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## Unravelling technology-acceptance factors influencing farmer use of banana tissue culture planting materials in Central Uganda

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Effective management of plant health is fundamental for food and income security to meet the growing demands of local and global markets. This however requires farmers' adequate access to quality planting materials under the prevailing contextual and psycho-social factors. This study, anchored in the Unified Theory of Acceptance and Use of Technologies, unravels technology-acceptance factors that influence farmers' intentions to use banana tissue culture planting materials in the control of Banana Xanthomonas Wilt. Data were collected from 248 randomly sampled banana farmers using a structured questionnaire and analyzed using structural equation modelling to examine hypothesized paths in the uptake of banana tissue culture planting materials. Results show that farmer intentions to use tissue culture planting materials are dependent on two constructs: social influence and farmer innovativeness. However, social influence is the main predictor of intentions to use tissue culture planting materials. In particular, farmer innovativeness mediates facilitating conditions and social influence in predicting intentions to use tissue culture planting materials. Thus, this study reveals two factors that influence farmer intentions to use tissue culture planting materials: social influence and farmer innovativeness. The findings imply that social influence and farmer innovativeness are critical in disseminating novel agricultural technologies in Uganda and elsewhere.

**Keywords:** banana tissue culture, Banana Xanthomonas Wilt, Central Uganda, use of technology

### Introduction

Good plant health is fundamental to ensure food and income security among smallholder farmers, so as to meet the demands of local and global markets (Danielsen et al. 2013). Likewise, effective plant healthcare is essential for producing healthy crops for both human and animal consumption (Karubanga, Matsiko, and Danielsen 2017), as well as for non-food purposes (Danielsen et al. 2012). However, substantial amounts of crop produce are lost every year due to plant health problems (Karubanga, Matsiko, and Danielsen 2017).

In sub-Saharan Africa, most of these losses are mainly due to pests and diseases associated with seed saved from previous harvests, that smallholder farmers rely on for planting material. In rural farming communities, the informal seed system<sup>1</sup> is usually preferred to the formal seed system.<sup>2</sup> Even when seed is available from the market, farmers often prefer using their own seed to save money and avert risks associated with the crops they grow (e.g. changes in weather, pests and erratic market prices). For example, in informal systems mostly in developing countries, the seed from vegetatively propagated crops such as banana is mainly produced locally. More than 90% of farmers in the banana farming systems in East and Central Africa rely on suckers sourced from friends, neighbours, relatives and/or their own fields to establish new banana gardens (Smith et al. 2008; Lwandasa et al. 2014). However, the banana planting material they use is seldom certifiably disease free, which poses a high risk

of transmitting pests and diseases across farms (Jogo et al. 2013). Seed-borne pests and diseases<sup>3</sup> continue to be a serious threat to banana production, more so in areas where the planting material is of poor quality and/or scarce.

Banana Xanthomonas Wilt (BXW) caused by the bacterium *Xanthomonas campestris* pv. *musacearum* is a major threat to food and income security among smallholder farmers in Uganda, especially in the areas where banana is an important staple and cash crop. If uncontrolled, BXW can eventually cause an estimated production loss of the banana crop of about 53% over a 10-year period (Tripathi et al. 2009), equivalent to a reduction from 10.5 to 5.6 million metric tonnes per year (FAOSTAT 2013). The disease can potentially decimate the entire crop where highly susceptible cultivars are grown (Kubiriba et al. 2012). Between 2002–2005, it is estimated that the disease caused a total loss equivalent to 61.1 million dollars to the country, mainly associated with the East African Highland Banana (EAHB) 'Matooke' (AAA-EAHB genome group) and the 'Kayinja' beer banana (ABB genome group) (Tushemereirwe et al. 2009). To avert the situation, use of tissue culture (TC) banana (*Musa spp.*) planting materials is one of the strategies that has been promoted for controlling the BXW disease. Using TC banana planting material is an effective method of providing pest- and disease-free plants (Dubois et al. 2013), guaranteed by high standards in the production process. It is therefore argued that as a

control measure in the spread of BXW, TC banana planting materials<sup>4</sup> can be of high quality (Wambugu et al. 2000) and consequently of utmost relevance for boosting banana productivity since they aid in the establishment of clean banana plantations – void of BXW.

Campaigns against BXW have since focused on encouraging farmers to adopt TC seedlings as a technology. However, the uptake of TC seedlings remains low (Jogo et al. 2013), at less than 7% of the total banana coverage in the country (Dubois et al. 2013). Previous research assessing adoption of TC banana planting materials has mainly focused on economic factors such as high cost of seedlings, and higher labour and input requirements (Muyanga 2009; Njau et al. 2011; Kabunga, Dubois, and Qaim 2012). Little attention has been paid to studying how farmers' beliefs and attitudes towards TC banana planting materials affects their intentions to use them to control BXW. Specifically, two objectives are addressed in this study: first, to identify and describe the contextual and psycho-social technology-acceptance factors that influence the use of TC banana planting materials in Uganda; and second, to explore their effects on the uptake of TC banana planting material. To our knowledge, there are no studies that have explicitly analyzed and explained how farmers' beliefs and attitudes predict acceptance and use of TC banana planting materials in combatting BXW. Our contribution to the literature is twofold: First, the study applies the Unified Theory of Acceptance and Use of Technology (UTAUT) model to an agricultural technology-adoption context in a developing country. Second, we extend the UTAUT model by including two additional variables that influence uptake of new technologies: perceived quality and farmer innovativeness.

### Theoretical framework

The technology-acceptance factors can negatively affect farmers' decisions to use TC banana planting materials. In this study, we use the Unified Theory of Acceptance and Use of Technology (UTAUT) to examine the effect of technology-acceptance factors on TC banana planting materials uptake in Central Uganda. We expect that understanding these factors could help increase uptake of TC banana planting material. Recent applications of UTAUT for assessing uptake of a new technology such as TC banana include: Wu, Tao, and Yang (2007); Maldonado et al. (2009); Islam and Grönlund (2011); and Taiwo and Downe (2013). Specifically, UTAUT has been applied to examine rural farmers' adoption of agricultural information technology services (Wu 2012); farmers' uptake of solar water pump technology in Northern Pakistan (Zhou and Abdullah 2017), and farmers' acceptance of pressurized irrigation technology (Nejadrezaei et al. 2018).

