



The contestations of diversity, culture and commercialization: why tissue culture technology alone cannot solve the banana *Xanthomonas* wilt problem in central Uganda

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Abstract

Several initiatives by the Government of Uganda, Research Institutes and CGIAR centers have promoted the use of tissue culture (TC) banana technology as an effective means of providing clean planting material to reduce the spread of Banana *Xanthomonas* wilt (BXW) but its uptake is still low. We examine factors that constrain uptake of tissue culture banana planting materials in central Uganda by considering the cultural context of banana cultivation. Data were collected using eight focus group discussions involving 64 banana farmers and 10 key informant interviews and subjected to thematic analysis. Results showed that banana cultivars in the study communities were important for food, cultural practices and medicine. Cultivars supplied through TC were based on commercial considerations focusing on market value and household income and insufficient attention was given to their cultural importance. Farmers regard banana from TC planting material to be incompatible with their tastes and preferences for traditional food and drinks, culture and medicine. Furthermore, the plantlets are perceived as complicated to use, and farmers report requiring more knowledge and information on how to plant and maintain the plantlets on-farm. In these aspects, TC planting material does not align with cultural values linked to societal welfare. Future efforts aimed at controlling pests and diseases would benefit from more location-specific and holistic approaches that integrate cultural dimensions alongside planting material hygiene, quality and vigor.

Keywords Banana tissue culture planting material · Cultural values · Diversity · Banana *Xanthomonas* Wilt (BXW) · Technology uptake

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Abbreviations

AGL	African Great Lakes
BX	Banana <i>Xanthomonas</i> Wilt
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agropecuaria Tropical
EAHB	East African Highland Bananas
FGDs	Focus Group Discussions
FHIA	<i>Fundación Hondureña de Investigación Agrícola</i> In Honduras (Honduras Foundation for Agricultural Research)
GM	Genetically Modified
IITA	International Institute of Tropical Agriculture
LC	Local Chairperson
NGOs	Non-Governmental Organization
TC	Tissue Culture

Introduction

Banana (*Musa spp.*) is a staple and cash crop in the East African region with over 30 million people depending on the crop for food and income (Dotto et al. 2019). The crop highly nutritious, providing a good source of carbohydrates, vitamins (A, B₁, B₂, B₆, and C), minerals (potassium, iron, zinc, calcium, phosphorous, magnesium and selenium), polyphenols, resistant starch, and antioxidants (Hardisson et al. 2001; Haslinda et al. 2009). Banana is a major staple for more than a half of Uganda's population. The average national *per capita* annual consumption of bananas is estimated at close to 1 kg per person per day, the highest in the world (Edmeades et al. 2015). The crop occupies the largest cultivated area (about 30% of cropland) on plots of less than 0.5 ha (Ngambeki et al. 2003; Edmeades et al. 2015). Banana cultivation in Uganda is dominated by the locally evolved clones known as the East African Highland bananas (EAHB) (Gold et al. 2002), which include the harder green cooking bananas locally called "matooke". *Matooke* is the leading staple food with an annual production of over 6 million tonnes (Kilwinger et al. 2019). The crop also provides a wide range of products (animal feeds, charcoal briquettes, crafts, and construction materials) which significantly contribute to food and income security of the populace and consequently to national development (Kikulwe et al. 2018).

Banana *Xanthomonas* Wilt (BXW) disease, caused by the bacterium *Xanthomonas campestris* pv. *musacearum*, is currently an important threat to banana production in East and Central Africa (Kikulwe et al. 2019). The disease can cause up to 100% yield loss where highly susceptible genotypes dominate the farming systems, severely compromising food security and livelihoods for banana-based farming households (Kubiriba et al. 2012; Cori et al. 2018). This disease has no cure and has been a main reason for poor yields since its emergence in the African Great Lakes (AGL) region in 2001 (Tushemereirwe et al. 2004; Kubiriba and Tushemereirwe 2014). In Uganda, the disease was first reported in Mukono District, Central Uganda in 2001 (Tushemereirwe et al. 2004) and by 2005 it had rapidly spread to South Western Uganda, the major banana producing areas. Between 2002–2005, the disease caused a cumulative economic loss of 61.1 million dollars by the country, mainly affecting EAHB, 'Matooke' (AAA-EAHB genome) and the 'Kayinja' beer banana (ABB genome) (Tushemereirwe et al. 2009). According to McCampbell et al. 2018, the disease is also of prominent importance in neighboring banana producing countries, namely: Burundi, Kenya, the Democratic Republic of Congo, Rwanda, and Tanzania.

The causative bacterium *Xanthomonas campestris* pv. *musacearum* is highly transmissible mainly through infected plant material, contaminated farm tools and soil, trade of

banana and its products, and occasionally through vectors such as insects, birds, and bats (Blomme et al. 2014; Ocimati et al. 2019) (Fig. 1). The mode of spread varies significantly based on the production system, agroecology and cultivars grown. All cultivars grown in the Great Lakes region of Eastern Africa are susceptible, and no source of resistance has been identified (Kalyebara et al. 2007; Tripathi et al. 2009; Kubiriba and Tushemereirwe 2014). Figure 1 illustrates the transmission pathways of the bacterium.

Over the past 16 years, various research and extension efforts at global, national and local echelons have converged to manage and contain the disease (Ocimati et al. 2019; Gotor et al. 2020). Epidemiology studies of BXW (e.g., see Blomme et al. 2005, 2017; Kubiriba et al. 2012; Nakato et al. 2015; Ocimati et al. 2015) informed control strategies including farmers sensitization and development and enforcement of bylaws for control of the disease (Kubiriba et al. 2012; Blomme et al. 2014). These efforts, however, have not been effective for landscape-wide control of BXW. Once the disease is established, its eradication has proved difficult (Eden-Green, 2004; Ocimati et al. 2019) due to inappropriate recommendations for agronomic and/or technical practices¹ (Karamura et al. 2008). Some farmers do not adhere to these recommendations due to the associated high labor cost and perceptions about the management practices (Jogo et al. 2013; Uwamahoro et al. 2019). Farmers are usually reluctant to employ labor-intensive and costly disease control measures (Namukwaya et al. 2011). These practices require regular monitoring, adding to the labor and time burden for the farmer. This compromises BXW eradication, resulting in farmers' reluctance to apply the recommended practices. Consequently, systematic application of such control practices is frequently done in large-sized households (Mbabazi et al. 2021).

Establishing banana plantations with clean (pathogen-free) seed² is the most effective way to manage the BXW (Also see Thomas-Sharma et al. 2016). This has led to popularization of Tissue Cultured (TC) plant material as a response strategy to supply disease-free seed and enhance productivity (Dubois et al. 2013; Mulugo et al. 2020). In this aspect, TC banana epitomizes many of the principles of the New Green Revolution of Africa³ (Vercillo et al.

¹ Such as timely removal of male buds with a forked stick, disinfection of farm tools, removal of infected plants and use of clean planting materials.

² Seed, TC banana planting materials and TC banana plantlets are used interchangeably throughout the manuscript.

