Original Research Article

Logistic Regression Analysis of Applicators' Compliance with the Recommended Doses of Pesticides on Watermelon in Yobe State, Nigeria

ABSTRACT

The study investigated applicators' compliance with the recommended doses of pesticides on watermelon in Yobe State, Nigeria. A multi-stage sampling procedure was adopted to select one hundred and seventy-three (173) respondents for the study. Primary data were collected using a structured questionnaire. Data were collected on socio-economic characteristics, training in pesticide application, awareness of hazards associated with pesticides, access to information on hazards associated with pesticides and compliance with recommended doses of pesticides. The results revealed that the mean age of the respondents was 43.19, 97.7% were married 73.4% did not have English language reading ability. Training in application of pesticides (0.18), awareness of hazards associated with pesticides (0.28) and access to information (0.43) were low. Most (91.9%) respondents did not comply with the recommended doses of pesticides. Awareness of hazards (B= 2.74, p = 0.01) and access to information (B= 1.45, p = 0.08) significantly influenced compliance with the recommended doses of pesticides. Stakeholders in the agriculture and food sectors should plan and implement schemes to train, inform and boost awareness of the pesticide applicators on hazards associated with pesticides to motivate compliance with recommended doses of pesticides, produce safe watermelon and sustain a healthy environment.

Keywords: Logistic regression, applicators' compliance, pesticides, recommended doses

1. INTRODUCTION

Watermelon (*Citrulus lanatus)* refers to the fruit and vine like plant of climbing and trailing herbs of the family Curcubitaceae [1]. It originated in tropical areas of Africa near Kalahari Desert [2], now widely cultivated and consumed in Nigeria. The fruit has a thick rind and fleshy center that possesses attractive colour, high water content and sweet combination of sucrose, glucose and fructose [3, 4]. Watermelon is rich in vitamins B, C, and E; minerals such as phosphorus, magnesium, calcium, and iron, as well as antioxidants, which naturally boost and sustain human health [3, 5]. Economically, it is a major income earner for the farmers as there is wide acceptance and consumption of the fruit as thirst-quenching summer snack throughout the country [6]. The highest production of watermelon occurs in the drier Savannah agro-ecology of the northern region of Nigeria [6].

The success of watermelon farming partially lies in farmers' capacity to manage and control pests. Watermelon attracts destructive insects that bring losses to farmers, except they are controlled. There would be 78% loss in fruit production without the use of pesticides [7]. According to [1] the watermelon farmers use pesticides to control pests on their farms. The motivating factor for using pesticides is to reduce crop losses and increase yields [8, 9]. Pest refers to any animal or plant which harms or causes damage to man, his animals, crops, or possession. Agricultural pests include insects, mites, plant pathogens, and weeds [10]. According to [11], pesticide is any substance, or mixture of substances of chemical or biological ingredients intended for repelling, destroying or controlling any pest. Pesticides therefore include insecticides (bug killers), herbicides (weed killers), and fungicides (fungus killers), rodenticides (rat killers) and antimicrobials [10].

The use of pesticides among farmers is ubiquitous worldwide [8]. In Nigeria, farmers rely heavily on pesticides for the control of pests [12, 13]. However, pesticide misuse has acute or chronic hazardous effects on human health [10]. About 3 million farmers suffer from severe pesticide poisoning while about 25 million suffer from mild pesticide poisoning, leading to 180, 000 deaths annually in developing countries [14]. The use of lindane, a banned pesticide, on fruit and vegetable crops over a prolonged period of time affect the nervous system, liver, kidney and may even induce cancer [15].

