

Determinants of Adherence to Safety Precautions in Herbicide Application among Farmers in Zuru Agricultural Zone, Kebbi State, Nigeria

Dabai, A.C¹; Hassan S.U² & Kaka, Y³

¹Department of Agricultural Economics and Extension, Federal University of Agriculture Zuru, Kebbi State, Nigeria.

²Department of Agricultural Economics and Extension, Abdullahi Fodiyo University of Science and technology Aliero, Nigeria.

*Corresponding Author: Dabai, A.C

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Copyright © 2025 The Author(s): This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY-NC) which permits unrestricted use, distribution, and reproduction in any medium for non-commercial use provided the original author and source are credited.	
Citation: Dabai, A.C., Hassan S.U., & Kaka, Y. (2026). Determinants of adherence to safety precautions in herbicide application among farmers in Zuru Agricultural Zone, Kebbi State, Nigeria. UKR Journal of Agriculture and Veterinary Sciences, 2(4), 01-11.	<i>This study examined the determinants of compliance with safety measures during herbicide application among farmers in the Zuru Agricultural Zone, Kebbi State, Nigeria. Through a multistage sampling procedure, a total of 120 participants were selected. Data analysis was conducted using descriptive statistics in conjunction with binary logistic regression. The respondents' socioeconomic characteristics indicated that most were in the economically active age range, with 53.3% aged 31 to 35 years and an average age of 43 years. All respondents (100%) were male, and 83.3% were married. The farmers exhibited a generally low level of education, as merely 60.0% had completed primary education, and 48.0% had received no formal education whatsoever. The typical household was large, averaging 7 members. While all respondents (100%) belonged to a farmers' association, their average farming experience stood at 15 years. Institutional support proved to be quite minimal, with just 6.0% of farmers having access to any kind of extension assistance and credit facilities. Nevertheless, the binary logistic regression analysis showed that the model was statistically significant ($R^2 = 0.68$; $F = 23.45$, $p < 0.01$) and possessed strong predictive capability. The factors predicting farmers' compliance with safety precaution practices comprised level of education ($\beta = 0.113$, $p < 0.01$), farm size ($\beta = 0.087$, $p < 0.05$), access to extension services ($\beta = 0.962$, $p < 0.01$), training on herbicide use ($\beta = 1.134$, $p < 0.01$), knowledge of hazards ($\beta = 0.721$, $p < 0.01$), availability of personal protective equipment (PPE) ($\beta = 0.843$, $p < 0.01$), and risk perception ($\beta = 0.506$, $p < 0.05$). Training on herbicide use exerted the greatest effect on farmers' compliance with safety precaution practices, raising the odds of farmers following safety precautions by more than threefold ($OR = 3.11$). Conversely, age ($\beta = -0.032$, $p < 0.05$), household size ($\beta = -0.058$, $p < 0.10$), and cost of PPE ($\beta = -0.615$, $p < 0.05$) were the factors that diminished the likelihood of adhering to safety precaution practices during herbicide application. The study concludes that compliance with herbicide safety precautions arises from a combination of socioeconomic, institutional, and knowledge-related factors, with extension access, training, and PPE availability serving as critical elements. It is recommended that extension services be strengthened, routine training programmes be established, and subsidized PPE be provided in order to enhance safe herbicide practices among crop farmers.</i> Keywords: Herbicide application, Safety precautions, Adherence, Zuru Agricultural Zone.

Introduction

Crop cultivation began approximately 9,000 years ago, at which point domesticating plants became essential in order to complement naturally available food sources in particular regions. Early farmers grew just a limited variety

of crops, and in most parts of the world cereals were the first to be cultivated. Often the same crop would be planted on a plot without interruption until declining yields forced farmers to relocate to fresh land. Such a method remains

common in certain areas of Africa (Scribd, 2025). In Nigeria, crop production has kept on serving as a major force behind economic growth (Osabohien & Ogunbiyi, 2019). According to Asoko insight (2019), crop production constitutes by far the biggest sub-sector, accounting for close to 90% of agriculture's nominal gross domestic product (GDP). Adam (2019) contends that crop production in Nigeria provides food security, jobs and income for over 90% of the indigenous population. Paul (2018) additionally observed that every food has its origin in some type of crop production, and that most adults hold a deep fear of lacking good and dependable crop production.