³ There are a host of environmental, health and social consequences of Green Revolution technologies, widely documented, which have implications for both food consumption and nutrition inadvertently leading to low uptake of such technologies in Africa (see Kerr 2012; Rock and Schurman 2020).

2015; Schnurr 2019). It is a form of micro-propagation that allows for replicating, regenerating, and rapid/y disseminating planting materials that are genetically identical and disease free (Kikulwe, 2016). Tissue Culture encapsulates a new paradigm of agricultural development efforts, in which its promoters have stepped in to address crop productivity failure by investing in the technology to manage and contain crop diseases whilst expanding farmers' livelihood opportunities, especially amongst vegetatively-propagated crops such as banana (Schnurr 2019). Therefore, adoption of TC seed has been collaboratively promoted by the Ministry of Agriculture Animal Industries and Fisheries, National Agricultural Research Institutes, CGIAR centers and private institutions (Mulugo 2021).

However, the penetration of TC banana planting materials is reportedly low—only 7% of national plantings (Dubois et al. 2013), with reported highest levels (19.3%) in the western region (Mmurongo et al. 2018). Reluctance by farmers to take up TC planting materials has to-date been explained by economic factors namely: access and high cost of plantlets, labor costs and input requirements (Kabunga et al. 2012; Njau et al. 2011). Without discounting the importance of these factors, they do not sufficiently embed banana cultivation in the cultural values and practices of central Uganda built on cultivar diversity. The economic perspective alone for example, cannot adequately explain the low uptake of TC planting materials among commercially-oriented farmers whose aim is supposedly to maximize productivity. In central Uganda, bananas are not only a commercial food crop, but also a cultural artefact. Values and cultural attachments to specific banana cultivars construct a contextual setting around the banana production system in Central Uganda that needs to be considered while assessing uptake of TC planting materials. In other circumstances, it has been shown that uptake of agricultural innovations in farming systems is influenced by cultural values (Warren et al. 2016), that are deeply ingrained in societal norms, belief systems, behavioral patterns and the way of life (Idang 2015). Whereas promotion of TC planting materials has focused on supplying a few commercial cultivars that can offset the labor and input costs, these cultivars do not meet the diverse cultural interests of farmers in central Uganda. Literature shows that though there are several drivers of TC technology adoption including economic, climatic and agronomic, there is scant emphasis on cultural aspects that may influence uptake of the technology. This study therefore contributes to the known literature by assessing the cultural context/dimension influencing uptake of TC technology using TC banana. We unravel critical cultural aspects of relevance in the enhancement, use and acceptance of TC technology by farmers in central Uganda.

Methodology

Study area

The study was conducted in central Uganda where banana production is anchored in cultural values and practices beyond food and income. Bananas have been grown for centuries in central Uganda (Lwandasa et al. 2014) then spreading to Western and South-western Uganda largely as a commercial crop. It is estimated that about 58% of agricultural households in central Uganda grow bananas (Uganda Census of Agriculture 2010) for multiple purposes. The study was carried out in Luwero and Mukono districts, where TC banana seed has been promoted by the International Institute of Tropical Agriculture (IITA), Bioversity International⁴ and private institutions (e.g. Agro-Genetic Technologies Limited, Biocrops Uganda Limited) for more than a decade. Despite this the region still continues to experience high BXW prevalence (Ocimati et al. 2015). The two districts pioneered community-based TC banana nurseries to facilitate farmer access to TC seed. The community nurseries were linked to TC laboratories that supplied the materials. Villages that hosted community nurseries were targeted on assumption that proximity enhances access to and hence uptake of TC banana plantlets. Nambi and Gonve villages in Luwero and Mukono districts respectively were the study sites (Fig. 2). The two were the pioneer villages where community TC nurseries and TC demonstration gardens were established.

Research Design and data collection

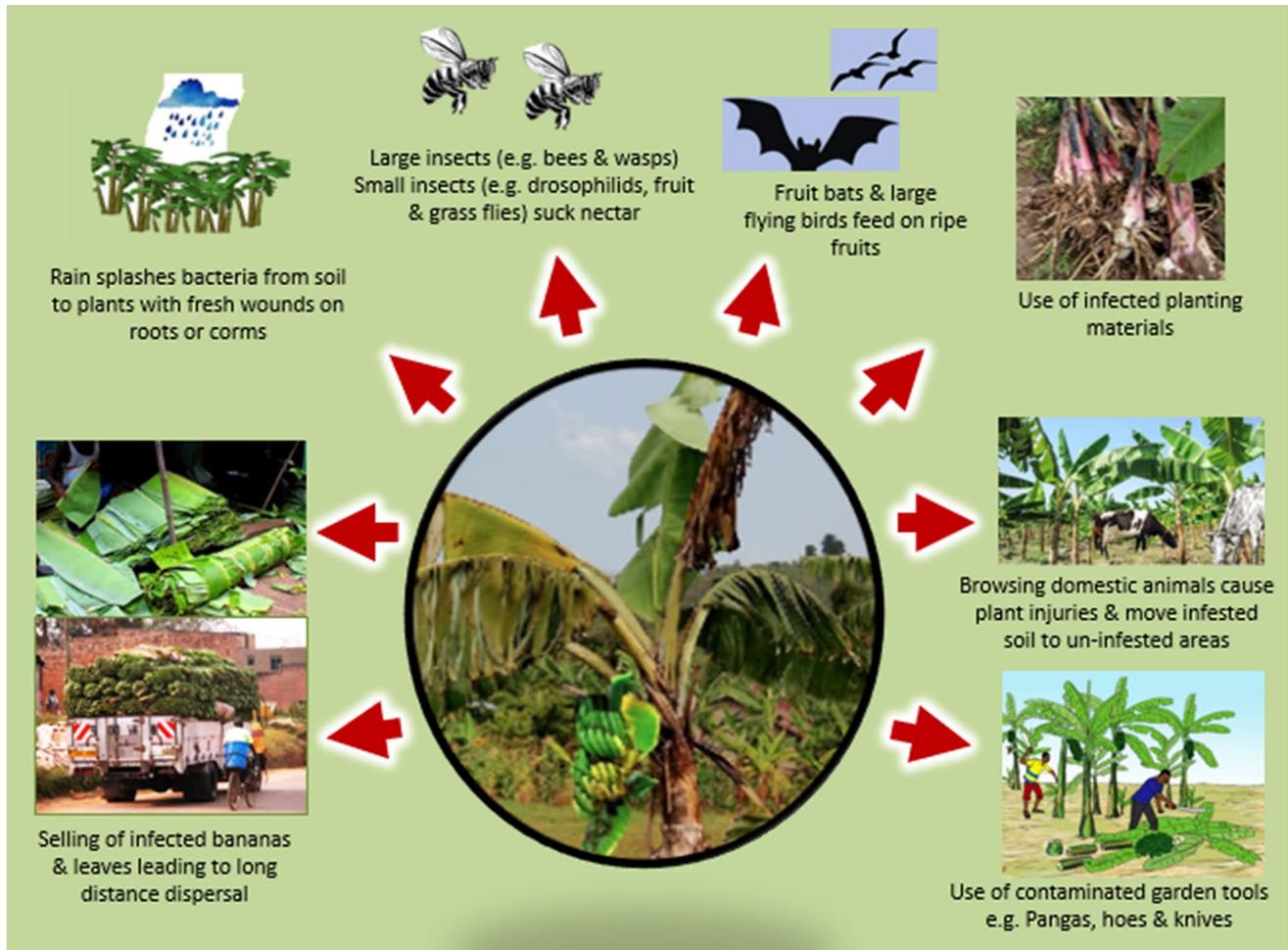
A qualitative study design was developed to better understand the cultural values, traditions, beliefs and practices associated with banana cultivation in the study communities. The purpose of this study is to go beyond commercial, economic and agronomic aspects such as cost of plantlets, and begin to understand how farmers think and understand what they do.

