Effect of on-farm testing on adoption of banana production technologies among smallholder farmers in Meru region, Kenya

Florence Kaumi Kirimi
Agricultural Economics and Extension, University of Embu, Embu, Kenya
Charles Nyambane Onyari
Land and Water Management, University of Embu, Embu, Kenya
Lucy Karega Njeru
College of Agriculture and Veterinary Sciences, University of Nairobi, Kangemi, Kenya, and
Hezron Rasugu Mogaka
Agricultural Economics and Extension, University of Embu, Embu, Kenya

Received 11 May 2021
Revised 11 August 2021
Accepted 20 August 2021

Abstract

Purpose – The purpose of this paper is to investigate the effect of on-farm testing on the adoption of banana production technologies among smallholder farmers in the Meru region, Kenya.

Design/methodology/approach – The study adopted a pragmatic paradigm and a cross-sectional survey design, sampling 370 and 30 farmers proportionately from 269,499 to 19,303 smallholder banana farmers in Meru and Tharaka-Nithi Counties of Kenya, respectively.

Findings – The study revealed that there was an association between belonging to a banana farming testing group and the adoption of banana technology. The study also revealed that most farmers were not interested in adopting banana technologies as they preferred the use of conventional methods, due to unstable market prices, lack of subsidized banana production input, inaccessibility to technological materials, few extension experts and lack of enough demonstrations.

Research limitations/implications – Some respondents were not willing to freely offer the information required for this study. This was delimited by assuring the informants of the confidentiality of their responses.

Originality/value – The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The agricultural extension service providers will have more light on the underlying issues that need to be considered if meaningful interventions are to be done on various aspects of the banana value chain.

Keywords On-farm testing, Adoption of banana production technology, Small holder farmers

Paper type Research paper

1. Introduction

In Sub-Saharan Africa (SSA), agricultural productivity has been the world's foremost global challenge (United Nations, 2013). Eastern and Southern Africa produce over 20 m tonnes of bananas annually which accounts for 26% of total world output. The region is also the world's leading consumer of bananas with an annual per capita consumption rate of 400–600 kg. The crop utilizes about 1.4 m hectares or 38% of agricultural land, making it the most widely grown crop and serves as one of the most important foods security crops for Central, Western and Eastern Africa (Obaga, 2018). It is also regarded as one of the most important staple crops,

The authors acknowledge the contributions of the University of Embu and the farmers who availed the useful information required during the research and the reviewers for enriching the article. The research was self-funded. No funding was received.

Journal of Agribusiness in Developing and Emerging Economies

2044-0839
DOI 10.1108/JADEE-04-2021-0100

contributing about 20% of total food consumption and 14% of total crop value. Nearly 24% of all agricultural households are engaged in banana production (Kalyebara and Islam, 2014).

Over the years, on-farm demonstrations have been used by extension providers all over the world to evaluate the performance and potential application of a particular farming practice using valid experiments (Ajayi and Solomon, 2017). Often, farmers receive minimal help from extension educators or researchers such as in designing the tests, locating portable weighing equipment for harvest and interpreting the results. The aim is for the farmer to learn through observation and experience, thereby making an informed decision to use the technology being tested. According to Corn agronomy (2015), today's farmers have access to a growing range of crop management resources. Precision farming innovations, biotechnology and advances in pesticides, machinery and other agricultural inputs are all convergent and arriving at the farm gate at an unparallelled pace. Farmers will easily learn how techniques, products and equipment can perform in their cropping systems by conducting on-farm testing. Farmers have been using on-farm testing for decades, putting rows or strips of various practices inside their fields for comparison. With the help of formalized on-farm test systems and the use of Global Positioning System (GPS) and precision technology, on-farm trials are now easier to perform.

In Kenya, a banana is the most popular fruit (Joachim *et al.*, 2018). In 2017, Meru County banana production was at a level of 210,450 tonnes, down from 276,919 tonnes in 2016 and 251,132 tonnes in 2015 (Horticultural Validated Report, 2014; Meru County Integrated Development Plan, 2018–2022). In 2016, Tharaka-Nithi County banana production was at a level of 76,633 tonnes, down from 79,823 in 2014 (Tharaka-Nithi County Integrated Development Plan, 2018–2022). This decline in banana production could be attributed to several challenges. Limited access to and use of improved and certified planting materials is a major challenge to banana production (Kikulwe *et al.*, 2018). Farmers in most areas predominantly rely on suckers obtained from uncertified sources or fields which do not guarantee optimal production (Ocimati *et al.*, 2013).

2. Literature review

2.1 On-farm testing and adoption of technologies

An efficient and effective extension system is a vital tool for the dissemination of information on improved practices as well as better uptake of these technologies (Suvedit *et al.*, 2017). A study on the appropriateness of various extension methods in Nigeria revealed that field demonstrations and individual farm visits are the most effective extension approaches (Abdulhamid *et al.*, 2017). However, the extension agents should employ various training strategies that ensure effective resource use and farmer participation for better adoption.

To improve adoption of chilli production technologies in Bangladesh, Sarker (2016) recommends that technology transfer agents should actively take up the responsibility of guiding farmers through extension visits to train them on the adoption of coming technologies. The significant role played by technology transfer agents in the adoption of farming technologies is further confirmed by Ajayi and Solomon (2010) who found that extension contact had a significant correlation with the adoption of oil palm technology in Nigeria. It is therefore important that agricultural scientists and extension officers seek to improve banana productivity through training, regular visits and constant guidance to farmers (Poonam and Jhariya, 2017). These works show that on-farm testing and adoption of new or emerging technologies on banana production can be useful tools in promoting a vibrant banana value chain in Kenya. New technology is "new" to a group of farmers or a particular place or represents a "new" use of technology that is already in use amongst a group of farmers or within a particular place (Loevinsohn *et al.*, 2013).

