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## Implication of Sprayer Types Used by Farmers for Controlling Insect Pests and Diseases of Cocoa in South West Nigeria

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### **Abstract:**

*Cocoa is vital in the economy of Nigeria and it has great potentials in the current economic diversification programme of the government of Nigeria. Pesticide application which involves the use of sprayers has been an important operation in cocoa production in Nigeria to ensure profitable yields. Due to paucity of information on this aspect of farmers' attitude, a study on what informs the decision of cocoa farmers to select the right sprayers from the various types available for controlling pests and diseases has therefore become imperative because the success of Crop Protection Product (CPP) depends on the effectiveness of its application. This work involves collecting information from farmers on the types of sprayers they used to apply pesticides on cocoa trees and some relevant personal characteristics from two major cocoa producing States (Ondo and Oyo) in South western Nigeria through structured questionnaires. The data from the field survey was further investigated based on the existing sprayers in the market. The results from the analysis of data obtained indicated that though most of the farmers used the right sprayers for pesticide application, the sprayers are inadequate in one way or the other for effectively applying pesticides on cocoa trees. Farmers' choice was mostly guided by affordability in cost term, and such factors as durability, ability to produce high pressure and weight. Thus, there is need for the improvement or development of sprayers to achieve better suitability for effective and efficient application of pesticides on the local breeds of cacao. It is noteworthy, that more educated youths should be involved in cocoa farming to sustain and boost production. Farmers' capacity building, subsidized inputs (especially sprayers) and periodic enlightenment programmes such as on-farm demonstration, and evaluation of sprayers for this purpose are also highly recommended.*

**Keywords:** *Sprayers, pesticides, cocoa tree, questionnaire, farmers*

### **1. Introduction**

Global food insecurity and hunger have led to various approaches to raise agricultural productivity and strengthen sustainable food production. Pesticides have been emphasized by the producers along a range of policy incentives as a major solution to pest and disease problems with farmers being progressively encouraged to apply pesticides to control diseases and pests, but there are other control options that are more environment-friendly. Moreover, abrupt change in cropping systems by farmers from mixed cropping to a more intensified mono-cropping has tendency of increasing pest and disease population, their distribution and dynamism because the natural ecosystem would have been destroyed in the process. An increased pest and disease population resulting from this practice as against the earlier Integrated Pest Management (IPM) approach has led to popular use of pesticides. Reliance on synthetic chemicals to control cocoa pests has given rise to problems ranging from environmental to health issues, which may affect the food chain and consequently impacting negatively on biological diversity of the ecology (Tijani and Sofoluwe, 2015)

Nigeria was rated 4<sup>th</sup> largest cocoa World producer (ICCO, 2015) and 2<sup>nd</sup> largest World producer in the 1960s (Adegbola and Abe, 1983) as the crop has been generating substantial foreign exchange for the country. The production of this important commodity crop in Nigeria has suffered a major problem of pest and disease infestation. The nuisance of pests and diseases is a strong factor responsible for the dwindling production of cocoa in Nigeria (Aikpopodion *et al*, 2012). Pesticide application equipment has been

introduced into the Nigerian Cocoa farming system ever since they were used in the industrialized World (Asogwa and Dongo, 2009). Pesticide use in Nigeria has been on the increase since its introduction in the early 1950s for cocoa production (Tijani and Sofoluwe, 2015). Cocoa pesticides accounted for about 31% of the total agrochemical market estimated at 125,000 – 130,000 metric tons in 1991 (Asogwa and Dongo, 2009). They added that Nigerian cocoa production is still dependent on pesticides to attain acceptable levels of production. They reported further that the anti-mirid campaign resulted in remarkable increase in cocoa production from an average of 103,000 tons/annum in 1961 – 67 to 212,000 tons/annum in 1961 – 65 periods. The pro-pesticide arrangement has generally led to excessive application of pesticides among farmers without considering both direct and indirect harmful negative effects on the farmers and the society at large. Direct effects border on human health, environmental degradation, destruction of natural enemy population and undesirable residues in the crops.

