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Evaluation of different sprayers used for the protection of cocoa farms in Nigeria

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ABSTRACT: A comprehensive laboratory and field evaluation of 12 hydraulic knapsack sprayers, 1 motorized knapsack sprayer and 4 trombone sprayers were carried out to determine their effectiveness as pesticide application equipment for the control of cocoa pests. The evaluations were carried out at the Cocoa Research Institute of Nigeria, Headquarters, Ibadan between 2003 and 2008. The inbuilt tank capacities for the Hydraulic and Motorised Knapsack (H & M K) sprayers are of various sizes ranging from 10L, 15L, and 16L to 20Litres, respectively. The trombone sprayers do not have a tank and its hose is usually fitted into an improvised 5L or 10L plastic keg/bucket. The total number of cocoa trees covered by the H & M K, and trombones sprayers ranged from 35 to 42 trees per 9 litres of the spray mixture. The Pulmic, Rosy and Osatu gave the highest horizontal thrust of 11.5m, 10.9m and 9.8m, respectively, while a vertical thrust of 7.5m, 7m, 6m and 5.9m, respectively were recorded for Matabi, Pulmic, Rosy and Osatu. The motorized knapsack sprayer gave a lower horizontal thrust of 3m and a vertical thrust of 7m. Osatu, Neptune, Kizan, Pulmic and Jacto each gave a discharge rate of 680mls, 650mls, 650mls, 610mls and 600mls per minute, respectively. However, considering the number of strokes required to build up pressure, Pulmic, Kizan, Titan, Jacto and Neptune gave a discharge rate per stroke of 101.67mls, 92.86mls, 80.83mls, 77mls and 72.22mls respectively. The motorised knapsack sprayer, which is machine powered gave the highest discharge of 1,140mls spray mixture per minute. New spraying equipment were screened regularly at CRIN and those found suitable were recommended for use by cocoa farmers.

Key words: Knapsack, trombone, motorised, pesticides, resistant, biotypes, pollution.

Introduction

Cocoa is an important cash crop in Nigeria, which had before the advent of the oil boom contributed tremendously to the infrastructural development of Nigeria. Nigerian cocoa farmers use a wide range of pesticides to limit losses from insect pests and diseases. The most commonly used pesticides include: cuprous oxide and Copper Hydroxide (fungicides popular for the control of the black pod disease); Chlorpyrifos and Thiamethoxam (insecticides effective for control of cocoa mirids) (Asogwa and Dongo, 2009).

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Pesticide use is associated with risk and can be hazardous if not handled properly. Cocoa farmers using these pesticides (containing different active ingredients) face constant exposure to these pesticides (Fajewonyomi, 1995). Human exposure to pesticides usually results in serious health problems such as epilepsy, stroke, respiratory disorders, cancer, leukemia, brain tumors and in some cases death (Takagi *et al.*, 1997). The environmental impact of pesticides manifests in the disturbance of the ecosystem, principally in the form of water pollution (ground water, river water, drinking water) soil and air pollution, reduction of fish and wildlife populations and destruction of natural vegetation (Pitmentel *et al.*, 1980; Takagi *et al.*, 1997). The technical state of the equipment used for the application of pesticides to a large extent determines their safety and effectiveness. In most cases pesticides are applied using either a nozzle or spinning disc to disperse the spraying liquid into a spraying cloud of small droplets (Meijden, 1998). Knapsack sprayers are used to apply any kind of pesticide (mostly insecticides, followed by fungicides and herbicides), usually with water volumes ranging from 100 to 400L/ha. Most likely because of the costs involved, a sprayer is more often used on cash crops such as cocoa, maize and cotton and also on garden crops and to a lesser extent on the staple food crops (Meijden, 1998).

Cocoa Research Institute of Nigeria has over the years tested and recommended sprayers for use on cocoa production in Nigeria. The importance of testing of new sprayers cannot be overemphasized. It leads to recommendations of more effective and safer application equipment adapted to our agricultural systems. 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 and emergence of new pest biotypes and pest outbreak. In a continuous effort to combat the resistance problems, new insecticides and spraying equipment were screened regularly at CRIN and those found suitable were recommended for cocoa growers (Omole *et al.*, 1977; Nwana *et al.*, 1983; Idowu, 1987; 1989).

