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History and recent development of pesticide usage on cocoa in Nigeria

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ABSTRACT: This paper highlights the history and status of pesticides used on cocoa in Nigeria before and after the recent European Union legislation on pesticide usage. As a result of an avalanche of insect pests' infestation and disease infection of cocoa from field to warehouses in Nigeria, the cultivation of organic cocoa is still far from reality, and this has consequently led to farmers' over-dependence on the use of synthetic pesticides to control these obnoxious pests. The major disease and major insect pest that dominate control practices of cocoa in the field in Nigeria are *Phytophthora* pod rot (caused by *P. palmivora* and *P. megakarya)* and the brown cocoa mirid, *Sahlbergella singularis*, respectively. These two organisms can cause substantial yield reduction of cocoa if there is no intervention put in place.

Over the years, a lot of pesticides have been recommended and used for the protection of cocoa farms from these pests. However, due to the recent ban of most of the pesticides following the EU legislation, very limited pesticides are now available for cocoa farmers to use. Only approved Thiamethoxam and Chlorpyrifos are available for use as insecticides while approved Glyphosate are the only herbicides. Copper sulphate (a well known fungicide) has been banned out rightly along with some other pesticides whose Maximum Residue Limits (MRL) are above those permitted on cocoa beans by the EU. Thus, only ten pesticides (comprising two insecticides for field application, two insecticides for storage pests, four fungicides and two herbicides) are presently allowed for use on cocoa from the vast array available before the ban.

Nigeria has fixed her MRL on cocoa at the 'zero tolerant limit', which by default, is fixed at 0.01 mg/kg. The Country has also advocated for Good Agricultural Practice (GAP) with active campaigns on the need for farmers to adopt GAP in their various farms. Good quality cocoa beans will surely be exported from Nigeria due to adherence to these measures by cocoa farmers.

Key Words: Weed control; Pesticides; Nigeria.

Introduction

Cocoa (*Theobroma cacao*) is a major commodity crop which continues to generate substantial foreign exchange earning for Nigeria. It is cultivated in fourteen States in Nigeria and Nigeria is ranked fifth among the five major producers of cocoa in the world, preceded by Côte d'Ivoire, Ghana, Brazil and Indonesia (Anikwe *et al.*, 2008).

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The cultivation of organic cocoa in Nigeria is at the moment not practicable due to an avalanche of insect pests' infestation as well as disease infection on cocoa. Consequently, there is heavy dependence on synthetic pesticides for the cultivation of cocoa to obtain optimal yield. Two major pests have been reported to drastically reduce the yield of cocoa in Nigeria viz: *Phytophthora* pod rot caused by *P. palmivora* and *P. megakarya* (Sansome *et al.*, 1975; Brasier and Griffin, 1979) is currently the most important yield-limiting factor in the Nigerian cocoa industry, with total annual losses estimated at up to 30 to 35% of the nation's crop (Gorenz and Okaisabor, 1972), while 30-90% of the total global crop loss is caused by this disease. The brown cocoa mirid, *Sahlbergella singularis* Haglund (Hemiptera: Miridae) which is also capable of causing 75% yield loss in farms that are left uncontrolled for two seasons and above (Anikwe *et al*., 2008). These two pests dominate control measures for the pests of cocoa in Nigeria. However, there is a myriad of other pest species which also cause substantial damage on cocoa. Table 1 shows a comprehensive list of insect pests and diseases of cocoa in Nigeria.

History of Pesticide usage on cocoa in Nigeria

The use of insecticides for the control of insect pests of cocoa could be traced to the 1938 to 1944 period when the miricidal efficacies of botanicals (Pyrethrum and Derrimac dusts), inorganic salts (Nicotine sulphate and Lime sulphur) and Tar petroleum oil distillates, were first evaluated on young and old cocoa under laboratory and field conditions (Idowu, 1989). Reasonable mirid mortality with these insecticides ranging from 50 to 79% was recorded. Later, organochloride insecticides were discovered. DDT in vegetable oil and emulsifiable concentrate dissolved in various solvents were evaluated. DDT 25 EC in water at 2.5% active ingredient concentration was applied with brushes to mirid resting sites, on seedlings and young cocoa, and with the pneumatic knapsack pumps to older trees twice each year (January/February and June/September) (Idowu, 1989). From 1944 to early fifties, other chlorinated hydrocarbons such as BHC, Aldrin, Dieldrin, Heptachlor and Chlordane were evaluated. Based on their relative miricidal effectiveness, persistence, phytotoxicity and cost of application, the use of three applications per year starting in August, September and October of gamma BHC at 0.25% concentration using knapsack sprayers, was eventually recommended in 1957, for use in Nigeria (Youdeowei, 1974). This same recommendation was adopted for the control of most other insect pests of cocoa in Nigeria. The cocoa shoot-feeding insect pests *Anomis leona*, *Earias biplaga* and even the cocoa pod borer, *Characoma stictigrapta* were routinely controlled by the use of Gammalin 20 EC at 0.25% a.i. concentration. Spraying for these shoot feeders commenced from the beginning of the early rains when cocoa trees produce new flushes and become favourable for the feeding and rapid build-up of the populations of these pests.