Sprayers are popularly used to apply pesticides on cocoa trees and other crops. A sprayer can be described as a machine designed, involving different components, to convert spray mixture into fine particles which is applied in appropriate quantity on the crop or soil through various techniques. The design of a sprayer, like any machine, depends on its specific application and determines its performance. There are various types of sprayers (Anonymous, 2013) in respect to design which determine their suitability for one spraying purpose or the other. Some of the major parts of a sprayer are tank, pump, filter, pressure regulator, lance and nozzle which are of various designs (Anonymous, 2013). The type of pump and nozzle greatly affect the performance of a sprayer as they determine the volume, uniformity, pattern and coverage, amount of drift of spray mixture and such things as comfort of the operator. For example, High Volume hydraulic nozzles are most commonly used for pesticide application while impact nozzles are usually used for applying herbicide (Anonymous, 2013). Hydraulic Manual Knapsacks (backed sprayers) are particularly used for spot spraying by small holding farmers and Pneumatic Knapsacks are undesirable for herbicides as spraying pressure declines after some time (Malik et al, 2012). Sprayers can be classified by source of power which includes manual, pneumatic and motorized or volume of spray which include high, low and ultra-low volume (ULV). According to Asogwa *et al* (2009) different brands of the Hydraulic Knapsack Pumps (High Volume Spraying), the Motorized Knapsack Sprayer (Low Volume Spraying) and the Swing Fog Machine (Insecticide/Oil smoke) have been evaluated and recommended as pesticide applicators. The nozzle is very important because it determines the pattern of spray particles/droplets which greatly affect spray results. Spraying nozzle is a device for emitting spray liquid, breaking it up into small droplets and throwing the droplets away from the orifice (Anonymous, 2013). Although nozzles have been developed for practically every kind of spray application, only a few types; flat fan, flood jets, solid cone and hollow cone are commonly used in the application of CPP (Malik et al, 2012). It was noted that the size of droplets required, spray pattern and rate of application are considered in choosing the nozzle for pesticide application. The right selection of sprayers and timely application of pesticides play vital roles for effective pest control (Malik et al, 2012). Accordingly, the choice of spraying equipment depends on its specific use and the need for a pest-weed control measure while noting that 70% of the success of CPP (Crop Protection Products) depends on the effectiveness of its application. Cocoa tree may require a special sprayer in this respect because, as a tree crop, it is different from most other crops. In most cases, pesticides are applied by using either a nozzle or spinning disc to disperse the spraying liquid into a spraying cloud of small droplets and the technical state of the equipment used determines the safety and effectiveness of pesticides according to Mejiden, 1998. Defective or malfunctioning spray equipment could lead to either over discharge or under discharge of spray mixture, which usually will result in environmental pollution, human toxicity, development of pest resistance by the target pests and resurgence and/or emergence of new pest biotypes which will lead to pest outbreak (Asogwa *et al*, 2009).

Standard recommendation for physical attributes of sprayers according to Asogwa *et al*, 2009 include tank height, width, length and weight, length of lance, length of lance with extension, length of hose, length and width of strap, diameter of tank opening, length of pump handle, vertical and horizontal thrust, efficiency of nozzle and width of discharge (swath). They added that majority of the Nigerian Cocoa farmers still use substandard and inappropriate spraying pumps while attention was not paid to the use of appropriate jets and extension lances where recommended pumps were used. Asogwa *et al.*, 2009, Asogwa and Dongo, 2009 and Tijani and Sofoluwe, 2012 reported that farmers in Nigeria have adopted little of the technical knowledge on cocoa pest management acquired from scientific research. The wrong use of the pesticide application equipment in cocoa production has attracted a global concern about the impact of these pesticides on public health with respect to pesticide residues in cocoa and its products: problems of over-or-under-application include crop injury, poor pest control and injury to subsequent crop when using residual pesticides (Malik et al, 2012). Ergonomics which is the science of the use of a machine in relation to the health, safety and comfort of the operator as affected by his body posture during operation is also very vital in pesticide application.

Proper technique of application of pesticide is very vital just as the selection of equipment used (Anonymous, 2013). It noted further that the main purpose of pesticide application is to cover the target with maximum efficiency and minimum effort to keep the pest under control as well as minimise contamination on non-target organisms or environment. Proper selection of equipment, knowledge of pest behaviour and skilful dispersal methods are vital in this regard. The complete knowledge of pest location (under or over the leaves, at root zone etc) and economically important stage of the pest will help to decide the target and timing. Timely application of chemicals plays a vital role in ensuring better yields, especially at peak periods of crops, according to (Malik et al, 2012). Malik et al, 2012 and Anonymous, 2013, observed that proper maintenance and storage of sprayers are very important for correct performance during operation. Steps such as using clean water and inlet net, cleaning the sprayer and nozzle thoroughly by flushing after each use will ensure effective performance, prevent damage to subsequent crops sprayed, corrosion of parts and undesirable reaction between residual and new CPPs. Storing the sprayer away from bad weather effects will enhance life span of the equipment. Asogwa (2008) and Asogwa and Dongo (2009) identified maintenance and mismanagement as one the problems of pesticide application among Nigerian cocoa farmers.