The wrong use of these application equipment for pesticide application in cocoa production has attracted a global concern about the impact of these pesticides on public health with respect to pesticide residues on cocoa and its products. This has therefore necessitated the continuous evaluation of these sprayers with a view to recommending appropriate ones for the protection of cocoa farms in Nigeria.

Materials and Methods

The various spraying equipment (hydraulic knapsack sprayers (12), trombone sprayers (4) and motorised knapsack sprayer (1) submitted to the Cocoa Research Institute of Nigeria for screening by Representatives of the various local manufacturers between 2003 and 2008, were assessed for their spraying effectiveness on cocoa trees. Their physical attributes ranging from tank height, width, length and weight, length of lance, length of lance with extension, length of hose, length of strap, diameter of tank opening, length of pump handle, vertical and horizontal thrust and width of discharge were assessed. The efficiency of their nozzles, their rate of discharge per minute, including their vertical and horizontal thrusts was also assessed according to standard recommendations (Clayphon, 1971; Mathew, 1973; 1975; COPR; 1975; Mathew *et al.*, 1969). The number of mature cocoa trees covered with 9-litre spray mixture by each pump was also recorded.

Results

Table 1 shows the list of sprayers tested and recommended between 2003 and 2008 for use on cocoa farms in Nigeria. A total of seventeen (17) sprayers, (12 hydraulic knapsack sprayers, 4 trombone sprayers and 1 motorised knapsack sprayer) were tested within the period at the Cocoa Research Institute of Nigeria, Ibadan. The following specifications were observed for the various sprayers:

Tank container: The tank container of the Hydraulic and Motorised Knapsack (H & M K) sprayers were made of propylene material, with a wide range of colours varying from sprayer to sprayer (Table 2). Graduation marks were usually molded into one side of all the tanks to provide accurate assessment of the level of spray liquid. The tanks of all the hydraulic sprayers are usually fitted with mechanical agitator. The

trombone sprayers do not have a tank and its hose is usually fitted into an improvised 5L or 10L plastic keg/bucket, which serves as its tank (Table 5).

Working capacity: The inbuilt tank capacities for the H & M K sprayers are of various sizes ranging from 10L, 15L, and 16L to 20Litres, respectively (Table 2). The trombone sprayers do not have a tank and its hose is usually fitted into an improvised 5L or 10L plastic keg/bucket, which serves as its tank.

Sprayer lance: The sprayer lance of the hydraulic knapsack sprayer is made of a fibre material ranging from 52cm to 82cm. Some of the pumps (Pulmic, Neptune, Titan (HD) and Garden 15) consist of two detachable telescopic components (Table 3). The length of the lance can easily be adjusted by moving the two components to give better canopy coverage. A lance holder is fitted to the body of the connecting lever rod for holding the lance. The trombones have a shorter lance, which does not usually have a telescopic component, while the motorised knapsack does not have a lance but discharges its content through a robust plastic or sometimes corrugated pipe of between 1cm to 2cm in diameter.

Nozzle: The nozzle of the hydraulic knapsack sprayer attached to the trigger is cone-shaped and has interchangeable discs for different pesticide (insecticide, fungicide, and herbicide) spray mixtures. The nozzle is also adjustable to provide long thrust of spray chemicals to treetops. The nozzle of the motorized knapsack sprayer provides fine spray droplets that could be controlled and adjusted by gear handles attached to the left base of the machine. The nozzle of the trombone sprayers is not interchangeable; hence it cannot be used to apply herbicides. It does not also build up nor retain pressure during spray exercise; therefore a lot of manual strength is required while spraying pesticides in cocoa farms with trombone sprayers.

Carrying harness: The straps of the H & M K sprayers are broad (3cm to 4cm), fully adjustable and made of reinforced plastic (Tables 3 & 4). Each strap has a clip, which can easily be attached to a hook located at the base of the tank. The considerable length of the straps (78.5cm to 242cm), their flexible nature and smooth body make for easy handling and cleaning (Tables 3 & 4). However, the straps of most of the hydraulic sprayers are reversible either for right or left-handed persons, by changing the position of the strap. The trombone sprayers do not have straps attached to them, but to their improvised tank (keg/bucket), which makes for their easy handling too.

Weight: The trombone sprayers are very light and easy to manipulate, followed by the hydraulic knapsack sprayers, while the motorized knapsack sprayer is heavy to carry.

