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ENVIRONMENTAL EFFECT OF PESTICIDE USE BY COCOA FARMERS IN NIGERIA

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ABSTRACT

Pesticide has been widely adopted in agricultural production for the control/prevention of pests, diseases and weeds but their use has significantly increased the concentration of toxic materials in the environment, with negative effects on plant, animal and non-target organisms. The study examined the environmental effect of pesticide use by cocoa farmers in Nigeria. It specifically identified the common pesticides used, highlighted the observed effects of pesticide use on the environment and determined the effects of pesticide use on the environment. A total of 390 cocoa farmers were selected from five geo-political zones where cocoa is commercially grown in Nigeria with the aid of structured questionnaire and interview guide using multi-stage sampling technique. Data were analysed using descriptive statistics and binary logistic regression model. Results reveal that the common pesticides used by majority of the cocoa farmers in the study area were cypermethrin, copper (1) oxide + Metalaxyl and glyphosate. The major effect of pesticide use observed on the environment were decrease in mosquito bites (76%), incidence of weeds (56.3%), beneficial insects such as bees (75.7%), earthworms (68.3%) and insect pests (75.1%). Pesticide dose used ($p<0.05$), reading and adherence to instructions on pesticide labels ($p<0.01$), use of pesticide cocktail ($p<0.05$), pesticide remnant ($p<0.01$), pesticide container disposal method ($p<0.01$) and equipment cleaning ($p<0.05$) were the significant factors influencing effects of pesticide on the environment in the study area. Cocoa farmers should therefore be trained regularly by both government and non-government organisations about right handling and safe use of pesticide.

Key words: Cocoa production, environment, lindane, logit regression, pesticide use,

INTRODUCTION

Cocoa (*Theobroma cacao* L.) is a perennial crop mainly cultivated in Africa, the Caribbean, South America and Asia (United Nations Development Programmes (UNDP), 2010) It is the leading cash crop in West Africa with over 70% of world cocoa production cultivated in the region (Afrane and Ntiamoah, 2011). Cocoa is cultivated either in agro-forestry systems in which some part of the natural forest is left in place or in newly cleared or converted land. This involves that the new land must be cleared under conditions which are ecologically not friendly (Asare, 2006). Cocoa grown under the canopy of original forest is considered the most environmentally friendly form of production. Even though shade-grown cocoa has its attendant consequences such as loss of biodiversity, shade systems have been shown to have higher biodiversity than full-sun systems. Shade system requires less pesticide and this may contribute to higher levels of biodiversity which is associated with better pest control, pollination and more efficient nutrient cycling (Clay, 2004). Despite the fact that shade trees may compete with cocoa, they have a lot of advantages to cocoa, these include: restrain weed growth, reduce soil erosion, protect the cocoa against adverse climatic conditions and pests, and increase the efficacy of nutrient use by the cocoa trees (Hartemink, 2005). Some farmers have moved their crops out of the shade and into direct sunlight due to the desire to increase output (Piasentin and Klare-Repnik, 2004). This practice yields a greater quantity in a short period but at lower quality. Cacao trees with no shade tend to be susceptible to more weeds as well as diseases such as Witches Broom and Frosty Pod Rot. If the crops begin to accommodate pests, farmers use large amounts of pesticides to curb the attack from these pests.

