STORE PRODUCE PROTECTION
(CRP 311)

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MODULE 1 THE MEANING, SIGNIFICANCE OF STORING AGRICULTURAL PRODUCE

UNIT 1 DEFINITION OF STORED PRODUCE AND SIGNIFICANCE OF STORING AGRICULTURAL PRODUCE

CONTENTS

1.0 INTRODUCTION

Agriculture is the act of cultivating crops and rising of livestock with a view to providing food for man and his livestock, provision of raw materials for industries and marketing of agricultural produce. Agriculture has always been a very important activity in the Nigerian economy, providing gainful employment and livelihood for about 70% of the populace. Major aspect agriculture is crop production which is largely practiced by peasant farmers and recently by a few semi large-scale farmers. A major challenge in the Nigerian crop production aspect of agriculture is that production is left mostly in the hands of small-scale farmers who use crude implements, small fragmented land holdings, low-yielding crop varieties, poor cultural practices and limited access to credit that all conspire to make output and productivity low. This hardly can meet the local consumption needs, production of raw materials for local industries and for export.

There are a lot of biotic factors that affect crop production, contributing to low productivity. These include insect pests and diseases that attack the crops in the field and in storage after they have been harvested. In spite of this low productivity, there is low level of storage technologies and facilities leading to postharvest loss of not less than 30% of annual food production in Nigeria. It is estimated that of the 10 million tonnes of food grains produced in Nigeria annually, about 1.5-2 million tonnes are lost due to poor storage. Apart from losses in weight and quantity, there are also losses in product quality. Thus, the problem of sustainable food production is not exclusively that of low productivity, but equally that of lack of storage and processing facilities.

The overall goal of storage is food security for the nation which is about self-sufficiency, self- reliance, availability and affordability of safe good quality food in adequate quantity all year round for daily consumption and reserve for emergency/disaster relief.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Define stored produce
- Differentiate between produce and products
- Give examples of produce and products
- State the significance of storing agricultural produce

3.0 MAIN CONTENT

3.1 Definition and Difference between produce and products

Stored produce is the harvested crop from the field which the farmer brings home and store without processing it into any form while stored product(s) is when the harvested produce has been processed into any finished product. Examples of stored produce are maize grains, sorghum, millet, cowpea, yams, cassava, groundnut, etc. Examples of stored products are biscuits, maize flour, yam flour, cassava flour, bread, beer, malt, etc.

3.2 Significance of Storing Agricultural Produce

The preservation and protection of excess agricultural commodities is an age-long practice. The overall goal of storage is food security which is a deliberate policy to guarantee the population of a country freedom from hunger and malnutrition. It is also to make food available and at affordable prices to all levels of mankind. Agricultural commodities are preserved in storage for the following reasons:

1. Price stabilization: Agricultural commodities are usually available in surplus during the harvest. This forces prices down but become scarce as time progresses with concomitant price increase. In order to regulate prices, agricultural commodities are stored so that they are affordable by the majority of people and at the same time to ensure that farmers receive rewarding financial returns for their effort and investment in farming.

2. National and domestic food security: It is not always possible for families or countries to consume all the agricultural produce of a particular season. Thus, steps must be taken to preserve the excess in a safe place for the future. By this, farming families and citizens of a country are assured of regular food supply throughout the year.
3. Provision of industrial raw materials and international trade: agricultural commodities serve as the raw materials for agro-based industries. They also serve as merchandize for international trade. The continuous availability of these raw materials and merchandize throughout the year guarantees the survival of these industries and trade. The Nigerian breweries now depend on the all-year-round availability of different sorghum grains for the production of alcoholic and non-alcoholic beverages. Commodities like palm kernels, cocoa and coffee beans, kolanut, maize, etc. are very important in international trade. The importers expect that these commodities should be made available in good condition on demand at any time of the year.
4. Provision for country's strategic stock or Reserve: The strategic stock/reserve of any country is of great importance to the survival of its citizens. The strategic reserve is a stock of food grains, and may be other agricultural commodities, which serve as an insurance against famine which may arise as a result of natural disasters, bad harvests due to pest infestation or unusually bad weather, leading to drought/flood, war or localized communal clashes accompanied by large-scale destructions. When any of these calamities happens, grains or other commodities are released systematically to meet urgent food needs. The strategic stock/reserve is often replenished regularly as the quantity of commodities diminishes.
5. Enhancement of a nation's international status: It is very common for nations to assist neighbouring nations in our global village facing natural and man-made disasters that threaten the citizens' access to adequate food supplies. Many developed countries capitalize on these occasions to enhance their importance and to earn goodwill of the affected countries. Ethiopia and Eritrea, because of their geographical location, are especially prone to drought and this has caused untold suffering at various times in their history. Thus, they have been frequent beneficiaries of food donations in recent times.
6. Provision of seed: Farmers have always been selecting seeds from the previous year's harvest which are carefully preserved and stored for use as seeds the following season.

4.0 CONCLUSION

In this unit, we have defined stored produce and have been able to differentiate between stored produce and stored products. We also saw why we store our farm produce. It can be concluded that we store our farm produce to ensure price stabilization, food security, provision of industrial raw materials, provision of the country's strategic reserve, enhancement of a country's international status and the provision of seed.

5.0 SUMMARY

In this unit we have learned that:

- The low productivity of agricultural crops is largely due to attack by insect pests and diseases both in the field and in storage.
- There are inadequate storage facilities for preserving the excess harvest
- Stored produce are the unprocessed harvested crops from the field
- Reason for storing agricultural produce include: price stabilization, food security, provision of industrial raw materials, provision of the country's strategic reserve, enhancement of a country's international status and the provision of seed.

6.0 TUTOR-MARKED ASSIGNMENT

1. Differentiate between stored produce and stored products.
2. Mention five (5) reasons why we need to store agricultural produce.

7.0 REFERENCES/FURTHER READING

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UNIT 2 ORGANISMS INIMICAL TO STORED PRODUCE

CONTENTS

1.0 INTRODUCTION

The harvested produce is the result of the Farmers' efforts of maintaining the crop in the field. Thus, need to be stored for some time before consumption for so many reasons we saw in Unit 1. During storage, harvested produce are usually attacked and damaged by organisms such as microorganisms, mites, insects, rodents and birds. Damage done to stored produce by pest organisms is important because it occurs after the crop has been harvested without any possibility for compensation.

Postharvest pest problems are greater in Tropical storage environment than the temperate climates because of optimal conditions of temperature and relative humidity for the development of pests found in the tropical climates. Many aspects of pest development and behavior are influenced by physical conditions of the environment. Temperature, for instance, has an important effect on insect development. At low temperatures, development of insects is very slow, mortality is relatively high and activity of individual insects is also slow. Consequently, the rate of population growth is low. As temperature increases, the rate of development of insects and their biological activity increase, mortality falls and eventually the rate of population growth becomes very high. All insect species have optimum a temperature (25-300C) at which population growth is at maximum possible. As the temperature increases above the optimum, rate of development and activity of individual insects increase, but mortality rises and the rate of population falls.

The effect of temperature on the biological activity of storage pests depends very much on the ambient humidity, which varies considerably according to region and time of year. Under low relative humidity, the rate of population growth for most storage pests is slowed down. Thus, high temperatures and low relative humidity can be exploited for the control of storage pests. In this unit, we will examine the various organisms that cause damage on stored produce.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Know the biotic and abiotic factors affecting stored produce
- Know the important insects and microorganisms that affect stored produce
- Know the effect of pests on the quality of stored produce

3.0 MAIN CONTENT

3.1 Organisms inimical to stored produce

Pest organisms which attack commodities in storage include microorganisms or microflora such as bacteria and fungi; mites, insects, rodents and birds. The fungi are probably second to the insects as agents of deterioration and loss in all kinds of stored products throughout the world. Fungi, especially moulds are the major factor restricting the storability of intermediate moisture grains. The fungi associated with stored foods and agricultural commodities include *Aspergillus* species, *Curvularia* species, *Fusarium* species, *Penicillium* species, *Verticillium* species, *Alternaria* species, *Cladosporium* species, etc.

3.2 Fungi and Bacteria

Fungi growing on or in stored grains cause a variety of losses. These include decrease in germinability; discolouration of parts (usually the germ or embryo) or all the seed; heating and mustiness; various biochemical changes such as in fatty acids, reducing sugar and respiration; production of mycotoxins which if consumed may be harmful to man and animals; and loss in weight. The fungi decrease the quality of the products for through discolouration or change in taste (bad flavor or smell) and also decrease the nutritive value. The fungi invade the embryo and have effect on germinability leading to rapid death of the germ.

Damage to stored produce by microflora includes:

i. ‘Damp grain heating’ which causes caking and fermentation or rotting
ii. A reduction in the food value as a result of degradation of the glucids (carbohydrates) and protids (proteins and lipids)
iii. A musty smell
iv. Damage to germ, jeopardizing germinability

v. Development of mycotoxin or p[oisons e.g. aflatoxin in groundnuts, due to fungal metabolism

vi. Encouragement of mite infestation which are fungivorous.

3.3 Insects and other vertebrate pests of stored produce

Storage insect pests are classified on the basis of their feeding into primary, secondary, fungus feeders and scavengers. The primary pests are able to penetrate the intact outer coats of grains, seeds and other undamaged produce. They include the Cowpea bruchid *Callosobruchus maculatus*, *Ephestia* spp., *Trogoderma* spp., *Rhizopertha dominica*, *Prostephanus truncatus*, *Sitophilus* spp., *Dermestes* spp., Kola beetle, etc. Secondary pests are only able to feed on grains already damaged by primary pests or physically damaged during harvest such as beetles like *Cryptolestes* spp., *Tribolium* spp., and *Oryzaephilus* spp. Some pests are more specific in the kind of host they attack. Members of the Bruchidae (*Callosobruchus* spp) attack only legumes seeds, *Sitophilus* spp. attack only cereal grains, while *Dermestes* spp. are only confined to animal and dried proteinaceous commodities.

The major storage pests in the tropics are beetles in the order Coleoptera belonging to so many families; a few moths in the order Lepidoptera in the family Pyralidae, a few mites, rats and mice, and birds which feed on the produce during drying. The produce is usually cereal grains of many types and flour made from them, dried pulses (usually shelled), nuts, oilseeds and other seeds and cakes, some dried fruits and berries, dried leaves, dried roots and tubers, animal feeds and feed ingredients, etc. Postharvest pest problems may begin once the crop has attained physiological maturity and is undergoing natural dehydration in the field e.g *Sitophilus zeamais.*

Losses and damage to stored produce by insects and mites may be manifested directly through consumption of the commodity (e.g. consumption of the endosperm in cereal grains or cotyledon in pulse seeds), death of the embryo of seeds or grains, and contamination with live insects, insect fragments, exuviae, excreta and chemical secretions. Indirect damage ranges from dry grain heating to moisture migration, to sprouting. Dry grain heating is caused by insects respiring within the grain mass. It may be localized as ‘hot spots’ or general, where temperature gradient and convection currents are established.

Rodents directly consume food commodities stored by man. A single average-sized rat may consume at least 500g of grain per month. Rodents may be more economically important in bulk grain largely because of the contamination of the commodity with their carcasses, hair, faeces and urine. Rodents may cause very serious damage storage structures. Birds also damage stored produce especially cereals by direct consumption. Their economic importance perhaps largely related to contamination of the grain with their droppings, feathers or various materials carried by them when building their nests. Additionally, their nests and faeces may provide harbourage and breeding sites for insects and mites.

4.0 CONCLUSION

In this unit, we have studied pest organisms which attack commodities in storage including microorganisms or microflora such as bacteria and fungi; mites, insects, rodents and birds. The fungi associated with stored foods and agricultural commodities include *Aspergillus* species, *Curvularia* species, *Fusarium* species, *Penicillium* species, *Verticillium* species, *Alternaria* species, *Cladosporium* species, etc. Fungi growing on or in stored grains cause a decrease in germinability; discolouration of parts (usually the germ or embryo) or all the seed; heating and mustiness; various biochemical changes such as in fatty acids, reducing sugar and respiration; production of mycotoxins which if consumed may be harmful to man and animals; and loss in weight. Storage insect pests are classified on the basis of their feeding into primary pests which are able to penetrate the intact outer coats of grains, seeds and other undamaged produce. They include the Cowpea bruchid *Callosobruchus maculatus, Ephestia* spp., *Trogoderma* spp., *Rhizopertha dominica, Prostephanus truncatus*, *Sitophilus* spp., *Dermestes* spp., Kola beetle, etc. The secondary pests are only able to feed on grains already damaged by primary pests or physically damaged during harvest such as beetles like *Cryptolestes* spp., *Tribolium* spp., and *Oryzaephilus* spp. Some pests are more specific in the kind of host they attack. Members of the Bruchidae (*Callosobruchus* spp) attack only legumes seeds, *Sitophilus* spp. attack only cereal grains, while *Dermestes* spp. are only confined to animal and dried proteinaceous commodities.

5.0 SUMMARY

In this unit we have learned that:

Damage to stored produce by microflora includes:

1. ‘Damp grain heating’ which causes caking and fermentation or rotting
2. A reduction in the food value as a result of degradation of the glucids (carbohydrates) and protids (proteins and lipids)
3. A musty smell
4. Damage to germ, jeopardizing germinability
5. Development of mycotoxin or p[oisons e.g. aflatoxin in groundnuts, due to fungal metabolism
6. Encouragement of mite infestation which are fungivorous.
7. Losses and damage to stored produce by insects and mites may be manifested directly through consumption of the commodity (e.g. consumption of the endosperm in cereal grains or cotyledon in pulse seeds), death of the embryo of seeds or grains, and contamination with live insects,

insect fragments, exuviae, excreta and chemical secretions. Indirect damage ranges from dry grain heating to moisture migration, to sprouting.

6.0 TUTOR-MARKED ASSIGNMENT

1. Differentiate between stored produce and stored products.
2. Mention five (5) reasons why we need to store agricultural produce.

7.0 REFERENCES/FURTHER READING

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UNIT 3 STORAGE METHODS/STRUCTURES FOR STORED PRODUCE

CONTENTS

1.0 INTRODUCTION

Storage is the act of preserving in a safe place, any commodity for future use. Agricultural produce are preserved over a certain period of time to serve as a continuous source of food materials, seed, merchandize or as a strategic stock. The length of storage period is determined by economic, social and structural features of the particular postharvest system. Storage is the most important postharvest operation and is affected by means of structures differing in shape, capacity, construction materials, durability, cost and effectiveness.

There are a wide range of plant and animal products which are preserved by man over different periods of time. They include dried and smoked fish, meat, hides and skin, timber products, household goods such as clothes, carpets, tea, cocoa, etc. Crop products constitute the major class of stored agricultural commodities which form the staple diets of man in most parts of the world. The stored produces are grouped into Durables, Semi-durables and Perishables. Durables include grains from cereals and pulses/grain legumes which can be stored for several months or years. Grains include rice, maize, sorghum, millet, wheat, groundnut, beans, soyabeans, cowpeas, Bambara groundnut, etc. Semi-durables include roots and tuber crops like Cassava, yam, potato, cocoyam, carrots, etc. They can only be stored for a short time. They form the main energy source in the diet of most developing tropical countries. They require special storage structures. Perishables are fruits and vegetables like oranges, mango, cashew, pear, pawpaw, water melon, tomato, onion, cabbage, etc.

The storage structures generally possess many features that are fairly conducive to good preservation. They are often constructed with natural local materials and relatively cheap. The designs and capacity differ according to the type of commodity and size of the harvest. The storage structures are broadly classified into two: ventilated and unventilated (hermetic) structures. Root and tuber crops are also stored but not for longer periods like grains and pulses.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Know the various storage methods
- Know the best way to store cereals and pulses
- Know how to store roots and tubers, fruits and vegetables

3.0 MAIN CONTENT

3.1 Storage methods for stored produce

3.1.1 Storage of Grains and Pulses

The structures for storage generally possess many features that are fairly conducive to good preservation. The storage structures are broadly classified into two: ventilated and unventilated (hermetic) structures. Two main ventilated structures commonly used for the storage of durable crop products in tropical Africa are the Cribs and Bags. They are referred to as ventilated structures because of the presence of vents or small holes which provide varying levels of ventilation to stored commodity and any pest it may be harbouring. At small farming scale, grains are stored traditionally in different styles of containers. Structures used traditionally are often not expensive and environmentally motivated. Subsistence stores may be made out of clay, thatch, mud, wood or stones. Larger granaries meant for storing large quantities for longer periods of time, may be built with more permanent structures e.g. metal silos or wooden granaries with iron sheets roofs. Open storage structure can simply be wooden platforms on stakes or posts, on top of which the crop rests either in heaps or regular layers. The harvest crop may be hung on frames in the house or sheaves to tree branches outside.

A more protected storage system is the use of Crib. Cribs are wooden four-cornered structures with ventilated sides. The sides are covered with woven straws, grass stalks or wire netting materials. Closed types are granaries of different sizes made out of mud, woven straws or mixture of mud and chopped straws. The granaries may be four-cornered, spherical, with a straw roof containing a protecting lid or in the shape of a cone with the tip pointing downwards and resting on foundation stones. Grains inside the granaries are well-protected against rains and the invasion of insect pests. Smaller amounts of grains may be stored in Calabashes (gourds), clay pots, sacks or woven baskets, jericans, etc. Such containers allow for frequent consumption of the product on a daily or weekly basis. Jericans and jars hermetically sealed with a stone on top leads to depletion of oxygen and accumulation of carbon dioxide inside the container, which eventually lead to elimination of insect pests.

Concrete or metal silos which can carry 5-10 tons of grains are now used among medium and large scale farmers. The use of plastic sacks, bags, prefabricated iron halls and flexible plastic silos are becoming popular. Large warehouses and metal silos are common among cooperatives and traders which can contain more than 3000 tons of produce. Plastic bags provide a good mean of preserving legumes and cereals because they can easily be transported. Grains are put into polyethylene sacks and sealed hermetically. Sometimes the bags are sealed after dosing with a recommended fumigant like Aluminium phosphide (Phostoxin) or Pirimiphos methyl (Actellic EC or Dust). These fumigants may pose some dangers or hazards, if not handled properly according to the instruction. An improved and safer method is to use one or two layers of transparent polyethylene along with the plastic sack. This is referred to as double or triple bagging which does not require the use of fumigants or synthetic chemical. Sacks are usually filled to three-quarter (3/4) of their volume and then sealed by twisting the neck and tying tightly with a knot. The bags/sacks are then stacked or piled up on platforms or wooden pallets to avoid direct contact with the floor or ground so that moisture absorption is also avoided. The bags are to be arranged in a criss-cross manner to avoid falling off.

3.1.2 Storage of Roots and Tuber Crops

Roots and tubers are classified as semi-durables which can only be stored for a short time. Cassava tubers cannot be stored for more than 3-4 days after harvesting because it will begin to deteriorate rapidly. They develop a bluish discolouration around the vascular bundles of the tuber. This is called vascular streaking. Streaking is caused by enzymatic processes. Streaking will fail to occur if the tubers are dipped in warm water (53^0C for 45 minutes), stored under anaerobic conditions, submerged in water, or kept under refrigeration. The quality of starch in the tuber also deteriorates during storage. Cassava roots could be stored in boxes containing moist sawdust for a period of eight (8) weeks. This long term storage is preceded by curing the tubers at 30-35^0C and 80-85% relative humidity. The high cyanide or prussic acid content of most Cassava cultivars implies that they can only be consumed after elaborate processing.

Yam is commonly stored in yam barns made up of a framework of vertically arranged wooden poles of about 3-4 metres high. The yam tubers are tied to the poles of the barn using twine, and the tubers being placed longitudinally. The barn is shaded and should be located in a well-ventilated area. The ventilation prevents the build-up of high humidity which favours rotting and prevents the tubers from heating up due to respiratory activities. The yam farmer should inspect the barn always, looking out for tubers which are beginning to rot. These should be removed from the barn so that the rot does not spread and infect other tubers. With each rain that falls, inoculum (disease pathogens) is spread from the rotted tuber to neighbouring ones especially those below it. Tubers which have started to sprout can be detected and the sprout be removed or broken. Shading, ventilation and constant inspection are three (3) essentials for good yam storage in a barn.

After harvesting Sweet and Irish potatoes, the tubers are subjected to curing to promote rapid healing of wounds inflicted during harvesting and increase the toughness of the skin (periderm) of the tuber. Curing minimizes infection by microorganisms during storage and to make the tuber more resistant to wounding during subsequent handling. After curing the tubers are stored at a temperature of 13-16^{0}C and a relative humidity of 85-90%. Tubers should be cured for 4-5 days under ambient conditions before they are stored away. Most farmers store sweet potato in underground pits lined and covered with dry grass. Tubers may also be kept in platforms or stored in baskets. The tubers may be left in the ground and harvested only when needed but this will make them prone to weevil attacks. The ascorbic acid decreases as the tubers stay in storage.

3.1.3 Storage of Fruits and Vegetables

Fruits and vegetable are considered as perishables because they cannot be stored for a long time naturally. They are best stored at low temperatures or in ventilated containers. Fruits like mango, oranges, pawpaw, and guava should be harvested when they have reached physiological maturity or when they are half-ripe. They can then be kept to complete the ripening in the store or in transit. They should be transported in ventilated structures like perforated cartons, jute woven bags, open vans, etc. Vegetables like tomato should be harvested when half-ripe and be transported in ventilated containers like woven baskets or under refrigerated condition. Onion can be stored for 3-4 months when spread thinly on a floor lined with dry sand or dry grass. Prior to storage, the onion bulbs should be cured by sun or shade-drying for 3-4 days before storing. The stored onions should be in a ventilated place and be inspected from time to time for rotting and sprouting bulbs which should be removed.

4.0 CONCLUSION

In this unit, we have defined stored produce and have been able to differentiate between stored produce and stored products. We also saw why we store our farm produce. It can be concluded that we store our farm produce to ensure price stabilization, food security, provision of industrial raw materials, provision of the country’s strategic reserve, enhancement of a country’s international status and the provision of seed.

5.0 SUMMARY

In this unit we have learned that:

- The low productivity of agricultural crops is largely due to attack by insect pests and diseases both in the field and in storage.
- There are inadequate storage facilities for preserving the excess harvest
- Stored produce are the unprocessed harvested crops from the field

- Reason for storing agricultural produce include: price stabilization, food security, provision of industrial raw materials, provision of the country's strategic reserve, enhancement of a country's international status and the provision of seed.

6.0 TUTOR-MARKED ASSIGNMENT

1. Differentiate between stored produce and stored products.
2. Mention five (5) reasons why we need to store agricultural produce.

7.0 REFERENCES/FURTHER READING

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MODULE 2

MODULE 2 PESTICIDES USED IN STORED PRODUCE PROTECTION

UNIT 1 ROLE OF PESTICIDES IN INTEGRATED PEST MANAGEMENT (IPM)

CONTENTS

1.0 INTRODUCTION

The popular outcry against the use of synthetic pesticides in agriculture cannot overshadow the necessity of their use nor can any speedy decline in their use be foreseen, so that protection of the consumers of treated produce and education of the users of the chemicals is imperative. Chemical pest control methods, if carried out intelligently and knowledgeably, can be both effective and safe. It is extremely important for users to have knowledge of the classification, mode of action, properties, metabolism and residues of the pesticides, to enable them to make proper appraisal of the benefits and potential hazards of the pesticides. Thus, they should be able to choose insecticides judiciously and formulate efficient control measures in any particular set of circumstances.

Of the many insecticides reported to be toxic and/or effective against stored product pests, the number which have been cleared for application on stored grain and for which maximum residue limits are established is limited. Insecticides are classified according to their mammalian toxicity, chemical origin or composition, mode of entry, and formulation. A fundamental goal of toxicology is to determine safe levels of exposure to potentially poisonous substances for humans and the environment. Traditionally, safe levels have been estimated in laboratory toxicity bioassays by calculating the non-observable effect level (NOEL) of a chemical to a variety of organisms which are representative of certain taxa, i.e. mammals, birds, fish, crustaceans, algae, etc.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Know the importance of pesticides in agriculture.
- Know why pesticides are better options in pest management.
- Disadvantages of pesticides in agriculture

3.0 MAIN CONTENT

3.1 Minimal use of pesticides

Pesticides are used in Integrated Pest Management programs when no effective alternatives are available or alternatives are not sufficient to keep pest populations from reaching damaging levels. The emphasis is to maximize the benefits and advantages that pesticides offer while minimizing any potential risks. Whenever a pesticide treatment is needed, selection of the chemical should be consistent with the pesticide label and all state and federal laws and regulations. Additional considerations include: effectiveness against the target organism, compatibility with the host plant, effects on beneficial organisms, degree of environmental and user safety, and cost. Wherever possible, use a material that is least toxic to humans and other non-target organisms, and is least likely to contaminate ground and surface waters.

