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Review Article

Evolving safety procedures for pesticide usage and application in Nigeria: A Review

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ABSTRACT: Food security in developing countries, including Nigeria, cannot be attained over the long term if made dependent on pesticide products only. Considering the role that pesticides play in Nigerian agriculture, what they hold for the near future and are likely to continue playing in the availability and accessibility of food production in the country, makes it all the more urgent for concrete steps to be taken by the government and all stakeholders. This will help to reduce the health and environmental risks of pesticide use in the country. In developing safe procedures for pesticide usage and application in Nigeria following measures are put forward: promoting integrated pest management and space technology, provision of training and education, regulating pesticide registration and distribution, developing and enforcing safety standards and conducting regular monitoring and evaluation. Integrated Pest Management (IPM) in conjunction with Space Technology stimulate new ecosystem knowledge and new pest and disease control technologies better adapted and less disruptive to local ecosystems. At present, international accords and declarations make governments responsible for ensuring access to safe food, implying food that is safe at each stage from its initial production to its final consumption, and there are international standards that set minimum residue limits for pesticides. Evolving safe procedures for the use of pesticides and application covers all stages of the pesticide life-cycle, from product manufacture to waste disposal. It is recommended that strengthening the regulations for pesticide usage in the country that focuses on the agricultural ecosystem to ensure a sustainable environment for agricultural productivity by all levels of government is highly encouraged. Equally, enforcement of all the laws and regulations concerning pesticide acquisition, handling and applications is desired to minimise food and environmental contamination.

Keywords: Pesticide, ecosystem, safe, technology, regulation.

INTRODUCTION

Pests present a serious risk to agriculture, with global annual crop production losses falling in the range of 20 to 40 % (FAO, 2011), and without protection provided by pesticides, these losses could reach 80 % (FAO/WHO, 2011; Savary et al., 2019). Damage caused to crops due to pest attack in the agricultural sector of the Nigerian economy is generally high, between 40-80% (Dadari *et a*l., 2005; EU, 2022). Today, food shortage is a persistent challenge in Nigeria and the world over. No doubt, the ever-growing population is mounting pressure on food production, and new manufacturing processes are creating another form of pressure on agricultural products. An example is the production of motor spirit from sugar cane and other grains (Brain, 1995; FAO, 2008; ACIAR, 2009). Shortages of suitable farm land are emerging; most fertile lands are diverted for other developmental uses such as urbanisation, recreational centres and road construction. These force the farmers to embark on continuous cropping on the limited land available, which favours the spread of pests and diseases (Brain 1995; Erich, 1997). In the tropics and sub-tropics, the damage potential of pests is favoured by warm climate and high rainfall, leading to low yield of most crops between 0.5t/ha-1t/ha compared to over 5t/ha in the developed countries (Ogunlela *et al*., 2005). Technological progress in the agricultural sector, which makes continuous feeding of the