UTAUT is one of the new models in the domain of technology acceptance and compared to other widely-used theories such as the Technology Acceptance Model (TAM), Innovation Diffusion Theory (IDT) and Theory of Planned Behavior (TPB), it utilizes a more integrative approach, combining variables from existing theories as predictors of technology acceptance and usage

(Nejadrezaei et al. 2018). The Unified Theory of Acceptance and Use of Technology integrates constructs across eight models that include: the Technology Acceptance Model (TAM) (Davis 1989), the Theory of Reasoned Action (TRA) (Fishbein and Ajzen 1975), the theory of Planned Behavior (TPB) (Ajzen 1991), the Combined TAM and TPB (Taylor and Todd 1995), the Innovation Diffusion Theory (IDT) (Rogers 2003), the Social Cognitive Theory (SCT) (Bandura 1989), the Motivational Model (MM) (Davis, Bagozzi, and Warshaw 1992), and the Model of PC Utilization (MPCU) (Thompson, Higgins, and Howell 1991). Consequently, it has a better predictive value than any one individual theory (San Martín and Herrero 2012; Okumus et al. 2018).

In explaining intentions to use technologies, UTAUT uses the concepts of social influence, facilitating conditions, effort expectancy and performance expectancy. The promotion of TC planting materials amongst small-holder farmers for adoption mirrors this structural set of the UTAUT model in the sense that the focus is on farmers' acceptance of TC as a technology. UTAUT explains that people accept new ideas, such as using banana TC planting materials, following a series of complex mental processes in which intentions precede behaviour (Venkatesh et al. 2003; Islam and Grönlund 2011). However, the concept of effort expectancy, which recounts the extent to which a farmer believes that using TC planting material is free of effort, was dropped in the analytical framework because it is a notion farmers in the current study communities are ardently aware of, having interfaced with this technology for over a decade now. Subsequently, we integrate farmer innovativeness and perceived quality of the technology as additional determinants of farmer acceptance and use of the TC banana technology. Previous studies have shown higher innovativeness in individuals to be associated with positive beliefs and perceptions towards technology uptake (Ali, Nair, and Hussain 2016; Okumus et al. 2018). Similarly, farmer perceptions of the quality of proposed planting materials have also been shown to be of significance for the acceptance and eventual use of proposed technologies (Andrade-Piedra et al. 2016). Thus, farmer innovativeness and perceived quality of the planting materials may be essential determinants of farmers' acceptance of the TC technology.

Previous research (Venkatesh, Thong, and Xu 2012; Ali, Nair, and Hussain 2016; Okumus et al. 2018) showed that intention to use a technology is the most significant predictor for uptake behaviour and actual usage. Ajzen (1991) asserted that individuals' intentions capture the motivational aspects that affect their behaviour and indicate any individual's willingness to develop an action. A common construct that explains intentions is social influence. For this study, *social influence* is defined as *the degree to which a farmer perceives that relevant people believe that he or she should use a technology* (Taylor and Todd 1995). El-Gayar, Moran, and Hawkes (2011) argue that social influence triggers individuals' behavioural intentions to use new technologies and various scholars (Abushanab and Pearson 2007; Eckhardt, Laumer, and Weitzel 2009; Ali, Nair, and Hussain 2016;

Okumus et al. 2018) attest to this. Since banana cultivation is embedded in the cultural values of exchange of planting materials and traditional practices (Mulugo 2019), the pressures created by social interactions and norms may motivate farmers in the uptake of TC as banana planting materials in the control of BXW. In the context of this study, social influence is operationalized as *being persuaded (informed) by faith based organizations, members of the community and farmer groups to use TC planting materials in growing bananas*. It can thus be assumed that social influence on the use of TC banana planting materials will influence farmer uptake intentions.

*Facilitating conditions* as a construct describes the degree to which a farmer believes that organizational and technical infrastructure exist to support his or her use of TC as banana planting material. A number of studies attest and confirm the effect of facilitating conditions on acceptance and usage of technologies (Venkatesh, Thong, and Xu 2012; Ali, Nair, and Hussain 2016; Okumus et al. 2018). Increasing levels of facilitating conditions are expected to reduce levels of uncertainty or ambiguity with the TC banana technology (Al-Gahtani, Hubona, and Wang 2007). For instance, Alawadhi and Morris (2008) tested and confirmed the significant effect of facilitating conditions on students' use of e-government services. In another study, Lakhal, Khechine, and Pascot (2013) verified facilitating conditions as a significant determinant of students' intentions to use desktop video conferencing in a distance learning course. In the context of this study, 'facilitating conditions' are operationalized as *TC nurseries having demonstration gardens and the TC nursery operators being willing to provide information to intending users on how to plant and manage the TC planting materials*. It can therefore be assumed that facilitating conditions will influence uptake intentions for TC banana planting materials. *Perceived seed quality* on the other hand is described as *the degree to which a farmer believes that TC planting materials are free of pests and diseases (particularly BXW) and are of high genetic purity (RTB 2016)*. Studies (Abay, Waters-Bayer, and Bjørnstad 2008; Kraft, de Jesús Luna-Ruíz, and Gepts 2010; Andrade-Piedra et al. 2016) attest and confirm the importance of seed quality in farmer acceptance and use of technologies. High perception levels of the quality of TC planting materials are expected to motivate farmers in their use of TC banana planting materials since their uncertainty/risk as a potential means of spreading BXW in farmers' banana crop is reduced. In the perspective of this research, seed quality is operationalized as *TC planting materials being perceived as pest and BXW free and void of mutants*. It is, as such, assumed that farmers' perceived quality of TC banana planting materials will influence their intentions to use this technology.