A pesticide is a toxic chemical substance or a mixture of substances or biological agents that are intentionally released into the environment in order to avert, deter, control and/or kill and destroy populations of insects, weeds, rodents, fungi or other harmful pests. Pesticides work by attracting, seducing and then destroying or mitigating the pests (Mahmood *et al.*, 2016). The pesticide used are dangerous to the environment and the health of the person applying the pesticide. Pesticides promise the effective mitigation of harmful bugs, but unfortunately, the risks associated with their use have surpassed their beneficial effects. Most of the pesticides reach a destination other than their target, non-selective pesticides kill non-target plants and animals along with the targeted ones (Mahmood *et al.*, 2016). Pesticide contaminates land and water when it escapes from production sites and storage tanks, when it runs off from fields, when it is discarded, when it is sprayed aerially and when it is sprayed into water to kill unwanted plants (Tashkent, 1998). Pesticide residue may enter streams through run-off and pose dangers to fish, birds, wild animals and plants in the aquatic habitat. Pesticides often are degraded in water (hydrolysis), by sunlight (photo degradation), and by soil and aquatic microorganisms (microbial degradation). Application rates and techniques have direct bearing on how a pesticide enters the environment. In addition, persistent pesticides such as DDT pesticide may bio-accumulate, move through the food chain and eventually be ingested by and adversely affect birds, wild animals and domestic livestock. Methyl bromide which is currently being replaced by phosphine for the fumigation of stored cocoa beans has been identified as an ozone-depleting substance (Olurominiyi and Emily, 2011).

Pesticide application in cocoa production is a widely adopted technology by cocoa farmers to combat pest attack which is a predominant phenomenon in cocoa production. Although, pesticide use in cocoa production by the farmers is for the purpose of improving productivity through reduced or no pest attack, it has the capacity of altering the fragile ecosystem, the environment and the health of farmer in general (Bentley *et al.*, 2004). From the foregoing, it is necessary to examine the environmental effect of pesticide use in cocoa production in Nigeria. Specifically, the study described the socioeconomic characteristics of the cocoa farmers, identified the common pesticides used, described the pesticide handling practices and highlighted the observed effect of pesticide use on the environment

MATERIALS AND METHODS

Study Area

The study was carried out in three geopolitical zones in Nigeria. Nigeria is made up of six geopolitical zones out of which cocoa is produced in exportable quantities in five geopolitical zones: South West, South South, South East, North Central and North East. Three zones (South West, South South and North Central) representing 60percent of the cocoa producing zones in Nigeria were selected for the study. These three zones were purposively chosen to give the study a nation-wide focus. However, the study was carried out in three States: Ondo State (South West zone), Edo State (South South zone) and Kwara State (North Central zone).

Sampling Procedure

The respondents were selected through a multi-stage sampling technique. The first stage involved purposive selection of five out of six geo-political zones where cocoa is commercially grown in Nigeria. In the second stage, stratified sampling technique was used to group the five cocoa producing geopolitical zones into high, medium and low zones. Following National Bureau of Statistics (NBS), (2012); National Survey on Agricultural Exportable Commodities (NSAEC), (2013), the zones are classified as high (South West), medium (South South) and low (South East, North Central and North East). The third stage involved purposive selection of one state from each of the high, medium and low zones. These are Ondo (high), Edo (medium) and Kwara (low). In the fourth stage, two agricultural zones were selected from each state through random sampling technique. The fifth stage involved the use of simple random sampling technique to select one Local Government Area (LGA) from each agricultural zone using the list of LGAs available in the agricultural zone as sampling frame. In the sixth stage, five villages were randomly selected from each of the LGAs giving a total of 30 villages. The basis of selection was the dominance of cocoa production in these villages. Finally, in the seventh stage, a simple random sampling procedure was used in choosing 13 cocoa farmers from each of the 30 villages giving a total of 390 farmers for interview using the list of cocoa farmers from the agricultural zones as the sample frame. However, a total of 350 questionnaires (110 for Kwara state; 118 for Edo state and 122 for Ondo state) were used for analyses as others were discarded due to incomplete information.

Primary data used for the study were collected with the aid of questionnaire assisted by personal interview schedule for illiterate farmers. Data were collected on socioeconomic characteristics of the cocoa farmers, commonly used pesticides, pesticide handling practices and observed environmental effects related to pesticide usage in cocoa production in the study area.

