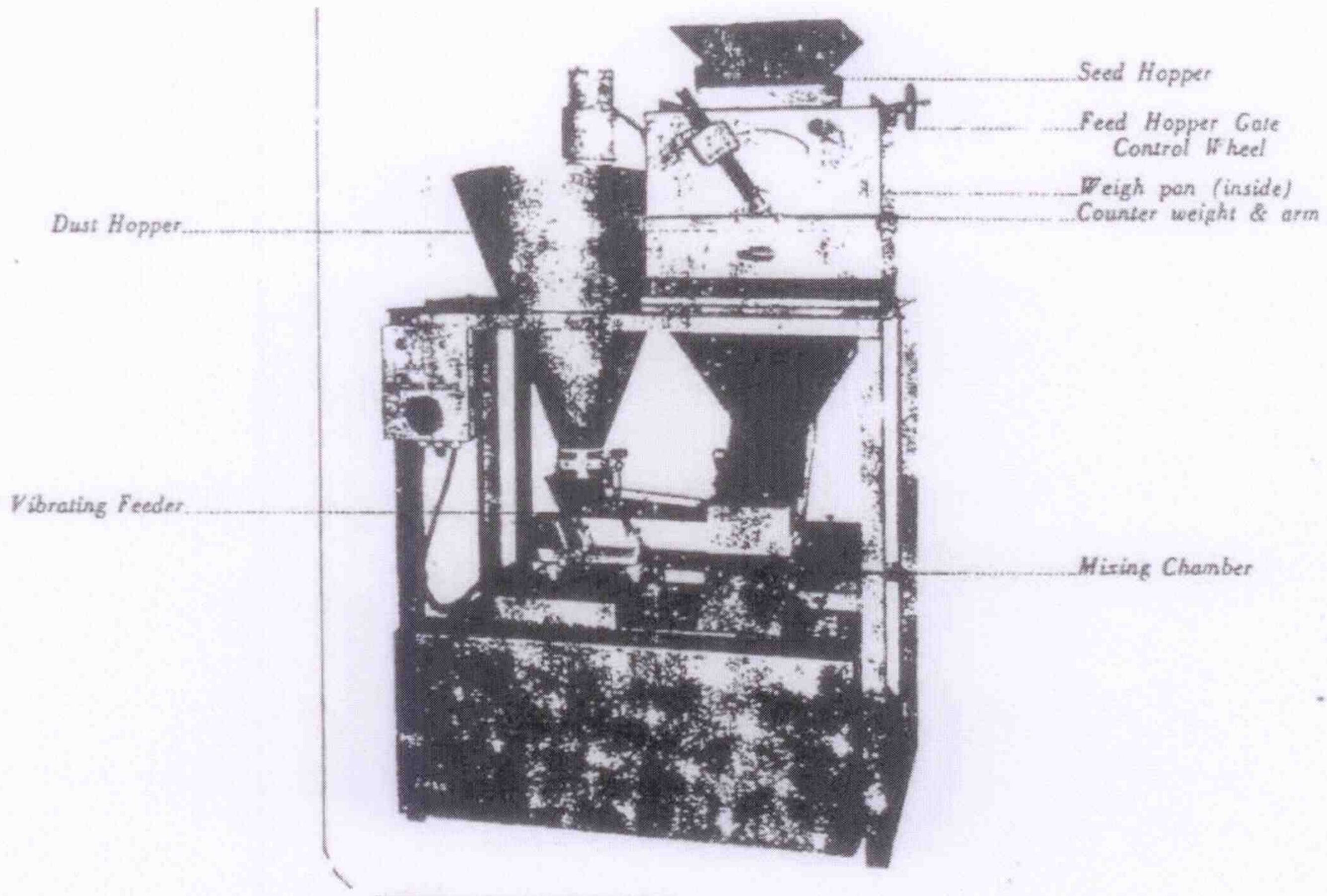
$$\frac{\text{128 ounces per gallon}}{\text{Oz. liquid applied/bu.}} \times \text{Oz. powdered chemical desired/bushel} =$$

Ounces of slurry to add to one gallon of water.