Later in the seventies, the insecticides used on cocoa were Lindane 20 EC, Gammalin 20 EC (gamma BHC), Lindex 20 EC, Capsitox 20 EC (lindane-based), Kokotine 20 EC (Lindane-based), Unden 20 EC, Elocron 75 WP, Mipcin 75 WP (Carbamates) and Dursban 4 EC (Organophosphate).
The organochlorines effectively controlled the major insect pests of cocoa for many years, their intensive and inefficient use created adverse effects such as the development of resistance and outbreak of some pests as major pests which were otherwise innocuous (Idowu, 1989).

However, following the recommendation and intensive use of the organochlorides for mirid control, *S. singularis* and *D. theobroma* developed resistance to these insecticides within five years (1957 – 1962) in Olode and Omifunfun, Southwest Nigeria and by 1977, resistance areas had increased to include Ife, Ile-Oluji, Oke-Igbo, Idanre and Ikere-Ekiti all in Southwest Nigeria (Entwistle, 1972; Idowu, 1989).

Contrary to the recommendation given by CRIN in 1977 that cocoa farms be sprayed at 21 days intervals commencing from August to November, depending on the number and seasonal distribution of mirids, most farmers began anti-capsid spraying at the onset of the early rains in April/May. This action by farmers often extended till the end of the blackpod season in August and as a result the target insects, mirids, escaped. Moreover, farmers in Ondo and Oyo States where mirid resistance to organochlorides was prominent, still made use of Gammalin 20 EC and other organochlorine insecticides (Idowu, 1989). Idowu (1989) gave a list of insecticides approved and recommended by CRIN as Gammalin 20 EC, Dursban 4 EC, Ekalux 50 EC, Mipcin 75 WP, Unden 20 EC and Elocron 50 WP.

Table 1: Insect Pests and Diseases of Cocoa and their Damage

COMMON NAMES	SCIENTIFIC NAMES	ORDER	PEST STATUS	DAMAGE
(a) INSECT PESTS				
Cocoa Mirids	*Sahlbergella singularis* *Distantiella theobroma* *Helopeltis bergrothi*	Hemiptera	Major	Nymphs and adults pierce and suck sap from cherelles, older cocoa pods and chupons causing tissue death which result in lesions on pods and cherelles, cherelle wilting and terminal death (die-back) of shoots and canker on stems and branches. Eventually, tree stag-headedness and death resulting in pole formation
Cocoa Shield Bug	*Bathycoelia thalassina*	Sub Order: Heteroptera	Emerging as Major	Pierces the pod husk and removes plant sap especially from young beans in cherelles resulting in collapse of developing beans and making the pod to lose its vigor.
Cocoa Psyllid	*Tyora(Mesohomotoma) tessmanni*	Sub Order: Heteroptera	Major	Oviposits on and sucks sap from the terminal buds, cherrelles and young leaves and thereby cause death of cherrelles and leaf fall.
Cocoa Mealybugs	*Planococcus citri* *Planococcoides njalensis* *Ferrisiana virgata*	Sub Order: Homoptera	Major	Suck sap from young shoots, and young pods. Transmit Cocoa Swollen Shoot Virus
Cocoa red-banded Thrips	*Selenothrips rubrocinctus*	Thysanoptera	Minor	Sucks sap from leaves and young shoots resulting in leaf fall.
Pod Husk Miner	*Marmara sp.*	Lepidoptera	Minor	Mines the pods and the leaves
Cocoa Pod Borer	*Characoma stictigrapta*	Lepidoptera	Major	Oviposits on young and mature pods escavates the husk out of the pod as frass, causing the pod to be attacked by pathogens. Also feeds on leaves.
Cocoa Boll Worm	*Earias biplaga* *Earias insulana*	Lepidoptera	Major	Larvae burrow into the pods, destroying them. Also destroy young trees, may destroy the pericarp of unripe pods.
Cocoa Stem Borer (a)	*Eulophonotus myrmeleon*	Lepidoptera	Emerging as Major	Larvae bore into the woody stems, branches and trunks of young and mature cocoa trees causing terminal death of the trunk or branch
Cocoa Stem Borer (b)	*Tragocephala castnia*	Coleoptera	Minors	Female beetles ring-bark or girdle the twigs prior to egg laying