Analytical Techniques

Descriptive statistics such as mean, frequencies and percentages were used to describe and summarize the socio-economic characteristics of the respondents, common pesticide use and environmental effect of pesticide usage in the study area. Binary Logistic Regression Model was used to analyse the factors determining the environmental changes occasioned by pesticide application observed by cocoa farmers in the study area. The dependent variable, the presence of environmental changes (yi) is a dummy. It takes the value of 1 if there are changes and 0 if otherwise. The model is specified as:

$$Z_i = b_o + b_1x_1 + b_2x_2 + b_3x_3 + \ldots\ldots\ldots + b_nx_n$$

Where:

X_s is a vector of explanatory variables and is expressed as:

X_1 = Pesticide dose (gram a.i./ha); X_2 = Pesticide application training (if trained = 1, 0 otherwise); X_3 = Weather condition (1 if windy, 0 otherwise); X_4 = Reading and adherence to instructions on pesticide labels (1 if read, 0 otherwise); X_5= use knapsack sprayer (1 if used, 0 otherwise); X_6 = Pesticide cocktail (1 if yes, 0 otherwise); X_7 = Pesticide remnant (1 if pour on ground, lake, stream, or river, 0 otherwise); X_8 = Pesticide container disposal (1 if left on farm, burnt or buried, 0 otherwise); X_9 = Equipment cleaning (1 if washed beside water source, 0 otherwise); ε = random error

RESULTS

Socio-economic characteristics of the cocoa farmers

Results on the socio-economic characteristics of the cocoa farmers are presented in Table 1. The result in Table 1 reveals that 64.5% and 37.7% of the cocoa farmers in Kwara and Ondo States were within the age range of 51-60 years respectively, while 32.2% were within 31-40 years of age in Edo state. The pooled sample result shows that majority (76.6%) of the sampled cocoa farmers in the study area were male while 23.4% were female. Most (49.1%) of the cocoa farmers in Kwara State had primary education, 39.8% had secondary education in Edo State and 41% had primary education in Ondo State. Also, 79.7% of all the respondents were married, 6.6% were widowed and 4.6%were divorced while 9.1% were single. The mean household sizes were 11, 10 and 8 people in Kwara, Edo and Ondo States respectively. Distribution by cocoa farming experience reveals that 45.5% of the cocoa farmers in Kwara and Edo States had between 11 and 20 years of experience respectively, while 34.4% of the farmers in Ondo State had farming experience of between 21 and 30 years. Furthermore, the mean farm size of cocoa production in the study areas were 3.62ha for Kwara State, 6.71ha for Edo State and 10.31ha for Ondo State.

Common Pesticide Used by Cocoa Farmers in the Study Area

Table 2 presents the results on the common pesticide used in the study area together with the World Health Organisation (WHO) classification. Table 2 shows that all the sampled cocoa farmers use one form of pesticide or the other in their cocoa farms in the study area. All the sampled cocoa farmers in Kwara State used bounty, a combination of fertilizer and insecticide in their cocoa farms. This was followed by herbicides, paraquat dichloride (90.9%) and glyphosate (88.2%). Cypermethrin (90.7%) was the most used insecticide in the state, while fungicide was used by 82.2% of the sampled cocoa farmers, 80.9% used herbicide paraquat dichloride and 64.4% used glyphosate, also an herbicide in the state. Fungicides (94.3%) were the most used pesticide in Ondo State. This was followed by lindane (71.3%), an insecticide

Table 1: Distribution of Cocoa Farmers by Socio-economic Characteristics ***n = 350***