*Performance expectancy* is contextualized in this study as *the extent to which a banana farmer believes that the use of TC as banana planting material enhances the performance and output from his or her banana plantation(s)* (Compeau and Higgins 1995). Previous studies have shown that intention to use a technology or system is significantly predicted by performance

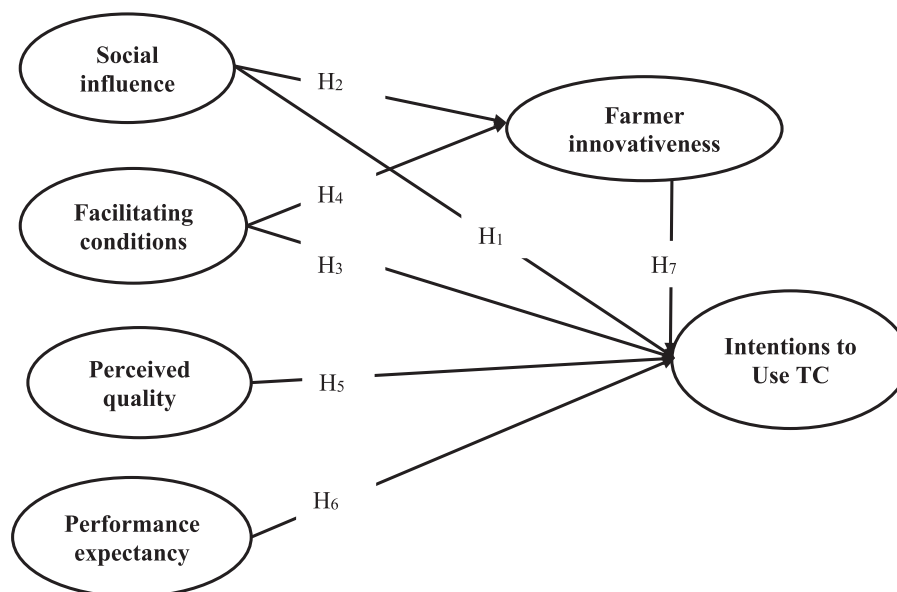
expectancy (Slade et al. 2015; Ali, Nair, and Hussain 2016; Okumus et al. 2018). Biemans et al. (2005) revealed that performance expectancy is a high predictor of a nurse's behavioural intention to use medical teleconferencing applications. Similarly, Fang, Li, and Liu (2008) showed that performance expectancy significantly predicts managers' intentions to engage in knowledge sharing using web2.0. We therefore presume that performance expectancy has a direct effect on TC technology uptake intentions. In light of this study, performance expectancy was operationalized as *TC planting materials yielding marketable large sized banana bunches and many suckers*. Thus, we further postulate that farmers' perceived performance expectancy of TC banana planting materials will positively influence uptake intentions of the TC banana technology.

*Farmer innovativeness* in the perspective of this study is *the degree to which a farmer is receptive to new agricultural related ideas and makes innovative decisions independently of the communicated experience of others* (Midgley and Dowling 1978). Previous studies have discussed the influence of innovativeness on individuals' perceptions and behaviours and its role in determining users' acceptance of technologies (Lu et al. 2003; Lu, Yao, and Yu 2005; Yi and Probst 2006; Turan, Tunç, and Zehir 2015). For instance, Okumus et al. (2018) showed individual innovativeness to be a significant predictor of restaurant customers' intentions to use smartphone diet apps while ordering food. Additionally, Liu, Li, and Carlsson (2010) revealed that innovativeness was a significant predictor of Chinese students' intentions to use mobile learning. In the field of self-service technologies, Chen (2008) also found that an individual's innovativeness directly influenced intentions to purchase and use these technologies. For this study, farmer innovativeness was operationalized as *farmer willingness to creatively integrate the use of TC planting materials with their local knowledge and other available materials in the control and management of BXW*. We expect farmers' innovativeness to influence TC planting materials uptake intentions. Moreover, highly innovative farmers may have better perceptions of TC planting materials in terms of facilitating conditions, influencing their uptake intentions compared to less innovative farmers (Okumus et al. 2018). Likewise, San Martín and Herrero (2012) argued that individuals with higher innovativeness are less influenced by others' opinions about technological innovations. Thus, higher innovativeness may result in weaker social influence on adoption and uptake of the TC technology. Consequently, for highly innovative users, facilitating conditions and social influence may be less influential when adopting a technology.

## Methodology

In this section, we first describe the research design, with some *a priori* expectations. Next, we describe the selection of participants and collection of data, including how items were measured. Finally, we discuss the different components of the data collected for SEM analysis and present some descriptive statistics.





**Figure 1:** Research model illustrating the hypothetical influence of technology acceptance factors on intentions to use TC banana planting materials.

### Research design

This study employs a structural equation modelling (SEM) approach to develop a research model that represents the relationships among six variables as adapted from UTAUT (Venkatesh et al. 2003). The six variables include: intention to use TC planting materials, social influence, facilitating conditions, perceived quality of TC technology, performance expectancy, and farmer innovativeness, as shown in Figure 1.

Based on the research model above, nine hypotheses were formulated:

- H<sub>1</sub>: Social influence has a positive and significant influence on farmer intentions to use banana TC planting materials.
- H<sub>2</sub>: Social influence has a positive and significant influence on farmer innovativeness in the use of banana TC planting materials.
- H<sub>3</sub>: Facilitating conditions have a positive and significant influence on farmer intentions to use banana TC planting materials.
- H<sub>4</sub>: Facilitating conditions have a positive and significant influence on farmer innovativeness to use banana TC planting materials.
- H<sub>5</sub>: Farmers' perceived quality of banana TC planting materials has a positive and significant influence on their intentions to use banana TC planting materials.
- H<sub>6</sub>: Performance expectancy has a positive and significant influence on farmer intentions to use banana TC planting materials.
- H<sub>7</sub>: Farmer innovativeness has a positive and significant influence on farmer intentions to use banana TC planting materials.
- H<sub>8</sub>: Social influence is mediated by farmer innovativeness in predicting farmer intentions to use banana TC planting materials.
- H<sub>9</sub>: Facilitating conditions is mediated by farmer innovativeness in predicting farmer intentions to use banana TC planting materials.

### Research participants and data collection methods

A total of 248 banana farmers were randomly sampled from two farming communities (Figure 2) that hosted community-based banana TC nurseries in Luweero and Mukono districts in Central Uganda using a village listing. The selected sample represented about 24% of the 1060 banana farmers in the study communities (Table 1). Data were collected using a structured questionnaire through face-to-face interviews. Data elicited included demographic information and farmers' responses to multiple items measuring each construct reflected in the research model of Figure 1. Notably, informed consent from the participating farmers was obtained prior to the individual interviews.