world's ever-growing population possible, is dependent on chemical plant protection (Brain, 1995; ACIAR, 2009). The success story in agricultural development cannot be made without paying adequate attention to the pest problem. Pesticides have demonstrated a track record of short-term success within the current market system, which desires high yields and low farm gate prices (Frezal and Garsous, 2020). The disappearance of traditional labour-sharing systems and increased options for off-farm employment increase the attractiveness of substituting local manual labour with pesticides. In addition, the widespread practice of mono-cropping as a preferred method for maximising profits means that pests and diseases evolve faster than the crops can develop resistance against them. Subsequently, after decades of use of pesticides, natural predators of pests have in many cases been killed off, and soils have been deeply damaged, further emboldening the use of pesticides and increasing the challenge of adopting alternative techniques (Frezal and Garsous, 2020). In the global world today, it is not unthinkable that one might drink coffee from Colombia in the morning, munch cashews from Vietnam for lunch and gobble grains from Ethiopia for dinner. That we can afford these assorted products is thanks, in large part, to extensive pesticide use across the developing world. Every year, some 3.5 billion kilograms (7.7 billion pounds) of pesticides — a catch-a generic term for the herbicides, insecticides and fungicides applied to crops from seed to harvest — are used to preserve the quality and quantity of fruits, vegetables and grains (Haggblade and Diarra, 2017: EU, 2021). In the developing countries, rising populations, increased urbanisation and growing economies create a demand for more food, which leads to the syndrome of producing quickly and inexpensively, thus causing pesticide application rates to rise. This is especially the case of vagaries in weather conditions related to global warming increase the uncertainties associated with crop yields. Natural disasters, such as the COVID-19 pandemic, have added another factor to the situation by pushing up costs for farmers while reducing income (Gregorio and Ancog, 2020; EU, 2021).The pandemic has also made it nearly impossible to get manual labour and more complicated to get crops to a functioning market. The pandemic has created inadequacies of Personal Protective Equipment (PPE) for farm workers globally as a result of total lockdown (Gregorio and Ancog, 2020; EU, 2021). Pesticides are widely used in Nigeria and indeed in most of the developing countries. Pesticide demand is increasing due to the current system of crop production, which places a high premium on agricultural yields at the expense of a sustainable environment (Haggblade and Diarra, 2017; EU, 2021). Many farmers in Nigeria view pesticide use as the best means to protect their crops against pests, and as such, pesticides can provide the only form of crop insurance available. Nigeria is a major destination for pesticides that have been banned for use within the European Union (Luckscheiter, 2023). One sector that has a critical role to play in poverty reduction in Nigeria is the agricultural sector (Nwafor *et al*., 2011). Agriculture is divided into four sectors in Nigeria–crop production, fishing, livestock and forestry (Nwafor *et al*., 2011). Crop production remains the largest segment, and it accounts for about 87.6% of the sector's total output. This is followed by livestock, fishing and forestry at 8.1%, 3.2% and 1.1% respectively (Nwafor *et al.,* 2011). Agriculture remains the largest sector in Nigeria, contributing an average of 40% to the nation's GDP, and more than 75% of Nigerians' population is directly or indirectly involved in agriculture (Nwafor *et al*., 2011; Oyakhilomen and Zibah, 2014; Handford *et al*., 2015). The use of pesticides in Nigeria is a necessary practice to control pests and diseases that can cause significant damage to crops, animals, and humans (Luckscheiter, 2023). However, over-reliance on chemical pesticides has resulted in many negative consequences. In Nigeria, incidences of food poisoning have become so rampant (Amodu *et al*., 2018; Luckscheiter, 2023). Pesticides can be poisonous to humans, pets, livestock, beneficial organisms and the natural environment (Luckscheiter, 2023). Invariably, it is essential to ensure that the use of pesticides is safe and does not harm the environment, human health, and non-target organisms. Against this background, there is a need for the safe use of pesticides in Nigeria in order to forestall disastrous consequences of indiscriminate use of chemical pesticides is an imperative (Oladayo et al., 2022; Luckscheiter, 2023). Safe pesticide use reduces risk to applicators, the public, and the environment, and the responsibility rests on the shoulders of the applicator (Mohammad *et al*., 2018). Safety is always the watchword when using pesticides. Applicators, bystanders, and the environment can be harmed by exposure to pesticide concentrates or vapour drift (Luckscheiter, 2023). Pesticide safety begins with choosing the correct product, proper pesticide storage, careful transportation, accurate mixing, and loading. Besides equipment cleanup, maintenance must also be done safely (Handford *et al*., 2015; Luckscheiter, 2023). The objective of this work was to systematise and evolve safety procedures for synthetic pesticides usage and application in Nigeria. In evolving the safety procedure for pesticide usage and application in Nigeria, focus should be on the following: promoting integrated pest management and space technology, provision of training and education, regulating pesticide registration and distribution, developing and enforcing safety standards and conducting regular monitoring and evaluation are specifically discussed.

PROMOTE INTEGRATED PEST MANAGEMENT (IPM) WITH SPACE TECHNOLOGY

Integrated Pest Management (IPM) is a decision-making process that considers all possible control measures, such

