6-1-2020

Gender and Trait Preferences for Banana Cultivation and Use in Sub-Saharan Africa: A Literature Review[1]

Pricilla Marimo
Bioversity International

Cynthia Caron
Clark University

Inge Van den Bergh
KU Leuven

Rhiannon Crichton
Bioversity International

Eva Weltzien
University of Wisconsin-Madison

See next page for additional authors

Gender and Trait Preferences for Banana Cultivation and Use in Sub-Saharan Africa: A Literature Review[1]

Pricilla Marimo*,[1], Cynthia Caron[2], Inge Van den Bergh[3], Rhiannon Crichton[4], Eva Weltzien[5], Rodomiro Ortiz[6], and Robooni Tumuhimbise[7]

[1]Bioversity International, Kampala, Uganda
[2]Clark University, Worcester, MA, USA
[3]Bioversity International, C/O KU Leuven, Leuven, Belgium
[4]Bioversity International, Montpellier, France
[5]University of Wisconsin-Madison, Madison, WI, USA
[6]Swedish University of Agricultural Sciences, Alnarp, Sweden
[7]National Agricultural Research Organization (NARO), Kawanda, Uganda
*Corresponding author; e-mail: p.marimo@cgiar.org

Understanding trait preferences of different actors in the banana value chain may facilitate the selection and adoption of new cultivars. We systematically reviewed the scholarly and gray literature on banana trait preferences, with specific attention to studies that document gender-differentiated traits. Of 44 publications reviewed, only four reported gender-specific trait preferences, indicating a significant gap in the literature. The review found that banana farmers, irrespective of gender, value similar characteristics that are related to production constraints, income enhancement, consumption, and cultural or ritual uses. Farmers (as producers, processors, and consumers) often prefer traditional cultivars because of their superior consumption attributes, even if new cultivars have better agronomic and host plant resistance characteristics. Potential differences between trait preferences of farmers and other actors in the value chain should be accounted for to enhance marketing potential. Gender-specific research along the banana value chain and engaging users at the initial stages of breeding can ensure that new cultivars are acceptable to users and may improve adoption. Interdisciplinary teamwork is essential for an efficient and effective breeding program.

Key Words: Breeding, end-user, *Musa* spp., value chain, ethnobotany.

Background

In 2018, around 155 million metric tons of banana were produced around the world, of which 27% came from sub-Saharan Africa (SSA) (FAOSTAT 2020). The majority of this production comes from small plots and backyard gardens. The highest per capita consumption of banana in the world is in the East African highlands, where one-third of the people depend on this crop as a staple food—the crop occupies between 20 to 30% of the acreage under cultivation (Karamura et al. 2012). In Uganda, millions of people rely on banana for income and daily food, with approximately 75% of farmers cultivating banana (Jogo et al. 2013; Ochola et al. 2013).

Over the past decades, new banana cultivars have been introduced across SSA to alleviate declining yields, contribute to household food security, and improve livelihoods (AATF 2009; Aïtchédji et al. 2010; Dzomeku et al. 2007; Gaidashova et al. 2008; Lemchi et al. 2005a, b; Nowakunda et al. 2015; Ortiz et al. 1997; Pedersen 2012; Swennen

[1] Received 14 May 2019; accepted 13 May 2020; published online 15 June 2020

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s12231-020-09496-y) contains supplementary material, which is available to authorized users.

et al. 2000; Uazire et al. 2008). Adoption rates of introduced banana cultivars are often low compared to their economic importance, and rates are lower than those of other staple crops (ISPC, SPIA 2014; Ortiz 2011; Walker and Alwang 2015). Studies that report adoption rates for new banana cultivars in SSA are scarce (De Weerdt 2003; Faturoti et al. 2006, 2009; Kagezi et al. 2012; Nkuba 2007). Reasons given by farmers for low uptake include inferior taste, poor marketability compared to local cultivars, and risks associated with growing new cultivars (Kagezi et al. 2012). Farmers indicate preference for local cultivars because of their superior consumption attributes (good taste, soft food texture, good aroma, and good/yellow color), even if new cultivars have better agronomic traits and better response to biotic and abiotic stresses (Akankwasa et al. 2013b; Barekye et al. 2013; Nwachukwu and Egwu 2008).

Understanding trait preferences of farmers, consumers, and other value chain actors is a first step for developing a demand-driven breeding program. Developing new cultivars and their subsequent dissemination and adoption is a complex process that starts with setting breeding objectives and developing a selection strategy for priority traits. Such a consultative process requires open dialog and collaboration between plant breeders, other researchers including social scientists, farmers, and other users such as traders and consumers, to understand the needs and preferences of different users, traits and their importance (Christinck et al. 2005).

Collecting trait information according to the role and position that an actor occupies in the value chain, as well as gender-specific information, yields wide-ranging and relevant knowledge about cultivars, their traits, and specific uses. The needs and preferences of men and women end-users intersect with various socio-economic and cultural factors at the individual (e.g., age, marital status), household (e.g., wealth), and community (e.g., culture, ethnicity) levels. These factors affect the adoption of new banana cultivars. Farmer preferences may not be the same as market traders and consumers (Ferris et al. 1997). Knowledge of traits that various end-users prefer will enable researchers and farmers to produce marketable cultivars with acceptable attributes (Mugisha et al. 2008).

The objective of this review article is to identify trait preferences reported by farmers and other actors in the banana value chain in SSA. We privilege gender-specific differences in trait preferences and the extent to which preferences can set breeding priorities in order to focus on the importance of gendered knowledge in improving food security and banana-based livelihoods. Results will be discussed with the objective to inform future banana breeding research on trait preferences that consider gender-specific needs, while developing product profiles for new cultivars.

Methods

We accessed English-language publications in both scholarly and gray literature from Musalit (www.musalit.org, repository of references on banana) and CG Space databases, using search terms that include: banana, attribute, trait, gender, preference, choice, priority(ies), end use, desirable, improved variety(ies); refer to Electronic Supplementary Material (ESM) File 1: Table S1 for a full list of the search terms. The main inclusion criteria were that the publication identified and documented banana trait preferences or cultivar preferences by end-users.

The initial screening filtered articles based on a review of their titles and abstracts using the inclusion criteria and generated 3489 articles (including duplicates). After the first round of screening, irrelevant articles were excluded. The remaining 86 research articles were screened again with a full-text reading. We then used reference snowballing to identify additional articles that the original search had missed. We excluded articles that did not meet the criteria at full document reading.

We present end-users' trait preferences according to the specified "trait" as well as the "trait state." Trait refers to a feature, attribute, or quantifiable measurement that can be described (e.g., taste, bunch size), while trait state refers to the observed or experienced state of the trait (e.g., sweet taste, big bunch). For breeders, "trait refers to a genetically determined characteristic that is associated to a specific phenotype." The phenotype is controlled by its genotype (G), the environment (E) where the plant grows, and the G × E interaction (Bechoff et al. 2018, 8–9).

Results

Results presented below are based on a full, analytical review of 44 articles published between 1994 and 2018. The reviews represent ten country experiences (Table 1), the majority from Eastern Africa (70%). Overall, 45% of the articles were from

TABLE 1. GEOGRAPHIC SCOPE OF STUDIES BY BANANA TYPE.

