integrity Research Journals

Journal of Agricultural Science and Practice
Volume 2(5), pages 90-96, October 2017
https://doi.org/10.31248/JASP2017.060
ISSN 2536-7072. Copyright © 2017
Article Number: 7A4D30A84
http://integrityresjournals.org/journal/JASP

Review

Review on pesticides safety on stored products in Nigeria

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Received 26th August, 2017; Accepted 21st September, 2017

ABSTRACT: Pesticides can be used to protect stored produce against pest damage despite its danger to humans, livestock and environment. This paper relied on secondary data and information to review the benefits of pesticide usage in stored produce, its toxicity and measures necessary for safe stored produce for local consumption and export. Pesticides was found to have a very strong positive impact in the prevention of crop produce losses due to insect and other pests in storage facilities, thus saving farmers money. Beside, pesticide usage was found to enhance human health by preventing disease out breaks through the control of rodents and also gives revenue to the government through taxes paid by pesticide manufacturers and handlers. It was suggested that to prevent pesticide toxicity only tested, recommended and certified pesticides from approved sources should be used by skilled hands as specified, especially at the economic threshold (ET) level. That is when it is absolutely necessary with adequate precautions. However, pesticides can be safe if they are used carefully as prescribed.

Key words: Pesticides, safety, storage, toxicity produce.

INTRODUCTION

Pesticides can be classified in several ways by the target organisms controlled**,** chemical structure (organic, inorganic, synthetic or biological (biopesticides) (CSAAMA, 1997) and physical state (gaseous – fumigant). The organic pesticides are pesticides that contain the element carbon as a major component. They include organochlorines or chlorinated hydrocarbons, organophosphate, carbamates and synthetic pyrethroids. The inorganic pesticides have no carbon elements (perenox). Pesticides are sometimes classified according to the method of application or method of administration, that is, the mode of entering the pest organism. For example, baits (poisoned food substance), spray (applying the pesticides directly on the organism), fumigants (enters the pest organism through the fumes of the pesticides) and systemic poisoning (pesticide is apply through the system of the host). Pesticides are further classified according to their mode of action on the pest. For instance, stomach poison (affect the pest organism in the stomach through feeding), contact poison (enters the pest through the skin), respiratory poison (interfering with the respiratory system of the pest), nerve poison (affect the nervous system of the organism and anticoagulants (cause bleeding in the pest externally or internally). Pesticides can be classified based on the form in which they are supplied (Wettable dispersible, granules, wet-table powder (WPs), liquid – emulsifiable concentrates (EC), suspension concentrate (SC), capsulated suspension (CS), ready for use aerosols – flit guns and canned sprays.

Further classification is based on the pesticide toxicity to the test animal, the oral dermal doze to kill 50% of small animals commonly rats/fish under text (LD50). A pesticide can be extremely toxic, highly toxic, moderately toxic and slightly toxic as the case may be. Pesticides consist of the active ingredient (ai) and the inactive or inert ingredient. The active ingredient of any pesticide is that part of the formulation that is biologically lethal while the inactive ingredients are needed to make the active ingredient available for ready use by the farmer. The

Table 1. Some pesticides used for pest control in stored products in Nigeria.

Trade Name	Pesticide (Group)	Formulation	Stored Product Protected
Insecticide			
Actellic, prime, stored force	Pirimiphos methyl	Dust, emulsiafiable concentrate, persistent insecticide	Maize, sorghum, millet on the cob or head
Phostoxin, celphos, protex, force toxin, aluphos, fitscoplus, ki-ox tablets	Aluminium phosphide	Tablets and pellets that evolve phoshine gas. It is a fumigant	Maize, sorghum, cowpea cocoa, groundnuts, palm kernel
Coopex, Rambo, pestox	Permethrin	Dust	Maize, sorghum, cowpea groundnut
Dizvan, gulfan, delvap, Vip	Dichlorvos	Emulsifiable concentrate	Maize, sorghum, millet
Rodenticide			
Commando	Zinc phosphide	Dust	Groundnut, maize, millet, sorghum
Fungicide			
Benlate	Benomyl	Dust	Groundnut, maize, millet, sorghum

Sources: NARELS (1999), Oyeniran (1984), Udoh et al (2005) and Anyim, (2015).

formulation may be in wet or dry form.