Adoption, on the other hand, is also defined in different ways by various authors. Loevinsohn *et al.* (2013) defines adoption as the integration of new technology into existing practice and is usually continue by a period of "trying" and some degree of adaptation. Adoption is in two categories; the rate of adoption and intensity of adoption. The former is the relative rate at which farmers adopt an innovation, has as one of its pillars, the element of "time." Technology adoption is a complex task because it varies with the technology being adopted. Adoption of agricultural technologies defines as the decision to apply technology and to continue with its use. The agricultural economists, extensionists and rural sociologists have long been of interest in the importance of farmers' adoption of new agricultural technology. It means the definition is based on the fact that the farmer is either an adopter of the technologies or a non-adopter taking values zero and one or the reply is a continuous variable (Challa, 2013).

A range of factors that influenced the rate of agricultural technologies adoption has been broadly categorized into economic, social and institutional factors (Mamudu *et al.*, 2012). Land size, the initial cost of a technology or its expected benefits after adoption versus the cost incurred during adoption and the farmers income levels from other off-farm economic activities are all the economic factors that have been identified. Social factors that have identified to influence the chances of adoption by a farmer include the farmer's age, level of education, gender and social groupings. Institutional factors that influence and determine the rate of agricultural technologies adoption and uptake by farmers include access to information about the technologies through the existing and accessible information sources, nature of policies and provisions enacted by the government and access and nature of the extension services provided.

In a study by Langat *et al.* (2013) having access to the plantlets could no longer be possible for those farmers who had earlier accessed tissue culture banana in Bungoma district because the hardening orchards were no longer in existence. Farmers lack access to inputs and/or where to sell their produce because there were no organized marketing organizations. Closeness to main markets was also the main issue, as most of the farmers sold their yield at the farm gate. Another major challenge in banana production is pests and diseases which prompt the application of biological and IPM (integrated pest management) in the control of pests and diseases.

Farmers who are participating in group demonstration have been found to more efficient in agricultural production. This has been shown by Bairagi and Mottaleb (2021) who conducted a study on "Participation in farmers' organization and production efficiency: empirical evidence from smallholder farmers in Bangladesh." They found out that farmers who participated in an organization had higher rice yield (11% more) and were technically more efficient (1.4% points higher) compared to farmers who did not participate. Therefore, this implies that on-farm group testing is important in improving agricultural productivity.

Farmers who are in groups are likely to benefit from their farm produce, unlike farmers who are not into groups. This has been demonstrated by Abdul-Rahaman and Abdulai (2020) who carried out a study on "Farmer groups, collective marketing and smallholder farm performance in rural Ghana" and found out that group members and collective marketing participants obtained higher prices and also incurred lower input costs. The authors also discovered that farmer group membership and joint marketing had a positive and substantial effect on farm net revenues. Nguyen *et al.* (2020) conducted a report on "Farmer Participation in the Lychee Value Chain in Bac Giang Province, Vietnam." Farmers' confidence levels, partner capability, geographical distance between participants, collaborative culture, participation strategy and the presence of specific government policies all had major impacts on farmer participation and the resulting chain thickness (Nguyen *et al.*, 2020).

Sathapatyanon *et al.* (2018) published a study titled "The role of farmer organizations and networks in the rice supply chain in Thailand." The study found that as a result of joining the cooperatives, key problems faced by members of the cooperatives, such as exploitation and opportunistic behaviour of merchants to whom they sell their goods, had been reduced. A research was carried out by Khandker and Thakurata (2018) on "Factor encouraging complete adoption of agriculture technology: Case of hybrid rice farming in India." The study found out that farmers with smaller landholdings, higher education and more experience growing hybrid rice were more likely to be full adopters. Farmers who reported strong demand for hybrid rice production and the availability of hybrid rice seed subsidies were more likely to be full adopters.

2.2 Conceptual framework

This study was developed on the foundation of innovation diffusion theory advanced by Rogers (2005). Rogers defined diffusion as the process by which an innovation is communicated through certain channels over time among the members of a social system. According to Rogers (2005) most farmers evaluate an innovation, not based on scientific research by experts, but through the subjective evaluations of near-peers who have adopted the innovation. The researcher notes that professionals in several disciplines, from agriculture to marketing, have used this theory to increase the adoption of innovative products and practices. Several factors are interacting to influence the diffusion of an innovation. The four major factors are the innovation itself, how information about the innovation is communicated, time and the nature of the social system into which the innovation is being introduced (Rogers, 2005).

There are five stages to the process of adopting innovation, namely knowledge, persuasion, decision, implementation and confirmation. For instance, innovators are the first percent of the individuals in a system to adopt a banana technology (Vejlgaard, 2018). This theory is relevant for the study since banana farmers become aware of innovation but do not have information about it, farmers thus become actively interested in seeking knowledge about the existence of innovation and its merits. They subsequently weigh the advantages and disadvantages of the innovation, decide whether or not to adopt it, implement the innovation in which the individual does adopt and uses the innovation and confirm the decision about whether or not to continue using it based on his/her own experience with it.