as cultural, mechanical, biological and chemical ones, selecting a control method to suit each situation (Dminić *et al*., 2010). IPM is an important component of sustainable agriculture, enabling the production of farm products with judicious use of pesticides (Dminić *et al*., 2010). The IPM approach of judicious use of pesticides to inhibit pest organisms has been a popular pest management strategy for many years. Safety problems and ecological disruption unknowingly resulted from the use of the chemical approach, thus, there are reawakening calls for effective, safe, and economically sound use of pesticides (Apan *et al*.,2004; Luckscheiter, 2023). Pest population monitoring in IPM is weak due to the following challenges: Firstly, knowledge of the farmer in relation of the pest in question. A new pest might have caused unimaginable damage before being noticed. Secondly, most of the surveillance/monitoring is carried out in the daytime, while most pests are nocturnal in nature. Thirdly, random sampling is done not on the whole farm. And fourthly, after the threshold of a particular pest population is exceeded, the farmer usually treats the whole farm, but pest infestation in a field is seldom evenly distributed (Amodu *et al*., 2020). The Space Technology comprises Remote Sensing (RS), Geographic Information System (GIS) and Global Positioning System (GPS) (Amodu *et al*., 2022). In pest management, detection of insect damage to crops along with weed infestation and crop diseases through Space technology provides important information for management planning and decision-making (Barnes *et al*., 1996; Amodu *et al*., 2020). Lasting benefits of using pesticides can be achieved only through the joint use of Space technology and IPM by restructuring and managing these systems in ways that scale up the array of “built-in” preventive strengths, with pesticides treatment tactics serving strictly as backups to natural regulators (Beeri and Peled, 2006: Amodu *et al*., 2020). Where chemical control is intended, specific pest populations are targeted for treatment at the time when they are most vulnerable, rather than simply carrying out a general and routine pesticide application. However, promoting IPM in conjunction with Space Technology advocates a paradigm shift from Blanket and uniform treatment of the field as it has been the practice of the generality of farmers when pest population has reached economic injury levels (Amodu *et al*., 2020). The development of agriculture in the global world today emphasises knowledge-intensity; hence, the agricultural systems in the developing world will have to leverage knowledge availability to achieve multiple goals of income, food and jobs creation (Okafor and Malizu, 2013; Amodu *et al*., 2022). IPM, when used in conjunction with space technology, may include variable rate pesticide applications, remote sensing of pest population development, sprayer/target sensing of application equipment or other technologies that reduce pesticide use relative to conventional pesticide applications (Amodu *et al*., 2020). Disease and pest management could be more effective if patches within fields can be identified timely, and treated (Amodu *et al*., 2022). Remote sensing provides a means of quick detection and delineation of various field conditions, a task that would be difficult and time-consuming using traditional ground surveys (Groves *et al*., 2005; Amodu *et al*.,2020). The Global Positioning System latitude and longitude data, when used with GIS technology to geo-reference pest location on a farm or region, have important implications for effective pest management (Groves *et al*., 2005; Amodu *et al*., 2022). Through the use of accurate management methods and their correct application, IPM can result in a reduction in the use of pesticides, including fumigants and herbicides. Thus, the IPM process begins with the farmer (who makes the decisions in the field) and not the pest. In order to take effective decisions, farmers need to understand the agro-ecosystem, the different components in the field interact, and how their decisions affect the balance (Amodu *et al*., 2020). Agricultural researchers need to understand local needs and provide farmers with a wide range of options that they can adapt and apply to their own individual situation. Truly lasting solutions to pest challenges will require a move to understand and promote intelligence gathering that ensure variable application of pesticide that will not deplete the population of naturally occurring biological agents and other inherent strengths as components of total agricultural ecosystems, and designing our cropping systems so that these natural forces keep the pests within acceptable bounds (Bongiovanni and Lowenberg-DeBoer, 2004; Amodu *et al*., 2020)). Detection and monitoring of pest populations can best be done through the use of Space technology. The varying spectral reflection of a field with respect to changes in the phenology (growth), stage type, and crop health can thus be measured and monitored by multispectral sensors mounted on the satellite (Amodu *et al*., 2020). Technological advances in plant protection research for key pests are of utmost importance to attain sustainability in agriculture (Pratap *et al*., 2000). The yield losses due to pest populations can be reduced to a greater extent if their incidence/occurrence is forecasted so that timely adoption of remedial measures is effective. This led to a concept of “forecasting”, a prediction or estimate of future trends which involves all the activities in ascertaining and notifying farmers in communities that conditions are sufficiently favourable for certain insect pests, that application of management options will result in economic gain, that the amount expected is most likely to be enough to justify the of time spent, energy and money for the control (Sudha-Rani *et a*l., 2018: Amodu *et al*., 2022). The utilisation of IPM in conjunction with Space Technology will inform the decision on the amount of pesticides required to effectively manage the pest situation in the field.