Description	Kwara State	Edo State	Ondo State	Pooled sample
Age (years)				
Less or Equal to 30	0(0.0%)	16(13.6%)	11(9.0%)	27(7.7%)
31-40	10(9.1%)	38(32.2%)	15(12.3%)	63(18.0%)
41-50	22(20.0%)	34(28.8%)	39(32.0%)	95(27.1%)
51-60	71(64.5%)	19(16.1%)	46(37.7%)	136(38.9%)
Above 60	7(6.4%)	11(9.3%)	11(9.0%)	29(8.3%)
Mean (years)	54.52 years	45.01 years	49.57 years	49.02 years
Sex				
Female	12(10.9%)	43(36.4%)	27(22.1%)	87(23.4%)
Male	98(89.1%)	75(63.6%)	95(77.9%)	268(76.6%)
Educational Status				
No formal Education	19(17.3%)	15(12.7%)	7(5.7%)	41(11.7%)
Primary	54(49.1%)	37(31.4%)	50(41.0%)	141(40.3%)
Secondary	37(33.6%)	47(39.8%)	36(29.5%)	120(34.3%)
Tertiary	0(0.0%)	19(16.1%)	29(23.8%)	48(13.7%)
Mode	Primary	Secondary	Primary	Primary
Marital Status				
Single	4(3.6%)	12(10.2%)	16(13.1%)	32(9.1%)
Married	98(89.1%)	90(76.3%)	91(74.6%)	279(79.7%)
Widowed	7(6.4%)	11(9.3%)	5(4.1%)	23(6.6%)
Divorced	1(0.9%)	5(4.2%)	10(8.2%)	16(4.6%)
Household Size (No of people)				
1-4	0(0.0%)	8(6.8%)	12(9.8%)	20(5.7%)
5-8	25(22.7%)	36(30.5%)	59(48.4%)	120(34.3%)
9-12	61(55.5%)	43(36.4%)	36(29.5%)	140(40.0%)
13-16	8(7.3%)	15(12.7%)	6(4.9%)	29(8.3%)
Above 16	16(14.5)	16(13.6%)	9(7.4%)	41(11.7%)
Mean (people)	11	10	8	10
Cocoa Farming Experience (years)				
Less or Equal to 10	0(0.0%)	31(26.3%)	20(16.4%)	51(14.6%)
11-20	50(45.5%)	55(46.6%)	32(26.2%)	137(39.1%)
21-30	46(41.8%)	20(16.9%)	42(34.4%)	109(30.9%)
31-40	12(10.9%)	8(6.8%)	19(15.6%)	39(11.1%)
Above 40	2(1.8%)	4(3.4%)	9(7.4%)	15(4.3%)
Mean	22.68	17.26	19.89	19.94
Total Farm Size				
Less than 2ha	37(33.6%)	0(0.0%)	0(0.0%)	0(0.0%)
2.1-4ha	20(18.2%)	17(14.4%)	1(0.8%)	55(15.7%)
4.1-6ha	45(40.9%)	32(27.1%)	19(15.6%)	96(27.4%)
6.1-8ha	6(5.5%)	49(41.5%)	24(19.7%)	93(26.6%)
8.1-10ha	2(1.8%)	12(10.2%)	36(29.5%)	54(15.4%)
Above 10ha	0(0.0%)	8(6.8%)	42(34.4%)	52(14.9%)
Mean	3.62	6.71	10.13	6.82

Table 2: Common Pesticide Used by Cocoa Farmers in the Study Area

Active Ingredient	Type	*WHO Class	Total
Kwara State			
Chloropyrifos	Insecticide	II	79(71.8%)
Lamda Cyhalothrin	Insecticide	II	29(26.4%)
Bounty	Insecticide + Fertilizer		110(100.0%)
Mancozeb,	Fungicide	III	18(16.4%)
Copper (1) oxide + Metalaxy	Fungicide	II	80(72.7%)
Paraquat dichloride	Herbicide	II	100(90.9%)
Glyphosate	Herbicide	III	97(88.2%)
Edo State			
Cypermethrin	Insecticide	II	107(90.7%)
Metalaxy + Difenoconazole + Thiamethoxam	Insecticide	II	37(31.4%)
Lindane	Insecticide	II	42(35.6%)
Metalaxy + Copper (1) oxide	Fungicide	II	97(82.2)
Paraquat dichloride	Herbicide	II	89(80.9%)
Glyphosate	Herbicide	III	76(64.4%)
Ondo State			
Copper (1) oxide + Metalaxyl	Fungicide	II	81(66.4%)
Copper hydroxide	Fungicide	II	34(27.9%)
Lindane	Insecticide	II	87(71.3%)
Thiamethoxam	Insecticide	II	77(63.1)
Dichlorovinyl dimethyl phosphate	Insecticide	II	29(23.8%)
Chlorpyrifos	Insecticide	II	75(61.5%)
Glyphosate	Herbicide	III	80(65.6%)

*II = moderately hazardous; III = slightly hazardous; NK = not known (WHO, 2009; PAN, 2009).