In Nigeria, average losses of stored produce due to storage pests have been estimated at 30% and in severe cases may lead to as much as 100% damage (Egwuatu, 1986; Anyim, 2013; 2016). Storage pests infest and damage produce, resulting in direct losses of both quality and quantity of food stored. The huge losses attributable to these pests aggravate the food deficit situation in Nigeria and drastically reduce the financial returns to farmers and their export earnings, hence, the use of pesticides by farmers to protect their stored products. Pesticides are substances or mixture of substances for preventing, destroying, attracting, repelling, or controlling any pest including vectors of human or animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of food, agricultural commodities, wood and wood products or animal feed stuffs, or substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant or agent for thinning fruit or preventing the premature fall of fruit (FAO, 2007). Also used as substances applied to crops either before or after harvest to protect the commodity from deteriorating during storage and transport. The term normally excludes fertilizers, plant and animal nutrients, food additions and animal drugs (FAO, 2007). However, pesticides, if not properly used, can cause serious problems, foremost among these is toxicity with an estimated 3,000,000 or more cases of pesticide poisoning annually, 20,000 of which proved fatal with yet unknown long term consequences for humans, wild life and environment (Emeribe, 2008; Anyim, 2016). On the other hand, pesticides can be safe if they are carefully used for prescribed purposes and by trained hands.

PESTICIDES USED FOR PEST CONTROL IN STORED PRODUCTS

There are three main groups of pesticides commonly used to prevent pest damage on stored produce, These are insecticides, rodenticides and fungicides (NARELS, 1999; Udoh et al., 2005) (Table 1).

Insecticides

The insecticides are of two or three types, namely; contact and/or stomach poisons and respiratory poisons or fumigants. A contact insecticide is a poison which is able to penetrate the insect cuticle and thereby enter the body tissues. A fumigant is a gas or vapour which is taken into the insect through its respiratory system (CTA, 1989). Fumigants penetrate through stack or bulks (IITA, 1995; NAERLS, 1999) and also the individual grains or kernels killing all stages of insect life within. The recommended insecticides, dosage rate, time and method of application are presented in Table 2.

Rodenticides

Similarly, the rodenticides are of two kinds, the acute poisons and chronic poisons. Acute poisons are groups of poisons that can cause quick death if eaten by the

Table 2. Recommended insecticides, dosage rate, time and method of application.

Insect pest	Insecticide	Dosage rate	Time and method of Application
Cowpea Pests	Phostoxin (Hydrogen Phosphide)	1tablet/100kg bag 2-5 tablets/ton of Grains in air-tight chamber	Introduce the tablet wrapped in Cotton wool or perforated envelope. Seal up the container or chamber and make it air-tight. Exposure of grains before consumption is 3 days
	Actelic (Pirimi-Phos methyl	15ppm.1ppm is 1milligram of chemical mixed in 1 ltr of water.	Spray layer of grains as they are loaded in the bag or container. Spray the bag after loading.
Cereal pests	Phostoxin	1.5kg/ton or	Use as described for cowpea pests above.
	Deltamethrin dust	1.5ppm	Put the chemical in empty tin of coffee or evaporated powdered milk. Perforate the lid cover of the tin and apply evenly to the product

Sources: IITA (1995), NAERLS (1999) and Anyim (2015).

Table 3. Common acute poisons and quantity that can kill a 200gm rat.

