Perception of agricultural biotechnology among farmers, journalists and scientists in Tanzania

Philbert S. Nyinondi
pnyinondi@yahoo.com

Frankwell W. Dulle
fwdulle@suanet.ac.tz

and

Julita Nawe
jnawe2015@yahoo.com

Abstract

This study sought to establish the perception of farmers, journalists and scientists of genetically-modified (GM) crops in Tanzania. Its specific objectives were to determine the perception of GM Crops among farmers, journalists and scientists in Tanzania, and to determine the factors that influence their perception. A cross-sectional survey was designed to generate both qualitative and quantitative data. The questionnaire, and focus group discussion and observation guides were deployed to collect requisite data from 265 respondents. This study found that Tanzania has infrastructure, researchers (inadequate but the number is growing), policies, legislations and guidelines for developing and deploying GM crops. The results further show that overall 70.5 percent of the sampled farmers, journalists and scientists had positive perception of GM crops whereas 23.8 percent had a neutral perception and 5.7 percent had a negative perception. Individual perceptions of GM crops in Tanzania is influenced by a combination of multiple factors, namely age, gender, educational level, marital status, religion, occupation and basic knowledge in science and technology. It is recommended that agricultural stakeholders should strive to have in place policies and legislations, which are supported by scientific evidence and which in turn support science advancement.

Key Words: Agricultural Innovation; Bio-safety; GM Crops; GM Technology; Tanzania

Introduction

High rates of malnutrition and escalating rates of dietary and nutrition-related diseases in developing countries are attributable to inadequate sources of vitamins, minerals and foods with high levels of anti-nutritional components and toxicants. In Tanzania, the population below minimum level of dietary energy consumption was estimated by the World Health Organisation (2005) at 32.1 percent. Malnutrition diminishes cognitive and productive potential, as undernourished population is more susceptible to infections and diseases. To address this largely global challenge, huge investments in advanced science innovations including Genetically Modified (GM) technology were made.

According to the United Nations Food and Agriculture Organisation (FAO) report of 2014 GM technology can impact on food and nutritional security in four different ways (FAO, 2014). First, GM technology can contribute to increased food production and productivity and, therefore, improve the availability of food at the household, national and global levels. Second, the technology can also improve the composition and nutritional quality of staple crops used for food and feeds. Third, GM technology can raise household income levels and, thus, improve access to sufficient, safe and nutritious food necessary for an active healthy life. Fourth, GM technology can improve the storage and shelf life of different food crops, hence contributing to the overall stability and resilience of the food systems.

It is anticipated that the world population will reach 8.5 billion in the next decade from the current 7.3 billion and will be 9.2 billion by 2050 (United Nations Department of Economic and Social Affairs [UNDESA], 2015). On the other hand, climate change limits water availability and introduces new pests and diseases (FAO, 2011). The United Nations Food and Agriculture Organisation - (FAO, 2014) reported that between 2012 and 2014 one-in-nine people globally suffered from chronic undernourishment and almost all the hungry people, 791 million, live in developing countries representing 13.5 percent, or one-in-eight, of the population of developing countries. To feed nine billion people in 2050 and to take care of about two billion people who are currently malnourished is one of the most unnerving challenges facing the mankind today (FAO, 2014).In Tanzania, malnutrition affects 42 percent of the under-five children (United Nations Children's Fund [UNICEF], 2014) and is cited as the country with highest rates of chronic malnutrition in the world and the rate has fallen by only two percent from 32.1 percent reported in 2005 (WHO, 2005). And Tanzania is challenged to feed more than 70 million people in the next decade (UNDESA, 2015). This implies that the application of advanced science innovations including GM technology is vital in meeting food challenges.

Problem Statement

GM technology can be used to develop GM crops that are resistant to diseases, pests and environmental conditions, with high profits and more desired nutritional value (FAO, 2008; Hellmich & Hellmich, 2012). Despite the documented benefits of GM crops elsewhere (Paarlberg, 2009; James, 2016), this technology has remained the subject of controversy for over three decades in Tanzania. Although studies on public understanding, perception and attitude to agricultural biotechnology have been intensively conducted in different parts of the world (Zhenhuan *et al.*, 2004; Poortinga & Pidgeon, 2007; Henry *et al.*, 2010; Kayabas & Mucan, 2011; Buah, 2011), only a few studies have been conducted in Tanzania (Lewis *et al.*, 2010; Ledermann, 2012). However, these studies had limitations, which included the use of rather small sample sizes, all targeting smallholder farmers. In addition, none of the studies conducted locally in Tanzania took into account the status of agricultural biotechnology in the country and factors determining individual perception of GM crops. This study, therefore, was aimed to contribute towards filling the knowledge gaps and provide a baseline for similar studies in future.