Tree coverage: The total number of cocoa trees coverage for the various sprayers (H & M K, and Trombones) ranged from 35 to 42 trees per 9 litres of the spray mixture (Tables 2 & 4). This conforms to the standard for knapsack sprayer for cocoa, which is 40 trees per 9 litres of spray mixture. This level of coverage makes the sprayer adequately economical for cocoa farm operations.

Thrust: The nozzle of the hydraulic knapsack and trombone sprayers when adjusted produced horizontal thrusts ranging between 6.7m and 11.5m and a vertical thrust of between 4m and 7.5m (Table 3 & 5). Pulmic, Rosy and Osatu gave the highest horizontal thrust of 11.5m, 10.9m and 9.8m, respectively, while a vertical thrust of 7.5m, 7m, 6m and 5.9m, respectively were recorded for Matabi, Pulmic, Rosy and Osatu (Table 3 & 5). The reverse was the case for the motorized knapsack sprayer with a lower horizontal thrust of 3m and a higher vertical thrust of 7m (Table 4). The thrust recorded for each of the knapsack sprayers was satisfactory enough to give good canopy coverage of mature cocoa tree plantations.

Discharge rate: The hydraulic spray pumps performed well in terms of their discharge rates per minute ranging between 360mls to 680mls per minute. However, Osatu, Neptune, Kizan, Pulmic and Jacto each gave a discharge rate of 680mls, 650mls, 650mls, 610mls and 600mls per minute respectively (Table 2). But, considering the number of strokes required to build up pressure for each of the hydraulic sprayers, Pulmic, Kizan, Titan, Jacto and Neptune gave a discharge rate per stroke of 101.67mls, 92.86mls, 80.83mls, 77mls and 72.22mls, respectively (Table 2). The motorised knapsack, which is machine powered does not need manual strokes to build up pressure and gave the highest discharge of 1,140mls spray materials per minute (Table 4).

Table 1: List of Sprayers tested and recommended for use on cocoa farms in Nigeria between 2003 and 2008

S/No	Name	Manufacturer/Local company Representative
Hydraulic knapsack sprayers		
1.	Pulmic PM 120:	Sanz hnos of Spain/The Candel Company, Nigeria.
2.	Jacto PJ – 16:	Maquinas Agricolas Jacto S.A./Dizengoff Company Ltd Nigeria.
3.	Rosy 16:	Di Martino, Italy/Saro Agro Science, Nigeria.
4.	Solo:	Solo Sprayers Ltd., England/Harvest Field Industries Ltd., Nigeria.
5.	Neptune 15:	Kwazar Corporation S.C., Jaktorow, Poland/Lajibam Auto & Agric Concerns Ltd., Nigeria.
6.	Osatu:	Goizper S. Coop, Spain/Adewale Oladayo Trading Stores Ltd., Nigeria
7.	CP 15:	Hardi International A/S of Denmark/Nunees Nigeria Limited.
8.	Kizan KJ – 16:	Indo German Agril Sprayer/African Agro Co Ltd., Nigeria.
9.	Volpi 78:	Davide Luigi Volpi S.P.A. Italy/Jubaili Agrotec Ltd., Nigeria.
10.	Titan heavy duty:	Marolex SP Zo. O Poland/Komes Ventures Ltd., Nigeria.
11.	Mob:	MOB Company UK/Harvest Field Industries Ltd., Nigeria.
12.	Garden 15:	Di Martino S.P.A Italy & Fem-Fun Nigeria Ltd/Timmy Fak General Works Ltd
Motorized knapsack sprayer		
13.	ANVL/Tornado WFB 18:	Agro Nigerian Ventures Ltd/ Lajibam Auto Agric Concerns Limited
Trombone sprayers		
14.	Solo 28 MKI:	Solo Sprayers Limited/ Adewale Oladayo Trading Store Ltd., Nigeria.
15.	Matabi Trombone:	Matabi Spain/Insis Crop Care Nigeria.
16.	Hudson trombone 61224	HD Hudson Asia Limited/ Harvest Field Industries Ltd., Nigeria.
17.	Hudson trombone 612219	HD Hudson Asia Limited/ Harvest Field Industries Ltd., Nigeria.