There is urgent need to assess sprayer types, including their accessories, and application practices popularly used among cocoa farmers in various cocoa producing zones. This study was carried out to obtain information on the suitability of various types, what informs farmers' selection of sprayers including the operational and component requirement, of agricultural sprayers used by cocoa farmers in South western Nigeria.

### 1.1. Objective

The study was carried out to obtain information on the implication of various sprayer types adopted by cocoa farmers for applying pesticides in Nigeria towards improving farmers' awareness for achieving better spraying results and possibly design a more suitable sprayer.

### 1.2. Specific Objectives

The specific objectives were to:

- determine different types of agricultural sprayer used by cocoa farmers.
- determine the suitability of the sprayers for pesticide application on cocoa trees.
- determine challenges faced by cocoa farmers in using various types of sprayers for applying pesticides.
- offer probable solutions to identified problems for effective and efficient pesticide application on cacao.

## 2. Materials and Method

The study was carried out in the Southwestern Nigeria. A pre-study exercise was carried out by interviewing Agricultural Input Dealers who sell sprayers in the study area and the information received were used in designing questionnaire used for collecting data from cocoa farmers. A multistage sampling procedure was adopted to select the sample for the study. In the first stage, Ondo and Oyo States were purposively selected due to their prominence in cocoa production. Secondly, one Local Government Area (LGA) each well-noted for cocoa production was selected from the two States. Idanre and Ogo-Oluwa were selected from Ondo and Oyo States respectively. Two villages were also chosen from each Local Government Area. They were Owena and Onikokojiya from Idanre and Otamokun and Ibere in Ogo-Oluwa. Fifty (50) and forty five (45) cocoa farmers respectively were randomly selected from Idanre and Ogo-Oluwa Local Government Area resulting in a total of Ninety Five (95) farmers.

### 2.1. Data Collection

A structured questionnaire was individually administered to the farmers.

### 2.2. Data Analysis

The data collected were analysed using descriptive statistics such as frequency and percentage. The variables considered include farmers' characteristics (age, sex, marital status, education and group membership), sprayer types and performance implication.

## 3. Results

### 3.1. Personal Characteristics of Cocoa Farmers

Personal characteristics of farmers in the study area are described in Table 1. The ages of farmers were between 20 and 90 years. Those within the ages of 20-50 years were relatively young being 57.9% of the total population studied while 42.1% were 51-90 years old. The implication of this is that substantial percentage of farmers in Southwestern Nigeria was relatively old. This does not encourage cocoa production since most of the farmers were aging. It was also noted that more males (77.9%) were involved in cocoa production than females (22.1%). This was corroborated by Adebisi *et al* (2009) for kola production and Agbongiarhuoyi *et al* (2013) for coffee production. This is a good trend as men are regarded to be more energetic to handle herculean tasks such as land clearing better than women, notwithstanding, women are more useful for such operations as processing as they further observed. Very high percentage (94.7%) of the farmers was married which will encourage division of labour between men and women. According to Adebisi *et al* (2009) female mostly undertook on-farm processing and preservation of kola; the contributions of women were more than men in primary processing of coffee beans (Agbongiarhuoyi *et al*, 2013).

