COCOA TRAINING MODULE

Pesticide Application

KEY ISSUES - PESTICIDES

- **Safety aspects - risks to growers and consumers**.
- **Cost - effectiveness.**
- **Technical problems with pesticide applications: including development of resistance by pests.**
- Other sustainability concerns including:
  - general **impact on the environment (*e.g. the*** build-up of copper in the soil after long-term use for disease control).

…. but pesticides can be important tools for farmers and cannot simply be wished away

LIST OF PESTICIDES CURRENTLY APPROVED FOR USE ON COCOA FARMS IN NIGERIA

S/n	Trade name	Active ingredient	Distribution company in Nigeria	Target pest
	Insecticide			
1.	Actara 25 WG	Thiamethoxam	SYNGENTA	Mirid
2.	Esiom 150 SL	Acetamiprid + Cypermethrin	INSIS	Mirid
	Fungicide			
1.	Funguran-OH	Copper hydroxide	INSIS	Black pod
2.	Champ DP	Copper hydroxide	SARO	Black pod
3.	Ridomil gold 66WP	Cuprous oxide + metalaxyl-M	SYNGENTA	Black pod
4.	Copper Nordox 75 WP	Cuprous oxide	DIZZENGOFF	Black pod
5.	Ultimax plus	Metalaxyl+ Copper hydroxide	HARVESTFIELD	Black pod.
6.	Kocide 101	Cuprous Oxide	SARO	Black pod.
7.	Kocide 2000	Cuprous hydroxiide	DUPONT	Black pod.
	Herbicides			
1.	Touch down	Glyphosate	SYNGENTA	Weed
3.	Clear weed	Glyphosate	HARVESTFIELD	Weed
2.	Round up	Glyphosate	CANDEL	Weed
	Fumigants			
1.	Phostoxin	Aluminum phosphide	GONGONI	Storage pests

What is a pesticide?

- The term “pesticide” can be defined simply as any substance which is used to control a pest
- at any stage in crop production, storage or transport.

The main pesticide groups include:

- Fungicides - for crop diseases such as black pod
- Herbicides - kill weeds
- Insecticides - control insect pests, but they may also be

  - acaricides: controlling mites

  - nematicides: controlling nematodes (eelworms)
- Rodenticides - kill rats and mice (they are often much less effective against squirrels)

- Other pesticide types include molluscicides (that kill slugs and snails) and bacteriacides, but they are not usually used on cocoa.

- Occasionally, some substances have multiple action (*e.g.* metam is a fungicide, herbicide and nematicide).

Of what Importance is pesticide use in cocoa?

- Cocoa, like other tropical crops, continues to be attacked by insects, diseases and other pests that must be controlled effectively and safely

- Pesticides can provide practical control solutions, but must be approved and used on the basis of GAP and SPS regulations.

- Pests pose a major threat to the safety, suitability and acceptability of Cocoa therefore pesticides may be used as protective and, or a control measure on pests.

- *Consumers do not always appreciate the high levels of disease and insect pressure that occur in tropical countries, and solving pest control problems for growers remains a crucial part of the "package".*

- Good hygiene and sanitation practices can also be employed to avoid creating unconducive (or risky)environment, couple with inspection of incoming materials and good monitoring can minimise risks of infestation in Stores / warehouses.

Why the need for GMPs?

- Consumer concerns on food safety and threat of contaminants to human health have caused tightening of regulations in consuming countries. This increases the risk of disruption to cocoa trade,
- Also poor **Sanitary and Phyto-Sanitary (SPS) standards have the potential to harm the welfare of farmers** in a number of cocoa-growing countries.