Banana type	Country
Cooking	Burundi, Democratic Republic of Congo (DRC), Rwanda, Tanzania, Uganda, Nigeria
Beverage/Beer	Burundi, DRC, Rwanda, Uganda
Dessert	Burundi, DRC, Kenya, Mozambique, Rwanda, Tanzania, Uganda
Plantain	DRC, Rwanda, Uganda, Tanzania, Cameroon, Côte d'Ivoire, Ghana, Nigeria

Uganda. Results were differentiated according to the four banana uses common in SSA—cooking, beverage/beer, dessert, and plantain. Karamura et al. (2012) and Swennen and Vuylsteke (1991) provide detailed descriptions of these types.

Key information vis-á-vis the geographic location of the study, data collection method, type of banana being studied, end-user's banana trait preferences specified in the studies is presented in ESM (Electronic Supplementary Material) File 1: Table S2.

Five main categories of banana traits emerged from the studies, and drawing from (Ssemwanga 1995), include: 1) physical traits (agronomic, size, and shape attributes); 2) sensory/organoleptic traits (texture, flavor, appearance attributes); 3) processing and product-related traits; 4) socio-economic and cultural traits (cultural, commercial, and market life attributes), and 5) other traits.

End-users are likely to prioritize different traits depending on factors that may include: role in the value chain (that may be gendered), end use of the crop (determined by cultivar characteristics), environmental constraints, geographic location, individual and household characteristics, and cultural factors. The list of traits is long, making prioritization for breeders challenging.

Using a summary of preferred attributes, we grouped banana traits into the five above-mentioned categories (Table 2). When available, we provide country-specific details or nuance to the specified traits in the corresponding table narrative. Several of the studies document end-user's preference in order of importance or highlight priority traits (Table 3, General Ranking of Banana Cultivars Irrespective of Type section). A discussion on the rankings and classification of traits' importance is provided for each banana type (if a study exists), providing breeders with additional information on mentioned traits (Cooking Bananas, Beverage/Beer Bananas, Dessert Bananas, Plantains sections). For all banana types, end-users mention common preferred traits linked to production constraints, particularly host plant resistance to pests and diseases, high yield to ensure food security and surplus production, high market demand, and price.

FARMERS' TRAIT PREFERENCES FOR BANANA

In their roles as producers, processors, marketers, and consumers of banana, farmers and farming households prefer a large range of traits.

Cooking Bananas

There are regional differences in preferred texture for cooking bananas; for example, farmers in Uganda prefer soft *matooke* cultivars (Akankwasa et al. 2013b, 2016; Barekye et al. 2013; Nowakunda et al. 2000; Nowakunda and Tushemereirwe 2004; Rutherford and Gowen 2003). In some parts of Tanzania, cultivars with a hard texture are preferred (Kibura et al. 2010). Characteristics include post-harvest attributes related to processing and value addition. Farmers prefer multi-purpose cooking cultivars that also produce juice and beer (Gaidashova et al. 2005; Nkuba 2007; Rutherford and Gowen 2003). Women value the cultural importance of banana in birthing ceremonies and food preparation, while men emphasize their use at funerals (Musimbi 2007). In one Ugandan study, women indicated that they preferred their traditional cooking cultivar "Katetema" because of its cultural values (Musimbi 2007). Farmers mention preference for cultivars that ensure normal sugar levels after eating them (Dzomeku et al. 2008). Consumption traits, such as good food quality, good taste, soft food, and good flavor, ranked high in Uganda (Akankwasa et al. 2013a, b; Barekye et al. 2013; Nasirumbi et al. 2018; Ssali et al. 2010).

Beverage/Beer Bananas

Beverage bananas are used in the production of juice, local beers, and local gin. Trait preferences are related more to the products rather than the plant itself or its fruits. Astringency, a characteristic of East African highland banana (EAHB) beer

TABLE 2. PREFERRED TRAITS FOR EACH BANANA TYPE IDENTIFIED IN THE REVIEW.

Trait type	Trait category	Trait	Cooking	Beverage	Dessert	Plantain
Physical	Agronomic	Medium to high suckering ability[w]	✓	✓	✓	✓
		Time to maturity[b]–early[w], quick	✓	✓	✓	✓
		Lifespan of the plantation/mats	✓	✓		✓
		Fruiting during the dry and wet seasons (all-year-round fruit character)	✓	✓		
		Long ripening period (not specified)–delayed ripening				✓
		High yield (as determined by bunch mass or weight)	✓	✓	✓	✓
		Yield stability (stable in terms of yield)	✓			
		Growth habit				✓
		Plant height (includes tolerance to lodging by wind)	✓	✓		✓
		Strength of pseudostem (strong and stout, not damaged by wind)			✓	
		Hardiness (not specified if its fruit or pseudostem)	✓			
		Resistance to pests–weevils[b], nematodes	✓	✓	✓	✓
		Resistance to diseases–Fusarium wilt[*], BLS[b]	✓	✓	✓	✓
		Resistance to toppling (linked to nematode resistance)		✓		✓
		Tolerance to drought[b]	✓	✓		✓
		Tolerance to wind (linked to plant height)	✓	✓		
		Tolerance to hailstorm (linked to plant height)	✓			
		Adaptation to poor soil fertility[w,b]	✓	✓		
		Intercropping ability	✓			
		Labor requirements	✓	✓		
	Size and shape attributes	Bunch size[b] (yield)	✓	✓	✓	✓
		Bunch size after maiden crop	✓			
		Bunch compactness	✓			✓
		Fruit size[b] (includes thickness/girth)	✓		✓	✓
		Fruit length				✓
		Fruit weight				✓
		Fruit uniformity	✓			
		Fruit shape	✓		✓	
		Number of fruits per bunch (related to yield)	✓			✓
		Number of fruits per hand or cluster of fruits (related to yield)	✓		✓	
		Hand size	✓			
		Number of hands per bunch (related to yield)	✓			✓
		Pulp: peel ratio				✓
Sensory / organoleptic		Freshness	✓		✓	✓
			✓		✓	✓

(Continued)

TABLE 2. (CONTINUED).

Trait type	Trait category	Trait	Cooking	Beverage	Dessert	Plantain
	Appearance (before processing)	Peel color and appearance (ripe/unripe)				
		Pulp color (ripe/unripe)	✓		✓	
	Appearance (after processing)	Pulp firmness	✓			✓
		Pulp appearance when cooked				✓
		Color when cooked[b]	✓			
	Texture attributes	Texture of cooked pulp[b]	✓			✓
		Texture of peeled uncooked pulp			✓	✓
		Uniform texture	✓			
	Flavor attributes	Flavor[b]	✓	✓	✓	✓
		Aroma/smell	✓		✓	✓
		Taste of ripe fruit			✓	✓
		Taste[m, b] (after cooking)	✓	✓		✓
		Juice flavor	✓			
Processing / product related	Processing attributes	Shelf life/perishability[b]	✓			✓
		Ease of peeling	✓		✓	
		Characteristics after peeling (does not dry as soon as peeled, does not brown when peeled)	✓			
		Fruit detachability			✓	
		Cooking quality (combination of taste, color, texture etc.)	✓			✓
		Traits after cooking	✓			
		Ease of cooking (cookability)	✓			
		Palatability	✓			✓
		Poundability				✓
		Cooking time	✓			✓
		Suitability for production of beverage products (multipurpose)	✓	✓		
		Suitability for production of food	✓	✓		
		Yield of processed beverage product (e.g., juice)		✓	✓	
		Flavor of processed beverage product			✓	
		Taste of processed beverage product			✓	
		Quality of processed product	✓	✓	✓	
Socio-economic / cultural	Commercial and market life attributes	Market demand, prices	✓	✓	✓	✓
		Rate of sheen loss	✓			
		Bruising	✓			
		Hand or fruit drop	✓			
		Ripening traits	✓			
		Non-presence of female flower buds	✓			
	Cultural attributes	Cultural uses[b]	✓			
		Uses of other plant parts (leaves for cooking)[w]		✓		
Other	Other attributes	Number of consumption uses	✓			
		Health benefit	✓			✓
		Accessibility of planting material	✓			
		Availability of planting material		✓		
		Type of biotechnology used to produce planting material	✓			