Note: Active ingredients (gm.ai/litre) was obtained from the containers of pesticides used by the cocoa farmers

Pesticide Handling Practices by the Cocoa Farmers in the Study Area

Results from the pooled sample in Table 3 indicate that majority (76.9%) of the cocoa farmers used pesticide frequently while 23.1% used pesticide occasionally in their cocoa farms, 52.6% used pesticide cocktail while 56% read and adhere to instructions on pesticides labels or manuals. Majority (50%) of the sampled cocoa farmers in Kwara State always used up their pesticide, while 51.7% and 45.1% reused their pesticide for spraying their cocoa farms next time in Edo and Ondo States respectively. On the average, 34.9% of the sampled cocoa farmers stored their unused pesticide to be used on their cocoa farms next time, 26.9% poured their unused pesticide on the farm ground and 4.6% in lakes, streams or rivers. Table 3 further reveals that most (48.9%) of the cocoa farmers buried their pesticide container after usage, 27.7% threw away their pesticide container or left them in the farm and 15.3% disposed their pesticide container by selling to other users while 6.8% of the respondents disposed their pesticide container by burning them. Generally, 85.4% of the cocoa farmers had observed changes occasioned by pesticide use on the environment while 14.6% said they did not observe any changes on the environment.

Observed Effects of Pesticide Use on the Environment by the Cocoa Farmers in the Study Area

Result in Table 4 indicates that 76% and 56.3% of the cocoa farmers across the study areas reported that they observed a decrease in mosquito bites and incidence of weeds or invasive **plants** respectively in their environment after spraying pesticide. Majority of the farmers reported that they had noticed a decrease in the numbers of beneficial insects such as bees (75.7%), earthworms (68.3%) and insect pests (75.1%). Some (37.1%) and (28.9%) of the farmers had observed a decrease in the number of mammals and birds in the study areas. Also, the farmers reported infrequent visits of honeybees to their farms and a scarcity of honeycombs, which used to be abundant in the area. Majority (55.7%) of the farmers in the study areas had also noticed injury to non-target plants in their environment after spraying pesticide in their cocoa farms.

Table 3: Distribution of Cocoa Farmers by Selected Pesticide Handling Practices

Parameter	Kwara State	Edo State	Ondo State	Pooled Sample
Use of Pesticide				
Occasionally	12(10.9%)	11(9.3%)	58(47.5%)	81(23.1%)
Frequently	98(89.1%)	107(90.7%)	64(52.5%)	269(76.9%)
Use of Pesticides Cocktail				
No	36(32.7%)	54(45.8%)	76(62.3%)	166(47.4%)
Yes	74(67.3%)	64(54.2%)	46(37.7%)	184(52.6%)
Read and Adhere to Instructions				
No	68(61.8%)	49(41.5%)	37(30.3%)	154(44.0%)
Yes	42(38.2%)	69(58.5%)	85(69.7%)	196(56.0%)
Pesticide Remnant				
Always Use Up	55(50.0%)	14(11.9%)	22(18.0%)	91(26.0%)
Pour on Ground	34(30.9%)	30(25.4%)	30(24.6%)	94(26.9%)
Reuse Next Time	6(5.5%)	61(51.7%)	25(45.1%)	122(34.9%)
Pour in Lake, Streams, River	5(4.5%)	9(7.6%)	2(1.6%)	16(4.6%)
Use for Other Purposes	10(9.1%)	4(3.4%)	13(10.7%)	27(7.7%)
Disposal of Pesticide Container				
Household needs	11(10.0%)	5(4.2%)	4(3.3%)	20(5.7%)
Throw Away	35(31.8%)	38(32.2%)	24(19.7%)	97(27.7%)
Bury it	64(58.2%)	49(41.5%)	58(47.5%)	171(48.9%)
Sell it	0(0.0%)	18(15.3%)	22(18.0%)	40(11.4%)
Burn it	0(0.0%)	8(6.8%)	14(11.5%)	22(6.3%)
Observed Changes in the Environment				
No	13(11.8%)	20(16.9%)	18(14.8%)	51(14.6%)
Yes	97(88.2%)	98(83.1%)	104(85.2%)	299(85.4%)