PROVIDE TRAINING AND EDUCATION

The need for farmers in Nigeria to access comprehensive

agricultural information regarding safe pesticide use in the field, stores, garden, and lawns cannot be over-emphasised (Jama *et al*., 2007). Such information is passed to all stakeholders through training and education, which can be both formal and informal systems. Training of Trainers (TOT) and Farmer Field Schools (FFS) are two core activities of the IPM training and extension process (FAO/WHO, 2001). The former is an effective way to help bring extension workers up to date on newly developed pesticide alternatives and on IPM in general. The knowledge gained will enable them to organise FFS for the farmers in their area. FFS are based on ecological principles, participatory training and non-formal educational methods. Information and Communication Technology (ICT) is generally seen as an important means of achieving such a transformation when used as a veritable tool for providing local farming communities with scientific knowledge (FAO/WHO, 2001). ICT heralds the formation of knowledge societies in the rural areas of developing countries, especially in the area of technological advancement (Okafor and Malizu, 2015). Indiscriminate and improper acquisition and sale of pesticides by illiterate vendors without requisite knowledge and procedure have resulted in widespread abuse of pesticides in Nigeria (Ogunlela *et al*., 2005; Amodu and Bolanle, 2018; Luckscheiter, 2023). The real problem of misuse of pesticides emanates from the place where farmers acquire pesticides that are supposed to give them adequate information on safe handling of the product (Amodu *et al*., 2022; Luckscheiter, 2023). The business of the acquisition and distribution of pesticides should be strictly handled by trained personnel. Hence, the creation of agricultural information is now often managed by agricultural organisations that aim to disseminate information to all stakeholders on pesticide handling. The farmers can make informed decisions to leverage novel technology opportunities and manage continuous changes in their production systems (Jones 1997). Training according to such principles implies facilitation of the learning process rather than instruction. In addition, FFSs give farmers the opportunity to experiment, sharpen their observation and research skills and take the initiative, adapting the innovations to local conditions. In fact, one of the major lessons learnt in the past by extension services has been that generalised recommendations to farmers from extension and research need to be carefully examined, tested and adapted by farmers themselves, according to the specific local conditions in their area. The actual information needed of the rural farmers is usually in line with the challenge(s) confronting them at the right time. Their needs could be how to control pests and diseases, environmental hazards, seedlings, preservation, finance and/or non-access to loan (Okafor and Malizu, 2013). Pesticide products are usually labelled in English, which most farmers cannot read (Amodu and Bolanle, 2018). The inability of users to read the directives on the package also leads to application of incorrect dosages (Dadari *et al*., 2005). In dealing with technical input like chemical pesticides, sources of impeccable information are paramount to farmers (Amodu and Bolanle, 2018). Access to extension and research agents can assist farmers in dealing with some technical complexities of chemical pesticides (Adesina, 1996; Nkamleu and Adesina, 2000). FFSs simplify this process by enhancing the existing knowledge and skills that the farmers have gained through years of experience. The conventional approach to farmer training, until recently, has been the organisation of field days where farmers were given demonstrations of new technologies. The pitfall with this type of training is that farmers are passive participants; they listen to the advice given by extension workers or agrochemical companies, but do not participate in the process of adapting the technology. The result is that farmers continue to use the traditional methods and are not encouraged to try out new technologies. FFSs provide farmers with the opportunity to test the alternatives and to improve upon them by introducing new principles. A field plot shared by several farmers is used to test the alternatives. The core aim of this training is that the farmers accept the new methods voluntarily and implement them in their field plots. The trainer who guides and facilitates the FFS should be an extension worker, plant protectionist, or other technician previously trained in a TOT, while the participants are growers organised into existing groups, or selected by the trainer in close consultation with the community leaders. A frequently observed problem is that chemical applicator rarely uses protective materials. This exposure could cause acute and chronic poisons to them. Investigation reveals that good protective clothing was not available and was often very expensive (Amodu and Bolanle 2018). There is a widespread dearth of information on first aid instructions in the event of accidental poisoning and on the residual effects of the product. The employer is mainly responsible for workplace health and safety. Employers must supply personal protective equipment (PPE). They must make sure that supervisors and employees are trained in the proper use of pesticides (EFSA, 2008). Employers must provide supervisors and employees with information on any pesticide to be handled. Consequently, when the information required by rural farmers is packaged in the language they understand and made available at the appropriate time, it will enhance agricultural productivity and ultimately improve food security (Okafor and Malizu, 2013). Pesticide labels must be on the containers, and a lack of labelling in local languages and high levels of illiteracy among farm workers mean critical safety information is often not communicated to the individuals who actually handle pesticides. The Globally Harmonised System of Classification and Labelling of Chemicals (GHS) is the accepted international standard for pesticide labelling (EU, 2022). Material Safety Data Sheets (MSDSs) should be given when available. Supervisors and employees must be trained to work safely when handling pesticides. Supervisors are responsible for

ensuring that all employees wear proper personal protective equipment (PPE) and that they understand and follow correct procedures in order to provide a safe workplace. Employees should request information on the pesticides they will be handling if it is not provided. Farmers, pesticide applicators, and the general public should be provided with training and education on the safe use and handling of pesticides. Studies have shown that most farmers who use pesticide practices calendar spray rather than using economic threshold. This will not only damage the environment and the non-target life but will also reduce the profit and expected yield (Amodu and Bolanle, 2018). The level of education, consciousness and awareness is also an important factor in determining the level of hygiene practice that food handlers can put into play as the technical ''know-how'' is pivotal in their roles for food safety. The problems posed to mankind as a result of poor hygiene underpin the importance of healthy practices. According to the World Health Organisation (WHO, 2015), an estimated 600 million world population, almost one in ten people fall sick after eating contaminated food, and 420,000 die every year from food poisoning. WHO also reported that children under 5 years of age are susceptible to food poisoning and have 40 per cent of the foodborne disease burden, with 125,000 deaths yearly. The education of the farming population should be enhanced, and this will forestall the misuse of agrochemicals.