Why Minimize Pesticide Use?

Several problems and limitations have become apparent by relying solely on pesticides to control pests. Some of the problems include: pest resistance to pesticides; increased costs; toxicity to fish, wildlife, beneficial natural enemies of pests, and other non-target organisms; concerns about human health and safety; ground water contamination; and overall environmental quality. Pesticides are chemicals that are used to destroy, repel, or otherwise lower pest infestations to protect crops from damage. Insecticides are pesticides used to control insects, herbicides are pesticides used to control weeds, fungicides are pesticides used to control fungi and nematicides are pesticides used to control nematodes.

3.2 Advantages and Benefits of Pesticides

1. Pesticides are readily available and easy to use.
2. Where resistance is not a problem, pesticides are generally highly effective for controlling pests.
3. Pesticide treatments can be rapidly implemented as needed with minimal lag time.
4. Pesticides can be used over large areas to control large populations of pests.
5. Pesticide treatments are often cost effective, especially if the alternatives require large increases in human labor.
6. No effective, reliable, non-chemical alternatives are available for many pests and chemical pesticides are the last resort.

3.3 Problems with Overuse of Pesticides

1. Pesticide Resistance:

In an attempt to achieve better or total pest control, resistance problems have increased because pesticides are applied more frequently and at higher dosage rates. These tactics have resulted in increased selection pressure. Naturally resistant individuals in a pest population are able to survive pesticide treatments. The survivors breed and pass on the resistance trait to their offspring. With each passing generation, the pest population becomes more difficult to control with the same pesticides as compared with earlier generations. Reducing pesticide use and alternating among classes of pesticides with different modes of action can help to lessen the possibility of pest resistance. Managing pest resistance is very important in helping to prolong the effective life of needed pesticides.

2. Toxicity to Natural Enemies and Other Non-target Organisms:

Natural enemies of pest species can be very helpful in keeping pest populations at lower levels. These beneficial organisms include organisms that are predators, parasites, or competitors to the detriment of the pest species. For example, aphids do not reach pest levels every year because many different natural enemies help to keep them in check. Unfortunately, many broad-spectrum, non-selective pesticides are more detrimental to numerous beneficial species than to the pests. The use of such pesticides often causes resurgence in pest populations and at a much faster rate compared to the natural enemies. Without the natural controls, primary (established) and secondary (new) pests are often free to reach damaging levels at faster rates. An increase in pest levels usually results in additional pesticide treatments, which further depresses or eliminates the natural enemies and further encourages the potential for pest resistance. Selecting effective alternatives that are less toxic to non-target organisms will increase natural enemy survival, and overall effectiveness of pest control.

3. Public Health and Environmental Concerns:

The public has become increasingly concerned about the use of pesticides and the possible adverse effects on human health, wildlife, ground water, and overall environmental quality. Pesticide exposure from drift to non-target areas; contamination of ground and surface waters; and residues on food are topics of concern to the general public. Applicators should be especially concerned because they may have the highest potential for exposure and thus, may have the greatest health risks. All applicators must be sensitive to public concerns about pesticide use and apply materials only in a safe and judicious manner.

4. Reduced Risk Pesticides

EPA has established a category of pesticides called "Reduced Risk" pesticides to encourage the development, registration and use of products which could result in reduced risks to human health and the environment. New conventional pesticides are considered for "Reduced Risk" status if they have at least one or more of the following characteristics: low risk to human health, low toxicity to non-target organisms, low potential to contaminate ground water, surface water or other valued environmental resources and have the potential to expand the adoption and effectiveness of IPM.

4.0 CONCLUSION

In this unit, we have learned about some of the problems of over-reliance on pesticides which include: pest resistance to pesticides; increased costs; toxicity to fish, wildlife, beneficial natural enemies of pests, and other non-target organisms; concerns about human health and safety; ground water contamination; and overall environmental quality. We also learned about the advantages and disadvantages of pesticide use. Pesticide treatments are often cost effective and can be used over large areas to control large populations of pests. In Integrated Pests Management (IPM), the use of pesticides is expected to be at the minimal usage along with other management methods.

5.0 SUMMARY

In this unit we have learned that in Integrated Pests Management (IPM), the use of pesticides is expected to be at the minimal usage along with other management methods. The advantages of pesticides usage include:

1. They are readily available and easy to use.
2. They are generally highly effective for controlling pests.
3. Pesticides can be used over large areas to control large populations of pests.

4. Pesticide treatments are often cost effective.

Some of the disadvantages of pesticides include: pest resistance to pesticides; increased costs; toxicity to fish, wildlife, beneficial natural enemies of pests, and other non-target organisms; concerns about human health and safety; ground water contamination; and overall environmental quality.

8.0 TUTOR-MARKED ASSIGNMENT

1. List the advantages of pesticides
2. Mention four (4) problems of pesticides use.

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UNIT 2 MAJOR GROUPS OF PESTICIDES USED IN STORED PRODUCE PROTECTION

CONTENTS

1.0 INTRODUCTION

The selection of insecticides for treatment of edible commodities is based mainly on the toxicological data (low mammal fan toxicity), effectiveness and persistence under certain storage conditions and absence of side effects such as discoloration, flavor alternation and odor. FAO and WHO collect toxicological information and give advice on overall tolerance figure. However, the maximum levels of pesticide residue acceptable in grain consumption must be calculated by local authorities who have relevant information on the inert feeding habits and agricultural practices.

Of the many insecticides reported to be toxic and/or effective against stored product pests, the number which have been cleared for application on stored grain and for which maximum residue limits are established is limited. To qualify for selection as possible candidate material for use on or around grain, the insecticide must fulfill the following requirements:

1. it must be effective at economic rates of use;
2. it must be effective against a wide variety of insect pests;
3. it must present no hazards to consumers of grain and grain products and to users or applicators;
4. it must be acceptable to health authorities;
5. it must not give rise to unacceptable residues;
6. legal maximum residue limit must be established;
7. it must not affect the quality, flavour, smell or handling of grain;
8. it must be acceptable in international grain trade;

9. it must not be flammable, explosive or corrosive; and
10. its method of use must be compatible with established grain handling procedures.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Know the types of Pesticides used in stored produce protection
- Know the major groups of pesticides: Pyrethroids, Organophoshporus; Organochlorines, and Carbamates.
- Know how pesticides enter the body of pests

3.0 MAIN CONTENT

3.1 Pesticides used in stored produce protection

Insecticides used on or around grain may be classified based on usage:

1. Knock down agents - i.e. Dichlorvos
2. Surface sprays - i.e. Bioresmethrin
3. Structural treatment - i.e. Fenitrothion
4. Grain protectants - i.e. Malation
5. Fumigants - i.e. Aluminum Phosphide, Pirimiphos methyl, Chlorpyrifos methyl, etc.

3.2 Major groups of pesticides

The common insecticides used in stored product pest control belong to four groups: the pyrethroids, the organophoshporus; the organochlorines, and the carbamates.

1. **The Pyrethroids**: They are either isolated from plants or synthesized (Natural Pyrethrins or Synthetic Pyrethroids)

Natural Pyrethrins

Pyrethrins remain one of the more widely used materials in stored product pest control. The rapid knockdown effect, a wide spectrum of activity against insect pests, a general acceptance of their use associated with foodstuff and an established codex of tolerance have been the principal reasons for their use. Their use has not been intensive as their cost has been prohibitive.
Their major disadvantages are high cost, poor stability, inadequate toxicity to some species and lack of ovicidal and acaricidal action have been offset somewhat by the use of synergists, i.e. piperonyl butoxide, sesamin, piperonyl cyclonene, propyl

isome, sesamex and sulfoxide. Synergists are usually present at ratios 1:3 or 1:10 (insecticide: synergist).

Synthetic Pyrethroids

The synthetic pyrethroids such as bioresmethrin, deltamethrin, permethrin, fenvalerate and phenothrin are becoming acceptable over pyrethrins because of their high levels of activity against a wide range of pests and a cost advantage. Bioresmethirn appears to be the most commonly used.

There have been deficiencies as with pyrethrins. For example, resistance is known although not extensive, and breakdown to malodorous decomposition products has presented a problem where repeated applications have been made on the same surface. In addition, like pyrethrins, control of *T. castaneum* has been less than desirable. Pyrethroids are highly summarized with piperonyl butoxide.

Bioresmethrin - It is one of the most potent broad spectrum insecticides currently available and has a good knockdown performance against insects. Bioresmethrin, at low concentrations, is an effective killing agent against most insect pests attacking households, industrial premises and food storage. Bioresmethrin is currently being used as:

a. household aerosols and sprays formulated in combination with pyrethrum, bioallethrin, tetramethrin and piperonyl butoxide;
b. an insecticide for the control of pests in food premises; and
c. in grain disinfestation and protection.

Bioresmethrin has an exceptionally high potency against some insect species, particularly *Rhizopertha dominica* and it has proved useful when applied at the rate of 1 mg/kg in conjunction with selected organophosphorus insecticides, enabling the amount of OP to be reduced considerably without loss of effectiveness. It has lower toxicity against *Sitophilus granarius, Tribolium castaneum* and moderately toxic against mites. The toxicity of bioresmethrin can be improved to a significant extent with piperonyl butoxide, the factor of synergism ranging from 2 to 9 fold. Bioresmethrin at 1 mg/kg plus fenitrothion at 12 mg/kg controls typical malation-resistant strains of *S. oryzae, R. dominica*, *T. castaneum* and *Ephestia cautella*.

Fenvalerate - It is an ester related and in many ways similar to pyrethroids. It is a highly active broad spectrum insecticide with adequate stability and relatively low mammalian toxicity. It has been shown to be effective at low doses against *R. dominica* and at higher doses against most species such as *Sitophilus* and *Tribolium* species. Fenvalerate is an effective alternative to bioresmethrin. It combines well with OP and its potency is synergized by the addition of piperonyl butoxide. Deposits on grain are stable, though the bulk of the deposit is removed with bran or hulls. Those residues which carry through the white flour or milled rice remain substantially undiminished following cooking. Fenvalerate at 1 mg/kg along with fenitrothion at 12 mg/kg and piperonyl butoxide at 8 mg/kg control common field strains of *S. oryzae* and *R. dominica* and completedly prevent progent production in *T. castaneum, T. confusum* and *E. cautella*. The same combination of fenvalerate control typical malathion resistant strains of above -mentioned species.

2. Organophosphorous compounds

There are several organophosphrous compounds (OP) used in stored product pest control. The most common are malathion, dichlorvos, fenitrothion, pirimiphos methyl and chlorpyrifos methyl.

Malathion - Malathion is the only OP that has been widely used for over 20 years for the routine protection of stored products especially cereals in practically every country in the world. It is effective against the many destructive pests of stored products at 5 to 20 mg/kg. It is virtually ineffective against stored product moths and requires higher dosage to control non-resistant *R. dominica*.

Malathion is intensively used in developed exporting countries such as Australia, Argentina and USA. Whereas before, malathion (premium or deodorized grade) was the most important material for admixture with grain, increasing use of dichlorvos was evident. Due to development of insert resistance, there appeared to be a significant move away from malathion for disinfestation of storage facilities and less marked but noticeable change to use alternative materials for treatment of bags.

The amount of the malathion deposit which penetrates the individual grains is relatively small and therefore most of the deposit is removed in the milling of wheat and rice. More than 95% of the deposit on the raw cereal grain is removed or destroyed before the cereal food reaches the consumer.

Malathion is used as admixture in dust or sprays form; for building and fabric treatment; floor wash; and surface treatment of bags and grains and associated buildings and fabrics.

Dichlorvos - It is the most commonly used material next to malathion. It is an extremely effective stored product insecticide due to its high vapour pressure and is used as fumigant rather than as contact insecticide. Enclosed spaces such as warehouses, storage and grain bins allow build-up of air concentrations of vapours toxic to most flying and crawling stored product insects. The vapour will not penetrate into grain masses, other commodities or the fabric of buildings. The principal uses for dichlorvos are in aerosol-dispensing units which could be programmed for automatic daily release, usually at dusks; space sprays or fogs; slow release formulations in which dichlorvos is dissolved in solid strips (or beads) of polyvinyl chloride plastic suspended in the free space of storages; surface application of concentrates on wooden floors; surface treatment for protection of bagged commodities; and direct application to grain either as a surface treatment for moth control or for admixture with grain as disinfestation treatment alone or mixed with residual protectants.

Dichlorvos has the advantage over other residual insecticides in that it is considerably more active against immature stages of pests that develop within individual grains. Whereas malathion, for example, will kill only first instar larvae of *S. oryzae,* dichlorvos will give a significant kill of all larval stages except final instar larvae and the pupal stage. Resistance from has *R. dominica*, been detected in low levels.

Fenitrothion - It is a broad spectrum insecticide with a much lower acute mammalian toxicity than many similar insecticides. It is widely used for the control of pests of many crops and principally as a residual spray in houses for the control of mosquitoes; pests of forest trees and for the management of locust swarms.

Fenitrothion has been used for a considerable time for structure, treatment and for surface treatment of bag stocks particularly where malathion resistance was present. Fenitrothion is considerably more effective than malathion against *Sitophilus* spp. and Lepidoptera and of comparable effectiveness against *Tribolium* spp. but not fully effective against *R. dominica*. High potency and good stability mean that deposits in the region of 5-10 mg/kg are sufficient under most storage conditions to give complete protection for 9 to 12 months. When combined with pyrethrum or synthetic pyrethroids, the effectiveness of fenitrothion is increased and the dosage level can be reduced. Fenitrothion is more effective than malathion for conditions where it is generally applied in the form of a very dilute dust. There is minimal penetration into the grain so that the deposit is mostly removed in bran of wheat and husks of rice.

Pirimiphos-methyl - It is a fast-acting broad spectrum OP with both contact and fumigant action. It gives long lasting control of insect pests of inert surfaces such as wood, sack and masonry. It retains its biological activity when applied to stored agricultural commodities including raw grain, nuts, pulses, dates and cheese.

Pirimiphos-methyl has been used in many situations against stored product pests. The minimum effective dose against a wide range of insects is lower than most other OP on use or under development as grain protectant. It is potent against beetles, weevils, moths and mites, but not sufficiently effective against some strains of *R. dominica.* It is useful against immature stages within the individual grains and it appears quite effective against many lindane-malathion resistant strains. Pirimiphos is more persistent in maize than in sorghum. Pirimiphos methyl-impregnated sacks is more effective than malathion for the control of storage pests of shelled corn.

Chlorpyrifos-methyl - It is a broad spectrum organophosphorous insecticide of relatively low toxicity and moderate persistence. It shows reasonably good stability in stored products such as grain and dried fruits. In these products it controls a wide spectrum of beetles, weevils, moths and mites including several species which may have developed resistance to insecticides.

Chlorpyrifos-methyl is potent against all storage pests except resistant *R. dominica*. It is effective against moths which are not readily controlled by malation. Deposits on grains and sacks are stable under most storage conditions. Studies in the Philippines show that it is a grain protectant more potent than tetrachlorvinphos, pirimiphos-methyl, malathion, MIPC against *Sitophilus* spp. for grain use. However, it was not as effective as tetrachlorvinphos against *R. dominica*. In general, the residual toxicity increased with higher concentration. Chlorpyrifos methyl was the most stable among the five OPs, evaluated in corn and sorghum.

Tetrachlorvinphos - This compound has been used in the field for control of non-storage pests for considerable time and it is only recently that it is being evaluated as grain protectant Tetrachlorvinphos has a very low level of toxicity and is a suitable compound for the protection of foodstuff. It has been shown to be effective against many species of stored product pests, both the immature and adult stages. It was also found to be highly stable in dry grain and posed no odour problem. It is more effective than malathion and pirimiphos-methyl and equally effective as chlorpyrifos methyl against *Rhizopertha*. Tetrachlorvinphos deposits do not penetrate the individual grains to any extent and appear to be removed on husks and bran.

Metacrifos - The compound acts as a contact, vapour and stomach poison against all important arthropod pests of stored products. It is also highly effective against major malathion and lindane resistant insects. It is one of the few compounds that is effective against *R. dominica*. It is particularly useful where grain temperature can be regulated and where aeration of the grain mass can take advantage of the high potency of methacrofos vapour. It is marketed under the trade name Dam Fine.

Metacrifos penetrates the individual grains fairly rapidly and is therefore effective against larval stages within the grain. It is extremely potent at lower temperature and has a pronounced vapour action, but it degrades rapidly at high temperature and humidity.

3. Organochlorines

As insecticides, many of the organochlorines are cheap and have excellent insecticidal property against many insects. These insecticides are photostable, and are resistant to degradation both in the environment and in biological systems. However, their resistance to environmental degradation and their stability after entering biological systems have led to general contamination of the world ecosystem. Also, because of the low cost and effectiveness, their widespread use has resulted in high levels of resistance in many insects. In addition, many of these chemicals exert profoundly deleterious long-term effects in animals, effects that were not known until after a long time that these chemicals were put into extensive use. Many organochlorines, including DDT and the cyclodienes have been shown to induce the formation of tumors in laboratory animals fed with a low dietary dose. Aside from tumorogenicity, it has been shown to upset reproduction in birds, and mammals.

Organochlorines that have been used for postharvest treatment were DDT, lindane and methoxychlor. DDT was used in foodstuffs since its introduction in the early 1940s. When its persistence and tumorogenicity effects were uncovered, its use has been stopped. Methoxychlor is a DDT analog where the chlorine is substituted with methoxy (CH3O) groups which render it more rapidly degraded by sunlight but is slowly converted to methoxy-DDE. But unlike DDT, it does not accumulate in fatty tissues. Although it has a very low mammalian toxicity (5000-7000 mg/kg rat) its uses is limited because of its high cost.

Lindane (gamma-BHC) replaced DDT which found a limited use in the immediate post-war years in postharvest treatment. It has many of the desirable traits required especially for stored pest control; a wide spectrum of insecticidal activity in both beetles and moths and reasonable effectiveness against mites; stability under a wide range of conditions; a significant vapour pressure allowing some fumigant effect; repellency in some circumstances; and a comparatively low mammalian toxicity. The major uses for lindane apart from seed dressings have been in surface treatment of bagged stocks of grains, coffee and cocoa beans and particularly, in treatment of warehouse and transport facilities.
It loses much of its effective residual life through evaporation and is very susceptible to dehydrochlorination when applied to alkaline surfaces.

4. Carbamates

Many of the properties of carbamates such as mode of action, lack of toxicity, lack of environmental persistence and lack of safety to beneficial insects are similar to organophosphates. However, the inhibition of carbamates is less permanent than with organophosphates. This means that at least for man, these insecticides are less dangerous than organophosphates as they have had a better safety record under practical use conditions.

Carbamates have been proven useful for storage pest control in the past, and the one that has carbaryl - has been largely replaced by the synthetic pyrethroids for controlling *Rhyzopertha*. Carbaryl, like other carbamates, is rapidly degraded into watersoluble, hydroxylated products which are easily conjugated to glucosides.

Others

Methoprene - This compound is the most commonly advanced example of the class of IGRs with juvenile hormone activity. This is available under the trade name Altosid. Methoprene is effective as protectant at 5 mg/kg against *Plodia interpunctelta, Lasioderma serricorne, R. dominica, Oryzaephilus surinamensis* and *mercator*, and at 10 mg/kg against *Ephestia cautella* and *T. castaneum*. The juvenile hormone analogue is relatively non-toxic and has moderate stability under storage conditions but is rapidly decomposed by light. It is expensive and effective against few insect species.

3.3 Mode of Entry of Pesticides

Insecticides can be divided into three main groups depending upon the way they penetrate into the body of the insect.
Contact insecticides - These insecticides are applied in such a manner that they come in contact with some part of the body of the insect; the compound is able to penetrate the exoskeleton and is transported to the tissues via the circulatory system. Most of the insecticides used in storage belong to this group. The inert insecticidal dusts which disrupt the thin epicuticle leading to the desiccation and death of the insect are included in this group.

Systemic insecticides - These are translocated to the untreated parts of plants or animals in concentration that makes the final translocation site toxic to insects. These are not used in stored product pest protection.
Fumigants - These are insecticidal gases at normal temperatures penetrating through the tracheal system into body tissues and are used in enclosed spaces. Examples are phosphine and methyl bromide. Some contact insecticides like Aluminium phosphide (Phostoxin), Pirimiphos methyl (Actellic EC or Dust) and Dichlorvos, vaporize partially in warm ambient conditions, thus having fumigant and contact actions.

Mode of Action

Physical insecticides - These materials such as the heavy mineral oils and inert dusts, characteristically exert a physical rather than a biochemical action. Mineral oils exert a purely asphyxiant effect and dusts affect loss of body moisture by abrasion (aluminum oxide) or by absorbing moisture (wood ash and charcoal).

4.0 CONCLUSION

The common insecticides used in stored product pest control belong to four groups: the pyrethroids, the organophoshporus; the organochlorines, and the carbamates. The synthetic pyrethroids such as bioresmethrin, deltamethrin, permethrin, fenvalerate and phenothrin are becoming acceptable because of their high levels of activity against a wide range of pests and a cost advantage. The organophosphrous compounds (OP) used in stored product pest control includes malathion, dichlorvos, fenitrothion, pirimiphos methyl and chlorpyrifos methyl. Organochlorines are cheap and have excellent insecticidal property against many insects. These insecticides are photostable, and are resistant to degradation both in the environment and in biological systems. Organochlorines that have been used for postharvest treatment were DDT, lindane and methoxychlor. But unlike DDT, methoxychlor does not accumulate in fatty tissues. Although it has a very low mammalian toxicity (5000-7000 mg/kg rat) its uses is limited because of its high cost. Carbamates have been proven useful for storage pest control in the past. They are less dangerous than organophosphates as they have had a better safety record under practical use conditions. They are rapidly degraded into watersoluble, hydroxylated products which are easily conjugated to glucosides.

Contact insecticides - they come in contact with some part of the body of the insect and penetrate the exoskeleton and is transported to the tissues via the circulatory system. The inert insecticidal dusts which disrupt the thin epicuticle leading to the desiccation and death of the insect are included in this group. Systemic insecticides - they are translocated to the untreated parts of plants or animals in concentration that makes the final translocation site toxic to insects. Fumigants - they are insecticidal gases at normal temperatures penetrating through the tracheal system into body tissues and are used in enclosed spaces.

5.0 SUMMARY

Insecticides used in stored product pest control belong to four groups: the pyrethroids, the organophoshporus; the organochlorines, and the carbamates. Insecticides can be divided into three main groups depending upon the way they penetrate into the body of the insect e.g. Contact, Systemic and Fumigants.

6.0 TUTOR-MARKED ASSIGNMENT

1. Mention three groups of insecticides used in storage
2. List three ways in which insecticides penetrate the bodies of insects.

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UNIT 3 TOXICOLOGY OF MAJOR GROUPS OF PESTICIDES

CONTENTS

1.0 INTRODUCTION

A pesticide is any substance used to control pests. Pests may be target insects, vegetation, fungi, etc. Most control the pests by poisoning them. Unfortunately, pesticides can be e or even kill humans. Others are relatively non-toxic. Pesticides can irritate the skin, eyepoisonous to humans as well. Some are very poisonous, or toxic, and may seriously injurs, nose, or mouth. The most important thing to remember is that you should always use caution whenever you work with any pesticide.