Name of poison	Quantity needed to kill a 200gram rat
Arsenous oxide	40 milligrams (very dangerous on mice and other animals)
Zinc phosphide (commando)	Less than 10 milligrams(very strong, odourless and fast acting)
Sodium monofluoroacetate	0.5 milligram (very dangerous and up to 20 times toxic than Zinc phosphide)
Norbormide	40 milligrams (very toxic on brown rats and less effective on black rats
Anti	40 milligrams (effective against brown rats)

Sources: CTA (1991) and Okunade (2006).

rodents in small quantities. Rodents need to eat only a mouthful of poison to die within half an hour. Acute poisons are extremely poisonous to man. The most common acute poisons and quantity needed to kill a 200 gm rat is presented in Table 3.

The chronic poisons or slow poison on the other hand are poisons that multiple doses have to be taken by rodents before killing them due its slow action. They are added to food and must be eaten for a number of days before death occurs. They cause rodents to bleed inside their bodies. Bleeding occurs from old wounds and their tissues which do not stop (CTA, 1991). The most common chronic poisons include warfarin (coumafen), Chlorophacinone, Bromaidiolone, Diphacinone, Difenacoum, coumatetrlyl and Indomethacin capsule (Okunade, 2006). However, warfarin is the most popular anticoagulant while Chlorophacinone is mostly preferred. Difenacoum is very effective against rat species that are resistant to warfarin. Besides, Diphacinone in a bait which is already mixed with a certain rodenticide but very dangerous to dogs and cats (CTA, 1991).

Fungicides

The major microorganisms found associated with stored foods are fungi and bacteria. Fungi are the most important microorganisms in storage because they are known to continue their development at moisture content which most produce are stored. Bacteria required higher moisture contents for their growth and development than moulds and as such they are most important on the perishable crops like yams, fruits and vegetables. However, moulds such as *Aspergillius*, *Fusarium* and *Penicilluim* are found on dry products such as cereals and pulses. Therefore, the most effective control measure for micro-organisms is to store produce at the moisture contents below the safe level and maintain them as such (Anyim, 2015). More so, the use of fungicides such as benomyl has been effective (Anyim, 2015).

BENEFITS OF USING PESTICIDES ON STORED PRODUCE AND STORAGE FACILITIES

The benefits are of two levels, primary and secondary. The primary benefits are the direct gains from the use of pesticides while the secondary benefits are effects that are more long term (Cooper and Dobson, 2007).

Primary benefits

The primary benefit of pesticide includes:

1. save farmers' money by preventing crop produce losses to insect and other pest in storage facilities (Emeribe, 2008).

Table 4. Estimated lethal dose for an adult man for different LD_{50} values.

Oral LD_{50} (mg/kg)	Estimated lethal dose
5	A few drops or a pinch
5 - 50	A pinch to a teaspoon (5ml)
50 - 500	A teaspoon to two table spoons (5-30ml)
500 - 5000	Two tablespoons to 0.5 litre

Sources: CTA (1989) and Anyim (2013).

2. prevent sickness that could have been caused by mould food or diseased produce if not protected.
3. protect farm stores from structural damage associated with termite infestations.
4. manage rodents and insect that infests food such as grain in grocery stores and food storage facilities.

Secondary benefits

Pesticides usage enhances food availability and security for local consumption and export. Invariably the nutrition and health of our people will be improved and export revenue increased. Government may derive revenue from tax paid by pesticide manufacturer's distributors, dealers, commercial applicators and farmers provide to boost Internally Generated Revenue (IGR).

PESTICIDE TOXICITY

It is a known fact that some pesticides are less hazardous than others, but when not used in the correct way any pesticide may become very toxic or poisonous. However, two types of toxicity have been identified. They are chronic toxicity and acute toxicity. Chronic toxicity is the effect of small non-lethal doses received over a long time, resulting in cancer, brain, liver or kidney damage while acute toxicity is the immediate poisonous effect of a single dose, resulting in nausea, nervous symptoms and eventual death (IITA, 1995; Anyim, 2013). The acute toxicity is commonly measured by calculating the LD_{50} (lethal dose for 50%) value which is the amount of pesticide (in mg per kg of animal weight) that kills half of a randomly selected population of test animals such as rat, rabbits and birds. To estimate the lethal dose for humans, the LD_{5O} should be multiplied by the body weight in kg. Consequently, the estimated lethal doses for an adult for different LD_{50} values are shown in Table 4.