Cocoa pesticides are there for a reason

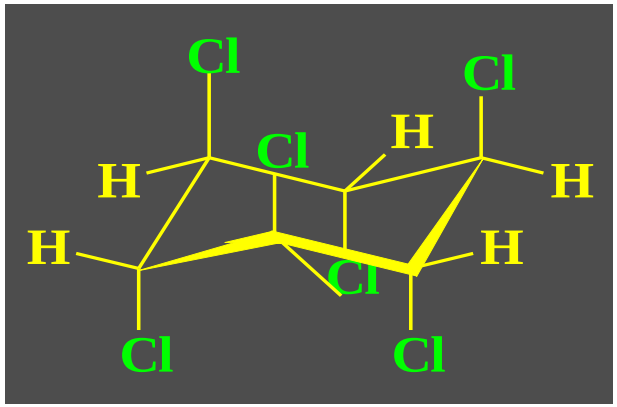
- Black pod diseases: *Phytophthora* spp. especially
  - *P. megakarya*
  - losses of ~90% if left untreated
- respond well to chemical control …… coupled with good cultural practices (crop sanitation, shade management, *etc.*)

- Traditionally: copper (oxide, hydroxide, oxychloride *etc*.) protective: since 1760s
- enhanced control with copper mixed with metalaxyl (1977; ~M: 1996)
- other new(ish) AIs promoted (*e.g*. Carboxylic Acid Amide compounds: 1990s) - but are they what farmers want to use?

Insects

- “Mirid blast” (tree die back)
- Crop loss estimates .
  (of about 100,000 T)

Originally with insecticides such as HCH (lindane): 1950s - 2001



- Long residual contact action
- Some fumigant activity
- Broad spectrum

- Now recommended:
  - pyrethroids
  - neo-nicotinoids

Storage pests

Criteria for use of pesticide

- Toxicity
- Residual activity (persistency)
- Ease of handling of such chemicals
- The cost of the chemicals.

Classifications of pesticides

The World Health Organization (WHO) classification

(LD50 to rats mg/kg body weight: of formulations where information is available)

Class	Solids		Liquids	
	Oral	dermal	oral	dermal
Ia Extremely Hazardous	5	10	20	40
Ib Highly Hazardous	6-50	11-100	21-200	41-400
II Moderately Hazardous	51-500	101-1000	201-2000	401-4000
III Slightly Hazardous	≥ 501	≥1001	≥ 2001	≥ 4001
(U) Unlikely to present acute hazard in normal use	> 2000	-	> 3000	-

The higher theLD50 of a pesticide the safer its use on stored products

Maximum Residue Limits for Cacao beans (commodity code SB 0715)

Pesticide	MRL	Year of Adoption
Hydrogen Phosphide	0.01 mg/Kg	Po
Thiamethoxam	0.02 mg/Kg	2011 (*)
Clothianidin	0.02 mg/Kg	2011 (*) T
Endosulfan	0.2 mg/Kg	2007
Metalaxyl	0.2 mg/Kg	1991
Methyl Bromide	5 mg/Kg	1999 Po

(*) At or about the limit of determination.
Po: The MRL accommodates post-harvest treatment of the commodity.
T: Temporary?

- Possibly an important source of high residues
  - –especially sprays to sacks?
- Phasing out of methyl bromide, heavy reliance on phostoxin:
  - –resistance issues?

Responsible pesticide use

Responsible Pesticide Use has at least four components:

(i) accurate diagnosis of problems and consequent decision making …

(ii) if their use is needed, the responsible use of pesticides or alternative control techniques;

(iii) choice of appropriate products that are registered for control of that problem and rotation of products to avoid build-up of resistance;