The educational status of farmers is very important for interpreting and accepting new innovations and technologies in agriculture. However, very low percentage of 5.3% farmers possessed higher certificates while 31.6% were holders of SSCE and substantial number of 21.0% had no formal education at all. It may be difficult for the reasonable percentage without formal education to interpret, understand and accept information on new techniques in farming. According to Asogwa (2008), most of the cocoa farmers are not literate; hence they indulge in serious malpractices in pesticide application such as wrong use of nozzles, wrong formulations and doses, inability to distinguish one pest from the other and wrong timing of application. Tijani and Sofoluwe (2012) had also noted that education is positively associated with pesticide use, indicating that highly educated use more pesticides. A reasonable percentage of 21.1 farmers did not belong to cooperative societies or similar organisations where they can receive financial assistance to improve their purchasing power for agricultural inputs such as sprayers, while only 15% were members of Cocoa Association of Nigeria (CAN) where information on new development in cocoa production or technology can be easily obtained. This poses danger for capacity building and information dissemination since few farmers are affiliated to relevant associations. Table 1 also indicates that about 75% of the farmers sampled had more than 10 years farming experience which will promote knowledge transfer and can boost productivity. However, a significant percentage of 76.8 farmers had small area of farm of between 0.1 – 4.0 hectares. This is an indication that majority of cocoa farmers are incapacitated in one way or the other to produce cocoa in large quantity, probably due to lack of incentives.

Variable	Frequency	Percentage
<b>Sex</b>		
Male	74	77.9
Female	21	22.1
<b>Age</b>		
≤30	9	9.4
31 – 40	17	17.9
41 – 50	29	30.6
51 – 60	19	20.0
61 – 70	14	14.7
> 70	7	7.4
<b>Marital status</b>		
Single	3	3.1
Married	90	94.7
Divorced	1	1.1
Widow	1	1.1
<b>Educational status</b>		
Tertiary	5	5.3
Secondary school	30	31.5
Primary	40	42.1
No formal education	20	21.1
<b>Membership of societies</b>		
Cocoa Association of Nigeria	15	15.7
Cocoa Farmers' Cooperative	17	17.9
Cocoa Farmers' Group	20	21.1
Cooperative Societies	23	24.2
None	20	21.1
<b>Farming experience (Years)</b>		
≤ 10	24	25.3
11 – 20	38	40.0
21 – 30	10	10.5
31 – 40	16	16.8
41 – 50	3	3.1
> 50	4	4.3
<b>Size of cocoa farm (Hectares)</b>		
≤2.0	41	43.1
2.1 – 4.0	32	33.7
4.1 – 6.0	14	14.7
6.1 – 8.0	7	7.4
> 8.0	1	1.1

Table 1: Personal characteristics of cocoa farmers

Source: Field Survey, 2015

### 3.2. Sprayer Types and Performance Implication

Types of sprayers used in the study area and their constraints are described in Table 2 and 3 respectively. All the farmers in the study area had used one sprayer or the other to apply pesticides to control pests and diseases of cocoa trees. Knapsack and hand-held (Trombone) were the most popular sprayers among farmers interviewed (Table2). The two types of sprayer were almost of equal importance to cocoa farmers in the study areas as 49.5% used knapsack while 50.5% adopted hand-held type, Trombone. These two sprayers were hydraulic types manually operated by hands. The knapsacks are pressurised through a hand lever while that of Trombone is through sliding by hand. Asogwa et al., (2009) reported Motorized Knapsack Sprayers among the sprayers they evaluated and recommended them for better pesticide application on cacao, and their availability in the market was also confirmed through our interaction with sprayer dealers in the course of this study. The motorized sprayers were not adopted by farmers in the study areas probably because of their relatively high cost, ranging between 55,000 to 70,000 Naira and maintenance requirement. Similar report was made by Asogwa and Dongo (2009) as they observed that its initial cost is relatively high, between \$1,000 – 1,250, operation requires sound technical knowhow and is not readily available in the local market. Oduwole (2001) identified financial constraint, poor techniques and inappropriate application equipment as major factors responsible for inefficient application of pesticides. However, motorized sprayers were reported to be more effective for reducing pest resistance in places such as Cameroon (Asogwa et al, 2009). They added that some of the sprayers adopted by cocoa farmers also did not possess some of the physical attributes such as extension lances.