COMMON NAMES	SCIENTIFIC NAMES	ORDER	PEST STATUS	DAMAGE
Cocoa Shoot Feeders (Defoliators)	*Anomis leona*	Lepidoptera	Major	Larvae feed on young leaves and other new growths/shoots
Scale Insects	*Stictococcus sjostedti, Coccus viridis Pseudococcus sp.*	Homoptera	Minor	Pierce and suck plant sap from developing pods.
Termites	*Macrotermes natalensis*	Isoptera	Minor	Tunnel into the seedling roots, feed on the stems causing destruction of the seedling. Injuries caused by termites enhance entry and development of pathogens into the plant.
	(b) DISEASES	D		
COMMON NAME	SCIENTIFIC NAME	GROUP	STATUS	SYMPTOMS OF ATTACK
Black Pod Disease	*Phytophthora palmivora P. megakarya,*	Fungus	Major	Attack both pods and beans causing light dark brownish spots/lesions (lesioned area is firm to the grip at the initial stage) on the pods which later turn black and cover the whole pod. The pods and the beans rot. Stem is also cancerous
Warty Pod Rot	*Botryodiplodia theobromae*	Fungus	Minor	Medium dark brown lesions are formed on the pods. At the initial stage, there is quick liquefaction of the internal tissues so that the lesioned area is very tender and liquid oozes out at slight pressure. The pods later turn dark brown or sooty black
Pod Rot disease	*Fusarium solani* *Fusarium decemcellulare*	Fungus Fungus	Minor Minor	Dark brown lesions with fairly regular margins – lesion area is initially tender but hardens up and shrinks later. Wound at initial entry point of the fungus is not usually distinct.
Pod Rot disease	*Monilia sp.*	*Fungus*	Minor	Common on cherelles and immature pods resulting in premature repening. Light – medium brown irregular

COMMON NAMES	SCIENTIFIC NAMES	ORDER	PEST STATUS	DAMAGE
				lesions with yellow or orange halo. Liquefaction of internal tissues is so rapid and extensive that diseased pod readily oozes out liquid with the slightest pressure.
Pod Rot disease	*Thielaviopsis sp.*	*Fungus*	Minor	Dark brown lesions; lesioned area usually hard and cracks in dry conditions
Pod Rot disease	*Collectotrichum sp.*	Fungus	Minor	Dark brown-black lesions. Lesioned area shrinks and hardens up as infection progresses.
Cocoa Swollen Shoot Virus disease	-	Virus	Minor	Formation of Red Vein Banding which later turns to Chlorotic Vein. The shoot and root of the affected plant are also swollen.

In a continuous effort to combat resistance problems, novel insecticides are regularly screened at CRIN and those found suitable are recommended to cocoa growers. In 1977, Unden 20 EC (Propoxur), Mipcin 75 WP (Isoprocarb) and Elocron 50 WP (Dioxacarb EC) (Carbarmates) were found to be very effective alternative insecticides and were so recommended for mirid control. Basudin 600 EC (Diazinon) and Dursban 4 EC (Chlorpyrifos) both Organophosphates were identified and recommended as other suitable alternatives to replace them in the mid-eighties. Thiodan 35EC (a.i. Endosulfan) and Cracker 282EC (a.i. Endosulfan + Deltamethrin) were also recommended in 2001 (Ojelade *et al.,* 2005). And recently, Actara 25 WG (Thiamethoxam) was recommended in 2008 by CRIN for use on cocoa farms in Nigeria. Table 2 shows the list of pesticides once approved for use on cocoa in Nigeria before the EU legislation.

TABLE 2: PESTICIDES PREVIOUSLY APPROVED FOR COCOA CULTIVATION AND STORAGE IN NIGERIA AFTER THE BAN OF THE ORGANOCHLORINES.