Focus Group Discussions (FGDs) and key informants' interviews were used to collect data between August 2016 and February 2017. Village leaders (Local Council I [LC I] Chairpersons) provided a list of farmers who had accessed TC banana seed. Farmers who had not accessed TC planting materials were excluded from the study as they were presumed not to have experience with the materials. From

⁴ Bioversity merged with the *Centro Internacional de Agropecuaria Tropical* (CIAT) in a research centre Alliance (<https://www.bioversityinternational.org/alliance/>) in 2020, and subsequently officially became part of the One CIAR in 2022 (<https://www.cgiar.org/food-security-impact/one-cgiar/>).

Table 1 Proportion of focus group participants by location and sex

Location	Number of FGDs by sex		Participants	Number
	Male	Female		
Village: Nambi Luwero district	2	2	Male (16) and female (16) farmers	32
Village: Gonve Mukono district	2	2	Male (16) and female (16) farmers	32
Total	4	4		64

**Fig. 1** Transmission pathways for the bacterium *Xanthomonas campestris* pv. *Musacearum* causing BXW

the list for each village, the village leaders helped identify 32 farmers (16 male and 16 female) who could participate in the FGDs and transmit their experiences. FGDs were conducted in each village guided by a checklist (attached) separately for male and female farmers. Gender segregation was necessary to allow freedom of expression (Braga 2001). For effective discussion and involvement of all FGD participants, two FGDs for male and female farmers were conducted each FGD involving eight farmers as summarized in Table 1. The intention was to generate diverse cultural practices, beliefs and values from the perspectives of male and

female farmers. Farmers were also questioned to determine whether or not they had observed any differences between using TC seed and banana suckers. Farmer responses were noted based on their consensus about the expressed views, explanations, attributes, ideas or reasons.

Based on the interactions of the researchers with farmers during FGDs, ten key informants (4 male and 6 female banana farmers from both villages) were identified (based on their wealth of knowledge and ability to articulate issues) for follow-up to obtain more in-depth information and clarification on the cultural practices and rituals performed associated