Trombone to which 10 litres capacity tank was usually adopted was mostly preferred among farmers in Ondo State; the next is CP3 Knapsack which has 20 litre tank and the third being CP15 Knapsack with 15 litre container. The level of preference of brands of popularly used sprayers in the study areas was 44.2, 29.5 and 21.0 percent of total sprayers for Trombone, CP3 and CP15 respectively. It was also noted that Trombone was more preferred in Ondo than Oyo State. Preference of Trombone was due to its ability to produce liquid of high pressure that can reach reasonable height of cocoa tree according to our personal interaction with the farmers in the study area as compared to other sprayers and its relatively small liquid tank, though this will result in high number of loading per hectare and time wasting. Trombone is ideal for tree crop spraying and highly favoured among cocoa farmers for applying pesticides because of its relative lower cost of between \$50 - 58.3 (Asogwa and Dongo, 2009). Unfortunately, it cannot be used to apply herbicides effectively, they added. Trombone nozzle is not interchangeable, designed for pesticide application only, does not build up or retain pressure and require manual strength during operation (Asogwa *et al.*, 2009). Knapsack sprayers are used to apply any kind of pesticides and herbicides with nozzles being adjustable to provide fine droplets that can be controlled (Asogwa *et al.*, 2009) or interchangeable to obtain the desired pattern of spray (Asogwa and Dongo, 2009). According to Asogwa *et al.*, (2009) knapsack sprayers produced thrust satisfactory enough to give good canopy coverage of matured cocoa trees, failure to use appropriate cone/fan nozzles and extension lances would result in most of the trees not being adequately covered or targets missed. Anonymous, 2013 reported that High Volume spraying produced sprayers such as Trombone and Hydraulic Knapsacks is very common method of pesticide spraying, but he added that Low Volume and Ultra Low Volume are preferred for economic pest control. However, Asogwa *et al.*, (2009) reported that relative higher deposition of spray fluids on cocoa trees by the use of High Volume spraying compared with the use of Low Volume spraying by motorized mist blower in Ghana and fogging sprayers in the Cameroon accelerated the development of resistance in Nigeria. Nigar *et al.*, (2011) reported that Hollow cones and Flat Fan cones can be used in high, normal and Low Volume application. Hollow cone nozzle is very popular for spraying pesticides (Anonymous, 2013) while Nigar *et al.*, (2011) obtained highest pesticide deposit and best biological efficiency from flat fan nozzle.

It was observed that some of the sprayers used by cocoa farmers in the study areas did not have equal or the same optional parts/accessories, such as nozzles and lance extension, while some optional parts, especially nozzles such as impact nozzle, which came with most sprayers, are not suitable for pesticide spraying. This makes selection of these optional parts necessary and crucial, but Asogwa and Dongo (2009) noted that Nigerian cocoa farmers make wrong choice of optional parts due to lack of technical knowhow. It could, therefore, be said that farmers in the study are used the appropriate sprayers for pesticide application from the existing types, depending on financial capacity or affordability. The report of Asogwa *et al.*, (2009) agrees with this observation as it noted that pesticide application trials with Manual Hydraulic Knapsack, Trombone and Motorized sprayers showed no significant miridal effects or phytotoxicity on cocoa trees.

Although, significant percentage of 68.4 of the sprayers had been in use for 1-5 years and only 31.6% was used for over this period, reasonable percentage of 52.7 of the sprayers was in fair or bad status. This implies serious danger on the durability, effectiveness and efficient performance of spraying operation as well as the economic buoyancy of the farmers. The high percentage of relatively old and poor sprayers still used by farmers may not be unconnected with high cost of better quality ones, because most farmers would not go for sprayers beyond average cost between Three Thousand Naira (N3,000) and Ten Thousand Naira (N10,000) according to Table 2. Substantial percentage of farmers (76.8 %) indicated that some major parts of their sprayers had been changed. Although some of them agreed that the replacement was occasional, 56.8% claimed parts for this maintenance were expensive while 91.6% observed that the parts were readily available in the market. Frequent breakdown of sprayers and expensive spare parts (Table 3) implies a serious threat on performance of spraying operation and farmers' economy.

Other challenges faced by farmers in using these types of sprayers mentioned above as in Table 3 range from hand pains or muscle strain, back pains (usually knapsacks), blockage of nozzles and hoses, leakages in the flow line, frequent activation of pump and replacement of fragile parts. Inadequate optional parts to meet various spraying requirement, high cost of an average quality sprayers and frequent loading were also among the constraints complained by the farmers. All these suggest negative implications on efficient and effective performance of pesticide application, more so that some of the farmers handled above 8 hectares (Table1) with these sprayers of average capacity of 0.1 – 0.5Ha/day, according to Malik *et al*, 2012. More than Eighty-seven percent (87.4%)of farmers complained of blockage which usually occurred when powdered pesticide which was the common practice in Ondo state was used while 75.8 percent complained of leakages which was usually associated with faulty water seals, especially in Trombone. Hand pains (8.5%), frequent loading (13.5%) and frequent activation of pump (5.3%) were associated with Trombone than knapsack. Inadequate optional parts (31.5%), mostly lance extension, for effective and efficient spraying of cocoa trees was more common with knapsack sprayers. Trombone sprayers which produce sufficient pressure for spraying high trees like cocoa were relatively expensive with average cost around Ten Thousand Naira (N10,000).

