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HUMAN HEALTH AND ENVIRONMENTAL CONSEQUENCES OF NON-ADOPTION OF RECOMMENDED AGROCHEMICAL PRACTICES AMONG CROP FARMERS IN KADUNA AND ONDO STATES, NIGERIA

Issa, Fadlullah Olayiwola
National Agricultural Extension and Research Liaison Services (NAERLS),
Ahmadu Bello University, Zaria, Nigeria
Corresponding Author's E-mail: issafola@gmail.com **Tel.:** +2348033339312

ABSTRACT
The study assessed human health and environmental consequences of non-adoption of recommended agrochemical practices (RAPs) among crop farmers in Kaduna and Ondo States of Nigeria. Multi-stage sampling procedure was used to select 260 crop farmers who had sustained usage of agrochemicals for at least five (5) years. Data were collected using pretested structured interview schedule. Descriptive statistics (frequency, percentage and means) were used for data analysis. Majority (63.5%) of farmers attested that agricultural extension officers constituted the major source of information about risks and hazards of pesticide applications. All (100%) the respondents indicated that pesticides caused damage to human health as well as the environment. Majority of the respondents knew that skin irritation (71.5%), coughing (60.8%) and eye irritation (51.5%), respectively, were the consequences of non-adoption of RAPs. Food contamination was the most frequently reported hazard as indicated by the majority (83.8%) of the farmers. The findings further disclosed that talking or singing while mixing or spraying ($\bar{x}$ = 0.74), eating while mixing or spraying ($\bar{x}$ =0.55) and not washing of personal protection equipment (PPE) before reuse ($\bar{x}$ =0.46) recorded the highest pesticide handling habits in the study area. It was recommended that campaign for attitudinal changes on the use of agrochemical should be mounted by extension agencies in collaboration with relevant stakeholders; also, policymakers should make policies to prevent the importation of banned chemicals into the country.

Keywords: Adoption of pesticides, Environmental safety, Human health, Pesticides, Recommended agrochemical practices.

INTRODUCTION
Agricultural intensification has been triggered by increasing food demand occasioned by rapidly growing population. Agrochemicals (fertilizers and diverse pesticides) are rigorously used to address the increasing food demand. Application of pesticides and fertilizers in agriculture has several benefits which range from yield increase of agricultural crops and soil fertility to pest management and crop protection. Studies indicate that fertilizers and pesticide use in agriculture have been substantially increased both in developed and developing countries in recent years for attaining maximum yields of crops (Carvalho, 2017). Commonly used pesticides include herbicides, insecticides, fungicides, fumigants and rodenticides (Sharma *et al.,* 2012). However, inappropriate use of agrochemicals constitutes both human health and environmental challenges. Hence, there is a growing concern worldwide over the use of synthetic fertilizers and pesticides in agriculture because of their toxicity to human, environment, and ecosystems (Majeed, 2018). Hicks (2013) assert that each pesticide or pesticide class comes with a specific set of environmental concerns because of their toxicity and persistence in the environment. Such undesirable effects have led many pesticides to be banned, while regulations have limited and/or reduced the use of others (Sharma *et al.,* 2012).

The extensive use of pesticides has led to an accumulation of a huge amount of residues in the environment, thereby causing a substantial environmental health hazard due to uptake and accumulation of these toxic compounds in the food chain and drinking water (Adesuyi *et al.*, 2015; Adesuyi *et al*., 2016; and Njoku *et al.*, 2017). Manyof the adverse effects of pesticides on the environment depend on the interactions between the physicochemical properties (vapour pressure, stability, solubility, pKa) of the pesticide, soil absorption and soil persistence, the soil factors (pH, organic components, inorganic surfaces, soil moisture, soil microflora, soil fauna), the plant species, and the climatic variation (Damalas and Eleftherohorinos, 2011).

Agricultural pesticides are chemicals that are used by farmers to prevent the effectivity of the pests on the growth and productivity of agricultural crops. Farmers who are directly involved in the handling are at a high risk of exposure to pesticides through contact with pesticide residues on treated crops, unsafe handling, storage and disposal practices (Manyilizu *et al.,* 2017). Poor maintenance of spraying equipment and the lack of protective equipment or failure to use it properly are other forms of exposures (Matthews, 2008). Pesticide exposure can occur through four routes: Mouth, skin, inhalation into the lungs and the eyes (Desalu *et al.,* 2014; and Jallow *et al.,* 2017). Inhalation exposure can occur while mixing granular and powder forms of pesticides, spraying of the solvent and during the burning of empty containers.