Brand Name	**Active Ingredient**	**Class**	**Target**
Insecticides			
Agrothion 20 EC	Fenitrothion	Organophosphate	Termite
Basudin 600 EC	Diazinon	Organophosphate	Mirids
Dursban 48 EC	Chlorpyrifos	Organophosphate	Mirids & Termites
Unden 20 EC	Propoxur	Carbamate	Mirids
Elocron 50 WP	Dioxacarb	Carbamate	Mirids
Mipcin 75 WP	Isoprocarb	Carbamate	Mirids
Thiodan 35 EC	Endosulfan	Sulphurous Ester	Mirids
Decis-Dan/Cracker 282 EC	Endosulfan & Deltamethrin	Sulphorous ester & Pyrethroid	Mirids
Decis 12 EC	Deltamethrin	Pyrethroid	Mirids
Cymbush 10 EC	Cypermethrin	Pyrethroid	Mirids
Actara	Thiamethoxam	Neonicotinoid	Mirids
*Proteus 170 O-Teq	Thiacloprid & Deltamethrin	Chloronicotiniod	Mirids
Fungicides			
Copper Sulphate	Copper Sulphate	Sulphate	Blackpod disease
Bordeaux mixture	Copper Sulphate + Lime	Sulphate + Lime	Blackpod disease
Caocobre-Sandoz	Cuprous oxide	Oxide	Blackpod disease
Perenox	Cuprous oxide	Oxide	Blackpod disease
Copper Nordox 50 WP	Cuprous oxide	Oxide	Blackpod disease
Kocide 101	Cuprous oxide	Oxide	Blackpod disease
Funguran-O. H.	Cupric Hydroxide	Hydroxide	Blackpod disease
Champ D. P.	Cupric Hydroxide	Hydroxide	Blackpod disease
Ridomil Plus 72 WP	Metalaxyl + cuprous oxide	Phenylamide	Blackpod disease
Ridomil Gold 66 WP	Metalaxyl – M + cuprous oxide	Phenylamide	Blackpod disease
Herbicides			
Paraquat	1:1-Dimethyl-4,4-	Post-emergence, Non-	Weeds

Brand Name	Active Ingredient	Class	Target
	Bipyridinium (cation) dichloride	selective, contact action	
Gramoxone	1:1-Dimethyl-4,4-Bipyridinium (cation) dichloride	Post-emergence, Non-selective, contact action	Weeds
Agroxone	1:1-Dimethyl-4,4-Bipyridinium (cation) dichloride	Post-emergence, Non-selective, contact action	Weeds
Gramuron	1:1-Dimethyl-4,4-Bipyridinium (cation) dichloride +3-(3,4-dichlorophenyl)-1,1-dimethylurea	Post-emergence, Selective	Weeds
Glyphosate	N-(Phosphonomethyl) glycine, (Isopropylamine salt)	Post-emergence, Broad spectrum, Systemic	Weeds
Touch down Forte	N-(Phosphonomethyl) glycine, (Isopropylamine salt)	Post-emergence, Broad spectrum, Systemic	Weeds
Round-up	N-(Phosphonomethyl) glycine, (Isopropylamine salt)	Post-emergence, Broad spectrum, Systemic	Weeds
Asulam + Ioxynil 2-4 D	Methyl 4-aminobenzene sulphonyl carbamate + 4-hydroxyl 3, 5-diodenzonitrile	Pre- and Post-emergence	Weeds
Folar 525	Glyphosate(N-(Phosphonomethyl) glycine and terbuthylazine (2-terbuthylamino-4-4 chloro-6 ethylamino-5-triazine	Post-emergence	Weeds
Insecticides for stored cocoa			
Dihin Gas/ Phostoxin/ Quickphos, etc.	Aluminium Phosphide	Phosphide	Insects in store
Methyl Bromide	Bromure de Methyl	Halogen	Insects in store
Actellic 25 EC	Pirimiphos Methyl	Organophosphate	Insects in store

*This product has just been recently recommended after the EU legislation

The European Union Legislation on Pesticide Usage

Maximum Residue Limit (MRL) is the maximum concentration of a residue that is legally permitted or recognized as acceptable in or on a food or agricultural commodity or animal feedstuff. The Maximum Residue Limits for pesticides in agricultural food products are therefore intended to ensure that these pesticides are used in compliance with recommendations for Good Agricultural Practices (GAP) designed to safeguard consumer health and the environment. In addition, they aim to facilitate international trade of food products treated with pesticides.