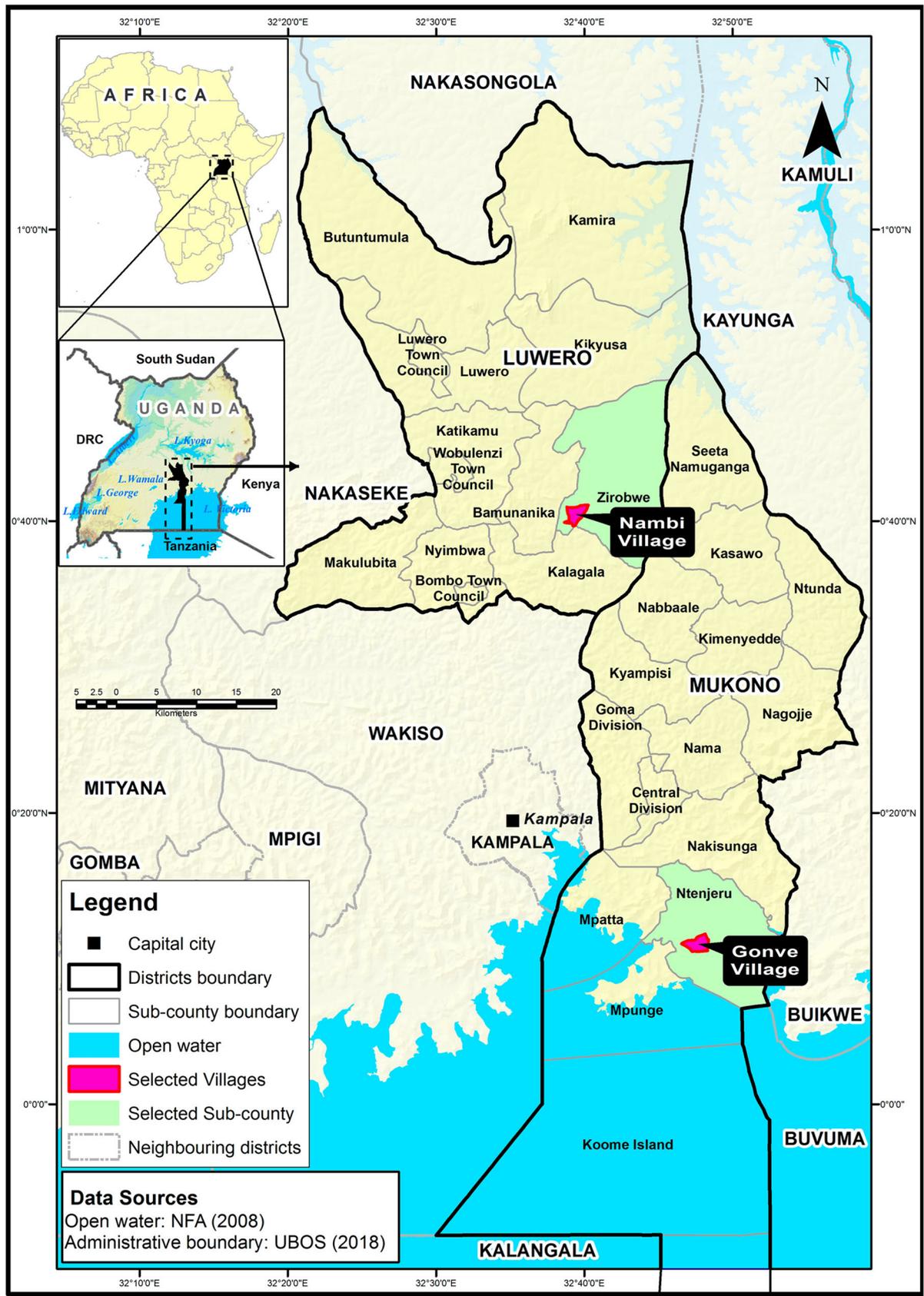


Fig. 2 Location of study villages

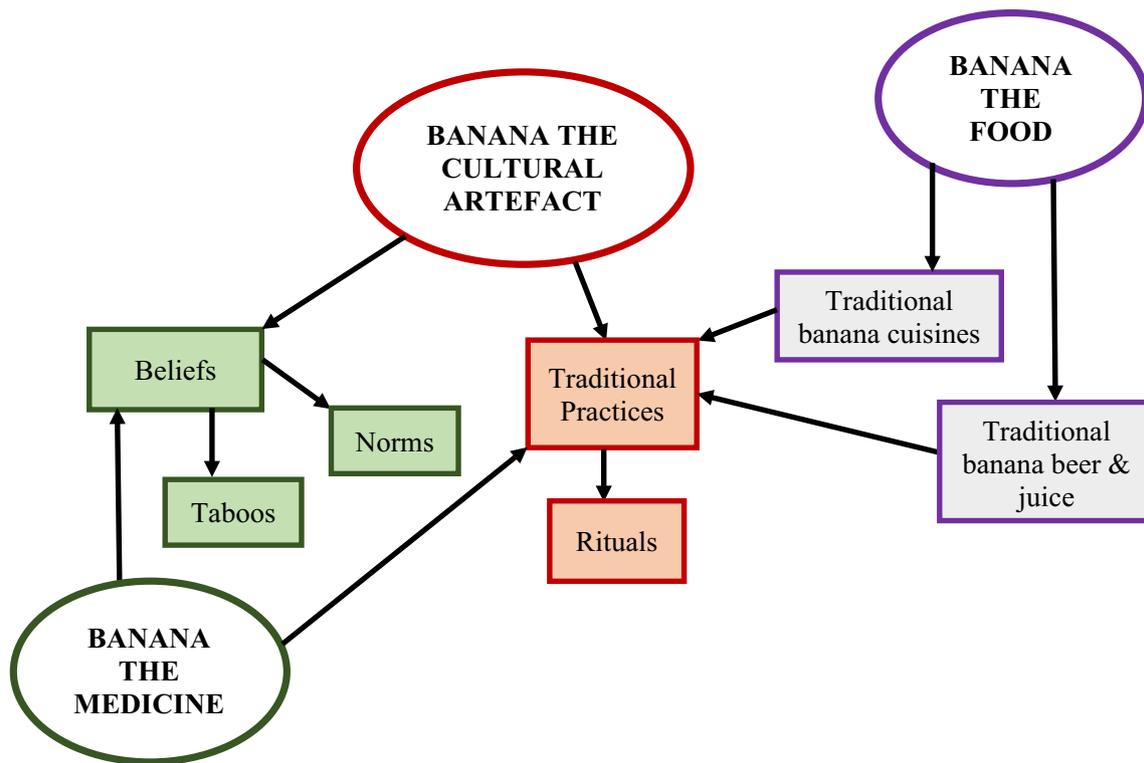


Fig. 3 Thematic map of uses of bananas in the Baganda culture

with different banana varieties. The interviews were conducted in the local language (*Luganda*) and recorded using a digital recorder for accurate capture of the narratives. Photographs illustrating cultural practices were taken for visualization.

Data analysis

The narratives were translated from *Luganda* to English and transcribed for analysis. Thematic-content analysis as described by Braun and Clarke (2006) was applied. Specifically, (i) chunks of data with similar information were clustered; (ii) initial codes for each chunk of data generated using the inductive coding approach (Chandra and Shang 2019); and lastly, (iii) themes were synthesized, reviewed, described and named. A thematic network (Fig. 3) was drawn to illustrate the relationships between, and interrelatedness of the themes developed. The works of Karamura et al. (2012) and Hamilton et al. (2016) were used to categorize the banana cultivars found in the study communities (by clone sets, genomes and genome groups).

Results and discussion

Three themes emerged regarding the major uses of banana in central Uganda: Banana as food; Banana as a cultural artefact; and Banana as medicine (Fig. 3). The uses are inter-related though specific cultivars are associated with or preferred for each use.

Banana cultivars and their cultural uses

Forty-five banana cultivars were found to be grown by farmers in the two villages studied (Table 2). The diversity of cultivars is also associated with the wide range of uses and preferences. Farmers usually grow several in the same garden partly to accommodate critical values/needs as explained later in this paper. With regard to use, cultivars are generally categorized as: cooking banana—commonly

Table 2 Banana cultivars grown in Gonve and Nambi communities in central Uganda

Banana varieties	Clone set	Genome	Genome Group	Major Use
<i>Kisansa</i> + <i>Mpologoma</i> + <i>Mpologoma omukadde</i> <i>Musakala</i> + <i>Muvubo</i> * <i>Namunwe</i> <i>Mayovu</i> *	Musakala	East African Highland	AAA-EA	Cooking
<i>Mbwazirume</i> <i>Nakamali</i> <i>Nakitembe</i> + <i>Nalugolimo</i> <i>Nandigobe</i> <i>Nasalugiri-Soola mwana</i> <i>Wakirigga</i> <i>Nabununike</i>	Nakitembe	East African Highland	AAA-EA	Cooking
<i>Kibuzi</i> + <i>Mukubyakonde</i> * <i>Nakabululu</i> <i>Nakyatengu</i> *	Nakabululu	East African Highland	AAA-EA	Cooking
<i>Atwalirannyina</i> <i>Katwalo</i> <i>Lusumba</i> <i>Muziranyama</i> <i>Nabusa</i> <i>Nakabinyi</i> <i>Nakawere</i> * <i>Nakinyika</i> <i>Nambi</i> * <i>Namwezi</i> * <i>Ndibwabalangira</i> <i>Nfuuka</i> + <i>Siira</i> * <i>Kyesusa</i>	Nfuuka	East African Highland	AAA-EA	Cooking
<i>Embidde enganda</i> <i>(Kabula & Nsowe)</i> * <i>Improved Ndiizi</i> + <i>Bogoya</i> <i>FHIA – 17</i> + <i>FHIA – 01</i> + <i>FHIA 25</i> + <i>KM5(Kabana 5)</i> + <i>Gonja (Nakatansese & Manjaya)</i> + <i>Kayinja</i> <i>Kisubi</i> <i>Kivuuvu</i> <i>Sukali Ndiizi</i>	Mbidde	East African Highland	AAA-EA	Juice/Brewing
		Gros Michel	AAA	Dessert
		Tetraploid hybrids	AAAA	Cooking & Dessert
		Tetraploid hybrids	AAAA	Cooking
		Tetraploid hybrids	AAAA	Juice/brewing
		Plantain	AAB	Dessert
		Pisang Awak	ABB	Roasting
		Ney Poovan	AB	Brewing
		Bluggoe	ABB	Brewing
		Kamaramasenge	AAB	Dessert

+ Cultivars introduced under TC; * Nearly extinct and still desired banana cultivars

known as *matooke*; dessert banana—eaten when ripe; brewing banana for making local beer known as *tonto*, and roasting banana. Most of these belong to the East African Highland genome group (AAA-EA), which according to Karamura et al. (2012) are grouped into five major clone sets namely: Musakala, Nakitembe, Mbidde, Nfuuka, and Nakabululu—each one with unique characteristic

attributes. The cooking-type group has the highest diversity in respect to cultivars than the other groups. Cultivars for brewing have high tannin content and astringent fruit (Hamilton et al. 2016). In addition to the economic use (food, or brewing), the cultivars have multiple cultural uses that compel a single farmer to grow several cultivars in the same plantation.