Refer to ESM File 1: Tables S3 to S6, for details on the corresponding trait states, as stated in the reviewed studies. Note: some traits were modified slightly to allow for categorization

[w] = Women specifically mentioned trait; [m] = Men specifically mentioned trait, [b] = Both men and women specifically mentioned trait

* = Study indicated differences but does not specify if men or women prefer the trait

TABLE 3. RANKING OF END-USER PREFERRED TRAITS IN BANANAS.

Banana type	Ranking criterion	Most important traits (in order of importance if specified)
Cooking	Most frequently mentioned desirable attributes of hybrid bananas in Uganda (Akankwasa et al. 2013b)	Good taste, big bunch, soft food, good flavor
	Ranked qualities desired for new cultivars in Uganda (Barekye et al. 2013)	1. Good food qualities (taste, softness, color); 2. Heavy bunches; 3. Resistance to pests/diseases, tolerance to drought, and early maturity (received equal importance) Consumption traits: 1. Pleasant taste; 2. Soft texture; 3. Yellow food color; 4. Aroma
	Ranked most important determinants of banana bunch choice for transgenic cultivars using utility coefficients derived from a latent class model in Uganda (Kikulwe et al. 2011).	Potential transgenic banana consumers: 1. Big bunch size; 2. Produced with genetic engineering; 3. Large benefits for producers Potential transgenic banana opponents: 1. Bunches that do not generate large benefits for producers; 2. Produced with non-transgenic technology; 3. Big bunch size
	Most important criteria for banana selection (use PCA) in Rwanda (Ocimati et al. 2014)	Big bunch, taste/flavor/quality of juice, market demand
Beverage/Beer	Most important criteria for banana selection (use PCA) in Rwanda (Ocimati et al. 2014)	Big bunch, taste/flavor/quality of juice, market demand
Dessert	Urban consumers ranked most important parameters for purchasing banana fruits in Nigeria (Ayinde et al. 2010)	1. Taste; 2. Fruit size; 3. Number of fruits/hands; 4. Texture; 5. Aroma; 6. Shelf life; 7. Color; 8. Appearance
	Assessment of factors influencing willingness to pay for introduced dessert bananas in Uganda (Mugisha et al. 2008)	Taste, skin color and texture (significant effect) Pulp color, flavor (not significant effect)
	Most important criteria for banana selection (use PCA) in Rwanda (Ocimati et al. 2014)	Big bunch, taste/flavor/quality of juice, market demand
Plantain	Five main criteria used by farmers to determine preference for plantain cultivars, ranked from most to least important in Cameroon (Mengue Efanden et al. 2003)	1. Bunch size; 2. Fruit length/weight; 3. Taste/softness of pulp; 4. Early maturity; 5. Suckering ability
	Most important criteria for banana selection (use PCA) in Rwanda (Ocimati et al. 2014)	Ability of plants to mature early, ability of mats to perpetuate for a long period
General	Criteria for selecting banana planting material. Farmers also ranked the best cultivars for: beer production; most productive cultivars in terms of bunch size and land allocation and cultivars with best taste/flavor. Results show differences in rankings in North and South Kivu, DRC (Dowiya et al. 2009)	All regions: 1. Flavor/taste; 2. Juice quality; 3. Resistance to disease; 4. Bunch size By region (in parentheses: rank in North Kivu and South Kivu, respectively): Resistance to pests (1, 9); Bunch size (2, 4); Flavor, taste and juice production (3, 1); Adaptation to poor soil fertility (4, 6); Short production cycle (5, 8); Sustainable production (6, 7); Availability of planting material (7, 2); Market demand/prices (8, 3); Tolerance to drought (9, 5)
	Farmers ranked criteria for selecting banana cultivars in Uganda (Gold et al. 2002)	Country wide: 1. Bunch size; 2. Cultivar longevity; 3. Marketability; 4. Taste; 5. Marginal fertility soil tolerance, early maturity, drought tolerance; 6. Pest tolerance; 7. Toppling; 8. Availability of planting material By region: Central (bunch size first; longevity, marketability and taste jointly second); Central South (bunch size, early maturity, tolerance to pest and

(Continued)

TABLE 3. (CONTINUED).

Banana type	Ranking criterion	Most important traits (in order of importance if specified)
		diseases); Central North (tolerance to marginal soil fertility, drought tolerance and bunch size); East (cultivar longevity, bunch size, early maturity); South West (bunch size, marketability, cultivar longevity) PCA: Longevity, tolerance to marginal soils, and drought tolerance were most important selection criteria across the country
	Cultivar selection criteria (use PCA) in Burundi (Ocimati et al. 2013)	PC1 and PC2 analysis ranked flavour, taste of pulp and juice quality as the most important selection criteria, while market demand/ prices ranked second across the beer, dessert and cooking types
	Ranking of farmer preferred traits when selecting banana germplasm in Uganda (Otieno et al. 2016)	1. Marketability; 2. High yields; 3. Good taste; 4. Easily adaptable to climate change; 5. Easy to cook; 6. Resistance to pests and diseases; 7. Maturity time; 8. Nutrition benefits; 9. Easily accessible; 10. Texture of planting material; 11. Nature of planting material

cultivars, is preferred for beverage and medicine production (Karamura et al. 2004). Farmers prefer cultivars that can be continuously de-leafed to provide leaves for steaming food, wrapping, and for sale without damaging the cultivar (Rubaihayo 1991) as well as cultivars that produce palatable food in times of food shortages (Musimbi 2007; Rubaihayo 1991).

Dessert Bananas

Organoleptic and market related attributes are key since dessert bananas are eaten raw and often sold (Ayinde et al. 2010; Kibura et al. 2010; Kwach et al. 2000; Mugisha et al. 2008; Ocimati et al. 2014; Uazire et al. 2008). Dessert bananas are often used for producing beverages (juice and wine) and snacks, hence characteristics related to the quality of the processed products are mentioned.

Plantains

Plantains are typically processed through boiling, roasting, deep frying and pounding to make food, chips, flour, and biscuits among others (Ekesa et al. 2012; Ubi et al. 2016). Traits related to the appearance of the fruit before processing and product attributes are mentioned. The pulp of "Apem" (small-fruit French plantain) is favored for a dish called *Ampesi* (where pulp segments are boiled until soft) as it is crispier, firmer, tastes better, and gives the best mouth feel compared to other cultivars in Ghana (Dadzie and Wainwright 1995). In Cameroon, farmers ranked attributes in order of importance as follows: bunch size, fruit length/weight, taste/softness of pulp, and early maturity (Mengue Efanden et al. 2003). Long banana mat perpetuation is preferred (Mengue Efanden et al. 2003). Rwandese farmers reported early maturity as an important criterion (Ocimati et al. 2014, 2016).