The use of pesticide in Nigeria has been on the increase ever since its introduction in cocoa production. Asogwa and Dongo (2009) estimated that about 125,000 - 130,000 metric tons of pesticides are applied every year in Nigeria. According to Pesticide Action Network International ([PAN], 2010), there is a global surge in the incidence of pesticide poisoning with an estimate of 1-41 million people suffering health from exposure to pesticides annually. It is estimated that a minimum of 300,000 people died from pesticides poisoning annually, with most of them (99%) from low- and middle-income countries (World Health Organization [WHO], 2009). The exposure to pesticides are reported to have effects on thyroid function, cause low sperm count in males, birth defects, increase in testicular cancer, reproductive and immune malfunction/problems, endocrine disruptions, dermatitis, behavioural changes, cancers, immunotoxicity, neurobehavioral and developmental disorders (Okoffo *et al.,* 2016). There are also reports on the effects such as headaches, body aches, coughing, stomach ache, skin and eye irritation, respiratory problems, dizziness, impaired vision and nausea (Okoffo *et al.*, 2016; and Jallow *et al.*, 2017).

Several chemical pesticides used in agriculture are known to cause health problems in human, livestock, and produce an adverse impact on plant diversity and environment in both short and long run (Yassin *et al.,* 2015). Improper pesticide handling causes accidental poisoning, and even acute or chronic health effects (Sharma *et al.,* 2012). In long run, pesticide exposure can cause long-lasting health issues such as dermatosis, cancer, and genotoxic, neurotoxic, and respiratory effects (Khan, 2015). In developing countries, the use of outdated, non-patented, more toxic, and environmentally persistent pesticide is the leading causes of higher toxicity (Van der *et al.,* 2014). In addition, farmers in developing countries are exposed to toxic chemicals due to a lack of technical knowledge on toxicity levels of pesticides and safety measures to protect themselves from the exposure (Yassin *et al.,* 2015; Khan, 2015; and Rijal *et al.,* 2018). The improper handling of pesticide occurs mainly at the time of mixing and application, during storage, and during pesticide disposal (Sharma *et al.,* 2012; and Yang *et al.,* 2014).

Risks to the environment through misuse of pesticides, including overuse, chemical substances may end up contaminating water, air and soil, with adverse effects on plants and wildlife, and a loss of biodiversity in general (although the latter is also influenced by a number of other factors). In particular, plant protection products released into the environment in an

uncontrolled way by spray drift; leaching or run-off may pollute soil, surface water and ground water (Majeed, 2017). Environmental contamination can also occur during and after application, when cleaning equipment, or through the uncontrolled illegal disposal of pesticides or of their containers. Indeed, a high proportion of contamination exceeds the 0.1 μg/l threshold value, in which case the water must be treated to remove the pesticides in excess before it can be distributed as drinking water. This background underscores the need for effective and broad-based policy on the safe use of agrochemicals. There is a need for assessing the possibility of modifying or even eliminating the policies that distort pesticide pricing and utilization to levels that are substantially different from the socially optimal levels.

In spite of the upsurge in the use of pesticides in Nigerian agriculture, there has been little or no awareness among the users on the hazard to the environment (Rijal *et al.,* 2018; Yassin *et al.,* 2015; and Zyoud *et al.,* 2010). Information on their use, distribution and environmental impacts is scanty in Nigeria. Until the old publication of the "Guidelines and Standards for Environmental Pollution Control in Nigeria" (1991) by the Federal Environmental Protection Agency (FEPA), there had been no government regulation or control of the use of pesticides and other toxic chemicals in the country. Sequel to this background, this study becomes significant.

Crop farmers in Kaduna and Ondo States use pesticides extensively for the control of pests and diseases in order to increase their farm yields (Issa and Kagbu, 2017). In third world, pesticides are used improperly with disregard for recommended safety measures hence exposing farmers to health risks (Adesuyi *et al.,* 2018). To worsen the already bad situation, there is inadequate empirical information on human health and environmental consequences of pesticides exposure by farmers during pesticides application.

The general objective of the study was to examine the human health and environmental consequences of non-adoption of Recommended Agrochemical Practices (RAPs) among crop farmers in Kaduna and Ondo States, Nigeria. The specific objectives were to: (i) describe the sources of information about risks and hazards of pesticide; (ii) assess farmers' awareness of pesticide-related discomfort/illness; (iii) examine farmers' awareness of pesticide-related environmental hazards, and (iv) examine pesticide handling attitudes of farmers.