Figure 1 shows the relationship between on-farm testing and the adoption of banana production technologies among smallholder farmers. The diagram is a figurative representation of the relationship between the variables that were used in the study. The independent variable is on-farm testing which is measured by (groups taking part in demonstrations/trials, number of extensions visits for trials/follow-ups) adoption of banana

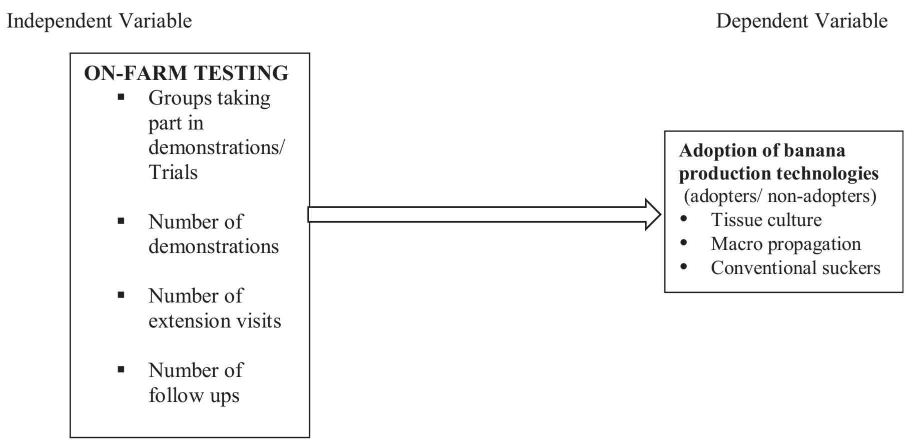

Figure 1.
Conceptual framework

production technologies among smallholder farmers. The dependent variable is the adoption of banana production technologies among smallholder farmers.

3. Methods

This study adopted a cross-sectional survey research design. Data were collected to make inferences about a population of interest (universe) at one point in time, thereby taking care of attrition (Cooper and Schindler, 2003) In this research design data was collected on one occasion and represents a snapshot of the respondents' responses at that specific point in time. Therefore, this design was used for the study to seek information on the effect of on-farm testing on the adoption of banana production technologies among smallholder farmers in Meru and Tharaka-Nithi counties. The study targeted 19,303 and 269,499 smallholder banana farmers' households in Tharaka-Nithi and Meru counties, respectively (Table 1). These counties initially formed the greater Meru District before splitting into the two administrative units.

3.1 Sampling design and procedure

The subcounty from each of the two counties formed a stratum. Based on the sampling formula provided by Yamane (1967) and adopted by Israel (1992), a sample size of 400 farmers for Meru and Tharaka-Nithi Counties were used.

$$n = \frac{N}{1 + N(e)^2} \tag{1}$$

where n was the sample size, N was the population size, e is the level of precision or the significance level.

Therefore,

$$\text{Sample size} = \frac{288,802}{1 + 288,802(0.05)^2} = 400$$

Questionnaires were administered face to face to proportionate samples of 370 and 30 banana farmers in Meru and Tharaka-Nithi Counties(Table 2 and Table 3), respectively. The suitable sample size for farmers in each subcounty was arrived at, first by calculating the proportional percentage of farmers in every subcounty and then using the percentage to get the actual sample size for farmers. The study used a structured and semi-structured questionnaire. The selection of tools was guided by the nature of the data that was collected as well as the objectives of the study. The questionnaires were used to solicit information on the views, opinions, and perception of the farmers on the adoption of tissue culture and macro propagation since they are the most suitable tool for survey research (see Tables 4 and 5).

County	Target population	Sample size
Meru County	269,499	370
Tharaka-Nithi County	19,303	30
Total	288,802	400

Source(s): Tharaka-Nithi County Integrated Development Programme, 2018–2022; Meru County Integrated Development Programme, 2018–2022

Table 1. Population

3.2 Empirical model

Descriptive and inferential statistics were used to analyse data. The Statistical Package for Social Science programme (SPSS) was used to analyse collected data. Descriptive statistics were used to summarize the data in the form of frequencies and percentages. The binary logistic regression model was used as follows:

Adoption was measured as a binary variable taking values 1 for adopters (farmers who have adopted banana production technology) and 0 for nonadopters (those farmers who have not adopted production technologies). The effect of on-farm testing on the adoption of banana production technologies was analysed using a binary logistic regression model which was represented as shown below:

$$P_i = F(Z_i) = 1/\left[1 + e^{-\ (\alpha + \Sigma\beta_i X_i\ )}\right] \quad (2)$$

Table 2. Distribution of sample size for Meru County

Sub county	Population (of banana farmers)	%	Sample size
Imenti South	114,911	42.638	157
Imenti North	52,800	19.592	72
Imenti Central	39,182	14.538	54
Tigania West	28,056	10.410	39
Tigania East	20,136	7.492	28
Igembe South	14,414	5.348	20
Total	269,499	100	370

Source(s): (Meru County Integrated Development Programme, 2018–2022)

Table 3. Distribution of sample size for Tharaka-Nithi County

Sub-county	Population (of banana farmers)	%	Sample size
Maara	10,886	56.395	17
Chuka/Igamba-ngo'mbe	8,417	43.605	13
Total	19,303	100	30

Source(s): (MOALF Reports, Tharaka-Nithi County 2019)

Table 4. Production characteristics

Production characteristics		*N*	%
Rate of banana production	High	65	16.3
	Average	285	71.3
	Low	36	9.0
	Not sure	14	3.5
	Total	400	100.0
Acreage of bananas	0–2	308	77.0
	2–4	69	17.3
	4–6	23	5.7
	Total	400	100.0
Variety of banana commonly grown	William hybrids	131	32.8
	Grand Nain	90	22.5
	Giant Cavendish	85	21.3
	Traditional	82	20.5
	Others	12	3.0
	Total	400	100.0

Source(s): (Author, 2021)

where P_i was the likelihood of adoption of production technologies, X_i represents ith predictor variable, α and β_i was the parameter estimates and e is the base of the natural logarithm. The equation can further be represented in terms of odds ratios and the log of odds as

$$\frac{P_i}{1 - P_i} = e_i^Z \tag{3}$$

where $1 - P_i$ is the probability of farmers not adopting production technology. Taking the natural log of the equation gives

$$\ln\left(\frac{P_i}{1 - P_i}\right) = Z_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_n X_n + U_i \tag{4}$$

where U_i is the error term.

4. Results and discussion

4.1 Study variables summary and expected effects

A total of 400 household questionnaires were distributed and 400 questionnaires were returned giving a response rate of 100%.