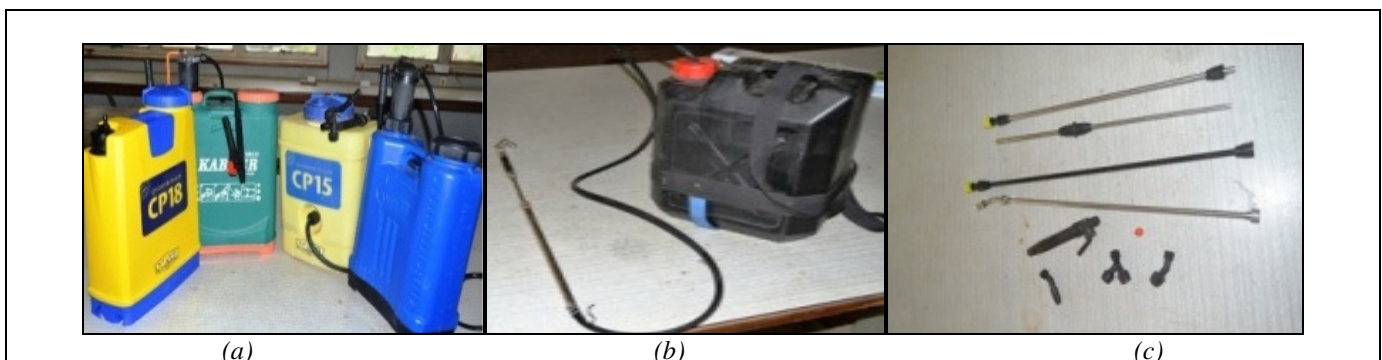


Figure 1: (a) Some Knapsack Sprayers adopted by Cocoa farmers (b) Trombone with adopted 5L tank  
(c) Some optional parts of Hydraulic Knapsacks

Notwithstanding very high percentage of farmers (91.6%) who claimed that there were readily available spare parts to maintain sprayers, a reasonable percentage of 56.8 complained that these parts are expensive. Asogwa *et al.* (2009) had reported that spare parts for Trombone and hydraulic Knapsack sprayers were available. However, Asogwa (2008) and Asogwa and Dongo (2009) identified lack of maintenance of pesticide application equipment as a result of lack of spare parts, due to unavailability and unavailability, and specialized mechanics to repair and maintain equipment as one of the problems of pesticide application in Nigeria. This could endanger proper and prompt maintenance of the sprayers which could indirectly lead to poor performance of the sprayers and bad application results.

All the afore-mentioned indicate that most of the sprayers used by cocoa farmers in the study area are not completely suitable for applying pesticides on cocoa trees as they are inadequate in one aspect or the other, such as lack of relevant optional parts, durability and ergonomics requirement. In effects, there is need to improve upon these sprayers or completely design a better suitable one that will specifically meet the spraying requirement, economy and comfort of cocoa farmers

Variable	Frequency	Percentage
<b>Types of sprayer</b>		
Knapsack	47	49.5
Hand-held	48	50.5
<b>Mode of operating sprayer</b>		
Manual	95	100
Motorized	-	-
<b>Sprayer brands</b>		
CP 3	28	29.5
CP 15	20	21.1
Amox NY	2	2.1
Jacto	2	2.1
Emilly	1	1.1
Trombone	42	44.2
<b>Liquid tank capacity (Litres)</b>		
20	28	29.5
16	5	6.3
15	20	21.1
10	42	44.2
<b>Length of use (Years)</b>		
1-5	65	68.4
6 - 10	16	16.8
11 - 15	8	8.5
16 – 20	6	6.3
<b>Status of sprayers</b>		
Very good	11	11.5
Good	34	35.8
Fair	45	47.4
Bad	5	5.3
<b>Discomfort experienced in operation</b>		
Back pains	33	34.7
Frequent loading	13	13.6
Tight strap	14	14.7
Hand pains	8	8.5
Blocked nozzle	2	2.1
Too hard to operate	5	5.3
Frequent breakdown	1	1.1
Nil	19	20.0
<b>Cost of sprayers (N0,000)</b>		
20 – 60	1	1.1
10 – 20	22	23.1
3 – 10	65	68.4
<3	7	7.4