MATERIALS AND METHODS

The Study Area

Kaduna and Ondo States from the Northern and Southern Nigeria, respectively, were used for the study. Both States have the highest record of use of agrochemicals in the different agroecology where they belong (National Agricultural Extension and Research Liaison Services [NAERLS] and National Programme on Agriculture and Food Security [NPAFS] (2011). Kaduna State lies between longitude 06′00 and 09′10′East of the Greenwich Meridian between and latitudes 090'00 and 11030 north of the Equator. Occupying an area of approximately 48,473.2 square kilometers (FOS, 2006), Kaduna State shares common borders with Kano and Katsina States to the north; Bauchi and Plateau States to the north-east; the Federal Capital Territory and Nasarawa State to the south; and Niger and Zamfara States to the south-west. Ondo State lies between latitudes 5°45' and 7°52'N and longitudes 4°20' and 6° 05'E. Its land area is about 15,500 square kilometers. Ondo State is bounded on the east by Edo and Delta States, on the west by Ogun and Osun States, on the north by Ekiti and Kogi States and to the south by the Bight of Benin and the Atlantic Ocean. Ondo State tops the list in cocoa production (Ogunlade and Aikpokpodion, 2010) which involves heavy use of fungicides for the control of fungal diseases. A wide range of fungicides are available in the State (Olabode *et al.,* 2011).

The two (2) States have markedly different agroecological condition. This difference could make crop protection practices (as well as the type of agrochemicals used) to vary substantially in the two States. However, both States are noted for heavy use of agrochemicals. Traditionally, Nigerian farmers have been relying heavily on pesticides for the control of various weeds, insect pests and diseases, leading to the high importation of these product and their prices have become so high that it is difficult for local farmers to afford (Njoku *et al.*, 2017).

Sampling Procedure and Sample Size

The study focused on crop farmers who have been using agrochemicals for at least five (5) years in Kaduna and Ondo States of Nigeria. The selection of these States and locations where primary data were collected was based on high volume of crop production and prominent use of agrochemical as reported by NAERLS and National Programme on Agriculture and Food Security (NAERLS and NPAFS, 2011). Multi-stage sampling procedure was employed in selecting 260 respondents (who are adopters of agrochemicals). Stages one and two were purposive selections of two agricultural zones of ADPs per State; and two (2) Blocks per Zone, respectively. The criterion for the purposive selections was the high intensity of agrochemical use based on the record of the ADPs. The third stage involved the purposive selection of two (2) villages per block. Lastly, the fourth stage involved using the list of farmers obtained from the reconnaissance survey to randomly select 15% of farmers from each of the eight (8) villages. In all, a total of 135 and 125 crop farmers were selected from Kaduna and Ondo State, respectively, making a total of 260 crop farmers.

Method of Data Collection

Data for the study were collected from primary source. Primary data was collected with the use of pretested, validated, structured interview schedule. Personal observation was also used for data collection. Recommended practices describe the efficient and effective use of a specific agrochemical in a worthwhile manner as suggested by relevant authority (producer or regulatory agent). Responses on farmers' habit were rated on a 3-point Likert type scale thus: 'good' (2), 'indifferent' (1), and 'poor' (0). Score for farmers' habit was computed by summing the responses of respondents' score for each habit to obtain a weighted sum. The weighted sum was further divided by the number of respondents to obtain a weighted mean for each of the items. The weighted mean (representing the habit) was classified thus: 2.5–3 (Good), 1.5–2.49 (Indifferent), and <1.5 (Poor). Awareness describes the perfect knowledge and understanding of recommended agrochemical practices by farmers. Responses on farmers' awareness were rated on a 2-point Likert type scale thus: 'aware' (1), 'not aware' (0). Score for farmers' awareness was computed by summing the responses of respondents' score for each effect on safety (human health and environmental) to obtain a weighted sum. The weighted sum was further divided by the number of respondents to obtain a weighted mean for each of the items. The weighted mean (representing the awareness) was classified as: >1-2 (aware) and <1 (not aware).

RESULTS AND DISCUSSION

Sources of Information about Risks and Hazards of Pesticide

As presented in Table 1, all (100%) the crop farmers had knowledge (full or partial) of the risks and hazards associated with pesticides usage. The majority (63.5%) sourced the information about risks and hazards of pesticides from agricultural officers. Only 20% of the crop farmers however, indicated input traders as source of information on these issues (Table 1). This result could be because the major aim of the input trader (agro-dealer) is majorly to make profit and not emphasize the risks and hazards of pesticides.

