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Awareness and acceptance of genetic modification technology and germplasm for trees and agricultural crops in Uganda

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ABSTRACT

Uganda is yet to put in place the legal framework to enable the application of genetic modification technology (GM) and promotion of genetically modified organisms (GMOs). In this study, we explored farmers' level of awareness and acceptance of GM technology and GMOs; we in particular focused on such for trees and agricultural crops germplasm. Results of analysis of data obtained from 158 randomly selected respondents in different districts from the North, South, East and Western Uganda show that majority (75.9%) knew what GM technology and GMOs were, 89 (56.3%) said they would accept GM technology application for trees and agricultural crops germplasm development and, 47.4% believed the technology would lead to better yields and 35.8% mentioned quick income would be realised from GM crops. Respondents who do not accept the technology perceive it to be expensive, produce tasteless crops and products shunned in the market, reduce genetic variation, and compete with indigenous species among other reasons. Overall, our findings give evidence of the readiness among farmers for the GM technology. Uganda thus needs to complete the pending policy and legal framework to enable application and research, especially focused on crop maturity time reduction and yield improvement for income enhancement. We recommend that the Parliament of Uganda enact legislation and the Executive assent to laws that will enable the application of GM technology and adoption of GMOs in agricultural production in Uganda.

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Introduction

The definition of genetically modified organisms (GMOs) in this study is taken from Giannakas and Fulton and Hadley et al, who define these as organisms whose genetic materials have been engineered/spliced or modified by deliberate introduction, or removal or suppression of genes (Giannakas and Fulton, 2000; Hadley et al., 2001). The introduced genes may be from other individuals of the same species or from individuals of other species, such as viruses, bacteria, other plants and animals. According to Ginnakas and Fulton (2000), genetic modification is a branch of biotechnology considered to enhance cost savings in production while delivering product characteristics that have no observable effects for the consumers. In forestry, GM technologies such as genetic marker-aided identification of pests, diseases, and herbicide resistance, faster-growing and good wood quality trees have been in use (Hadley et al., 2001; Mmbando, 2024). Its application in the improvement of crops such as soybeans, cotton, corn, canola, maize, rice, wheat, potatoes, cassava, barley, sweet potatoes, and bananas is documented (Mmbando, 2024). Promoters deem the technology will help in developing crops adaptable to climate change and thus securing people's food and other livelihood needs (Gbashi et al., 2021; Lanre et al., 2022). However, its advancement has been met with resistance to the extent that many countries still do not have any policy and regulatory frameworks to support applications, while others have. Some 130 countries have signed biosafety protocols while others still have total bans on GM technology. It has been found that people's main concern about GM technology and GMOs is the technology's effect on health, environment, morals, and philosophies (Hobbs and Plunkett, 1999; Plunkett and Gaisford, 2000; Bekele-Alemu et al., 2025). Earlier in countries like the US, British Columbia, Germany, and Austria, concerns regarding the risk of cross-contamination of wild populations through cross-pollination with GMOs, the potential of transgenic competition with wild relatives, and the effect introduced genes may have on non-target genes in the GMOs were reported (Hadley *et al*., 2001; Mmbando, 2024). In Africa, although some 11 countries already have GM crops being grown, concerns regarding the not yet fully known effects of GM technology and GMOs on health, beliefs, environment, genetic resources of indigenous plants, etc abound and are curtailing progress (Dolapo et al., 2025; Bekele-Alemu et al., 2025). For the region, comprehensive knowledge of the misinformation and misbeliefs and addressing these will be a precursor to meaningful development and adoption of GM technology.

In practice, farmers' acceptance of technologies often depends, among others, on the knowledge they have (Nyadoi et al., 2020). For GM technology, a low level of knowledge has been reported, for example in Nigeria, where most farmers reported lacking knowledge on GM technology (Obi-Egbedi et al., 2020). In Uganda, initial studies that were being conducted on GM technology and GMOs stalled, with the collapse of the draft of the regulatory act that was named the Biosafety Bill 2017. The Bill was shelved after the President did not assent to it due to concerns related to the many unknowns about the technology. Legislators were asked to make provisions for the possible effects of GM technology or GMOs on genetic resources of indigenous species and wild relatives; this created a challenge since no sufficient studies had been done by scientists to address this knowledge gap. Moreover, limited effort had been made to consult with farmers and consumers, and it was questionable if the legal framework would have taken care of the unique socioeconomic issues of the latter, as their perspectives had not been documented. The Draft Biosafety Bill was therefore overwhelmingly opposed by many citizens, and its rejection by the President was welcomed. The collapse of the Biosafety Bill in Uganda was considered an impact of activism occasioned by neglect of citizens' participation and perspectives on the GM technology (Lukanda, 2020). Indeed, more recent studies involving farmers/consumers in Uganda, in identifying biases and unlocking the potential of GM crops in agriculture, revealed a lack of stakeholder consultations as one of the factors propagating misinformation and fear of GMOs. This is in part the reason, curtailing progress on GM technology legalization and adoption in the country (Mwanga & Turyamureeba, 2025). It had earlier been reported that farmers needed to know more about GM technology and products (Mustafa et al., 2023).

Genetic Modification technology and GMOs remain topical, given the need for sustainable production systems in the future with expected climate instability. The majority of the countries in Africa, Uganda inclusive, need to complete pending policy and regulatory frameworks to pave the way for adoption of the technology. In doing this, as highlighted earlier in this section, consultation and integration of perspectives of citizens will be crucial. Thus, we investigated knowledge, acceptance, and reasons for acceptance of GM technology and GM germplasm among farmers in Uganda's four geographic regions.

Materials and Methods

This study was carried out in five randomly selected sites from Uganda's four regions, namely East, West, North, and Central (Figure 1). The regions fall in different agroecological zones, have

different ethnic groups of people, and socioeconomic conditions. Their farming, cultural, and livelihood strategies and practices also differ. We envisioned that these differences uniquely influence livelihoods, choices, behaviors, attitudes, beliefs, cultures, and responses/needs of the farmers towards emerging technologies for production, such as genetic modification and genetically modified germplasm.