Olalekan (2021) disclosed that before independence, the colonial Nigerian economy depended on three principal export crops: cocoa, palm produce and groundnut. From that time onward, crop production has remained the foremost engine of the agricultural sector. In 2022, Nigeria's output reached 59.4 million tons of cassava, 47.5 million tons of yam, 2.6 million tons of cowpea, and 6.8 million tons of sorghum (making it the world's largest producer) (FAO, 2022, world agricultural production, 2022). Since the beginning of history, the core characteristics of crop production have barely changed. According to Scribd (2025), these characteristics encompass collecting and conserving seeds from desired crop plants, clearing other types of vegetation from the land, tilling the soil to create a seed bed, sowing at the proper time of season and weather as indicated by prior experience, eliminating weeds, shielding the crop from natural foes, harvesting, processing and storing the yield, and so on.

Prior to the arrival of selective herbicides, farmers relied on a mix of approaches, including crop rotation, cover cropping, proper tillage and others, to keep weeds under control (Bolliger et al., 2006). Because manual weeding is such arduous work in agriculture, research persisted across the globe, and selective herbicides were introduced in the late 1940s. Subsequently, numerous new herbicides came into being, providing farmers with a fresh weed management instrument dubbed the 'chemical hoe' (Kudsk & Streibig, 2003). Herbicides reduce how much farmers must depend on manual weed control efforts. Furthermore, herbicides, alongside other pesticides, played a vital part in the success of the green revolution, particularly in the developing nations of Asia (Pimentel, 1996). The identification of various selective herbicide molecules reshaped the modern agricultural system, steering it further toward productivity (Hamill et al., 2004). The age-old custom of weeding fields by hand can no longer be sustained in today's world, and the human toil of hand weeding is among the earliest jobs that workers are

eager to give up as countries industrialize. Around the world, the shortage of workers available for hand weeding makes the application of herbicides an unavoidable practice. When set against the cost of workers for manual weeding, herbicides prove cheaper and can be procured with greater ease (Gianessi, 2013).

Statement of the Research Problem

The widespread and unselective application of herbicides by crop farmers prompted the conception of this study, aimed at determining whether these farmers followed safety measures when applying herbicides. This is based on the finding by Bulu et al. (2017) that herbicide use for weed control has become fashionable in recent times and is practiced without regard for the associated health impacts on humans and the environment. According to Carmona et al. (2020), these herbicides are applied in tons because they substitute for manual labor, boost productive capacity, and substantially reduce production costs. They stressed that herbicides can have toxic effects on the health of agricultural workers, through both direct and indirect modes of action. Korres (2019) further stated that insufficient caution and unprotected exposure to herbicides could lead to short-term or long-term poisoning.

There is no question that herbicides play a crucial role, because present-day crop production suffers from a shortage of laborers available for hand weeding, and using herbicides costs less and is more readily accessible than hiring workers to weed by hand. Furthermore, hand weeding has never proven to be a particularly effective approach to controlling weeds, given that it is frequently carried out too late and with insufficient frequency. In contrast to tillage, the application of herbicides not only removes weeds but additionally reduces erosion and nutrient runoff while conserving moisture (Gianessi, 2013). Gianessi (2014) found that in comparisons between minimum tillage combined with herbicides and minimum tillage combined with hand weeding, grain yield was greater in 60% of the cases where herbicides were used rather than hand weeding. This study will be of great value to farmers, extension agents, policy makers, herbicide handlers, students, and anyone who might want to carry out similar research. It is against this backdrop that the current study aims to address the following research questions;

1. What are the socio-economic characteristics of the respondents in the study area?
2. What are the determinants of adherence and non-adherence to safety precautions in herbicide application?