MEASURES NECESSARY FOR SAFE STORED PRODUCTS

It is a well-known fact that pesticides are poisons and can contaminate food, cause injury, illness or even accidental deaths if misused (Miller, 2004). Therefore, to avert the adverse side effects of pesticides on stored products, humans and environment, the following measures are recommended.

Prevention of pest infestation from field to store

1. farms should be kept clean by weeding either manually or use of prescribed herbicides to reduce alternate host plants for insect pest multiplication.
2. crops should be harvested at the appropriate time to avoid infestation.
3. produce should be dried to appropriate and acceptable moisture content before storage.
4. only clean and healthy grain is retained for long-term storage.
5. grain or seed should be cleaned for storage to remove cracked material and live insects and then place in clean bins free from insects.
6. walls and floors of the cleaned bin should be sprayed with appropriate insecticide before storage.
7. new harvest should not be stored with the remainders of a previous harvest.
8. bags of stored produce should be neatly stacked in such a way that air can pass through the sacks to dry and cool the grain or produce.
9. there should be a space of about 40 cm between the walls and the piles of produce to reduce condensation and facilitate inspection and cleaning.
10. first in, first out principle should be followed during storage: that is, the first produce to go into the store will be the first one to come out.
11. temperature fluctuations in the storage facility should be controlled by shading, insulation or some other method to avoid caked or mould produce if dew occurred or faster development of the insect-pests at higher temperatures.
12. the use of air-tight storage container should be encouraged. The air–tight storage works on the principle that insects will die due to lack of anoxia.

Use of certified pesticides

It is important to buy and use certified pesticides that have labels, with National Agency for Food Administration and Control (NAFDAC) registration numbers. Besides, the product label must indicate direction for use, equipment to be used, active ingredient of the product,

World health Organization (WHO) hazard symbols, warnings, date of manufacture and date of expiration.

Use of pesticides for stored produce

Although, stored produce pesticides may be a bit expensive, it is advisable to use them exclusively in storing grains. Since they are safer to use for this purpose and will not pose problems to the user and eventual consumer of the grains if all necessary precautions are fully obeyed. Therefore, pesticides meant for field application must not be used on stored foods, especially grains.

Every consumer must wait for the specified period of time before consuming grains treated with pesticides. This is called “waiting period”. The length of this period depends on the type of pesticide used, mode of application and residual period (Okunade, 2006). For example grains treated with pirimiphos methyl (Actellic dust) should be left for at least 6 weeks while grains treated with only fumigant (Aluminum phosphide) could be consumed after exposure to air for about 4 hours and the content of the piece of paper/cloth removed. It is not advisable to consume grains treated with pesticides immediately because of the inherent toxic effect (Anyim, 2016).

Establishment of pesticides tolerance levels

The tolerance level of the different classes of pesticides must be established at registration by NAFDAC to guide stored produce protectionist, farmers and food dealers on the maximum amount of pesticide residue that may legally remain on or in treated grains. A tolerance is the maximum amount of pesticide residue that may legally remain on stored produce that are to be sold for food or feed.

Rodent poisons should not be used near stored produce or food

Under normal conditions, acute poison must be used outside not in stores containing food to avoid contamination. Rodents are mobile creatures and can poison the food by walking over poison and after spread it over the food, if it is kept near it. However, rodent poison can be used only when other means (hygiene, rodent-proofing, trapping) have failed (CTA, 1991).

Initiating fumigation at economic threshold (ET) levels

It is important to state that stored products should be fumigated when it becomes infested with insect pest at the economic threshold level which is the population density at which control measures should be initiated to prevent pest population from reaching the economic injury level (Figure 1). The economic injury level (EIL) is the population density that will cause economic damage while economic damage is the amount of injury which will justify the use of artificial control measures.