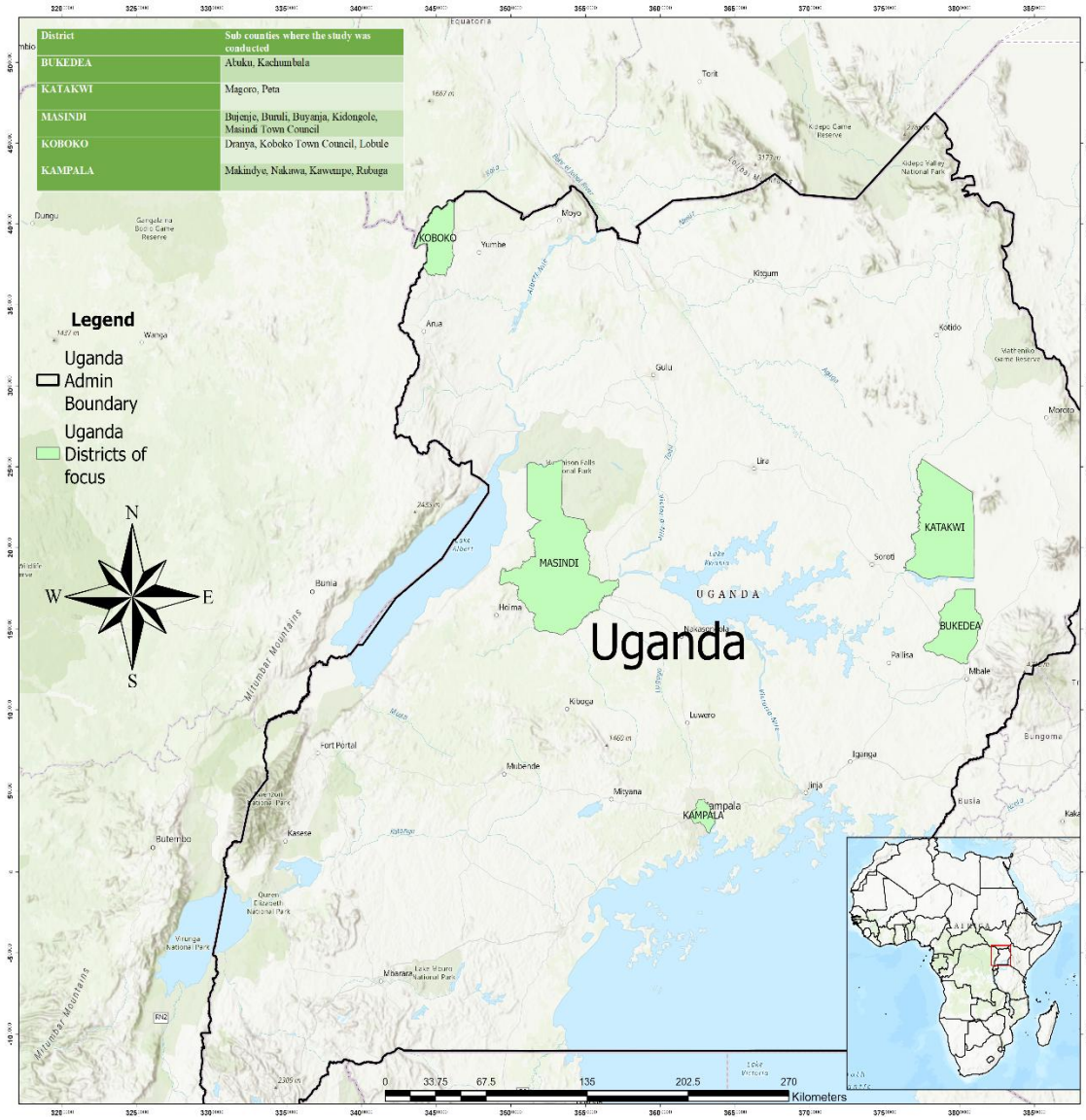

Figure 1. Map of Uganda showing sites where the study was conducted

Within each selected study site, respondents were chosen from households, with the households sampled at systematic intervals of 1 kilometre apart. Respondent selection ensured gender neutrality by taking the first sighted adult member of the household visited as the respondent, regardless of their gender. The selected respondent was interviewed using a pre-designed

questionnaire with questions that elicited perceptions on their awareness or knowledge held on and acceptance of genetic modification technology and/or genetically modified trees and crops germplasm. The questionnaire included questions asking respondents to provide information on their sub-county, village, farm size, age, level of education, family size, crops grown, and animals kept on the farm, marital status, gender, and occupation. Questions asked respondents to give perspectives on awareness/knowledge of GMOs and GM technology, willingness to accept/adopt these, reasons for and/or against adoption/acceptance, among others. Collection of data on these was done from respondents sampled at the household level at systematic intervals of 1 km apart in the study site. Collection of data from respective respondents was continued until the point of saturation, whereby new respondents added to the sample were not giving any new information but repeating or giving information that the previous respondents had given. Throughout the data collection, respondents were informed prior of the study purpose, and their consent to be interviewed was obtained. The respondents were assured of confidentiality, and this was maintained in data handling and analysis. The data obtained from a total of 158 respondents from the five study sites were entered into the SPSS software (Bennett and Allen, 2012). Frequencies, percentages, and relationships showing awareness and acceptance of genetic modification technology and genetically modified trees and agricultural crops germplasm among respondents were generated using the software's analytical tools.

Results

Socioeconomic characteristics of the respondents involved in the study.

The majority of the respondents were 31- 40 years old (43.7%), Males (62.7%), attained lower secondary level education (43.0%), had large family size (34.2%), were farmers (54.4%), and 72.2% had farm sizes less than 1 hectare (Table 1). Of the 22 different crops identified, maize was the most commonly reported to be on farm, as mentioned by 18.5% of the respondents, followed by Cassava and beans (15.9% each), Banana (10.4%), groundnuts (6.7%), Sweet potatoes (5.8%), and Millet (5.4%), among others. Of the 17 different tree species identified, mangoes were the most commonly reported to be on farm as mentioned by 22.1% the respondents, followed by Avacado (16.0%), Oranges (11.5%), Pawpaw (10.3%), Jack fruit (9.6%) Pines (6.6%), Eucalyptus (5.4%), Quavas (4.5%) and Coffee (3.8%) among others (Table 1). Goats were the most reported to be kept on farms by the respondents; other animals included Cows, Pigs, Sheep, Dogs, rabbits, and chickens (Table 1).

Table 1. Socioeconomic characteristics of the respondents involved in the study (N=158)

Socioeconomic characteristics of respondents	**Frequency of respondents mentioning character**	**Percent**
Regions of Uganda from which respondents were sampled	**Frequency**	**Percentage**
Central	41	25.9
East	40	25.3
West Nile/North	38	24.1
Western	39	24.7
District respondents were sampled from	**Frequency**	**Percent**
Bukedea	20	12.7
Kampala	41	25.9
Katakwi	20	12.7
Koboko	38	24.1
Masindi	39	24.7
Sub-counties within districts from where respondents were selected	**Frequency**	**Percent**
Abuku (Bukedea)	10	6.3
Bujenje (Masindi)	10	6.3
Buruli (Masindi)	10	6.3
Buyanja (Masindi)	9	5.7
Dranya (Koboko)	10	6.3
Kachumbala (Bukedea)	10	6.3
Kawempe (Kampala)	10	6.3
Kidongole (Masindi)	10	6.3
Koboko Town Council	8	5.1
Lobule (Koboko)	10	6.3
Magoro (Katakwi)	10	6.3
Makindye (Kampala)	10	6.3
Masindi Town Council	10	6.3
Nakawa (Kampala)	11	7.0
Peta (Katakwi)	10	6.3
Rubaga (Kampala)	10	6.3
Age of respondents	**Frequency**	**Percent**
18-30	36	22.8
31-40	69	43.7
41-50	36	22.8
51 above	15	9.5
Age not mentioned	2	1.3
Respondent's gender	**Frequency**	**Percent**
Female	59	37.3
Male	99	62.7
Respondent's family size	**Frequency**	**Percent**
2-5	48	30.4
6-10	53	33.5
Above 10	54	34.2
Not mentioned	3	1.9