REGULATE PESTICIDE REGISTRATION AND DISTRIBUTION

Globally, pesticides are the major sources of food poisoning and are also implicated in a significant number of suicides every year (EU, 2022). Indeed, hardly any day passes without incidents of some families dying after consuming food that may have been contaminated through improper processing, preservation, and service (Zikankuba *et al.*, 2019). There are many channels through which foods can be contaminated. Clearly, there is a need to enact stiffer laws to prohibit the use of toxic and hazardous pesticides by farmers to ensure healthy living and a safer farming system in the country (Luckscheiter, 2023). Regulatory requirements have remained the only successful pathway to mitigating harmful pesticides (Handford *et al*., 2015; Frezal and Garsous, 2020). Self-regulation by industry has had minimal impact on reducing the sale of harmful products. Many pesticide manufacturers do not give understandable instructions to end users (EU, 2022). Local salespersons and dealers who are relied upon for instructions often give erroneous or improper information (Amodu and Bolanle, 2018). Pesticide manufacturers are primarily concentrated on profits and can oftentimes twist public and environmental health perspectives for competitive reasons rather than a general care for human and environmental health (Jansen, 2017). They can and are ready to act as partners to achieve greater levels of safety, but cannot be trusted to do so on their own. On the surface, the lower prices of pesticides might be seen as favourable for users. However, the availability of cheap products makes the introduction more expensive, but sometimes safer products are less attractive to companies with a large research and development (R&D) focus (Zikankuba *et al*., 2019). Paraquat is an example of a pesticide that attracted a huge market share, leaving little incentive to invest in the development of less toxic alternatives. Another example is glyphosate, which is predominantly produced by Monsanto as RoundUp. Paraquat is banned for use within the EU, while glyphosate could be used until 2022. The moment the patents on these products elapsed, several companies started producing generic alternatives, with lower prices, but led to almost no success in terms of lower toxicity (EU, 2022). Understanding the full extent of pesticide poisoning to human health has been hampered by a lack of systematic monitoring and rigorous testing (EU, 2022). In Central America for instance, regulations of the EU and other importing countries are the main yardstick for deciding which pesticides to use in their crop protection programmes (Handford *et al*., 2015). This has for sure mitigated harmful pesticides from the markets and intensified the search for safer alternatives. Without this type of standard setting by the EU and others, pest control would still be depending on highly hazardous pesticides such as DDT, Methyl-parathion, and Dibromochloropropane. Information is provided on the difficulties of controlling these poisonous substances, along with the extent to which pesticides banned within the European Union (EU) are exported to third world countries (EU, 2022). In April 2023, National Agency for Food and Drug Administration and Control (NAFDAC) raised the alarm of the existence of EU banned pesticide in Nigeria market (Luckscheiter, 2023). NAFDAC as a regulatory body has to review the registration of chemical companies registered for the supply of pesticides as half of the ones used in Nigeria have been banned in Europe (Luckscheiter, 2023). The use of these types of pesticides makes enforcement of regulations more unfruitful, while also increasing the damage to human health and the environment. In some cases, a pesticide banned for agricultural use may be on the official market for another reason, further attenuating the ability of authorities to control the use of such banned product. DDT, for example, is used for vector control to combat malaria (Luckscheiter, 2023). Recent developments indicate that concerns about the health and environmental impacts of this pesticide are more pronounced among elite groups in developing countries, probably related to greater awareness of the risk associated with pesticides and the growing extent of their use (Möhring *et al*., 2020). The stakeholders in agriculture attributed the continuation of these banned products to inadequacy of standard safety procedure in Nigeria and indeed many African countries. Regulations are intended

to improve the ability of all people, including future generations, to have access to healthy food in line with United Nations declarations that make regulatory risk data more transparent and accessible; strengthen research and education on the safe use of pesticides; stop all exports of crop protection products banned in the EU: but allow the export of severely restricted pesticides if these are regulated accordingly and used properly in the importing country; and support the re-evaluation of pesticide registrations in developing countries to be in line with FAO/WHO Code of Conduct (Handford *et al*., 2015). Lethal pesticides and other poisons are less tightly regulated in Nigeria - and many countries in Africa - than they are in the United States or other developed countries. The resulting easy access and easy familiarity are among the reasons that mass poisonings remain more common here than they are in the developed countries in Europe, America and Asia. The use of unapproved pesticides is a serious challenge around the world and especially in developing countries (UN, 2020). To achieve this noble objective, the Federal Government of Nigeria should make a proposal to the National Assembly to enact laws as a target to reduce the misuse of chemical pesticides in Nigeria with a time frame of between 5-10 years. The main content of the proposal may include: Nigeria should have legally binding targets on use of hazardous pesticides at the national level, environmental friendly pest control is to be used, a ban on all pesticides uses in sensitive areas, stringent regulation on the use of chemical pesticides and government should review safety procedures on a regular basis as explained below:.

Nigeria should have legally binding targets on the use of hazardous pesticides at the national level

The legal binding target is to reduce by at least 50% the use and the risk of chemical pesticides as well as the use of the more hazardous pesticides. Every State of the federation will set its own local reduction targets within defined parameters to ensure that the national targets are achieved. Although the federal Ministry of Agriculture and Rural Development has this as Department but the enforcement has been so weak thereby making little or no impact in the agro ecosystem.

Environmental friendly pest control is to be used

This measure will ensure that all farmers and other professional pesticide users practice Integrated Pest Management (IPM) with special focus on bio-pesticides and bio-herbicides. This is an environmentally friendly system of pest control which focuses on pest prevention and prioritizes alternative pest control methods, with chemical pesticides only used as a last resort.

