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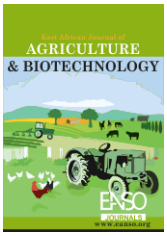

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Original Article

Farmers' Awareness and Use of Mobile Phones in the Management of Banana Xanthomonas Wilt Disease in Uganda

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Banana, Digital Applications, Xanthomonas Wilt, Mobile Phone, Agricultural Information.

ABSTRACT

Mobile phone technology awareness and use in developing countries, Uganda inclusive, is growing at a faster rate in many sectors, including Agriculture. Mobile phone usage has enhanced information flow to the rural communities for the advancement of agriculture. A survey was conducted in four banana-growing districts of Uganda, representing the western region (Isingiro and Mitooma Districts) and the central region (Luwero and Mukono Districts), to assess the extent of awareness and use of mobile phone applications by smallholder banana growers. Data were collected using a questionnaire from 144 farmers representing 144 households. Most of the farmers (66.7%) were aware of mobile phone applications used for accessing agricultural information, although the percentage of farmers (25.7%) using mobile phones to access information for banana Xanthomonas disease management was low. Many factors determined mobile phone use, but banana plantation size, education level, and constraints encountered in the use of mobile phones were the most significant. The leading challenges encountered by farmers using mobile phones for accessing agricultural information were identified as a lack of smartphones, limited knowledge and skills, and poor network connection. We recommend the creation of awareness about mobile phone applications and their use in farming communities by both public and private agricultural extension and advisory service providers.

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INTRODUCTION

Most African economies rely mostly on agricultural systems as sources of employment and income (AGRA, 2021). Food is produced mainly by smallholder farmers in developing countries, who contribute about 80% of the food produced. Like many other countries in sub-Saharan Africa, the livelihood of about 77% of Uganda's population depends on agriculture (FAO, 2017). Unfortunately, agriculture is not as productive as it should be (FAO, 2011; Nguthi, 2007). This is partly attributed to limitations in information flow between farmers and other stakeholders. Hence, e-extension, where Information and Communication Technologies (ICTs) are used in the provision of agricultural extension services, can improve agricultural information flow, subsequently improving agricultural production (Muzamil et al., 2025; Qiang et al., 2012; Walter et al., 2017). Mobile phone technologies are one of the ICTs that have been harnessed to improve farmers' access to agricultural information (Hoang, 2020; Misaki et al., 2016; Mittal & Tripathi, 2009; Muzamil et al., 2025).

Mobile phones offer new opportunities to rural households to get information on agronomic practices, markets, and financial services. Mobile phone use allows information to reach farmers across diverse rural settings (Duncombe, 2016; Hoang, 2020; Ogbeide & Ele, 2015). Mobile technology use has also enabled a large number of farmers to obtain agricultural extension services (Aker & Ksoll, 2016; FAO, 2006). Mobile phone subscribers can obtain mobile phone-enabled services or 'm-services' to get service-related information (Wyche & Steinfield, 2016). These m-services deliver electronic media content using mobile technologies such as m-agri, m-commerce, and m-banking, among others. M-services come in different forms, for example, mobile applications (apps), short message services (SMS), and unstructured supplementary service data (USSD). These services can connect buyers to sellers; provide agriculture information, alerts concerning incidences of pests and diseases, and weather forecasts (Baumuller, 2018). Mobile communications technology is increasingly being used in the developing world as a way of transmitting voice, data, and banking services (Qiang et al., 2012). Mobile applications (M-apps) and Mobile applications for Agricultural and Rural Development (M-ARD apps) offer a potential for agricultural development (Qiang et al., 2012). Several studies conducted in different countries, including China, Ethiopia, Tanzania, and Uganda, showed that mobile phones are important tools in disseminating agricultural information to the agrarian and rural population through calls, SMS messages and multimedia-supported systems (Tadesse & Bahiigwa, 2015). Hence, mobile phone technology use can boost agricultural information flow from agricultural experts to farmers, and among farmers themselves.