General Ranking of Banana Cultivars Irrespective of Type

Differences in trait rankings based on the geographical location and type of banana grown exist (Table 3). Gold et al. (2002) showed regional differences in the relative importance of banana cultivar selection criteria in Uganda. Principal component analysis (PCA) revealed that farmers preferred drought tolerance, marginal soil tolerance, and longevity (as determined by the first principal component or PC1), which means a robust cultivar that grows as a perennial but with fewer inputs (i.e., a labor-saving cultivar). In the second principal component (PC2), ripening and post-harvest characteristics were preferred (bunch size, taste, maturation, marketability). Dowiya et al. (2009) found regional differences in selecting banana planting material

types in North and South Kivu of DRC where plantains and beer bananas are popular. In South Kivu, the most important criterion was a combination of flavor, taste, and juice production; in North Kivu, it was pest resistance.

Farmers' selection criteria also reflect the major challenges faced in banana production. In areas where soil fertility is low, or where incidences of pests and diseases are high, adaptability to low soil fertility and resistance to pests and diseases would be critical selection criteria (Ocimati et al. 2016). Following outbreaks of *Xanthomonas* wilt, farmers might switch to other crops if alternative banana cultivars with the traits they prefer are not available; e.g., in Uganda farmers switched to sweet potatoes and cassava to cope with the devastation of fields by *Xanthomonas* wilt (Kalyebara et al. 2006; Karamura et al. 2006).

Trait Preferences of Other Actors in the Banana Value Chain (Outside the Farming Household)

Consumers and traders have their own preferred trait preferences. For cooking bananas and plantains, consumer trait preferences are determined by the product type and processing method (Dadzie and Wainwright 1995; Dury et al. 2002; Dzomeku et al. 2006, 2008). Consumers indicate preference for cultivars whose fruit are firm and crunchy when boiled and soft for *fufu* preparation. At the time of purchase, consumers prefer cooking bananas with big bunches and big fruits that are fresh. Price and the type of biotechnology used to produce the planting material are taken into consideration (Kikulwe et al. 2011; Nalunga et al. 2015; Pillay and Tenkouano 2011). With respect to dessert bananas, consumers prefer yellow skin color, light yellow pulp color, no spots on peel, soft, sweet, firm fruits with easily separable skin and easily detachable fruit. Urban consumers in Nigeria purchase dessert banana fruits according to taste, fruit size, number of fruit/hand (cluster of fruit), texture, aroma, and shelf life of 9 to 12 days (Ayinde et al. 2010). With respect to plantain, fruit shape, fruit size, aspect of the fruit, ripening/maturity stage, bunch size, and good textural qualities after cooking (depends on product and processing method) are desired attributes (Dadzie and Wainwright 1995; Dury et al. 2002; Dzomeku et al. 2006, 2008; Kouamé et al. 2015). Kouamé et al. (2015) found that for urban consumers in Cote d'Ivoire, plantain ripening/maturity stage used to prepare different foods was more important than other physical attributes.

Traders prefer cooking bananas with big bunch sizes, long fruit, more fruit per bunch and per hand, big hands, more hands per bunch and compact bunches for easy transportation. With respect to appearance, traders prefer cooking cultivars with a good fruit sheen and a pale green fruit color. Other commercial and market life attributes for cooking banana include hands and fruits that do not easily fall off (fruit drop), gradual ripening down the bunch, no easy bruising or quick wilting, a long shelf life, low rate of sheen loss, and price (Akankwasa et al. 2013b; Nalunga et al. 2015; Ssemwanga 1995). For plantain, traders prefer large bunch size (Dadzie and Wainwright 1995; Dury et al. 2002; Dzomeku et al. 2006, 2008; Kouamé et al. 2015).

Gender-Differentiated Banana Trait Preferences

Literature on gender-differentiated trait preferences in the banana value chain is scarce. Although several studies focus on end-user's banana trait preferences ($N = 44$), only four of these provided some form of gender-specific data (Edmeades et al. 2004; Miriti 2013; Musimbi 2007; Nasirumbi et al. 2018). Table 4 presents the review's gender-specific trait preference findings. These studies documented farmers' preferred traits for cooking and dessert bananas but did not examine trait preferences directly, except Nasirumbi et al. (2018). Rather the focus was on household cultivar demand, gender-responsive strategies in banana production, and impact of gender on adoption.

Statistical differences in the importance of banana traits between men and women banana farmers were found for cooking quality (taste, color, softness), beer quality, and resistance to Fusarium wilt. Differences were attributed to underlying preferences based on gender roles; men /beer production and women /cooking, respectively (Edmeades et al. 2004). Miriti (2013) provided male and female farmers' preference rankings for banana cultivars, but did not specify traits they preferred in the different cultivars.

Discussion

This article contributes to general knowledge of banana trait preferences, including gender. It

TABLE 4. TRAIT-PREFERENCES ACCORDING TO RESPONDENTS' GENDER.

Trait preferences mentioned by women	Trait preferences mentioned by men	Trait preferences mentioned by both men and women
High suckering ability, early maturity, adaptable to poor soils, leaves can be used for other purposes (e.g., cooking), cultivars with both cash and food value (Cavendish "Lacatan" dessert and "Uganda green" cooking)	Good food taste, good food color, commercial dessert Cavendish types ("Valery" and "Grand Nain")	Cultural use—women specifically mention uses at birth ceremonies while men mention funerals, resistance to weevils and black leaf streak, big bunches, big fruits, tolerance to drought, tolerance to poor soils, maturity period, good taste, good food color, rich flavor, soft texture, deep yellow color when steamed

illuminates the needs and preferences of farmers and banana value chain actors that can be used to orient "product profiles" for new banana cultivars of the different banana types in different ecologies, recognizing the significance of gender-specific trait preferences (Weltzien et al. 2020).

Product profiles are used for priority setting for breeding cultivars of *matooke* and *mchare* cooking bananas, types popular in Uganda and Tanzania, and are publicly available (http://breedingbetterbananas.org/wp-content/uploads/2018/07). At the time of submitting this manuscript, the product profile for plantain was not yet publicly available (pers. comm. R. Swennen, November 2019; rony.swennen@kuleuven.be). There is no published product profile for beer or dessert bananas. The published banana product profiles include some of the traits identified above and could be expanded. Product profiles mostly include production and adaptation related traits, such as pest and disease resistance, suckering ability, early maturity, tolerance to drought, and resistance to wind (through plant height). Traits not currently included in profiles include: agronomic attributes (e.g., adaptability to poor soils); processing traits related to value addition (e.g., size and shape attributes, such as uniform fruit size, straight fruit for ease of peeling, and compact bunches for easy transport); social and cultural traits—plant parts which can be used for multiple purposes (e.g., banana leaves for use in food preparation or roots for medicines). End-users mention contrasting traits such as big bunches for the market and small bunches for home consumption.

Although sensory/organoleptic/consumption traits are included in product profiles, they are categorized under one umbrella, and treated as a single trait: "table quality/palatability." There might be need to separate the traits in this category, as color, taste, or texture are highly complex characteristics. For example, traits such as "good textural quality after cooking and suitability for various uses" or "firm and crunchy when boiled and soft for fufu preparation" indicate specific demands from consumers, which could need to be incorporated into the product profile.