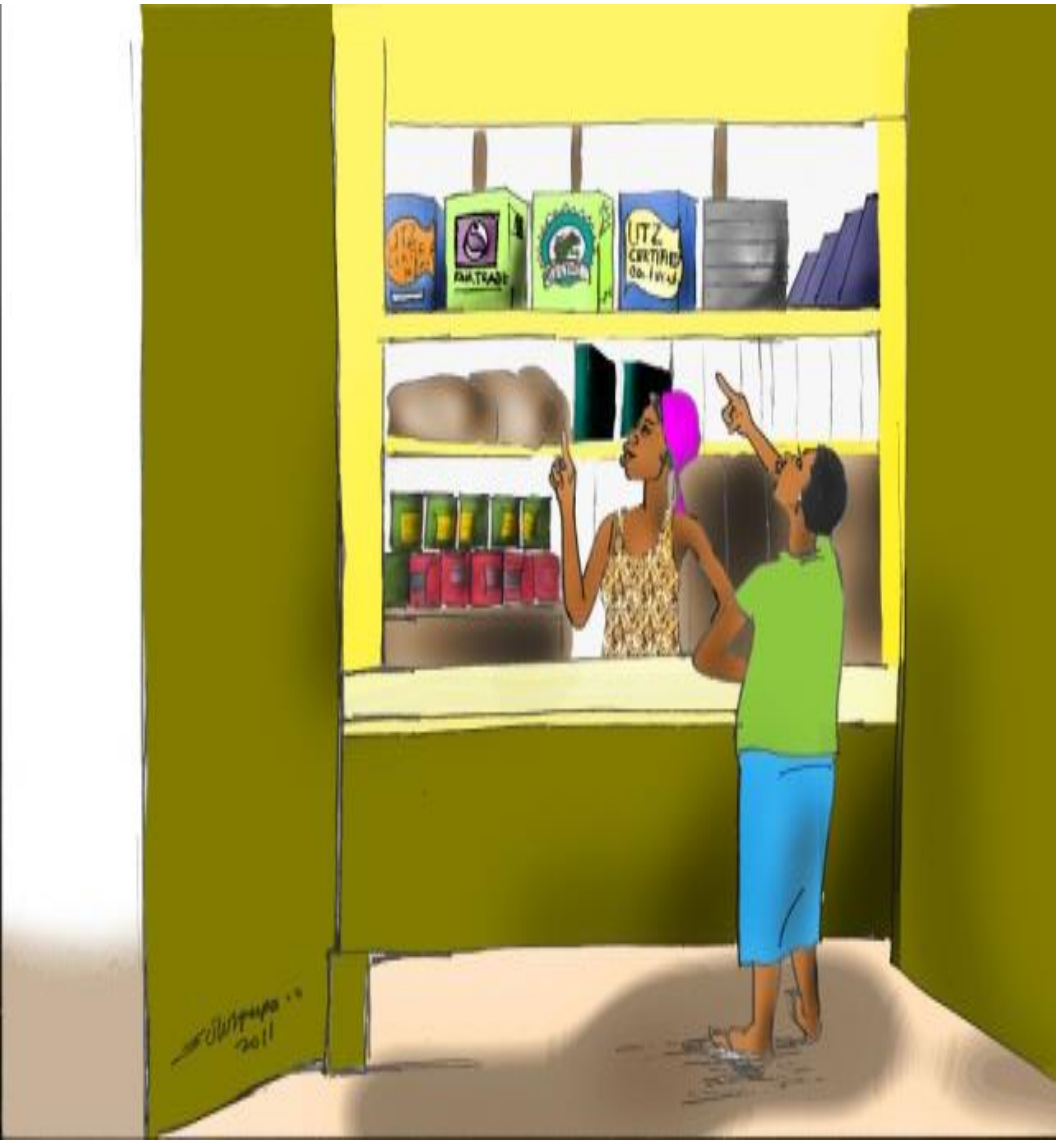
(iv) efficient application: to maximize efficacy and minimize costs and impacts on non-target organisms.