Farmers in sub–Saharan Africa face several challenges in accessing agricultural information using mobile phone technologies. The key ones include low education and training, high costs of

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operations, poor electricity supply, use of foreign languages, low awareness, and lack of network in remote areas (Ayim et al., 2022; Misaki et al., 2016; Nyamba & Mlozi, 2012; Songol et al., 2021). These challenges have led to limited adoption of mobile phones for accessing agricultural information.

In Uganda, there are currently several mobile phone innovations that are being used to provide agricultural information, such as M-omulimisa, Erignu-surface, EzyAgric, Akello bank, Ensibuuko, and Viamo 321 services. These mobile phone applications have been developed and are being used by farmers when carrying out their farm businesses, from land mapping to marketing of the produce (Mwombe et al., 2013; Tinzaara et al., 2021; Uganda Communications Commission, 2019). For instance, banana farmers can seek agricultural information concerning the growing of bananas from such platforms through their mobile phones.

Bananas are affected by several challenges which include among others, including pests and diseases, poor climate, soil infertility, and remote markets (Tinzaara et al., 2018). One of the greatest devastating diseases in banana production is the banana Xanthomonas wilt (BXW). The disease has destroyed many banana plantations in central and western Uganda, and other parts of the country (Kubiriba et al., 2023), and this threatens the food security of over 14 million consumers of banana as a staple food in the country. Some farmers have lost entire plantations, leading to the abandonment of banana farming despite the crop being the major source of food and income (Kubiriba et al., 2023). Though BXW is a dangerous and endemic disease that causes 100% of yield loss, it can be managed by correct and timely information flow to farmers on how to manage it. Specific Mobile phone applications have been developed to manage the disease; for example, the BXW app, which is currently being used to diagnose, control, and prevent BXW in Rwanda. The potential of using mobile phones for the management of crop pests and diseases in Uganda has been assessed (Masuki et al., 2010; Nakato et al., 2016; Tinzaara et al., 2021). Farmers' awareness of mobile applications that disseminate agricultural information in Uganda is crucial in enabling them to obtain advice to manage the BXW disease. The use of such applications in Uganda among smallholder banana growers is not sufficiently explained.

This study aimed to assess the awareness and use of mobile phone applications by smallholder banana farmers in western and central Uganda. The specific objectives were to: i) assess the level of farmers' awareness of mobile phone applications for accessing agricultural information on banana production; ii) examine farmers' usage of mobile phone applications in obtaining agricultural information for managing BXW disease; and iii) determine the factors that influence banana farmers' use of mobile phone applications in accessing information for managing BXW disease.

MATERIALS AND METHODS

Study Area Description

This study was conducted in four banana growing districts of Uganda, representing the western region (Isingiro and Mitooma Districts) and the central region (Luwero and Mukono Districts). The choice of the two regions was justified by (NIRA, 2017), which showed the two regions for dominance in the application of digital solutions, but are also major banana growing areas in Uganda. According to (NIRA, 2017). The population of Central and Western Uganda that embraces digital technology is estimated to be 2,243,500. Uganda's western region is known for the East African Highland Banana system, and central Uganda is known mainly for the Kayinja-based system.

Study Design and Sampling Procedure

The respondents were from the districts of Isingiro and Mitooma (western region), Luwero and Mukono (central Uganda). The criterion for the choice of sampling districts was purposive, based on

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the population that dominantly grows bananas and utilises mobile phone applications in agriculture.

A total of 144 respondents (households) were involved in this study. Within each region, two districts were selected, in each district two parishes were chosen, in each parish two villages, and in each village nine respondents were interviewed (i.e., 2 regions × 2 districts per region × 2 parishes per district × 2 villages per parish x 9 respondents per village =144 respondents. This was done in the guidance of the agricultural officer because they had the best knowledge of the farmers who take part in banana production at subsistence and commercial levels. The selected respondents were 50% females and 50% males per district, considering the age (youth 20-35 years; elder = 35 years and above) and economic status (subsistence vs commercial banana farming).

Data Collection Methods

A questionnaire was used to collect data from 144 banana farmers/households. During the survey, data were collected on farmers' awareness of mobile phone applications for disseminating agricultural information in banana production. Additional data were collected on phone ownership, phone type, total number of mobile phones in a household, duration of phone ownership, applications on the mobile phone and frequency of mobile phone use in obtaining agricultural information, and presence of FM radio on the mobile phone.