FOR EXAMPLE:

$$\frac{128}{15.6} \times 1.5 = 12.3$$ ounces powdered chemical to add to one gallon of water.

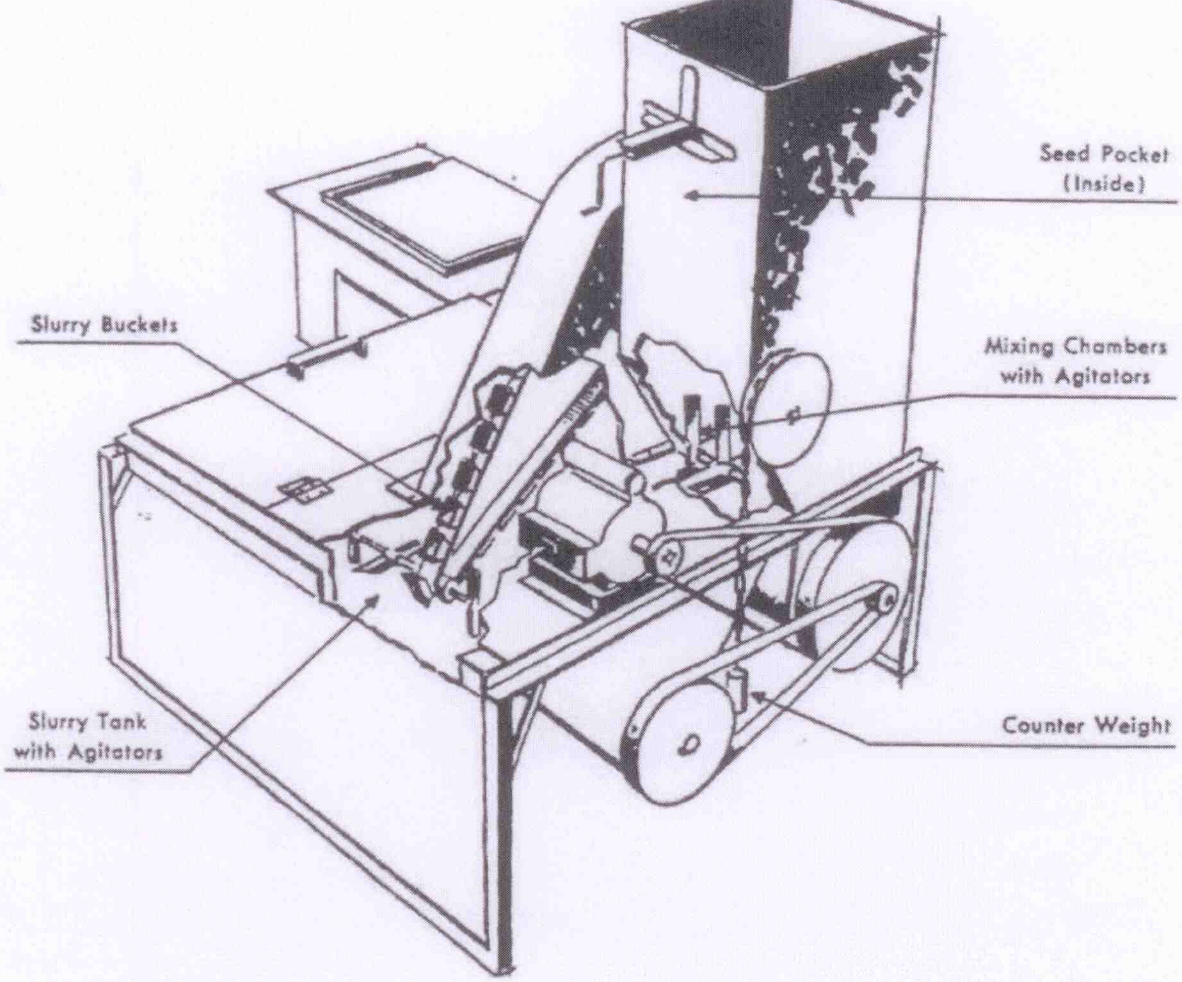
NOTE: For additional information see the Calibration instruction manual furnished with each machine by the manufacturer.