The study sought to determine the size of land devoted to banana production in the two counties and the results presented in Table 2. The results show that more than three-quarters of the responses (77.0%) had land sized up to two acres set aside for growing bananas while 17.3% owned between 2 and 4 acres of land for the crop. Only a few (5.7%) owned lands set aside for the crop. These findings imply that all the banana growers interviewed are small-scale farmers, which in itself can limit expanded production and subsequently low farm incomes from the crop. The findings are in line with those of (Mwendia, 2019) who carried out a study on an investigation of the drivers of diversification to banana farming among households in Meru county, Kenya, and found out that most of the respondents had very small portions of land sizes which limited diversification to large scale banana farming in the study area. The main cause for small portions of land sizes under banana farming was increased population which led to subdivisions of land among the main beneficiaries of land from their parents.

4.2 Rate of banana production

The study sought to find out the farmers' view on the rate of banana production (Table 2). It was noted that 71.3% of the respondents were of the view that the production level of the crop was average, while 16.3 and 9.0% felt that the production rates were high and low, respectively. This shows that a great majority (87.6%) can confidently opine above-average production level and only 9.0% thought that the production level of the crop was low. It was

Involvement in farm testing of the technology		*N*	%
Involvement in any one farm testing banana production technologies	Yes	169	62.1
	No	103	37.8
	Total	272	100
If yes which production technology	Tissue Culture	68	17.0
	Macro propagation	9	2.3
	Conventional suckers	80	20.0
	Others	12	3.0
	Total	169	42.3

Table 5. Adoption of banana technologies

noted that partly 3.8% of the interviewees were not sure of the level of banana production in their home areas. Work by Macharia *et al.* (2010) reveals that the decline in banana production in the Eastern region, especially in Tharaka-Nithi County, is mainly attributed to poor agronomic practices, pests and diseases and inadequate access to clean planting materials among other aspects in the banana value chain. William (2018) asserts that climate variability is a key factor affecting banana production globally. The findings are also in line with those of Khandker and Thakurata (2018) who found out that farmers who reported strong demand for hybrid rice production and the availability of hybrid rice seed subsidies were more likely to be full adopters of technology.

4.3 Variety of banana commonly grown

The study sought to find out the varieties of bananas commonly grown by the farmers (Table 2). The findings revealed that the most popular variety was William Hybrid (32.5%) followed by Grand Nain (22.5%), Giant Cavendish (21.3%) and the local or traditional type (20.5%). This shows that the preference for the latter three is relatively similar among the farmers, although about one-third grow more of the William Hybrids due to market demand. The findings are in agreement with those of (Meru county government report, 2019) who found out that Meru County is known for the production of different varieties of banana, such as the William Hybrid, Gross Mitchel (Kampala), Giant Carendash, Uganda Green (Kiganda) and plantains are commonly known as Gichagara, among others, Meru is the leading banana producer the country, with an estimated value of over Ksh. 6 B as per the research done in 2016 (Meru county government report, 2019).

4.4 Adoption of banana production technologies

The results for the proportion of respondents who had adopted various technologies in banana production are presented in Table 3. The majority of the respondents, 62.1% ($n = 169$) stated that they had adopted banana production technologies while 37.8% ($n = 103$) reported having not adopted the technologies in their farming system. The study also found out that the other respondents [20% ($n = 80$) and 17% ($n = 68$)] had adopted conventional suckers and tissue culture technologies, respectively. Only 2.3% of the responses had adopted the use of macropropagation technology while the rest had adopted other unidentified technologies in banana production. Also, it was observed that more than half (57.8%) of the interviewees did not respond to this question, which is the same proportion of farmers who reported not to use any banana growing technologies. The findings are in line with Wambugu *et al.* (2015) who found out that tissues culture banana is grown for both subsistence and commercial purposes, but the potential benefit of tissue culture materials is yet to be fully realized amongst the Kenyan population due to low adoption. Though adaptable, the tissue culture bananas are highly suitable in the eastern region of Kenya and may significantly contribute to the improved food situation in areas very vulnerable to food insecurity (Wambugu *et al.*, 2015).

4.5 On-farm testing and adoption of banana production technologies

The study sought to find out the level of on-farm testing and adoption of banana production technologies among the farmers in the two subcounties of Meru (Table 6). The findings showed that certain variables influenced the level of adoption of banana technologies by the farmers. The association between belonging to a banana farming group and adoption of technology was statistically significant at the 1% level of significance (p-value $= 0.000 < 0.01$, $\chi^2 = 71.648$, DF1), implying that group dynamic can sway a farmer's decision to adopt a technology. The reason for the group formation and adoption of technology was statistically

Variable		Adoption of banana technology		Statistical significance		
On-farm testing		Yes	No	*p*-value	X^2	DF
		N (%)	*N* (%)	0.000	71.648[a]	1
Belonging to a banana farming group	Yes	162 (59.6)	110 (40.4)			
	No	6 (7.1)	79 (92.9)			
	Enhance banana production	57 (57.0)	43 (43.0)			
	Learn on new banana production technologies	66 (54.5)	55 (45.5)			
	Easy to train farmers as a group	13 (50.0)	13 (50.0)			
	Others	17 (89.5)	2 (10.5)			
Extension service providers	Public/Government	124 (52.3)	113 (47.7)	0.000	34.853[a]	2
	Private	38 (100.0)	0 (0.0)			
	Others	0 (0.0)	3 (100.0)			
Assistance in the formation of the group by extension providers	Creating awareness	88 (62.9)	52 (37.1)	0.004	10.835[a]	2
	Training on group dynamics	32 (71.1)	13 (28.9)			
	Registering the group	42 (45.2)	(54.8)			
Reason for joining the group	Improve banana production	87 (58.4)	62 (41.6)	0.004	15.565[a]	4
	Learn value additional	7 (22.6%)	24 (77.4)			
	Learn marketing strategies	56 (96.6%)	2 (3.4%)			
	Enhance information access	4 (18.2)	18 (81.8)			
	Partner with farmers	8 (66.7%)	4 (33.3%)			
	Others	0 (0.0%)	3 (100.0%)			
Trainers/Facilitators in the on-farm demonstration of the technologies	Extension officers	90 (55.2)	73 (44.8)	0.074	8.538[a]	4
	Contact officers	30 (73.2)	11 (26.8)			
	NGOs	2 (100)	0 (0%)			
	Consultant	233.3%	4 (66.7%)			
	Others	168 (60.2)	111 (39.8)			
Ways to encourage other farmers to adopt the production technologies demonstrated on firm	Adequate/more demonstration	49 (50.5)	48 (49.5)	0.094	9.399[a]	5
	Subsidy for banana production	52 (59.8)	35 (40.2)			
	Provision of more experts	20 (66.7)	10 (33.3)			
	Accessibility to technology materials	9 (56.3)	13 (25.5)			
	Improved/stable market price	38 (74.5)	13 (25.5)			