The maximum residue limits for pesticides in agricultural food products are set internationally by the Codex Alimentarius Commission, a joint FAO and WHO body which rules through the work of Joint expert (FAO/WHO) meeting on Pesticide Residues (JMPR); and the deliberations of its Pesticide Residue Committee (CCPR). Apart from the Codex standards, the majority of developed countries have legislation regulating the use of pesticides and fixing maximum residue limits for pesticides in agricultural food products. MRLs are not available for all the pesticides in all the agricultural food products. In addition, the Codex standards and national standards already fixed are re-assessed regularly due to changes in analytical techniques. A product can therefore be banned at any time in such a crop if it proves dangerous to man, the environment or for the balance of the ecosystem. Codex Maximum Residue Limits (MRLS) are recommended on the basis of appropriate residue data obtained from supervised trials; The MRLS for pesticides are adopted by the codex committee on Pesticide Residues, based on the recommendations of Joint expert (FAO/WHO) meeting on Pesticide Residues (JMPR); The Goal of JMPR is to evaluate pesticide residues and establish safe level of intake by setting acceptable Daily intakes (ADIS) and develop maximum residue limits when pesticides are used in accordance with good agricultural practices; Codex MRLS for pesticides therefore represent residue levels which are toxicologically acceptable. Data available show that individual EU member countries have its own specific MRL for different products, for example, for Metalaxyl in cocoa: Germany – 0.05mg/kg, Netherlands- 0.05mg/kg, Spain - 0.10mg/kg. And for Thiametoxam in cocoa: Germany – 0.02mg/kg, Netherlands - 0.05mg/kg, Spain - 0.05mg/kg.

The objective of the EU legislation (EC 396/2005) was to harmonize MRL in member countries and thus facilitate free trade among these countries. It also involves making the most of technical advances to improve consumer protection, particularly those most at risk - children and old people. The new legislation applies to imported food products and these include cocoa beans. The implications therefore are that (i) No approval for a pesticide without an established MRL, (ii) theoretically, the rule of "zero tolerance limit" to any pesticide/agricultural product with no established, Codex or national MRL applies. By "zero tolerance limit", it means that the detection threshold of pesticide residues in the food products, by default, is fixed at 0.01 mg/kg.

It is expected that other consuming countries, in particular the USA and Japan may adopt similar legislation.

Pesticides approved for use on cocoa after the European Union legislation

In order to ensure compliance to the new regulation by the European Union, stakeholders in the cocoa sector acted quickly to ensure that appropriate Maximum Residue Limits (MRLs) are put in place. Consequent on these developments and realising that Nigerian cocoa may be rejected if urgent actions were not taken to send out the right signals that Nigeria has taken steps to meet international expectations, the Honourable Minister of Agriculture and Water Resources set up a Ministerial Action Committee on Pesticide Usage on cocoa on Wednesday 14th August 2007. The various committees that were set up met and CRIN being a major stakeholder was mandated to withdraw approval given to some earlier recommended pesticides used on cocoa. Following the ban on pesticides used on cocoa which were found in the EU annex 1 list, only ten products (pesticides) were passed and considered suitable for use in protecting cocoa farms against pests and diseases in Nigeria. Table 3 shows the list of pesticides approved for use on cocoa in Nigeria in compliance with the European Union legislation on pesticide usage.

Conclusions and Recommendations

It is obvious that with the recent development, in which pesticides used on cocoa are limited, cocoa farmers no longer have options making a choice from the vast array of pesticides that used to be. For example, only one approved insecticide, that is, Thiamethoxam is currently available in the Nigerian market. Over-dependence on this product over a period of time may lead to pests' problems due to development of resistance by insect pests. It is therefore imperative that novel products, with acceptable EU MRLs be evaluated for their efficacies for the protection of cocoa farms in Nigeria.

At the time of writing this paper, the implementation of Good Agricultural Practice (GAP) is being encouraged by relevant authorities for adoption by cocoa farmers in Nigeria. There are active campaigns on the need for farmers to adopt GAP in their various farms. GAP will ensure proper and adequate fermentation, drying of cocoa on elevated platforms instead of tarred roads where the beans can be contaminated, use of only recommended pesticides and adoption of various cultural practices in line with Integrated Pests Management (IPM) strategies that will ensure safety of the farmer as well as

the environment, use of good hydrocarbon-free jute bags for packaging of cocoa beans, among other practices.

TABLE 3: PESTICIDES RECENTLY APPROVED IN NIGERIA FOR COCOA CULTIVATION THAT MEET EU MRL REQUIREMENT

Pesticide	Active Ingredient
Insecticides	
1. Dursban	Chlorpyrifos
2. Actara	Thiamethoxam
Fungicides	
1. Ridomil Gold	Metalaxyl-M + Cuprous Oxide
2. Funguran OH	Copper Hydroxide
3. Copper Nordox	Copper oxide
4. Champ D.P.	Copper Hydroxide
Herbicides	
1. Touchdown Forte	Glyphosate
2. Round-up	Glyphosate
Storage	
1. Actellic	Pirimiphos methyl
Phostoxin	Aluminium phosphide

In view of the above, and when cocoa farmers conscientiously follow these recommendations, then cocoa beans coming from Nigeria will be of high premium quality, devoid of chemical residues, and these will subsequently bring enormous benefits to the farmers, consumers as well as the environment in a long run.

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