Objectives of the Study

The broad objective of the study is to analyse the determinants of adherence to safety precautions in

herbicide application among farmers in Zuru Agricultural Zone Kebbi State, Nigeria. The specific objectives of the study are to:

1. describe the socio-economic characteristics of farmers in the study area.
2. determine the factors influencing adherence and non-adherence to safety precautions in herbicide application on farms in the study area.

Methodology

Description of the Study Area

The southern section of Kebbi State, Nigeria is home to the Zuru Agricultural Zone. Its total land area measures 8,176 square kilometers (Eight Thousand, One Hundred and Seventy Six square kilometers). It extends across latitudes 10.84°N to 11.84°N and longitudes 4.45°E to 6.00°E. Borders of the zone include Anka Local Government Area of Zamfara State on the eastern side, Rijau Local Government Area of Niger State to the south, Koko/Besse Local Government Area of Kebbi State on the western edge, and Gummi Local Government Area of Zamfara State to the north (FRN, 2006). A population of 641,899 people (Six Hundred and Forty One Thousand, Eight Hundred and Ninety Nine) resides in Zuru Agricultural Zone, which comprises Four (4) Local Government Areas: Danko/Wasagu, Fakai, Sakaba and Zuru. It is made up of

five administrative chiefdoms, specifically Dabai, Danko, Fakai, Sakaba and Wasagu (FRN, 2006). Within Dabai Chiefdom, the Dakarkari (Lelna) people constitute the predominant ethnic group. Kelawa, also referred to as Fakkawa, inhabit Fakai Chiefdom, while Bangawa are located in Danko Chiefdom. The chiefdom headquarters of Wasagu is dominated by Katsinawa, whereas Dukkawa, Achifawa and Kambari peoples reside in Sakaba Chiefdom (Olusanya, 1993). What is now known as Zuru land came into being through the merging of these tribes.

Farming, animal rearing, and blacksmithing, a prestigious trade are the main occupations of the Zuru people. The Zone enjoys climatic conditions that are favourable for cultivating a wide range of crops, including maize, sorghum, groundnut, beans, rice, and cassava. The soils are sandy-loam, moderately deep, and well drained. Rainfall averages roughly 1825mm, while the mean temperature stands at about 27°C. The wet season spans April through October. From December to February, the area goes through a harmattan period. Zuru Agricultural Zone features savanna-type vegetation that lies transitionally between Northern Guinea Savanna and Sudan Savanna, with patches of woodland vegetation along river basins covered by a more or less continuous grass layer, though in certain parts tree growth suppresses grass growth (Nanoh et al. 2014 and Bawa, 2021).