Table 2 presents the cultivars found in the study area and those that were available through TC. It is noted that the cultivars supplied through TC represent only a very small proportion of the cultivars that farmers currently grow. Farmers make choices of cultivars planted to meet their diverse uses including the cultural values. This implies that even farmers who choose to grow the cultivars supplied through TC also grow other cultivars (in the same plantation) to include a range of banana uses. This practice encourages cross-infection thereby defeating the intention of controlling BXW using TC technology. We discuss how the different uses of banana are embedded in the culture and traditional practices of the *Baganda* with a view of elucidating how the TC planting materials may be ineffective in controlling BXW.

Banana cultivars as food

As food, bananas are consumed in different forms; as *matooke*,⁵ roasted (plantain), dessert, juice/traditional beer. Among the cooking varieties, farmers may prefer specific ones for their own consumption while others are grown for the market (also see Bagamba et al. 2006; Kitanishi et al. 2018). Those for family consumption may not be high yielding but are preferred for their taste, color (yellowish) and texture (soft). Food in the cultural context wields power to bring joy and happiness to the consumer (Lee 2011). Culinary practices in Uganda call for different kinds of banana for different kinds of dishes/beverages that bring pleasure or good taste. However, the *matooke* Cultivars introduced under TC (Mpologoma, FHIA-01 and FHIA-17) were reported to have undesirable color (whitish) when cooked, with no aroma and a ‘flat’ taste. This finding is in tandem with Kikulwe et al. (2011) who found out that consumers in Uganda are willing to purchase genetically modified (GM) banana cultivars only if they contain tangible benefits, such as agronomic, nutritional and taste traits. Similarly, according to Schnurr et al. (2020), if banana cultivars targeted for biofortification to address vitamin A deficiency in children under five and lactating mothers in Uganda are not the preferred traditional varieties, such biofortified cultivars are less likely to be adopted by consumers.

For some cultural events like traditional marriage ceremonies known as ‘*kwanjula*’, the specific cultivar (*Nakitembe*) is used to prepare a special meal for the groom’s family and/or presented as gift to the bride’s family. Its stem and leaves also possess medicinal properties useful for treating menstrual pains and infants’ skin diseases (*ekyogero*). Out of the seven cultivars that constitute the *Nakitembe* clone-set

for example, only one cultivar was supplied through TC. This constrains the diversity of cultivars within a particular clone-set that is used for several cultural functions. It is noted that cultivars supplied through TC were based on commercial considerations (bunch and finger size) focusing on the market value and household income (also see Bagamba et al. 2006; Kitanishi et al. 2018) and inadequate attention was paid to cultural significance. In Central Uganda, farmers choose cultivars not only for food and income but also the cultural practices among the *Baganda*. Even for food, not all commercial cultivars would be preferred for household consumption. The available TC planting materials do not provide a wide range of choices to serve farmers’ diverse uses and preferences. For example, one of the farmers in an FGD in Luweero District stated:

Not all cooking-type cultivars make good *matooke*. Some cultivars are better and as a farmer who has a choice, I would prefer *matooke* from specific cultivars like *Nakitembe*, *Mukubyakonde*, *Muziranyama* and *Nakawere* even though these may not be the best commercial varieties (October, 2016).

Other cooking cultivars have special cultural significance. For example, the *Ndibwabalangira* literally by its name implies, it is best for royalty—meaning it has attributes that only royalty merits. Another variety, *Nakawere* by its name implies it is best for mothers that have just given birth, probably due to its nutritional value. *Atwalirannyina*’s name implies that the cultivar is the best gift one can give to their mother because of its taste, large finger and bunch size. Banana cultivars also symbolize social status and therefore focusing solely on commercial value in selecting TC-produced cultivars will also encourage growing local cultivars infected with BXW alongside the TC varieties, thus compromising overall BXW control.

Traditional beer (*omwenge omuganda-tonto*, *akaliga*, *kwete*, *omusetulo* and *enguli*) is central and used at all cultural and social functions whether it is a celebration or funeral or other cultural ceremonies. Brewing banana cultivars are also used to produce juice (*omubisi*). None of the traditional brewing cultivars were supplied through TC, instead new hybrid cultivars (FHIA-25 and KM5) were provided, to which farmers are unaccustomed. The scientific explanation was that the local brewing cultivars are highly susceptible to BXW (Adikini et al. 2013; Tripathi et al. 2009) but at the same time farmers claim new cultivars have low sugar content and do not make good quality beer. It is not possible for farmers to abandon such an important cultural value and will continue to plant their local cultivars even though this practice favors cross-infection and hence BXW spread.

Though in varying proportions, all farmers grow a wide range of cultivars in the same plantation to meet both their

⁵ *Matooke* is prepared by peeling green fingers of a mature bunch. They are wrapped in banana leaves, steamed, and mashed. Different varieties present different taste, flavour, colour, texture and aroma.