To determine factors that influence banana farmers' usage of mobile applications, the questionnaire was also used to collect data on socio-demographic parameters such as age, gender, level of education, and household size. Farming experience, farm size, and the purpose of growing bananas were also addressed.

Data Processing and Analysis

Data were cleaned, coded, and checked for consistency before analysis. Quantitative data were analysed using Stata version 14 software. Descriptive and inferential statistics were both analysed. Descriptive statistics such as mean and percentages were used to make cross-tabulations and frequency tables. Inferential statistics, for instance, correlation analysis and chi-square test were used to analyse data on factors that influence banana farmers' usage of mobile phone applications in obtaining agricultural information data.

RESULTS

Assessing the Extent of Farmers' Awareness about Mobile Phone Applications

Respondents' Socio-economic Characteristics

The average age of farmers in the study sites was 47 years (Table 1). On average, five members in a family participate actively in banana plantation activities. Male respondents (52.1%) were slightly more than the female respondents (47.9%). The results indicate that slightly more than three-quarters (77.1%) of families had 4 to 9 members. The study also established that the average years of experience in farming of the respondents were 19 years. From the survey, farmers had different sizes of banana plantations, with the majority having more than one and a half hectares (59%). Results show that most of the respondents (84%) grow bananas for both food and cash.

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Table 1: Socio-economic Characteristics of Respondents

Characteristics	Number of respondents	Mean	SD
Age (years)	144	47.2	12.3
Farming experience (years)	144	19.3	11.7
Member participating in the banana plantation	144	4.7	2.6
		Number of respondents	% respondents
Sex	Female	69	47.9
	Male	75	52.1
Household size	1-3	9	6.3
	4-6	53	36.8
	7-9	58	40.3
	≥10	24	16.7
Size of banana plantation (Ha)	≤0.5	26	18.1
	0.51-1	33	22.9
	1.01-1.5	30	20.8
	1.51-2	59	38.2
Farm size (Ha)	<1	22	15.3
	1-3	57	39.6
	3.1-5	29	20.1
	>5	36	25.0
Purpose of banana growing	Food only	21	14.6
	Cash only	2	1.4
	Both	121	84.0

Farmer's ownership of mobile phones

All the respondents owned a mobile phone (100%), but most of the respondents (61.8%) owned basic phones (Table 2). The study also revealed that families had different numbers of mobile phones, where most (88.2%) of the families had more than two phones. The study established that farmers had varied levels of awareness that mobile phones had different applications, including SMS text, FM radio, camera/ video, calculator, and audio recorder.

Table 2: Farmers' Ownership and Usage of Mobile Phones

Variable		Frequency	% respondents
Phone ownership	Yes	144	100.0
Phone type	Basic phone	89	61.8
	Smartphone	55	38.2
Number of phones in a family	1	17	11.8
	2	47	32.6
	3	43	29.9
	>3	37	25.7
Usage of applications on the phone	SMS text	144	100.0
	FM radio	140	97.2
	Camera or video	112	77.8
	Calculator	141	97.9
	Audio recorder	108	75.0

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Phone Calls and the Purpose for Calling

Results show that 38.2% of the respondents made phone calls in the last twelve months for agricultural reasons (Table 3). Farmers make phone calls for specific agricultural purposes, with the majority calling for extension services (33.2%), followed by 28.6% of respondents who call for market information. The results indicate that most of the farmers have ever used mobile phones to obtain agricultural information (66.8%). The study revealed that farmers' frequency of using mobile phones to obtain agricultural information varied, with 35.5% using it frequently, 18.8% using it occasionally, 12.5% rarely using the phone and 33.3% never using the phone for agricultural reasons.