A ban on all pesticide use in sensitive areas

The use of all pesticides is prohibited in places such as urban green areas, including public parks or gardens, playgrounds, recreation or sports grounds, public paths, as well as protected areas and any ecologically sensitive area to be preserved for threatened insect pollinators.

Stringent regulation on the use of chemical pesticides

The government should regulate the registration, distribution, and use of pesticides to ensure that only approved and safe products are used. This can include monitoring the importation and sale of pesticides and enforcing penalties for non-compliance. To some extent, such regulations exist in the country, but enforcement is nothing to be desired.

The government should review safety procedures on a regular basis

Pesticide label and safety procedures should be checked periodically because applicators/users can become over familiar and careless with the product. Hence, regular review of the safety measures will make pesticide users conscious and careful in handling and utilisation of the poisonous product (EFSA, 2008). Furthermore, to encourage the shift to safer use of pesticides, enhanced regulation and enforcement at both the national and state levels are required. Bottlenecks in relation to the implementation and enforcement of these regulations should be removed. Regrettably, regulators in many developing countries often take years to approve new pesticides, meaning that older (and possibly more harmful) products are more likely to be available (Wordofa *et a*l., 2021). These older pesticide companies have usually recouped their development cost and so can afford to offer products at a lower cost, making them more attractive in low-income countries as well as compromising regulation, enforcement and standardisation (EU, 2022). Communication will also be key to managing and diminishing the risks of pesticide use in developing countries (EFSA, 2008). The overall target of pesticide handling strictly according to the regulations and also to address the public concerns about pesticide residues in food and drinking water could contribute to the reduction of the adverse effects of pesticides on human health and the environment. All these may sound difficult, but seem to be promising for the use of safe food production within a viable agricultural production system. Evolving safety procedures for the use of pesticides and application cover all stages of the pesticide life-cycle, from product manufacture to waste disposal.

DEVELOP AND ENFORCE SAFETY STANDARDS

IPM is an important component of sustainable agriculture,

enabling the production of farm products with judicious use of pesticides (Dminić *et al*., 2010). However, the type and high dose of pesticides used in the country are part of the reasons Nigerian agro products are rejected in the international markets (Luckscheiter, 2023). If the situation in this country does not change for the better, especially in the area of regulation and enforcement of safety standards for the use of pesticides, exports of more products from the country can be further suspended. The most effective way to ensure 'safer', residue-free exports is to implement better monitoring and control systems in the country (Zikankuba *et al*., 2019; Luckscheiter, 2023). Safety problems and ecological disruption unintended followed the use of the chemical pesticide approach to manage pest attack, and there are renewed calls to develop and enforce safety standards (Apan *et al.,* 2004; Dminić *et al*., 2010). Different formulated chemicals that can control pests and disease are currently and widely used across developing countries (Zikankuba *et al*., 2019). Concomitantly, human health and environmental issues related to pesticide handling are often pronounced in Nigeria owing to the fact that safety standards are not enforced. Aside from ecosystem disruption that ensues from the use of chemical pesticides, cases of acute food poisoning by unsuspected victims are rampant in Nigeria (Oladayo *et al*., 2022). Food poisoning is an acute disease caused by consuming pesticide-contaminated food or water, or a chronic disease caused by pesticide residue in foods, animals and aquatic materials (WHO 2006; EFSA, 2008). It was reported that no fewer than 200,000 persons die annually of food poisoning in Nigeria (Oladayo *et al*., 2022). A video had gone viral on how some retailers were using Sniper, a powerful insecticide, to preserve beans before bagging them for sale. The practice is allegedly commonplace, often used to eliminate or protect beans from weevil infection. Sniper, a dichlorovinyl, available over the counter, is a dangerous chemical used for killing bugs and insects. Although pesticides have been developed to function with reasonable certainty and minimal risk to human health and the environment, the published results are not always in agreement with this fact (EU, 2022). Even though the development of toxicity reference levels for pesticides incorporates uncertainty factors that serve to achieve this regulatory standard, in reality, we may never know whether a pesticide is safe under all circumstances, nor can we predict with certainty its performance in hypothetical situations (Damalas and Eletherohorinos, 2011). However, pesticide usage and handling as prescribed by the manufacturers are often not realistic in the settings in which pesticides are deployed: this is a significant problem given the scale of their use by both large and small-scale farms and the pressure to produce crop yields that are affordable. Safety standards for pesticide usage and application should be enforced by the government to stem the tide of the haphazard manner pesticides are handled in Nigeria. This should include guidelines on the safe use and handling of pesticides, aswell as regulations on the amount and frequency of application. Specific instructions are followed for their application on crops, and residue analysis is used as one of the indicators for enforcement. Pesticides that should be in IPM are: biologically effective (high selectivity, fast impact, optimal residual effect, good plant tolerance, low risk of resistance), user friendly (low acute toxicity and low chronic toxicity, optimum formulation, safe packaging, easy application method, long store stability), environmentally-friendly/compatible (low toxicity to non-target organisms, fast degradation in the environment, low mobility in the soil, no residues in food and fodder above the Minimum Residue Levels (MRLs), low application rate), economically viable/profitable (good cost/profit ratio for the farmer, broad spectrum of activity, applicable in IPM, innovative product characteristics, competitive, patentable (Wordofa *et al*., 2021). Above all, chemical pesticides procurement, distribution and sale should be strictly handled by trained, and accredited professionals with the stern warning not to over-apply pesticides because excessive application could cause the pesticide to run off or seep into water supplies and contaminate them and once contaminated it is difficult or impossible to clean the water or food sources (EFSA, 2008). Excess spray may leave harmful residues on your fruit and vegetables, which could affect other plants, wildlife, and fish. The National Orientation Agency (NOA) and other regulatory agencies must ensure proper public awareness of the proper use of chemicals. The National Agency for Food and Drug Administration and Control (NAFDAC) must be well-positioned to live up to its responsibilities. The Agriculture Ministry itself could do a lot better by ensuring that useful and relevant information – from planting to harvesting and preservation- is passed on to farmers and retailers, many of whom are unaware of the associated risks. It is important that we work to ensure that the food we put on the table meets the minimum standard of safety.