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Table 1: Farmers' Sources of Information about Risks and Hazards of Pesticides

Sources of information	Kaduna (n = 135)	Ondo (n = 125)	Both (n = 260)
Agricultural extension officer	72 (53.3)	93 (74.4)	165 (63.5)
Input trader (Agro-dealer)	34 (25.2)	18 (14.4)	52 (20.0)
Personal experience	28 (20.7)	11 (8.8)	39 (15.0)
Health officer	1 (0.7)	3 (2.4)	4 (1.5)
Research officers	32 (23.7)	17 (13.6)	49 (18.8)

Figures presented are percentages

Farmers' Awareness of Pesticide-Related Discomfort/Illness

Crop farmers were aware of the various pesticide-related discomforts/illnesses. The majority (71.5%, 60.8% and 51.5%) knew that skin irritation, coughing and eye irritation, respectively were consequences of non-adoption of RAPs (Table 2). This indicates that skin irritation, coughing and eye irritation were the common symptoms exhibited as a result of non-adherence to good practices. Bull (1982) reported regular and widespread incidence of poisoning and misuse of pesticides. Improper handling of pesticides could cause various discomforts. Zyoud *et al.* (2010) found that the common symptoms exhibited after pesticide application among the farm workers were skin rash, headache, excessive sweating, and diarrhea. However, in Ghana, body weakness and headache/dizziness were the most frequently reported symptoms (Ntow, 2008). A study by Udoh (2009) on pesticide use in Akwa-Ibom State, Nigeria found unsafe practices of application of pesticides among farmers. He asserted that more than 600,000 farming households in the State might have been exposed to various problems due to poor handling and use of pesticides.

These findings could be due to the poor maintenance of spraying equipment especially with the use of highly toxic pesticides which are still being used in developing countries (Hicks, 2013; and Majeed, 2018). A major cause of poisoning when using knapsack or trombone sprayer is the spilling of pesticides over the back of the operator because of a faulty locking cap of the container. Cracks and leaks in containers and in over-aged rubber hoses, and not renewing or loosing washers caused leakages that often poison the user, wastes pesticides, causes environmental pollution and may become phytotoxic where pesticides fall on crops at high doses (Negatu *et al.*, 2016).

Table 2: Farmers' Awareness of Pesticide-Related Discomfort/Illness

Types of Discomfort/Illness	Kaduna (n = 135)*	Ondo (n = 125)*	Both (n = 260)*
Skin irritation	93 (68.9)	93 (74.4)	186 (71.5)
Coughing	81 (60.0)	77 (61.6)	158 (60.8)
Eye irritation	76 (56.2)	58 (46.4)	134 (51.5)
Head/body ache	46 (34.1)	35 (28.0)	81 (31.2)
Nausea (stomach upset)	43 (31.8)	33 (26.4)	76 (29.2)
Vomiting	29 (21.5)	35 (28.0)	64 (24.6)
Cramps (muscle pain)	26 (19.2)	32 (25.6)	58 (22.3)
Shortness of breath	32 (23.7)	25 (20.0)	57 (21.9)
Fatigue/weakness	17 (12.5)	23 (18.4)	40 (15.4)
Excessive sweating	22 (16.3)	22 (17.6)	44 (16.9)

*Multiple responses indicated; Figures in parentheses are percentages

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Farmers' Awareness of Pesticide-Related Environmental Hazards

Food contamination was the most frequently reported hazard as indicated by the majority (83.8%) of the farmers. Burning of crop was indicated by the majority (75.6% and 77.6%) of the crop farmers in Kaduna and Ondo State, respectively, as environmental hazards of pesticides. Pesticide failure was indicated by 72.7% of the farmers as major hazard (Table 3). Dugje *et al.* (2008) reported that whole fields of crops had been lost in many cases because the application of herbicides had been carried out wrongly. Pesticide use on cocoa farms has over the years become more specific and less toxic but environmental pollution still exists. However, since practically no data exist on this issue in Nigeria, the extent of the pollution of the agrarian communities can only be guessed.