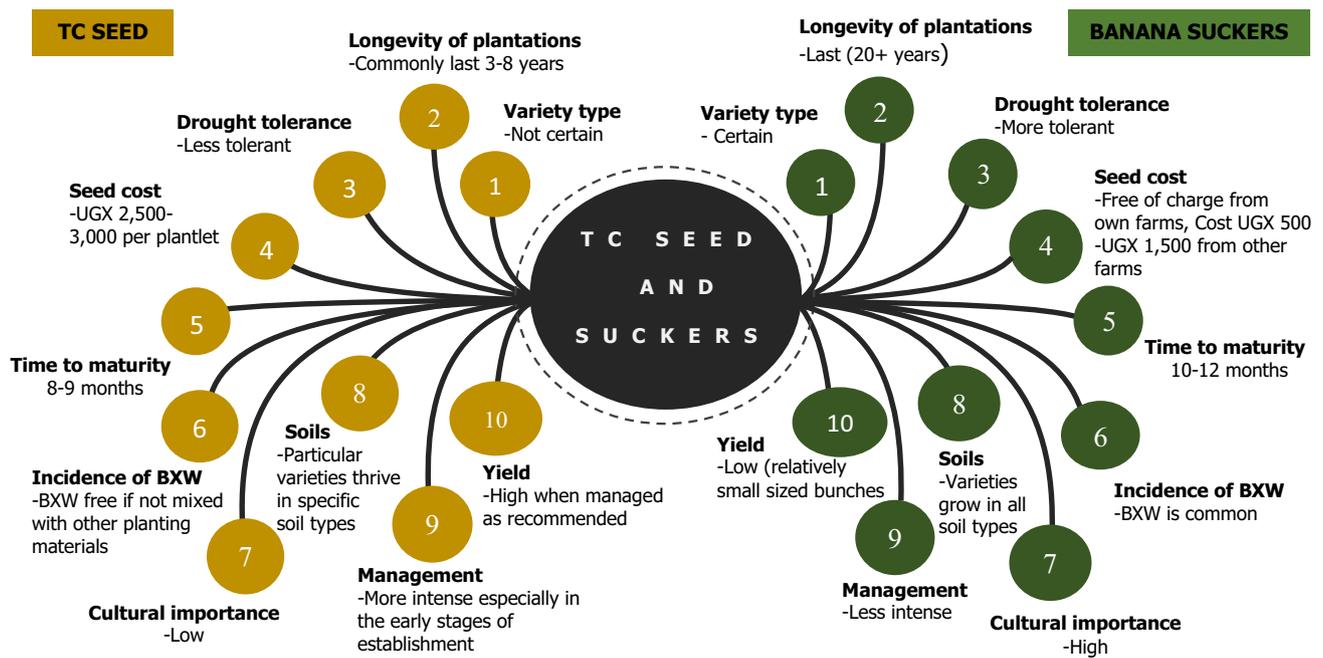


Fig. 4 Farmers' comparison by performance of TC banana seed and suckers

economic and socio-cultural interests (Gold et al. 2002; Karamura et al. 2012). Specific to the central region, banana plantations are at times split into part for the male and part for the female household members—the former producing mainly for the market and the latter for home consumption and including cultural uses (Karamura et al. 2004). In these two parts, the cultivars may be different. Diversity is also desirable for food security and sustainability of the food system (Bioversity International 2017). Nonetheless, it is difficult to maintain this diversity with TC due to high cost of propagation and yet some cultivars may not be in sufficiently high demand to be economically viable for any TC business. Our findings are consistent with previous studies (Kabunga et al. 2012; Mmurongo et al. 2018) postulating cultural values, higher labor and input requirements as key barriers to TC use. However, these findings notably diverge with Mukasa (2018) who associates limited uptake of innovations in Tanzania and Uganda with long distances—limiting farmer accessibility to agricultural technologies. This study is nested in a specific cultural context and cannot be generalized, the same way that other studies need not over-generalize. Effective BXW management and promotion of TC technology require context-specific considerations especially for communities where banana is a traditional crop.

Additionally, in our study men preferred growing high yielding cultivars with big fingers and bunches (e.g., Mpologoma, Musakala, Kisansa) for the market, which are mainly promoted through TC. However, women preferred cultivars that yield multiple bunches (e.g., Nakabululu,

Nakabinyi, Mukubyakonde) continuously throughout the year (Plate 1). These cultivars produce small- to medium-sized bunches with perceived good taste (in relation to flavor, color, texture and aroma), but there are hardly available through TC. A possible explanation for men's interest in high-yielding cultivars is that men traditionally control household finances (e.g. for education, healthcare, and investments) while women customarily ensure their household food security, a key cultural role especially in central Uganda (Sanya et al. 2020). Results also showed that women prefer traditional cultivars with soft leaves (e.g., Kayinja, Bogoya, Ndizi) important for steaming food and preparing traditional dishes locally known as *mpombo* (see Plates 2 and 3). Leaves of introduced TC cultivars such as FHIA 17 were mentioned to be very large and brittle, seldom used during traditional ceremonies like burial ceremonies and last funeral rites when large amounts of *matooke* are prepared. In such situations, the large leaves are the final wrapping material to cover the huge mounds of food. In terms of division of labour in banana production in central Uganda, men mostly perform labour-intensive activities such as digging holes, removal of unwanted suckers, stump removal, harvesting for the market and transportation of large bunches. The women carry out activities requiring less physical strength such as weeding, removal of old leaves and fibres and harvesting bunches for food. Our findings resonate with Rietveld et al. (2016) whose results show different roles of men and women among banana-producing households in

South Western Uganda. To foster uptake of TC banana, especially among women, it is imperative that promoters of TC technology factor in cultivar diversity and women-preferred attributes in their promotion campaigns.

In comparison of performance between TC seed and suckers, farmers had perceptions that tended to disadvantage the use of TC seed as outlined in Fig. 4.

From their own experience, farmers observed that any new cultivar supplied through TC required more intensive management including greater use of fertilizers/manure, mulching and water availability than in the traditional system. It is noted that since these are largely selected for high yields, their crop nutrient requirements are also higher for optimum performance. If managed the same way as the local varieties, they may yield even less than the local varieties. This increases management costs in addition to the high seed cost. In this perspective, TC plantlets are considered to offer no relative advantage, complicated to grow, and require changes in practices which have to be accompanied by new management information. Some farmers who planted TC seed complained about not being able to precisely identify the cultivars before planting unlike for the suckers. It is possible that plantlets are mixed up in the nursery or mislabeled and the farmer may only realize after a long time. Bananas being a perennial crop, farmers have to bear with the undesired effects for several years. This complexity exists not only at the farm level, but also across in the entire seed system, posing a greater risk where a farmer may have mistakenly planted an unintended variety.

One of the farmers expressed disappointment with TC materials as follows:

These are the kind of ‘plants’ (referring to TC) that can be easily identified from your plantation due to poor growth characteristics, in spite of the fertilizers, labor, capital and time you spend on them. They simply ‘refuse’ to grow! (FGD Mukono District November 2016).

It is also possible that such disappointment could be due other factors such as weevil damage (also see Robinson 1996) and therefore a package of knowledge and management practices is required to effectively grow TC bananas.

Additionally, farmers indicated TC seed established plantations did not last as long as those planted with suckers. In the words of one farmer:

We got fifteen (15) free TC plantlets and a bag of manure each to establish a demo TC plantation. We were also encouraged to plant 10 local banana cultivars alongside the TC plants for comparison. However, due to prolonged dry spells we experienced in the recent past, currently, all the TC plants wilted

and dried but the 10 local cultivars survived and still exist. (FGD Mukono district, November 2016).

This may be attributable to challenges in the tissue culture micro propagation process related to somaclonal variations (Damasco et al. 1996), poor physiology (George 1996) and the lack of soil micro-biota. As established by Nowak (1998), these factors can render the performance of TC seed to be poor, especially under environmental stress. It is also argued that the survival of TC seed at establishment may be hampered by climatic stress since plantlets are devoid of food reserves (Kavoo-Mwangi et al. 2014). Besides, the performance of commercial cultivars (big bunches and big fingers) as is the case with newly introduced TC seed requires higher soil fertility to sustain their production. Nevertheless, the soils in the central region have for various reasons considerably deteriorated in fertility (Zake et al. 2000; Nyombi 2013) which can contribute to a shorter survival period of TC-established plantations. In such aspects, there is lack of demonstrated relative advantages that TC seed has over suckers to convince farmers to take up TC planting materials.

Banana as a cultural artefact

Specific banana cultivars were used for different cultural practices. The banana in this case is not just a crop but also a cultural artefact. Propagation of TC planting materials would therefore have to accommodate the cultural use of banana and supply essential varieties. Table 3 presents the cultural uses of five different banana cultivars in central Uganda.

These cultural practices are performed at household level, thereby requiring every household to have these varieties. Such cultivars are not among those supplied through TC because they are not of commercial value. A farmer in Nambi village emphasized:

It is almost mandatory that in every household, each banana plantation will have cultivars such as *Nakitembe*, *Embidde enganda* and even *Gonja*. (October 2016).

These cultivars are used in several cultural practices related to child-birth ceremonies, marriage ceremonies, funerals and funeral rites. Even with current modernization, it is common for women to give birth at home or within the community. Traditionally, when a mother gives birth at home, the placentas are not thrown away as they are symbolic to the new-born child. For example, if a baby girl is borne, the placenta is wrapped in cloth by family and/or clan members and placed in a mat of *Nakitembe* cultivars (Plate 1). For a baby boy, the placenta is placed in a mat of *Embidde enganda* or *Kayinja* varieties. It is then covered with herbs- ‘*bombo*’ [*Mormodica foetida* Schum.]