### Measures

To measure the constructs in this study, 21 statements were used. Social influence (SI) was measured with 3 items (e.g. 'If I am informed about TC seed by a faith-based leader in my church/mosque, then I can use it as banana seed'). Facilitating conditions (FC) was measured with 3 items (e.g. 'The TC nursery operator is welcoming and willingly provides information on how to plant TC seed'), and perceived quality (PQ) had 3 items (e.g. 'TC seed is BXW free') as proposed by RTB (2016). The performance expectancy (PE) variable had 4 items (e.g. 'TC seed yields bunches with large banana fingers') as well as farmer innovativeness (FI) variable (e.g. 'I apply wood ash around TC banana mats that have exhibited BXW symptoms to prevent further infection'). Finally, the intention for uptake of TC technology (IU) had 4 items (e.g. Given the chance, I intend to use TC seed when expanding my banana plantation) as adapted from Okumus et al. (2018). Each item was measured on a five-point Likert scale with 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree.

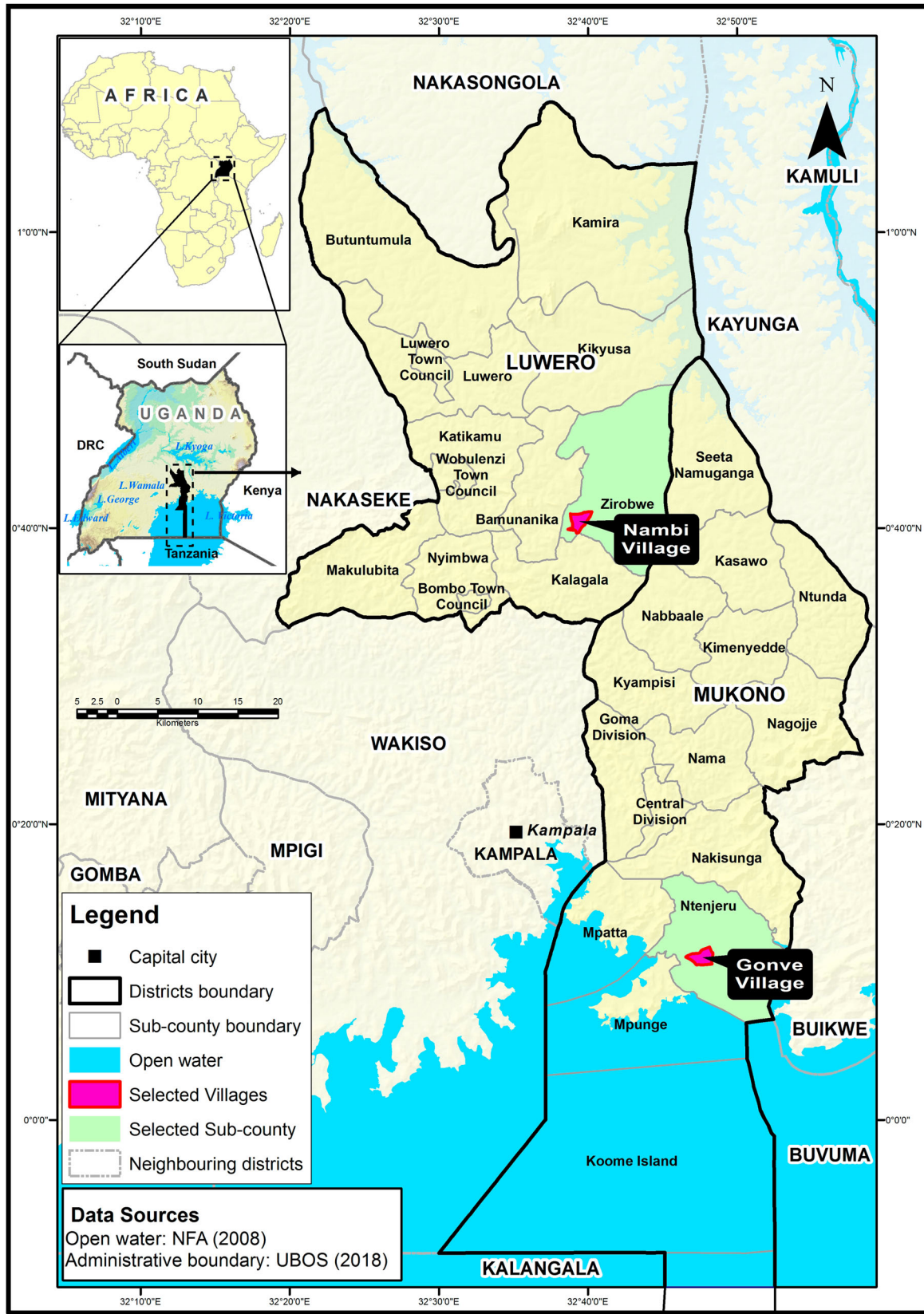


Figure 2. Map showing the study areas.

Table 1: Number of farmers selected for the study.

Location	Total number of farmers	Number of farmers selected
Village: Nambi Luwero district	500	122
Village: Gonve Mukono district	560	126
<b>Total</b>	<b>1060</b>	<b>248</b>

**Table 2:** Descriptive statistics of the study constructs.

Construct	Item	Mean	SD	Skewness	Kurtosis
SI	3	3.80	0.82	-1.34	2.65
FC	3	3.02	1.05	-0.57	-0.57
PQ	3	3.50	0.88	-0.64	0.03
PE	4	4.10	0.70	-1.20	3.40
FI	4	1.79	1.34	1.25	-0.15
IU	4	4.11	0.82	-1.89	5.04

SI-Social influence; FC-Facilitating conditions; PQ-Perceived quality; PE-Performance expectancy; FI-Farmer innovativeness; IU-Intention for uptake of TC technology

**Assessment of assumptions for SEM analysis**

Preceding path analysis, four assumptions of SEM were assessed, namely: Normality, measurement validity, convergent validity, discriminant validity and multicollinearity. First, the normality of the data was examined. Skewness and kurtosis stretched from -1.89-1.25 and -0.57-5.04 respectively (Table 2). Following Kline’s (2005) recommendations that the skewness and kurtosis indices should be within 3 and 10 respectively, the data in this study are regarded as normal.