FAO,2002

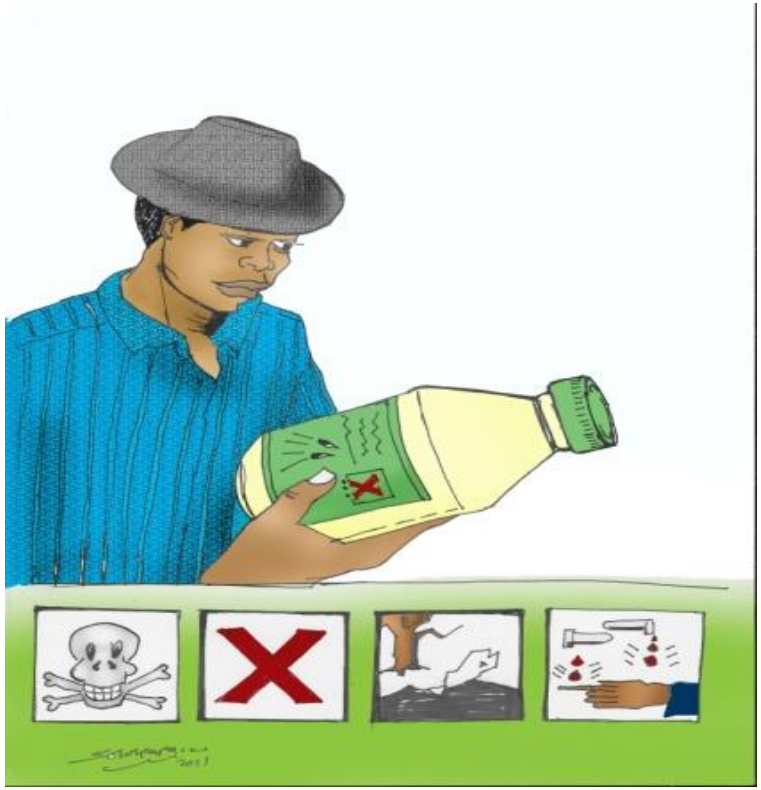
Application of pesticides

1. Choice of pesticide

- Which product to choose?
- Is it effective?
- Is it safe?
- Is it genuine (of the right quality)?
- Is it affordable?



2.) Select the right pesticide for the problem:



3.) **Think safety first.**

It is important to understand the hazard labelling signs (pictograms) on labels. For products in/from the EU, the new Regulations* have changed hazard pictograms required for chemicals

very toxic

harmful/irritant

danger to the environment

flammable

corrosive

4.) **Personal Protective Equipment** (PPE).

For decades, the use of PPE (mask, goggles, gloves, *etc.)* ***has been recommended to small-holder*** farmers in order to protect them from the effects of pesticides.

In addition, PPE is only of value if they are well maintained and worn properly.

Since it may also be too hot to wear heavy protective gear, a rational approach would be to recommend:

- ✓ Selection of less toxic products
- ✓ Guidelines on minimum standards for personal protection (as opposed to none)
- ✓ Appropriate application skills for avoiding exposure when spraying
- ✓ Hygiene practices

Minimum Personal Protection Measures

- Wear a hat to protect against falling droplets
- Wear comfortable clothing that protects as much of the body, arms and legs as possible.
- Never put on previously contaminated overalls or other clothing
- A face visor is especially important if you are using irritant or harmful pesticides
- Wear trousers on outside of boots
- Pest managers / fumigators should be made aware that **it is safer to use no gloves at all than gloves with holes in them.**