CONDUCT REGULAR MONITORING AND EXERCISE

A functioning system for monitoring and evaluation is vital to the success of safe pesticide use strategy (Sharma *et al*., 2019). Monitoring and evaluation have several purposes: to guide the planning and implementation of safe pesticide use policy to assess its effectiveness, to identify how the strategy should be licensed. Hence, monitoring and evaluation represent a feedback mechanism. The combination of monitoring and evaluation allows full comprehension of the cause-and-effect relations between implementation and impact. This may show any shortcomings, which are used to improve the programme or strategy (Zikankuba *et al.,* 2019). A major impediment in monitoring and evaluation is identifying valid indicators that can be measured objectively and systematically, especially in a complex issue like pesticide use (EU, 2021). Systematic data are important for measuring progress or impacts and for making cross-

sectional comparisons. The most useful types of indicators are quantitative (numbers, percentages) or logical (presence or absence) (Zikankuba *et al*., 2019). Some changes or processes, however, cannot be measured in quantitative terms but require a descriptive narrative. Such 'descriptive indicators' can help the country to better understand the rationale and reasons behind an observed outcome. Consequently, a combination of strong quantitative indicators and 'soft' descriptive indicators is often desirable (EU, 2021). Evaluation is part of the learning process, and pre- and post-training tests may be used as evaluation tools. The tests may consist of questions intended to demonstrate the trainees' level of knowledge related to safe pesticide use, as well as alternative technologies for its replacement. The challenge in monitoring and evaluation is in measuring the 'safe use of pesticide', assessing positive change in each IPM component, from policy to capacity building (EU, 2021). Therefore, indicators should be identified that are specific to each expected outcome and are easy to measure. The following cogent indicators such as reduced food poison/contamination, reduced level of chemical in exported produce, increased number of agro-chemical industries/dealers involves in safety campaign and increased availability of safety equipment are required for effective monitoring and evaluation (FAO, 2001; Zikankuba *et al*., 2019; EU, 2021).

The Nigerian National Policy on Pesticide Management should be put in place as Department under Federal Ministry of Agriculture and Rural Development

The existence of a national policy on pesticide management is indicative of a country's readiness to providing an enabling environment for sound management of pesticides, including their judicious use for pest control and the effective management of insecticide resistance. In order to confirm the people's awareness of the presence or absence of a national policy on pesticide management, an interview or survey should be conducted with the relevant government body (Wordofa *et a*l., 2021). The information obtained can be verified by referring to a copy of the policy document domiciled in the Department of Agricultural Monitoring and Evaluation, Federal Ministry of Agriculture and Rural Development, and National Agency for Food and Drug Administration and Control at the national level and could be complimented by the state and Local Government ministry of Agriculture. This indicator, which requires a simple yes-or-no answer, reflects the government's endorsement of sound management of pesticides (FAO, 2001; Zikankuba *et al.*, 2019; EU, 2021).

National coordinating unit on safe use of pesticide should be put in place under the Ministry of Agriculture of both the Federal, State and Local Governments

A national coordinating unit on pesticide control ensures that existing control activities and programmes are harmonised to increase the efficient use of resources. As the response to this indicator is a simple yes-or-no answer, it gives no qualitative information about whether a coordinating unit is functioning. Government regulation bodies are encouraged to verify the functionality of their coordinating unit, in addition to the indicator (FAO, 2001; Zikankuba *et al*., 2019; EU, 2021).

National strategic and implementation plan on the safe use of pesticides should be in place under the Ministry of Agriculture of both the Federal, State and Local Governments

The existence of a national strategic and implementation plan for the safe use of pesticides indicates that policy has been translated into a plan for concrete action and that national coordination and planning for the safe use of pesticides has commenced (FAO, 2001; Zikankuba *et al.*, 2019; EU, 2021).