All pesticides must be toxic, or poisonous, to be effective against the pests they are intended to control. Because pesticides are toxic, they are potentially hazardous to humans, animals, other organisms, and the environment. Therefore, people who use pesticides or regularly come in contact with them must understand the relative toxicity and potential health effects of the products they use. The toxicity of a substance is its capacity to cause injury or illness to a living system. A living system can be many things: a human body, or parts of the body (such as the lungs or the respiratory system); a pond, a forest and those creatures that live there. Toxicity represents the kind and extent of damage that can be done by a chemical. In other words, if you know the toxicity of a pesticide, you know "how poisonous" it is. The effect of a pesticide, or any substance for that matter, is dependent on a number of factors. The most important factor is the dose-time relationship. Dose is the quantity of a substance that a surface, plant, or animal is exposed to. Time means how often the exposure occurs. Thus, the dose- time relationship is how much of the substance is involved and how often the exposure to the substance occurs. The toxicity of a particular pesticide is determined by subjecting test animals to varying dosages of the active ingredient (a.i.) and each of its formulated products. The active ingredient is the chemical component in the pesticide product that controls the pest.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Understand what toxicity is and how it affects humans.
- Types of pesticide toxicity
- Learn the three routes of entry (how pesticides enter the body) and the importance of each.
- Determination of pesticide toxicity

3.0 MAIN CONTENT

3.1 What is toxicity and how it affect humans

The toxicity of a substance is its capacity to cause injury to a living system. A living system can be many things: a human body, or parts of the body (such as the lungs or the respiratory system); a pond, a forest and those creatures that live there. Toxicity represents the kind and extent of damage that can be done by a chemical. In other words, if you know the toxicity of a pesticide, you know "how poisonous" it is.

The effect of a pesticide, or any substance for that matter, is dependent on a number of factors. The most important factor is the dose-time relationship. Dose is the quantity of a substance that a surface, plant, or animal is exposed to. Time means how often the exposure occurs. Thus, the dose- time relationship is how much of the substance is involved and how often the exposure to the substance occurs. This relationship gives rise to two different types of toxicity that pesticide applicators must know and understand. They are acute and chronic toxicity.

3.1.1 Acute toxicity

refers to how poisonous a pesticide is to a human, animal, or plant after a single short-term exposure. Acute toxicity is used to describe effects which appear promptly, or within 24 hours of exposure. It is nearly always as a result of an accident or suicide attempt or careless handling. A pesticide with a high acute toxicity is deadly even when a very small amount is absorbed. Acute toxicity levels are used as a way to assess and compare how poisonous pesticides are. The acute toxicity of a pesticide is used as the basis for the warning statements on the label. Acute toxicity may be measured as acute oral toxicity, acute dermal toxicity, and acute inhalation toxicity.

Products are categorized on the basis of their relative acute toxicity (their LD_{50} or LC_{50}values). **Toxicity Category/Class I**: Pesticides that are classified as highly toxic on the basis of either oral, dermal, or inhalation toxicity must have the signal words DANGER and POISON printed in red with a skull and crossbones symbol prominently displayed on the front panel of the package label. The Spanish equivalent for DANGER, “PELIGRO” (the Spanish equivalent) must also appear on the labels of highly toxic chemicals. The acute (single dosage) oral LD_{50} for pesticide products in this group ranges from a trace amount to 50 mg/kg. For example, exposure of a few drops of a material taken orally could be fatal to a 150-pound person. Some pesticide products have the signal word DANGER without the skull and crossbones symbol. This is because possible skin and eye effects are more severe than suggested by the acute toxicity (LD_{50}) of the product.

Toxicity Category/Class II: Pesticide products considered moderately toxic must have the signal word WARNING and “AVISO” (the Spanish equivalent) displayed on the product label. In this category, the acute oral LD_{50} ranges from 50 to 500 mg/kg. A teaspoon to an ounce of this material could be fatal to a 150-pound person.

Toxicity Categories/Classes III and IV: Pesticide products classified as either slightly toxic or relatively nontoxic respectively and are required to have the signal word CAUTION on the pesticide label. Acute oral LD_{50} values in this group are greater than 500 mg/kg. An ounce or more of this material could be fatal to a 150-pound person. REI (Restricted-entry interval): Re-entry interval is the period required after treatment of a field or store for people or livestock to enter the treated area. The Environmental Protection Agency of the United States of America Worker Protection Standard requires minimum 12-hour reentry times for all Category III (CAUTION) pesticides, 24-hour minimum reentry times for all Category II (WARNING) pesticides, and 48-hour minimum reentry times for all Category I (DANGER) pesticides.

Despite the fact that some pesticide products are considered only slightly toxic or relatively nontoxic, all pesticides can be hazardous to humans, animals, other organisms, and the environment if the instructions on the product label are not followed. Use the pesticide only as recommended by the manufacturer. As the applicator, you are legally responsible for any misuse of a pesticide.

3.1.2 Chronic toxicity

refers to the harmful effects produced by long-term, low-level exposure to chemicals. Chronic toxicity of pesticides concerns the general public, as well as those working directly with pesticides because of potential exposure to small amounts of pesticides while mixing, loading and applying pesticides or by working in fields after pesticides have been applied, or on/in food products, water, and the air. It is measured in experimental conditions after three months of either continuous or occasional exposure.

Types of Pesticide Exposures

A pesticide exposure is defined as coming in contact with a pesticide. There are two types of exposure that may occur, acute and chronic.

Acute exposure refers to a one-time contact with a pesticide. When experimental animals are exposed to a pesticide to study its acute toxicity, acute exposure is defined as contact for 24 hours or less. Acute effects can be readily detected and more easily studied than chronic effects. Immediate toxic effects are more likely to be produced by those pesticides that are rapidly absorbed.

Chronic exposure refers to a repeated contact with a pesticide. The study of chronic toxicity is accomplished by repeatedly exposing test animals for more than three months. In addition to producing long-term low-level effects, chronic exposure to pesticides may result in immediate, "acute" effects after each exposure. In other words, frequent exposure to a chemical can produce acute and chronic symptoms. The potential for a chronic effect is related to the level and frequency of exposure received. Chronic Exposure to pesticides may result in the following:

- **Reproductive effects:** effects on the reproductive system or on the ability to produce healthy offspring.
- **Teratogenic effects:** effects on unborn offspring, such as birth defects.
- **Carcinogenic effects:** produces cancer in living animal tissues.
- **Oncogenic effects:** tumor-forming effects (not necessarily cancerous.)
- **Mutagenic effects:** permanent effects on genetic material that can be inherited.
- **Neurotoxicity:** poisoning of the nervous system, including the brain.
- **Immunosuppression:** blocking of natural responses of the immune system responsible for protecting the body.

In addition to being acute or chronic, toxic effects can be any of the following:

- **Local or systemic** (Both effects can occur with some pesticides.)
- Local effects refer to those that take place at the site of contact with a material. Examples of this include: skin inflammation on the hand, in response to hand contact with a pesticide; or irritation of the mucous membrane lining the lungs, due to inhalation of toxic fumes.
- Systemic effects are quite different because they occur away from the original point of contact. Systemic effects may occur when pesticides are distributed throughout the body, or "system". An example of a systemic effect is the blocking of an essential chemical of the nervous system, called "cholinesterase" (pronounced ko-li-nes-ter-ace), upon exposure to some types of pesticides.
- **Immediate or delayed** (Both effects can occur with some materials.)

- Immediate toxic effects are those which are experienced upon or shortly after exposure. (For example, a sneezing attack in response to inhaling pesticides during mixing).
- Delayed effects occur after some time has passed. While they may not be obvious, such as long term reproductive effects, delayed effects can result from a single exposure. Tumors may not be observed in chronically exposed people for 20 to 30 years after the original exposure to a cancer-causing or "carcinogenic" chemical.
- **Reversible or irreversible**
- Reversible effects are not permanent and can be changed or remedied. Skin rash, nausea, eye irritation, dizziness, etc. are all considered reversible toxic effects. Injury to the liver is usually reversible since this organ has an ability to regenerate itself.
- Irreversible effects are permanent and cannot be changed once they have occurred. Injury to the nervous system is usually irreversible since its cells cannot divide and be replaced. Irreversible effects include birth defects, mutations, and cancer.

3.2 Routes of Entry of Pesticides

There are three specific ways in which pesticides may enter your body. You may be poisoned no matter how they enter. Sometimes you can even be poisoned without knowing it, especially if the pesticide enters through the skin or lungs.

3.2.1 Dermal Route

Wet, dry, or gaseous forms of pesticides can be absorbed through the skin. This may occur if pesticides are allowed to get on the skin while mixing or applying or if pesticide-contaminated clothing is not removed promptly and properly cleaned before being worn again. Oil or paste forms allow greater absorption through the skin than water-based pesticides. Some pesticides do not pass through the skin very readily. Others are quickly absorbed through the skin and can be as dangerous as if they were swallowed. Skin varies in its capacity to act as a barrier to pesticide absorption. The eyes, ear drums, scalp and groin area absorbs pesticides more quickly than other areas on the body. Damaged or open skin can be penetrated by a pesticide much more readily than healthy, intact skin. Once they are absorbed through skin, pesticides enter the blood stream and are carried throughout the body.

3.2.2 Inhalation Route

Whether as dusts, spray mist, or fumes, pesticides can be drawn into your lungs as you breathe. Inhalation of pesticides can occur during the mixing of wettable powders, dusts, or granules. Poisoning can also occur while fumigating or spraying without a self-contained breathing apparatus or a proper respirator in enclosed or poorly ventilated areas such as greenhouses, apartments, or grain bins. The largest particles that are inhaled tend to stay on the surface of the throat and nasal passages, and do not enter the lungs. Smaller particles can be inhaled directly into the lungs. The number of particles needed to poison by inhalation depends upon the concentration of the chemical in the particles. Even inhalation of dilute pesticides can result in poisoning. Once they are absorbed through the surfaces of the lungs, chemicals enter the blood stream and are distributed to the rest of the body.

3.2.3 Oral Route

Pesticides can enter the body through the mouth (also called ingestion). This can occur when hands are not properly washed before eating or smoking. They may be swallowed by mistake, if they are improperly stored in food containers. Ingested materials can be absorbed anywhere along the gastrointestinal tract; the major absorption site is the small intestine. Once absorbed, they eventually enter the blood stream by one of several means, and circulate throughout the body.

Which Route Is More Important?

You can be poisoned no matter which way pesticides enter your body. While there are few chemicals that are equally poisonous by all routes of entry, some pesticides can enter all three ways and poison you. (For example, parathion is toxic regardless of how it is absorbed).
The dermal and inhalation routes of pesticide entry are likely to be the most important routes of pesticide applicator exposure. It is unlikely that you would purposely eat or drink the chemicals you are using, but you may breathe them in, splash them on your skin, or expose yourself to pesticide "fallout."

Healthy skin can slow the absorption of a pesticide when dermal contact occurs. Liquid pesticides containing solvents and oil based pesticides are absorbed quickly compared to dry pesticides. The applicator must know that damaged skin (chapped, cut, or abraded) has lost its ability to slow the entry of a pesticide into the body.

3.3 Determination of Pesticide Toxicity

Acute Toxicity

Acute toxicity is determined by examining the dermal toxicity, inhalation toxicity, and oral toxicity of test animals. In addition, eye and skin irritation are also examined. Acute toxicity is measured as the amount or concentration of a toxicant (the a.i.) required to kill 50 percent of the animals in a test population. This measure is usually expressed as LD_{50} (lethal dose 50) or LC_{50} (lethal concentration 50). To measure acute toxicity of a pesticide, a specific dose/quantity of a pesticide is given (orally or dermally) to a group of laboratory animals. The test animals should be of the same species, same age and averagely of the same size and be confined/caged under the same laboratory condition. The test animals are observed for a period of 14 days for changes.

Lethal Dose Fifty (LD_{50})

The commonly used term for measuring acute toxicity is "Lethal Dose Fifty" (LD_{50}) or deathly amount. The subscript 50 means the amount of a pesticide that will kill half (50%) of the animals in the laboratory administered the pesticide dose. The LD_{50} is found for both dermal and oral routes of exposure. For example, an acute oral LD_{50} indicates the amount of pesticide swallowed that has killed half of the animals tested.
The smaller the LD_{50} value, the less chemical required to kill half of the test animals and the more poisonous the pesticide. So, a pesticide with a dermal LD_{50} of 25 (rabbit) is more poisonous than a pesticide with a dermal LD_{50} of 2000 (rabbit).
LD_{50} values are generally expressed on the basis of active ingredient (a.i.). The LD_{50} is also expressed as milligrams per Kilogram (mg/Kg), which means milligrams of the pesticide per Kilogram of body weight of the animal. The LD_{50} value refers to the number of milligrams of pesticide that was needed to kill half of the test animals for each kilogram of the animal's body weight. For example, an acute oral LD_{50} of 5 mg/kg for pesticide A (rats) indicates that it is toxic when there are 5 mg of this chemical given orally for every kilogram of the animal's weight. Milligram (mg) per Kilogram (Kg) is the same as parts per million (ppm). One part per million (ppm) means that for every million parts of a solution or mixture, there is one part of the substance (pesticide) being measured. The measures mg/kg and ppm are used interchangeably because a milligram is one millionth of a kilogram (parts per million (ppm) = 1 milligram (mg)/kilogram (kg). Other measures that you might come across when looking at the toxicity of a pesticide include: "parts per billion" (ppb) and "parts per trillion" (ppt).

Lethal Concentration Fifty (LC_{50})

To measure out the "acute inhalation toxicity" of a pesticide, scientists add a known amount of the pesticide to air. The amount that causes half of the animals to die is the "Lethal Concentration Fifty" (LC_{50}) of the pesticide. Concentration is used instead of dose because the amount of pesticide inhaled from the air is what is being measured. The lower the LC_{50} value, the more poisonous the pesticide. Lethal Concentration Fifty is measured in milligrams per liter (mg/l) or ppm and sometimes in milligrams per cubic meter (mg/m3).

Chronic Toxicity Measures

There is no standard measure like LD_{50} for chronic toxicity studies. The chronic toxicity of a pesticide is determined by subjecting test animals to long-term exposure to the active ingredient. Any harmful effects that occur from small doses repeated over a period of time are termed chronic effects. Often the length of the experiment is in days, months, or years and the amount of each dose is stated. For example, a study of chronic oral toxicity might look like this: " 8 milligrams of pesticide were fed to rats daily for two years. No symptoms of poisoning appeared." Some of the suspected chronic effects from exposure to certain pesticides include birth defects, production of tumors, blood disorders, and neurotoxic effects (nerve disorders). The chronic toxicity of a pesticide is more difficult to determine through laboratory analysis than acute toxicity. Two classes of pesticides, the organophosphates and carbamates, can slowly poison by attacking an essential body chemical called "cholinesterase". The chronic exposure to organophosphate pesticides can be measured by monitoring changes in blood cholinesterase levels. In humans, decreased blood cholinesterase levels are a sure sign that exposure to these types of pesticides should be avoided until the level is measured as being normal again. Thus, it is advisable for people working with pesticides to go for routine cholinesterase level check in the hospital.

Based on the LD_{50} and the results of other acute tests, each pesticide is classified into a "toxicity category" and given an associated "signal word". A signal word must appear on every product label so that pesticide users are alerted to the pesticide's acute toxicity. Toxicity categories are based on the acute oral, dermal, and inhalation toxicities, as well as eye and skin irritation effects of each pesticide.

The following table indicates the four categories of pesticide toxicity:

Categories of Acute Toxicity

Category	**Signal Word Required on Label**	**Oral LD50 Mg/kg**	**Dermal LD50 mg/kg**	**Inhalation LC50 mg/l**	**Approximate Oral dose that can Kill an Average Person**
Highly toxic Class I	DANGER-*[Poison! Skull Crossbones]	From 0 to 50	From 0 to 200	From 0 to 0.2	A few drops to 1 teaspoon full [or a few drops on the skin]
Moderately Toxic Class II	WARNING!	From 50 to 500	From 200 to 2000	From 0.2 to 2	Over 1 teaspoonful to 1 ounce
Slightly Toxic Class III	CAUTION!!	From 500 to 5000	From 2000 to 20,000	From 2.0 to 20	Over 1 ounce to 1 pint or 1 pound
Relatively Non-toxic Class IV	CAUTION!!	More than 5000	More than 20,000	Greater than 20	Over 1 pint or 1 pound

* Not used for skin and eye irritation effects.
Insecticides can be classified according to their toxicity based on the LD_{50} values:

1. HighIy toxic

Acute orally (AO) LD_{50} = 0-50 mg/kg
Acute dermally (AD) LD_{50} = 0-200 mg/kg
Inhalation tests (IT) LD_{50} = 0-2000 ug/l
Danger, skull and crossbones and poison on label.

2. Moderately toxic

Acute orally (AO) LD_{50} = 51-500 mg/kg
Acute dermally (AD) LD_{50} = 201-2000 mg/kg
Inhalation tests (IT) LC_{50} = 2,001-20,000 ug/l
Warning on label.

3. Slightly toxic

Acute orally (AO) LD_{50} = 501 -5000 mg/kg
Acute dermally (AD) LD_{50} = 2000-20,000 mg/kg
Inhalation tests (IT) LC_{50} = more than 20,000 ug/l

4. Relatively non-toxic

Acute orally (AO) LD_{50} = 5000 + mg/kg
Acute dermally (AD) LD_{50} = 20,000 + mg/kg

4.0 CONCLUSION

The toxicity of a substance is its capacity to cause injury or illness to a living system. All pesticides must be toxic, or poisonous, to be effective against the pests they are intended to control. Because pesticides are toxic, they are potentially hazardous to humans, animals, other organisms, and the environment.

5.0 SUMMARY

Pesticides are categorized on the basis of their relative acute toxicity (their LD_{50} or LC_{50}values). **Toxicity Category/Class I** are classified as highly toxic on the basis of either oral, dermal, or inhalation toxicity must have the signal words DANGER and POISON printed in red with a skull and crossbones symbol prominently displayed on the front panel of the package label. **Toxicity Category/Class II** are considered moderately toxic must have the signal word WARNING and displayed on the product label. **Toxicity Categories/Classes III and IV** are classified as either slightly toxic or relatively nontoxic respectively and are required to have the signal word CAUTION on the pesticide label.
There are two types of toxicity namely acute and chronic toxicity. Acute toxicity is measured as the amount or concentration of a toxicant (the a.i.) of pesticide required to kill 50 percent of the animals in a test population and it expressed as LD_{50} (lethal

dose 50) or LC_{50} (lethal concentration 50). The LD_{50} is also expressed as milligrams per Kilogram (mg/Kg), which means milligrams of the pesticide per Kilogram of body weight of the animal. The chronic toxicity of a pesticide is determined by subjecting test animals to long-term exposure to the active ingredient. Some of the suspected chronic effects from exposure to certain pesticides include birth defects, production of tumors, blood disorders, and neurotoxic effects (nerve disorders).

6.0 TUTOR-MARKED ASSIGNMENT

1. Mention three signal words that are used to express pesticide toxicity.
2. Name two types of pesticide toxicity.

7.0 REFERENCES/FURTHER READING

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MODULE 3

MODULE 3 PESTICIDES APPLICATION IN STORED PRODUCE PROTECTION

UNIT 1 PRINCIPLES OF PESTICIDES APPLICATION

CONTENTS

1.0 INTRODUCTION

Despite the increase in food production due to technological advances in agriculture, enormous quantities of harvested food are wasted due to inadequate protection of stored products. According to an FAO estimate, the loss due to insect infestation is about 10 per cent or more in developing countries. The losses can be potentially greater now with the increasing attention being given to the establishment of national and international buffer stocks of foodstuff to guard against irregularities in production due to the unpredictable climatic conditions.

The popular outcry against the use of synthetic pesticides is agriculture cannot overshadow the necessity of their use nor can any speedy decline in their use be foreseen, so that protection of the consumers of treated produce and education of the users of the chemicals is imperative. Chemical pest control methods, if carried out intelligently and knowledgeably, can be both effective and safe. It is extremely important for users to have knowledge of the classification, mode of action, properties, metabolism and residues of the pesticides, to enable them to make proper appraisal of the benefits and potential hazards of the pesticides. Thus, they should be able to choose insecticides judiciously and formulate efficient control measures in any particular set of circumstances.
Pesticide application refers to the practical way in which pesticides are delivered to their *biological targets* (*e.g.* pest organism, crop or other plant). Public concern

about the use of pesticides has highlighted the need to make this process as efficient as possible, in order to minimize their release into the environment and human exposure (including operators, bystanders and consumers of produce).

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Know the control techniques of Pest in stored produce
- Know the various classes of pesticides stored produce protection
- Know the characteristics of pesticides used in stored produce protection

3.0 MAIN CONTENT

3.1 Pest Control in Stored Produce

Various techniques are used to control insect pests in stored produce-from sunning and smoking on the traditional farm to irradiation in large-scale bulk handling. Special recommendations are difficult to make. A technique must be tested for a particular situation, since it may become inappropriate as a result of changes in:

(a) economics (the value of the product, relative to the cost of materials and labour);
(b) pest problems (such as occurrence and resistance); and
(c) techniques within the farming system or through the availability of new products.

Therefore, it is important to consider both:

(a) economics; and
(b) technical specifications for effectiveness against target pests and hazards to farmer and consumer.

Will the improvement resulting from the use of a control technique pay for the cost of carrying it out? This question can only be answered satisfactorily by field trials supported by an effective loss assessment.

Insect control in sacks stored in warehouses

There are three common chemical methods for controlling insects in sacks stored in a warehouse:
(a) admixture of insecticidal dusts with the produce before loading it into the sack;
(b) the spraying of successive layers of sacks with liquid insecticides or dusts as the stack is built; and
(c) enclosing a fumigant with the sacks under a gas-proof sheet.

The admixture of insecticidal dusts can be very effective if a suitable insecticide is used. Recently, some synthetic pyrethroids and pirimiphos methyl dust, applied at rates of between 2.5 ppm and 15 ppm active ingredient (depending on the insecticide), have been found to completely eliminate insects in stored bags for at least eight months.

Mixing of the dusts with the grain can be done in various ways, such as shovel mixing on a tarpaulin, or, for large-scale operations, a drum with an eccentric axle is used.

The admixture of dusts with stored grain gives rise to a potential health hazard and is not to be recommended, unless a very safe insecticide is used and the grain is only to be consumed after a prolonged period in storage.

Spraying or dusting successive layers of sacks with insecticides (as shown) is less hazardous to humans, but is not always effective. Recently, however, pirimiphos-methyl (as emulsifiable concentrate, Actellic 50 EC) was applied undiluted (50 EC) at the rate of two to three strokes per bag with a simple domestic applicator; and it largely eliminated weevils from heavily infested sacks of maize and kept the population at a very low level even after eight months. But there is always a danger in applying undiluted insecticides.

Ultimately, the most satisfactory method of insect elimination and control in bagged grain is by fumigation. A gas is released among bags covered by a gas-proof sheet, which is held down by "sand snakes" or a heavy chain wrapped in hessian. The sheeted stack is left for at least three days.

For relatively small-scale storage (100-300 tonnes) the most convenient fumigant to use is Aluminium phosphide, which releases phosphine gas when it absorbs moisture. One tablet of the fumigant for every two bags is recommended, provided the stack is of a size that will be hermetically enclosed within two hours. Phosphine and other fumigant gases may also be used effectively for larger quantities of grain.

3.2 Pest control techniques in stored produce

Sanitation. It is crucially important to reduce the initial pest population and prevent development of any insect pests in the crop products. Before bringing a new crop into store, the following steps are necessary.

(a) Remove infested material. Do not mix new grain with old; old material that must be kept should be thoroughly fumigated.
(b) Clean the storage structure.

- brush away all traces of spilled grain, dust, etc.;
- remove dust from handling equipment and machinery;
- disinfect sacks and baskets by sunning or chemical treatment; and
- be aware of the following specifications:
- large structures usually require chemical treatment; and
- small rural structures can be cleaned by using smoke, and making use of the sun and rain-after some time insects will usually leave a clean empty crib or rumbu.

Take control measures early to prevent infestation of crops maturing in the field.

Natural resistance. Crop varieties differ in their susceptibility to storage pests.

Traditional varieties are usually more resistant to storage pests than new varieties. If new varieties are introduced, measures must be taken to improve storage techniques and pest control.

Some new varieties of maize and cowpea are now being selected for improved storage resistance and they are now becoming commercially available.

There are some useful general resistant characteristics in the following crop varieties:

(a) maize: good husk cover can reduce field infestation, and storing in the husk reduces the rate of pest increase;
(b) sorghum: varieties where the glumes cover the grain tend to be more resistant before threshing;
(c) rice: paddy rice is considerably more resistant to pests than milled rice;
(d) cowpeas: intact dry pods provide some protection against bruchids; if fumigation or airtight storage is impracticable, cowpeas are better stored unthreshed;
(e) cereals: grain hardness affects resistance.