5.) Pesticide formulation

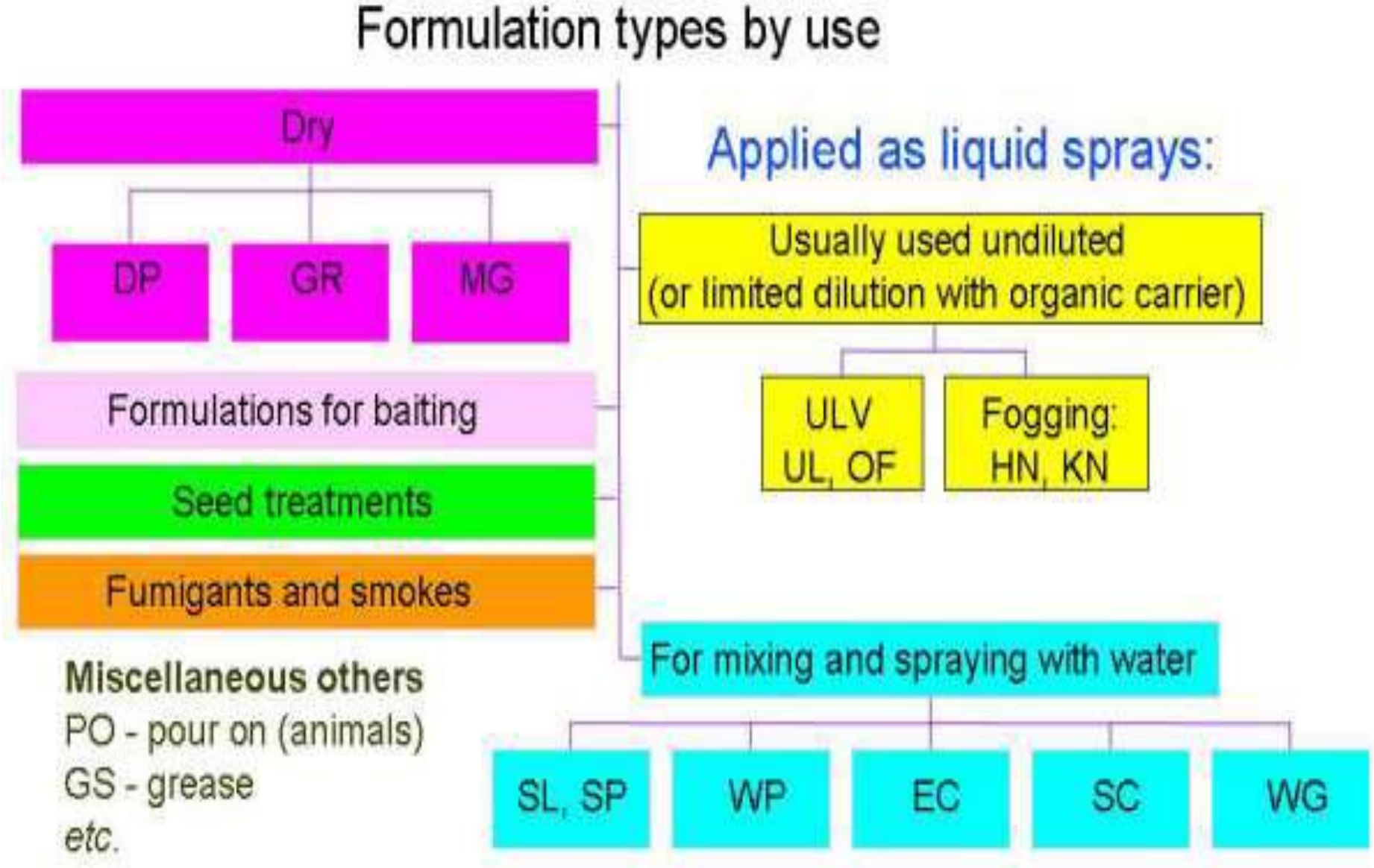
- ✓ Use the right amount of water (volume rate) and pesticide mixture as indicated on the label.
- ✓ Ask yourself the questions:

→ how many liters can my sprayer tank hold?

→ how many areas are treated per tank load?

→ how many tank loads are required to spray the warehouse or store?

The major groups of pesticide formulations can be illustrated as follows:



Frequently used products are formulations for mixing with water then applying as sprays.

- Water miscible, older formulations include:
- Emulsifiable concentrate EC
- Wettable powder WP
- Soluble (liquid) concentrate SL
- Soluble powder SP