Secondly, measurement validity was assessed using construct reliability (CR), instead of Cronbach’s alpha

because the latter understates reliability (Hair et al. 2006). The precondition is that CR=0.70 and above to satisfy measurement validity (Nunnally and Bernstein 1994). Convergent validity, concerned with whether observable variables (items) share adequate variance in the construct/latent variable was assessed using two indicators; namely factor loadings and AVE. This study adopted the criteria of Hair et al. (1998) on assessing factor loadings. They specify that a minimum threshold value of 0.4 for a sample size of 200 is adequate for confirming convergent validity. The AVE minimum threshold value adopted for this study in assessing convergent validity was 0.5 as suggested by Segars (1977). Discriminant validity was assessed by comparing the values of correlates to square root of AVE values. The preconditions are that the correlates must be smaller than the square root of AVE to satisfy the condition of discriminant validity (Fornell and Larcker 1981). Correlation analysis was conducted following Hamilton (2006) to evaluate whether there was no more than one correlate exceeding 0.600 and so ruling out the risk of multicollinearity.

Measurement validity, based on composite reliability (CR) values for all constructs, ranged from 0.70 to 0.99 (Table 3) which were all above the minimum threshold

**Table 3:** Validity and reliability for constructs.

Constructs	Items	Loadings ( $\geq .50$ )* <sup>a</sup>	AVE ( $\geq .50$ )* <sup>b</sup>	CR ( $\geq .70$ )*
Social influence	If I am informed about TC seed by a faith-based leader in my church/mosque, then I can use it as banana seed (SI_1).	0.917	0.854	0.990
	If I am informed about TC seed by a community leader in my village, then I can use it as banana seed (SI_2).	0.984		
	If I am informed about TC seed by one of the group members in a farmer group, then I can use it as banana seed (SI_3).	0.868		
Farmer innovativeness	I use a concoction of organic pesticides (fermented human and animal urine, wood ash and red pepper) to control pests in TC seed (FI_2).	0.980	0.924	0.992
	I use organic fertilizer (concoction of fermented human and animal urine and wood ash) to increase the fertility of soils where I have planted TC seed (FI_3).	0.988		
	I spray inorganic pesticides onto TC seed to control pests that attack during earlier months (FI_4).	0.952		
	I apply wood ash around TC banana mats that have exhibited BXW symptoms to prevent further infection (FI_5).	0.923		
	The TC nursery operator is welcoming and willingly provides information on how to plant TC seed (FC_4).	0.991		
Facilitating conditions	The TC nursery operator is welcoming and willingly provides information on how to manage TC seed (FC_5).	0.985	0.814	0.834
	The TC nursery has a TC banana demonstration garden (FC_12).	0.699		
	TC seed is BXW free (PQ_1).	0.804		
Perceived quality	TC seed is pest free (PQ_2).	0.935	0.561	0.703
	TC seed has no mutants (PQ_4).	0.402		
	TC seed produces many suckers (PE_1).	0.472		
Performance expectancy	TC seed yields large banana bunches (PE_2).	0.888	0.511	0.994
	TC seed yields bunches with large banana fingers (PE_3).	0.884		
	Banana suckers from TC seed are highly marketable (PE_5).	0.500		
Intentions to use TC	Given the chance, I intend to use TC seed when expanding my banana plantation(s) (IU_2).	0.935	0.824	0.998
	Given the chance, I plan to use TC to gap fill (IU_3).	0.955		
	Given the chance, I intend to use TC seed when I have no suckers (IU_4).	0.907		
	Given the chance, I intend to use TC when establishing a commercial banana plantation. (IU_6).	0.829		

\* Acceptable level of reliability or validity. <sup>a</sup> AVE is computed by adding the squared factor loadings divided by the number of factors of the underlying construct. <sup>b</sup> CR =  $(\sum\lambda)^2/(\sum\lambda)^2+(\sum\delta)$

**Table 4:** Testing for multicollinearity and discriminant validity.

Fornell and Larcker's (1981) procedure						
	1	2	3	4	5	6
1. Social influence	.924					
2. Facilitating conditions	.085	.902				
3. Perceived quality	.054	.124	.749			
4. Performance expectancy	.301**	.098	.538**	.715		
5. Farmer innovativeness	.199**	.366**	.167**	.280**	.961	
6. Intent for uptake	.502**	.034	.134*	.341**	.237**	.908

\*\* $P < .01$ , \* $P < .05$

Diagonal in parentheses: Square root of average variance extracted from observed variables (items); Off-diagonal: Correlations between constructs

of 0.70. Accordingly, measurement validity was confirmed in this study. Similarly, convergent validity was confirmed, since all factor loading had values above 0.4 (Hair et al. 1998) and AVE values were also all above 0.5. Regarding the discriminant validity, the values of correlates were less than the square root of values of AVE (Table 4). Since inter-construct variance was less than intra-construct variance, it meant that all constructs exhibited distinctness from each other. Accordingly, discriminant validity was confirmed. In testing for multicollinearity, the values of correlates ranged between 0.034 and 0.538 and were all below the minimum threshold value of 0.60 as suggested by Hamilton (2006). This ruled out the risk of multicollinearity.

#### Structural model assessment

Using Analysis of Moment Structure (AMOS) version 21 programme, the research model for this study was tested. As recommended by Hair et al. (2006), a variety of indices were used to test for model fit, namely the  $\chi^2$  statistic, the adjusted goodness of fit index (AGFI), the root mean square error of approximation (RMSEA), comparative fit index (CFI) and Tucker-Lewis index (TLI) (Table 5).

Further analysis was done using bootstrapping to assess mediation relationships as well as determining effect sizes of prediction relationships. A model-based bootstrapping simulation of up to two thousand repetitions was performed as suggested by Byrne (2010). Notably, Byrne (2010) explained that this procedure is important for ascertaining that the overall fit is not inflated because of the small sample size relative to the degrees of freedom of the model. On effect sizes, Cohen (1988) reasoned that effects with values less than 0.1 are considered small, those with less than 0.3 medium and values with 0.5 or more are considered large. In this study, the Cohen (1988) criterion of evaluating effect sizes was adopted to assess the extent of influence the independent variables had on the dependent variable.