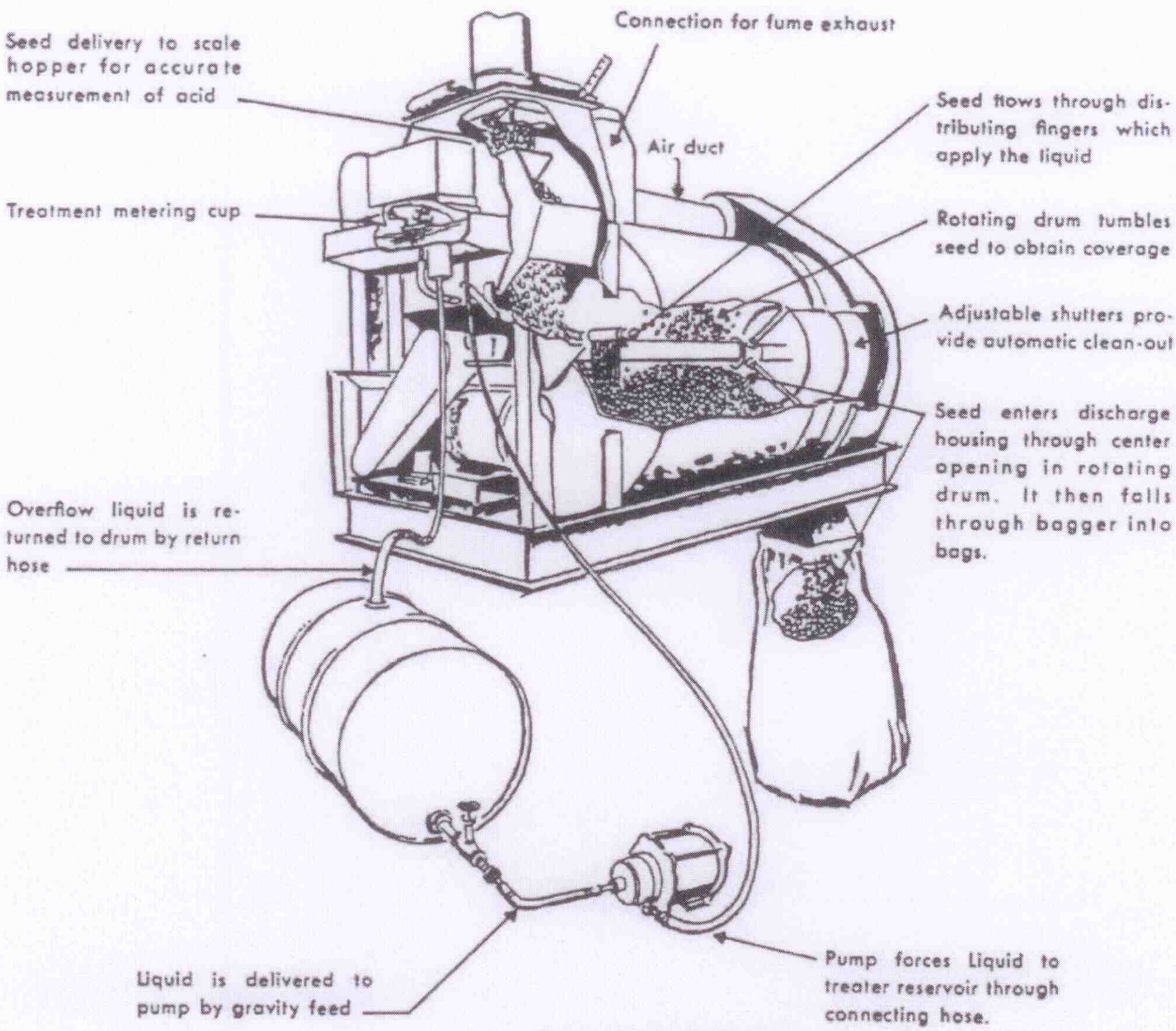
Dust Treater

Dust Treater