Hermetic or sealed storage. In airtight conditions, reduced oxygen and increased carbon dioxide will eventually arrest insect and mould development.

Grain for human consumption or seed must be dry; in damp grain bacterial and enzymatic action will continue, causing tainting and loss of viability.

Bagged material must be protected; if the seal is broken (by insects, rodents or careless handling) the grain is unprotected and unventilated, and losses may be severe.

A method that has been found satisfactory in North Nigeria (a dry area) is that of storing threshed cowpeas in sealed plastic bags with cotton liners; the cotton prevents emerging insects from perforating the plastic bag.

Chemical control: Methods of using insecticides on stored products are: dusting, spraying and fumigation.

Insecticidal dusts. The method of dispersing dusts usually involves using an admixture of dilute dust at 2.5- 15 ppm active ingredient, depending on the insecticide, at the time of loading/bagging.

The appropriate quantity of dust is measured into a perforated tin or punctured plastic bag and sprinkled onto the produce layer by layer. For bulk grain the dust is mixed more effectively by shaking in a tin with the produce, shoveling on a groundsheet or mixing in a revolving drum. For larger-scale operations commercial devices are available.

There are several problems with this type of insecticide.

Applications of dusts include use in cribs and bulk stores but they are more effective in the cribs. They are also only suitable for dry conditions.

(a) It is difficult to obtain accurate dosage and a thorough admixture.
(b) Application can only be carried out at loading, when it makes an extra demand on labour; so it is often not properly done.
(c) Breakdown of the active ingredient can be particularly serious with local formulations in which the carrier is not sufficiently "inert"; no scope exists for reapplication.
(d) Insect resistance depends on the insecticide used and the insect species, rather than on the formulation.
Among suitable chemicals are the established (malathion, lindane/gamma BHC) and the potentially better (pirimiphos-methyl, synthetic pyrethroids).

Insecticidal sprays. The method of using sprays is to allow 10-15 ppm active ingredient (ai), contained in the minimum of water necessary to give an even coverage (about 0.3-2 l/tonne, depending on the applicator). Such a small quantity of water will not cause moulding. The insecticide can be applied with a small domestic applicator (Shell/ox-type), but a knapsack sprayer reduces labour requirements.

Application of sprays differs with the type of storage facility used. In warehouses, the following procedures are used.

(a) Bagged produce. Each layer of bags is sprayed as the stack is built; this should give protection for several months, but in case of reinfestation, the stack should be re-sprayed and fumigated for effective penetration.

(b) Space spraying. A non-persistent insecticide is sprayed to kill the adults of flying insects, especially warehouse moths; used in conjunction with fumigation under sheets.

(c) Fogging. For the same purpose, an electric applicator delivers very fine droplets, which hang in the air, maximizing effectiveness.

(d) Surface treatment. A persistent insecticide is sprayed on walls, roof and floor of the storage structure.

In cribs, the insecticide is sprayed directly onto the produce. If there is significant field infestation it is advantageous to spray each basketful during loading; otherwise, insecticides should be applied to the outside of the crib after loading, and reapplied at intervals as necessary (monthly is suggested).

Problems with sprays include the following:

(a) breakdown of chemicals in the highly ventilated crib environment (although this implies a minimum residual toxicity for consumers);
(b) poor penetration with some types of structures; and
(c) lack of availability of sprayers and suitable chemicals.

Among suitable chemicals are the synthetic pyrethroids, usually used for space-spraying and/or control of the larger grain borer; dichlorvos for automatic fogging (Note: this is highly toxic to mammals); and malathion or pirimiphos methyl for general use (since it costs less and has lower toxicity).

Fumigation. Methods include fumigating produce in containers, or fumigating surfaces. The produce is placed in drums, plastic bags under tarpaulins or plastic sheets. After addition of the chemical, the produce must be kept in airtight conditions for at least three days for Phostoxin or about one day for Ethylene Dibromide, depending on the doses applied. For fumigation of stacks in warehouses, it is necessary to spray the roof and walls simultaneously to prevent re-infestation. Grains must be protected from subsequent re-infestation. Applications of fumigants differ with the type of crop they are used on. They are indispensable for export crops such as groundnuts, coffee and cocoa. At the small-farm level, fumigation might be justifiable for seed material of high-value crops such as grain legumes. Fumigants can be very dangerous if incorrectly used; they should not be used in domestic living quarters. Another problem is that they have no residual action.

There are two types of formulation of chemicals used in fumigation.

(a) Phosphine gas (e.g. Phostoxin) is supplied as tablets of aluminium phosphide, which release phosphine on contact with moisture in the air. It is convenient to use, but requires airtight conditions for three to four days for total kill, and longer in cool conditions.

(b) With ethylene dibromide, methyl bromide, and carbon tetrachloride there are various combinations and formulations available (e.g. Trogocide). All are volatile liquid fumigants. Capsules and sachets are available for small scale applications and pressure cylinders for large-scale ones. They are difficult to use and there is some residual toxicity and a possible consumer hazard: a shorter time is required for fumigation-normally less than one day-depending on the formulation used. Not recommended for farm- or village-level use, and only to be carried out by trained personnel.

Insecticides usually show some degree of toxicity to humans, domestic animals, poultry, etc. and must be used with caution. Be sure to:

(a) read the manufacturers' instructions;
(b) choose a chemical with low toxicity to mammals and birds;
(c) stay within the recommended dosage; and
(d) protect workers with careful instruction, constant supervision and provision of protective clothing.

Insecticides are usually specific, and do not kill all insects and mites; choose a chemical approved for use in stores and/or on stored products that has either a "broad spectrum" or specific toxicity to moths and beetles. Mites may require special treatment.

Insecticides tend to lose their persistence, or effectiveness, with: high humidity, high temperatures, sunlight, and time. Stored chemicals must be protected from these factors to ensure their continued effectiveness. In stored products, long-persistence insecticides give long protection against pests, but increase the risk to the consumer. Insecticides vary widely in their persistence. Choose one appropriate to the job: for example, persistent chemicals for the treatment of storage structures, non-persistent ones for space-spraying. Insects can develop physiological and behavioural resistance to insecticides. Excessive or inappropriate use of chemicals will lead to the insects becoming resistant; therefore, use the right dose and use insecticides only when strictly necessary.

3.3 Classification and characteristics of stored produce pesticides

Insecticides are classified according to their mammalian toxicity, chemical origin or composition, mode of entry, and formulation.

Mammalian Toxicity

Toxicological studies are conducted to determine the threshold limit of a chemical which an animal or human is capable of handling without significant biological effects. The usual beginning in any toxicological evaluation is the assessment of the acute toxicity, i.e. the effects of a single dosage of the chemical. The general technique is the determination of the LD_{50} (the dosage necessary to produce death or reproducible effect in 50% of the animal population tested). The compound is administered on a weight/weight basis (milligram or gram of compound per kg of body weight of test animals) in a suitable solvent or suspension system. This is evaluated by acute tests, orally (AO) or dermally (AD); chronic oral tests (CO), Vapor toxicity tests (VA) and chronic vapors tests (VC) or inhalation tests (IT).

Generally, the insecticide used in stored product treatment is of low mammalian toxicity in a formulation that is likely to be effective against the species involved, persistent for the required period of time under given storage conditions and will not alter the flavor, color and odor of the stored commodity.

Chemical Origin and Composition

Botanicals - The toxic principles are extracted from plants such as pyrethrum from the flowers of *Chrysanthemum cinerariafolium* and *C. cocciniu*. It has remarkable low toxicity to mammals but toxic to insects.

Synthetic insecticides - They are syntihesized in the laboratory and are classified into three main groups: the organochlorine, organophosphates, and carbamates.

Organochlorines - These are chlorine (C1) - containing compounds further subdivided into DDT type, Hexachloro-cyclohexane type and Cyclodicnes. Most of them are quite toxic to man and are not used on stored food commodities.

Organophosphates - This is a generic term for all pesticides containing phosphorus which can be an ester of phosphoric acid (P = 0) or phosphorothioate acid (P = S). The organophosphorus compounds, however, decompose rapidly and recent advances in understanding the mechanisms of selective toxicity of insecticides such as malathion have led to safer insecticides such as malathion, bromphos, pirimiphos methyl, chlorpyrifos methyl, etc.

Carbamates - These are esters of carbamic acid, HOC (O) NH2 .This contains compounds of high to low mammalian toxicity such as carbaryl and have so far shown limited application in stored product pest control.

Mode of Entry

Insecticides can be divided into three main groups depending upon the way they penetrate into the body of the insect.

Contact insecticides - These insecticides are applied in such a manner that they come in contact with some part of the body of the insect; the compound is able to penetrate the exoskeleton and is transported to the tissues via the circulatory system. Most of the insecticides used in storage belong to this group. The inert insecticidal dusts which disrupt the thin epicuticle leading to the desiccation and death of the insect are included in this group.

Systemic insecticides - These are translocated to the untreated parts of plants or animals in concentration that makes the final translocation site toxic to insects. These are not used in stored product pest protection.

Fumigants - These are insecticidal gases at normal temperatures penetrating through the tracheal system into body tissues and are used in enclosed spaces. Examples are phosphine and methyl bromide. Some contact insecticides like Aluminium phosphide (Phostoxin), Pirimiphos methyl (Actellic EC or Dust) and Dichlorvos, vaporize partially in warm ambient conditions, thus having fumigant and contact actions.

Mode of Action

Physical insecticides - These materials such as the heavy mineral oils and inert dusts, characteristically exert a physical rather than a biochemical action. Mineral oils exert a purely asphyxiant effect and dusts affect loss of body moisture by abrasion (aluminum oxide) or by absorbing moisture (wood ash and charcoal).

Usage in Stored Grain

Insecticides used on or around grain may be classified based on usage:

1. Knock down agents - i.e. Dichlorvos
2. Surface sprays - i.e. Bioresmethrin
3. Structural treatment - i.e. Fenitrothion
4. Grain protectants - i.e. Malation
5. Fumigants - i.e. Aluminum Phosphide, Pirimiphos methyl, Chlorpyrifos methyl, etc.

4.0 CONCLUSION

Pesticide application refers to the practical way in which pesticides are delivered to their *biological targets* (*e.g.* pest organism, crop or other plant). There are three common chemical methods for controlling insects in sacks stored in a warehouse: (a) admixture of insecticidal dusts with the produce before loading it into the sack; (b) the spraying of successive layers of sacks with liquid insecticides or dusts as the stack is built; and (c) enclosing a fumigant with the sacks under a gas-proof sheet. The most satisfactory method of insect elimination and control in bagged grain is by fumigation. A gas is released among bags covered by a gas-proof sheet, which is held down by "sand snakes" or a heavy chain wrapped in hessian. The sheeted stack is left for at least three days.

Pest control techniques include Sanitation; Natural resistance; Hermetic or sealed storage; Chemical control e.g. Fumigation, Dusting, Residual spray, etc. Insecticides used in stored product treatment are of low mammalian toxicity in a formulation that is likely to be effective against the species involved, persistent for the required period of time under given storage conditions and will not alter the flavor, color and odor of the stored commodity.

Insecticides used on or around grain may be classified based on usage: Knock down agents - i.e. Dichlorvos; Surface sprays - i.e. Bioresmethrin; Structural treatment - i.e. Fenitrothion; Grain protectants - i.e. Malation; Fumigants - i.e. Aluminum Phosphide, Pirimiphos methyl, Chlorpyrifos methyl, etc.

5.0 SUMMARY

The three common chemical methods for controlling insects in sacks stored in a warehouse are admixture of insecticidal dusts with the produce before loading it into the sack; the spraying of successive layers of sacks with liquid insecticides or dusts as the stack is built; and enclosing a fumigant with the sacks under a gas-proof sheet (Fumigation). Pest control techniques include Sanitation; Natural resistance; Hermetic or sealed storage and Chemical control. Insecticides used on or around grain may be classified based on usage: Knock down agents; Surface sprays; Structural treatment; Grain protectants; and Fumigants.

6.0 TUTOR-MARKED ASSIGNMENT

1. Mention four (4) control techniques for stored produce pests.
2. Name two commonly used fumigants in stored produce protection

7.0 REFERENCES/FURTHER READING

CHAMP, B.R. and C.E. DYTE. 1976. Report of the FAO Global Survey of Pesticide Susceptibility of Stored Grain Pests. FAO Plant Protection and Production Series, No. 5. Rome, FAO, 297 p.

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UNIT 2 SIGNIFICANCE OF DROPLET SIZE

CONTENTS

1.0 INTRODUCTION

Droplet size is highly important if pesticides are to be applied efficiently with minimum contamination of the environment. Pesticidal sprays are generally classified according to droplet size. Sprays contain a large number of droplets, i.e. very small spheres of liquid, mostly less than 0.5 mm in diameter. Aerosol sprays are used principally for drift spraying against flying insects. Some aerosols (30-50 μm) and mists are ideal for treating foliage with Very Low Volume (VLV) and Ultra Low Volume (ULV) rates of application. When drift must be minimized a medium or coarse spray is required, irrespective of volume applied. A fine spray is used when compromise between reduced drift and good coverage is needed.

When choosing a given droplet size for a particular target, consideration must be given to the movement of spray droplets or particles from the application equipment towards the target. The magnitude of the effect of gravitational, meteorological and electrostatic forces on the movement of droplets is influenced by the size of the droplets. When the volume of spray applied is reduced, there is effective coverage to control a sessile pest with a large number of small droplets.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Know the factors affecting movement of pesticide droplets
- Know the types of nozzles used in applying pesticides

3.0 MAIN CONTENT

3.1 Factors affecting movement of pesticides droplets

Movement of droplets

Effect of evaporation: The surface area of the spray liquid is increased enormously when broken into small droplets, especially when the diameter of the droplets is less than 50 μm. A droplet will lose any volatile liquid over this surface area. The rate of evaporation decreases as the evaporation from a droplet saturates the surrounding air. Changes in the concentration of spray due to non-volatile ingredients may depress the vapour pressure of the solvent. The disadvantage of water, the principal diluent of pesticidal sprays and many of the organic solvents used in emulsifiable concentrates, is that it is volatile. The size of small droplets of water-based sprays decreases rapidly, leaving an aerosol droplet of involatile material or a particle even in temperate conditions of 20^0C with 80% relative humidity. The speed at which droplet size decreases is faster, under tropical conditions at a higher temperature and lower humidity.

Effect of gravity: A droplet released in still air will accelerate downwards under the force of gravity until the gravitational force is counterbalanced by aerodynamic drag forces when the fall will continue at a constant terminal velocity. Terminal velocity is normally reached in less than 25 mm by droplets smaller than 100 μm diameter, and 70 cm for a 500 μm droplet. The size, density and shape of the droplet, and the density and velocity of the air all affect terminal velocity. The most important factor affecting terminal velocity is droplet size. Owing to their low terminal velocities, droplets less than 30 μm diameter will take several minutes to fall in still air. Small droplets are thus exposed for a longer period to the influence of air movements.

Effect of meteorological factors: The proportion of spray which reaches the target is greatly influenced by local climatic conditions, so an understanding of the meteorological factors affecting the movement of droplets necessitates information on the climate close to the groundnut. The basic factors are temperature, wind velocity, wind direction and relative humidity. Air temperature is affected by atmospheric pressure which decreases with height above ground level, so that if a mass of air rises without adding or removing heat, it expands and cools.

Droplet dispersal: A droplet will follow the resultant direction depending on the combined effects of gravity, mean wind velocity and turbulence which can be upward when convection forces prevail. This can be seen when spray is drifted over several rows during unstable conditions. A large proportion of the spray may not be collected within the crop being treated. Peak deposition of small droplets downwind is proportional to the height of the nozzle and inversely proportional to the intensity of turbulence, whereas larger droplets are relatively unaffected by turbulence.

3.2 Types of Nozzles

Nozzles

A nozzle is the end of a pipe through which liquid can emerge as a jet. It is any device through which spray liquid is emitted, broken up into droplets and dispersed at least over a short distance. Nozzles are classified according to the energy used, e.g. hydraulic, gaseous, centrifugal, kinetic and thermal.

Impact nozzle: a fan-shaped spray pattern is produced. Droplets produced by this type of nozzle are large. The impact nozzle is normally operated at low pressures and is widely used for herbicide application to reduce the number of small droplets liable to drift. When applying herbicides, the spray is normally directed downwards. They are also called flooding, anvil or deflector nozzles. They are used in applying nematicides, herbicides and systemic insecticides in orchards and into irrigation water.

Fan nozzles: They are suitable for spraying flat surfaces like the soil surface and walls. They have been widely used on conventional tractor and aerial spray booms and on compression sprayers for spraying huts to control mosquitoes.

Cone nozzle: Cone nozzles are widely used for spraying foliage because droplets approach leaves from more directions than in the single plane produced by flat fan.

4.0 CONCLUSION

Droplet size is highly important if pesticides are to be applied efficiently with minimum contamination of the environment. Pesticidal sprays are generally classified according to droplet size. Several factors affect movement of droplet sizes including Effect of evaporation; Effect of gravity; Effect of meteorological factors; and Droplet dispersal.
A nozzle is any device through which spray liquid is emitted, broken up into droplets and dispersed at least over a short distance. Nozzles are classified according to the energy used, e.g. hydraulic, gaseous, centrifugal, kinetic and thermal. They may be Impact nozzle which produce a fan-shaped spray pattern is produced. Droplets produced by this type of nozzle are large and they are operated at low pressures and widely used for herbicide application to reduce the number of small droplets liable to drift; Fan nozzles which are suitable for spraying flat surfaces like the soil surface and walls or Cone nozzle which are widely used for spraying foliage because droplets approach leaves from more directions than in the single plane produced by flat fan.

5.0 SUMMARY

A nozzle is a device through which spray liquid is emitted, broken up into droplets and dispersed over a short distance. Droplet sizes allow the application of pesticides efficiently with minimum contamination of the environment. Factors that affect movement of droplet sizes include evaporation; gravity; meteorological factors; and Droplet dispersal. Nozzles are classified according to the energy used, e.g.

hydraulic, gaseous, centrifugal, kinetic and thermal energy. They may be Impact nozzle; Fan nozzles or Cone nozzle

6.0 TUTOR-MARKED ASSIGNMENT

1. Mention four (4) factors that affect droplet sizes.
2. Name three types of pesticides application nozzles.

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UNIT 3 APPLICATION TECHNIQUES FOR CONTROL OF STORAGE PESTS

CONTENTS

1.0 INTRODUCTION

The choice of insecticide concentration, type and frequency of application depend on a variety of factors such as the species of pest present, the type of storage facilities, length of storage, local insecticide regulations, etc. Therefore, only certain generalized recommendations could be made. Pest control strategies must utilize combinations of techniques that are effective, economical and emphasize prevention of food product contamination. These strategies must be directed at immediate pest problems; at preventing future infestation problems; and must respond to routine daily needs, yet be flexible to meet emergency pest control situations. Stored-product pest control strategies tend to emphasize the non-chemical aspects of pest control with the judicious use of pesticides.

Unsatisfactory control of pests results in contaminated products that can cause health, financial, legal and aesthetic problems. Financial losses can result from (1) presence of live or dead insects in products and containers; (2) presence of odors, webbing and frass in products and containers; (3) loss in faith in the company by the consumer because of these conditions and (4) direct loss in weight resulting from insect feeding.

Control of stored-product pests is necessary to prevent contamination/adulteration of human foods. Persons involved in commodity/food storage, handling and/or processing have the responsibility to prevent food adulteration. Failure to do so can result in human illness and/or death, the violation of laws, loss of good will and resulting loss of revenue.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Explain the different methods of pesticides application
- Give examples of pesticides that could be used for each method

3.0 MAIN CONTENT

3.1 Types of pesticides application methods

3.1.1 Residual (Structural) Treatments

A residual spray is usually applied to inside surfaces of warehouses, storage bins, transport vehicles or other structural surfaces. A good residual spray should not only kill the insects but should deposit on the treated surface to kill walking insects. Application may be made during the cleaning of storage facilities before intake of new stocks or to fit in with fumigation or spraying of the stock in storage. It is important to make sure that corners, ledges, cracks and other places difficult to get at are treated. The effectiveness of the residual deposit will decrease with time. The effective life of the deposit depends on the insecticide used, the climatic conditions prevailing and the type of surface sprayed.
Examples are fenitrothion, malathion, synthetic pyrethroids, and chlorpyrifos methyl. Wettable Powders (WP) are generally more persistent than Emulsifiable Concentrates (EC) but are less easy to apply. For most surfaces it is preferable to use the dispersible WP formulations of insecticides especially for absorbent surface such as cement, brick, stone or white washed surfaces. EC may be used on non-absorbent surfaces like metal or painted wood. Insecticides are much more persistent on wood. Malathion is not very satisfactory on alkaline surfaces, e.g. whitewash, bare, concrete or cement, but it has been shown to be effective for over 20 weeks on plywood and fiber board and has remained active through 16 up to 52 weeks. Frequency of treatment depends partly on the insecticide used and partly on the infestation to be controlled. For example, Lindane and malathion treatments should be repeated at least every three weeks in tropical climates. Pyrethroid and carbaryl are more effective than OP against *R. dominica*, while OP are more effective against *Sitophilus* spp.

3.1.2 Space Treatment

Space spraying or fogging of the warehouse is used to control infestations of flying insects that are not controlled by residual treatments, and of flying pests migrating from outside. It has to be carried out frequently and at a time of day when the pests are most active which is generally at dusk. The insecticides used are those with knockdown action. Examples are pyrethrin sprays and aerosols with or without synergists, synthetic pyrethroids with or without synergists, lindane smoke or fog, dichlorvos aerosols and strips.

Aerosols may be dispensed from the household type canister, containing a mixture of liquefied gas and insecticide. The internal pressure "blasts" the insecticide into aerosol-sized droplets as the mixtures leave the nozzles. Slow release dichlorvos plastic strip hung inside the warehouse at a density of 1 strip/30 cu m. space is also recommended to kill flying moths.

3.1.3 Grain Protectants

Grain protectants are defined as pesticides which are incorporated directly into the grain mass to protect it against insect and mite attack. This is also known as admixture treatment. The insecticides used as grain protectants are of low mammalian toxicity and are generally safe to use and need only simple equipment for their application.

Grain protectants are usually applied as sprays directed into the grain stream during the movement of the grain or at the beginning of long-term storage. The most suitable equipment for spraying grain on a moving belt is a machine with an electrically operated pump, feeding in insecticide through a pressure regulating valve and a precision nozzle. Where a power supply is not available, a pressure retaining knapsack sprayer, equipped with a pressure regulating valve and precision nozzle, may be used. EC are normally used but the volume must not exceed 2.5 liters per 1000 kilos of grain to avoid any appreciable increase in moisture content. It is better applied through a precision apparatus. This is most efficient in bulk handling but could be practical in bag handling system. The use of small pumps with coarse spray nozzles and low pump pressure produce large spray droplets and gives good results while minimizing spray drift.

In the drip feed system, tiny quantities of the concentrate are dripped directly into the grain stream through micro-capillary tubes. For a small scale treatment of bulk or bagged grain dusts it is best to be admixed with simple mechanical aids (rotating drum, shoveling, etc.) but adequate mixing is difficult to achieve.

3.1.4 Fumigation

Fumigation is a widely used procedure particularly for the control of stored product insects because the fumigants diffuse and penetrate into places where other forms of control are impractical or impossible. A fumigant is defined as a chemical which, at a required temperature and pressure, can exist in a prescribed period of time. Fumigation is the process of applying the gas under appropriate conditions to control the target organisms.

Materials with suitable characteristics for fumigation are limited. These vary widely in chemical composition and properties. Consequently, the types of formulations, methods of handling, methods of analysis, and the purposes for which they are used vary considerably. The choice of fumigant depends largely on its ability to give effective and economical control of insects without adversely affecting the commodity.

All of the fumigants used to control pest organisms are toxic to human beings. They also may have other adverse properties - they may be highly flammable or corrosive; they may produce offensive odors; they may be phytotoxic; or they may leave harmful residues in food materials. Usually, adverse effects can be eliminated by choosing the most suitable fumigant for the particular treatment in question and by applying the proper methods of handling and use. A few of the fumigants are known to have or are suspected of having the potential for producing long-term chronic effects on human health and some are listed as carcinogenic. Appropriate precautions should be taken to avoid exposure to all fumigants and additional measures should be taken to prevent any contact carcinogenic compounds.