Presently, there is neither any detailed research on environmental impact of pesticides in Nigeria nor any monitoring process in place. The only form of regulation involves the registration of brands of agro-chemicals by the National Agency for Food and Drug Administration and Control (NAFDAC) and screening and recommendation of pesticide formulations and spraying equipment by various research institutes with mandates for different crops. The procedures are to ensure that substandard products are not marketed in Nigeria and to confirm the efficacy of formulations offered for crop pest control. The stated results that majority (77.3%) had knowledge of death of livestock/fish corroborates the findings of Adesuyi *et al*. (2018) who reported that farmers bath around nearby water bodies which is a potential threat and risk to aquatic lives and livestock due to pesticides contamination.

Table 3: Farmers' Awareness of Pesticide-Related Environmental Hazards

Environmental hazards	Kaduna (n = 135)	Ondo (n = 125)	Both (n = 260)
Contamination of food	123 (91.1)	95 (76.0)	218 (83.8)
Death of livestock/fish	98 (15.7)	103 (82.4)	201 (77.3)
Burning of crops	102 (75.6)	97 (77.6)	199 (76.5)
Pesticide failure	116 (85.9)	73 (58.4)	189 (72.7)
Contamination of water	79 (72.6)	92 (73.6)	171 (65.8)
Loss of bio-diversity	42 (31.1)	41 (32.8)	83 (31.9)

*Multiple responses indicated; Figures in parentheses are percentages

Pesticide Handling Habits of Farmers

Results in Table 4 present some operational habits exhibited by farmers during or after pesticide application. The mean score for all the habits measured indicate that only few farmers sometimes exhibit the habits which are regarded as bad because of their capability to expose farmers to danger of pesticide use. Talking/singing while mixing or spraying ($\bar{x}$ = 0.74), eating while mixing or spraying ($\bar{x}$ = 0.55), and not washing of personal protection equipment (PPE) before reuse ($\bar{x}$ = 0.46) recorded the highest. Ugwu *et al.* (2015) and Adesuyi *et al*. (2018) reported similar results where the majority of vegetable farmers reported not eating, talking, singing or smoking while mixing or spraying pesticides. Similar habits by farmers during pesticides application have been reported in studies by Sosan and Akingbohungbe (2009) and Ogunjimi and Farinde (2012) in Nigeria. However, the result is in contrast with the findings of Negatu *et al.* (2016) who found that farmers are found eating, smoking or drinking in-between spraying activities.

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Table 4: Pesticide Handling Habits of Farmers

Handling habits	**Mean ($\bar{x}$)**			
	Kaduna (n = 135)	**Ondo (n = 125)**	**Both (n = 260)**	**Standard deviation**
Talking/singing while mixing or spraying	0.76	0.72	0.74	0.983
Eating while mixing or spraying	0.59	0.52	0.55	0.946
Not washing of PPE before reuse	0.50	0.42	0.46	0.481
Not bathing after application	0.30	0.29	0.30	0.683
Drinking while mixing or spraying	0.20	0.38	0.29	0.504
Smoking while mixing or spraying	0.23	0.30	0.26	0.659
Entering sprayed farm immediately after spraying	0.28	0.23	0.26	0.889
Spraying along the wind direction	0.24	0.19	0.14	1.220
Stirring/scoping chemicals with hands	0.09	0.08	0.09	1.211

CONCLUSION AND RECOMMENDATIONS

Agricultural officers constitute a major source of information about risks and hazards of pesticide. Also, farmers' awareness of pesticide-related discomfort/illness, and pesticide-related hazards was high. However, farmers' pesticide handling habit was only fair. Based on the results of the study and considering the long-term effects of agrochemicals on environment and ecosystem, policymakers should make policies to prevent the importation of banned chemicals into the country. Local production should be encouraged by the government. Agrochemical value-chain should be regulated by the Federal Department of Agriculture and National Agency for Food and Drugs Administration and Control (NAFDAC) to combat the problem of adulteration. All pesticides should be evaluated and authorized before they can be placed on the market. The FMARD in collaboration with NAFDAC should develop pesticide policy package (PPP) aimed at banning the use of some hazardous pesticides. The PPP should be a multi-pronged approach to the safe and effective use of pesticides that directly targeted: the use of highly toxic insecticides; regulatory policies and implementing guidelines on the importation, formulation, distribution, sale, and use of pesticides; the illegal smuggling of pesticides; regulation on the labeling and advertising of pesticides; hazard awareness, through an agro-medical training program; improved product stewardship, undertaken jointly by the pesticide industry and the government. Furthermore, agricultural extension officers and input-dealers represent key stakeholders in pesticide issues and hence they have more shares of responsibilities to educate farmers on safe use of chemicals.

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