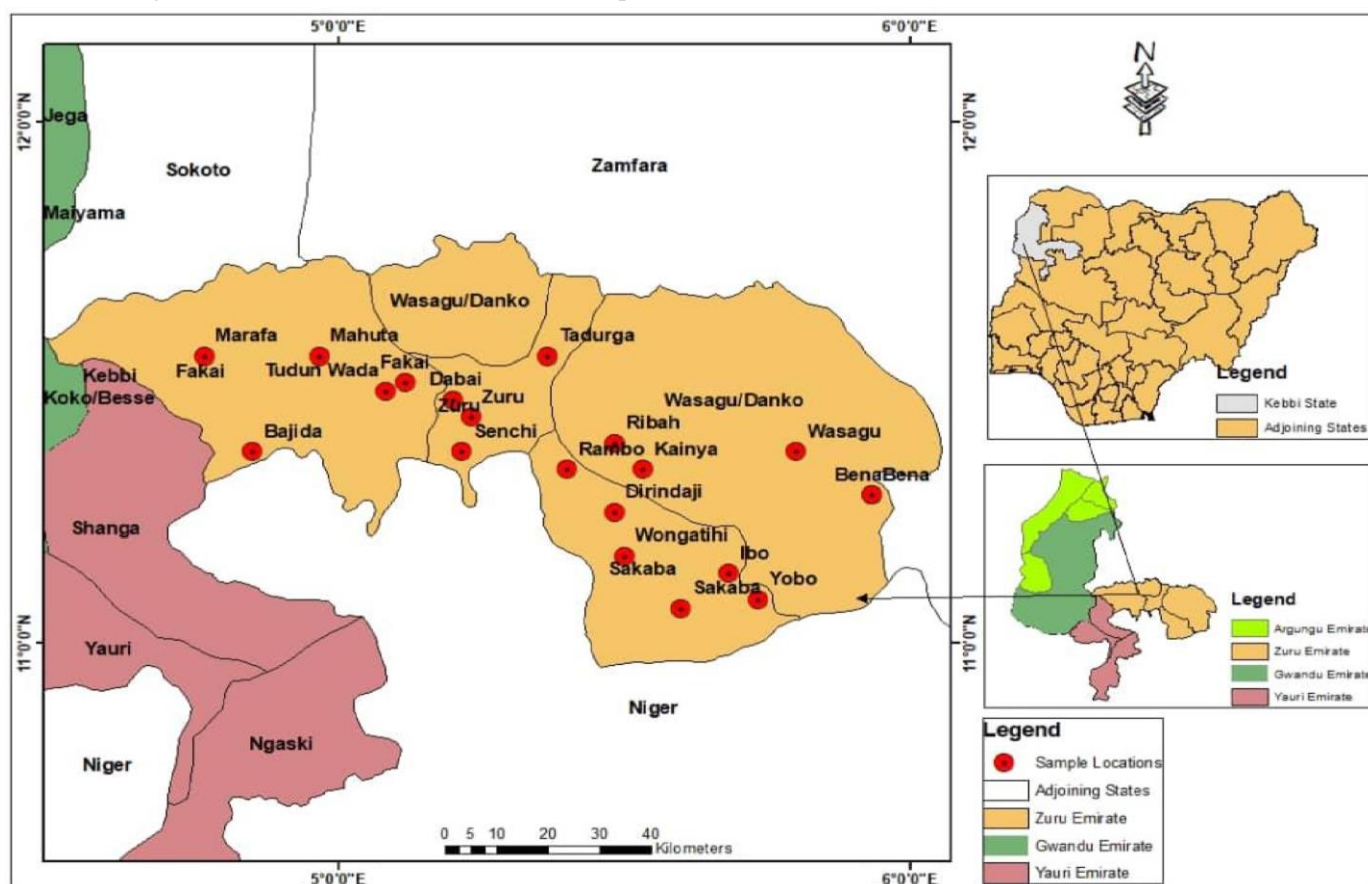


Figure 1: Map of the Study Area Extracted from the map of Nigeria

Data Collection

Both primary and secondary sources of data were used in this study. A structured questionnaire along with interview schedules, both designed to align with the study's objectives, were used to collect the primary data. The data were obtained from the four (4) Local Government Areas situated within the Agricultural Zone. Respondents in each Local Government Area were drawn from five (5) registered Farmers Associations found in five (5) villages selected across those areas. The questionnaires and interviews were carried out with the respondents with the help of trained enumerators, who act as village extension agents. The enumerators explained and interpreted the questionnaire and interview schedule questions to the respondents. Information gathered in the data included the socio-economic characteristics of the crop farmers, their extension needs, the safety precautions they followed, the factors influencing adherence and non-adherence to safety precautions, the hazards associated with herbicides

application, and so forth. Relevant literature served as the source of the secondary data.