In applying a fumigant to a commodity, it is particularly important to carry out the operation in such a way that the insects are controlled without damaging the commodity and without creating any hazard for personnel. Effective methods of detection and analysis of the fumigant are especially important. Misuse or abuse of fumigants can lead to accidents that endanger human life or property, and consequently may give adverse publicity to the practice of applying chemicals to food commodities for insect control.

The most common fumigants that are extensively used throughout the world are Pirimiphos methyl (Actellic EC), Aluminium phosphide (Phostoxin) and Dichlorvos. Most usage involved is fumigation of bag stacks under gas-proof sheets and in bulk with recirculation of air. It is used where short exposure periods only are practical and grain has moisture content less than 11 %. FAO recommends 10 mg/kg body weight as acceptable daily intake. Phosphine is a very efficient fumigant and its use complements that of methyl bromide. It is preferred in horizontal bulks of grain that can be probed with tablets and vertical storage where methyl bromide cannot be used. Exposure during fumigation must be of adequate duration and at minimum concentration of gas. For cereals in international trade a tolerance of 0.1 ppm expressed as PH_3 is recommended.

3.1.5 Surface Sprays

Surface sprays are treatments applied to the surface of bulk grain or to the outer surfaces of bags. Examples are pyrethrum synergized with piperonyl butoxide, dichlorvos, malathion, pirimiphos methyl; chlorpyrifos methyl and tetrachlorvinphos.

Treatment of bag stacks. There are two methods of treatments: layer by layer (Sandwich method) and external stack treatment. The former method is also known as "sandwich" method where sprays or dusts are applied to each layer of bags during construction of a bag stack.

The external stack treatment usually consists of a spray application to the four sides and the top surface of a bag stack. This method is used to prevent re-infestation. Spraying is usually made immediately following a fumigation, or prior to sheeting in order to minimize the risk of cross infestation. Insecticides most commonly used for this purpose are malathion, primiphos-methyl and fenitrothion at 1-2%. Treatment of bag stacks are only capable of reducing infestations.

3.1.6 Sack Treatment

Sacks may either be sprayed (50 ml/m²) or dipped in insecticide solution before filling with the grains. Treated sacks should be air-dried after treatment. Malathion, pirimiphos-methyl, and chlorpyrifos methyl at 2-4% are very effective. At 2% malathion is only effective for 2-4 months while pirimiphos-methyi and chlorpyrifos methyl can be effective for 4-6 months. At 4% these two compounds can control infestation for 9-12 months.

4.0 CONCLUSION

Pest control strategies must utilize combinations of techniques that are effective, economical and emphasize prevention of food product contamination. These strategies must be directed at immediate pest problems; at preventing future infestation problems; and must respond to routine daily needs, yet be flexible to meet emergency pest control situations. Stored-product pest control strategies tend to emphasize the non-chemical aspects of pest control with the judicious use of pesticides.

5.0 SUMMARY

Pest control strategies must utilize combinations of techniques that are effective, economical and emphasize prevention of food product contamination. These strategies must be directed at immediate pest problems; at preventing future infestation problems; and must respond to routine daily needs, yet be flexible to meet emergency pest control situations. Stored-product pest control strategies tend to emphasize the non-chemical aspects of pest control with the judicious use of pesticides.
Unsatisfactory control of pests results in contaminated products that can cause health, financial, legal and aesthetic problems. Financial losses can result from (1) presence of live or dead insects in products and containers; (2) presence of odors, webbing and frass in products and containers; (3) loss in faith in the company by the consumer because of these conditions and (4) direct loss in weight resulting from insect feeding.

Control of stored-product pests is necessary to prevent contamination/adulteration of human foods. Persons involved in commodity/food storage, handling and/or processing have the responsibility to prevent food adulteration. Failure to do so can result in human illness and/or death, the violation of laws, loss of good will and resulting loss of revenue. A residual spray is usually applied to inside surfaces of warehouses, storage bins, transport vehicles or other structural surfaces. A good residual spray should not only kill the insects but should deposit on the treated surface to kill walking insects. Space spraying or fogging of the warehouse is used to control infestations of flying insects that are not controlled by residual treatments, and of flying pests migrating from outside. Grain protectants are defined as pesticides which are incorporated directly into the grain mass to protect it against insect and mite attack. The insecticides used as grain protectants are of low mammalian toxicity and are generally safe to use and need only simple equipment for their application. Fumigation is a widely used procedure particularly for the control of stored product insects because the fumigants diffuse and penetrate into places where other forms of control are impractical or impossible.

6.0 TUTOR-MARKED ASSIGNMENT

1. List five (5) methods used in application of pesticides to stored produce
2. Give two (2) examples of pesticides used for each method listed above

7.0 REFERENCES/FURTHER READING

CHAMP, B.R. and C.E. DYTE. 1976. Report of the FAO Global Survey of Pesticide Susceptibility of Stored Grain Pests. FAO Plant Protection and Production Series, No. 5. Rome, FAO, 297 p.

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UNIT 4 PRINCIPLES OF PESTICIDES APPLICATION FOR CONTROLLING FIELD PESTS

CONTENTS

1.0 INTRODUCTION

Despite the increase in food production due to technological advances in agriculture, enormous quantities of harvested food are wasted due to inadequate protection of stored products. According to an FAO estimate, the loss due to insect infestation is about 10 per cent or more in developing countries. The losses can be potentially greater now with the increasing attention being given to the establishment of national and international buffer stocks of foodstuff to guard against irregularities in production due to the unpredictable climatic conditions.

The popular outcry against the use of synthetic pesticides is agriculture cannot overshadow the necessity of their use nor can any speedy decline in their use be foreseen, so that protection of the consumers of treated produce and education of the users of the chemicals is imperative. Chemical pest control methods, if carried out intelligently and knowledgeably, can be both effective and safe. It is extremely important for users to have knowledge of the classification, mode of action, properties, metabolism and residues of the pesticides, to enable them to make proper appraisal of the benefits and potential hazards of the pesticides. Thus, they should be able to choose insecticides judiciously and formulate efficient control measures in any particular set of circumstances.

2.0 OBJECTIVES

- To know the various pest control techniques for field pests
- To know the types of pre-emergent and post-emergent pesticides used
- To the causes of spraying inefficiencies

3.0 MAIN CONTENT

This refers to the practical way in which pesticides, including herbicides, fungicides, insecticides, or nematode control agents) are delivered to their *biological targets* (*e.g.* pest organism, crop or other plant). Public concern about the use of pesticides has highlighted the need to make this process as efficient as possible, in order to minimise their release into the environment and human exposure (including operators, bystanders and consumers of produce).

Spray application

One of the most common forms of pesticide application, especially in conventional agriculture, is the use of mechanical sprayers. Hydraulic sprayers consist of a tank, a pump, a lance (for single nozzles) or boom, and a nozzle (or multiple nozzles). Sprayers convert a pesticide formulation, often containing a mixture of water (or another liquid chemical carrier, such as fertilizer) and chemical, into droplets, which can be large rain-type drops or tiny almost-invisible particles. This conversion is accomplished by forcing the spray mixture through a spray nozzle under pressure. The size of droplets can be altered through the use of different nozzle sizes, or by altering the pressure under which it is forced, or a combination of both. Large droplets have the advantage of being less susceptible to spray drift, but require more water per unit of land covered. Due to static electricity, small droplets are able to maximize contact with a target organism, but very still wind conditions are required.

Spraying pre- and post-emergent crops

Traditional agricultural crop pesticides can either be applied pre-emergent or post-emergent, a term referring to the germination status of the plant. Pre-emergent pesticide application, in conventional agriculture, attempts to reduce competitive pressure on newly germinated plants by removing undesirable organisms and maximizing the amount of water, soil nutrients, and sunlight available for the crop. An example of pre-emergent pesticide application is atrazine application for maize and sorghum and 2, 4-Dichlorophenoxyacetic acid (2, 4-D) for rice.

Similarly, glyphosate mixtures are often applied pre-emergent on agricultural fields to remove early-germinating weeds and prepare for subsequent crops. Pre-emergent application equipment often has large, wide tires designed to float on soft soil, minimizing both soil compaction and damage to planted (but not yet emerged) crops. A three-wheel application machine, is designed so that tires do not follow the same path, minimizing the creation of ruts in the field and limiting sub-soil damage.

Post-emergent pesticide application requires the use of specific chemicals chosen to minimize harm to the desirable target organism. An example is 2,4-Dichlorophenoxyacetic acid, which will injure broadleaf weeds (dicots) but leave behind grasses (monocots). Such a chemical has been used extensively on wheat crops, for example. A number of companies have also created genetically modified organisms that are resistant to various pesticides. Examples include glyphosate-resistant soybeans and Bt maize, which change the types of formulations involved in addressing post-emergent pesticide pressure. It is important to also note that even given appropriate chemical choices, high ambient temperatures or other environmental influences, can allow the non-targeted desirable organism to be damaged during application. As plants have already germinated, post-emergent pesticide application necessitates limited field contact in order to minimize losses due to crop and soil damage.

Typical industrial application equipment will utilize very tall and narrow tires and combine this with a sprayer body which can be raised and lowered depending on crop height. These sprayers usually carry the label 'high-clearance' as they can rise over growing crops, although usually not much more than 1 or 2 meters high. In addition, these sprayers often have very wide booms in order to minimize the number of passes required over a field, again designed to limit crop damage and maximize efficiency. In industrial agriculture, spray booms 120 feet (40 meters) wide are not uncommon, especially in prairie agriculture with large, flat fields. Related to this, aerial pesticide application is a method of top dressing a pesticide to an emerged crop which eliminates physical contact with soil and crops. The normal Knapsack sprayers may be used for applying pesticides but should be fitted with herbicide nozzles so that adequate flow rate of the pesticide is discharged or an insecticide nozzle which will reduce the flow rate.

Air Blast sprayers, also known as air-assisted or mist sprayers, are often used for tall crops, such as tree fruit, where boom sprayers and aerial application would be ineffective. These types of sprayers can only be used where overspray (spray drift) is less of a concern, either through the choice of chemical which does not have undesirable effects on other desirable organisms, or by adequate buffer distance. These can be used for insects, weeds, and other pests to crops, humans, and animals. Air blast sprayers inject liquid into a fast-moving stream of air, breaking down large droplets into smaller particles by introducing a small amount of liquid into a fast-moving stream of air.

Foggers fulfill a similar role to mist sprayers in producing particles of very small size, but use a different method. Whereas mist sprayers create a high-speed stream of air which can travel significant distances, foggers use a piston or bellows to create a stagnant area of pesticide that is often used for enclosed areas, such as houses and animal shelters. Foggers are specially used for space treatment like ship cargo and high altitude structures like orchards and tall buildings.

Spraying inefficiencies

There are so many factors responsible for spray inefficiencies. When pesticides are applied in the field, depending on the time of the day, most of it is lost through evaporation into the atmosphere resulting in air pollution. Thus, it is advisable that pesticides should be applied early in the morning or late in the evening when the environmental temperature is low. Drift is another factor responsible for spray inefficiency where pesticides are blown away or carried away by wind from the target which will also contribute to air pollution. There is also surface runoff where pesticides are washed away from targets into rivers or ponds resulting in contamination of aquatic environment. There is also seepage and leaching of pesticides into ground water which results in contamination of both soil and water.

Herbicide volatilisation refers to evaporation or sublimation of a volatile herbicide. The effect of gaseous chemical is lost at its intended place of application and may move downwind and affect other plants not intended to be affected causing crop damage. Herbicides vary in their susceptibility to volatilisation. Prompt incorporation of the herbicide into the soil may reduce or prevent volatilisation. Wind, temperature, and humidity also affect the rate of volatilisation with humidity reducing in. 2,4-D and dicamba are commonly used chemicals that are known to be subject to volatilisation but there are many others. Application of herbicides later in the season to protect herbicide-resistant genetically modified plants increases the risk of volatilisation as the temperature is higher and incorporation into the soil impractical.

Understanding the biology and life cycle of the pest is also an important factor in determining droplet size. For the management of the corn earworms to be effective, the pesticide needs to penetrate through the corn's silk, where the earworm's larvae hatch. Thus, larger pesticide droplets best penetrate the targeted corn silk. Knowing where the pest's destruction originates is crucial in targeting the amount of pesticide needed.

4.0 CONCLUSION

One of the most common forms of pesticide application, especially in conventional agriculture, is the use of mechanical sprayers. Hydraulic sprayers consist of a tank, a pump, a lance (for single nozzles) or boom, and a nozzle (or multiple nozzles). Sprayers convert a pesticide formulation into droplets, which can be large rain-type drops or tiny almost-invisible particles. This conversion is accomplished by forcing the spray mixture through a spray nozzle under pressure. Crop pesticides can either be applied pre-emergent or post-emergent, a term referring to the germination status of the plant. Pre-emergent pesticide application, attempts to reduce competitive pressure on newly germinated plants by removing undesirable organisms and maximizing the amount of water, soil nutrients, and sunlight available for the crop. An example of pre-emergent pesticide application is atrazine application for maize and sorghum. Post-emergent pesticide application requires the use of specific chemicals chosen to minimize harm to the desirable target organism. An example is 2,4-Dichlorophenoxyacetic acid, which will injure broadleaf weeds (dicots) but leave behind grasses (monocots). There are genetically modified organisms that are resistant to various pesticides e.g. glyphosate-resistant soybeans and Bt maize. Typical industrial application equipment will utilize very tall and narrow tires and combine this with a sprayer body which can be raised and lowered depending on crop height. The normal Knapsack sprayers may be used for applying pesticides but should be fitted with herbicide nozzles so that adequate flow rate of the pesticide is discharged or an insecticide nozzle which will reduce the flow rate. When pesticides are applied in the field, depending on the time of the day, most of it is lost through evaporation into the atmosphere resulting in air pollution. Drift is another factor responsible for spray inefficiency where pesticides are blown away or carried away by wind from the target which will also contribute to air pollution. There is surface runoff where pesticides are washed away from targets into rivers or ponds resulting in contamination of aquatic environment. There is also seepage and leaching of pesticides into ground water which results in contamination of both soil and water.

5.0 SUMMARY

Hydraulic sprayers consist of a tank, a pump, a lance (for single nozzles) or boom, and a nozzle (single or multiple nozzles). Sprayers convert a pesticide formulation into droplets, which can be large rain-type drops or tiny almost-invisible particles. Crop pesticides can either be applied pre-emergent or post-emergent, a term referring to the germination status of the plant. There are genetically modified organisms that are resistant to various pesticides e.g. glyphosate-resistant soybeans and Bt maize. Spray inefficiencies may occur as a result of evaporation, drift, surface runoff, underground leakage or seepage, etc.

6.0 TUTOR-MARKED ASSIGNMENT

1. Name four major components of a sprayer
2. Name two stages of pesticides application based on crop growth status
3. Mention three possible reasons for spray inefficiencies.

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MODULE 4

MODULE 4 APPLICATION MACHINERY AND SAFE HANDLING OF PESTICIDES

UNIT 1 PESTICIDE APPLICATION EQUIPMENT

CONTENTS

1.0 INTRODUCTION

Chemicals are widely used for controlling disease, insects and weeds in the crops. They are able to save a crop from pest attack only when applied in time. They need to be applied on plants and soil in the form of spray, dust or mist. The chemicals are costly. Therefore, equipment for uniform and effective application is essential. Dusters and sprayers are generally used for applying chemicals. Dusting, the simpler method of applying chemical, is best suited to portable machinery and it usually requires simple equipment. But it is less efficient than spraying, because of the low retention of the dust. High volume spraying is usually effective and reliable but is expensive. Low volume spraying to some extent overcomes the failings of each of the above two methods while retaining the good points of both. Spraying is employed for a variety of purposes such as application of:

i. Herbicides in order to reduce competition from weeds,
ii. Protective fungicides to minimize the effects of fungal diseases,
iii. Insecticides to control various kinds of insects pests,
iv. Micro-nutrients such as manganese or boron,

The main function of a sprayer is to break the liquid into droplets of effective size and distribute them uniformly over the surface or space to be protected. Another function is to regulate the amount of insecticide to avoid excessive application that might prove harmful or wasteful. A sprayer that delivers droplets large enough to wet the surface readily should be used for proper application. Extremely fine droplets of less than 100 micron size tend to be diverted by air currents and get wasted. Crops should, as far as possible, be treated in regular swaths. By use of a boom, uniform application can be obtained with constant output of the machine and uniform forward travel.

Spraying techniques are classified as high volume (HV), low volume (LV) and ultra-low volume (UL V), according to the total volume of liquid applied per unit of ground area. Initially high volume spraying technique was used for pesticide application but with the advent of new pesticides the trend is to use least amount of carrier or diluent's liquid. In spraying, the optimum droplet size differs for different types of application. Fine droplets are required to control insects, pests or diseases and bigger size droplets for application of herbicides, etc. The greater the number of fine droplets produced by the device better will be deposition on target area. The size of droplet is important as it affects drift and penetration distance of droplets towards the target. Hence a compromise is to be made to prevent drift, achieve wide coverage of plant or target area and more penetration.

Different designs of spraying equipment have been developed for different types of applications and field and crop conditions. Manually operated hydraulic sprayers viz. Knapsack sprayers, twin knapsack sprayers, foot sprayers, hand compression sprayers; air carrier sprayers such as motorized knapsack mist blower cum duster (LV) and centrifugal rotary disc type sprayers are specially suitable for spray applications in crops. The present trend is to apply concentrated pesticides by means of low and ultra-low volume sprayers. This has been possible through the development of better formulations and special nozzles. New Controlled Droplet Application (CDA) atomizers require less than 15 l/ha of spray mixture and are easy to operate. Although new type of spray atomizers are available but the correct chemical formulations are commonly not produced. Hence their use is limited to particular crop, pest or disease. The instructions of the manufacturer should be carefully read whether a formulation is recommended for ultra-low or low volume application

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Know the sources of energy for different types of spraying equipment
- Know the different types of spraying equipment
- Know the types of formulation used in the different types of spraying equipment.

3.0 MAIN CONTENT

Pests and disease incident on the crops / plants are to be overcome by the application of poisonous chemicals.

- As the technology advances and newer crop varieties are introduced newer insects, pests and diseases are also growing up and methods are devised to control them.
- Many chemicals used for plant protection cannot be handled by human operators directly.
- Also, that needs to be applied in fine particles.
- This necessitates the use of suitable machines.

The Sprayer is one which atomises the spray fluid (which may be a suspension, an emulsion or a solution) into a small droplets and eject it with little force for distributing it properly. It also regulates the amount of pesticide to avoid excessive application that might prove wasteful or harmful. The mechanical appliances that are used for distributing the dust formulations of pesticides are called as dusters.

3.1 Types of spraying equipment (sprayers)

Sprayers are classified into four categories on the basis of energy employed to atomise and eject the spray fluid. This includes:

- hydraulic energy sprayer
- gaseous energy sprayer
- centrifugal energy sprayer and,
- kinetic energy sprayer

Hydraulic energy sprayer

- Hydraulic Energy Sprayer is one which the spray fluid is pressurised either directly by using a positive displacement pump or by using an air pump to build the air pressure above the spray fluid in the air tight container.
- The pressurized fluid is then forced through the spray lance, which controls the spray quantity and pattern.

Gaseous energy sprayer

- In Gaseous Energy Sprayer high velocity air stream is generated by a blower and directed through a pipe at the end of which the spray fluid will be allowed to trickle by the action of gravity through a diffuser plate.

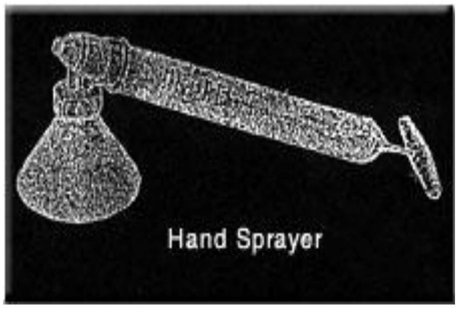
Centrifugal energy sprayer

- In the Centrifugal Energy Sprayer the spray fluid fed under low pressure at the centre of a high speed rotating device (Such as flat, concave or convex disc a wire mesh cage or bucket, a perforate sieve or cylinder or a brush) is atomised by centrifugal force as it leaves the periphery of the atomizer or nozzle .
- The droplets are carried by the air stream generated by the blower of the sprayer or by the prevailing wind, if the sprayer is not provided with a fan.

Kinetic energy sprayer

- In Kinetic Energy Sprayer the spray fluid flows by gravity to a vibrating or oscillating nozzle which produces a coarse fan shaped spray pattern.
- This is used for application of herbicides.

Hand sprayer



The hand sprayer is a small, light and compact unit.

- The capacity of the container varies from 500 to 1000 ml.
- This is generally used for spraying small areas like kitchen, garden and experimental laboratory plots.
- It is a hydraulic energy sprayer.
- It has a hydraulic pump inside the container, with cylinder, plunger and a plunger rod.
- By operating the plunger up, the spray fluid in the container is sucked into the cylinder through a ball valve assembly and then pressurised during the downward stroke.

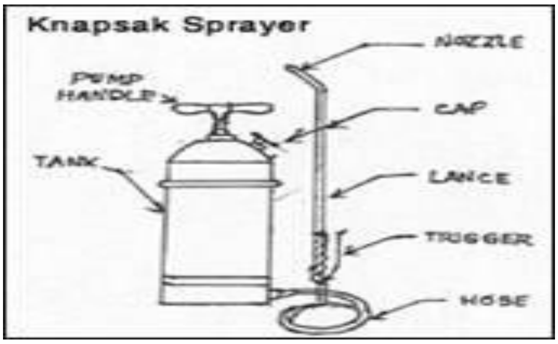
The pressurised fluid is then let out through a nozzle, and sprayed into fine droplets.

- If the pressure to be built inside the container an air pump with cylinder, plunge and plunger rod is required.
- When the plunger is pulled up, the air is sucked into the cylinder and when pushed down the air bubble is releases into the container with 80% of its volume filled with the fluid.
- The air reaches the space above the free fluid surface and presses the fluid.

- The pressurised fluid is drawn up through a trigger cut of valve to the nozzle, where is atomized and sprayed.
- In some other type, air pump and the container are separate pieces and the pump is attached to the container is such a way to release the pressurised air through an orifice at the top of the container.
- The fluid is lifted through an office at the top of the container.
- The fluid is lifted through a capillary tube due to surface tension developed by the high velocity air at the outlet and sheared away by the air and sprayed as droplets.

Knapsack sprayer

- Any sprayer which is carried on the back of the operator is called a knapsack sprayer.
- The commonly used manually operated knapsack sprayer will have one hydraulic pump working inside the container.
- The plunger works inside the replacement well attached at the bottom of the container, for easier maintenance.
- The pump can be operated through the appropriate linkages by oscillating the handle, with the sprayer carried on the back.

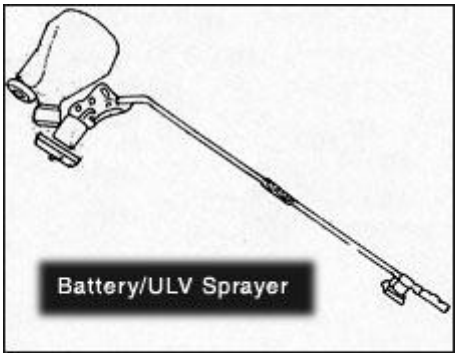


- An agitator is also provided with the pressure chamber to agitate the fluid so that the particles in suspension will not be allowed to settle down.
- A delivery tube is attached on the other end of the pump which carries the pressurised fluid to the spray lance.
- The flow to the nozzle is controlled by a trigger cut-off valve.
- In the case of compression knapsack sprayer, an air pump is used to build air pressure above the free surface of the spray fluid in the container and

normally the pumping of the air will be done by keeping the unit on ground and then sprayed till the air pressure comes down.

- The unit is again brought back to the ground for pumping air and then the spraying is contained as before.
- The spray fluid, which does not enquire any agitation only can be sprayed by using this type of sprayers.

3.3 Battery or Ultra Low Volume sprayer



ULV sprayer was invented as a result of the desire to reduce the quantum of chemical carried by the man for application and to eliminate the water as a medium to carry the chemicals.