In Nigeria, food produce contain pesticide residues [8], many of which were reported for their adverse impacts and deaths [10, 16, 8] and there is no legal duty to monitor them [17]. A study conducted in Gashua, Bade Local Government of Yobe State in Nigeria on assessment of organophosphorus and pyrethroid pesticide residues in watermelon and soil samples established the presence of alarming levels of pesticide residues much higher than maximum residue limits (MRLs) and acceptable daily intake values (ADIs) for vegetables and soil set by the European Union (EU) [1]. Furthermore, [18] in their study on the assessment of pesticide residue levels in common fruits consumed in Lagos State, Nigeria, further affirmed that watermelon exceptionally had residues of atrazine, clothianidin, omethoate and oxamyloxime above WHO/FAO MRLs. It is not only farmers' health that may be endangered but also the health of the consumers of watermelon. The rising cases of ailments and deaths of consumers of agricultural produce linked to the use of pesticides on the farms bring to the fore the germane issue of compliance with the manufacturers' recommended doses of pesticides on watermelon farms in the study.

Misuse of pesticides has been linked to lack of adequate information, lack of knowledge and awareness of hazards associated with misuse of pesticides, lack of training on correct handling of pesticides, low education level of the rural populace, poor application technology, and weak legal provision [10, 17]. The study is a sequel to the finding of [1] on the presence of pesticide residues in watermelon in Bade Local Government Area of Yobe State. The current study made attempt to ascertain the determinants of compliance of applicators with the recommended doses of pesticides in Yobe State. Specifically, the study aimed to identify the socio-economic characteristics of pesticides applicators, ascertain whether or not they had training on appropriate use of pesticides, examine the applicators' level of awareness of hazards associated with pesticides, identify the level of access to information on hazards associated with pesticides, and ascertain compliance of applicators with the recommended doses of pesticides.

2. METHODOLOGY

The study was carried out in Yobe State in the Northeast of Nigeria. The State is bounded on the North by Niger Republic and on the East by Borno State. Also, it borders Gombe State to the Southwest, Bauchi to the West and Jigawa State to the Northwest. Its vegetation is predominantly Sudan Savannah with a fringe of Sahel Savannah in the far North. Yobe land consists of plain drained seasonally by Komadugu River and its tributaries in the North and by the Gongola River in the South. It is situated within latitudes 11° 45′ N and 13° 30′ N and longitudes 9° 30′ E and 12° 30′ E, with a total land area of 47,153 square kilometers [19]. The State experiences between 120 to 140 days of rainfall annually ranging between 500 mm to 1000 mm from north to south. Between December and February is the harmattan period, which is characterized by dry, cold and dusty wind. The hottest period in a year is between March and early June with temperature recording over 40°C [19]. The State's projected population was 3, 924, 186 in 2021 using a population growth rate of 3.56% from population of 2, 321, 339 in 2006 [20].

The population of the study comprised all pesticide applicators (farmers or farm workers) in watermelon farms in Yobe State. Yobe State Agricultural development Project (ADP) has two zones; namely Zone 1 and Zone 2. The Local Government Areas (LGAs) in Zone 1 are Bade, Jakusko, Karasuwa, Nguru, Machina, Bursari, Gaidam, Yusufari and Yunusari while Zone 2 comprises Fika, Nangere, Damaturu, Tarmuwa, Gujba, Gulani Fune and Potiskum LGAs.

A descriptive survey research design was adopted in the study. A multi-stage sampling procedure was used to select the sample for the study. First stage involved purposive sampling of zone 1 because of the presence of high number of watermelon farmers. Second stage involved a purposive sampling of four (4) LGAs from the zone; the selected LGAs were Bursari, Geidam, Jakusko and Yusufari based on high concentration of watermelon farmers. The third stage was a simple random sampling of six (6), four (4), two (2) and four (4) wards from Bursari, Geidam, Jakusko and Yusufari respectively. The list of applicators was generated in a reconnaissance survey of the study areas in collaboration with four enumerators. A total of one hundred and seventy three (173) respondents were finally selected for the study as shown in Table 1 below.