Source(s): "a" means Chi Square

Table 6. On-farm testing and adoption of banana production technologies

significant at the 5% level of significance (p value = 0.004 < 0.05, χ^2 = 15.565, DF4), showing that acceptable reasons for forming a common interest group positively determine the farmers' adoption of the banana production technologies. The findings are supported by (Barham and Chitemi, 2009) who found out that farmer groups play a vital role in improving members' knowledge and experience to access production resources as well as increasing negotiating strength and establishing product certification and label.

The relationship between extension service providers and adoption of technology was found to be statistically significant at a 1% level of significance (p-value = 0.000 < 0.01, χ^2 = 34.853, DF2), revealing that a good relationship between the service providers and the farmers enhanced trust that was reflected in adopting of the technologies (Table 6). This was further observed in the assistance by the extension providers in the formation of the farmers' group and adoption of the technology, which was statistically significant at a 5% level of significance (p value = 0.004 < 0.05, χ^2 = 10.835, DF2). The reason for joining the farmers' group and the adoption of banana production technologies had a statistically significant relationship at a 1% level of significance (p-value = 0.000 < 0.01, χ^2 = 70.544, DF5), indicating that the purpose for joining directly influenced the farmer's willingness to adopt the technology. Researchers have remained the main link through extension staff in the dissemination of technology to bring the materials to the proximity of farmer (Wambugu, *et al.*,2015). The participation of households in Tc banana production is also a variable. For a household that participates in Tc bananas as a family business project the household head could be expected to have good knowledge of the benefits of Tc bananas technology, and thus adopting it easily (Nyang *et al.*, 2010). Membership in farmer groups is a variable that takes a value from being a member of a registered farmer group (Nyang *et al.*, 2010). Some of the households who are members of merry-go-round groups could be provided with an avenue to multiple services like credit and access to cash. Therefore, it is hypothesized that farmers who are members of groups could have more access to new technologies like Tc bananas.

The study noted that there was no association between trainers/facilitators in the on-farm demonstration of the technologies and adoption of banana production technology, which was not statistically significant (p-value = 0.074, χ^2 = 8.538, DF4) (Table 6). This implies that it does not matter the facilitator who trains the farmers as long as the farmers are not ready this will not influence their decision to adopt the technology because the farmers may lack the required resources in adopting the technology. The findings are in agreement with those of Nyang *et al.* (2010) who carried out a study on Agricultural Extension and Technology Adoption for Food Security in Uganda. Their study found out that the agricultural extension services significantly increase the usage of improved cultivation methods that require a low upfront monetary investment. Farmers residing in eligible villages are 9.2% points more likely to use manure (organic fertilizer) and 3% points more likely to irrigate their land compared with those residing in ineligible villages. Being eligible for the programme also increases farmers' adoption rate of intercropping and crop rotation by 6 and 8% points, respectively (Nyang *et al.*, 2010). This is a clear indication that extension service providers play a very important role when it comes to determining the decision of farmers to adopt or not adopt the technology.

The study revealed that there was no association between various ways to encourage other farmers to adopt the banana production technologies and adoption, this was not statistically significant since the p-value (0.094 was greater than 0.05, χ^2 = 9.399, DF5), the findings imply that most farmers were not interested in adopting banana technologies and they preferred the use of the conventional method this was due to unstable market prices, lack of subsidized banana production input, inaccessibility to technological materials, few extension experts and lack of enough demonstrations. Nemoto *et al.* (2010) contended that studies about farmers' adoption of new technology highlight the adoption-decision as well as the timing (late or early) primarily in terms of the decision-making perception, not forgetting the inherent characteristics, with "innovators" at one extreme and "laggards" at the other. According to Nemoto *et al.* (2010) the farmers' decision-making is manifestly more complex than this implies. Woolley asserts that farmers have multiple objectives among which include adequate cash income, food security, social security and a secure asset or resource base.

4.6 Binary logistic regression of on-farm testing and adoption of banana production technologies

The study was to test a null hypothesis that there is no relationship between on-farm testing and adoption of banana production technologies (Table 7). The study evaluated the individual effects of the independent subvariables and the overall effect of the independent variable. In testing the hypothesis, binary logistic regression was used. The variables of the study were X1 = Reason for the formation of the Group, X2 = Initiator of the formation of the Group, X3 = Extension service providers, X4 = Assistance in the formation of the Group by extension providers, X5 = Reason for joining the Group, and X6 = Trainers in the on-farm demonstration of the technologies.

$$\text{Logit of adoption of banana production technologies} = -828.642 + 0.422X_1 + 1.15X_2 - 23.677X_3 + 0.621X_4 + 0.621X_4 + 0.212X_5 + 0.053X_6$$