Respondent's education (years spent in formal education)	**Frequency**	**Percent**
0-7	30	19
08-11	68	43
12-13	34	21.5
14-17	15	9.5
Not mentioned	11	7
Respondent's occupation	**Frequency**	**Percent**
Employed as farmer	86	54.4
Other occupation	69	43.7
Not mentioned	3	1.9
Respondent's farm size	**Frequency**	**Percent**
<1 ha	114	72.2
1-2.5 ha	21	13.3
Above 2.5 ha	19	12
Not mentioned	4	2.5
Crops respondents mentioned to have on farm	**Frequency**	**Percent**
Banana (*Musa acuminata*)	56	10.4
Sweet potatoes (*Ipomoea batatas*)	31	5.8
Beans (*Phaseolus vulgaris*)	85	15.9
Maize (*Zea mays*)	99	18.5
Green vegetables	28	5.2
Cabbage (*Brassica olearacea* L.)	9	1.7
Ground nuts (*Arachis hypogaea*)	36	6.7
Carrots (*Daucus carota sativus*)	10	1.9
Onions (*Allium cepa*)	10	1.9
Irish potatoes (*Solanum tuberosum* L)	1	0.2
Cassava (*Manihot esculenta*)	85	15.9
Millet (*Pennisetum glaucum*)	29	5.4
Sorghum (*Sorghum bicolor* L. Moench)	16	3.0
Pineapple (*Ananas comosus*)	5	0.9
Soya (*Glycine max*)	2	0.4
Peas (*Pisum sativum* L.)	3	0.6
Pumpkin (*Cucurbita pepo*)	1	0.2
Yam (*Dioscorea* sp)	2	0.4
Sugarcane (*Saccharum officinarum*)	11	2.0
Rice (*Oryza sativa*)	13	2.4
Simsim (*Sesamum indicum* L.)	9	1.7
Tobacco (*Nicotiana tabacum*)	2	0.4
Sunflower (*Helianthus annuus*)	3	0.6
Tree species respondents mentioned having on farm	**Frequency**	**Percentage**
Orange (*Citrus sinensis*)	49	11.5
Avocado (*Persea americana*)	68	16.0
Pawpaw (*Carica papaya*)	44	10.3
Mango (*Mangifera indica*)	94	22.1
Passion fruit (*Passiflora edulis*)	8	1.9
Jack fruit (*Artocarpus heterophyllus*)	41	9.6
Jambula (*Syzygium cumini*)	9	2.1

Eucalyptus (*Eucalyptus globulus*)	23	5.4
Mvule (*Milicia excelsa*)	10	2.4
Pines (*Pinus sp*)	28	6.6
Moringa (*Moringa oleifera* Lam.)	4	0.9
Guavas (*Psidium guajava*)	19	4.5
Mahogany (*Khaya anthotheca*)	4	0.9
Coffee (*Coffea* sps)	16	3.8
Teak (*Tectona grandis* L.f)	3	0.7
Brother heart/ Soursop (*Annona muricata*)	3	0.7
Jacaranda (*Jacaranda mimosifolia* D.)	2	0.5
Animals on the farm that respondents mentioned they had	**Frequency**	**Percent**
Pigs (*Sus scrofa domesticus*)	35	13.9
Goats (*Capra aegagrus hircus*)	87	34.5
Cows (*Bos indicus*)	72	28.6
Chicken (*Gallus gallus domesticus*)	33	13.1
Rabbits (*Poelagus marjorita*)	1	0.4
Dogs (*Canis lupus familiaris*)	3	1.2
Sheep (*Ovis aries*)	21	8.3

Respondents' knowledge/awareness of GM technology and GMOs

Of the 158 respondents involved in this study, 120 (75.9%) said yes, they were aware/had knowledge of what GM technology and GMOs are, while 38 (24.1%) said no, indicating that they did not know/were not aware of what GM technology and GMOs are. The pattern in level of knowledge/awareness of GM technology and GMOs was similar, with the majority saying they had knowledge and fewer mentioning being unknowledgeable, across the different respondents' socioeconomic categories (Table 2).

Table 2. Knowledge on GM technology and GMOs among respondents in the study

Farmers socio-economics	**Area**	**Farmers' level of knowledge of GM technology and GMOs**		**Total**
Region	**Region**	**Yes**	**No**	
	Central	34	7	41
	East	34	6	40
	West Nile	22	16	38
	Western	30	9	39
District	**Districts**	**Yes**	**No**	
	Bukedea	15	5	20
	Kampala	34	7	41
	Katakwi	19	1	20
	Koboko	22	16	38
	Masindi	30	9	39
	Subcounty	**Yes**	**No**	

Sub county/division	Abuku	5	5	10
	Bujenje	5	5	10
	Buruli	9	1	10
	Buyanja	8	1	9
	Dranya	7	3	10
	Kachumbala	7	3	10
	Kawempe	9	1	10
	Kidongole	8	2	10
	Koboko Town Council	5	3	8
	Lobule	5	5	10
	Magoro	9	1	10
	Makindye	9	1	10
	Masindi Town Council	8	2	10
	Nakawa	7	4	11
	Peta	10	0	10
	Rubaga	9	1	10
Farmers age	Respondent's age	Yes	No	
	18-30	28	8	36
	31-40	50	19	69
	41-50	31	5	36
	51 and above	10	5	15
	Age not mentioned	1	1	2
Farmers sex	Respondents gender	Yes	No	
	Female	45	14	59
	Male	75	24	99
Farmer's family size	Respondent's family size	Yes	No	
	2-5	35	13	48
	6-10	42	11	53
	Above 10	41	13	54
	Not mentioned	2	1	3
Years farmers spent in formal education.	Years spent in formal education	Yes	No	
	0-7	18	12	30
	8-11	51	17	68
	12-13	27	7	34
	14-17	14	1	15
	Not mentioned	10	1	11
Farmers occupation	Respondent's occupation	Yes	No	
	Employed as farmer	62	24	86
	Other occupation	55	14	69
	Not mentioned	3	0	3

Farmers farm size	Size of Respondent's farm	Yes	No	
	<1 ha	88	26	114
	1-2.5 ha	14	7	21
	Above 2.5 ha	16	3	19
	Not mentioned	2	2	4

Respondent's Acceptance and/or Rejection of GM technology and GM trees and crops germplasm

Of the total 158 respondents involved in this study, 89 (56.3%) said they accept GM technology and GM for trees and crops germplasm development, while 69 (43.7%) said they do not want it. This pattern in acceptance and/or rejection of GM technology and GMOs was followed similarly across the different respondents' socioeconomic categories (Table 3).

Table 3. Respondents' Acceptance and/or Rejection of GM Technology and GM trees and crops germplasm (N=158)

Farmers socio-economics	**Respondents socioeconomic characteristics**	**Farmers' acceptance (Yes) and/or rejection (No) of GM technology and germplasm**		**Total**
	Region	**Yes**	**No**	
Region	Central	19	22	41
	East	12	28	40
	West Nile	38	0	38
	Western	20	19	39
District	**District**	**Yes**	**No**	
	Bukedea	7	13	20
	Kampala	19	22	41
	Katakwi	5	15	20
	Koboko	38	0	38
	Masindi	20	19	39
Sub county/division	**Subcounty**	**Yes**	**No**	
	Abuku	10	0	10
	Bujenje	7	3	10
	Buruli	4	6	10
	Buyanja	3	6	9

	Dranya	10	0	10
	Kachumbala	4	6	10
	Kawempe	3	7	10
	Kidongole	3	7	10
	Koboko Town Council	8	0	8
	Lobule	10	0	10
	Magoro	1	9	10
	Makindye	5	5	10
	Masindi Town Council	6	4	10
	Nakawa	9	2	11
	Peta	4	6	10
	Rubaga	2	8	10
Farmers age	Years respondents spent in formal education	Yes	No	
	18-30	32	4	36
	31-40	28	41	69
	41-50	16	20	36
	51 above	12	3	15
	Age not mentioned	1	1	2
Farmers sex	**Respondent's gender**	**Yes**	**No**	
	Female	31	28	59
	Male	58	41	99
Farmers family size	**Respondent's family size**	**Yes**	**No**	
	2-5	36	12	48
	6-10	29	24	53
	Above 10	23	31	54
	Not mentioned	1	2	3
Years Farmers spent in formal education.	**Years respondents spent in formal education**	**Yes**	**No**	
	0-7	22	8	30
	0-11	33	35	68
	12-13	21	13	34
	14-17	9	6	15
	Not mentioned	4	7	11
	Respondents Occupation	**Yes**	**No**	
Farmers occupation	Employed as farmer	53	33	86
	Other occupation	34	35	69
	Not mentioned	2	1	3
Farmers farm size	**Respondent's farm size**	**Yes**	**No**	
	<1 ha	66	48	114
	1-2.5 ha	13	8	21
	Above 2.5 ha	8	11	19
	Not mentioned	2	2	4

Respondents' reasons for acceptance and/or rejection of GM technology and GM trees and crops germplasm

The majority (47.4%) of the respondents who agree to have GM technology and GMOs for trees and crops germplasm development want it for better yields, other reasons being quick income (mentioned by 35.8% of the respondents), early maturity of crops (11.7%), among others (Table 4). On the other hand, the respondents who reject the technology and GM germplasm said that the GMOs are tasteless, mentioned by 23.0% of the respondents, the technology is expensive and time consuming (21.8%), they have chemicals that harm the body (13.8%), shunned by the markets (10.3%), fail to produce (9.2%) and may reduce genetic variation in indigenous species, compete with the indigenous species and degrade the environment (each mentioned by 5.7% of the respondents) among others (Table 4).