Table 3 Banana cultivars and their cultural practices in central Uganda

Variety	Cultural importance
<i>Nakitembe</i>	Disposal of placentas for newly borne baby girls Treating menstrual pains especially for young girls experiencing menstruation for the first time Herbal baths for baby girls Practices for celebrating birth of twins Cleaning of the dead (females) before burial (Mid rib of <i>Nakitembe</i> pseudo stems crushed and used to 'wash' the deceased's face. Believed to keep away the spirits of the dead) Marriage ceremonies -Leaves used in <i>matooke</i> preparation for in-laws during introduction (<i>Kwanjula</i>) ceremonies -Leaves important for herbal baths of brides before marriage -Ceremonial meal to husband prepared by bride after honeymoon
<i>Embidde enganda</i> (<i>Kabula & Nsowe</i>)	Disposal of placentas of newborn baby boys Cleaning of the dead (males) before burial. Mid rib of pseudo stems crushed and used by relatives to 'wash' the deceased's face Herbal bath ' <i>Ekyogero</i> ' for male babies Leaves used for herbal baths of bridegrooms
<i>Kayinja</i>	Used in practices to divert rains. A stick is pierced through a banana finger and roasted in a fireplace (' <i>Ekyoto</i> ') Used in practices for celebrating last funeral rites and burial ceremonies. Dry leaves ' <i>essanja</i> ' laid on the ground and the casket is placed on it. The dry leaves are also used to make huts for household members and guests at the last funeral rites
<i>Gonja</i>	Used in cleansing ceremonies. Believed to cleanse curses and bad omen

Table 4 Banana cultivars and their associated beliefs in central Uganda

Variety	Associated beliefs
<i>Nakabinyi</i>	Banana bunches not fit to be given as gifts to in-laws since shape of male bud elongates in the semblance of a male human reproductive organ
<i>Mbwazirume</i>	Believed to 'change' to <i>Nakitembe</i> (losing the reddish color of the mid ribs of its banana leaves) if its leaves are used in food preparation
<i>Siira</i>	Transforms to <i>Nfuuka</i> cultivar if leaves are used in food preparation
<i>Embidde enganda</i> (<i>Kabula & Nsowe</i>)	Believed to be the 'husband' of a plantation. The first cultivar planted in the middle of a plantation
<i>Embidde (Kabula & Nsowe) & Kayinja</i>	Considered 'male' varieties
<i>Nfuuka</i>	Changes to another cultivar if knife used to cut animal meat is used to cut the leaves
<i>Nakitembe</i>	Bestow blessings to infants when used for herbal baths
<i>Embidde enganda/Kayinja</i>	
<i>Tissue culture</i> <i>banana varieties</i>	Hybrids which have been modified from their original form and even some farmers have perceptions that they are GMOs

and '*Iweza*' [*Aerva lanata* (L.) Juss. ex Schult.] that connote peace and blessings upon the newborn.

The *Gonja* cultivar is used in cleansing ceremonies and restoring peace and harmonious relationships in families or in practices for reconciling individuals and families. Literally translated, *Gonja*, means '*soften*' implying that when people share *Gonja* in a peace-making ceremony, the parties involved *soften* and become more tolerant of each other. The leaves of *Kayinja*, *Ndiizi* and *Bogoya* are preferred for preparing a special sauce (*luwombo*) or *matooke* before they are steamed. In particular, *luwombo* is special way of preparing sauce for respectable guests such as in-laws (Plate 2 and 3).

Beliefs associated with bananas

Farmer beliefs associated with banana cultivars (Table 4) guide farmers' use and cultural connections with the cultivars that they grow. These relate to taboos and norms that are strongly held and observed in relation to some banana varieties. For example, in one of the FGDs in Mukono district the TC nursery operator specified:

Some time ago I had the *Gonja* cultivar among the TC planting materials and that season, my sales were very low. A community member advised that my sales were very low because of the bad luck associ-

Table 5 Medicinal uses of banana cultivars in central Uganda

Variety	Disease/ailment
<i>Embidde enganda</i> (<i>Kabula</i> & <i>Nsowe</i>)	Diarrhea - Sap from suckers mixed with herbs and drank Treatment of umbilical cords in infants - Sap from suckers placed on the umbilical cords of infants Fractures in both humans and animals - Sap from suckers used to set and massage fractured bones Snake bites - Sap from sucker mixed with tree herbs and drank Abscesses - Sap from sucker mixed with herbs, ant hill ' <i>ekifulufu</i> ' soil and concoction smeared on boils
<i>Gonja</i>	Healing of umbilical cords in infants - A finger is burnt, resultant ash gently rubbed on umbilical cords of infants Childbirth - Mother in labor chews roots to hasten the child delivery process Colic in infants - A mother of twins (<i>Nalongo</i>) weaves a small rope from banana fiber that is tied around the waist of the infant Diarrhea in infants - Fiber tied around waist of sick infant till the condition stops Mumps - Banana fiber tied around the child's chest
<i>Kibuzi</i>	Wounds and skin infections - Rachis cut into pieces, boiled and resultant liquid bathed or applied on wounds
<i>Nakamali</i>	Impotence in men - Geotropic roots crushed, mixed with hot water and drank
<i>Nakitembe, Embidde enganda</i> & <i>Kayinja</i>	Skin diseases and epilepsy

**Plate 1** A placenta wrapped in cloth and placed in shallow hole between two '*Nakitembe*' pseudo stems

ated with the *Gonja* cultivar and he cautioned that I get rid of them. When I did as advised, my sales went higher the next season. (November, 2016).

This finding implies that some cultivars such as *Gonja* are associated with bad luck and are not commonly grown in the region or where grown, caution is taken. For instance, it is believed that farmers have higher chances of experiencing lightning if they plant *Gonja* around their homesteads. As such, in homesteads where it is grown (most especially for use in performance of particular rituals), only a few mats are planted and precisely on the peripheries of plantations. Additionally, even buyers are keen not to carry *Gonja* among other bananas and to minimize on this effect, a finger of *Gonja* is placed under the vehicle wheel so that it is crushed prior to transportation. Unless going for burial, caution is taken by farmers not to consume *Gonja* or have anything to do with this cultivar as it is believed any anticipated success for the day will ultimately turn to failure.