**Table 5:** Fit indices for the measurement model.

Model fit index	Baseline for Goodness of fit	References
$\chi^2/df$ (deg. of freedom)	< 3	Kline (2005); Cheng (2007)
AGFI	> 0.8	Chau (1997); Cheng (2007)
RMSEA	< 0.08	MacCallum, Browne, and Sugawara (1996); Chen, Kwok, and Goodson (2008)
CFI	$\geq 0.90$	McDonald and Ho (2002); Cleveland, Laroche, and Papadopoulos (2009)
TLI	$\geq 0.90$	McDonald and Ho (2002); Loibl et al. (2009)

## Results

### Sample characteristics

Results in Table 2 show that the sample of respondents comprised more females (55%) than males (45%). Most were married (67%) and were between the ages of 30 and 49 years (55%). Forty-six percent of the respondents earn between UGX 1,000,000–4,999,900 annually, with most of them (77%) having attained primary and secondary school education. The Baganda ethnic group is the most dominant (92%) in the study communities and other minor groups comprise the Basoga (2%) Bakiga (1%) and others. (Table 6)

### Structural equation model results

Figure 3 shows the results of the structural equation model predicting the intention to use banana TC planting materials in the control of BXW. The overall goodness-of-fit of the illustrated model, as measured by the fit indices, indicated a good fit to the data. Furthermore, all independent and mediating variables explain 28% of the variance in intentions to use the TC banana technology (Figure 2). The  $R^2$  value of 0.28 is higher than the 0.26 value that Cohen (1988) suggested would indicate a substantial model.

Results presented in Table 7 show that social influence ( $\beta = 0.432$ ;  $t = 7.651$ ;  $p < 0.01$ ) had a positive and significant influence on farmers' intentions to use TC planting materials. This finding supports hypothesis  $H_1$  implying that social influence is a significant predictor of farmer intentions to use banana TC planting materials. Furthermore, social influence ( $\beta = 0.240$ ;  $t = 2.720$ ;  $p < 0.01$ ) and facilitating conditions ( $\beta = 0.340$ ;  $t = 5.062$ ;  $p < 0.01$ ) indicated a positive and significant influence on farmer innovativeness, confirming hypotheses  $H_2$  and  $H_4$ . Similarly, farmer innovativeness had a positive and significant influence on intentions to use TC planting materials ( $\beta = 0.095$ ;  $t = 2.396$ ;  $p < 0.05$ ), thus supporting hypothesis  $H_7$  that farmer innovativeness significantly predicts farmer intentions to use banana TC planting materials.



**Table 6:** Demographic characteristics of study participants.

Item (N = 248)	%
Sex	45
Male	55
Female	
Age	
18–29 years	14
30–39 years	30
40–49 years	25
50 and over	31
Marital status	
Married	67
Single	9
Widowed/Separated	16
Unmarried living together	8
Annual income (UGX)	
< 1,000,000	10
1,000,000–4,999,900	46
5,000,000–9,999,900	26
10,000,000–14,999,900	13
>15,000,000	5
Education	
No formal education	11
Primary school education	40
Secondary school education	37
College/University education	12
Ethnicity	
Baganda	92
Basoga	2
Bakiga	1
Other (Japadhola, Bagishu, Balulu, Banyakole, Banyarwanda)	5

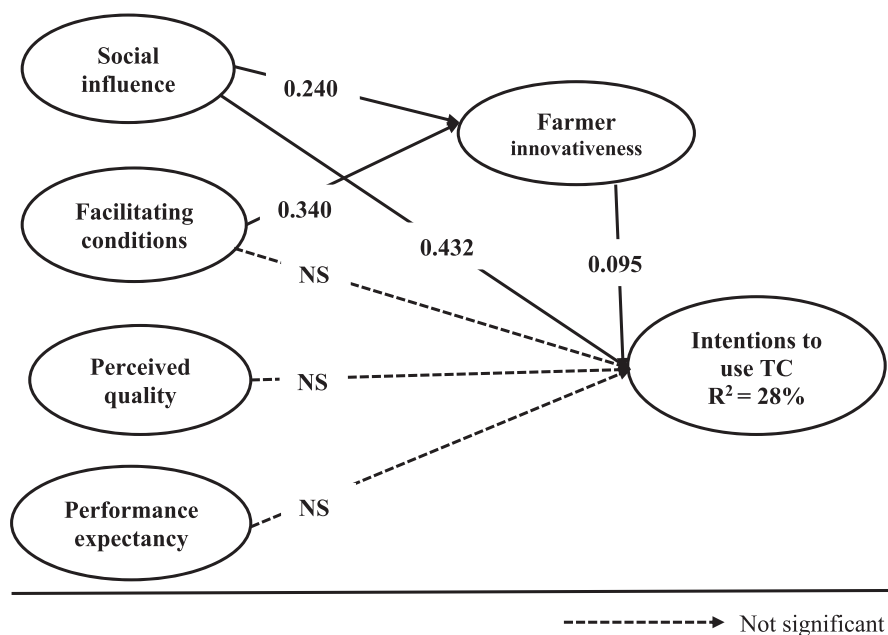
However, none of facilitating conditions ( $\beta = -0.044$ ;  $t = -1.043$ ;  $p > 0.05$ ), perceived quality of the TC planting materials ( $\beta = 0.031$ ;  $t = 0.574$ ;  $p > 0.05$ ) and performance expectancy ( $\beta = 0.175$ ;  $t = 1.913$ ;  $p > 0.05$ ) were significant predictors of farmer intentions to use TC planting materials. Hence, hypotheses H<sub>3</sub>, H<sub>5</sub> and H<sub>6</sub> were not supported in this study, implying that facilitating conditions,

perceived quality and performance expectancy are not perceived as important constructs in predicting farmer intentions to use TC banana planting materials.

**Extent of influence of technology-acceptance factors**

Bootstrapping results (Table 8) show that the indirect standardized effects for farmers’ innovativeness ( $\beta = 0.025$ ; 95% CI = 0.003 ~ 0.054) in mediating social influence to predict intention for uptake of TC planting materials was significant. Thus, the hypothesis (H<sub>8</sub>) that farmer innovativeness mediates social influence in predicting intentions for uptake of TC was confirmed. Similarly, the indirect standardized effects for farmers’ innovativeness ( $\beta = 0.046$ ; 95% CI = 0.008 ~ 0.098) in mediating facilitating conditions to predict intention to use TC planting materials was significant. Likewise, hypothesis (H<sub>9</sub>), that farmer innovativeness mediates facilitating conditions in predicting intentions to use TC, was confirmed.