The basic requirements of ULV spraying are

- The narrow and controllable droplet spectrum (100-250 µm for fine sprayers, 50-100 µm for mist sprayers and 0.1 to 50 µm for aerosols)

The accurately controllable emission rate and

- The non-volatile pesticide formulation of suitable viscosity and density.

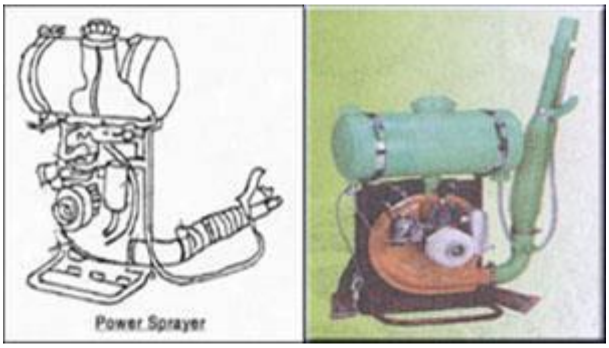
The reduction in volume of the spray fluid decreases the time spent in travelling to recharge sprayer, in fetching water, in mixing the pesticide and filling the tank. In a day of 8 hour about 8 ha can be covered in ULV spraying against 3 ha with power sprayer.

- A battery operated ULV sprayer has a long handle at the horse power D.C. motor is fitted with a spinning disc and a cover.

- A HDPE bottle is fixed close to the motor, in such a way that spray fluid is allowed to trickle at the centre of the spinning disc in operation.
- Centrifugal energy imparted fluid comes out of the nozzle and atomizes.
- The hand held ULV applicators are so designed to release the spray droplets at 1 m away from the body of the operator.
- Further, it is recommended that they should be operated only when the spray cloud would be blown away from him by the breeze so as to minimize the risk of contamination.
- After spraying, the atomizer must be flushed with paraffin to remove the residual pesticide.
- Inefficient cleaning would leave the pesticide deposit in the feeder stem to completely of partially block the flow of the pesticide.

3.3 Power sprayer

All the sprayers which impart the mechanical energy developed by an I.C. Engine, on the spray fluid before spraying is called as a power sprayer. The most commonly used type of power sprayer is a gaseous energy type knapsack sprayer. In construction, it has a back pack stand on which a blower with a S.I. Engine of 1.2 to 3 hose power (HP) capacity, the spray fluid tank and the petrol tank are fixed rigidly. A pleated hose is attached to the blower elbow to carry the high velocity air and at the end of that a shear nozzle is fixed to allow the spray fluid to trickle in from the spray fluid storage tank, with a valve control.



- From the top of the blower casing, an air hose is taken into the spray fluid tank, which carries little quantum of air to press the spray fluid during operation.
- In operation, the engine is started by keeping the unit on the ground and then carried by the operator.
- The blower sucks the air behind the backrest and forces it into the pleated hose.
- The valve of the shear nozzle is opened or the shear nozzle with selective opening and discharged through the nozzle.
- The high velocity air shears off the droplets and atomizes by the impact of diffuse and delivers it on the plant the surface.

- An air current of 2.7 to 9.1 m2 / minute is delivered at a velocity of 175 to 320 km/ph.
- The spray fluid tank capacity varies from 7 to 12 litres.
- The fuel tank capacity varies from 0.75 to 2.25 litres.
- The spray fluid discharge can be varied from 0.5 to 5 lit / minute.

A power sprayer can be used as a power duster by making the following changes:

- Chemical filler cap is removed to dismantle that strainer with the air pipe.
- The liquid delivery pipe below the chemical tank is dismantled and removed with the shear nozzle.
- The tank is thoroughly cleaned to remove possible traces of moisture left inside.
- The dust agitator tube is fixed at the bottom of the chemical tank.
- This tube has holes at the bottom to prevent the entry of dust into the agitator and clogging it.
- Dust intake tube is inserted into the chemical tank at the discharge and this tube has no. of large size holes on its periphery.
- Dust intake tube and the blower elbow are connected by using the dust outlet pipe, which is a pleated hose.

The thermal fogging

The thermal fogging is a technique widely used in pest control, vector and disinfection routines in the area of public health. This technique differs from other spraying methods, mainly by the size of the droplets produced, which are in the order of 10 microns in diameter. This small droplet size is achieved through a double process, which simultaneously sprays and partially evaporates the formulation through the use of thermo-pneumatic energy.

Thermal Fogging machine

In a thermal fogger, the formulation (mixture of the active ingredient with a carrier that is usually a mineral oil), is exposed to a hot air current coming from the exhaust of a pulse-jet engine.
The high velocity and temperature of these gases causes immediate fragmentation and partial evaporation of the fluid which is expelled through the exhaust pipe. As soon as it encounters with the ambient air at a much lower temperature, this stream is condensed into tiny droplets that form a dense fog. This mist contain an appropriate dose of the active ingredient in each of the micro droplets that compose it, and has the ability to "float" and move long distances without losing their effectiveness, penetrating and accessing sites with dense vegetation, reaching the most inaccessible places within a warehouse or store.

3.4 Types of formulation

This technique allows the use of 2 basic types of formulations.

Depending on the type of carrier used, we may have:

- Water-based formulations
- Oil-based formulations

Water-based formulations

It is used in cases where you do not want to leave a thin oily film on objects within the area to be sprayed. However, water-based formulations have the following disadvantages:

- The micro droplets generated are larger and heavier due to the poor thermal properties of water sprays.
- The droplets are also more vulnerable to evaporate before they can reach or impact on its target due to its poor ability to travel long distances, because of their greater weight originated in its larger size. This limits their use in a large interior space, where the fog is intended to cover all the spaces and surfaces of it.
- The thermal fogger cannot work properly with the same flow rate with aqueous formulations than oily formulations. The lower viscosity of water compared to mineral oil, requires a reduction of the flow rate of formulation to avoid generating droplets of larger size that are not effective in such treatments. For this reason, the use of water-based formulations is generally accompanied by a reduction of the diameter of the formulation nozzle.

Oil-based formulations

They are the most widely used because the tiny droplet size produces better performance and achieves a high effectiveness of the active ingredient besides ensuring excellent coverage in large spaces. However, such formulations are generally flammable and since thermal foggers have elements operating at high temperatures is essential to strictly observe all safety rules contained in the operating manuals for this equipment.

4.0 CONCLUSION

Sprayers are classified into four categories on the basis of energy employed to atomise and eject the spray fluid. This includes: hydraulic energy sprayer; gaseous energy sprayer; centrifugal energy sprayer and, kinetic energy sprayer. All the sprayers which impart the mechanical energy developed by an I.C. Engine, on the spray fluid before spraying is called as a power sprayer. The most commonly used type of power sprayer is a gaseous energy type knapsack sprayer. The thermal fogging is a technique widely used in pest control, vector and disinfection routines in the area of public health. In a thermal fogger, the formulation is exposed to a hot air current coming from the exhaust of a pulse-jet engine which produces a mist that contain an appropriate dose of the active ingredient in each of the micro droplets that compose it. The mist has the ability to "float" and move long distances without losing their effectiveness, penetrating and accessing sites with dense vegetation, reaching the most inaccessible places within a warehouse or store. This technique allows the use of 2 basic types of formulations, namely; Water-based and Oil-based formulations.

5.0 SUMMARY

Sprayers are classified into four categories on the basis of energy employed to atomise and eject the spray fluid. This includes: hydraulic energy sprayer; gaseous energy sprayer; centrifugal energy sprayer and, kinetic energy sprayer. There are also power-generated sprayers including Power Mist blower and Thermal Fogging Machine.

6.0 TUTOR-MARKED ASSIGNMENT

1. Mention four (4) categories of sprayers on the basis of energy used.
2. Name two types of power-operated sprayers.

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UNIT 2 SAFETY PRECAUTION IN HANDLING PESTICIDES

CONTENTS

1.0 INTRODUCTION

Agrochemicals or pesticides are chemical products that can kill or control pests. Pests are animals (insects, nematodes, ticks and mites, snails, rodents) or plants (fungi, bacteria, weeds) which cause damage to crops, animals and stored foodstuffs. Pesticides have played a major role in crop protection and the control of vector-borne diseases. They are effective, relatively simple and quick method of pest control. Pesticides remain our most powerful tool in pest management, and will continue to be an important part of integrated management programmes. Pesticides may be grouped on the basis of their mode of action: systemic (absorbed and transported round the body), contact (act only upon direct contact with the pest), fumigant (act as a gas that penetrates into treated produce), and stomach poison (which must be swallowed).

Most pesticides are highly toxic to pests, man and livestock. Sometimes colours are usually used on the pesticide containers to indicate the level of toxicity of a given pesticide which are designated with a triangle (Δ). For instance:

Green colour- The pesticide is slightly toxic.
Yellow colour-The pesticide is moderately toxic.
Blue colour – The pesticide is highly toxic.
Red colour – The pesticide is extremely toxic.

There are two types of pesticide toxicity: Acute and chronic. Acute toxicity is the ability to cause injury to a person after a single exposure. They are generally of a short duration. It may be from accidental or deliberate ingestion of pesticide. It is described with LD_{50} (lethal dose or deadly amount and the subscript 50 means that the dose was acutely lethal for 50% of the animals administered with the pesticides under laboratory conditions. Test animals are given a specific amount of the chemical orally or intravenously and observed for 14 days. LD_{50} values are from zero upward. The lower LD_{50} the more acutely toxic the pesticide. The values are expressed as milligrams per kilogram (mg/kg)- milligrams of pesticide per kilogram of body weight of the animal. Chronic toxicity is as a result of inhalation or absorption of small doses of pesticide after a long period of exposure. Some major effects of chronic toxicity are carcinogenesis (production of tumours or cancers), teratogenesis (production of birth defects, changes in the structure or function of offspring when the embryo or foetus) and mutagenesis (production of changes in genetic structure).

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Know the Safety Precautions in handling pesticides.
- Know the basic Personal Protective Equipment.

3.0 MAIN CONTENT

3.1 Safety precaution for Transportation of Agro-chemicals (storage pesticides)

Carelessness in transporting pesticides can result in broken containers, spills and contamination. Once pesticides are in your possession, you are responsible for safely transporting them. Accidents can occur even when transporting materials a short distance. If a pesticide accident occurs, you are responsible. Do all you can to prevent a transport problem, but be prepared in case an emergency should arise.

The safest way to carry pesticides is in the back of a truck. Never carry pesticides inside your car, van, or truck cab. Pesticides may cause injury or death if they spill on you or your passengers; hazardous fumes may be released. Spills on seat covers are very hard to remove, and may be a source of future contamination if they are not cleaned up properly. Never leave your vehicle unattended when transporting pesticides in an unlocked trunk compartment or open-bed truck. Always transport Agro-chemicals in original containers.

Never transport food items and livestock products or livestock feed along with Agro-chemicals. Secure all pesticide containers in such a way that they cannot shift, roll, or bounce around. All containers should be protected from moisture that would saturate paper and cardboard packages or rust metal. Any spills in or from the vehicle must be immediately cleaned up, using correct procedures.

Storage of Agro-chemicals

Agrochemicals should be packed and loaded in a manner that the containers will not break or spill. Cover all agrochemicals to prevent exposure to excessive heat.

Always store pesticides in their original, labeled containers and check the containers periodically for leakage, corrosion, breaks and tears. Do not transfer agrochemicals to containers, which normally hold food or drink, e.g. lemon, milk, coke, juice or cooking oil bottles so that they will not be mistaken for food. Agrochemicals must be separated from food and livestock feeds. Storerooms must be kept clean, cool and well ventilated to prevent accumulation of toxic fumes. Only authorized persons should hold the key to the Agrochemical store.

3.2 Safety recommendations for spraying pesticides

1. Before you start applying pesticides, READ THE LABEL. Do not trust your memory for details concerning the use of any pesticide.
2. Check the application equipment for leaking hoses or connections, plugged or worn nozzles and examine the seals on the filter openings to make sure that they will prevent spillage of the chemicals.
3. Calibrate your equipment before use. The equipment should be adjusted according to the manufacturers' specifications and meet label requirements for the product being applied. This will assure that the proper dosage is being applied to the target site.
4. Before the pesticide application starts, clear all livestock, pets and people from the area to be treated
5. Know the pest to be controlled so that you use correct pesticide.
6. Wear protective clothing- hand gloves, facemasks, laboratory jackets, rain boots, etc.
7. Always stand up wind/pro-wind direction when mixing or spraying pesticides.
8. Apply the pesticides at the recommended rate
9. Apply pesticides early in the morning or in the evening under acceptable weather conditions. Avoid applying pesticides when temperatures are extremely high or low.
10. Avoid eating, drinking or smoking when mixing or spraying pesticides.
11. Never work alone when spraying pesticides
12. Use extreme care to prevent the pesticide from contaminating water bodies
13. Do not leave pesticides unattended in the field.
14. Have plenty of water for washing after mixing or application
15. Do not blow out clogged nozzles or holes.
16. Do not allow other people to enter the treated area for the required period(re-entry period)
17. Operator should have appropriate rest after each operation.
18. Dispose of all empty containers by burying.
19. It is absolutely impossible to clean out a container sufficiently well to make it safe for use for storage of food, water or as a cooking utensil.

3.3 Personal Protective Equipment (PPE)

The need for personal protective equipment depends mainly on the pesticide being handled. You may wear ordinary work clothes (long sleeve shirt and trousers) while using pesticides of low toxicity (category III or IV), but it is a good idea to reserve one set of work clothes specifically for this purpose. More toxic chemicals (categories I and II) require coveralls worn over another layer of clothes, or chemical-resistant protective suits. Wear a cotton overall or laboratory coat during handling and spraying of Agro-chemicals. Wear face cover or mask to prevent Agro-chemicals from splashing onto eyes while spraying. Wear nose air filter or respirator to reduce inhalation of Agro-chemicals. Wear a pair of hand gloves. Put on eye goggles. Wear a pair of rain boots. Put on a hat or a cap.

Personal protective equipment requirements are printed on pesticide labels. These requirements are based on the toxicity, route of exposure, and formulation of that pesticide. When working with moderately (category II) or highly toxic (category I) pesticides, wear coveralls over another layer of clothes or a chemical-resistant protective suit, chemical -resistant gloves, and chemical-resistant footwear to prevent exposure of the skin to the pesticide. If the pesticide is an eye irritant, wear goggles, shielded safety glasses, or a face shield. If ordinary coveralls will wet through, use a chemical-resistant suit or apron. Synthetic rubber boots protect against liquid and dry formulations. Natural rubber boots are effective only for dry formulations.

The activity, the environment, and the handler also influence the choice of protective equipment. The activity-related factors are type of activity, duration, equipment, and deposition pattern of the pesticide onto the handler. Mixing/loading procedures often require extra precautions when the pesticide is in concentrated form, but a closed mixing/loading system can reduce this risk. Air-blast application more often results in greater applicator exposure than in other application methods, so additional precautions are advisable. Activities that deposit pesticides on the head or scrotum require protective head- or body-gear because these body parts absorb pesticides at a much faster rate than other body parts.
Wind increases the risk of outdoor pesticide application. When exposed to downward drift, wear a wide brimmed, chemical-resistant hat that protects the face and back of the neck. Consider wearing a face mask, shielded safety glasses, or goggles. Be aware that extreme heat and humidity can cause heat stroke and exhaustion. Other environmental considerations are terrain, proximity to public places, and open versus closed spaces.

You, the pesticide applicator, make the final decisions in the selection, use, and care of personal protective equipment. No one protective garment offers universal protection. Each pesticide use demands individual choices of protective equipment. Carefully read the pesticide label for protective equipment requirements and take additional precautions as indicated by the activity, environment, and your own personal needs.

Mixing and Filling. Protective gear is especially important when you mix and load pesticides in their undiluted, concentrated forms. Studies show that you are at a greater risk of accidental poisoning when handling pesticide concentrates. Pouring pesticide concentrates from one container to another is the most hazardous activity. That is why it is important that you wear protective clothing and equipment before you handle pesticides.

Read and carefully follow the label directions each time you mix pesticides. Even if you have used a pesticide before, read the label again. Pesticide labels frequently change. Each new container may have important new label information that must be followed. Carefully choose the pesticide mixing and loading area. It should be outside or in a well-ventilated area away from other people, livestock, pets, and food or feed. It is best to mix and load pesticides on a concrete pad where spills are easily cleaned up. Pesticides should not be mixed in areas where a spill or overflow could get into a water supply. Handling areas are frequently located near a pond or stream bank. In such a situation, grade the area to slope away from the water. If you or your workers must work indoors, or at night, work in a well-ventilated area with good lighting. If possible, do not work alone, especially when using highly toxic pesticides. It is a good idea for anyone handling extremely poisonous materials to talk to, or make eye contact with another person every two hours.

Measure pesticides carefully, making sure to mix them in the appropriate proportions. Different pesticides should not be mixed together unless a combination is called for on a label, and/or if an authority has been consulted. Remember, pesticides should be kept in their original containers so that the label directions and precautions are always with the toxic material. It is always a good idea to label all items that are used for handling pesticides (measuring utensils, protective equipment, etc.) to prevent their use for other purposes.

The overuse of pesticides may:

- raise the cost of pest control.
- increase the chance of illegal pesticide residues in treated foods.
- increase the possibility that pesticides may reach and contaminate groundwater.
- lead to pesticide resistance.

Open pesticide containers carefully to decrease the possibility of accidental splashes, spills, or drift. Do not tear paper containers open, use scissors for safe, spill free opening. Be sure to clean tools that are used for opening containers. To prevent contamination, always make sure opening tools are used only for pesticide-related work.

When pouring pesticides, always stand with your head well above the container and the filling hole of the spray tank, so that you and your clothing do not get splashed. Never use your mouth to siphon a pesticide from a container. While you should not be using pesticides when there is a strong wind, if there is any breeze, make sure that it is blowing away from you or from your right or left when you pour or mix these toxic materials.

Never leave a spray tank unattended while it is being filled, as it may overflow. Install anti-siphon devices on filler pipes and/or always maintain an air gap between the filler pipe and the tank. Close containers after each use to prevent spills. If a pesticide spills on the floor or ground, it should be cleaned up immediately. A pesticide spill can potentially cause great harm to others, as well as cause environmental contamination. Toxic quantities of some concentrated chemicals may remain in soil for many months or years.

Equipment: Carefully choose the most suitable equipment for applying your pesticides. Always use equipment correctly and take good care of it. Before you begin using your equipment, check it thoroughly to be absolutely sure that everything is working properly. Calibrate your equipment so that you apply the exact amount of pesticide necessary. Be sure there are no leaks in hoses, pumps, or tanks. Check for loose connections and worn spots in hoses that could leak or burst. One way to check for leaks is to operate the equipment at normal pressures with clean water before filling with pesticide mixture. If belts, pulleys, or drive chains are exposed, put guards around them so that you, children, or other people cannot be injured. The spray tank should have a tight lid so that neither you nor others will be splashed and spray materials will not leak onto the ground. Before application, make sure that the treatment area is clear of all unprotected people.

Avoid Exposure: Even moderately toxic chemicals can be poisonous to you when they are used day after day. Pesticides can contaminate clothing and may soak through to your skin. Do not work in drift, spray, or runoff unless you are properly protected. If pesticides spill on your gloves, be careful not to wipe your hands on your clothing. Work in pairs when you are dealing with hazardous pesticides. Handlers of highly toxic pesticides should try to make visual or voice contact with another person every two hours. Carefully supervise your employees to make sure that all safety precautions are followed.

Never blow out clogged hoses or nozzles with your mouth. Use a nylon bristle brush for clearing out these equipment parts. Wash your hands and face thoroughly after you use pesticides and before you do any other activity. Never eat, drink, or smoke when handling pesticides. Chemicals can get transferred from your hands to your mouth during smoking. Don't smoke in recently treated areas. Smoking with pesticide-soiled hands can also be extremely dangerous if flammable chemicals are being used. Keep children, unauthorized persons, and pets out of the area to be sprayed and at a safe distance from sprayers, dusters, filler tanks, storage areas, and/or old pesticide containers.

Avoid Sensitive Areas: Avoid spraying near houses, schools, playgrounds, hospitals, bee hives (apiaries), lakes, streams, pastures, or sensitive crops. If you must spray near sensitive areas, never spray or dust outside on windy days. Even with low winds, always apply downwind from any sensitive area. Plan your applications for times when people, animals, pets, and non-target pests (such as honey bees) will not be exposed. Notify residents and beekeepers when you plan to spray in their areas and urge them to take appropriate precautions. Completely cover or remove toys and pet dishes, as well as close all of the windows. Be sure that children and pets are not present in the area of the pesticide application. Avoid sensitive indoor areas such as infants' rooms, food preparation and storage areas, heating and air conditioning systems, and also be familiar with pet and fish tank locations.

Avoid Drift, Runoff, and Spills: Pesticides that fall anywhere but on the target area can injure people, crops, and the environment. Choose weather conditions, pesticides, application equipment, pressure, droplet size, formulations, and adjuvants that minimize drift and runoff hazard. Spills can be avoided by taking simple precautions.

Avoid Equipment Accidents: Properly maintained and carefully used equipment contribute to safe pesticide application. Poor maintenance and careless use of equipment add to the hazard posed by pesticides.

Be sure to turn off your machinery before making any adjustments or repairs on it. If someone else is doing repair work on equipment that has not been cleaned, warn them of possible hazards.

Storage and Disposal: Try to use all the pesticide in your tank. If you have some left at the end of the job, use the remainder on other target locations at the recommended dosage. Clean the equipment and put it away immediately after use to prevent accidents.

Do not leave pesticides or pesticide containers out in the field or at the application site. Be sure to account for every container used. Safely dispose of empty containers. Do not reuse pesticide containers for any purpose. NEVER give them to children for any use. Partially used pesticides should be stored in their tight original containers in a locked building. Keep children and uninformed people away from the storage area.

3.4 Importance of Clean up Measures

Clean Up. Mixing, loading, and application equipment must be cleaned as soon as you have finished using them. Cleaning should be done in a special area that has a wash rack or concrete apron with a sump for catching contaminated wash water. The best way to dispose of wash water containing a registered pesticide is to use it as directed on the label. Collect the contaminated water and use it to dilute the pesticide or a compatible pesticide if possible. **Waste from equipment cleanup must be kept out of water supplies and streams.**

It is extremely important for pesticide equipment to be properly cleaned between applications. Accidental injury or death of sensitive plants or animals may occur from applications that are made with slight residues of previously-used pesticides in equipment.

Be sure to clean the inside and outside of the equipment, including the nozzles. This job should only be done by trained persons who are wearing proper personal protective equipment. The outside of your equipment should be washed so that people touching it will not be exposed to pesticides. The inside must also be cleaned so that dangerous chemical mixing does not occur.

At the end of each day take a shower. Wash your body and scalp thoroughly with soap and water. Remember to scrub your nails. Place pesticide-soiled protective equipment in a designated place away from people, pets, and the family laundry. Launder washable clothing separately every day this applies to regular work clothes worn under protective coveralls, as well as to garments directly exposed to pesticides. Disposable or limited-use garments should not be reused.

Wash Pesticide-Soiled Clothing. Spray clothing should be changed and washed daily. The pesticides on your clothes could harm other people who touch them. Keep pesticide-soiled clothing away from the family laundry and warn the person who will be washing your spray clothes of possible dangers. The person doing the laundry should wear chemical -resistant gloves. Do not allow children to play in or near the contaminated clothing. Do not dry-clean pesticide-contaminated clothing.

The recommended procedures for cleaning pesticide-soiled clothing for re-use are as follows:

- Hang garments outdoors to air. Sunshine and ventilation aid in the breakdown of certain pesticides. Do not hang contaminated garments with uncontaminated garments. Do not hang contaminated garments close to residences or in areas frequented by people or pets.
- Always wash garments separately from family wash. Pesticides can move from contaminated clothing to other clothing, to equipment, or to the unprotected hands of the person doing the laundry. Wash garments contaminated with the same pesticide together.
- Wash contaminated garments two or three times before reuse for more complete pesticide removal.
- Hang outdoors to avoid contaminating dryer and to encourage further dissipation of the chemical.