Table 1: Sampling procedure and sample size

LGAs	Wards	Sample size
BURSARI	JAWA/GARUNDO	02
	GUBA/DAPSO	15
	GUJI/METILARI	08
	DAPCHI	03
	DANANI/LAWANTI	10
	BAYAMARI/DAMAYA	15
GEIDAM	JORORO	11
	MA’ANNA	11
	ASHEIKRI	11
	BALLE	22
JAKUSKO	GIRGIR BA’YAM	13
	JAWUR KATAMMA	19
YUNUSARI	KACHALLARI	10
	BANDERI	10
	YUSUFARI	09
	ALAJIRI	04
4 LGAs	**16 WARDs**	**173**

A structured questionnaire was used to collect primary data. The dependent variable of the study is compliance with the recommended doses of pesticides, which was measured by asking the respondents to tick how they determine the doses of pesticides to add to water in 16litre capacity Knapsack. If they were guided by using label information to determine the quantity, the score is 1, otherwise the score is 0. Independent variables include socio-economic characteristics, training on pesticide handling and use, awareness of hazards associated with pesticides, and access to information on hazards associated with pesticides. Training on pesticides was measured by asking the respondents to indicate whether or not they had training on pesticide handling and use. There were five items with 'Yes' and 'No' responses, which were scored '1' and '0' respectively. The total score is the training index for each respondent. If the estimated mean is greater than 0.5, it implies that training is high and otherwise low. Awareness of hazards associated with pesticides was measured by asking the respondents to indicate whether or not they were aware of different hazards associated with pesticides. There were five items with 'Yes' and 'No' responses, which were scored '1' and '0' respectively. The total is the awareness index for each respondent. If the estimated mean is greater than 0.5, it implies that awareness is high and otherwise low. Access to information on hazards associated with pesticides was measured by asking the respondents to indicate the extent to which they had access to information from different media and sources using a three-point rating scale of 'Always', 'Occasionally' and 'Never' which attracted 2,1, and 0 respectively. The total score is the access index for each respondent. If the estimated mean is greater than 1.0, it implies that access is high and otherwise low. Data were analysed with both descriptive (percentages, frequency counts and means) and inferential statistics (Logit Regression Analysis) using IBM SPSS Statistics version 25. The definitions of variables and logit model are given in Table 2 below:

Table 2: Definitions of variables

Variable	**Definition**	**Sign**
Dependent variable	Dummy	
Y	Compliance = 1, Non-compliance =0	+/-
Independent variables		
Age	Continuous, age (year)	+/-
Education level	Continuous, the number of years of formal education	+
English language reading ability	Dummy, can read =1, cannot read =0	+
Hausa language reading ability	Dummy, can read =1, cannot read =0	+
Household size	Continuous, number of people living and eating from the same pot	+
Experience in pesticide application	Continuous, number of years of application of pesticides	+

Primary occupation	Dummy, farming =1, others =0	+/-
Estimated annual income	Continuous, income from farming in Naira	+
Training in pesticide application	Continuous, training index	+
Awareness of hazards associated with pesticides	Continuous, awareness index	+
Access to information on hazards associated with pesticides	Continuous, access index	+

Binary logit model was used to determine factors affecting compliance of applicators with pesticides doses recommendation. The study assumed that the probability of applicators' compliance with recommended doses of pesticides is influenced by their socio-economic characteristics, cognitive and institutional factors:

Binary logistic regression model of compliance

$$\frac{Pi}{(1-Pi)} = \alpha + \beta \text{Ln} Age + \beta \text{Ln} Edu + \beta A \text{Ln} Engrabl + \beta \text{Ln} Haurabl + \\ + \beta \text{Ln} Houssiz + \beta \text{Ln} \text{E}xp + \beta \text{Ln} Priocc + \beta \text{Ln} Anninc + \beta \text{Ln} Trnpesa + \beta \text{Ln} Awahaz \\ + \beta \text{Ln} Accinf$$

Where:

Ln Y= Compliance of applicators (1=Compliance, 0=Non-compliance

α = Constant

βi = Regression coefficient (I =1, 2, 3,……,11)

LnAge = Age (years)

LnEdu = Education (years)

LnEngrabl = English reading ability (Can read=1, Cannot read=0)

LnHaurabl = Hausa reading ability (Can read=1, Cannot read=0)

LnHoussiz = Household size (number of people living together)

LnExp = Experience (years)

LnPriocc = Primary occupation (Farming =1, otherwise =0)

LnAnninc = Annual income (₦aira)

LnTrnpesa = Training in pesticide application (index)