Results further show that social influence is the most dominant predictor of intentions to use TC planting materials with the largest total effect of 0.492. Additionally, this finding is statistically significant ( $\beta = 0.492$ ; 95% CI = 0.308 ~ 0.647) and close to the large effect size criterion of Cohen (1988). The finding implies that social influence predicted about 49.2% of the variance in farmer willingness to use banana TC planting materials. Furthermore, facilitating conditions ( $\beta = -0.016$ ; 95% CI = -0.159 ~ 0.133), perceived quality of the TC planting materials ( $\beta = 0.040$ ; 95% CI = -0.126 ~ 0.203), performance expectancy ( $\beta = 0.141$ ; 95% CI = -0.068 ~ 0.332) and farmer innovativeness ( $\beta = 0.148$ ; 95% CI = 0.029 ~ 0.279) respectively predict 1.6%, 4%, 14.1% and 14.8% of the variation in the farmers’ intentions to use TC planting materials. Much as all these findings were significant, they fell short of meeting the medium size criterion of effect sizes as suggested by Cohen (1988).



Model fit:  $\chi^2/df = 2.349$ , AGFI = 0.826, RMSEA = 0.074, CFI = 0.954 and TLI = 0.950

**Figure 3:** Structural equation model.

**Table 7:** Path analysis results for testing hypotheses.

Hypotheses	Standardized estimates ( $\beta$ )	S.E	t-value	Decision
H <sub>1</sub> : SI $\rightarrow$ IU	0.432	0.057	7.651**	Supported
H <sub>2</sub> : SI $\rightarrow$ FI	0.240	0.088	2.720**	Supported
H <sub>3</sub> : FC $\rightarrow$ IU	-0.044	0.042	-1.043	Not supported
H <sub>4</sub> : FC $\rightarrow$ FI	0.340	0.067	5.062**	Supported
H <sub>5</sub> : PQ $\rightarrow$ IU	0.031	0.054	0.574	Not supported
H <sub>6</sub> : PE $\rightarrow$ IU	0.175	0.092	1.913	Not supported
H <sub>7</sub> : FI $\rightarrow$ IU	0.095	0.040	2.396*	Supported

\*\* $P < 0.01$ , \*  $P < 0.05$

The effect size in the relationship between facilitating conditions and farmer innovativeness ( $\beta = 0.310$ ; 95%  $CI = 0.192 \sim 0.423$ ) was significant and fell within the criterion of medium size. This finding implies that facilitating conditions predicted about 31% of the variation in farmer innovativeness to use the TC planting materials in controlling BXW. On the other hand, the effect size in the relationship between social influence and farmer innovativeness ( $\beta = 0.167$ ; 95%  $CI = 0.040 \sim 0.289$ ) was significant but it was only meeting small size criterion. This finding implies that facilitating conditions predicted about 16.7% of the variation in farmer innovativeness to use the TC planting materials in controlling BXW.

**Discussion**

Considering the importance of agricultural technology in the livelihoods of farmers, it is necessary to have a deeper understanding of the factors that are likely to influence easy uptake of new technologies such as a banana tissue culture. This study aimed to identify and examine technology-acceptance factors that reportedly influence the uptake of banana TC planting materials, this technology being part of the strategy of the Government of Uganda to control the prevalence of BXW. Based on UTAUT, the study aimed at investigating hypotheses on factors that were presumed to influence farmers' adoption and use of banana TC planting materials including; social influence, facilitating conditions and performance. Owing to the relevance of individuals' innovativeness towards acceptance of new agricultural technologies and farmers' perceptions of the quality of proposed planting materials, this study also examined the role of farmer innovativeness and farmers' perceived quality of the planting materials and how these influence farmer intentions to use the TC technology. The proposed model consists of explanatory variables from UTAUT, and is extended by two additional variables, viz; perceived quality and farmer

innovativeness. Results showed that social influence and farmer innovativeness are significant predictors of uptake of banana TC technology and that social influence was the most important among all predictors for intentions to use the TC technology. Results point to the fact that farmers will have positive intentions to use TC as planting material if there is influence from a farmer's social circle or if a farmer is innovative and creatively integrates the use of TC planting materials with local knowledge and other available materials in the control and management of BXW. This is consistent with several previous studies (Eckhardt, Laumer, and Weitzel 2009; Amoroso and Lim 2015; Okumus et al. 2018). The study findings further reveal that social influence and facilitating conditions influence farmer innovativeness. This indicates that a farmer's social circle and enabling conditions in the use of TC are essential in stimulating farmer innovativeness, an important predictor in TC planting materials uptake. This infers that social interactions and facilitating conditions are crucial in creating an enabling environment for farmers to be innovative.

Another important finding is the non-significant influence of facilitating conditions in predicting farmers' intentions for use of banana TC technology. This finding may be due to the fact that TC planting materials have been promoted in the study area for over a decade, and even campaigns against BXW have mainly focused on encouraging farmers to use TC seedlings. In addition, TC nurseries have been established in the study communities and, as such, farmers are familiar with TC planting materials and facilitating conditions, which explains why TC may not be of relevance to them in deciding whether or not to use them. Interestingly, this finding contrasts with previous literature supporting the significant effect of facilitating conditions on an individual's acceptance and uptake of technologies (Venkatesh et al. 2003; Alawadhi and Morris 2008; Eckhardt, Laumer, and Weitzel