Table 4. Respondents' reasons for acceptance and/or rejection of GM technology and GM trees and crops germplasm (N=158)

Reasons for respondents' acceptance of GM technology and/or GM trees and crops germplasm	**Frequency of responses**	**Percent**
Need for development of disease-resistant crops	7	5.1
Better agricultural yields	65	47.4
Quick income	49	35.8
Early maturity	16	11.7
Reasons not specified	21	13.3
Reasons respondents give for rejection of GM Technology and GM germplasm	**Frequency of responses**	**Percent**
Expensive and time-consuming	19	21.8
Fail to produce	8	9.2
Tasteless	20	23.0
Have chemicals harmful to body/cause disease	12	13.8
Competes with indigenous species	5	5.7
May reduce genetic variation	5	5.7
Rots easily	4	4.6
Degrades soil/environment	5	5.7
Shunned in markets by customers	9	10.3

Cross evaluation, acceptance/rejection of GM technology and germplasm, reasons for choice and respondents' socioeconomic characteristics

On ability develop disease resistance crops as reasons for acceptance of GM technology and germplasm by gender of the respondents; 57.1% of the respondents who mentioned this were

females while 42.9% were males, by family size, this reason was mostly mentioned among respondents with small (2-5 persons per family) and those with very large – above 10 persons family size (42.9% for both cases), those in age group 41-50 years old (42.9%), those with 8-11 years of formal education (42.9%) and those with small farm sizes less than 1hectare (57.1%), (Table 5). On ability to provide quick income as reasons for acceptance of GM technology and germplasm, by gender of the respondents; 34.7% of the respondents who mentioned this were females while 65.3% were males, by family size, this reason was mostly mentioned among respondents with small (2-5 persons per family) and large families of 5- 10 persons family size (38.8% for both cases), those in age group 18- 40 years old (above 30%), those with 8-11 years of formal education (38.8%) and those with small farm sizes less than 1hectare (71.4%), (Table 5). On ability to provide better yields as reasons for acceptance of GM technology and germplasm, by gender of the respondents; 40% of the respondents who mentioned this were females while 60% were males, by family size, this reason was mostly mentioned among respondents with small family size of 2-5 persons per family (43.1%), those in age group 18- 40 years old (above 30.8%), those with 8-11 years of formal education (35.4%) and those with small farm sizes less than 1hectare (70.8%), (Table 5). On ability to mature early (early maturity) as reasons for acceptance of GM technology and germplasm, by gender of the respondents; 62.5% of the respondents who mentioned this were females while 37.5% were males, by family size, this reason was mostly mentioned among respondents with small family size of 2-5 persons per family (42.5%), those in age group 18- 30 years old (above 50.0%), those with 8-11 years of formal education (50.0%) and those with small farm sizes less than 1hectare (50.0%), (Table 5).

Table 5. Cross-examination, reasons for acceptance of GM technology and germplasm and respondents' socioeconomic characteristics

Acceptance*Sex					
			Farmers sex		Total
			Female	Male	
	To develop disease-resistant crops	Count	4	3	7
		% within acceptance	57.1%	42.9%	
		% within Sex	1.7%	0.8%	
		% of Total	0.6%	0.5%	1.1%
	Better yields	Count	26	39	65
		% within acceptance	40.0%	60.0%	
		% within Sex	11.0%	9.8%	
		% of Total	4.1%	6.2%	10.3%
	Quick income	Count	17	32	49
		% within acceptance	34.7%	65.3%	
		% within Sex	7.2%	8.1%	
		% of Total	2.7%	5.1%	7.8%

	Early maturity	Count	10	6	16
		% within acceptance	62.5%	37.5%	
		% within Sex	4.2%	1.5%	
		% of Total	1.6%	0.9%	2.5%

acceptance*Family size

			Farmers family size				Total
			Not mentioned	2-5	6-10	Above 10	
	To develop disease-resistant crops	Count	0	3	1	3	7
		% within acceptance	0.0%	42.9%	14.3%	42.9%	
		% within Family	0.0%	1.6%	0.5%	1.4%	
		% of Total	0.0%	0.5%	0.2%	0.5%	1.1%
	Better yields	Count	0	28	20	17	65
		% within acceptance	0.0%	43.1%	30.8%	26.2%	
		% within Family	0.0%	14.6%	9.4%	7.9%	
		% of Total	0.0%	4.4%	3.2%	2.7%	10.3%
	Quick income	Count	1	19	19	10	49
		% within acceptance	2.0%	38.8%	38.8%	20.4%	
		% within Family	8.3%	9.9%	9.0%	4.6%	
		% of Total	0.2%	3.0%	3.0%	1.6%	7.8%
	Early maturity	Count	0	9	6	1	16
		% within acceptance	0.0%	56.2%	37.5%	6.2%	
		% within Family	0.0%	4.7%	2.8%	0.5%	
		% of Total	0.0%	1.4%	0.9%	0.2%	2.5%

acceptance*Farmers Age

			Farmers Age					Total
			Age not mentioned	18-30	31-40	41-50	51 above	
	To develop disease-resistant crops	Count	0	2	1	3	1	7
		% within acceptance	0.0%	28.6%	14.3%	42.9%	14.3%	
		% within Age	0.0%	1.4%	0.4%	2.1%	1.7%	
		% of Total	0.0%	0.3%	0.2%	0.5%	0.2%	1.1%
	Better yields	Count	1	20	20	14	10	65
		% within acceptance	1.5%	30.8%	30.8%	21.5%	15.4%	
		% within Age	12.5%	13.9%	7.2%	9.7%	16.7%	
		% of Total	0.2%	3.2%	3.2%	2.2%	1.6%	10.3%
	Quick income	Count	0	17	16	8	8	49
		% within acceptance	0.0%	34.7%	32.7%	16.3%	16.3%	