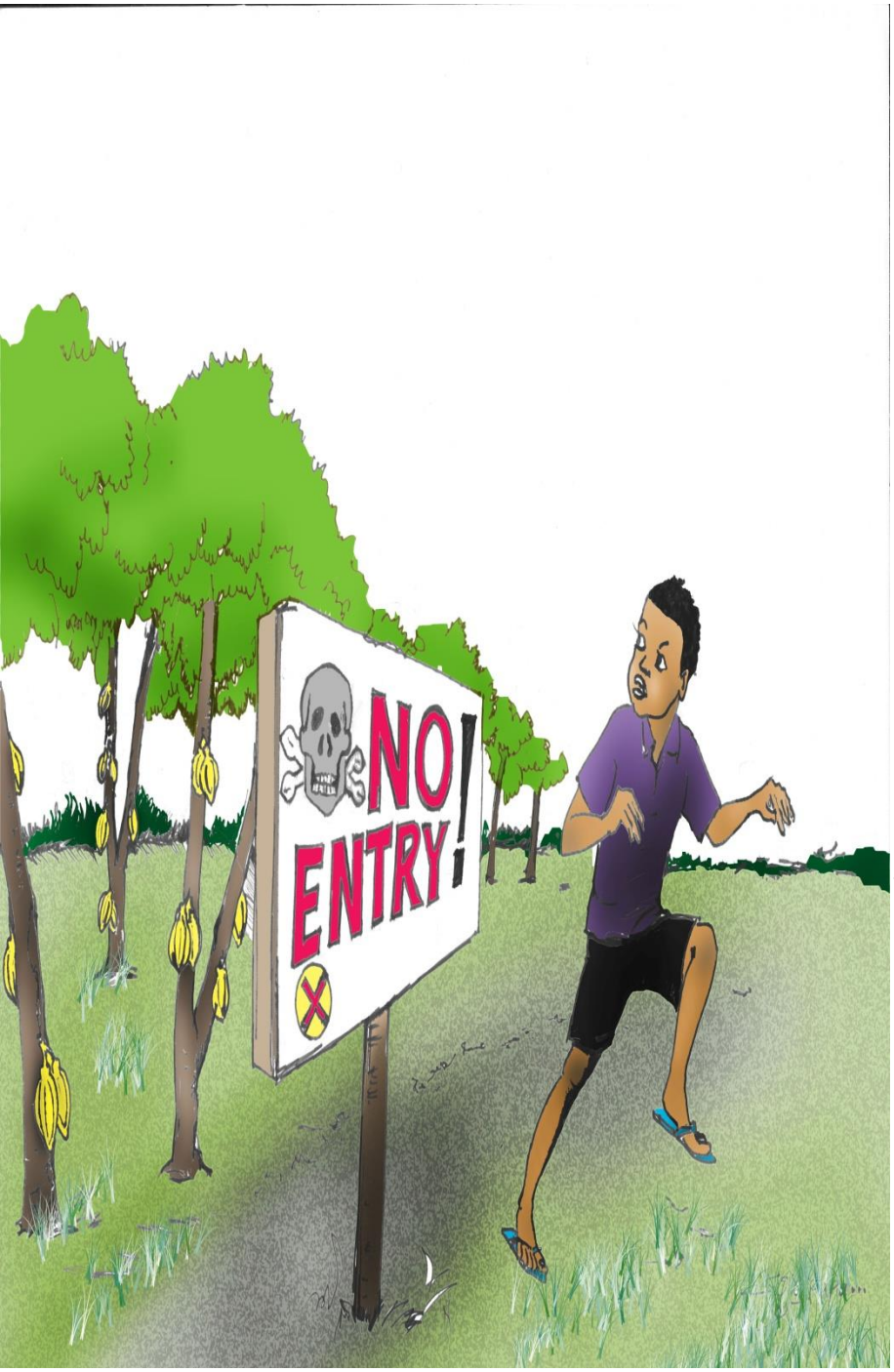
- Newer, non-powdery formulations with reduced or no use of hazardous solvents and improved stability include:
- Suspension concentrate SC
- Capsule suspensions CS
- Water dispersible granules WG

6.) Apply pesticides in the right way to achieve effective pest control. Good application includes control of the amount of product delivered to the crop. This means good nozzle selection, calibration and application technique.

Application technique

- Test the spraying equipment first with water.
- Only mix as much pesticide as you need for the day
- Be systematic: spray evenly and make sure you don't miss any target areas……or spray them twice!
- Are all the target pests being sprayed effectively?
- Is a lot of spray landing in areas that it shouldn't be?
- Specifically …… is there dripping?

  … if so, you are spraying too much - reduce your volume application rate.



7.) Apply pesticides at the right time - before the Pre-Harvest Interval (PHI): which is the minimum permitted number of days between the last spray and harvest.

This can be one of the most important considerations for avoiding harmful residues on produce.