Determinants of Environmental Effects of Pesticide Use in the Study Area

Binary logistic regression model was used to determine the effects of pesticide on the environment in the study area. As shown in Table 5, the log likelihood value of the model is -92.311. The chi-square (LR-statistics) value of 32.663 statistically significant at 1% level attests to the overall goodness of fit of the model. The result reveals that pesticide dose used ($p<0.05$), reading and adherence to instructions on pesticide labels ($p<0.01$), use of pesticide cocktail ($p<0.05$), pesticide remnant ($p<0.01$), pesticide container disposal method ($p<0.01$) and equipment cleaning ($p<0.05$) were the significant factors influencing effects of pesticide on the environment in the study area.

Table 4: Observed Effect of Pesticide Use on the Environment

Description	Observation	Kwara State	Edo State	Ondo State	Pooled
Incidence of Mosquito bites	Increasing	0(0.0%)	8(6.8%)	0(0.0%)	8(2.3%)
	Decreasing	76(69.1%)	98(83.1%)	92(75.4%)	266(76.0%)
	Constant	18(16.4%)	8(6.8%)	10(8.2%)	36(10.3%)
	No idea	16(14.5%)	4(3.4%)	20(16.4%)	40(11.4%)
Weed or invasive plants	Increasing	2(1.8%)	29(24.6%)	10(8.2%)	41(11.7%)
	Decreasing	56(50.9%)	75(63.6%)	66(54.1%)	197(56.3%)
	Constant	29(26.4%)	7(5.9%)	30(24.6%)	66(18.9%)
	No idea	23(20.9%)	13(11.0%)	16(13.1%)	52(14.9%)
Bees	Increasing	0(0.0%)	5(4.2%)	1(0.8%)	6(1.7%)
	Decreasing	81(16.0%)	80(67.8%)	104(85.2%)	265(75.7%)
	Constant	7(24.0%)	14(11.9%)	6(4.9%)	27(7.7%)
	No idea	22(52.7%)	19(16.1%)	11(9.0%)	52(14.9%)
Earthworms	Increasing	0(0.0%)	13(11.0%)	1(0.8%)	14(4.0%)
	Decreasing	81(73.6%)	64(54.2%)	94(77.0%)	239(68.3%)
	Constant	9(8.2%)	17(14.4%)	13(10.7%)	39(11.1%)
	No idea	20(18.2%)	24(20.3%)	14(11.5%)	58(16.6%)
Insect pests	Increasing	1(0.9%)	0(0.0%)	2(1.6%)	3(0.9%)
	Decreasing	72(65.5%)	93(78.8%)	98(80.3)	263(75.1%)
	Constant	16(14.5%)	11(9.3%)	16(13.1%)	43(12.3%)
	No idea	21(19.1%)	14(11.9%)	6(4.9%)	41(11.7%)
Mammals and birds	Increasing	0(0.0%)	41(34.7%)	0(0.0%)	41(11.7%)
	Decreasing	19(17.3%)	30(25.4%)	81(66.4%)	130(37.1%)
	Constant	37(33.6%)	18(15.3%)	21(17.2%)	76(21.7%)
	No idea	54(49.1%)	29(24.6%)	20(16.4%)	103(29.4%)
Death of aquatic animals	No	97(88.2%)	86(72.9%)	66(54.1%)	249(71.1%)
	Yes	13(11.8%)	32(27.1%)	56(45.9%)	101(28.9%)
Injury on non-target plants	No	50(45.5%)	46(39.0%)	59(48.4%)	155(44.3%)
	Yes	60(54.5%)	72(61.0%)	63(51.6%)	195(55.7%)