Table 2: Sprayer type and Attributes

Source: Field Survey, 2015

Variable	Yes		Never		Occasionally		Always	
	Freq	%	Freq	%	Freq	%	Freq	%
Lance is long enough to reach targets required	56	58.9	39	41.1	54	56.8	2	2.1
Optional parts sufficient for purposes required	65	68.4	30	31.5	65	68.4	-	-
Does flow line blocks?	83	87.4	12	12.6	82	86.3	1	1.1
Have you replaced major parts of your sprayer?	73	76.8	22	23.2	70	73.7	3	3.1
Parts for maintenance are readily available	87	91.6	8	8.4	34	35.8	53	55.8
Does the flow line leaks?	72	75.8	23	24.2	72	75.8	-	-
Parts for maintenance are expensive	54	56.8	41	43.2	50	52.6	4	4.2
Does liquid come out of nozzle with high pressure without pumping frequently	11	11.6	84	88.4	11	11.6	-	-

Table 3: Sprayer constraints

Source: Field Survey, 2015

#### 4. Conclusion

It could be deduced from the result of this study that though, most cocoa farmers used the right sprayers for applying pesticides on cocoa trees, the sprayers are inadequate in one way or the other for spraying cocoa trees and may need to be improved upon to meet spraying requirements of an average Nigerian cocoa farmer. Most of the sprayers used for applying pesticides on cacao also poses serious challenges to ergonomics and economics of the farmers and may endanger their health. Some of these sprayers were made with many fragile parts which have negative implication on their durability, efficiency and effectiveness, and economy of the farmers. Generally, most cocoa farmers apparently use spraying equipment based on what are at their disposal without serious basic knowledge and recourse to guiding principles for effective and efficient application of pesticide for controlling pests and diseases. There were also many old farmers who are relatively beyond productive age. Some of them were neither member of Cocoa Association of Nigeria (CAN) nor Cooperative Societies. All these trends will directly affect their level of capacity building for increased cocoa production and access to genuine information on new techniques and technologies in cocoa production. The result of this study will add to the body of existing literature on the use of sprayers by cocoa farmers in Nigeria which can enlighten them on requirement of appropriate sprayers to apply pesticides on cacao. It will also engender the improvement of existing sprayers or design and production of indigenous quality one for effective and safe control of insect pests and diseases of cocoa.

#### 5. Recommendations

With the prominence of cocoa production in the economy of Nigeria and its potentials in the current dwindling economic situation, it should be highly desired to improve or design sprayers that will be more suitable for spraying cocoa trees which will be within the economic capacity of an average Nigerian Cocoa Farmer. Such sprayer design should also consider ergonomic and health of farmers in addition to possessing adequate optional parts or accessories to meet various spraying requirements of cocoa farmers for effective and efficient pesticide application and other agricultural spraying needs such as herbicides application for better spread of purchasing and running costs. More literate and energetic youths should be encouraged to go into cocoa production by providing an enabling environment that will increase and stabilise cocoa production. This will also encourage easy transfer and better understanding of new innovations and techniques. Capacity building of cocoa farmers for suitable sprayers and appropriate knowledge acquisition should be taken more seriously by relevant Ministry, Departments and agencies (MDAs). Agricultural inputs for cocoa production including sprayers should also be subsidized to reduce cost to encourage acquisition. Farmers should be encouraged to increase their farm size probably through provision of incentives. The aspect of information dissemination is also very vital. This could be improved by establishing Liaison Offices in different zones of major cocoa producing areas of the country where seminars, workshops and on-farm demonstrations could be organised on the choice of sprayers and pesticide application techniques. Better spraying results may be achieved by establishing demonstration plots around farmers' farm where convenient sizeable number of them could be personally contacted. Current information on sprayers, pesticide and other vital agricultural inputs affecting cocoa production should be promptly and periodically made available at farmers' groups for easy access. The Extension Officers should ensure that required information about pesticides and sprayers are disseminated to cocoa farmers promptly. Periodic survey, evaluation and recommendation of agricultural sprayers should be carried out by relevant departments of Cocoa Research Institute of Nigeria (CRIN), Ibadan to ensure cocoa farmers adopt the right sprayers for effective pesticide application and safety of users.

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