Sampling Procedure and Sample Size

The study's data were gathered through the application of a multistage sampling technique. The present investigation focuses upon the Zuru agricultural zone, which comprises four (4) Local Government Areas, namely Fakai, Danko Wasagu, Sakaba, and Zuru. Within each of the four local government areas (LGAs), five villages were selected at random, yielding a cumulative total of twenty (20) villages. The second stage entailed the selection of one registered Farmer's Cooperative Association (FCA) from every village chosen, which produced a cumulative total of Twenty (20) Farmer's Cooperative Associations. At the third stage, a proportionate sample of 10% was taken from each FCA, which yielded One hundred and Twenty (120) respondents out of an overall population of 1181 (Cooperative and Tourism Zonal Headquarters Zuru Kebbi state, 2024).

Table 1: Summary for Sampling Procedure and Sample Size

Study Location	Selected Villages	No of Registered Farmers per Village	10% of the Population Crop Farmers
Zuru Agricultural Zone			
Danko/Wasagu LGA Ribah		45	5
	Kanya	45	5
	Wasagu	62	6
	Bena	88	9
	Rambo	43	4
	Total	283	29
Fakai LGA.	Birnin Tudu	42	4
	Fakai	45	5
	Bajida	80	8
	Mahuta	85	9
	Marafa	48	5
	Total	300	31
Sakaba LGA	Dirin Daji	85	9
	Ibo	45	5
	Sakaba	50	5
	Wangachi	48	5
	Yabo	40	4
	Total	268	28
Zuru LGA.	Dabai	83	8
	Tadurga	44	4
	Bedi	80	8
	Zuru	41	4
	Senchi	82	8
	Total	330	32
Overall Total		1,181	120

Source: Cooperative and Tourism, Zonal Headquarters Zuru, Kebbi State, 2024

Method of Data Analysis

The gathered data were examined through descriptive statistics as well as inferential statistics. To examine the first objective, descriptive statistics including frequency counts, percentages, means, and rankings were applied, whereas the second objective was analyzed using Binary logistic Regression.

Binary Logistic Regression Analysis

Specification of the model

To examine objective 2, a binary logistic regression analysis (LRA) was applied. The logit model is a regression technique used for statistical inference that characterizes how a censored continuous dependent variable, y_i , relates to a set of independent variables, x_i .

The independent variables are X_1 through X_{12} , while Y_i serves as the dependent variable.

Mathematically, the general logit regression model can be written as:

The general Logit regression model is mathematically expressed as:

$$Y = \alpha + \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + U \dots \dots \dots (1)$$

Where Y = Adherence (a binary dependent variable valued as 1 when crop farmers adhered to safety precautions and 0 when otherwise)

Y_i is the dependent variable and $X_1 - X_{12}$ are the independent variables

X_1 =Age of the farmer (Years)

X_2 = Sex (1 for male, 0 for female)

X_3 = Farming experience (Years)

X_4 =Level of formal education of the farmer (Years)

X_5 = Farm size (ha)

X_6 = Household size (Number)

X_7 =Access to extension services by the farmer (1 for access, 0 for otherwise)

X_8 = Training on herbicide usage (1 received training, 0 otherwise)

X_9 = Knowledge of Hazards (1 have knowledge, 0 otherwise)

X_{10} = Cost of herbicide (Naira)

X_{11} = Availability of PPE (1 for available, 0 otherwise)

X_{12} = Risk Perception (1 Perceived, 0 otherwise)

U =Error term

β_i =Constant term

$\beta_i - \beta_{12}$ =Regression coefficients estimated

Results And Discussion

Table 4. 1: Socioeconomic Characteristics of the Respondents (n = 120)

Variables	Frequency	Percentage	Mean
Age			
<30	18	15.0	
31-35	64	53.3	
36-40	21	17.5	
>40+	17	14.2	
Total	120	100	43
Sex			
Female	0	0	
Male	120	100	
Total	120	100	
Marital Status			
Married	100	83.3	
Single	20	16.7	
Divorced	0	0	
Widowed	0	0	