Such consumption and processing attributes are poorly understood in terms of assessment (measurement), inheritance, and their physicochemical nature. Physicochemical characterization, molecular assessments, and interdisciplinary work with food scientists and geneticists would increase the options for inclusion of such traits.

The relative priority of different traits in new cultivar design is an important process in breeding. The review presents a long list of traits for each banana type, requiring trait prioritization to set breeding goals and objectives. It is not feasible to include all trait preferences in a banana breeding program due to limited resources and time. A decision-tree analysis, with the critical actors in the value, is one way to prioritize traits and address conflicting factors (Shimelis 2017).

BANANA TRAIT PREFERENCES

Different banana types share common preferred traits linked to production constraints, such as resistance to pests and diseases, high yield, and high market demand/prices. The review found more preference studies for cooking and plantain types than for dessert and beer banana types. Cooking and plantain types share several common traits, especially related to processing and consumption (appearance, texture, and flavor attributes) as "cooking" types. Dessert and beer bananas are processed into juice and other beverages that may contribute to household income, hence traits related to

yield, flavor, taste, and quality of beverage products are mentioned. Traits like fruit length appear to be less important for marketing as each size has its own market, indicating these traits have a wide range of acceptable states.

This review found that traits such as host plant resistance (e.g., black leaf streak, Fusarium wilt, and weevils), abiotic stress tolerance (e.g., short plants and strong root systems to avoid wind damage), superior agronomic performance (heavy bunch with big fruit sizes), and vegetative propagation (as related to suckering behavior) are traits that farmers mention and prefer, and are those that breeders target in their programs (Brown et al. 2017). While there appear to be some common priority attributes, cultivars are more likely to be selected if they are better adapted to a region's agro-climatic conditions, local farming systems, and show resistance to prevailing pests and pathogens.

Superior consumption attributes, such as taste, flavor, pulp color, and other fruit post-harvest traits (e.g., pulp texture, shelf-life) appear to be of critical importance for cultivar preference and thus adoption of new banana cultivars. Farmers in different regions, however, prefer different banana types for different end uses and cultural events, and hence prioritize different consumption and use related traits. For example, farmers in some regions in Tanzania prefer cooking banana types with a hard texture (Kibura et al. 2010; Pedersen 2012) like *mchare,* whereas in Uganda consumers prefer EAHB cooking cultivars that make soft food. Edmeades et al. (2004) and Tenkouano et al. (2010) argue that ethnicity strongly influences some of the preferences for organoleptic attributes, such as taste, color, and feel of food.

A small number of studies focused on trait preferences of other actors in the banana value chain indicating that cultivars should be marketable (high market demand) and have traits that other value chain actors (traders, processors, consumers) prefer. Farmers sell surplus to consumers and traders in local, urban, or regional markets where preferences are likely to differ by region.

Consumers who are not producers are versatile—their consumption patterns depend on what is available in the market. They may substitute or switch to a different product (e.g., rice or potato) if the preferred banana cultivar is not available. Additionally, household demand from urban consumers for a certain product depends on income level.

In view of this high diversity of demands for a wide range of traits, banana breeding programs need reliable, detailed information about agronomic, use, and market-related trait preferences of their potential customers. This information can help to identify traits and trait complexes that are important for a large proportion of priority customers. The breeding programs can target improvements for such priority traits, and thus improve the chances that the new cultivar can be beneficial for a large proportion of farmers, farm families, and possibly other consumers. In addition, there is a need to holistically understand the traits and the diverse factors that may affect preferences and eventually other factors that influence adoption. Thus, the revisions of product profiles need to reflect the available understanding of consumer demands in terms of trait combinations and acceptable trade-offs, including gender impacts. As available evidence and trends that could lead to changes are scarce, breeding programs would benefit from well targeted forward-looking consumer studies.

Gender-Differentiated Trait Preferences

The review found that male and female banana farmers often have similar production constraints or common goals such as food security or ceremonial uses, and that men and women might prefer cultivars with big bunches and fruit with a commercial value. Musimbi (2007) found that women mentioned traits related to production (high suckering ability and early maturity), whereas men emphasized consumption-related traits (good taste and color). Women preferred high-suckering cultivars given the potential to earn higher income from selling suckers.

We contend that potential differences in preferences, which are not specifically discussed in the reviewed studies, might stem from the different roles that men and women play in the banana value chain, e.g., cooking attributes for women and beer production for men (Edmeades et al. 2004). Women are traditionally responsible for food preparation and processing of banana (Musimbi 2007), whereas men are involved in the preparation of juice that can be fermented to produce local beer (Edmeades et al. 2004; Musimbi 2007; Nkuba 2007). Studies done in Kenya and eastern Uganda indicate that women predominantly participate in ripening and marketing activities at local markets, along roadsides, in trading centers, and in nearby schools (Miriti 2013; Musimbi 2007), whereas men sell at organized

markets or farm gates which might lead to differences in preferences. Differences in production goals may lead to varied preferences. Men and women might also face different constraints e.g., related to mobility, information, and input constraints that may affect adoption of new cultivars (Christinck et al. 2017; De Weerdt 2003; Musimbi 2007). Such constraints need to be addressed when designing breeding programs.

Farmers often associate new cultivars with increased labor burdens. Musimbi (2007) notes that the introduction of FHIA banana cultivars required digging bigger holes, use of more crop residue, farmyard, and animal manure, and de-leafing in order to produce big fruit. This increased work burden might have different negative implications for men and women farmers, depending on their roles and responsibilities in the production system.

Gender roles, constraints, opportunities, and preferences are not static. Information on trait preferences, though, is often collected at only one point in time and may not include on-going changes in gender relations. Recognizing such change will support the targeting of breeding programs towards needs of their priority customers taking socio-economic and agronomic factors, such as geographic location, gender, ethnicity, culture, age and their interactions into account. Overall, the few studies focusing on gender-specific information indicate that it is essential to capture gender-differentiated preferences of actors in the whole value chain to improve the chances that new cultivars can be adopted and generate maximum benefit.

Conclusion

The finding that farmers often prefer traditional cultivars because of their superior consumption attributes, even if new cultivars have better agronomic and host resistance characteristics, is a recurring theme of the reviewed studies. Using local germplasm to produce new cultivars can potentially improve acceptance rates, especially as these cultivars would meet the farmers' and consumers' preferences for taste, color, and processing related traits. Understanding what end-users and farmers want in cultivars early on can assist breeders with appropriate targeting of efforts. Bridging the divide between farmers and breeders is one way to ensure that new cultivars have farmers' desired traits, which might lead to faster adoption.

Sustained interaction between breeders, other researchers such as pathologists, agronomists, food scientists, social scientists, and entomologists, farmers, and other value chain actors is necessary to understand local context and exchange vital information for an efficient and effective breeding program. Interdisciplinary teams can build "product profiles" for improved cultivar banana types that may be highly acceptable to well-targeted farmers in specific prioritized growing regions (Ragot et al. 2018). Preference studies provide entry points for discussions that prioritize targets for the improvement of specific traits, and priorities for selection in the short and longer term. This can contribute significantly to enhancing the efficiency of a breeding program by improving the chances that the new cultivar would be adopted by farmers and contribute to improving livelihoods. A cultivar product profile based on the priority needs and preferences of priority end-users can be the basis for developing an effective breeding strategy.