Table 5: Determinants of Environmental Effects of Pesticide Use in the Study Area

Variables	Coefficient	Wald	Sig.
Pesticide dose used	1.001***	2.146	0.021
Pesticide training	1.065	1.855	0.173
Weather condition	0.777	0.265	0.132
Reading and adherence to instructions	-1.021***	-2.523	0.001
Knapsack sprayer	1.685	0.518	0.156
Pesticide cocktail	0.112**	2.041	0.033
Pesticide remnant	1.427***	2.613	0.000
container disposal method	0.069***	4.722	0.000
Equipment cleaning	0.879**	2.321	0.035
Constant	0.271	2.298	0.036
Log likelihood	-92.311		
Chi square	32.663***		

***significant at 5%, *** significant at 1%*

DISCUSSION

The results of the socio-economic characteristics presented in Table 1 reveals that cocoa farmers in Kwara and Ondo State were old and beyond their productive years. This supports the findings of Adeniyi and Ogunsola, (2014); Nmadu *et al.*, (2015) that most of the farmers were getting too old and might find it difficult to meet the demands which the intensive care of cocoa farms required. Cocoa farmers in Edo State on the contrary, were young, in their active age group and possess the needed strength required for the rigours of cocoa production. This is in line with Nkang *et al.*, (2007) that cocoa farmers in Cross River State which is in the same region with Edo State were in their prime ages. Cocoa farming in the study areas was male dominated. This result agrees with Adeniyi and Ogunsola (2014) that males were mainly the carriers of responsibilities of household needs and therefore need engagement in gainful occupation like cocoa production which is known to give relatively higher incomes compared to other farming endeavours. The modal years of schooling of primary school implies that the sampled cocoa farmers were literates and this could serve as an impetus in adopting cocoa technologies. This results confirms the findings of Oluyole (2005), who reported that high literacy level will enable farmers to understand the intricacies of factors and products market and also predispose them to adopt and use improved farm practices. Also, the large percentage of married respondents implies that more members of farm family were likely going to be available for cocoa production in the study area. Effiong (2005) reported that a relatively large household size enhances the availability of family labour which reduces constraints on labour demand in cocoa production particularly during the peak production season. The area cultivated to cocoa in the study area indicates that the cocoa farmers were medium scale farmers. This has implication for output level and revenue accruable to the cocoa farmers.

Pesticide use in cocoa production is a *sine qua non* to increased cocoa yield because almost all the stages of cocoa production cycle are affected by one pest or the other. The pesticide commonly used in cocoa production in the study areas as presented in Table 2 were insecticides, fungicides and herbicides, most of which are dangerous to both the health of the sprayer and the environment. Lindane, which was used by some of the sampled cocoa farmers in Ondo and Edo States belong to a group of pesticides popularly known as the ‘dirty dozen’ (PAN, 1993; 2009). These pesticides have been banned, severely restricted or deregistered in some countries because of their established hazardous effects on humans and the environment.

However, the farmers were able to purchase lindane in agrochemical shops in the state without restrictions which implies that there is improper monitoring of pesticide distribution in the state. This result confirms the reports of Osibanjo (2001) that pesticides regulation policy in Nigeria as whole is poorly implemented.