Total	120	100	
Level of Education			
Primary Education	51	60.0	
Secondary Education	20	24.0	
Tertiary Education	9	10.8	
No Formal Education	40	48.0	
Total	120	100	
Household Size			
Less than or equal to ⁵	2	1.7	
3-6	56	46.7	7
7-10	44	36.7	
11-14	17	14.2	
>15	1	0.8	
Total	120	100	
Membership of Association			
Member	120	100	
Non-Member	0	0	
Total	120	100	
Farming Experience			
Less than 5	6	7.2	
6 – 13	10	12.0	
14 – 21	44	52.8	15
22-29	53	63.6	
30-37	5	6.0	
38 above	2	2.4	
Total	120	100	
Access to Extension			
No	115	138	
Yes	5	6.0	
Total	120	100	
Access to Credit			
No	74	88.8	
Yes	46	55.2	
Total	120	100	

Source: Field Survey, 2025

Table 4.1 presents the socioeconomic characteristics of the respondents (n = 120), which provides important background information to understand farmers' production behaviour, the adoption of technologies and the interaction with extension services. Socioeconomic variables such as age, sex, education, household size, farming experience and access to institutional services are recognized as critical

determinants of agricultural decision-making and productivity outcomes.

The distribution by age shows that the majority of the respondents are in the economically active age groups. The largest group (53.3%) consisted of farmers aged 31 – 35 years, followed by 17.5% of respondents aged 36 – 40

years, whereas 15.0% of respondents were under 30 years. This suggests that the majority of farmers are in their most productive working years, which are associated with greater physical capabilities, receptiveness to new ideas and willingness to adopt better farming practices (Ayalew & Girma, 2025). It has been observed in Nigeria and elsewhere in sub-Saharan Africa that farmers aged 30 – 45 tend to respond more readily to extension advice and are more likely to try new technologies than their older counterparts (Ogunleye et al., 2022). Nonetheless, the fact that 14.2% of respondents are above 40 years suggests a store of farming experience, which can positively influence farm management decisions, despite the potential reluctance to change (Abdul-Rahman & Abdulai, 2018). The table indicates that all respondents (100%) were male, which suggests complete male dominance in the farming activity under study. This finding reflects the prevailing socio-cultural norms in many rural areas of northern Nigeria, where land ownership, decision-making and chemical input application are predominantly controlled by men (Nwafor et al., 2021). Although male dominance may increase access to land and labour, the exclusion or limited participation of women in such activities raises concerns regarding gender equity and the potential contribution of women to agricultural productivity and household welfare (FAO, 2023). A significant proportion of the respondents were married (83.3%), while (16.7%) were single. The predominance of married farmers suggests higher household responsibilities, which can motivate increased engagement in farming activities in order to meet family needs. Married farmers tend to be more stable and committed to farming as a primary livelihood source, which can positively influence farm investment decisions and the adoption of productivity-enhancing practices (Ahituv & Lerman, 2005). However, higher family responsibilities may also lead to increased risk aversion, particularly in the adoption of unfamiliar technologies.

The educational profile shows that a considerable proportion of respondents had primary education (60.0%), while 24.0% had secondary education and only 10.8% attained tertiary education. Notably, a significant proportion of respondents had no formal education (48.0%), indicating generally low literacy levels among the farmers. Low educational attainment has been widely reported as a constraint to understanding extension messages, agrochemical labels and safe farm practices (Damalas & Koutroubas, 2016; Okoffo et al., 2022). Farmers with higher levels of education are generally more capable of understanding technical recommendations, record-keeping and the environmental and health

implications of agrochemical use (World Bank, 2022). The observed low level of formal education suggests the need for simplified, participatory and visual-based extension approaches.