Table 2: Features, specifications and performance of various hydraulic knapsack sprayers evaluated for protection of cocoa at the Cocoa Research Institute of Nigeria (2003 to 2008)

Sprayer*	Colour	Capacity (L)	Tree coverage (L)	Weight (kg)	No of strokes	Discharge/Min (mls)	Discharge/Stroke (mls)
Mob	Yellow	16	38	3.4	6	380	63.33
Volpi	Orange	16	36	3.8	9	465	51.67
CP 15	Yellow	15	37	4.3	11	400	36.36
Jacto	Blue	16	37	4.8	8	600	77
Kizan	Blue	16	35	4.8	7	650	92.86
Neptune	Red	15	35	4.2	9	650	72.22
Osatu	Red	16	35	3.3	10	680	68
Pulmic	Red	20	42	3.9	6	610	101.67
Rosy	Green	16	38	3.2	7	380	54.2
Solo	Yellow	16	35	3.6	11	365	33.18
Titan (HD)	Yellow	16	36	4.3	6	485	80.83
Garden 15	Green	15	38	2.5	13	460	35.38

*Each value represents a mean of 3 pump measurements

Table 3: Measurements and spray capabilities knapsack sprayers evaluated for protection of cocoa at the Cocoa Research Institute of Nigeria (2003 to 2008)

Attributes	Mob	Volpi	C.P	Jacto	Kizan	Neptune	Osatu	Pulmic	Rosy	Solo	Titan	G.15
Tank height (cm)	43*	43	39	44	51	50	46	42	52	46	56	51
Tank length (top)(cm)	35	34	32	33	31	34.5	36	34	35	34	37	31
Tank length (base) (cm)	35	19	32	33	31	31	36	34	35	34	29	31
Tank width (top) (cm)	16	17	19	15	14	18.5	15	19.5	15	15	15	16
Tank width (base) (cm)	13	17	17	15	14	15	17.5	21.5	15	15	14	15
Length of lance + trigger(cm)	64	77	52	52	66	77	76	75	74	70	82	58.1
Length of lance (cm) + extension	0	0	0	0	0	140	0	120	0	0	128	97.2
Length of hose (cm)	112	119	144	132	110	150	126	124	124	131	132	119
Length of strap (cm)	204	78.5	175	84	98	145	91	92	104	95	242	120
Width of strap (cm)	3.5	4	3	3	3.7	3.8	4	3.8	3	4	3.7	3
Diameter of tank opening (cm)	13	14	14.5	13	11.5	12.5	13.5	14	12	13	11	10
Length of pump handle (cm)	46	48.5	44	50	48	58	54	52	46	51.5	50	51
Thrust (m) (horizontal)	8	9	9	8	8.3	8.5	9.8	11.5	10.9	8.5	8.1	7
Thrust (m) (vertical)	5.7	4.4	6	5	4.7	4	5.9	7	6	6	5	4.9
Width of discharge (Swath) (cm)	33	41	60	45	39	60	77	56	55	48	60	28

*Each value represents a mean of 3 pump measurements

Table 4: Attributes of ANVL/ TORNADO WFB 18AC motorised knapsack sprayer

Pump attributes	Dimensions*
Height of sprayer	68.5cm
Height of pesticide tank	15.5cm
Length of pesticide tank (top)	40cm
Length of pesticide tank (base)	24cm
Width of pesticide tank (top)	21.5cm
Width of pesticide tank (base)	12.5cm
Height of fuel tank	9.5cm
Length of fuel tank (top)	27.5cm
Length of fuel tank (base)	22.3cm
Width of fuel tank (top)	5cm
Width of fuel tank (base)	8.5cm
Length of strap	96.5cm
Width of strap	3.8cm
Diameter of pesticide tank opening	12.5cm
Diameter of fuel tank opening	3.6cm
Thrust (horizontal)	3.0m
Thrust (vertical)	7.0m
Weight empty	11.7kg
Total tank capacity	10 litres
Length of charging pipe	29cm
Length of pipe	48.7cm
Length of hose	36cm
Length of nozzle	14.6cm
Rate of discharge per minute	1,140mls
Width of discharge (Swath)	128cm
Tree coverage (9L)	36