**Table 8:** Boot strapping for mediation and effect sizes.

Path	Standardized effect sizes			Bias-corrected 95% CI	
	Direct	Indirect	Total	LL	UL
H <sub>1</sub> : SI $\rightarrow$ FI	0.167	-	0.167	0.040	0.289
H <sub>2</sub> : FC $\rightarrow$ FI	0.310	-	0.310	0.192	0.423
H <sub>3</sub> : SI $\rightarrow$ IU	0.467	0.025	0.492	0.308	0.647
H <sub>4</sub> : FC $\rightarrow$ IU	-0.062	0.046	-0.016	-0.159	0.133
H <sub>5</sub> : PQ $\rightarrow$ IU	0.040	-	0.040	-0.126	0.203
H <sub>6</sub> : PE $\rightarrow$ IU	0.141	-	0.141	-0.068	0.332
H <sub>7</sub> : FI $\rightarrow$ IU	0.148	-	0.148	0.029	0.279
H <sub>8</sub> : SI $\rightarrow$ FI $\rightarrow$ IU	-	0.025	0.025	0.003	0.054
H <sub>9</sub> : FC $\rightarrow$ FI $\rightarrow$ IU	-	0.046	0.046	0.008	0.098

2009; Lakhal, Khechine, and Pascot 2013; Ali, Nair, and Hussain 2016). For example, Alawadhi and Morris (2008) tested and confirmed the significant effect of facilitating conditions on students' use of e-government services and Lakhal, Khechine, and Pascot (2013) verified facilitating conditions as a significant determinant of students' intentions to use desktop video conferencing in a distance learning course.

Likewise, performance expectancy is not a significant predictor of farmer adoption of TC. This is perhaps explained by the fact that farmers have for the past decades interfaced with TC technology and have observed its performance on their respective farmsteads. Thus, they are keenly aware of the benefits that they can derive from the technology and possibly rather than buy TC banana seed, they use suckers from their TC planted mats as planting material to expand or fill gaps in their banana plantations. Our findings however contrast with previous literature supporting the significant effect of performance expectancy on intended users' acceptance and use of technologies (Biemans et al. 2005; Fang, Li, and Liu 2008; Eckhardt, Laumer, and Weitzel 2009; Ali, Nair, and Hussain 2016; Okumus et al. 2018). For example, Biemans et al. (2005) examined nurses' behavioural intentions to use medical teleconferencing applications and their findings reveal that performance expectancy is a high predictor of behavioural intention. Similarly, empirical evidence from a study by Fang, Li, and Liu (2008) shows that performance expectancy significantly predicts managers' intentions to engage in knowledge sharing using web2.0.

Conversely, the perceived quality of TC planting materials was also found to be a non-significant predictor of farmer use of TC. This is probably because for the past decade, farmers in the study communities have been intensively sensitized to and trained in the importance of TC as clean planting materials in attempts to control BXW. The finding implies that the farmers are undoubtedly aware of the quality of the TC planting materials, efforts that can be attributed to the role played by agricultural extension programmes through the Government of Uganda (Barungi, Guloba, and Adong 2015). Lastly, our findings further reveal that the mediating role of farmer innovativeness is significant in enhancing the potential of social influence and facilitating conditions in predicting the intentions of farmers to use the TC planting materials. This means however that farmers' innovativeness is a critical construct in intervening social influence and facilitating conditions if proper prediction for use of TC planting materials is to be made by the farmers (see also Turan, Tunç, and Zehir 2015).

### **Conclusion**

This study applied the UTAUT model to investigate factors influencing the use of TC banana planting materials as a strategy to control BXW. In attempts to achieve this overall objective, this study further used the constructs of farmer innovativeness and perceived quality of planting materials to extend the theoretical model of UTAUT. Our results have revealed that farmer innovativeness is an important and critical factor in

influencing the adoption of any agricultural technologies; in this case the TC banana planting materials. Farmer innovativeness also serves as a cardinal influence in mediating other technological-acceptance factors, such as social influence, and facilitating conditions for more meaningful and accurate prediction of farmers' intentions to use the available quality TC planting materials with the purpose of curbing BXW to enhance food and income security of smallholder farmers. This study reveals critical factors and thus expands the UTAUT framework in the context of farmers' use of TC planting materials by proposing two additional constructs that are ideal in predicting the technological acceptance behaviour among the farming communities – i.e. *farmer innovativeness* and *perceived quality* of TC planting materials. It can be concluded that these two are direct determinants of farmers' intentions to use agricultural technologies, such as banana TC planting materials. This study provides strong empirical insights to propose and test a model for assessing technology-acceptance related factors that influence farmers' intentions to use promoted and approved agricultural technologies for enhancing rural livelihoods. This implies that the results provide a strong foundation for application in different contexts and theoretical assessments in other research fields.

Furthermore, this study offers practical implications in relation to banana farmers and supporting institutions (e.g. TC Laboratories and research institutions) that help in breeding and propagating banana TC planting materials. Concerning rural-based farmers, the research findings also suggest that social influence needs to be taken as the most significant predictor in assessing their intentions to use the new TC planting materials. This is a key implication for research and other technology promoting institutions and extension efforts for the success of future related technologies meant for the marginalized rural farming communities. Results recommend that new interventions, such as the banana TC planting materials, need to be promoted through locally institutionalized mechanisms, like faith-based leaders, political and community leaders and their respective members. Thus, fostering individual and group-based forms of interactive learning (e.g. through farmer groups, experimental gardens and extension) can act as systems for more enhanced encouragement purposely to trigger the acceptance and use of agricultural technologies, such as the TC banana planting materials.

However, it should be noted that this research was basically designed to investigate perceptions of farmers towards TC planting materials with limited attention paid to the actual measurement of farmer use of the TC planting materials in study area. Thus, this calls for future research efforts to focus on investigating the actual uptake of the TC banana technology in Uganda and elsewhere in the world. Additionally, prospective studies may also propose comparative models for TC technology users and non-users to establish the extent to which the intentions to use the technology differ among the two independent groups. The study sample was limited to Central Uganda and future studies should collect empirical data from other banana growing regions to ascertain

whether use of technologies like TC banana planting materials are influenced by different ecological zones and/or regions.

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No potential conflict of interest was reported by the authors.

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#### Notes

1. An informal seed system is managed by the farmers without the public sector (Thiele 1999).
2. A formal seed system is regulated by the public sector, usually by an inspection process known as 'certification' and controls variety release to ensure that available seed is of a recognized variety with a low incidence of disease (RTB 2016).
3. Nematodes, weevils, bacterial and fungal wilts (incl. BXW) and viral diseases.
4. TC banana planting materials and TC seedlings are used interchangeably throughout the manuscript.

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