Table 3: Proportion of Respondents Making Phone Calls for Different Purposes

Variable	Farmer response	Number of respondents	% respondents
Phone calls made in the past 12 months for agricultural reasons	Yes	55	38.2
	No	89	61.8
Specific agricultural purpose for calling others	Access to agricultural inputs	61	28.1
	Extension services	72	33.2
	Market information	62	28.6
	Financial transactions	22	10.1
Frequency of use of mobile phones to obtain agricultural information	Frequently	51	35.5
	Occasionally	27	18.8
	Rarely	18	12.5
	Never	48	33.2

The Farmer's Frequency of Calling and Messages Received

Most farmers call 1 to 3 times (39.6%) in a month to obtain agricultural information (Table 4). Few farmers (3.4%) call more than 10 times a month. The agricultural messages received are mainly technical advice from experts (32.2%), followed by information concerning markets (28.8%), information on agro inputs (28.4%), agriculture emergency security (6.4%), and financial-related information (4.2%).

Table 4: Farmers' Use of Mobile Phones to Access Agricultural Information

Variable		Number of respondents	% respondents
Frequency of calling to obtain agricultural information	1-3 times	57	39.6
	4-6 times	27	18.8
	7-10 times	12	8.3
	>10 times	5	3.5
Agricultural message received	Information on agricultural inputs	67	28.4
	Technical expert advice	76	32.2
	Market information	68	28.8
	Agriculture emergency security	15	6.4
	Financial-related information	10	4.2

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Farmer's Awareness of Mobile Phone Applications

Most of the farmers (66.7%) were aware of mobile phone applications used for accessing agricultural information. Farmers were aware of WhatsApp (34.9%) and Facebook (31.4%) as the main mobile phone applications that provide agricultural information. Others, such as M-voucher (0.8%) and ERIGUNU SURFACE (1.1%), were the least known to farmers (Table 5).

Table 5: Proportion of Respondents Aware of Mobile Phone Applications that Provide Agricultural Information

Variable	Mobile phone application awareness	Number of respondents	% respondents
Awareness of mobile phone applications	Yes	96	66.7
	No	48	33.3
Mobile phone applications that provide agricultural information	M-Omulimisa	45	17.1
	ERIGUNU-SURFACE	3	1.1
	Jaguza	7	2.7
	M-Voucher	2	0.8
	WhatsApp	92	34.9
	EasyAgric	5	1.9
	Ensibuko	27	10.2
	FaceBook	83	31.4

Farmers' Usage of Mobile Phone Applications in Obtaining Agricultural Information for Managing BXW Disease

Mobile Phone Applications Used by Farmers for BXW Management

The study revealed that most of the farmers were not using mobile phone applications for accessing information on banana Xanthomonas wilt disease (74.3%). WhatsApp (53.9%) and Facebook (29.2%) were mostly used by the farmers to obtain BXW management information (Table 6).

Table 6: Farmers' Use of Mobile Phone Applications in the Management of BXW

Variable	Applications used	Number of respondents	% respondents
Mobile phone use for BXW management	Yes	37	25.7
	No	107	74.3
Applications used	M-Omulimisa	10	15.4
	WhatsApp	35	53.9
	Ensibuko	1	1.5
	Facebook	19	29.2

Information Received by Farmers through Mobile Phones Concerning BXW

The study shows that respondents received different information through mobile phones concerning BXW (Table 7). Information received mostly was on the destruction of infected plants (29.7%) and least on the prevention of disease spread from one farm to another (20.2%).

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Table 7: Information Received for Control of BXW through Mobile Phone Application

Information received for BXW management	Number of respondents	% respondents
Source of disease-free suckers and corms	81	23.3
Symptoms of diseased banana plants	93	26.8
Destruction of infected plants	103	29.7
Prevention of disease spread from one farm to another	70	20.2

Determinants of Banana Farmers' Usage of Mobile Phone Applications

Findings on factors that influence mobile phone use by farmers are presented in Table 8. Factors included age, gender, number of years in school, household size, farming experience, banana plantation size, average number of bunches per season, and constraints encountered while using the mobile phone application. Number of years in school (P = 0.014), banana plantation size (P = 0.049), and constraints encountered while using mobile phone applications (P = 0.023) were significant in influencing mobile phone use.