The β coefficients for predictor variables (Reason for Formation of the Group, Initiator of the formation of the Group, Extension service providers, Assistance in the formation of the Group by Extension providers, Reason for Joining the Group and Trainers in the on-farm demonstration of the technologies) were positive excluding (extension service providers which were negative). Positive predictors show that the increase in predictor score is associated with an increased probability of adopting banana production technologies. From the results, the reason for the formation of the group was statistically significant in predicting whether a farmer will adopt the banana production technology or not if provided with on-farm testing. The odds ratio was 1.525, implying that the farmers who belong to a group are 2 times more likely to adopt banana technologies than farmers who do not belong to any group. The reason for the formation of the group has the most overall effect on the adoption of banana technologies with the overall effect being Wald 41.849, DF = 1, p = 0.000. This was because the majority of the farmers joined the group to learn about new banana technologies, enhance high banana production and it's easier to train farmers as a group. The findings are supported by Barham and Chitemi (2009) who found out that farmer groups play a vital role

Variables in the equation		*B*	S.E.	Wald	DF	Sig	Exp(*B*)	95% C.I. for EXP(*B*) Lower	Upper
Step 1[a]	Reason for formation of the group	0.422	0.065	41.849	1	0.000	1.525	1.342	1.732
	Initiator of the formation of the group	1.150	0.641	3.223	1	0.073	3.159	0.900	11.088
	Extension service providers	−23.677	5304.780	0.000	1	0.996	0.000	0.000	
	Assistance in the formation of the group	0.621	0.234	7.038	1	0.008	1.861	1.176	2.946
	Reason for joining the group	0.212	0.166	1.635	1	0.201	1.236	0.893	1.711
	Trainers in the on-farm demonstration of the technologies	0.053	0.179	0.088	1	0.767	1.054	0.742	1.498
	Constant	−828.642	5306.400	0.024	1	0.876	0.000		

Note(s): [a]Variable(s) entered on step 1: Formation of the Group, Initiator of the formation of the Group, Extension providers assist in the Formation of the Group, Assistance in the formation of the Group by Extension providers, Reason for Joining the Group, Trainers in the on-farm demonstration of the technologies

Table 7. Binary logistic regression of on-farm testing and adoption of banana production technologies

in improving members' knowledge and experience to access production resources as well as increasing negotiating strength and establishing product certification and label. The findings also are in agreement with Abdul-Rahaman and Abdulai (2020) who found out that group members and collective marketing participants obtained higher prices and also incurred lower input costs. Farm net revenues.

The study revealed that the initiators of the formation of the banana farmers' groups had a positive influence with a B coefficient of 1.150 on the adoption of banana production technologies with the overall effect of Wald 3.223, DF $= 1$, $p = 0.073$. The odds ratio was 3.159, this implies that the farmers who had initiators in the group formation are 3 times more likely to adopt banana technology than farmers who did not have initiators. The initiators of the group were extension officers and contact farmers. Sarker (2016) argued that extension provides a source of information on new technologies for farming communities which, when adopted can improve the production, incomes and standards of living.

The study found out that extension service provision had a negative influence with a B coefficient of -23.677 on the adoption of banana production technologies with the overall effect of Wald 0.000 DF $= 1$, $p = 0.0996$. The odds ratio was 0.000, this implies that whether the farmers got extension services from either the public/government or private did not affect the likelihood to adopt or not adopt banana production technologies; to them, the extension providers bear the same message. Assistance in the formation of the group by extension providers was also statistically significant in predicting whether a farmer will adopt banana production technology or not if provided with on test farming with the overall effect of Wald $= 7.038$, DF $= 1$, $p = 0.008$. The odds ratio was 1.861 this implies that farmers who were assisted in the formation of the group by the extension service provider were 2 times more likely to adopt banana technology than farmers who did not get any assistance from the extension service providers. Extension service providers make an innovation known to farm households, act as a catalyst to speed up adoption rate and also control change and attempt to prevent some individuals in the system from discontinuing the diffusion process (Shaibu *et al.*, 2012).

In reaching farmers, extension officers demonstrate the technology to farmers, but with much concentration on early adopters since the laggards would learn later from the early adopting farmers. Through extension services, farmers' problems are identified for further investigation and policy direction. The study revealed that the reason for joining the group had a positive influence on the adoption of banana production technologies with the overall effect of Wald 1.635, DF $= 1$, $p = 0.201$. The odds ratio was 1.236, this implies that the farmers who had a reason for joining the group are slightly more likely to adopt banana technology than farmers who did not have a reason for joining the group. The study found out that the trainers/facilitators on the on-farm demonstration of the technologies had a low positive influence on the adoption of banana production technologies with the overall effect of Wald 0.088, DF $= 1$, $p = 0.767$. The odds ratio was 1.054, this implies that the farmers who had been trained by different facilitators in the on-farm demonstration of the technologies are equally likely to adopt banana technology as the farmers who were not trained.

The findings are in agreement with Sarker (2016) who found out an efficient and effective extension system is a vital tool for the dissemination of information on improved practices as well as better uptake of these technologies. The study findings also go in line with those of Lim (2017) who conducted a study on the appropriateness of various extension methods in Nigeria and found out that field demonstrations and individual farm visits are the most effective extension approaches and the extension agents employ various training strategies that ensure effective resource use and farmer participation for better adoption.

The following indicators had a larger p-value; extension service providers; reason for joining the group and trainers in the on-farm demonstration. The study found out that there was no association between extension service providers and adoption of banana production technologies since the p-value (0.996) was greater than 0.05. This suggests that farmers who adopted or failed to adopt banana production technologies had other factors that influenced their decision other than extension service provision. The study found out that there was a relationship between the reason for joining the group and the adoption of banana production technologies, this is because the p-value was (0.201) which is greater than 0.05. The findings imply that farmers joined the groups intending to enhance banana production but in the long run they might have realized that the groups were not functional or collapsed at the grass-root level. The result revealed trainers in the on-farm demonstration of the technologies had a p-value of (0.767) which is greater than 0.05. The findings suggest that either the trainers were not actively engaged with the training, or farmers did not turn up for the demonstration or the training were on other aspects rather than banana production technologies.