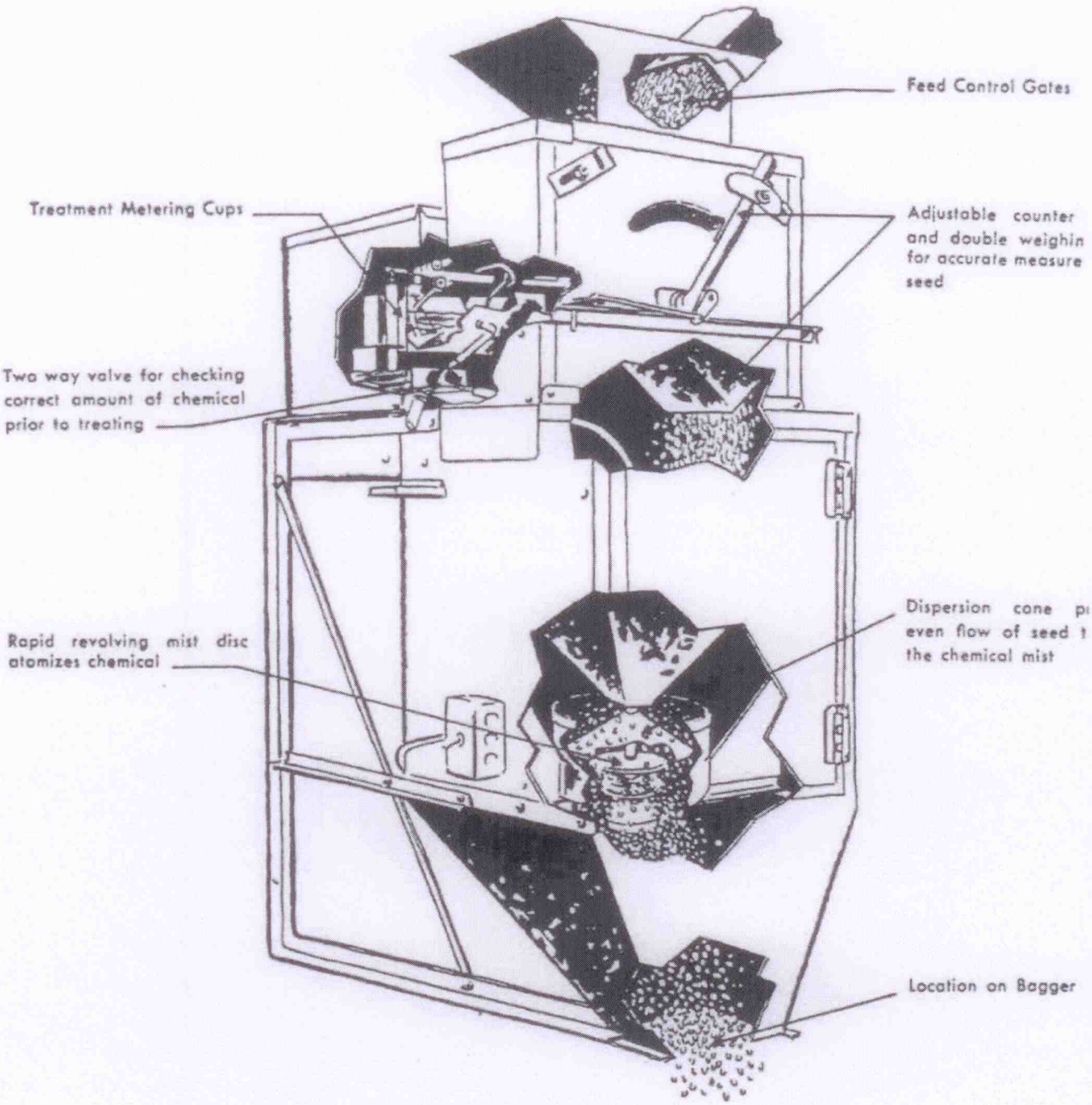
(Using Gustafson XL Dry Powder Seed Treater as an example):