Table 8: Logit Regression Model for Mobile Phone Use by Farmers

Factor	Coef.	Std. Err.	Z	P>z	95% Conf.	Interval
Sex	0.53	0.39	1.38	0.168	-0.22	1.29
Age	-0.04	0.02	-1.58	0.115	-0.08	0.01
Number of years in school	0.12	0.05	2.46	**0.014**	0.02	0.21
Household size	0.19	0.30	0.65	0.516	-0.39	0.78
Farming experience	0.01	0.02	0.33	0.738	-0.04	0.05
Household member participating in banana growing	-0.07	0.09	-0.8	0.425	-0.25	0.10
Banana plantation size	0.35	0.18	1.97	**0.049**	0.00	0.69
Number of bunches per season	0.01	0.01	0.89	0.375	-0.01	0.02
Ever used a mobile phone to obtain information on BXW	0.62	0.48	1.31	0.192	-0.31	1.56
Number of mobile phones	0.35	0.24	1.45	0.146	-0.12	0.82
Constraints	-3.34	1.47	-2.28	**0.023**	-6.22	-0.47
Overall logistic model evaluation						
Number of observations			144			
Likelihood Ratio χ^2			24.6			
P-value (LRT)			**0.006**			
Log likelihood			-83.443			
Pseudo R^2			0.128			

The overall fit of the logistic regression model was assessed using the likelihood ratio test, which yielded a value of -83.443. The model with the predictor variables showed a significantly better fit to the data compared to the null model (Likelihood Ratio $\chi^2 = 24.6$, $p = 0.006$). The model explained 12.8% of the variance in banana farmers' use of mobile phone applications to access information on management of BXW.

Results show that farmers encounter several challenges while using mobile phone applications for accessing agricultural information (Table 9). According to the ranking, lack of smartphones is the

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first challenge, followed by limited knowledge and skills, poor network and reception, lack of electricity for recharging phone batteries, language barrier, high cost of maintenance, too complicated, increased taxes, and high rates for services.

Table 9: Challenges Encountered by Banana Farmers while Using Mobile Phones for Accessing Agricultural Information

Challenges faced while using mobile phones	Frequency	% respondents
Language barrier	57	10.0
Too complicated for the farmer	50	8.8
High maintenance cost	54	9.5
Poor network and reception	71	12.5
High payment rates for services	39	6.9
Lack of electricity for recharging phone batteries	66	11.6
Increased taxes	46	8.1
Lack of smartphones	100	17.6
Need more knowledge and skills to improve the services	86	15.1

DISCUSSIONS

Socio-economic Characteristics of Farmers and Their Extent of Awareness about Mobile Phone Applications

The results indicate that the average age of farmers was 47 years. The farmers were in the active age bracket, explaining why some farmers were willing to use new technologies like mobile phones. A farmer's age highly affects adoptions and use of ICTs (Das et al., 2012; Mittal & Tripathi, 2009). According to the results, the male farmers (52.1%) used mobile phones more than their female counterparts (47.9%). This may be attributed to most farm resources being controlled by males. Related results were recorded in Uganda, where women had 36% fewer ICT-related opportunities and benefits than men (Masuki et al., 2010).

The survey results showed that more than three-quarters (77.1%) of the households had a number of household members ranging from four to nine, suggesting big family sizes per household in the study area. It is anticipated that many household members greatly increase the likelihood of mobile phone use compared to a smaller family size (Ogutu et al., 2014; Senthilkumar et al., 2013). Survey findings also reveal that on average, farmers' experience in banana growing was 19 years. More years of experience in farming may prompt farmers to embrace mobile phones in obtaining agricultural-related information. The experience a farmer has in agriculture may correlate positively with ICT use (Adegbidi et al., 2012). Experienced farmers have a tendency to use mobile technology more than individuals having less experience. As a result, there is increased exposure to the use of ICT in farm activities, including market access (Abebe & Mammo Cherinet, 2019; Do et al., 2023; Hoang, 2020).

The size of the farm plays a central role in the adoption of mobile phone technologies (Do et al., 2023; Michels et al., 2020; Ogutu et al., 2014). Due to population pressure in the surveyed area, land is limited. For example, 54.9% of the farmers owned less than three hectares of cultivable land. Limited farmland may therefore have contributed to lower farmers' revenues, and as a result, it leads to less access for farmers to technologies, for instance use of smartphones. Related studies show that farmers having large-sized farms have better earnings, which may promote enhanced access to

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technological innovations (Adegbidi et al., 2012; Ogutu et al., 2014; Senthilkumar et al., 2013). These findings recommend that families having large sizes of farms should be targeted for smartphone use in enhancing banana production.