		% within Age	0.0%	11.8%	5.8%	5.6%	13.3%	
		% of Total	0.0%	2.7%	2.5%	1.3%	1.3%	7.8%
	Early maturity	Count	1	8	3	2	2	16
		% within acceptance	6.2%	50.0%	18.8%	12.5%	12.5%	
		% within Age	12.5%	5.6%	1.1%	1.4%	3.3%	
		% of Total	0.2%	1.3%	0.5%	0.3%	0.3%	2.5%

acceptance*Education Years

			Years Farmers spent in formal education.					Total
			Not mentioned	0-7	8-11	12-13	14-17	
	To develop disease-resistant crops	Count	0	1	3	2	1	7
		% within acceptance	0.0%	14.3%	42.9%	28.6%	14.3%	
		% within Education Years	0.0%	0.8%	1.1%	1.5%	1.7%	
		% of Total	0.0%	0.2%	0.5%	0.3%	0.2%	1.1%
	Better yields	Count	1	17	23	18	6	65
		% within acceptance	1.5%	26.2%	35.4%	27.7%	9.2%	
		% within Education Years	2.3%	14.2%	8.5%	13.2%	10.0%	
		% of Total	0.2%	2.7%	3.6%	2.8%	0.9%	10.3%
	Quick income	Count	2	10	19	12	6	49
		% within acceptance	4.1%	20.4%	38.8%	24.5%	12.2%	
		% within Education Years	4.5%	8.3%	7.0%	8.8%	10.0%	
		% of Total	0.3%	1.6%	3.0%	1.9%	0.9%	7.8%
	Early maturity	Count	0	3	8	3	2	16
		% within acceptance	0.0%	18.8%	50.0%	18.8%	12.5%	
		% within Education Years	0.0%	2.5%	2.9%	2.2%	3.3%	
		% of Total	0.0%	0.5%	1.3%	0.5%	0.3%	2.5%

acceptance*Farm size

			Farmers farm size				Total
			Not mentioned	<1 ha	1-2.5 ha	Above 2.5 ha	
	To develop disease-resistant crops	Count	0	4	1	2	7
		% within acceptance	0.0%	57.1%	14.3%	28.6%	
		% within Farm Size	0.0%	0.9%	1.2%	2.6%	

		% of Total	0.0%	0.6%	0.2%	0.3%	1.1%
	Better yields	Count	1	46	11	7	65
		% within acceptance	1.5%	70.8%	16.9%	10.8%	
		% within Farm Size	6.2%	10.1%	13.1%	9.2%	
		% of Total	0.2%	7.3%	1.7%	1.1%	10.3%
	Quick income	Count	1	35	8	5	49
		% within acceptance	2.0%	71.4%	16.3%	10.2%	
		% within Farm Size	6.2%	7.7%	9.5%	6.6%	
		% of Total	0.2%	5.5%	1.3%	0.8%	7.8%
	Early maturity	Count	1	8	4	3	16
		% within acceptance	6.2%	50.0%	25.0%	18.8%	
		% within Farm Size	6.2%	1.8%	4.8%	3.9%	
		% of Total	0.2%	1.3%	0.6%	0.5%	2.5%

Cross evaluation, reasons for rejection of GM technology and germplasm and respondents' socioeconomic characteristics

Among the reasons respondents gave for rejection of GM technology and germplasm, being expensive and time consuming as reasons for rejection given by gender of the respondents; 31.6% of the respondents who mentioned this were females while 68.4% were males, by family size, this reason was mostly mentioned among respondents with very large family size – above 10 persons (52.6%), those in age group 31- 40 years old (68.4%), those with 8-11 years of formal education (68.4%) and those with small farm sizes less than 1hectare (84.2%), (Table 6). On failing to produce (failure to produce) as reasons for rejection of GM technology and germplasm, by gender of the respondents; 50.0% of the respondents who mentioned this were females while 50.0% were males, by family size, this reason was mostly mentioned among respondents with very large families of more than 10 persons (50.0%), those in age group 31- 50 years old (50.0%), those with 8-11 years of formal education (68.4%) and those with small farm sizes less than 1hectare (75.0%), (Table 6). On GMOs being tasteless as reasons for rejection of the GM technology and germplasm, by gender of the respondents; 45% of the respondents who mentioned this were females while 55% were males, by family size, this reason was mostly mentioned among respondents with large family size of 6-10 persons per family (55.0%), those in age group 31- 40 years old (above 50.0%), those with 8-11 years of formal education (45.0%) and those with small farm sizes less than

1hectare (55.0%), (Table 6). On having chemicals and being harmful to the body as reasons for rejection GM technology and germplasm; 33.3% of the respondents who mentioned this were females while 66.7% were males, the reason was mostly mentioned among respondents with large and very large family sizes of 6 people and above 10 persons per family (41.7%), those in age group 31- 40 years old (above 50.0%), those with 8-11 years of formal education (41.7%) and those with small farm sizes less than 1hectare (58.3%), (Table 6).

On possible competition with indigenous species as being reasons for rejection GM technology and germplasm; 20.0% of the respondents who mentioned this were females while 80.07% were males, the reason was mostly mentioned among respondents with small and those with very large family sizes of less than 6 or above 10 persons per family (40.0% in each case), those in age group 31- 40 years old (80.0%), those with 8-11 years of formal education (40.0%) and those with small farm sizes less than 1hectare (60.0%), (Table 6). On possible ability to reduce genetic variation in species, as being reasons for rejection GM technology and germplasm; 40.0% of the respondents who mentioned this were females while 60.0% were males, the reason was mostly mentioned among respondents with large family sizes of less than 6 to 10 persons per family (60.0%), those in age group 31- 50 years old (40.0%), those with 14-17 years of formal education (60.0%) and those with small to medium sized farms of less than 1 to 2.5 hectare (40.0%), (Table 6). On rotting easily being reasons for rejection GM technology and germplasm; 25.0% of the respondents who mentioned this were females while 75.0% were males, the reason was mostly mentioned among respondents with very large family sizes of more than 10 persons per family (50.0%), those in age group 31- 40 years old (100.0%), those with 14-17 years of formal education (50.0%) and those with small sized farms of less than 1 hectare (75.0%), (Table 6). On degrading the soil/environment being reasons for rejection GM technology and germplasm; 40.0% of the respondents who mentioned this were females while 60.0% were males, the reason was mostly mentioned among respondents with very large family sizes of more than 10 persons per family (60.0%), those in age group 31- 40 years old (40.0%), those with 0-7 years of formal education (70.0%) and those with small sized farms of less than 1 hectare (100.0%), (Table 6).On being shunned/no wanted in the market being reasons for rejection GM technology and germplasm; 33.3% of the respondents who mentioned this were females while 66.7% were males, the reason was mostly mentioned among respondents with large family sizes of 6-10 persons per family (55.6%), those in age group 31- 40

years old (66.7%), those with 8-11 years of formal education (33.3%) and those with small sized farms of less than 1 hectare (77.8%), (Table 6).

Table 6. Cross-examination, reasons for rejection of GM technology and germplasm and respondents' socioeconomic characteristics

Rejection*Farmers Sex					
			Farmer sex		Total
			Female	Male	
	Expensive and time consuming	Count	6	13	19
		% within Rejection	31.6%	68.4%	
		% within Sex	1.1%	1.5%	
		% of Total	0.4%	0.9%	1.3%
	Fail to produce	Count	4	4	8
		% within Rejection	50.0%	50.0%	
		% within Sex	0.8%	0.4%	
		% of Total	0.3%	0.3%	0.6%
	Tasteless	Count	9	11	20
		% within Rejection	45.0%	55.0%	
		% within Sex	1.7%	1.2%	
		% of Total	0.6%	0.8%	1.4%
	Have chemicals harmful to body/cause disease	Count	4	8	12
		% within Rejection	33.3%	66.7%	
		% within Sex	0.8%	0.9%	
		% of Total	0.3%	0.6%	0.8%
	Compete with indigenous species	Count	1	4	5
		% within Rejection	20.0%	80.0%	
		% within Sex	0.2%	0.4%	
		% of Total	0.1%	0.3%	0.4%
	May reduce genetic variation	Count	2	3	5
		% within Rejection	40.0%	60.0%	
		% within Sex	0.4%	0.3%	
		% of Total	0.1%	0.2%	0.4%
	Rots easily	Count	1	3	4
		% within Rejection	25.0%	75.0%	
		% within Sex	0.2%	0.3%	
		% of Total	0.1%	0.2%	0.3%
	Degrades soil/environment	Count	2	3	5
		% within Rejection	40.0%	60.0%	
		% within Sex	0.4%	0.3%	
		% of Total	0.1%	0.2%	0.4%
	Shunned in markets	Count	3	6	9
		% within Rejection	33.3%	66.7%	
		% within Sex	0.6%	0.7%	
		% of Total	0.2%	0.4%	0.6%