LnAwahaz =Awareness of hazards (index)

LnAccinf = Access to information (index)

3. RESULTS AND DISCUSSION

3.1 Socio-economic Characteristics of the Respondents

The results in Table 3 reveal that 27.8% of the respondents were within the age bracket of 31-40 years while 41.0% were within the age bracket of 41-50 years. The mean age was 43.19. The results imply that most respondents were young and active applicators. The finding is similar to the finding reported by [6] on watermelon farmers being within active and productive age brackets. Table 3 further reveals that all (100%) the respondents were males. Therefore, watermelon production and application of pesticides was an exclusive male business. Most (56.1%) of the respondents did not have formal education. Only 17.3% and 22.5% had primary and secondary education respectively. The finding corroborates the finding reported by [6] that majority of watermelon farmers were not educated. Lack of formal education impedes farmers' ability to read and write and make critical decisions in their productive activities. Also, Table 3 reveals that 73.4% of the respondents did not have English Language reading ability despite the fact that pesticide labels were printed in English. Also, 49.7% could not read Hausa Language materials. Inability to read pesticide labels implies that most respondents are predisposed to misapply pesticides on their farms. Furthermore, most (97.7%) of the respondents were married. The result implies that they had to shoulder family responsibilities, which places high demand on them to boost watermelon production and earn high income. The finding is corroborated by the finding of [21] that most watermelon farmers were married. Table 3 also shows that 53.2% of the respondents had 1-10 years of experience in pesticide application. The mean year of experience was 9.96. The result implies that the respondents had a substantial level of experience in pesticide application. Also, Table 3 reveals that the primary occupation of 96.5% of the respondents was farming. It implies that farming was the predominant livelihood of the respondents in the area. Furthermore, the estimated annual income of the respondents from farming fell within ₦350,000.0 and ₦1, 350,000.0. The mean annual income was ₦1,550,058.8. The finding implies that farming generated a modest income for the respondents.

Table 3: Socio-economic characteristic of the respondents

Variable	Percentage (n=173)	Mean	Standard Deviation
Age			

21 – 30	12.7		
31 – 40	27.8		
41 – 50	41.0		
51 and above	18.5	43.19	9.36
Sex			
Male	100.0		
Education level			
No formal education	56.1		
Primary education	17.3		
Secondary education	22.5		
Tertiary education	4.0		
English language reading ability			
Can read	26.6		
Cannot read	73.4		
Hausa language reading ability	4.2		
Can read	50.3		
Cannot read	49.7		
Marital status			
Married	97.7		
Not married	2.3		
Household size			
1-10	53.2		
11-20	42.8		
21 and above	4.0	9.96	5.48
Experience in pesticide application (Years)			
1-10	63.0		
11-20	34.7		6.37
21 and above	2.3	9.91	
Primary occupation			
Farming	96.5		
Trading	3.5		
Estimated annual income (Naira)			
₦350,000 – ₦1,350,000	60.0		
₦1,350,001– ₦2,350,000	21.7		
₦2,350,001 and above	7.5	1,550,058.8	891, 223.7

Source: Field Survey, 2024

3.2 Respondents' Training in Pesticide Application

Table 4 reveals that the overall mean (0.18) of training in pesticide application undergone by the respondents was low. Training in mixing the right dose of pesticide (mean= 0.18), maintenance of sprayer (mean=0.18), spraying of pesticide (mean=0.18), safe disposal of pesticide containers (mean=0.18), and use of personal protective equipment (mean=0.18) were low. The finding implies that the respondents were very disposed to misuse pesticides and this poses a great risk to human and environmental health. The finding is similar to the finding of [12] about lack of training among applicators of pesticides.