Household size analysis shows that the majority of respondents had relatively large households, where 46.7% had 3 – 6 members and 36.7% had 7 – 10 members and the mean household size was 7 persons. Large household sizes are common in rural Nigeria and usually provide a source of family labour for farming operations (Ayaz & Mughal, 2022). Nonetheless, large households may also place greater pressure on household income, potentially limiting the farmers' ability to invest in improved technologies and inputs (Bitana et al., 2024). All respondents (100%) were members of farmers' associations, which indicates strong social organization in the study area. Membership in associations facilitates information sharing, collective action, access to extension services, credit facilities and input subsidies (Ogunlana & Oladele, 2021). Farmer groups also serve as effective platforms for extension delivery, particularly in areas with limited extension personnel, thus improving the dissemination of best agricultural practices.

The results indicate that the majority of respondents had substantial farming experience. Farmers with 14 – 21 years (52.8%) and 22 – 29 years (63.6%) of experience dominated the sample with a mean farming experience of 15 years. Extensive farming experience is often associated with better indigenous knowledge, improved farm management skills and greater confidence in decision-making (Abebe et al., 2016). However, experienced farmers may sometimes rely heavily on traditional practices, which emphasizes the need for targeted extension strategies that integrate indigenous knowledge with modern recommendations. The table indicates very limited access to extension services as 115 respondents (approximately 94%) reported no access, while only 5 respondents (6.0%) had access. This finding reflects the persistent challenge of inadequate extension coverage in Nigeria, where the extension agent-to-farmer ratio remains critically low (FMARD, 2022). Limited access to extension services restricts farmers' exposure to improved technologies, safe agrochemical use and climate-smart practices, ultimately affecting productivity and sustainability (Anderson & Feder, 2004). With respect to credit access, the majority of respondents lacked access to credit facilities (88.8%), while only (55.2%) reported having access, which indicates severe financial constraints. Limited access to credit restricts farmers' ability to purchase improved inputs, adopt mechanization and manage production risks (World Bank, 2023).

Table 2: Logistic Regression Estimates of the Determinants of Farmers' Adherence to Safety Precautions in Herbicide Application (n = 120)

Variable	Coefficient (β)	Std. Error	Odds Ratio (Exp (β))	Significance
Constant	2.604	1.610	1.62	**
Age	-0.032	0.014	0.97	**
Sex (Male = 1)	0.418	0.237	1.52	*
Farming Experience	0.045	0.021	1.05	**
Education Level	0.113	0.036	1.12	***
Farm Size	0.087	0.039	1.09	**
Household Size	-0.058	0.034	0.94	*
Access to Extension	0.962	0.298	2.62	***
Training on Herbicide Use	1.134	0.331	3.11	***
Knowledge of Hazards	0.721	0.244	2.06	***
Cost of PPE	-0.615	0.271	0.54	**
Availability of PPE	0.843	0.289	2.32	***
Risk Perception	0.506	0.212	1.66	**
R ²	0.68			
Adjusted R ²	0.65			
F-statistic	23.45			
Number of Observations	120			

Source: Field Survey, 2025 *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 2 presents a logistic regression analysis that pinpoints the main factors shaping whether farmers follow safety measures when applying herbicides. With an R^2 of 0.68, an adjusted R^2 of 0.65, and an F-statistic of 23.45 ($p < 0.001$), the model shows considerable explanatory strength, suggesting that the variables included account for roughly 68% of the variance in adherence behaviour. Drawing on 120 observations, the analysis benefits from a high F-statistic, which verifies that the model is significant overall.

Socio-Demographic Determinants

Age was found to negatively influence adherence ($\beta = -0.032$, $p < 0.05$, OR = 0.97), suggesting that older farmers are slightly less likely to comply with safety precautions. This may reflect resistance to adopting new safety practices or reliance on traditional methods, consistent with previous findings in smallholder farming contexts (Damalas & Koutroubas, 2016; Okoffo *et al.*, 2022). Sex (male = 1) was positively associated with adherence ($\beta = 0.418$, $p < 0.1$, OR = 1.52), indicating that male farmers are approximately 1.5 times more likely than females to observe safety measures. This may be attributable to gendered roles in farm operations, where males often handle herbicide application (FAO, 2022). Farming experience also positively influenced adherence ($\beta = 0.045$, $p < 0.05$, OR =

1.05), implying that more experienced farmers are slightly more likely to observe recommended precautions, likely due to accumulated knowledge and exposure to past incidents (Chauhan, 2020).