Rejection*Family size							
			Farmers family size				Total
			Not mentioned	2-5	6-10	Above 10	
	Expensive and time consuming	Count	0	5	4	10	19
		% within Rejection	0.0%	26.3%	21.1%	52.6%	
		% within Family	0.0%	1.2%	0.8%	2.1%	

		% of Total	0.0%	0.4%	0.3%	0.7%	1.3%
	Fail to produce	Count	1	1	2	4	8
		% within Rejection	12.5%	12.5%	25.0%	50.0%	
		% within Family	3.7%	0.2%	0.4%	0.8%	
		% of Total	0.1%	0.1%	0.1%	0.3%	0.6%
	Tasteless	Count	1	3	11	5	20
		% within Rejection	5.0%	15.0%	55.0%	25.0%	
		% within Family	3.7%	0.7%	2.3%	1.0%	
		% of Total	0.1%	0.2%	0.8%	0.4%	1.4%
	Have chemicals harmful to body/cause disease	Count	0	2	5	5	12
		% within Rejection	0.0%	16.7%	41.7%	41.7%	
		% within Family	0.0%	0.5%	1.0%	1.0%	
		% of Total	0.0%	0.1%	0.4%	0.4%	0.8%
	Compete with indigenous species.	Count	0	2	1	2	5
		% within Rejection	0.0%	40.0%	20.0%	40.0%	
		% within Family	0.0%	0.5%	0.2%	0.4%	
		% of Total	0.0%	0.1%	0.1%	0.1%	0.4%
	May reduce genetic variation	Count	0	2	3	0	5
		% within Rejection	0.0%	40.0%	60.0%	0.0%	
		% within Family	0.0%	0.5%	0.6%	0.0%	
		% of Total	0.0%	0.1%	0.2%	0.0%	0.4%
	Rots easily	Count	0	1	1	2	4
		% within Rejection	0.0%	25.0%	25.0%	50.0%	
		% within Family	0.0%	0.2%	0.2%	0.4%	
		% of Total	0.0%	0.1%	0.1%	0.1%	0.3%
	Degrades soil/environment	Count	0	1	1	3	5
		% within Rejection	0.0%	20.0%	20.0%	60.0%	
		% within Family	0.0%	0.2%	0.2%	0.6%	
		% of Total	0.0%	0.1%	0.1%	0.2%	0.4%
	Shunned in markets	Count	0	1	5	3	9
		% within Rejection	0.0%	11.1%	55.6%	33.3%	
		% within Family	0.0%	0.2%	1.0%	0.6%	
		% of Total	0.0%	0.1%	0.4%	0.2%	0.6%

Rejection*Farmers Age

	Farmers Age					Total
	Age not mentioned	18-30	31-40	41-50	51 above	

	Expensive and time consuming	Count	0	2	13	4	0	19
		% within Rejection	0.0%	10.5%	68.4%	21.1%	0.0%	
		% within Age	0.0%	0.6%	2.1%	1.2%	0.0%	
		% of Total	0.0%	0.1%	0.9%	0.3%	0.0%	1.3%
	Fail to produce	Count	0	0	4	4	0	8
		% within Rejection	0.0%	0.0%	50.0%	50.0%	0.0%	
		% within Age	0.0%	0.0%	0.6%	1.2%	0.0%	
		% of Total	0.0%	0.0%	0.3%	0.3%	0.0%	0.6%
	Tasteless	Count	1	1	10	7	1	20
		% within Rejection	5.0%	5.0%	50.0%	35.0%	5.0%	
		% within Age	5.6%	0.3%	1.6%	2.2%	0.7%	
		% of Total	0.1%	0.1%	0.7%	0.5%	0.1%	1.4%
	Have chemicals harmful to body/cause disease	Count	1	0	6	4	1	12
		% within Rejection	8.3%	0.0%	50.0%	33.3%	8.3%	
		% within Age	5.6%	0.0%	1.0%	1.2%	0.7%	
		% of Total	0.1%	0.0%	0.4%	0.3%	0.1%	0.8%
	Compete with indigenous species.	Count	0	0	4	0	1	5
		% within Rejection	0.0%	0.0%	80.0%	0.0%	20.0%	
		% within Age	0.0%	0.0%	0.6%	0.0%	0.7%	
		% of Total	0.0%	0.0%	0.3%	0.0%	0.1%	0.4%
	May reduce genetic variation	Count	0	1	2	2	0	5
		% within Rejection	0.0%	20.0%	40.0%	40.0%	0.0%	
		% within Age	0.0%	0.3%	0.3%	0.6%	0.0%	
		% of Total	0.0%	0.1%	0.1%	0.1%	0.0%	0.4%
	Rots easily	Count	0	0	4	0	0	4
		% within Rejection	0.0%	0.0%	100.0%	0.0%	0.0%	
		% within Age	0.0%	0.0%	0.6%	0.0%	0.0%	
		% of Total	0.0%	0.0%	0.3%	0.0%	0.0%	0.3%
	Degrades soil/environment	Count	0	1	2	1	1	5
		% within Rejection	0.0%	20.0%	40.0%	20.0%	20.0%	
		% within Age	0.0%	0.3%	0.3%	0.3%	0.7%	
		% of Total	0.0%	0.1%	0.1%	0.1%	0.1%	0.4%
	Shunned in markets	Count	0	0	6	3	0	9
		% within Rejection	0.0%	0.0%	66.7%	33.3%	0.0%	
		% within Age	0.0%	0.0%	1.0%	0.9%	0.0%	

		% of Total	0.0%	0.0%	0.4%	0.2%	0.0%	0.6%

Rejection*Education Years

			Years Farmers spent in formal education.					Total
			Not mentioned	0-7	8-11	12-13	14-17	
	Expensive and time-consuming	Count	0	1	13	4	1	19
		% within Rejection	0.0%	5.3%	68.4%	21.1%	5.3%	
		% within Education Years	0.0%	0.4%	2.1%	1.3%	0.7%	
		% of Total	0.0%	0.1%	0.9%	0.3%	0.1%	1.3%
	Fail to produce	Count	2	0	5	1	0	8
		% within Rejection	25.0%	0.0%	62.5%	12.5%	0.0%	
		% within Education Years	2.0%	0.0%	0.8%	0.3%	0.0%	
		% of Total	0.1%	0.0%	0.4%	0.1%	0.0%	0.6%
	Tasteless	Count	2	2	9	5	2	20
		% within Rejection	10.0%	10.0%	45.0%	25.0%	10.0%	
		% within Education Years	2.0%	0.7%	1.5%	1.6%	1.5%	
		% of Total	0.1%	0.1%	0.6%	0.4%	0.1%	1.4%
	Have chemicals harmful to body/cause disease	Count	3	1	5	3	0	12
		% within Rejection	25.0%	8.3%	41.7%	25.0%	0.0%	
		% within Education Years	3.0%	0.4%	0.8%	1.0%	0.0%	
		% of Total	0.2%	0.1%	0.4%	0.2%	0.0%	0.8%
	Compete with indigenous species.	Count	0	2	2	1	0	5
		% within Rejection	0.0%	40.0%	40.0%	20.0%	0.0%	
		% within Education Years	0.0%	0.7%	0.3%	0.3%	0.0%	
		% of Total	0.0%	0.1%	0.1%	0.1%	0.0%	0.4%
	May reduce genetic variation	Count	0	0	1	1	3	5
		% within Rejection	0.0%	0.0%	20.0%	20.0%	60.0%	
		% within Education Years	0.0%	0.0%	0.2%	0.3%	2.2%	
		% of Total	0.0%	0.0%	0.1%	0.1%	0.2%	0.4%
	Rots easily	Count	1	0	1	0	2	4