The reviewed publications contribute only partial information to building such profiles. Research documenting successes and failures of past cultivar releases, adoption rates of introduced banana cultivars, adoption rationales, and a better understanding of the farming production and seed systems remains scanty or missing. Collecting information and understanding why some cultivars are more popular than others is recommended. Popular cultivars are more likely to have traits that end-users prefer, which can help guide breeding programs on what traits to target. Banana breeders need quantifiable information on trait preferences and guidance to set priorities for selection. Traits ranked in order of importance by end-users can provide useful information to help banana breeding teams to adapt and revisit the product profiles and breeding priorities (Ragot et al. 2018).

Finally, the review did not find research that evaluated gender differentiation from a value chain perspective. However, as men, women, and other social groups such as traders might have gender-specific knowledge on production, processing, or consumption of particular cultivars, a gender approach can improve efficiency of the breeding program by contributing to the development and refinement of breeding product profiles (Christinck et al. 2017; Ragot et al. 2018).

Availability of Data and Materials

All the papers used in this review are included in the reference section below.

Authors' Contributions PM conducted the review, and was involved in designing the methodology and manuscript writing. CC, IV, and RC were involved in designing the methodology and manuscript writing. EW, RO, CC, and RT were involved in manuscript revision. All authors of this review agree to its publication.

Funding Information

The CGIAR Consortium through the CGIAR Collaborative Platform for Gender Research, CGIAR Research Program on Roots, Tubers, and Bananas, and the International Institute of Tropical Agriculture (IITA) through the Breeding Better Bananas project funded this review.

Compliance with Ethical Standards

Competing Interests. The authors declare that there are no competing interests.

Literature Cited

AATF. 2009. Feasibility study on technologies for improving banana for resistance against bacterial wilt in Sub-Saharan Africa. Nairobi: African Agricultural Technology Foundation.

Aïtchédji, C., A. Tenkouano, and O. Coulibaly. 2010. Factors affecting the adoption of disease-resistant plantain and banana (*Musa spp.*) hybrids in Nigeria. Acta Horticulturae, 879: 741–748. https://doi.org/10.17660/ActaHortic.2010.879.80.

Akankwasa, K., G. F. Ortmann, E. Wale, and W. K. Tushemereirwe. 2013a. Determinants of consumers' willingness to purchase East African Highland cooking banana hybrids in Uganda. African Journal of Agricultural Research 8(9): 780–791.

Akankwasa, K., G. F. Ortmann, E. Wale, and W. K. Tushemereirwe. 2013b. Farmers' choice among recently developed hybrid banana varieties in Uganda: A multinomial logit analysis. Agrekon 52(2): 25–51. https://doi.org/10.1080/03031853.2013.798063.

Akankwasa, K., G. F. Ortmann, E. Wale, and W. K. Tushemereirwe. 2016. Early-stage adoption of improved banana "Matooke" hybrids in Uganda: A count data analysis based on farmers' perceptions. International Journal of Innovation and Technology Management 13(01): 1650001. https://doi.org/10.1142/S0219877016500012.

Ayinde, O. E., M. O. Adewumi, and W. O. Folorunsho. 2010. Consumer preference of banana (*Musa spp.*) in Kwara State. Acta Horticulturae, 879: 89–93. https://doi.org/10.17660/ActaHortic.2010.879.6.

Barekye, A., P. Tongoona, J. Derera, M. D. Laing, and W. K. Tushemereirwe. 2013. Analysis of farmer-preferred traits as a basis for participatory improvement of East African highland bananas in Uganda. In: Banana systems in the humid highlands of Sub-Saharan Africa enhancing resilience and productivity, eds. G. Blomme, P. J. A. van Asten, and B. Vanlauwe, 30–36. Wallingford: CABI.

Bechoff, A., K. Tomlins, G. Fliedel, L. A. Becerra Lopez-Lavalle, A. Westby, C. Hershey, and D. Dufour. 2018. Cassava traits and end-user preference: Relating traits to consumer liking, sensory perception, and genetics. Critical Reviews in Food Science and Nutrition 58 (4): 547–567. https://doi.org/10.1080/10408398.2016.1202888.

Brown, A., R. Tumuhimbise, D. Amah, B. Uwimana, M. Nyine, H. Mduma, D. Talengera, D. Karamura, J. Kubiriba, and R. Swennen. 2017. Bananas and plantains (*Musa spp*). In: Genetic improvement of tropical crops, eds. H. Campos and P. D. S. Caligari, 219–240. Cham: Springer.

Christinck, A., E. Weltzien, and V. Hoffmann. 2005. Setting breeding objectives and

developing seed systems with farmers: A handbook for practical use in participatory plant breeding projects. Weikersheim: Margraf Verlag.

Christinck, A., E. Weltzien, and F. Rattunde, and J. Ashby. 2017. Gender differentiation of farmer preferences for varietal traits in crop improvement: Evidence and issues. Working Paper No. 2. Cali: CGIAR Gender and Agriculture Research Network; CGIAR System Management Office and International Center for Tropical Agriculture (CIAT).

Dadzie, B. K. and H. Wainwright. 1995. Plantain utilization in Ghana. Tropical Science 35(4): 405–410.

De Weerdt, J. 2003. Adoption of superior banana varieties in the Kagera Region: Accomplishments and constraints. Bukoba: Kagera Community Development Programme and Economic Development Initiatives Limited.

Dowiya, N. B., C. L. Rweyemamu, and A. P. Maerere. 2009. Banana (Musa spp. Colla) cropping systems, production constraints and cultivar preferences in Eastern Democratic Republic of Congo. Journal of Animal and Plant Sciences 4(2): 341–356. http://www.m.elewa.org/JAPS/2009/4.2/3.pdf.

Dury, S., L. Temple, J. Tchango Tchango, N. Bricas, and A. Bikoï. 2002. The determinants of urban plantain consumption in Cameroon. Food Quality and Preference 13(2): 81–88. https://doi.org/10.1016/S0950-3293(01)00061-1.

Dzomeku, B. M., M. Osei-Owusu, A. A. Ankomah, E. Akyeampong, and S. K. Darkey. 2006. Sensory evaluation of some cooking bananas in Ghana. Journal of Applied Sciences 6(4): 835–837. https://doi.org/10.3923/jas.2006.835.837.

Dzomeku, B. M., S. K. Darkey, R. K. Bam, and A. A. Ankomah. 2007. Sensory evaluation of four FHIA tetraploid hybrids for kaakle (a local dish) in Ghana. Journal of Plant Sciences 2(6): 640–643. https://doi.org/10.3923/jps.2007.640.643.

Dzomeku, B. M., F. Armo-Annor., K. Adjei-Gyan., J. Ansah., A. Nkakwa, and S. K. Darkey. 2008. On-farm evaluation and consumer acceptability study of selected tetraploid Musa hybrid in Ghana. Journal of Plant Sciences 3(3): 216–223. https://doi.org/10.3923/jps.2008.216.223.

Edmeades, S. O., M. Smale, M. Renkow, and D. Phaneuf. 2004. Variety demand within the framework of an agricultural household model with attributes: The case of bananas in Uganda. EPTD Discussion Paper No. 125. Washington, D.C.: IFPRI.

Ekesa, B. N., J. Kimiywe, M.W. Davey, C. Dhuique-Mayer, I. Van den Bergh, D. Karamura, and G. Blomme. 2012. Banana and plaintain (Musa spp.) cultivar preference, local processing techniques and consumption patterns in Eastern Democratic Republic of Congo. International Journal of Agriculture Sciences 4(8): 312–319.