Table 4: Respondents' Training in Pesticide Application

S/N	Training item	Yes	No	Mean
i	Mixing the correct pesticide doses	18.5	81.5	0.18
ii	Maintenance of knapsack sprayer	17.9	82.1	0.18
iii	Pesticide application	17.9	82.1	0.18
iv	Safe disposal of pesticide containers	17.9	82.1	0.18
v	Use of personal protective equipment	18.5	81.5	0.18
	Overall mean			0.18

Source: Field survey, 2024 Mean > 0.5 indicates high training while mean < 0.5 indicates low training

3.3 Respondents' Awareness of Hazards Associated with Pesticides

Table 5 reveals the level of awareness of hazards associated with pesticide application. Majority (79.8%) were not aware that improper pesticide application can contaminate the rivers/streams, 77.5% were not aware that consumption of watermelon containing high pesticide residues can damage the kidneys of consumers, 74.0% were not aware that non-use of personal protective equipment exposes the applicators to various health issues, 71.1% were unaware that the consumers of watermelon containing pesticide residues can get sick while 56.1% were not aware that pesticide residues accumulate in high quantity in watermelon due to overdose. The findings imply that awareness level of the respondents on the hazards associated with pesticide (mean=0.28) was low. The finding agrees with the findings reported by [22, 23] on prevailing pesticide users' lack of knowledge of the risks associated with pesticides. This can affect the respondents' application practices in a way that poses a great danger to humans and their environment.

Table 5: Respondents' Awareness of Hazards Associated with Pesticides

S/N	Awareness item	Aware %	Not aware	Mean

			%	
i	Pesticide residues accumulate due to overdose	43.9	56.1	0.44
ii	Consumers of contaminated watermelon can get sick	28.9	71.1	0.29
iii	Possible damage to the kidneys of consumers of watermelon with high pesticide residues	22.5	77.5	0.23
iv	Non-use of personal protective equipment exposes applicators to hazards	26.0	74.0	0.26
v	Improper application of pesticide contaminates river/stream	20.2	79.8	0.20
	Overall mean			0.28

Source: Field survey, 2024 Mean > 0.5 indicates high awareness while mean < 0.5 indicates low
Low awareness

3.4 Respondents' Access to Information on Hazards Associated with Pesticides

Table 6 reveals that the overall mean (0.43) of access to information on hazards associated with pesticides was low. Access to radio information (mean=0.53), television information (mean=0.31), social media information (mean=0.47), extension agents' information (mean=0.70), farmers association' information (mean=0.31), pesticide dealers' information (mean=0.60) and NAFDAC' information (mean=0.10) were low. However, extension agents were ranked 1st, pesticide dealers were ranked 2nd and radio was ranked 3rd as sources of information on hazards associated with pesticides. The finding is corroborated by the finding of [10] who reported lack of access to adequate information as one of the factors responsible for the misuse of pesticides. The findings' implication is that more information dissemination needs to be carried out using different channels/media in order to boost respondents' awareness of hazards associated with pesticides.

Table 6: Respondents' Access to Information on Hazards Associated with Pesticides

S/N	Access to information	Always	Occasionally	Never	Mean	Rank
i	Radio information	1.2	50.3	48.6	0.53	3rd
ii	Television information	0.6	30.1	69.4	0.31	5th
iii	Social media information	1.7	43.4	54.9	0.47	4th
iv	Extension agents' information	16.2	37.6	46.2	0.70	1st
v	Farmers association' information	2.9	24.9	72.3	0.31	6th
vi	Pesticide dealers' information	23.1	13.3	63.6	0.60	2nd
vii	National Agency for Food Drug Administration and Control (NAFDAC)	0.6	9.2	90.2	0.10	7th
	Overall mean				0.43	

Source: Field survey, 2024 Mean > 1.0 indicates high access while mean < 1.0 indicates low access

3.5 Respondents' Compliance with Recommended Pesticide Application Doses

Table 7 shows that 76.3% of the respondents mixed pesticide doses with water by imitating the practice of fellow farmers. However, giving the low training acquired by the majority of respondents in Table 4, the implication is that they were imitating a wrong practice. Only 8.1% of the respondents applied the pesticide label information to determine the correct doses of pesticides. Hence, 8.1% of the respondents complied with the recommended application doses of pesticides while 91.9% did not comply. The finding is similar to the findings reported by [22, 14] on poor compliance with pesticide doses. But the finding contrasts with the finding of [24] who reported that most applicators read through the label instruction before application of pesticides.