		% within Rejection	25.0%	0.0%	25.0%	0.0%	50.0%	
		% within Education Years	1.0%	0.0%	0.2%	0.0%	1.5%	
		% of Total	0.1%	0.0%	0.1%	0.0%	0.1%	0.3%
	Degrades soil/environment	Count	0	4	0	1	0	5
		% within $Rejection	0.0%	80.0%	0.0%	20.0%	0.0%	
		% within Education Years	0.0%	1.5%	0.0%	0.3%	0.0%	
		% of Total	0.0%	0.3%	0.0%	0.1%	0.0%	0.4%
	Shunned in markets	Count	2	0	3	2	2	9
		% within Rejection	22.2%	0.0%	33.3%	22.2%	22.2%	
		% within Education Years	2.0%	0.0%	0.5%	0.7%	1.5%	
		% of Total	0.1%	0.0%	0.2%	0.1%	0.1%	0.6%

Rejection*Farm Size							
			Farmers farm size				Total
			Not mentioned	<1 ha	1-2.5 ha	Above 2.5 ha	
	Expensive and time-consuming	Count	0	16	2	1	19
		% within Rejection	0.0%	84.2%	10.5%	5.3%	
		% within Farm size	0.0%	1.6%	1.1%	0.6%	
		% of Total	0.0%	1.1%	0.1%	0.1%	1.3%
	Fail to produce	Count	0	6	1	1	8
		% within Rejection	0.0%	75.0%	12.5%	12.5%	
		% within Farm size	0.0%	0.6%	0.5%	0.6%	
		% of Total	0.0%	0.4%	0.1%	0.1%	0.6%
	Tasteless	Count	2	11	2	5	20
		% within Rejection	10.0%	55.0%	10.0%	25.0%	
		% within Farm size	5.6%	1.1%	1.1%	2.9%	
		% of Total	0.1%	0.8%	0.1%	0.4%	1.4%
	Have chemicals harmful to body/cause disease	Count	1	7	1	3	12
		% within Rejection	8.3%	58.3%	8.3%	25.0%	
		% within Farm size	2.8%	0.7%	0.5%	1.8%	

		% of Total	0.1%	0.5%	0.1%	0.2%	0.8%
	Compete with indigenous species.	Count	0	3	1	1	5
		% within Rejection	0.0%	60.0%	20.0%	20.0%	
		% within Farm size	0.0%	0.3%	0.5%	0.6%	
		% of Total	0.0%	0.2%	0.1%	0.1%	0.4%
	May reduce genetic variation	Count	0	2	2	1	5
		% within Rejection	0.0%	40.0%	40.0%	20.0%	
		% within Farm size	0.0%	0.2%	1.1%	0.6%	
		% of Total	0.0%	0.1%	0.1%	0.1%	0.4%
	Rots easily	Count	0	3	0	1	4
		% within Rejection	0.0%	75.0%	0.0%	25.0%	
		% within Farm size	0.0%	0.3%	0.0%	0.6%	
		% of Total	0.0%	0.2%	0.0%	0.1%	0.3%
	Degrades soil/environment	Count	0	5	0	0	5
		% within Rejection	0.0%	100.0%	0.0%	0.0%	
		% within Farm size	0.0%	0.5%	0.0%	0.0%	
		% of Total	0.0%	0.4%	0.0%	0.0%	0.4%
	Shunned in markets	Count	1	7	0	1	9
		% within Rejection	11.1%	77.8%	0.0%	11.1%	
		% within Farm size	2.8%	0.7%	0.0%	0.6%	
		% of Total	0.1%	0.5%	0.0%	0.1%	0.6%

Discussion

Awareness and acceptance of GM technology and germplasm in Uganda

Findings of this study reveal that even though GM technology application has not yet been legalised in Uganda, the technology is well known to farmers, many of whom have perceived that the technology would be useful in tree and agricultural crop improvement, for better yields, early maturity, and disease resistance characteristics, among others. These findings are in line with those reported elsewhere on perceptions of the promoters of the GM technology who posit that the technology will play a critical role in securing food production and other production systems under climate change scenarios expected in the future (Mmbando, 2024; Bekele-Alemu et al., 2025). In Uganda, as shown in our results, the majority of the farmers say they know about GM, while very

few say they do not know about it. The contrast revealed, whereby the majority of farmers know about GM and also the majority say they would welcome the technology if promoted, may be due to the limited knowledge yet in Uganda on GM technology and GMOs, given that the country has not yet legalised the application of the technology and research, and hence knowledge production and dissemination on the same is still very limited.

Our findings on the level of knowledge on GM technology and GMOs, that show that more farmers know about the technology compared to those who do not know, and in part align with findings by Mustafa and others in 2023 that indicated the majority of people involved in their study had moderate to high understanding of GM crops (Mustafa et al., 2023). The finding, however, contradicts their report in the aspect where they indicate the majority of the respondents said they had not heard about the GM technology. This variation on their part could arise from the interpretation the respondents made of the questions they were asked, given that the same sample reported moderate to high knowledge/understanding of GM crops. Additionally, in the current study, data were based on a random sample of respondents from more regions of Uganda, beyond the west, central, and east that was the focus of Mustafa and his coauthors' study. The contradiction also raises the need for a more comprehensive and in-depth study on this issue of farmers' knowledge and acceptance of GM technology and GMOs in Uganda. Even though we relied on saturation point in sample size consideration under limitations of resource constraint, inclusion of more districts and more people from all the regions in Uganda may help generate more conclusive knowledge on this aspect. For the policy and regulatory framework for such scientific technology-based developments as GM technology is, this will be worthwhile.

In Uganda, as revealed in the findings of our study, farmers who want GM technology for germplasm development believe the application will enable realisation of better yields, early maturity and therefore quick income from the GMOs, other reasons being disease resistance. On the other hand, farmers who do not want the technology believe GMOs are expensive and time-consuming in management and production, tasteless, have chemicals that harm the body, and the products are shunned by the markets. The others believe GMOs fail to produce, reduce genetic variation, and may compete with indigenous species as well as degrade the environment. These findings provide additional evidence on reasons for GM rejection, reported before, for example, among consumers in countries in Africa and other continents (Lanre et al., 2022; Dolapo et al., 2025). The findings on reasons farmers give for acceptance and/or non-acceptance of GM

technologies and GMO/germplasm provide useful information to guide direction on policy and legal framework development and deployment in support of GM application in Uganda, for the benefit of farmers. Evidently, the results show farmers' high level of awareness/knowledge of the technology and readiness for its adoption even though the Uganda government has lagged in regard to making the necessary developments to cause its legalisation and promotion in the country. In Uganda, our findings show more farmers have knowledge of GM technology and GMOs compared to those who do not know about it. This finding contrasts the situation reported in the case of Nigeria, where the country has already put in place a policy and legal framework for adoption and promotion of the technology, but the majority of its farmers do not yet have knowledge of the GM technology (Obi-Egbedi et al., 2020).