5. Conclusion and recommendation

The study concludes that there was an association belonging to a banana farming group and the adoption of banana technology, this is clear evidence that group dynamics sway a farmer's decision to adopt a technology. The study also revealed there was a good relationship between the service providers and the farmers' enhanced trust that was reflected in adopting the technologies. The study also concludes that it does not matter the facilitator who trains the farmers as long as the farmers are not ready this will not influence their decision to adopt the technology because the farmers may lack the required resources in adopting the technology. Furthermore, the study revealed that there was no association between various ways to encourage other farmers to adopt the banana production technologies and adoption, this was an indication that most farmers were not interested in adopting banana technologies and they preferred the use of the conventional method this was due to unstable market prices, lack of subsidized banana production input, inaccessibility to technological materials, few extension experts and lack of enough demonstrations. The study recommends that more on-farm testing be carried out, this would encourage farmers to adopt various methods of banana technologies instead of using the conventional method.

The study recommends that more on-farm group testing is conducted as it would encourage farmers to adopt various banana technologies for increased production. It is recommended that the government create and implement more policies that will favour and encourage farmers to adopt banana production value addition. This will help farmers increase their income through banana value addition. The study also recommends the government and other non-governmental organization to be innovative when it comes to training farmers, for example, come up with a mobile application technology that will provide training online or via *Short Message Service* (SMS); by doing that, this will target a wide population of farmers since most people in Kenya own smartphones.

References

Abdul-Rahaman, A. and Abdulai, A. (2020), "Farmer groups, collective marketing and smallholder farm performance in rural Ghana", *Journal of Agribusiness in Developing and Emerging Economies*, Vol. 10 No. 5, pp. 511-527, doi: 10.1108/jadee-07-2019-0095.

Abdulhamid, S.L., Jeong, G. and Eun, J. (2017), "Comparison of fruit quality and GC–MS-based metabolite profiling of kiwifruit 'Jecy green': natural and exogenous ethylene-induced ripening", *Journal of Agriculture and Life Sciences*, Seoul National University, Seoul, Vol. 36 No. 1, pp. 112-129.

Ajayi, M.T. and Solomon, O. (2010), "Value chain analysis: a tool for enhancing export supply policies", *International Journal of Technological Learning, Innovation and Development*, Vol. 10 No. 4, pp. 283-308.

Ajayi, M.T. and Solomon, O. (2017), "Influence of extension contact and farmers' socio-economic characteristics on adoption of oil palm technologies in Aniocha North Local Government, Delta State, Nigeria", *Journal of Agricultural Science and Technology*, Vol. 12 No. 2, pp. 300-382.

Bairagi, S. and Mottaleb, A. (2021), "Participation in farmers' organization and production efficiency: empirical evidence from smallholder farmers in Bangladesh", *Journal of Agribusiness in Developing and Emerging Economies*, Emerald Group Publishing, Vol. 11 No. 2, pp. 73-87, February.

Barham, J. and Chitemi, C. (2009), "Collective action initiatives to improve marketing performance: lessons from farmer groups in Tanzania", *Food Policy*, Vol. 34, pp. 53-59.

Challa, M. (2013), *Determining Factors and Impacts of Modern Agricultural Technology Adoption in West Wollega*, GRIN Publishing GmbH, Munich, available at: http://www.grin.com/en/e-book/280336/determiningfactors-and-impacts-of-modern-agricultural-technology-adoption.

Cooper, D.R. and Schindler, P.S. (2003), *Business Research Methods*, 8th ed., McGraw-Hill Irwin, Boston, pp. 742-744.

Corn Agronomy (2015), *On-farm Testing*, October 7, Wisconsin Corn Agronomy, Madison, available at: https://corn.agronomy.wisc.edu/OnFarmTesting/Default.aspx.

Israel (1992), *Sampling the Evidence of Extension Program Impact*, Program Evaluation and Organizational Development, IFAS, University of Florida, PEOD-5, October.

Joachim, D., Athanasia, O. and Patrick, A. (2018), "Potential of cooking bananas in addressing food security in East Africa", *International Journal of Biosciences*, Vol. 13 No. 4, pp. 278-294.

Kalyebara, B. and Islam, S.M.N. (2014), "Discussion and implications", in *Contributions to Management Science*, Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 155-171, doi: 10.1007/978-3-642-35907-1_6.

Khandker, V. and Thakurata, I. (2018), "Factors encouraging complete adoption of agricultural technologies", *Journal of Agribusiness in Developing and Emerging Economies*, Vol. 8 No. 2, pp. 270-287, doi: 10.1108/jadee-05-2016-0037.

Kikulwe, E., Okurut, S., Ajambo, S., Nowakunda, K., Stoian, D. and Naziri, D. (2018), "Postharvest losses and their determinants: a challenge to creating a sustainable cooking banana value chain in Uganda", *Sustainability*, Vol. 10 No. 7, p. 2381, (Switzerland), ISSN 2071-1050.

Langat, B.K., Ngeno, V.K., Nyangweso, P.M., Mutwol, M.J., Kipsat, M.J., Gohole, L. and Yaninek, S. (2013), "Drivers of technology adoption in a subsistence economy: the case of tissue culture bananas in Western Kenya", *Invited Paper Presented at The 4th International Conference of the African Association of Agricultural Economists*, September 22-25, 2013, Hammamet, Tunisia, Vol. 6, pp. 1-17, Journal of Agricultural Economics.

Lim, S., Lee, J.G. and Lee, E.J. (2017), "Comparison of fruit quality and GC-MS-based metabolite profiling of kiwifruit 'Jecy green': natural and exogenous ethylene-induced ripening", *Food Chemistry*, Vol. 234, pp. 81-92, doi: 10.1016/j.foodchem.2017.04.163.