8.) Pesticide Containers and Hygiene

- If you use sachets - dispose of them carefully If you must recycle pesticide bottles: rinse at least 3 times before disposal.
- Never use your mouth to clean nozzles… or to prime your sprayer
- Never eat, drink or smoke while spraying.
- After spraying: - clean out the sprayer first - then wash yourself and your clothes, but …
- Never dispose of washing water near water sources (use waste ground or discard away from children and animals)

9.) Differentiate between chemical store and farm produce store

GOOD WAREHOUSE PRACTICES

- **General sanitation**: as with most pest control, basic measures must be taken to prevent the carry over of infestations by cleaning and clearing up debris that can harbour pests.

End 2011 a brand new warehouse has been commissioned by Cargill Cocoa & Chocolate in port of Amsterdam.

❖**Maintaining a low moisture content:**

In most stored crops, if moisture content is reduced to below 8%, metabolic activity of any organisms present practically ceases. Drying is therefore a standard treatment before storage. Drying processes are well documented and results can be predicted reliably.

- **The use of modified atmospheres (MA):**

  where oxygen availability is reduced and temperature is well controlled (insect activity rises with increasing temperatures up to 42°C). These methods were rarely used in cocoa until steps were taken to withdraw the important fumigant

- **methyl bromide** (restricted under the international Montreal Protocol agreement because of concerns about ozone depletion).
- Treatments involving use of carbon dioxide have been investigated widely and are now seen as acceptable and viable alternative treatments.

- **Application and timing of insecticide treatments** in storage, including fumigant treatments, are chemical methods for controlling storage insects.

- **Enclosing a fumigant with the sacks under a gas-proof sheet.** This is usually the most effective method of insect control and when used correctly is safe and least likely to lead to residue problems.

Fumigating sacks under sheets with phostoxin-generating sachets (aluminium phosphide)

- **Phosphine (phostoxin)** is a toxic gas that is generated from sachets containing metal phosphides. It is slowly released among bags covered by a gas-proof sheet: With phosphine, the covered stack is typically left for between 5 and 16 days, and then opened up to allow the gas to escape. The time depends on the temperature and the commodity, but is never less than 96 hours

Space treatment with a pyrethroid UL formulation: using a thermal fogger before closing the container

❖ **Introduction of fogs into enclosed spaces such as containers.** The application of insecticides (*e.g.* synergized pyrethroids) using thermal foggers is primarily designed to kill flying insects such as warehouse moths that might escape or hatch inside containers.

- **Treatment of the wooden pallets on which cocoa sacks are stored** - especially for the control of termites. Termite insecticides are often, out of necessity, persistent and toxic and have included chemicals such as chlorpyrifos and fipronil, together with other now obsolete organochlorines.

It is now thought that some high residue incidents in produce have arisen from indiscriminate treatment of pallets, and that greater care must be taken in future.

Precautions

- ❖ Phosphine fumigation should only be carried out by trained staff to ensure:
- ➢ Acceptable standard of gas-tightness of the area under fumigation
- ➢ Appropriately-timed application of optimal doses, and maintenance of the exposure over a minimum required length of time

- Regular monitoring of gas concentrations, to ensure maintenance of effective levels
- Post-fumigation assessment of the effectiveness of each treatment
- Integration with other methods (*e.g. surface treatments with approved residual insecticides, or*

  provision of a physical barrier) to reduce the risk of re-infestation during subsequent storage.

Other methods for pest control

1) **Biological means such as pheromones and hymenoptera** High potential. These methods involve disruption of the breeding cycles of the pests.

2) **Use of Sulfuryl Difluoride (SO_2F_2)** High potential. There will be follow up by the warehouses over a longer period of time. This method had been tested and now needs to be accepted by European regulators. Some warehouses elsewhere have successfully implemented the product.

3) Use of gamma radiation

Problematic as cocoa is used for consumer goods which must be labeled after treatment with gamma radiation.

4) Use of polypropylene bags

These were effective but are not favoured by the countries of origin.