Our findings that show Uganda farmers' readiness to adopt GMOs and perception of the technology's ability to improve crops for yields and other benefits in this study also align with findings of Kikulwe and Asindu in 2020 in Uganda, where they demonstrated farmers' willingness to buy genetically modified banana germplasm (Kikulwe and Asindu, 2020). Similarly, our findings pinpoint the direction that research on GM technology and GMOs in Uganda should take, once the policy and legal frameworks have been put in place. Farmers' needs for early maturing, disease-resistant, and high-yielding crops need to be met, with appropriate GM technology applications. These give directions to the government on where, how and when to act, with regard to completing pending policy and legal frameworks for GM technology in Uganda. On specifics for example, development of disease resistant crops as reasons for acceptance of GM technology and germplasm, our results revealed that more females than males gave this reason, by family size, this was mostly mentioned among respondents with small or very large family sizes, by people in the age group of 41-50 years old and those with secondary level of education and hard small farm sizes less than 1hectare. Getting quick income as a reason for acceptance of GM technology was mentioned predominantly among male respondents compared to females, among respondents with small and very large family sizes, mostly in the youthful age group of 18- 40-year-olds with secondary level education and small farm sizes. Better yields as a reason for GM acceptance was prominent among males compared to females, among respondents with small family sizes, in the youthful age groups, with secondary level education and small farm sizes. For early maturity of crops as reasons for acceptance of GM technology and germplasm, this was mentioned more among the females compared to men, among those with small family sizes, among the youth in

the age group 18- 30 years old, with secondary level education and small farm sizes. We can postulate from the findings of this study that early maturity and disease resistance are qualities of crops that women would desire in emerging technological applications in Agriculture. On the other hand, for men, our findings show that better yields and quick income generation take priority. These observed potential disparities in needs with regard to GM technology application also pinpoint the need not only for more study of needs for GM technology among the different population segments in a country, but also to streamline policies and regulatory frameworks in applications. Our findings also give evidence that the voices coming out on GM technology are mainly from young adults/youthful population with secondary level education and small farm sizes, while it remains unknown the perspectives and aspirations of the elderly, the young and the uneducated in communities. In consideration of the goals and aspirations of the Sustainable Development Goals of leaving no one behind, our findings provide evidence of the need for studies to elucidate the needs of this category, to ensure that their aspirations are not left out in technological developments.

More in terms of characterising the farmers involved in this study and their unique needs with regard to GM technology developments, our findings show that more than twenty different crops are found on farms. The most common crops were maize, Cassava, beans, Bananas, groundnuts, sweet potatoes and Millet. These are therefore candidate crops that farmers may want to improve for desired qualities such as disease resistance, higher yield, and early maturity, using the GM technology. Some of these crops were also included in the initial studies that were focusing on GM improvements for trials precursor to the GM approval in Uganda. Use of biotechnology for improvement of such crops has indeed been ongoing in Uganda for a longer period of time as reported elsewhere (Bigirwa, 2005; Mmbando, 2024). Similarly, the trees reported on farm in the study included 17 species, of which fruit trees, namely Mangoes, Avocado, Oranges, Pawpaw, jackfruit, Quavas, and coffee, were common. Commercial non-fruit trees, namely Pines and eucalyptus, were also fairly commonly mentioned. It is important to note that among the qualities desired of the GMOs were improved yields, early maturity, and quick income. Taking this for tree species, we can postulate that most of the crops and the trees on the farm are for meeting both food and income needs of the farmers. Thus, GM technologies that help farmers realise early maturity, improved yields, disease resistance, and other improvements on the trees and crops would cause more acceptance and adoption of the GM technologies and GM germplasm once Uganda legalises

the technology. We can give similar reasoning to the animals reported on farm in this study. Goats were the most common; other animals included Cows, Pigs, Sheep, Dogs, rabbits, and chickens.

In relation to rejection of GM technology and GMOs among the respondents in our study, our findings show that being expensive and time-consuming is perceived as a problem of the technology, prominently among males compared to females, among respondents from very large family sizes, youthful in age with secondary level education, and small farm sizes. Concern regarding the GMO seed failure to reproduce was equally acknowledged by both male and female respondents, those with very large family sizes, and by both youthful and middle-aged respondent groups with secondary level education and small farm sizes. Similarly, more males than females were concerned about GMOs being tasteless; this was also the concern among respondents from large family sizes, the youthful with secondary level education, and small farm sizes. Having chemicals that may be harmful to the body was a concern mainly among males compared to females, for respondents with large and very large family sizes, the youthful with secondary level education, and small farm sizes. Similarly, more males compared to females were concerned with GMOs' possible competition with indigenous species, so were respondents with very large family sizes, the youthful with secondary level education, and small farm sizes. The concern with possible GMOs' ability to reduce genetic variation in species was prominent among males compared to females, respondents with large family sizes, the youth and middle-aged groups with tertiary education levels, and small to medium-sized farms. On rotting easily was a concern with GMOs among males compared to females, respondents with large family sizes, the youthful, with tertiary level education, and small farm sizes. Degradation of the environment was a concern with GMOs among males compared to females, respondents with very large family sizes, the youthful, and those with primary level education and small farm sizes. Similarly, more males than females were concerned with GMOs being shunned in the markets, as were respondents with large family sizes, the youthful with secondary level education, and small-sized farms.

These results seemingly suggest that highly educated people care more about the consequences of GM technology and GMOs on species' genetic resources, while the less educated care about the consequences on the environment in general. Another interesting finding relating respondents' socioeconomic characteristics and their perspectives on GMOs here is the equal concern both men and women are on the GMOs' failure to reproduce. We can also postulate from the results of this study that, for people with large farm sizes of 2.5 hectares and above, the main concern with GMOs

is the potential effect on genetic resources of indigenous species. We can, from these findings, postulate relationships between acceptance and needs for particular characteristics in GMOs with diverse socioeconomic characteristics of farmers and/or consumers. These could include family sizes, sex, education level, farm sizes, and age, among others, as revealed in our study. Our findings provide evidence of specific concerns about GMOs in the context of citizens in Uganda. Evidence emerges from our study, for example, on how people would relate to GMOs if legalised in the country. More importantly, the information generated here will guide the development of GM technologies and GMO products relevant to the diverse sectors of the Ugandan population. We provide guidelines for consideration in policy and regulatory framework development, in a way that would prevent another collapse alluded to by activists (Lukanda, 2020) of the Biosafety Bill 2017, Uganda.

It is evident from our findings that studies that will generate information that helps dispel negative perceptions held on GM technology and GMOs in Uganda are still needed. Such studies need to provide answers to questions like: do GMOs cause a decline in genetic variation? Do they cause reproductive failures? Are they expensive and time-consuming to produce? Do they compete with indigenous species? Does the need for GM technology among farmers differ with their socioeconomic-environmental conditions such as gender, age, landholding size, family size, and education level? These are all research questions emerging from our study, and researchers can make the best use of them once GM technology and GMOs become legalised in Uganda.

Conclusions and Recommendations

Our findings provide evidence that the majority of farmers in the country know what GM technology and GMOs are and would adopt these for tree and crop germplasm improvements for better yields and quick income generation. Uganda thus needs to complete the pending policy and legal framework to enable application and research on GM technology and GMOs, especially focused on crop maturity time reduction and yield improvements. We recommend that the Parliament of Uganda enact enabling legislation and the executive assents to laws that will allow application of GM technology and adoption of GMOs in agricultural production. For the farmers who do not accept GM technology and GMOs, our findings show that they believe the technology is expensive and reduces genetic variation in indigenous species. They also believed that the GMOs compete with indigenous species, are tasteless, and are shunned in the market. This finding pinpoints the need for further studies on the impact of GMOs on indigenous species and cost-

benefit analyses of GM technology application on farm productivity and income generation. Such studies will help generate information that helps dispel negative perceptions held on GM technology and GMOs in Uganda. Such studies will help generate knowledge that will further guide lawmakers in legislation for appropriate policies, laws, and regulatory frameworks for GM applications and GMO promotion in Agriculture in Uganda.

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