FAOSTAT. 2020. Food and Agricultural Organisation of the United Nations. FAOSTAT statistical database. http://www.fao.org/faostat/en/#data/QC (April 2020).

Faturoti, B. O., G. N. Emah, B. I. Isife, A. Tenkouano, and J. Lemchi. 2006. Prospects and determinants of adoption of IITA plantain and banana-based technologies in three Niger Delta states of Nigeria. African Journal of Biotechnology 5(14): 1319–1323.

Faturoti, B. O., A. Ajayi, P. Baiyeri, and M. Madukwe. 2009. Impact of International Institute of Tropical Agriculture banana (Musa Spp.) production technologies on small holder farmers in Southern Nigeria. Journal of Applied Sciences 9(14): 2592–2598. https://doi.org/10.3923/jas.2009.2592.2598.

Ferris, S., R. Ortiz, U. E. Chukwu, O. Y. Akalumhe, S. Akele, A. Ubi, and D. Vuylsteke. 1997. The introduction and market potential of exotic black sigatoka resistant cooking banana cultivars in West Africa. Quarterly Journal of International Agriculture 36(2): 141–152.

Gaidashova, S. V., S. H. O. Okech, C. S. Gold, and I. Nyagahungu. 2005. Why beer bananas: The case for Rwanda. InfoMusa 14(1): 2–6.

Gaidashova, S. V., F. Karemera, and E. B. Karamura. 2008. Agronomic performance of introduced banana varieties in lowlands of Rwanda. African Crop Science Journal 16(1): 9–16. https://doi.org/10.4314/acsj.v16i1.54321.

Gold, C. S., A. Kiggundu, A. M. K. Abera, and D. Karamura. 2002. Selection criteria of Musa cultivars through a farmer participatory appraisal survey in Uganda. Experimental Agriculture 38(1): 29–38. https://doi.org/10.1017/S0014479702000133.

ISPC, SPIA. 2014. Adoption of modern varieties of food crops in Sub-Saharan Africa., Impact Brief No. 42. Rome: Independent Science and Partnership Council Secretariat. https://cas.cgiar.org/spia/publications/adoption-modern-varieties-food-crops-sub-saharan-africa (November 2018).

Jogo, W., E. Karamura, W. Tinzaara, J. Kubiriba, and A. Rietveld. 2013. Determinants of farm-level adoption of cultural practices for Banana Xanthomonas Wilt control in Uganda. Journal of Agricultural Science 5(7): 70–82. https://doi.org/10.5539/jas.v5n7p70.

Kagezi, G., S. Mpiira, W. Jogo, E. Karamura, E. Gotor, H. Garming, and V. Johnson. 2012. Adoption of new banana varieties in Uganda Report for the DIIVA Project. Rome: Bioversity International

Kalyebara, M. R., P. E. Ragama, E. Kikulwe, F. Bagamba, K. C. Nankinga, and W. K. Tushemereirwe. 2006. Economic importance of the banana bacterial wilt in Uganda. African Crop Science Journal 14(2): 93–103. https://doi.org/10.4314/acsj.v14i2.27915.

Karamura, D. A., B. Mgenzi, E. Karamura, and S. Sharrock. 2004. Exploiting indigenous knowledge for the management and maintenance of *Musa* biodiversity on farm. African Crop Science Journal 12(1): 67–74. https://doi.org/10.4314/acsj.v12i1.27664.

Karamura, E., G. Kayobyo, G. Blomme, S. Benin, S. J. Eden-Green, and R. Markham. 2006. Impacts of BXW epidemic on the livelihoods of rural communities in Uganda. In: Abstract book of the 4th International Bacterial Wilt Symposium, eds. G. Saddler and J. Elphinstone, 17–20. York: Central Science Laboratory.

Karamura, D. A., E. B. Karamura, and W. Tinzaara. 2012. Banana cultivar names, synonyms and their usage in Eastern Africa. Kampala: Bioversity International.

Kibura, J. A., A. Azath, and C. Mushongi. 2010. Farmer's assessment on acceptability of new banana varieties in Kibondo District, Kigoma Region. Bukoba: Maruku Agricultural Research Institute.

Kikulwe, E. M., E. Birol, J. Wesseler, and J. Falck-Zepeda. 2011. A latent class approach to investigating demand for genetically modified banana in Uganda. Agricultural Economics 42(5): 547–560. https://doi.org/10.1111/j.1574-0862.2010.00529.

Kouamé, C. A., N. K. Kouassi, D. Y. N'dri, and G. N. Amani. 2015. Plantain (Musa Spp., AAB Genome) cultivar preference, local processing techniques and consumption patterns of plantain-based foods mostly consumed in urban area of Abidjan, Côte d'Ivoire. Nature and Technology B 12: 117–129.

Kwach, K. J., S. Makworo, S. Nasambu, and M. Onyango. 2000. Performance of banana cultivars in South Western Kenya. Acta Horticulturae 540: 239–243. https://doi.org/10.17660/ActaHortic.2000.540.27.

Lemchi, J. I., C. I. Ezedinma, M. Tshiunza, Tenkouano, and B. O. Faturoti. 2005a. Agroeconomic evaluation of black sigatoka resistant hybrid plantains under smallholder management systems. African Journal of Biotechnology 4(10): 1045–1053.

Lemchi, J. I., M. Tshiunza, U. Onyeka, and A. Tenkouano. 2005b. Factors driving the adoption of cooking banana processing and utilisation methods in Nigeria. African Journal of Biotechnology 4(11): 1335–1347.

Mengue Efanden, C., L. Temple, and K. Tomekpe. 2003. Varietal selection by growers in Central Cameroon. Infomusa 12(1): 4–8.

Miriti, L. 2013. Gender responsive strategies employed in banana production and marketing in Imenti South District, Meru County. M.A. thesis. Nairobi: Kenyatta University. http://ir-library.ku.ac.ke/handle/123456789/7589%20 (December 2018).

Mugisha, J., K. Akankwasa, W. Tushemereirwe, and P. Ragama. 2008. Urban consumer willingness to pay for introduced dessert bananas in Uganda. African Crop Science Journal 16(4): 251–258. https://doi.org/10.4314/acsj.v16i4.54399.

Musimbi, J. 2007. Impact of gender on adoption of improved banana cultivars: The case of Jinja and Kamuli Districts in Uganda. M.A. thesis. Kampala: Makerere University.

Nalunga, A., E. Kikulwe, K. Nowakunda, S. Ajambo, and D. Naziri. 2015. Structure of the cooking banana value chain in Uganda and opportunities for value addition and post-harvest losses reduction: CRP: RTB.

Nasirumbi, L., R. T. Ssali, K. Akankwasa, K. Nowakunda, A. Barekye, M. G. Namuddu, and J. Kubiriba. 2018. Gender-differentiated preferences in breeding for new matooke hybrids in Uganda. In: State of the knowledge for gender in breeding: Case studies for practitioners. CGIAR Gender and Breeding Initiative Working Paper No. 3, eds. H. A. Tufan, S. Grando, and C. Meola. Lima: CGIAR Gender and Breeding Initiative.