Entering a Treated Area: Unprotected people should wait until the proper time to enter an area that has had a pesticide application. The entry restriction is the period of time that should pass between treatment and returning to a treatment area. Entry restrictions may be found on some pesticide labels. Do not allow workers, children, or other persons to re-enter the sprayed area until this time has passed. When no restricted entry times are stated on the label, use good judgment in allowing people to return to treated areas or structures. Always wait at least until sprays dry, dusts settle, and vapors disperse. If you must reenter an area early after spraying:

- Be sure to wear all the necessary personal protective equipment required on the label.
- Do not touch treated surfaces.
- Be sure to have decontamination water nearby and know how to use it.

Some highly toxic pesticides (organophosphates and carbamates) have legally specified entry restrictions of 24 or 48 hours. These time periods are listed on the pesticide labels. There may be longer re-entry times for some pesticides because of particular climatic conditions and other special hazards that exist in their areas.

4.0 CONCLUSION

The safest way to carry pesticides is in the back of a truck. Never carry pesticides inside your car, van, or truck cab. Never transport food items and livestock products or livestock feed along with Agro-chemicals. Always store pesticides in their original, labeled containers and check the containers periodically for leakage, corrosion, breaks and tears. Do not transfer agrochemicals to containers, which normally hold food or drink, e.g. lemon, milk, coke, juice or cooking oil bottles so that they will not be mistaken for food. Agrochemicals must be separated from food and livestock feeds. Storerooms must be kept clean, cool and well ventilated to prevent accumulation of toxic fumes. Only authorized persons should hold the key to the Agrochemical store.

Before you start applying pesticides, READ THE LABEL. Before the pesticide application starts, clear all livestock, pets and people from the area to be treated. Always stand up wind/pro-wind direction when mixing or spraying pesticides. Apply pesticides early in the morning or in the evening under acceptable weather conditions. Avoid applying pesticides when temperatures are extremely high or low. Avoid eating, drinking or smoking when mixing or spraying pesticides. Never work alone when spraying pesticides. Use extreme care to prevent the pesticide from contaminating water bodies. Do not blow out clogged nozzles or holes. Do not allow other people to enter the treated area for the required period (re-entry period). Dispose of all empty containers by burying. It is absolutely impossible to clean out a container sufficiently well to make it safe for use for storage of food, water or as a cooking utensil. Wear protective clothing- hand gloves, facemasks, laboratory jackets, rain boots, etc.

5.0 SUMMARY

Always carry pesticides at the back of a truck. Never carry pesticides inside your car, van, or truck cab. Never transport food items and livestock products or livestock feed along with Agro-chemicals. Always store pesticides in their original, labeled containers and check the containers periodically for leakage, corrosion, breaks and tears. Do not transfer agrochemicals to containers, which normally hold food or drink, e.g. lemon, milk, coke, juice or cooking oil bottles so that they will not be mistaken for food. Agrochemicals must be separated from food and livestock feeds. Storerooms must be kept clean, cool and well ventilated to prevent accumulation of toxic fumes. Only authorized persons should hold the key to the Agrochemical store. Before you start applying pesticides, READ THE LABEL. Always wear protective clothing when handling pesticides.

6.0 TUTOR-MARKED ASSIGNMENT

1. Lists the conditions for transporting pesticides
2. Mention five precautions for handling pesticides.
3. List the basic protective clothing.

7.0 REFERENCES/FURTHER READING

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UNIT 3 SIGNS AND FIRST AIDS FOR PESTICIDE POISONING

CONTENTS

1.0 INTRODUCTION

A pesticide poisoning occurs when chemicals intended to control a pest affect non-target organisms such as humans, wildlife, or bees. There are three types of pesticide poisoning. The first of the three is a single and short-term very high level of exposure which can be experienced by individuals who commit suicide, as well as pesticide formulators. The second type of poisoning is long-term high-level exposure, which can occur in pesticide formulators and manufacturers. The third type of poisoning is a long-term low-level exposure, which individuals are exposed to from sources such as pesticide residues in food as well as contact with pesticide residues in the air, water, soil, sediment, food materials, plants and animals. The most common exposure scenarios for pesticide-poisoning cases are accidental or suicidal poisonings, occupational exposure, by-stander exposure to off-target drift, and the general public who are exposed through environmental contamination.

Family members, co-workers, and applicators play an important role in noticing when someone may be poisoned, providing immediate first aid, or calling for help. Anyone living or working on farms where pesticides are used should be aware of the symptoms of pesticide poisoning and what to do should a poisoning occur. Pesticide poisoning may be obvious when a person is exposed to very high levels from an accidental spill or splash. However, pesticide poisoning is often hard to recognize because the effects vary from person to person, the symptoms may be similar to those of other ailments (flu, cold, hangover, etc.), or symptoms may not appear immediately.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Be able to determine whether or not a person has been poisoned by a pesticide.
- Learn to recognize kinds of poisoning and their symptoms.
- Learn the first-aids methods for various types of poisoning

3.0 MAIN CONTENT

3.1 General Signs for Pesticides Poisoning

Pesticide poisoning can happen from one short exposure (acute poisoning) or from many exposures over a long time (chronic poisoning). Both acute and chronic poisoning can exhibit mild, moderate or severe symptoms. You should be aware of the early signs and symptoms of poisoning. It is important to remove the person from the source of exposure quickly. Remove contaminated clothing and wash off any chemical which has soaked through. You may save a life. Poisoning symptoms for individual pesticides are listed on pesticide labels. The symptoms are usually listed in the section called Toxicological Information. Become familiar with the symptoms of the pesticides used or stored on your farm. All pesticides in a given chemical group generally affect the human body in the same way; however, severity of the effects vary depending on the formulation, concentration, toxicity and route of exposure of the pesticide. It is important, therefore, to know both the type of pesticide you are using and poisoning symptoms for it. Pesticide poisoning can happen from one short exposure (acute poisoning) or from many exposures over a long time (chronic poisoning). Both acute and chronic poisoning can exhibit mild, moderate or severe symptoms.

General Symptoms Which Might Indicate Pesticide Poisoning

mild poisoning	moderate poisoning	severe poisoning
• headache • dizziness • weakness • fatigue • nervousness • loss of appetite • thirst • nausea • irritation of throat and nose • eye irritation • constriction of pupils • blurred vision • skin irritation • changes in mood • loss of weight	any mild symptoms plus any of: • abdominal cramps • vomiting • diarrhea • excessive salivation • constriction in throat and chest • abdominal cramps • rapid or slow pulse • excessive perspiration • trembling • muscle incoordination • mental confusion	any mild or moderate symptoms plus any of: • inability to breathe • chemical burns on skin • respiratory distress • loss of reflexes • uncontrollable muscle twitching • unconsciousness • convulsions

3.2 First Aid for Pesticide Poisoning

It is essential that pesticide poisoning incidents be recognized immediately, because prompt treatment may mean the difference between life and death.

General instructions

1. Stop the exposure immediately by separating the victim and the pesticide source.
2. If the victim is unconscious, check to see if the victim is breathing. If not, give artificial respiration. If highly toxic material is present in the victim's mouth or respiratory path, use chest compression, not mouth-to-mouth.
3. Decontaminate the victim immediately by washing off any skin residues of pesticide, and remove any contaminated clothing. Speed is absolutely essential in this step.
4. Obtain professional help by calling the nearest physician.

In all cases due consideration must be given to the protection of yourself and other personnel in the vicinity of the incident. This is critical in the case of a large pesticide spill. Speed is essential in performing first aid for pesticide poisoning. If you are alone with the victim, you must give first attention to the victim, especially in re-starting breathing, separating the victim from the pesticide source, and decontaminating the victim's skin. If another person is with you and the victim, one of you should perform first aid, the other should seek professional help.

Recognizing the signs and symptoms of pesticide poisoning quickly and following appropriate procedures may help save a person's life, but first aid should never be considered a substitute for professional medical treatment. First aid is only to help the patient get well enough so proper medical treatment may be provided. After the victim has been fully cared for and professional help has been sought, these additional steps should be taken. As with the first aid procedures, due consideration must be given to your safety and those around you.

1. Bring the label and MSDS to provide to the physician or poison control center. You should also save the pesticide container and any remaining pesticide should an official request to see it.
2. Eliminate the source of the contamination to prevent or reduce the risk that others may be exposed to the pesticide. In the case of a significant pesticide spill, this will have to be done by professionals trained to respond to these kinds of emergencies.
3. Decontaminate any clothing or equipment as needed. Never put on clothing previously contaminated with pesticide, and always wash contaminated clothing by itself with detergent and water.

In vector control, we are fortunate that few restricted use and highly toxic pesticides are still in use. Most modern pesticides are easy to mix, load, and apply safely, and have extremely low mammalian toxicity. The most dangerous pesticides used for vector control are organophosphates used for mosquito control, fumigants used for rodent control, and some aquatic herbicides.

3.3 First Aid for Specific Types of Poisoning Exposure

Skin Exposure

If pesticide contacts the skin:

- Put on waterproof gloves.
- Remove the victim's contaminated clothing.
- Drench affected skin with water (shower, hose, faucet). Wash contaminated skin and/or hair thoroughly with soap and water. Clean under fingernails and toenails if they have been contaminated. Rinse the area with rubbing alcohol if available, then wash again with soap and water.
- Dry the victim and wrap in a blanket.
- Place any contaminated clothing in a plastic bag. Label the bag "pesticides".

Chemical Burns on Skin

- Put on waterproof gloves.
- Remove victims contaminated clothing.
- Wash the burned areas with large amounts of water.
- Cover burned area with a loosely-applied clean cloth (any kind will do).
- Do not apply any drugs or medications to the burned area. Do not use ointments, greases, creams, lotions, powders or other drugs.
- If the victim is in shock, keep the person lying down and warm until medical help arrives.

Eye Exposure

If a pesticide contacts the eyes:

- Put on waterproof gloves.
- Hold the eyelids open and rinse eyes with large amounts of clean water. If possible, use a gentle stream of clean warm water.
- Continue washing for 15 minutes or more.
- Do not use chemicals or drugs in wash water.
- They may increase the extent of injury

Inhalation Exposure

If pesticide was breathed in (dust, mist, vapor, gases):

- Protect yourself. If the victim is in an enclosed space, do not attempt to rescue without proper respiratory equipment.
- Carry the victim to fresh air as quickly as possible.
- Loosen tight clothing.
- Watch for signs of unconsciousness or convulsions. If convulsions occur, keep the airway open.
- If breathing has stopped or is difficult, begin resuscitation. Use a plastic face mask to protect yourself.
- Prevent chilling (wrap patient in blankets but do not overheat).
- Keep patient as quiet as possible.

Oral Exposure

If pesticide was swallowed:

- If a person is conscious and able to swallow, give them 1/2 to 1 glass of milk or water. Larger quantities may cause vomiting.
- Do not induce vomiting.
- Call for medical assistance.
- If the patient is retching or vomiting, place the patient face down with their head lower than their body in the recovery position. This prevents vomit from entering the lungs and causing more damage. Do not let the patient lie on their back. Clean the vomit from the patient and collect some in case the doctor needs it for chemical tests.
- When medical advice cannot be obtained, check and follow the pesticide label for directions.
- The doctor may recommend activated charcoal be administered to adsorb any remaining pesticide in the stomach. Follow the doctor's instructions. Activated charcoal should be administered only with the advice of a medical attendant or doctor.

3.4 Signs of agro-chemical poisoning

The general symptoms of acute and chronic pesticide poisoning are headache, fatigue, weakness, dizziness, anxiety, perspiration, nausea and vomiting, diarrhea and loss of appetite. An increase in the severity of the symptoms leads to excessive saliva and perspiration, stomach cramps, trembling with poor muscle coordination and twitching. There may be blurred vision, rapid pulse and difficult in the breathing. Severe poisoning leads to convulsion, eyes bulging out, inability to breathe and eventually unconsciousness.

Whole body- Serious weakness or tiredness after spraying.

Skin- Uncomfortable feeling, burning, heavy sweating and change in colour.

Eyes- Heavy watering, blurred vision, narrowing or widening of the black portion of the eyes.

Digestive system- Burning of the mouth, vomiting, etc.

Respiratory system-Difficulty in breathing, unpleasant noise in the chest when breathing, coughing and chest pain.

Nervous system- Dizziness, restlessness**, confusion**, headache, uncontrollable movement of muscles, staggering, unclear speech, convulsion and unconsciousness.

If you are the victim

If you are exposed to a pesticide while you are working alone, remain calm. Symptoms of pesticide poisoning from vector control products are usually mild, and take time to develop.

For possible ingestion of pesticides, follow the labeling and consult the Poison Control Center or other medical professionals as quickly as possible.

If you spill a pesticide on yourself, always remove the source of the contamination as quickly as possible – including contaminated clothing, rinse immediately and wash with soap and water as soon as possible. By acting quickly and following label guidelines, you will minimize the effects of the pesticide, and may save your own life. Call or send for help while you are rinsing and washing!

If you splash or spill a pesticide in your eyes, wash your eyes with water at once. Use a clear stream of running water, keep your eyes open and wash for at least 15 minutes. After washing your eyes for 15 minutes, get to a doctor. Do not use any medicated eyewash. Call or send for help while you are washing your eyes. In any case, if you swallow a pesticide or get some in your eyes, see a doctor before symptoms develop. Any delay can cause temporary or permanent blindness or other injury; it could even be fatal.

If you have been exposed to a highly toxic pesticide by any exposure route and feel any illness, have someone take you and the label or labeled container to the doctor. Do not delay!

Emergency Information

If you have employees working with pesticides **-** you are required to post the name, address, and current telephone number of the physician, clinic, or hospital emergency room that will provide care in the event a person should be poisoned. This information must be clearly posted at all work sites (including vehicles, storage facilities, mixing areas, and loading areas).

It is impossible to overstress the importance of having well-designed emergency poison incident plans in place before an emergency arises. It is especially critical to have contact information available everywhere pesticides are handled. This information must include names, addresses, and telephone numbers for medical facilities for pesticide poisoning treatment, as well as the telephone number for poison control centers.

4.0 CONCLUSION

A pesticide poisoning occurs when chemicals intended to control a pest affect non-target organisms such as humans, wildlife, or bees. Pesticide poisoning can happen from one short exposure (acute poisoning) or from many exposures over a long time (chronic poisoning). Both acute and chronic poisoning can exhibit mild, moderate or severe symptoms. Some general considerations in the event of pesticide poisoning include the following: Stop the exposure immediately by separating the victim and the pesticide source; if the victim is unconscious, check to see if the victim is breathing. If not, give artificial respiration. If highly toxic material is present in the victim's mouth or respiratory path, use chest compression, not mouth-to-mouth. Decontaminate the victim immediately by washing off any skin residues of pesticide, and remove any contaminated clothing. Speed is absolutely essential in this step. Obtain professional help by calling the nearest physician. The general symptoms of acute and chronic pesticide poisoning are headache, fatigue, weakness, dizziness, anxiety, perspiration, nausea and vomiting, diarrhea and loss of appetite. An increase in the severity of the symptoms leads to excessive saliva and perspiration, stomach cramps, trembling with poor muscle coordination and twitching. There may be blurred vision, rapid pulse and difficult in the breathing. Severe poisoning leads to convulsion, eyes bulging out, inability to breathe and eventually unconsciousness.

5.0 SUMMARY

Pesticide poisoning can happen from one short exposure (acute poisoning) or from many exposures over a long time (chronic poisoning). The general symptoms of acute and chronic pesticide poisoning are headache, fatigue, weakness, dizziness, anxiety, perspiration, nausea and vomiting, diarrhea and loss of appetite. The exposure could affect any of the following: Whole body- Serious weakness or tiredness after spraying. Skin- Uncomfortable feeling, burning, heavy sweating and change in colour. Eyes- Heavy watering blurred vision, narrowing or widening of the black portion of the eyes. Digestive system- Burning of the mouth, vomiting, etc. Respiratory system-Difficulty in breathing, unpleasant noise in the chest when breathing, coughing and chest pain. Nervous system- Dizziness, restlessness**,** confusion, headache, uncontrollable movement of muscles, staggering, unclear speech, convulsion and unconsciousness.

6.0 TUTOR-MARKED ASSIGNMENT

1. Name two types of exposures to pesticides
2. Mention six symptoms of pesticides poisoning

7.0 REFERENCES/FURTHER READING

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MODULE 5

MODULE 5 PESTICIDE RESIDUE

UNIT 1 PESTICIDES AND THE ENVIRONMENT

CONTENTS

1.0 INTRODUCTION

Pesticides can enter the body through inhalation of aerosols, dust and vapor that contain pesticides; through oral exposure by consuming food/water; and through skin exposure by direct contact. Pesticides secrete into soils and groundwater which can end up in drinking water and pesticide spray can drift and pollute the air. The effects of pesticides on human health depend on the toxicity of the chemical and the length and magnitude of exposure. Farm workers and their families experience the greatest exposure to agricultural pesticides through direct contact. Every human contains pesticides in their fat cells.

Children are more susceptible and sensitive to pesticides, because they are still developing and have a weaker immune system than adults. Children may be more exposed due to their closer proximity to the ground and tendency to put unfamiliar objects in their mouth. Hand to mouth contact depends on the child's age, much like lead exposure. Children under the age of six months are more apt to experience exposure from breast milk and inhalation of small particles. Pesticides tracked into the home from family members increase the risk of exposure. Toxic residue in food may contribute to a child’s exposure. The chemicals can bioaccumulate in the body over time.

Exposure effects can range from mild skin irritation to birth defects, tumors, genetic changes, blood and nerve disorders, endocrine disruption, coma or death. Developmental effects have been associated with pesticides. Recent increases in childhood cancers in throughout North America, such as leukemia, may be a result of somatic cell mutations. Insecticides targeted to disrupt insects can have harmful effects on mammalian nervous systems. Both chronic and acute alterations have been observed in exposes. DDT and its breakdown product DDE disturb estrogenic activity and possibly lead to breast cancer. Fetal DDT exposure reduces male penis size in animals and can produce undescended testicles. Pesticide can affect fetuses in early stages of development, in utero and even if a parent was exposed before conception. Reproductive disruption has the potential to occur by chemical reactivity and through structural changes.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Know the effects pesticide on the soil.
- Know how pesticides affect domestic and wild animals
- Know how pesticides affect aquatic life

3.0 MAIN CONTENT

3.1 Effects of Pesticides on the Terrestrial Environment

Pesticides are biocides designed to be toxic to particular groups of organisms. They can have considerable adverse environmental effects, which may be extremely diverse: sometimes relatively obvious but often extremely subtle and complex. Some pesticides are highly specific and others broad spectrum; both types can affect terrestrial wildlife, soil, water systems, and humans.

Pesticides have had some of their most striking effects on birds, particularly those in the higher trophic levels of food chains, such as bald eagles, hawks, and owls. These birds are often rare, endangered, and susceptible to pesticide residues such as those occurring from the bioconcentration of organochlorine insecticides through terrestrial food chains. Pesticides may kill grain- and plant-feeding birds, and the elimination of many rare species of ducks and geese has been reported. Populations of insect-eating birds such as partridges, grouse, and pheasants have decreased due to the loss of their insect food in agricultural fields through the use of insecticides.

Bees are extremely important in the pollination of crops and wild plants, and although pesticides are screened for toxicity to bees, and the use of pesticides toxic to bees is permitted only under stringent conditions, many bees are killed by pesticides, resulting in the considerably reduced yield of crops dependent on bee pollination.

The literature on pest control lists many examples of new pest species that have developed when their natural enemies are killed by pesticides. This has created a further dependence on pesticides not dissimilar to drug dependence. Finally, the effects of pesticides on the biodiversity of plants and animals in agricultural landscapes, whether caused directly or indirectly by pesticides, constitute a major adverse environmental impact of pesticides.

The environmental impact of pesticides consists of the effects of pesticides on non-target species. Over 98% of sprayed insecticides and 95% of herbicides reach a destination other than their target species, because they are sprayed or spread across entire agricultural fields. Runoff can carry pesticides into aquatic environments while wind can carry them to other fields, grazing areas, human settlements and undeveloped areas, potentially affecting other species. Other problems emerge from poor production, transport and storage practices. Over time, repeated application increases pest resistance, while its effects on other species can facilitate the pest's resurgence.

Each pesticide or pesticide class comes with a specific set of environmental concerns. Such undesirable effects have led many pesticides to be banned, while regulations have limited and/or reduced the use of others. Over time, pesticides have generally become less persistent and more species-specific, reducing their environmental footprint. In addition the amounts of pesticides applied per hectare have declined, in some cases by 99%. However, the global spread of pesticide use, including the use of older/obsolete pesticides that have been banned in some jurisdictions, has increased overall.

Pesticides can contribute to air pollution. Pesticide drift occurs when pesticides suspended in the air as particles are carried by wind to other areas, potentially contaminating them. Pesticides that are applied to crops can volatilize and may be blown by winds into nearby areas, potentially posing a threat to wildlife. Weather conditions at the time of application as well as temperature and relative humidity change the spread of the pesticide in the air. As wind velocity increases so does the spray drift and exposure. Low relative humidity and high temperature result in more spray evaporating. The amount of inhalable pesticides in the outdoor environment is therefore often dependent on the season. Also, droplets of sprayed pesticides or particles from pesticides applied as dusts may travel on the wind to other areas, or pesticides may adhere to particles that blow in the wind, such as dust particles. Ground spraying produces less pesticide drift than aerial spraying does. Farmers can employ a buffer zone around their crop, consisting of empty land or non-crop plants such as evergreen trees to serve as windbreaks and absorb the pesticides, preventing drift into other areas. Pesticides that are sprayed on to fields and used to fumigate soil can give off chemicals called volatile organic compounds,

which can react with other chemicals and form a pollutant called tropospheric ozone. Pesticide use accounts for about 6 percent of total tropospheric ozone levels.

Many of the chemicals used in pesticides are persistent soil contaminants, whose impact may endure for decades and adversely affect soil conservation. The use of pesticides decreases the general biodiversity in the soil. Not using the chemicals results in higher soil quality, with the additional effect that more organic matter in the soil allows for higher water retention. This helps increase yields for farms in drought years, when organic farms have had yields 20-40% higher than their conventional counterparts. A smaller content of organic matter in the soil increases the amount of pesticide that will leave the area of application, because organic matter binds to and helps break down pesticides. Degradation and sorption are both factors which influence the persistence of pesticides in soil. Depending on the chemical nature of the pesticide, such processes control directly the transportation from soil to water, and in turn to air and our food. Breaking down organic substances, degradation, involves interactions among microorganisms in the soil. Sorption affects bioaccumulation of pesticides which are dependent on organic matter in the soil.

Nitrogen fixation, which is required for the growth of higher plants, is hindered by pesticides in soil. The insecticides DDT, methyl parathion, and especially pentachlorophenol have been shown to interfere with legume-rhizobium chemical signaling. Reduction of this symbiotic chemical signaling result in reduced nitrogen fixation and thus reduced crop yields. Root nodule formation in these plants reduces the amount of synthetic nitrogen fertilizer required for plant growth. Pesticides can kill bees and are strongly implicated in pollinator decline, the loss of species that pollinate plants in which worker bees from a beehive abruptly disappear. Application of pesticides to crops that are in bloom can kill honeybees which act as pollinators. On the other side, pesticides have some direct harmful effect on plant including poor root hair development, shoot yellowing and reduced plant growth.

3.2 Effects of Pesticides on the Aquatic Environment

The movement of pesticides into surface and groundwater is well documented. Wildlife is affected, and human drinking water is sometimes contaminated beyond acceptable safety levels. A major environmental impact has been the widespread mortality of fish and marine invertebrates due to the contamination of aquatic systems by pesticides. This has resulted from the agricultural contamination of waterways through fallout, drainage, or runoff erosion, and from the discharge of industrial effluents containing pesticides into waterways. Additionally, many of the organisms that provide food for fish are extremely susceptible to pesticides, so the indirect effects of pesticides on the fish food supply may have an even greater effect on fish populations. Some pesticides, such as pyrethroid insecticides, are extremely toxic to most aquatic organisms. It is evident that pesticides cause major losses in global fish production.

Fish and other aquatic biota may be harmed by pesticide-contaminated water. Application of herbicides to bodies of water can cause plants to die, diminishing the water's oxygen and suffocating the fish. Repeated exposure of some pesticides can cause physiological and behavioral changes in fish that reduce populations, such as abandonment of nests, decreased immunity to disease, and increased failure to avoid predators.