Loevinsohn, M., Sumberg, J., Diagne, A. and Whitfield, S. (2013), "Under what circumstances and conditions does adoption of technology result in increased agricultural productivity? A systematic review", doi: 10.13140/RG.2.1.3336.4242.

Macharia, I., Kagundu, A.M., Kimani, E.W. and Otieno, W. (2010), "Combating phytosanitary constraints to banana (*Musa* spp.) production: the Kenyan example", in Dubois, T. (Ed.), *Proceedings of IC on Banana and Plantain in Africa*, Acta Hort. 879, ISHS.

Mamudu, A., Guo, E. and Dadzie, S. (2012), "Adoption of modern agricultural production technologies by farm households in Ghana: what factors influence their decisions?", *Journal of Biology, Agriculture and Healthcare*, Vol. 2, pp. 1-13.

Meru County Government (2019), "Meru county banana stakeholder's forum", May 17, available at: https://meru.go.ke/content.php?com=31&item=578.

Mwendia, A.S. (2019), "An investigation of the drivers of diversification to banana farming among households in Meru County, Kenya", Master's thesis, Kenyatta University, Nairobi, Kenya, available at: https://ir-library.ku.ac.ke/handle/123456789/19932.

Nemoto, M.C.M.O., Vasconcellos, E.P.G. and Nelson, R. (2010), "The adoption of new technology: conceptual model and application", *Journal of Technology Management and Innovation*, Vol. 5 No. 4, pp. 95-107, doi: 10.4067/S0718-27242010000400008.

Nguyen, D.D., Le, T.M. and Kingsbury, A.J. (2020), "Farmer participation in the lychee value chain in BAC Giang province, Vietnam", *Journal of Agribusiness in Developing and Emerging Economies*, Vol. 10 No. 2, pp. 203-216, doi: 10.1108/jadee-05-2019-0076.

Nyang, M.N., Webo, C. and Roothaert, R.L. (2010), "The power of farmers organisations in smallholder agriculture in East Africa working papers", A review of 5 project initiatives of the Maendeleo Agricultural Technology Fund, in FARM-Africa Working Paper, FARM-Africa, London, pp. 1-44.

Obaga, B. (2018), "Impact of farmers' participation in banana value addition in household welfare in Kisii Central Sub-County", *International Academic Journal of Social Sciences and Education*, Vol. 2 No. 1, pp. 25-46.

Ocimati, W., Nakato, G.V., Fiaboe, K.M., Beed, F. and Blomme, G. (2013), "Incomplete systemic movement of *Xanthomonas campestris* pv. *musacearum* and the occurrence of latent infections in Xanthomonas wilt-infected banana mats. Plant Path", *International Journal of Advances in Agricultural Science and Technology*, Vol. 64 No. 1, pp. 81-90.

Poonam, P. and Jhariya, M. (2017), "Knowledge, adoption and managerial perspectives of banana growing communities in Durg, Chhattisgarh, India", *Journal of Human Ecology*, Vol. 59, pp. 10-19, doi: 10.1080/09709274.2017.1334398.

Rogers, E.M. (2005), *Diffusion of Innovation*, Free Press, New York, pp. 157-159.

Sarker, M.N.I. (2016), "Knowledge, adoption and constraint analysis of chilli technological area of Bangladesh", *International Journal of Ecology and Development Research*, Vol. 1 No. 1, pp. 16-18, available at: https://www.researchgate.net/publication/305279648.

Sathapatyanon, J., Kuwornu, J.K., Shivakoti, G.P., Soni, P., Anal, A.K. and Datta, A. (2018), "The role of farmer organizations and networks in the rice supply chain in Thailand", *Journal of Agribusiness in Developing and Emerging Economies*, Vol. 8 No. 3, pp. 554-578, doi: 10.1108/jadee-01-2017-0016.

Shaibu, A.A., Maji, E.A. and Ogburia, M.N. (2012), "Yield evaluation of plantain and banana landraces and hybrids in the humid agro-ecological zone of Nigeria", *Journal of Agricultural Research and Development*, Vol. 2 No. 3, pp. 74-79, Corpus ID: 174795296.

Suvediet, Wang, B., Li, R., Ruan, Y., Ou, Y., Zhao, Y. and Shen, Q. (2017), "Pineapple–banana rotation reduced the amount of *Fusarium oxysporum* more than maize–banana rotation mainly through modulating fungal communities. Soil Biol", *International Journal of Advances in Agricultural Science and Technology Biochemistry*, Vol. 86, pp. 77-86.

United Nations (2013), "Facing the challenges of climate change and food security: the role of research, extension and communication institutions - final report", Food and Agriculture Organization of the United Nations, Wageningen University and UNU-MERIT, Rome, October.

Vejlgaard, H. (2018), "Process knowledge in the innovation-decision period", in *Digital Communication Management*, InTech.

Wambugu, F.M., Mbogoh, S.G. and Wakhusama, S. (2015), "Socio-economic impact of biotechnology applications: some lessons from the pilot tissue culture (TC) banana production promotion project in Kenya, 1997-2002", *Document Transformation Technologies. Proceedings of the 25th International Conference of Agricultural Economists (IAAE)*, doi: 10.22004/ag.econ.25929.

William, T. (2018), "Challenges and opportunities for smallholders in banana value chains", available at: https://www.researchgate.net/publication/328105469Wollega.

Yamane, T. (1967), *Statistics, an Introductory Analysis*, 2nd ed., Harper & Row, New York, pp. 178-184.

Further reading

Yao, P., Smith, S.C. and Sulaiman, M. (2018), "Agricultural extension and technology adoption for food security: evidence from Uganda", *American Journal of Agricultural Economics*. doi: 10.1093/ajae/aay012.

Corresponding author
Florence Kaumi Kirimi can be contacted at: kaumi.florence@embuni.ac.ke