*Each value represents a mean of 3 pump measurements

Table 5: Attributes of trombone sprayers

Pump attributes	Sprayers and dimensions*			
	Matabi	Mki 28	Hudson 61224	Hudson 61219
Length of lance (cm)	53	45	54	47
Length of lance (extended) (cm)	78	-	89.2	68
Length of outer tube (cm)	-	36	42.3	32
Diameter of outer tube (cm)	-	-	2	0.8
Length of inner tube (cm)	-	42	35.4	22
Diameter of inner tube (cm)	-	-	1.4	0.3
Length of nozzle (cm)	-	-	1.8	2
Width of nozzle (cm)	-	-	0.7	0.7
Length of hose (cm)	150	244	183	183.5
Support lever distance (minimum) (cm)	-	-	16.3	-
Support lever distance (maximum) (cm)	-	-	52	-
Thrust (horizontal) (m)	7.8	6.7	8.0	7.8
Thrust (vertical) (m)	7.5	4.2	4.6	4.4
Width of discharge (Swath) (cm)	48	35	30	30
Weight (g)	0.36	0.65	900	400
No of trees covered/9L spray mixture	38	35	37	35

*Each value represents a mean of 3 pump measurements

Availability of spare parts and maintenance: The spare parts of the hydraulic knapsack and trombone sprayers are readily available and the sprayers do not require any special tools for their maintenance, unlike the motorised knapsack sprayer that requires special tools and technical know-how for its maintenance.

Discussion

Poor insecticide coverage resulting from the use of inefficient application equipment, wrong timing, irregularity and wrong technique of spraying are capable of accelerating the rate at which insects develop resistance to pesticides. Hence, along with the screening of new insecticides, fungicides and herbicides, new spraying pumps are usually evaluated by the Cocoa Research Institute of Nigeria, for their efficiency before they are recommended for use in the application of cocoa pesticides. 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 swing fogging method was established as the quickest method of applying miricides in large cacao farms and was capable of covering in one hour about 30 to 50 times of the area which the mistblower and the pneumatic knapsack pumps, respectively, would cover within the same period (Idowu, 1985; 1989; Idowu and Olunloyo, 1984). However the major constraints to the adoption of the fogging technique are the initial high cost out-lay (e.g. high cost of the machine) inadequate technical expertise to train, organize and supervise cocoa fogging and especially due to the fact that most (90%) cocoa farms in Nigeria are owned by peasant farmers with small holdings (1-2 ha) having nearby farm settlements and animals (Omole and Ojo, 1981).

The intensive use of organochlorides and Lindane-based insecticides for mirid control in Nigeria in the 1960s resulted in the development of resistance by the mirids, thereby rendering the insecticides ineffective (Entwistle, 1964; Gerard, 1967; Booker, 1969; Youdeowei, 1971; 1974; Omole *et al.*, 1977). The development of resistance to these insecticides by the pests according to Idowu (1989) may be attributed to the following reasons:

1. Inadequate coverage of cocoa trees during blanket spraying, which could be as a result of using poor spray equipment or irrational selection of trees within the plantation.
2. Application of sub-lethal dosages of the pesticide. This could be as a result of use of un-recommended pesticide or adulterated/expired pesticides or complete disregard by farmers for CRIN recommendations for pesticide application.

Majority of the Nigerian cocoa farmers still make use of substandard and inappropriate spraying pumps such as the 'Lancet'. The 'Lancet spraying pumps' despite its popularity among cocoa farmers (because of its relative low cost and ease of operation and maintenance) was not approved because it does not give adequate spray coverage. Its use has also been found to result in considerable wastage of insecticides during spraying (Idowu, 1989). However, even in cases where they use recommended pumps, little attention was paid to the use of appropriate (cone/fan) jets and extension lances. Most of the trees are not covered adequately by the pesticides, the target pests are missed or partially attacked, resulting in the gradual emergence of resistant strains (Idowu, 1989). The relatively higher deposition of spray fluids on cacao trees by the use mainly, of high volume spraying with the pneumatic knapsack sprayer in Nigeria, as compared with the use of low-volume spraying with motorized mist blower in Ghana, and with fogging sprayers (insecticide/oil smoke) in the Cameroon, accelerated the development of resistance in Nigeria (Collingwood, 1976).

Finally, due to the fact that pesticide application trials with the various equipment showed no significant miricidal effects or phytotoxicity on the cocoa tree, it is recommended that the various sprayers could be used by cocoa farmers for application of pesticides for routine protection of cocoa farms in Nigeria depending on the availability and the farmers' capability to afford them.

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