Ownership of a mobile phone influences the level of adoption of farming technologies (Ogbeide & Ele, 2015). Ownership creates the willingness to explore the phone and its functionalities and increases the ability to use them for diverse situations. The results show that all (100%) respondents owned a mobile phone; however, only 38.2% owned smartphones. This implies that smartphone ownership and use among respondents were low. Previous studies observed that limited use of mobile phones could be attributed to limited knowledge on their importance in accessing farming information (Ogutu et al., 2014; Senthilkumar et al., 2013). In addition, this could be attributed to the small farm size, which directly affects the farmer's income and hence not able to purchase a smartphone. Thus, the use of mobile applications like m-Omulimisa, WhatsApp, Facebook, EasyAgric, Jaguza and Ensibuko was infrequent. The owning and use of basic phones by most (61.8%) farmers implies that these phones are affordable, and their features are not as complicated as those of smartphones. Several authors have argued that once an innovation is not too complex, it will be easily adopted (Batz et al., 1999; Giua et al., 2022; Kumar et al., 2018; Park & Chen, 2007). Results showed that most of the families had more than two phones (88.2%). Most of the family members having more than two phones could have increased the probability of phone usage in obtaining agricultural-related information in a family.

The duration of mobile phone ownership has been previously reported to enhance the possibility of using a mobile phone for farm-related activities (Tadesse & Bahiigwa, 2015). The results showed that most of the respondents had used a mobile phone for an average of 15 years. Studies by Ogbeide and Ele (2015) show that more than 65% of the surveyed farmers have used a mobile phone for more than six years. The two studies both indicate a strong adoption of the phone technology and agree with the findings of Qiang et al. (2011) that the adoption of information technology in agriculture is increasing in the Sub-Saharan Africa.

The low level of awareness in the use of mobile phones for accessing farming information has been reported by several authors, Akinyemi et al. (2024) and Songol et al. (2024). Our survey results, however, indicated that most of the farmers were aware of mobile phone applications used for farming information. They were mostly aware of WhatsApp, followed by Facebook. This could be due to the ability of some basic phones also have such applications and have access to the internet. Most farmers were not aware of other mobile phone applications such as ERIGUNU SURFACE, EasyAgric, Jaguza, Ensibuko, and m-Omulimisa, probably because of limited sensitisation about the existence of such applications (Misaki et al., 2018).

Farmers' Use of Mobile Phone Applications in the Management of BXW

The results show that few (25.7%) farmers were using mobile phone applications to obtain information for BXW disease management. This could be attributed to the availability of other sources of information like extension workers, radios and televisions, which are perceived by farmers as cheap and reliable. The few farmers who use smartphones for accessing information on BXW are likely to be educated and with a good source of income. The level of education and farmer income were highlighted as key factors in adopting mobile phone technologies (Giua et al., 2022). WhatsApp and Facebook were the applications used by the farmers most because of their compatibility with both smartphones and some basic phones. Other applications used included m-Omulimisa and Ensibuko, which were used to a limited extent because farmers were not aware of them and/or did not know how to use them to obtain the needed information.

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Banana disease surveillance was reported to be conducted using smartphone technologies (Nakato et al., 2016). Access to farming information has been indicated as the best tool for the management of BXW (Kubiriba et al., 2023; Tinzaara et al., 2018). The current study results indicate that farmers received information on their phones mainly on how to destroy infected banana plants, identify various symptoms of diseased banana plants, source disease-free planting materials, and to prevent disease spread from one farm to another. This information has been so helpful in the management of BXW, and farmers stated that they have been able to manage BXW by putting into practice the information received. There is a general feeling among farmers that there is increased banana production because of the information they receive from mobile phones.