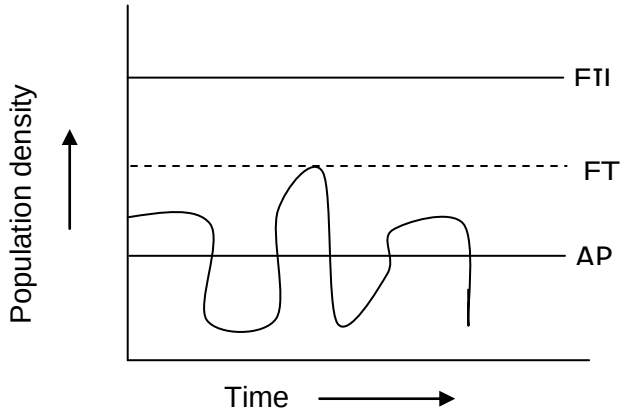

Figure 1. Pest population oscillations in a habitat. (**EIL,** Economic injury level, **ET,** Economic threshold, **GEP**, General equilibrium position).

Use of alternatives to synthetic pesticides

Miller (2004) noted that alternative to synthetic pesticides are available and include methods of interfering with pest breeding. Besides, use of plant extracts has shown strong potentials and effectiveness in the control of stored produce pest. Singh (1990) revealed that *Piper guineense, Vernonia amygdalina* and others have long history of primary usage against storage pests. Burkill (1984) reported that *Piper guineense* controlled kola weevil effectively while Asawalam (2001) reported that the powder from leaves of *P. guineese* protect maize grains from damage against the maize weevil (Sitophilus oryzae) and leaf powder of *Vernonia amygdalina* gave substantial control on the larvae of *Callsobruchus maculatus* (Kabeh and Jalingo, 2007).

Aghale et al. (2016) reported that leaf powder of *Xylopia, Alstonia boonei* and *Crotoleria spp*. prevent bio-deterioration of yam tubers in storage.

However research should be intensified in the development of new classes of safer pesticides across the globe. This is the corner stone of integrated pest management (IPM) in stored product safety.

Mounting of pesticide safety education and pesticide applicator regulation

As a matter of urgency, pesticides safety education and pesticide applicator regulation should be mounted and

implemented respectively to protect the public from pesticide misuse. The Government at all levels should empower Agricultural Extension Agents and Plant protectionists to educate the public on safe use of pesticides through strategic professional campaigns.

Observing rules governing fumigation in stores

The pesticide applicator must obey the following rules before, during and after fumigation in stores (Anyim, 2016):

1. wearing of protective clothing (high cotton, gloves, boots).
2. following the instructions on the labels.
3. making sure that the spray tank rests comfortably on back of the sprayer.
4. keep other people and animals away from the area when spraying.
5. if a spray nozzle become blocked during use, never blow it clear by mouth.
6. never eat, drink or smoke when applying a pesticide.
7. concentrated products should be kept in their original containers well sealed after use and then safely store away, especially out of reach of children.
8. clean spraying equipment used and allow to dry.
9. empty containers should buried or burned and not leave lying about.
10. after spraying, body should be wash with soap and water.

CONCLUSION

The whole effort, so far has been to x-ray the benefits of using pesticides in stored products, its toxicity to life and measures that will ensure safe stored products for local consumption and export. It was observed that pesticides are very useful in the protection of stored produce against pest damage. Beside, pesticide usage can save farmers by preventing crop produce losses, contribute to the health of humans by preventing disease outbreak through the control of pests like rodents. It was also observed that pesticides give revenue to government at all levels through taxes paid by pesticide manufacturers, wholesalers and application. However, for storage produce to be safe for human consumption and export, only tested, recommended and certified pesticides from approved source should be used, while every consumer must wait for a specified period of time before consuming produce treated with pesticides.

Hence, plant protection agencies or Departments in school of Agriculture should intensify research on the development of new classes of safer pesticides since alternatives to the synthetic pesticides have shown great promise and effectiveness in Nigeria.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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