Similarly, some banana cultivars are believed to 'transform' to other cultivars when specific norms are evaded. For example, *Nambi* is believed to change to *Nakitembe* when its banana leaves are used for cooking food. However, this is indicative of such cultivars belonging to the *Nfuuka* clone set (characterized by high susceptibility to morphological



Plate 2 A-Preparing 'luwombo' with ground nut sauce; B-Groundnut sauce wrapped in 'empombo' and tied with a banana fiber, traditionally referred to as 'luwombo' ready to be steamed



Plate 3 Preparing matooke the traditional way. A-Peeled cooking banana, 'matooke' placed in banana leaves; B-Matooke wrapped in banana leaves and tied with banana fiber; C-Matooke covered with banana leaves in a saucepan ready to be steamed

change) (Karamura et al. 2012) and not necessarily because particular norms have been evaded. Banana cultivars are known to present superficial expressions of morphological traits which are often not stable and some cultivars as well show different phenotypic expressions under different ecological conditions (also see Karamura and Karamura 1994; Karamura 1999). It is also believed by farmers in the study communities that the TC planting materials are 'hybrids' meaning that such a cultivar has been modified from its original form; implying that such cultivars are not suitable for performing cultural functions and rituals. This points to farmers' perceived incompatibility of TC banana planting materials with their socio-cultural identity, which acts a significant barrier to using the technology in the study communities since *tradition* as a cultural value is compromised. On the contrary, TC-established cultivars are genetically similar with the original (local) cultivars from which they are cloned (Hrahsel and Thangjam 2013). The hesitation to take on TC planting materials is therefore partly attributed

to inadequate information and understanding of processes of TC propagation on the part of the farmers.

Banana as medicine

Some banana cultivars are also used as medicine in the *Baganda* culture. Table 5 illustrates how these cultivars are used to treat various ailments. For instance, epilepsy in infants is treated through a ritual where the infant is bathed from a *Mbidde* mat. Whereas neither fire nor hot water are used, the leaves of the cultivar *Mbidde* should appear 'burnt/scotched' after the ritual—a sign that the epileptic 'demon' is gone and if it does not, the child is not healed, and the procedure has to be repeated. On the contrary, piles in males is treated by placing a patient up on *Mbidde's* pseudostem (for females a *Nakitembe* pseudo stem is used) that has not flowered. S/he faces in the sun's direction and is gently lowered every morning and evening. It is believed that by the time the banana plant flowers, s/he will have healed.

However, farmers indicated that TC cultivars do not harbor desirable traditional characteristics important for treatment/management of ailments. For example, a farmer expressed:

...Those TCs are not our own, they are ‘adulterated’ and cannot be used for our traditional medicine... (October 2016).

Another explained:

.. TCs lack traditional characteristics and we cannot use them for medicinal purposes. They make a sword-like corm beneath the mat rather than a semi-flat base that culturally is not acceptable ... (October 2016).

Worldwide, cultural systems recognize health and well-being of individuals’ as being complex, combining spiritual and physical dimensions (Bodeker 1989; Fisher 2011). It is believed that both dimensions have to be harmoniously developed for the total well-being of an individual. In accordance with our findings, studies (Shibre et al. 2008; Degonda and Scheidegger 2012; Sorketti et al. 2013) have documented positive outcomes from traditional medicine in sub-Saharan Africa, a factor which could explain the popularity attributed to the treatment. Traditional medicine is often preferred over western medicine, being viewed as a culturally meaningful approach, easily accessible, affordable and at times given free (Degonda and Scheidegger 2012). In Uganda, estimates indicate that the ratio of traditional medicine practitioners to the population is 1:700, significantly contrasting with available trained medical personnel for whom the ratio is 1:8547 (Kasilo et al. 2010; Akol et al. 2018). These statistics point to the crucial role that traditional medicine still plays in the Ugandan health system.

Nevertheless, as indicated above and earlier (Table 4), farmers’ beliefs that TC materials are genetically modified (or hybrids) was mentioned to be an impediment to farmer use of banana cultivars generated from TC as medicine—they are not trusted for potency of their medicinal properties. Elsewhere, authors (McRobert and Rickards 2010; Jha et al. 2020) have shown that farmers’ beliefs and opinions are at the center in their decision-making regarding uptake of agricultural technologies. For this reason, farmers in the study communities will continue to plant their local materials even alongside the TC seed, and thereby sustaining the risk of BXW through cross-contamination.

Conclusion and implications

This study highlights how culture and traditions may constrain uptake and effectiveness of TC banana planting materials as a strategy for controlling BXW in central Uganda and in the context of the *Baganda* culture. Findings indicate

that farming is indeed ‘agri-culture’, not merely economic or scientific. Culture is integral to agriculture and has to be considered in all agricultural technologies. The cultural uses of banana in central Uganda are anchored in diversity of cultivars where different cultivars are used for specific cultural practices, and yet TC promotes only a few commercial varieties. In the attempt to accommodate their diverse uses of banana, farmers will plant TC seed alongside their local preferred varieties, which facilitates cross-infection of BXW. To enhance effectiveness of TC in control of BXW, it is important to identify the cultivars of cultural importance and broaden the range of TC cultivars available to the farmers. It is imperative that a wide range of cultivars through TC seed are provided which fit the socio-cultural context and satisfy the multiple functions of banana to foster greater uptake. Even so, TC seed producers (e.g. TC laboratories and TC nursery operators) should consider this whilst increasing seed supplies to break-even in their businesses. Only a few plantlets (one or two for a farmer) suffice for cultural purposes and as such not all cultivars may be in sufficiently high demand.

Farmers’ beliefs that TC seed is genetically modified and that such cultivars would not be suitable for cultural practices also constrain the uptake of TC materials. Increased awareness creation is needed among banana farmers in central Uganda regarding the processes of TC and the non-interference of the propagation technique with the genetic composition of the variety. The commercial cultivars promoted through TC are also heavy feeders and require soil fertility improvement practices such as use of organic manure or fertilizers to sustain productivity. Otherwise, farmers believe that their soils are not suitable for TC banana as productivity declines faster compared to their traditional varieties. It is therefore important that to disseminate TC technology widely, NGOs, local extension staff, the TC laboratories and nursery operators all better package the technology with detailed information showing its production process, advantages and disadvantages, and agronomic practices. This can be disseminated through farmer-preferred information dissemination pathways such as radios as reported by Kikulwe et al. (2019).

The cultural dimensions of bananas in central Uganda present a more complex context for technology uptake than anticipated by many stakeholders in the industry. Such circumstances call for deeper engagement and involvement of men and women farmers who are the intended users of the technology to understand their unique context in order to tailor the technology to the diverse interests and uses of the products promoted. In this case, the tension between gender, cultivar diversity, cultural practices, and commercialization of banana hinders using TC plantlets to control BXW. The results not only provide a ‘reality check’ but also highlight the importance of farmer engagement in the development

and promotion of any agricultural-related innovation. For sustainable use of agricultural innovations such as TC, it is important that breeders and TC plantlet producers not only put into consideration economic and biological attributes of targeted crops, but also gender and cultural aspects. This will help promoters of agricultural technologies to diversify gender-responsive cultivar attributes required by end-users, and in turn will increase adoption of such innovations. Future efforts towards the control of pests and diseases would benefit from more location-specific and holistic approaches that integrate gender and cultural dimensions alongside clean seed.

It should, however, be noted that this is a field note and that many important questions remain unanswered due to limitations of methods and space for publication. For instance, the "politics" of TC varieties, whether the farmers see themselves as upholding local traditions in light of globalization, or are experimenting with TC technologies to maintain good relations with government technocrats for benefits is not captured. Therefore, it is highly recommended that future research should consider incorporating such aspects to develop a better understanding of the political factors that might influence uptake of agricultural innovations. In addition, the authors recommend a systematic and scientific inquiry regarding the medicinal values of some banana cultivars and to address farmer concerns about TC innovations being 'adulterated'.

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