Determinants of Banana Farmers' Usage of Mobile Phone Applications

The findings showed that the number of years in school, banana plantation size, and constraints encountered while using mobile phone applications were the only significant factors influencing mobile phone use. These results contradict most existing studies, which showed that farmers' gender, age, household size, farming experience, and number of mobile phones are determinants of smartphone adoption (Akinyemi et al., 2024; Michels et al., 2020; Songol et al., 2024). However, the results are related to those from the studies conducted by Kirui et al. (2010) and Misaki et al. (2018), which indicated that the level of education is key in the adoption and use of mobile phone technology among farmers. Thus, the low level of education among farmers in Africa limits its use and adoption. In addition, it is generally thought that the level of education enhances the ability to comprehend and adopt relevant agricultural information. Indeed, according to Kalungu and Leal Filho (2018) and Olayemi et al. (2020), highly educated farmers tend to adopt relevant agricultural technologies better than illiterate ones. Most banana farmers in Uganda are illiterate, and this limits their adoption of smartphone technologies (Olayemi et al., 2020). Introduction of mobile phone technologies early to students who are the future farmers and extensionists will facilitate adoption and introduction to other farmers through training, sensitisation, and interactions.

The size of the banana plantation was a significant factor in influencing the use of the mobile phone application to obtain agricultural information. Studies conducted by Williams and Agbo (2013) revealed that farmers with large pieces of land under production between 6 to 20 acres are better at new technology use and adoption due to better production than the small-scale farmer. Equally, large-scale farmers are willing to try out a new technology because even if it fails, it will not affect their income greatly, as it would with the small-scale farmer with a low income (Deribe, 2011). It is argued that farmers having big farm sizes have better income levels, which results in more access to technologies (Adegbidi et al., 2012; Deribe, 2011; Martin & Kahamba, 2017).

Furthermore, the study showed that farmers encountered several challenges while using mobile phone applications. Lack of smartphones was one of the key challenges, followed by limited knowledge and skills. This could be attributed to small farm sizes, which lead to low incomes, making it expensive for the farmers to afford smartphones. These challenges that limit the use of smartphones for accessing agricultural information by sub-Saharan farmers have been previously reported (Akinyemi et al., 2024; Jato & Terna, 2015; Kabirigi et al., 2023; Misaki et al., 2016; Songol et al., 2024). This, coupled with low education levels of the farmers, makes it difficult for the farmers to fully operate smartphones. Due to the rural setup of most of the farms, farmers have encountered, among others, a poor network and the absence of electric power for recharging phone batteries. This agrees with previous reports which pointed out the high cost of mobile phones, low education level,

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absence of electric power for recharging phone batteries, and erratic network in villages as the main barriers to owning and use of mobile phones (Akinyemi et al., 2024; Dehnen-Schutz et al., 2016; Kabirigi et al., 2023; Okello et al., 2010). To address some of the key challenges, the government should provide incentives for or collaborate with telecommunications companies to improve infrastructure and to lower the costs of sending messages, making phone calls, and internet bundles. Further, farmers can collaborate to access information through mobile phones by contributing money for internet data bundles or making phone calls to experts.

CONCLUSIONS

Mobile phones are increasingly becoming vital as a communication tool in increasing farmers' access to agricultural information, especially concerning BXW, which has been and still is a threat in banana production. There is generally limited awareness about the existing mobile phone applications as key sources of information among banana farmers in Uganda. Most farmers had mobile phones but revealed low skills in operating them, hence usage is mostly limited to phone calls. Due to limited knowledge of mobile phone use, the farmers could not obtain information from Internet-based sources, for instance, web portals and Android applications. Few farmers use mobile phone applications. The major constraints to banana farmers' use of mobile phone applications to obtain agricultural information for managing BXW disease are not owning a smartphone, lack of electricity for recharging phone batteries, poor network and reception, and language barrier. Three factors, i.e., banana plantation size, education level, and constraints encountered in mobile phone use, are the most important factors that influence farmers' use of mobile phone applications in the management of BXW.

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Informed Consent Statement:

Informed consent was obtained from all subjects of the study

Data Availability Statement:

Access to the data from this study is available upon request via email.

Conflict of Interest:

The authors declare no conflict of interest.

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