Slurry Seed Treater



Panogen Seed Treater



Mist-O-Matic Seed Treater

Safety Precautions

Hazards Associated with Handling, Sorting, Mixing and Storage of Treated Seed

1. Read the label and follow instructions carefully as over-treatment may injure the seed and under-treatment will not control the pest.
2. When handling mercurials or similarly toxic substances, the operating personnel must be provided with protective clothing such as coveralls, cap, protective glasses, rubber apron, rubber boots, rubber gloves, and respirator designed for use with the material. Personnel should not inhale the dust or vapor nor permit the material to contact the skin or eyes. Operator should wash thoroughly with soap and water before eating and smoking. Bathe immediately after work and change all clothing. Wash clothing thoroughly with soap and water before reuse. In case of contact, immediately remove contaminated clothing and wash skin thoroughly with soap and water.
3. A safety shower should be installed in the immediate vicinity of the treater.
4. An exhaust system should be installed to remove vapors and dust from the operating area. The exhaust air should discharge into a cyclone or bag-type dust collecter. The treater should also be vented and tied into the exhaust system.

to p..

5. Do not reuse pesticide containers. Destroy them by mutilating and burying at least 18 inches deep in an isolated area away from water supplies. NOTE: On 55 gallon drums follow manufacturers' recommendations for decontamination and container disposal.

6. Empty treated seed containers and low germinating seed should be destroyed by burying at least 18 inches deep in an isolated area away from the water supplies. NOTE: Treated seed exposed on soil surface will be hazardous to birds and wildlife.

Coloring Grain Seed Treated with Poisonous Substances

All interstate shipments of the food seeds, such as wheat, corn, oats, barley and sorghum, bearing a poisonous treatment in excess of a recognized tolerance or treatment for which no tolerance or exemption from tolerance is recognized, must be denatured by a suitable color to prevent their use as food, feed or oil.

Many of the pesticides now come from the manufacturer with the dye or color added as a convenience to the operator; however, some seed processors prefer to mix the dye with the pesticide at the plant so that the desired color may be obtained. Most all treated seed are now colored, with the dye causing no apparent injury to seed germination or danger to personnel processing or using the seed.

Pesticide Carriers, Binders and Stickers

These materials are listed on the label as inert ingredients. There is no requirement that the name of these materials be given.

Requirements Under the Federal and State Seed Laws For Labeling of Treated Seed

Information required to be shown on the label is as follows:

1. A word or statement in type no smaller than 8 points indicating that the seed has been treated.
2. The commonly accepted, coined, chemical or abbreviated chemical (generic) name of the applied substance and rate of application.
3. A "caution" statement if the substance used in treatment in the amount remaining with the seed is harmful to humans or other vertebrate animals.
4. Any agricultural seeds that have been treated with any chemical designed to control or repel seed-borne diseases or insect pests must bear a label on each container showing the name of the chemical or seed treatment used and rate of application per bushel or per 100 pounds. If the chemical used is of a poisonous nature the words "POISON TREATED" shall be plainly shown on the label in red color and in not less than 8 point type. On burlap or cloth bags, if the chemical used is of a poisonous nature, the word "POISON" shall be printed or stamped in red ink in letters at least one inch high on the burlap or cloth bags.
5. Seed treated with less toxic substances, if the amount remaining with the seed is harmful to humans or other vertebrate animals, shall be labeled to show a caution statement in type no smaller than 8 points, such as "Do Not Use for Food, Feed or Oil."