5) Replacement of jute bags by Big Bags.

Effective for storage but difficult to apply on a large scale. Need specialized handling equipment.

6) Electrocution

Too complex and against animal protection laws when carried out by the cocoa warehouses.

7. Carbon dioxide

- Carbon dioxide (CO_2) causes insects to open their pores and greatly increases the efficacy of several insecticides and fumigants. It is also a fumigant in its own right.

Methods of application are described below.

- *Under high pressure. Cocoa on pallets is placed into large pressure vessels in* which the atmospheric air is replaced with highly pressurized CO_2. The method is 100% effective (it kills all insects in all stages) after only minutes of application.
- The disadvantages are the high cost of capital investment, labour intensity and the need to transport the cocoa to the facility. There have also been reports that the German chocolate industry is no longer interested in the system as it is suspected of causing the migration of cocoa butter from the
- nib into the shell.

8. ***Neem*** Preliminary studies conducted by the United States cocoa industry have established the potential usefulness of neem extracts as both insect repellents and insecticides on cocoa. Further studies are underway and being pursued as a priority.

9. Diatomaceous earth

The are various versions of this substance, which is also known as silica gel or *kieselguhr. It is a naturally occurring fossilized silicon abrasive.*

It is non-toxic to mammals (and is often used as a free flowing agent in food products, such as flour and sugar). It will break the insect's (outer) skeleton on contact, causing it to dehydrate. However, it is effective only in low humidity environments, which generally rules it out for use on cocoa, especially in producing countries

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10. Carbonyl sulphide

Carbonyl sulphide (COS) is a by-product of oil refining, and refineries have little use for it. It is a highly effective soil fumigant, can be used for space fumigation, and could probably also be sprayed over cocoa beans. It decays within a few hours into harmless substances. It has been known as a pest-control material for some decades, but its incendiary characteristics have made it somewhat impractical and unpopular.

One oil-refining company has developed a process of stabilizing these characteristics in an aqueous solution, thus making it suitable for application by sprayers and foggers. This would appear to be, potentially, a comparatively safe material to use but further product development is needed.

11. Heat treatment

Heating systems exist which can heat up a container of wheat to a temperature high enough to achieve a total kill of any live infestation. Another method of applying heat would be to use giant microwave ovens. This system has not been tested on cocoa, however, and it is doubtful whether the treatment would be satisfactory, given the high fat content of cocoa beans.

Furthermore, it takes a long time for heat to penetrate a pile of cocoa beans, and its effect on the structure of cocoa butter remains unknown. More research is needed before conclusions can be drawn.

12. Vacuums

An American company has developed a system of placing cocoa beans, in their sacks, into a plastic bag and removing the air to achieve a good vacuum. Large-scale trials are currently underway. This method is already being used by importers of organic cocoa beans, as it is considered an organic pest control system in itself.

13. *Propylene oxide*

- The manufacturer of propylene oxide (CH3H6O) is claiming this chemical to be an ideal substitute for methyl bromide, but the industry is less enthusiastic about it. It has various drawbacks, including its flammability – it is a Class 3 flammable substance.
- Moreover, its application depends on a minimum temperature of 27°C (80°F) and it has to be applied in a vacuum, requiring the cocoa to be brought to the fumigation facility. The possibility of using a mixture of propylene oxide and carbon dioxide is now being explored, however, and appears to hold some promise as a practical alternative to methyl bromide.

14. Refrigerated storage

Storing cocoa beans in refrigerated warehouses may be less expensive than first assumed, as the need for cooling is not as great as in regular reefer warehouses (the cost of cooling increases exponentially with the lowering of temperatures).

The reduced, or total absence of, the need for insect control may be an important positive cost factor, however.

Summary

- Only use registered pesticides/pesticides permitted in importing countries
- Use at recommended dose/timing
- Use correct nozzle
- Observe pre-harvest interval (PHI)
- Use personal protective equipment (PPE) when applying pesticides
- Reduce pesticide use, IPM approach
- Follow GAP, pruning to manage tree height etc.
- Avoid cross contamination