Education level had a significant positive effect on adherence ($\beta = 0.113$, $p < 0.01$, OR = 1.12), demonstrating that literate or formally educated farmers are better equipped to interpret herbicide labels and hazard warnings. This is consistent with studies highlighting the role of education in promoting safe pesticide use (Damalas & Koutroubas, 2016; FAO & WHO, 2019). Farm size was positively associated with adherence ($\beta = 0.087$, $p < 0.05$, OR = 1.09), suggesting that farmers with larger plots are more likely to follow safety protocols, potentially due to increased commercialization and formalization of farm practices. In contrast, household size negatively affected adherence ($\beta = -0.058$, $p < 0.1$, OR = 0.94), indicating that larger households may face competing labor demands that limit compliance (Okoffo *et al.*, 2022).

Institutional and Knowledge-Based Determinants

Access to extension services significantly increased adherence ($\beta = 0.962$, $p < 0.01$, OR = 2.62), indicating that farmers with extension support are more than twice as likely to observe safety precautions. This underscores the

critical role of extension services in disseminating knowledge on safe herbicide use and associated health risks (Anderson & Feder, 2004). Training on herbicide use emerged as the strongest predictor ($\beta = 1.134$, $p < 0.01$, OR = 3.11), suggesting that farmers who received training are three times more likely to comply with safety measures. This highlights the importance of targeted capacity-building interventions in enhancing occupational safety (Chauhan, 2020).

Knowledge of hazards positively influenced adherence ($\beta = 0.721$, $p < 0.01$, OR = 2.06), reflecting that awareness of potential health and environmental risks motivates farmers to adopt protective behaviours (WHO, 1990). Similarly, availability of personal protective equipment (PPE) significantly increased adherence ($\beta = 0.843$, $p < 0.01$, OR = 2.32), emphasizing that access to protective tools is critical for translating knowledge into practice. Conversely, cost of PPE negatively affected adherence ($\beta = -0.615$, $p < 0.05$, OR = 0.54), indicating that high costs constitute a barrier to safety compliance, consistent with prior studies (Damalas & Koutroubas, 2016). Finally, risk perception positively influenced adherence ($\beta = 0.506$, $p < 0.05$, OR = 1.66), suggesting that farmers who perceive herbicide use as hazardous are approximately 1.7 times more likely to follow safety precautions (Kim *et al.*, 2021; Okoffo *et al.*, 2022). The analysis demonstrates that adherence to herbicide safety precautions is shaped by a combination of socio-demographic factors, institutional support, knowledge of hazards, and access to protective equipment. Access to extension services, training, hazard knowledge, and availability of PPE were the most critical determinants of compliance, while older age, larger household size, and high PPE cost reduced adherence. These findings highlight the need for integrated interventions that combine capacity-building, risk communication, extension support, and provision of affordable PPE to promote safe herbicide practices among smallholder farmers.

Conclusion/ Recommendations

The study concludes that although farmers demonstrate awareness of basic safety measures, adherence to comprehensive precautions, particularly the use of personal protective equipment, remains extremely low. Consequently, farmers remain exposed to both acute and chronic health risks as well as environmental hazards. Adherence to safety precautions is influenced by socio-demographic factors, access to extension services, training, knowledge of hazards, and availability of protective equipment. Therefore, interventions that strengthen extension services, provide capacity-building on safe herbicide use, and improve access to affordable PPE are critical for promoting safe farming practices. Based on the

findings of the study, the following recommendations were put forward:

1. Farmers should be encouraged to adopt full personal protective equipment, while cooperatives and government agencies should provide subsidized PPE to improve safety compliance.
2. Cooperative societies should expand their role beyond credit provision to include training and technical support on safe herbicide practices.

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