Standards for professions and careers in pest and disease control and public health must be in place under NAFDAC

The creation of standards for professions and careers on the safe use of pesticides and public health is an indication that a career structure with opportunities for advancement exists in the areas of pesticide research (Wordofa *et al*., 2021). A career structure is an important incentive for people to seek training and is necessary to keep graduates in their profession. For this indicator, surveys or interviews should be conducted in relevant government units and tertiary institutions. The response should be verified by reference to documents outlining the standards (FAO, 2001; Zikankuba *et al*., 2019; EU, 2021).

Operational research outcomes on safe pesticide use should be in place under the Ministry of Agriculture of both the Federal, State and Local Governments

Utilisation of the outcomes of operational research is an indication that practical methods or solutions have been found and adopted for implementing the programmes. Information on operational research can be obtained from technical reports, surveys or interviews with the relevant government units or research institutions (EFSA, 2008). This indicator is the number of operational research outcomes that have actually been used during the reporting period. An outcome that has been used is a distinct method, tool or decision rule resulting from operational research that has been successfully adopted for an implementation programme, not as part of field-testing but as an accepted method (FAO, 2001; Zikankuba *et al*., 2019; EU, 2021).

Advocacy, communication and social mobilisation should be in place under the National Orientation Agency (NOA)

Advocacy meetings with officials of the main stakeholders are an indication that efforts have been made to increase awareness about and commitment to the safe use of pesticides. Advocacy meetings with senior-level stakeholders are desirable as frequently as possible to make the message widely circulate among the stakeholders (FAO, 2001; Zikankuba *et al*., 2019; EU, 2021).

Number (and percentage) of villages in which communities have been mobilised for the safe use of pesticides

The number of villages with community mobilisation is an indication of the extent of local farmers' readiness and commitment to the safe use of pesticides. Local participation by communities and leaders is essential for increasing awareness and creation of sustainability of pesticide use in agriculture. A community is considered "mobilised" if there is plausible evidence that residents have planned, implemented and evaluated their safe use of chemical pesticides. 'Community mobilisation', which can result in empowerment, occurs when a group of people become aware of a common problem, organise themselves and decide together to take action to solve the problem (FAO, 2001; Zikankuba *et al*., 2019; EU, 2021).

Prevalence and incidence rates of pesticide poisons report

The prevalence and incidence of poisoning of man, animals or non-target organisms or the environment indicate whether the strategy has been effective in reducing it. A reduction in chemical food poisoning, morbidity or mortality is ultimately the best measure of impact (FAO, 2001, (Zikankuba *et al*., 2019): EU, 2021). After the FFS, extension workers, under the supervision of the TOT trainer, should follow up on the application of the safe use of chemical pesticides in order to ensure their adoption and continued use. To ensure a successful application, the follow-up should consist of visits to farms on a monthly basis to ensure the correct application of new chemical pesticides and rectify possible shortcomings (FAO, 2001; Zikankuba *et al*., 2019; EU, 2021).

Farmers' experiences would provide useful feedback for future research and training activities on the safe use of chemical pesticides in the country (Wordofa *et al*., 2021). In many cases, experienced farmers may serve as facilitators of new FFSs. Regular monitoring and evaluation of pesticide usage and application can help to identify potential risks and ensure that safety standards are being monitored (EFSA, 2008). This can include testing of pesticide residues in food and water, as well as monitoring of the health of pesticide applicators and nearby communities.

CONCLUSION

Pesticides have played a key role in providing reliable supplies of agricultural produce at prices affordable to consumers, improving the quality of produce, and ensuring high profits to farmers. Although pesticides are developed to function with reasonable certainty and minimal risk to human health and the environment, several studies have raised concerns about health risks from exposure of farmers (or other end-users of pesticides) and from non-occupational exposure of the population to residues found in food and drinking water. Driven by growing global concerns about the environment and sustainable food production, a transition away from exclusive reliance on chemical pesticides has gained critical importance. Integrated Pest Management (IPM) is advocated by the Food and Agriculture Organisation of the United Nations (FAO) and the European Union (EU), meaning the use of natural predators and bio-pesticides in conjunction with mixed cropping and rotation where possible. Building awareness of the hazards associated with pesticides as well as of the benefits of alternatives will be an integral part of the approach that is needed. By implementing these steps, Nigeria can evolve safety procedures for pesticide usage and application, leading to a more sustainable agricultural system and a healthier environment and population. The need for farmers in Nigeria to access comprehensive agricultural information regarding safe pesticide use in the field, stores, garden, and lawns cannot be overemphasised.

Recommendation

It is recommended that strengthening the regulations for pesticide usage in the country that focuses on the agricultural ecosystem to ensure a sustainable environment for agricultural productivity by all levels of government, is highly encouraged. Also, enforcement of all the laws and regulations concerning pesticide acquisition, handling and applications is desired to minimise food and environmental contamination.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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