Table 7: Respondents' Compliance with Recommended Pesticide Application Doses

S/N	Compliance indicator	Compliance %	Non-compliance %
i	I mix the dose I think is enough		11.0
ii	I use my past experience with other pesticides		4.6
iii	I apply label information to determine the dose	8.1	
v	I imitate the dose as done by fellow farmers		76.3
	Total	8.1	91.9

Source: Field survey, 2024

3.6 Determinants of Compliance with the Recommended Pesticide Application Doses

The logistic regression analysis of the compliance of the respondents with the recommended pesticide doses was carried out. The Dependent Variable (DV) was compliance, and age, education, English language reading ability, Hausa language reading ability, household size, experience in pesticide application, primary occupation, estimated annual income, training in pesticide application, awareness of hazards associated with pesticide application and access to information on hazards associated with pesticide application as predictor variables. A total of 173 cases were analysed, and the full model significantly predicted compliance (Omnibus Chi-square= 55.613, df=11, p<0.001). The model accounted for between 27.5% and 63.9% of the variance in compliance, with 98.1 non-compliance of respondents successfully predicted. However, only 50.0% of prediction for the compliance group was accurate. Overall, 94.2% of the prediction was accurate. Table 8 shows that awareness of hazards associated with pesticides and access to information on hazards associated with pesticides reliably predicted compliance. The value of the coefficients reveals that each unit increase in awareness is associated with an increase in the odds of compliance by a factor of 2.74. The odd ratio=2.74 implies that ceteris paribus, awareness of hazards associated with the use of pesticides increases the respondents' log odds of compliance with the application of recommended doses of pesticides by 2.74. Furthermore, access to information on hazards associated with pesticides reliably predicted compliance. The odd ratio =1.45 implies that ceteris paribus, access to information on hazards associated with pesticides increases the respondents' log odds of compliance with the application of recommended doses of pesticides by 1.45.

Table 8: Determinants of Compliance with the Recommended Pesticide Application Doses

Variable	B Coefficient	S.E.	Wald	p>z	Odds Ratio
Age	0.153	0.105	2.129	0.145	1.165
Education	-15.304	3002.136	0.000	0.996	0.000
English language reading ability	-2.266	1.489	2.317	0.128	0.104
Hausa language reading ability	-13.553	3084.781	0.000	0.996	0.000
Household size	-0.177	0.114	2.440	0.118	0.837
Experience with pesticide application	0.183	0.120	2.321	0.128	1.201
Primary occupation	-1.297	1.897	0.497	0.494	0.273
Estimated annual income	0.000	0.000	0.174	0.677	1.000
Training in pesticide application	0.091	0.233	0.153	0.696	1.096
Awareness of hazards associated with pesticides	1.006	0.390	6.643	0.010**	2.735
Access to information on hazards associated with pesticides	0.370	0.212	3.049	0.081*	1.448
Constant	-11.216	4.117	7.424	0.006	0.000
Omnibus tests	Chi-square 55.613, df=11, p<0.001 (0.000)				
Cox & Snell R^2	0.275				
Nagelkerke R^2	0.639				
Hosmer and Lemeshow	p>0.05 (0.997)				

Source: Field survey, 2024 ** p<0.05

4. CONCLUSION AND RECOMMENDATIONS

The study concluded that watermelon farmers had low training in pesticide application. They also had low awareness of hazards associated with the application of pesticides. Access to information on hazards associated with the use of pesticides through different channels/media was also low. Most of the watermelon farmers did not comply with the recommended doses of pesticides. Awareness of hazards associated with the use of pesticides and access to information on hazards associated with the use of pesticides statistically and significantly influenced positively the watermelon farmers' compliance with the recommended doses of pesticides. Therefore, based on the findings of the study, it was recommended that training on correct handling and application of pesticides should be made a regular practice by the agricultural stakeholders, governments, individuals and agencies whose concerns are food security, food safety and environmental health. There should be a regular dissemination of information to watermelon farmers on hazards associated with the use of pesticides and the need to comply with recommended pesticides application doses.

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