Nkuba, J. M. 2007. Assessing adoption and economic impacts of new banana varieties on livelihoods of farmers in Kagera Region, Tanzania. Ph.D. thesis, Morogoro: Sokoine University of Agriculture.

Nowakunda, K., and W. Tushemereirwe 2004. Farmer acceptance of introduced banana

genotypes in Uganda. African Crop Science Journal 12(1): 1–6. https://doi.org/10.4314/acsj.v12i1.27656.

Nowakunda, K., P. R. Rubaihayo, M. A. Ameny, and W. Tushemereirwe. 2000. Consumer acceptability of introduced bananas in Uganda. Infomusa 9(2): 22–25.

Nowakunda, K., A. Barekye, R. T. Ssali, J. Namaganda, W. K. Tushemereirwe, G. Nabulya, R. Erima, K. Akankwasa, E. Hilman, M. Batte, and D. Karamura. 2015. "Kiwangaazi" (syn "KABANA 6H") black sigatoka nematode and banana weevil tolerant "Matooke" hybrid banana released in Uganda. HortScience 50(4): 621–623. https://doi.org/10.21273/HORTSCI.50.4.621.

Nwachukwu, N. and N. J. Egwu. 2008. Response of farmers to the adoption of a new resistant hybrid plantain variety in Nigeria. Agricultural Journal 3(6): 463–468. http://medwelljournals.com/abstract/?doi=aj.2008.463.468.

Ochola, D., W. Jogo, W. Ocimati, A. Rietveld, W. Tinzaara, D. A. Karamura, and E. B. Karamura. 2013. Farmers' awareness and perceived benefits of agro-ecological intensification practices in banana systems in Uganda. African Journal of Biotechnology 12(29): 4603–4613. https://doi.org/10.5897/AJB12.2868.

Ocimati, W., G. Blomme, D. Karamura, P. Ragama, P. Lepoint, J. P. Kanyaruguru, F. Ngezahayo, V. Ndungo, and S. Hakizimana. 2013. On-farm *Musa* germplasm diversity in different agro-ecologies of Burundi. International Journal of Biodiversity and Conservation 5 (11): 751–60.

Ocimati, W., G. Blomme, A. Rutikanga, P. Ragama, S. Gaidashova, A. Nsabimana, and C. Murekezi. 2014. Musa germplasm diversity status across a wide range of agro-ecological zones in Rwanda. Journal of Applied Biosciences 73(1): 5979–5990.

Ocimati, W., D. Karamura, C. Sivirihauma, V. Ndungo, E. De Langhe, J. Adheka, B. Dheda, J. Ntamwira, H. Muhindo, P. Ragama, and G. Blomme. 2016. On-farm banana (Musa) cultivar diversity status across different altitudes in North and South Kivu provinces of Eastern Democratic Republic of Congo. Acta Horticulturae 1114: 35–44. https://doi.org/10.17660/ActaHortic.2016.1114.5.

Ortiz, R. 2011. Conventional banana and plantain breeding. Acta Horticulturae 986: 177–194. https://doi.org/10.17660/ActaHortic.2013.986.19.

Ortiz, R., P. D. Austin, and D. R. Vuylsteke. 1997. IITA high rainfall station: Twenty years of research for sustainable agriculture in the West African humid forest. HortScience 32(6): 969–972. https://doi.org/10.21273/hortsci.32.6.969.

Otieno, G., I. Lopez Noriega, and T.W. Reynolds. 2016. Smallholder access to quality and diverse seed in Uganda: Implications for food security. Brief. Rome: Bioversity International. https://hdl.handle.net/10568/78822.

Pedersen, E. K. 2012. Factors affecting the adoption of improved banana technologies in Northern Tanzania, Evaluation note no. 1. Copenhagen: Rockwool Foundation Research.

Pillay, M. and A. Tenkouano. 2011. Banana breeding: Progress and challenges. Boca Raton, Florida: CRC Press.

Ragot, M., E. Bonierbale, and E. Weltzien. 2018. From market demand to breeding decisions: A Framework. CGIAR Gender and Breeding Initiative Working Paper 2, Lima: CGIAR Gender and Breeding Initiative.

Rubaihayo, P. R. 1991. Banana based systems cropping research: A report on rapid rural appraisal survey of banana production. Research Bulletin 2. Kampala: Makerere University.

Rutherford, M. A. and S. Gowen. 2003. Integrated management of banana diseases in Uganda. DFID Crop Protection Programme. Annual report. Egham: CABI Bioscience.

Shimelis, H. 2017. New variety design and product profiling. In: The business of plant breeding: Market-led approaches to new variety design in Africa, eds. G. J. Persley and V. M. Anthony. Wallingford: CABI.

Ssali, R. T., K. Nowakunda, E. R. Barekye, M. Batte, and W. Tushemereirwe. 2010. On-farm participatory evaluation of East African highland banana "Matooke" hybrids (Musa spp.). Acta Horticulturae 879: 585–591. https://doi.org/10.17660/ActaHortic.2010.879.65.

Ssemwanga, J. K. 1995. Quality attributes of matooke banana cultivars according to farmers and traders in Uganda. Musafrica (NGA) (7): 7–9.

Swennen, R., D. Vuylsteke.1991. Bananas in Africa: Diversity, uses and prospects for improvement. In: Crop genetic resources of Africa: Proceedings of an International Conference 17–20 October 1988, eds. N.Q. Ng, P. Perrino, F. Attere and H. Zedan. 2: 151–160. Ibadan: IITA.

Swennen, R., S. Sharrock, and E. Frison. 2000. Biotechnology in support of smallholders cultivating bananas in the tropics. In: Proceedings of sustainable agriculture in the new millennium. The impact of biotechnology on developing countries 28–31 May 2000, eds. K. Plenderleith and P. De Meyer, 155–161. Brussels: Friends of the Earth Europe, Oxfam, BUND, Dag Hammarskjöld Foundation.

Tenkouano, A., B. O. Faturoti, and P. K. Baiyeri. 2010. On-farm evaluation of Musa hybrids in Southern Nigeria. Tree and Forestry Science and Biotechnology 4(2): 30–34. https://www.cabdirect.org/cabdirect/abstract/20113196632.

Uazire, A. T., C. M. Ribeiro, C. R. B. Mussane, M. Pillay, G. Blomme, C. Fraser, C. Staver, and E. Karamura. 2008. Preliminary evaluation of improved banana varieties in Mozambique. African Crop Science Journal 16(1): 17–25. https://doi.org/10.4314/acsj.v16i1.54325.

Ubi, G., K. Nwagu, J. Jemide, C. Egu, M. Onabe, and I. Essien. 2016. Organoleptic and horticultural characterization of selected elite cultivars of plantain (*Musa paradisiaca* L.) for value addition and food security in Nigeria. Journal of Advances in Biology and Biotechnology 6(4): 1–19. https://doi.org/10.9734/JABB/2016/26420.

Walker, T. S. and J. Alwang. 2015. Crop improvement, adoption and impact of improved varieties in food crops in sub-Saharan Africa. Wallingford: CGIAR and CABI.

Weltzien, E., F. Rattunde, A. Christinck, K. Isaacs, and J. Ashby. 2020. Gender and farmer preferences for varietal traits: Evidence and issues for crop improvement. In: Plant breeding reviews, vol. 43, ed. I. Goldman, 243–278. New Jersey: John Wiley and Sons, Ltd. https://doi.org/10.1002/9781119616801.ch7.