Results in Table 3 indicate that majority of the sampled cocoa farmers used pesticide frequently in their cocoa farms. This implies that the cocoa farmers were able to nib the incidence of pests and diseases attack in the bud with frequent pesticide application, which could impact negatively on the environment. Many farmers misused chemicals by making cocktails of different kinds of pesticides before spraying. These farmers believed that mixing different pesticides saved time because they could apply more than one pesticide in a single spraying operation. Oluwole and Cheke (2009) reported that these farmers argued that mixing different pesticides increased the efficacy of the pesticide solution and ensured effective control of the target pests and diseases. About half of the cocoa farmers interviewed read, understand and adhere to instructions on pesticide labels and manuals. Omari (2014) opined that, the failure of most farmers to read the labels and adhere to instructions could mean that, unaware, these farmers may be using expired chemicals on their farms. Also, the farmers poured their unused pesticide on the farm ground, lakes, streams or rivers. This is a practice that could have negative effect on non-target and beneficial organisms in the environment and kill aquatic organisms in the water bodies. This finding confirms the reports of Olurominiyi and Emily, (2011); Ikpesu and Ariyo, (2013). Furthermore, burying pesticide container after usage is in tandem with findings of Oseni and Adams (2013) that burying empty pesticide container is an acceptable way of disposing pesticide container. However, leaving pesticide container on the farm could increase the exposure of the farmers and people around to pesticide toxicity. Ajayi and Akinnifesi, (2007) submitted that leaving the containers in the field after use could pose serious risks to nearby streams, animal, food and child health while burning empty containers could explode and give off poisonous gases. Pesticide Environmental Stewardship recommends that empty pesticide container should be triple rinsed and disposed of according to label instructions.

It was observed by the cocoa farmers that pesticide application had positive effect on the environment in the areas of reduction in mosquito bites, incidence of weed and invasive plants in the study area. However, beneficial insects such as bees, earthworms, insect pests; birds and other animals may be decreasing in the study area due to pesticide application. These declines according to Pain *et al.*, (2004) may be attributable to accidental contacts by the animals' due to misuse of pesticide by the farmers. This is an indication that pesticide sometimes destroys non-target crops in adjacent plots which translates to economic loss to farmers so affected.

Glyphosate is used by majority of the farmers; this pesticide can exterminate populations of many frog species and other aquatic organisms (Relyea, 2005). Also, infrequent visits of honeybees to the farms and scarcity of honeycombs, could have been as a result of the use of a neurotoxic insecticide on their farms which have been documented to be highly toxic to birds and bees; also the use of Thiamethoxam is known to alter bees' foraging behaviour (USNLM, 1995; Guez, 2001; PAN, 2009).

Pesticide dose used in cocoa production was found to have a positive significant relationship with environmental effect in the study area. This implies that an increase in the quantity of pesticide use in cocoa production will increase their effects on the environment in the study area. Also, the coefficients of use of pesticide cocktail, pouring pesticide remnant on the farm ground, lakes, streams or rivers, disposal of pesticide container by leaving them on the farm, burying or burning them were positive and significant implying that these practices will increase the effects of pesticide on the environment. This corroborates the findings of Oluwole and Cheke (2009) that these practices have negative impacts on non-target organisms as well as aquatic organisms living in the water bodies such as snails and frogs. However, the coefficient of reading and adherence to instructions on pesticide labels and manuals was found to decrease the effect of pesticide use on the environment as it was negative and significant at 1% alpha levels. Reading and adherence to guidelines on pesticide labels and manuals will help the farmers to apply the right quantity of pesticide and use appropriate application method thereby reducing their effects on the environment.

CONCLUSION AND RECOMMENDATIONS

Majority of the cocoa farmers used pesticide frequently on their farms in the study area. The study revealed that the farmers were aware of the peril accompanying the use of pesticide on the environment. It is therefore recommended that cocoa farmers should be trained regularly by both government and non-government organisations about right handling and safe use of pesticide as well as risks involved in indiscriminate disposal of pesticide remnants and containers. Information diffused to farmers through these agents should emphasise on the need for cocoa farmers to read and adhere to instruction on pesticide labels and manuals. In addition, there is need for reorientation and training of the farmers on integrated pest management (IPM) methods, which are environment friendly and could reduce the potential exposures to pesticide.

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