Pesticides can reach surface water through runoff from treated plants and soil. Contamination of water by pesticides is widespread. Groundwater pollution due to pesticides is a worldwide problem. Once ground water is polluted with toxic chemicals, it may take many years for the contamination to dissipate or be cleaned up. Cleanup may also be very costly and complex, if not impossible.

There are four major routes through which pesticides reach the water: it may drift outside of the intended area when it is sprayed, it may percolate, or leach, through the soil, it may be carried to the water as runoff, or it may be spilled, for example accidentally or through neglect. They may also be carried to water by eroding soil. Factors that affect a pesticide's ability to contaminate water include its water solubility, the distance from an application site to a body of water, weather, soil type, presence of a growing crop, and the method used to apply the chemical.

Fish and other aquatic biota may be harmed by pesticide-contaminated water. Pesticide surface runoff into rivers and streams can be highly lethal to aquatic life, sometimes killing all the fish in a particular stream. Application of herbicides to bodies of water can cause fish kills when the dead plants decay and consume the water's oxygen, suffocating the fish. Herbicides such as copper sulfite that are applied to water to kill plants are toxic to fish and other water animals at concentrations similar to those used to kill the plants. Repeated exposure to sub-lethal doses of some pesticides can cause physiological and behavioral changes that reduce fish populations, such as abandonment of nests and broods, decreased immunity to disease and decreased predator avoidance.

Application of herbicides to bodies of water can kill plants on which fish depend for their habitat. Pesticides can accumulate in bodies of water to levels that kill off zooplankton, the main source of food for young fish. Pesticides can also kill off insects on which some fish feed, causing the fish to travel farther in search of food and exposing them to greater risk from predators. The faster a given pesticide breaks down in the environment, the less threat it poses to aquatic life. Insecticides are typically more toxic to aquatic life than herbicides and fungicides. In the past several decades, amphibian populations have declined across the world, for unexplained reasons which are thought to be varied but of which pesticides may be a part. Pesticide mixtures appear to have a cumulative toxic effect on frogs. Tadpoles from ponds containing multiple pesticides take longer to metamorphose and are smaller when they do, decreasing their ability to catch prey and avoid predators. Exposing tadpoles to the organochloride endosulfan at levels likely to be found in habitats near fields sprayed with the chemical kills the tadpoles and causes behavioral and growth abnormalities. The herbicide atrazine can turn male frogs into hermaphrodites, decreasing their ability to reproduce. Both reproductive and non-reproductive effects in aquatic reptiles and amphibians have been reported.

4.0 CONCLUSION

Pesticides are biocides designed to be toxic to particular groups of organisms. They can have considerable adverse environmental effects. Pesticides have had some of their most striking effects on birds, particularly those in the higher trophic levels of food chains, such as bald eagles, hawks, and owls. The effects of pesticides on the biodiversity of plants and animals in agricultural landscapes, whether caused directly or indirectly by pesticides, constitute a major adverse environmental impact of pesticides. Pesticides can contribute to air pollution through drift which occurs when pesticides suspended in the air as particles are carried by wind to other areas, potentially contaminating them. Many of the chemicals used in pesticides are persistent soil contaminants, whose impact may endure for decades and adversely affect soil conservation. The use of pesticides decreases the general biodiversity in the soil. Nitrogen fixation, which is required for the growth of higher plants, is hindered by pesticides in soil. The movement of pesticides into surface and groundwater affects wildlife and human drinking water is sometimes contaminated beyond acceptable safety levels. A major environmental impact has been the widespread mortality of fish and marine invertebrates due to the contamination of aquatic systems by pesticides. There are four major routes through which pesticides reach the water: it may drift outside of the intended area when it is sprayed, it may percolate, or leach, through the soil, it may be carried to the water as runoff, or it may be spilled, for example accidentally or through neglect.

5.0 SUMMARY

The effects of pesticides on the biodiversity of plants and animals in agricultural landscapes, whether caused directly or indirectly by pesticides, constitute a major adverse environmental impact of pesticides. Pesticides can contribute to air pollution through drift which occurs when pesticides suspended in the air as particles are carried by wind to other areas, potentially contaminating them. The use of pesticides decreases the general biodiversity in the soil. Nitrogen fixation is hindered by pesticides in soil. The movement of pesticides into surface and groundwater affects wildlife and human drinking water is sometimes contaminated beyond acceptable safety levels. A major environmental impact has been the widespread mortality of fish and marine invertebrates due to the contamination of aquatic systems by pesticides. There are four major routes through which pesticides reach the water: it may drift outside of the intended area when it is sprayed, it may percolate, or leach, through the soil, it may be carried to the water as runoff, or it may be spilled, for example accidentally or through neglect.

6.0 TUTOR-MARKED ASSIGNMENT

1. Mention three (3) ways in which pesticides affect the environment
2. Name four (4) major routes through which pesticides reach the water

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UNIT 2 PESTICIDES/CHEMICAL RESIDUE IN STORED PRODUCE

CONTENTS

1.0 INTRODUCTION

Pesticide residues are generally meant to include pesticides that are detectible in or on places other than their intended target. Fresh water reservoirs, stream bed sediments, and harvested food would be examples of places that would be tested for pesticide residues. Needless to say, if high levels of residues were found to occur in such situations, few would consider the test results to be a good thing. Pesticide residues are usually measured and tolerances expressed in parts per million (ppm) to parts per billion (ppb) on a weight basis. One ppm is one milligram in a kilogram, or one ounce of salt in 62,500 pounds of sugar, or one pound of pesticide in one million pounds of raw agricultural commodity. In some instances modern analytical chemistry techniques can test residue levels below one ppb.

The residue levels allowed on food crops at harvest are legally set by the federal and state regulatory agencies and are called tolerances. Tolerances are simply the maximum amounts of pesticide permitted to be present on or in raw agricultural commodities. These tolerances represent levels of pesticide residues which scientists have determined may safely remain on the food crop without injury to the consumer. Tolerances vary according to the pesticide and the crop. When pesticide tolerances are found to exceed legal tolerances, the agricultural commodities involved may be seized and destroyed. Ordinarily, such situations would arise from the application of agricultural pesticides on crops, but it could happen even where pesticide applications are not specifically targeted at a crop pest, such as the application of pesticides on rice fields for mosquito control. Before allowing the use of a pesticide on food crops, EPA sets a tolerance. If no tolerance has been set for that pesticide on that crop, the pesticide cannot be legally applied on the crop. Some pesticides may be considered "safe" by EPA, and they would be exempted from a tolerance.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Know how much pesticides remain on the food we harvest
- Know how much pesticides can be tolerated in the food we eat
- Know ways in which pesticide residue may be reduced in our food

3.0 MAIN CONTENT

3.1 What is Pesticide Residues

Pesticides are commonly used on the food we eat to control pests that may damage the crops during production, storage or transport. Pesticides allow growers to increase the amount of usable food from each crop at the time of harvest. Pesticides may also improve the quality, safety, and shelf-life of certain foods. The amount of pesticide that remains in or on food is called the pesticide residue. The U.S. EPA (Nigerian NAFDAC equivalent) determines the maximum amount of pesticide residue that can remain in or on a particular food. This legal limit is called the pesticide tolerance. By the time food reaches your food store, pesticide residues are generally well below the legal limit, or tolerance. However, there are several healthy, sensible food practices that will allow you to further reduce your exposure to any pesticide residues that may remain on your food.

3.2 Minimizing Pesticide Residues in Food

The U.S. EPA and other agencies regulate pesticide residues in or on our food. These agencies ensure that residue levels remain below established limits to safeguard human health. Pesticide residues tend to decline as the pesticide breaks down over time, and diminish as the commodities are washed and processed prior to sale. By the time food reaches your grocery store, pesticide residues are generally far below the legal limits. However, low levels of pesticide residues may still remain on some foods, even organic foods.

How to reduce pesticide residue on the food you eat:

- First, eat a variety of fruits and vegetables to minimize the potential of increased exposure to a single pesticide. Do not consume too much of a given fruit or vegetable at a time.
- Thoroughly wash all produce, even that which is labeled organic and that which you plan to peel.
- Wash your produce under running water rather than soaking or dunking it.
- Dry produce with a clean cloth towel or paper towel when possible.
- Scrub firm fruits and vegetables, like melons and root vegetables.

- Discard the outer layer of leafy vegetables, such as lettuce or cabbage.
- Peel fruits and vegetables when possible.
- Trim fat and skin from meat, poultry, and fish to minimize pesticide residue that may accumulate in the fat.

In addition, you may consider growing your own garden, or participating in a community garden! This will allow you to control which pesticides, if any, are used on the food you eat. You can choose Integrated Pest Management (IPM) options that allow you to control garden pests with the least possible hazard.

Raw produce: Selecting and serving it safely

Fruits and vegetables are an important part of a healthy diet. The markets carry an amazing variety of fresh fruits and vegetables that are both nutritious and delicious. However, harmful bacteria that may be in the soil or water where produce grows may come in contact with fruits and vegetables and contaminate them. Fresh produce may also become contaminated after it is harvested, such as during preparation or storage. Eating contaminated produce (or fruit and vegetable juices made from contaminated produce) can lead to foodborne illness, often called "food poisoning." As you enjoy fresh produce and fresh-squeezed fruit and vegetable juices, follow these safe handling tips to help protect yourself and your family.

Buy Right

You can help keep produce safe by making wise buying decisions at the food store.

- Purchase produce that is not bruised or damaged.
- When selecting pre-cut produce — such as a half a watermelon or bagged salad greens — choose only those items that are refrigerated or surrounded by ice.
- Bag fresh fruits and vegetables separately from meat, poultry and seafood products when packing them to take home from the market.

Separate for Safety

Keep fruits and vegetables that will be eaten raw separate from other foods such as raw meat, poultry or seafood — and from kitchen utensils used for those products. Wash cutting boards, dishes, utensils and counter tops with soap and hot water between the preparation of raw meat, poultry and seafood products and the preparation of produce that will not be cooked.

Prepare Safely

When preparing any fresh produce, begin with clean hands. Wash your hands for at least 20 seconds with soap and warm water before and after preparation.

- Cut away any damaged or bruised areas on fresh fruits and vegetables before preparing and/or eating. Produce that looks rotten should be discarded.
- Even if you plan to peel the produce before eating, it is still important to wash it first so dirt and bacteria aren't transferred from the knife onto the fruit or vegetable.
- Scrub firm produce, such as melons and cucumbers, with a clean produce brush.
- Dry produce with a clean cloth towel or paper towel to further reduce bacteria that may be present.

Many pre-cut, bagged, or packaged produce items like lettuce are pre-washed and ready-to-eat. If so, it will be stated on the packaging. If the package indicates that the contents are pre-washed and ready-to-eat, you can use the produce without further washing.
If you do chose to wash a product marked "pre-washed" or "ready-to-eat," be sure to use safe handling practices to avoid any cross contamination.

4.0 CONCLUSION

Pesticides are commonly used on the food we eat to control pests that may damage the crops during production, storage or transport. The amount of pesticide that remains in or on harvested food, soil, water, milk, meat, etc. is called the pesticide residue. The residue levels allowed on food crops at harvest are legally set by the federal and state regulatory agencies and are called tolerances. Tolerances are simply the maximum amounts of pesticide permitted to be present on or in raw agricultural commodities. These tolerances represent levels of pesticide residues which may safely remain on the food crop without injury to the consumer. When pesticide tolerances are found to exceed legal tolerances (Maximum Tolerance Limit=MXL), the agricultural commodities involved may be seized and destroyed because they are not safe for human or livestock consumption. Pesticide residues tend to decline as the pesticide breaks down over time, and diminish as the commodities are washed and processed prior to sale or consumption. Eating contaminated produce (or fruit and vegetable juices made from contaminated produce) can lead to foodborne illness, often called "food poisoning." To reduce pesticide residues in food, purchase produce that is not bruised or damaged. Keep fruits and vegetables that will be eaten raw separate from other foods such as raw meat, poultry or seafood — and from kitchen utensils used for those products. Even if you plan to peel the produce before eating, it is still important to wash it first so dirt and bacteria aren't transferred from the knife onto the fruit or vegetable.

5.0 SUMMARY

Pesticides are commonly used on the food we eat to control pests that may damage the crops during production, storage or transport. The amount of pesticide that remains in or on harvested food, soil, water, milk, meat, etc. is called the pesticide residue. Tolerances are simply the maximum amounts of pesticide permitted to be present on or in raw agricultural commodities. These tolerances represent levels of pesticide residues which may safely remain on the food crop without injury to the consumer.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is pesticide residue?
2. Mention four (4) ways in which you can reduce pesticide residues on you food.

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UNIT 3 DECLINE OF PESTICIDES IN TREATED PRODUCE

CONTENTS

1.0 INTRODUCTION

Food is a more basic need of man than shelter and clothing. It provides adequate nutrients for the body's growth, maintenance, repair and reproduction. Food security is one of the major concerns for most developing countries. Nigeria has diverse agro climatic conditions which allows for different approaches for cultivation and crop protection. With the limitation of expansion of land area under cultivation, most of the gains in agricultural production may have to come from increased productivity through two major inputs i.e. fertilizers and pesticides.

The losses of crops caused by pests and plant diseases are quite high both in developed and developing countries. They range from 10–30% in the developed countries and 40–75% in the developing countries (Roy 2002). Even greater losses occur after the crop is harvested which are caused by the pests that attack the stored products, particularly in the tropics. Chemical control of pests aimed at minimizing these losses has been the main tool throughout the world. Approximately 70% of the pesticides used in the world are applied in developed countries and 30% in the developing countries (Usha and Sandhu, 2014).

Pesticides slowly start dissipating or declining after they are sprayed. Every pesticide used on crops needs some waiting period before harvesting that differs from pesticide to pesticide and also from one crop to another. Food products become safe for consumption only after waiting period has lapsed. If fruits and vegetables are harvested before completion of the waiting period, they are likely to have higher level of residues, which are hazardous to health. The incidence of excessive pesticide residues may cause blindness, cancer, diseases of liver and nervous system etc. The long term effects could result in reduction of live sperm and fertility, increase in cholesterol levels, high infant mortality rates and several metabolic and genetic disorders (Gupta 2006).

2.0 OBJECTIVES

At the end of this uit, you should be able to:

- Know that pesticide residue decline on treated food
- Know how handling and processing reduce pesticide residue in food
- Learn the first-aids methods for various types of poisoning

3.0 MAIN CONTENT

3.1 How Pesticides decline in treated produce

Pesticide residues are generally meant to include pesticides that are detectible in or on places other than their intended target. Fresh water reservoirs, stream bed sediments, and harvested food would be examples of places that would be tested for pesticide residues. Needless to say, if high levels of residues were found to occur in such situations, few would consider the test results to be a good thing. Pesticide residues are usually measured and tolerances expressed in parts per million (ppm) to parts per billion (ppb) on a weight basis. One ppm is one milligram in a kilogram, or one ounce of salt in 62,500 pounds of sugar, or one pound of pesticide in one million pounds of raw agricultural commodity. In some instances modern analytical chemistry techniques can test residue levels below one ppb.

The residue levels allowed on food crops at harvest are legally set by the federal and state regulatory agencies and are called tolerances. Tolerances are simply the maximum amounts of pesticide permitted to be present on or in raw agricultural commodities. These tolerances represent levels of pesticide residues which scientists have determined may safely remain on the food crop without injury to the consumer. Tolerances vary according to the pesticide and the crop.

Some factors affecting residue levels

Most organochlorine pesticides (e.g., DDT, chlordane) are very persistent. Most of the organophosphates (e.g., parathion, malathion) and pyrethroids are much less persistent. Pyrethrins, and carbamate pesticides are nonpersistent. Some factors that influence the persistence of a chemical and the possibility that residues may remain are:

The amount of chemical applied

The formulation

The pH (acidity or alkalinity) of the water diluent and of the target tissue, soil, or water.

The nature of the surface to which it is applied

Exposure to weathering from wind, rain, etc.

Chemical breakdown from high temperatures and humidity

Photochemical reactions from sunlight

Biological reactions.

If public health pesticides are applied properly and in accordance with label restrictions for applications around food crops residues on or in the crop should never be a problem.

3.2 Decline of pesticide residues in food commodities

Composition and properties of various food commodities vary according to their nature and group they belong. The same is true for pesticides. There are numerous factors that affect the extent of pesticide absorbance, penetration and degradation and differ from one category of food to another. The rate at which pesticides are moved and dissipated is closely related to the physico-chemical parameters of pesticide itself and surrounding environmental conditions. The ability to resist degradation (persistence) under various conditions is measured as half-life of the pesticide. The "half-life" is the time required for half of the pesticide to break down/disappear. Half-life of a pesticide can range from hours or days, to years for more persistent ones. Half-lives are only estimates and they can vary depending on environmental conditions. The amount of pesticides remaining after a half-life depends on the amount of pesticide originally applied. Pesticide can be degraded by photolysis, hydrolysis, oxidation and reduction, metabolism (plants, animals or microbes), temperature, and pH. The values of half-life for different pesticides are extensively reported in the literature. These differ according to pesticides, food/crop, application dose and experimental conditions.

The retention of pesticides depends on the physiochemical properties of the pesticide molecules as well as food. In fruits and vegetables, most of the pesticide residues are retained on peel surface. This is the reason that majority of the residues are removed by washing, peeling or treatments with chemical solutions like vinegar, turmeric, sodium bicarbonate, common salt or alcohol. Pesticides may be introduced to fruits and vegetables during different phases of production. Some pesticides are used before blooming, some while fruits are growing and others after harvesting. Therefore the location of pesticides in the same fruit may be different. Very little quantity of systemic pesticides may be absorbed into flesh. The leaching of pesticides from the surface of fruits and leafy commodities is due to their solubility in water. The effectiveness of washing is also dependent and may be reduced for insecticides, specifically on synthetic pyrethroids, due to strong bonding between the insecticide molecules and waxy layer of fruit skin and also their non-systemic and non-translaminar movement characteristics.

In cereal grains, most of the pesticides are contained in outer layer of grain i.e. bran and therefore, milling and similar processing techniques remove the residues to varied extent. Also, cereal grains are invariably sprayed with insecticides for storage in bulk silos after harvest to reduce losses during storage for 1 year or more at ambient temperature. The residues of more lipophilic pesticides tend to remain on seed coat although a fraction can move to bran and germ. In other crops like cowpea grain, residues of cypermethrin and deltamethrin cannot be removed by washing and cooking in stored grains because the residues penetrate the interior of grains.

Milk and milk products sometimes are found contaminated with insecticides from feed and fodder which remain associated with its fat portion. Therefore, residues may be found in greater concentration (on a fat basis) in milk products (butter, cheese) than milk from which these were manufactured. In meat, pesticides are mainly concentrated in fat component. Those pesticides which tend to be lipid soluble, are found in much higher concentration in egg yolk than in albumin. The most organic pesticides have high affinity for oils which makes their removal extremely difficult from different oils and fats.

The fat soluble insecticides, like organochlorines, after reaching a body of water tend to adhere to suspended organics which are consumed by small invertebrates that dwell upon them. Fish feeding upon small aquatic invertebrates accumulate the pesticides in their tissues, besides directly absorbing them from polluted water around. The organochlorine insecticides with their high lipid solubility easily accumulate in fat tissues of fish.

3.3 Effect of handling and processing on pesticides residue

Foods after harvest/slaughter are subjected to various handling and processing operations both at home or industry level, involving a simple washing to more multi-step and complex processing aimed to extend shelf-life, add variety, increase palatability and nutrient availability and to generate income. The various techniques and methods applied usually reduce residue levels because of washing or cleaning, peeling, blanching, juicing, cooking, milling baking, pasteurization, canning etc. The extent of pesticide reduction depends upon the washing operations, nature of pesticide molecule and other preparatory steps used. Loosely held residues of several pesticides are removed with reasonable efficiency by varied type of washing processes. Moreover, majority of pesticides applied to crops are confined to the outer surfaces and undergo limited movement or penetration of the cuticle. Therefore, they are amenable to removal by washing, peeling and trimming operations.

Thus, there is an increasing need for information about the effects of various processes on the fate of pesticide residues in foods both from a regulatory and public concern perspective. A set of processing techniques are used to convert raw materials into a variety of products for consumption. The amount of residue in the final product may be reduced or enhanced depending upon a set of parameters employed and length of processing. In addition, micro-organisms/fermentation, if employed, also contributes to residual degradation of pesticides. Processes like drying and dehydration, grain milling, baking, malting and brewing, canning of fruits and vegetables, and other postharvest handling processes reduce pesticide residues in agricultural products

a) Washing with water: Fruits and vegetables are invariably washed before consumption. Vegetables are often peeled off and cooked prior to eating. For example, only one minute washing of okra having an initial deposit of 15.20 ppm of malathion removed the residue to the extent that only traces were detected on washed okra. Only 11.83 cm rainfall washed the initial deposit of carbaryl in okra to nil thereby recording a 100% reduction. Washing of treated okra for 30 s with tap water will result in considerable removal of malathion deposits. Various pesticide decontamination processes like washing the fruits with water dislodges the residues to varying degrees depending on constitution of the fruit, chemical nature of the pesticide and environmental conditions. Washing one of the most effective means of removing pesticide residues and minimizing dietary intakes from cabbage. Cold water washing removed 96% malathion residue from beans.

b) Washing with salt solution: Washing with dilute salt (sodium chloride) solution is a convenient method to lower the load of contaminants from food surfaces particularly fruits and vegetables. This method could be equally effective for reducing the pesticide residue from other commodities too. This procedure is recommended as being practical for household use.

c) Kitchen type and combination processing (Trimming, washing, peeling, cooking etc.*):* Kitchen-type processing techniques could remove 40–77% of diazinon residues and 37–82% of dimethoate residue in green beans and cauliflower. Washing alone reduced the levels of dimethoate residues by approximately 25–80% whereas washing and cooking of cauliflower curds reduced the level of residues by 52–91%. Peeling is the most effective way to remove the pesticide from the vegetables followed by frying. Boiling is effective in reducing the level of water-soluble pesticides.

Thermal Treatment

Foods are invariably subjected to heat treatment during preparation and preservation. The heat treatment is given in many ways including pasteurization, boiling, cooking etc. depending upon the nature of food and aim of processing. The loss of pesticide residue during heat processing may be due to evaporation, co-distillation, thermal degradation which vary with the chemical nature of the individual pesticide.

a) *Pasteurization*: Pasteurization reduced HCH content by 65–73%, thus, consumption of heat-treated milk and dairy products is safer than consumption of raw milk in terms of HCH residue intake.

4.0 CONCLUSION

Pesticide residues remain in almost all the food commodities, as a result of preharvest or postharvest application. The location of pesticides in different parts of food varies with the nature of molecule and type of food commodity and environmental conditions. Pesticide can be degraded by photolysis, hydrolysis, oxidation and reduction, metabolism, temperature, and pH. The level of pesticide residues is affected by washing, preparatory steps, heating or cooking, processing during product manufacturing and postharvest handling and storage. The extent of reduction varies with nature of pesticide molecule, point of location, type of commodity, processing steps and product prepared. The washing of raw materials is the simplest way to reduce the pesticide residue in the final product. The more effective and convenient alternative could be washing with chlorine water or with dilute solutions of other chemicals depending upon food commodity. Special precautions should be taken to dislodge the residues from raw materials to be used for preparation of concentrated and dehydrated products. Judicious and systematic approach must be followed to adopt preharvest practices and postharvest treatments to minimize the residue levels in finished products. Pest management is one of the major inputs in agricultural production; therefore, this area needs great attention to economize the production, to provide safe foods and to lower the medical expenses for treatment of resulting ailments.

5.0 SUMMARY

Pesticide residues remain in almost all the food commodities, as a result of preharvest or postharvest application. Pesticide can be degraded (decline) by photolysis, hydrolysis, oxidation and reduction, metabolism, temperature, and pH. The level of pesticide residues is affected by washing, preparatory steps, heating or cooking, processing during product manufacturing and postharvest handling and storage. The washing of raw materials is the simplest way to reduce the pesticide residue in the final product. The more effective and convenient alternative could be washing with chlorine water or with dilute solutions of other chemicals depending upon food commodity.

6.0 TUTOR-MARKED ASSIGNMENT

1. List four (4) ways in which pesticides are degraded from treated produce.
2. Mention three (3) ways that affect pesticide residue in harvested food.

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