Objectives

The broad objective of the study was to establish the perception of farmers, journalists and scientists towards Genetically Modified (GM) Crops in Tanzania and specific objectives were to determine the perception of GM crops among farmers, journalists and scientists and to find out factors that influence their perceptions.

Research Questions

This research was guided by three key research questions: (a) How ready is Tanzania for GM Crops? (b) What is the perception of farmers, journalists and scientists of GM crops in Tanzania (c) What factors influence their perception of GM crops in Tanzania?

Literature Review

Global Status of Agricultural Biotechnology

The emerging global challenges such as drought, crop pests, diseases, viruses and food shortage have made biotechnology an essential part of the solution to addressing them. Biotechnology in this case, is any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify a product/process for practical purposes (UN Convention on Biological Diversity, 1992). Tanzania's scientists consistently mention cassava mosaic virus disease (CMD), cassava brown streak disease (CBSD), maize stalk borer, banana bacterial wilt, coconut lethal disease (LD) and tomato leaf miner as farming challenges that require the use of biotechnology.

Globally, the product of the latest agricultural biotechnology known as genetically-modified organism (GMO) has been in use for more than 20 years. Over two billon hectares of arable land were cumulatively planted with GM crops worldwide between 1996 and 2015 (James, 2016). According to James (2016), there is global increase in GM crops cultivation from 1.7 million hectares in 1996 to 179.7 million hectares in 2015. Twenty-eight countries, including 20 developing ones, have been applying GM technology. The GM crops that are available on the market, not in Tanzania, are mainly those improved to address agronomic challenges such as yield and tolerance to abiotic (pest and diseases) and biotic stresses (salinity, drought, and temperature extremes). Countries have different preferences when it comes to GM crops depending on the local farmers' challenges (See Table 1).

Table 1: Global GM Crops in 2015 by Country

Country	GM Crops
US	Maize, soybean, cotton, canola, sugar beet, alfalfa, papaya, squash
Brazil	Soybean, maize, cotton
Argentina	Soybean, maize, cotton
Canada	Canola, maize, soybean, sugar beet
China	Cotton, papaya, poplar, tomato, sweet pepper
Paraguay	Soybean, maize, cotton
South Africa	Maize, soybean, cotton
Uruguay	Soybean, maize
Bolivia	Soybean
Philippines	Maize
Australia	Cotton, canola
Mexico	Cotton, soybean
Colombia	Cotton, maize
Chile	Maize, soybean, canola
Costa Rica	Cotton, soybean
Bangladesh	Brinjal/Eggplant
India, Pakistan, Burkina Faso, Myanmar, Sudan (5 countries)	Cotton
Spain, Honduras, Portugal, Cuba, Czech Republic, Romania, Slovakia (8 countries)	Maize

Source: Information extracted from James (2016)

As Table 1 illustrates, only Sudan, Burkina Faso and South Africa apply GM technology for maize, cotton and soybean in Africa. Reports from success stories indicate that farmers using the GM technology managed to reduce the application of insecticides and increased their crop yields significantly (James, 2016).

The scenario in East African is unique. None of the countries in the region has commercialised GM crops. However, Kenya and Uganda are ahead of Tanzania, Rwanda and Burundi by having more research on GM crops. In Uganda, GM crops in the confined field trial are bananas, maize, cassava, cotton, sweet potatoes and rice. Kenya is the second in the region with five GM crops in the confined field trials. These are cotton, maize, sorghum, cassava and sweet potatoes (ISAAA, 2015). Tanzania lags behind Kenya and Uganda.

Perception towards GM Crops

There are many reported positive aspects of GM crops, the most cited being resistance to diseases, pests and environmental conditions; high profits and more desired nutritional value (Hellmich & Hellmich, 2012; Kayabaş & Mucan, 2011). Regardless of the benefits of GM crops, there are perceived concerns over possible side-effects on human health, farmers over-dependence on biotech seeds, genetic pollution, market problems, possibility of unleashing new virus or toxins into the environment and threats to the biodiversity of crops (Kayabaş & Mucan, 2011; Kruger *et al.,* 2011). Therefore, individual perception of GM crops depends on the attendant benefits and risks (Henry *et al*., 2010; Buah, 2011; Lucht, 2015).

Factors Influencing the Perception of GM crops

There is a growing body of work on public perceptions of GM Crops. A review of previous studies reveals that knowledge, trust, benefits, and socio-demographic variables are associated with consumer perceptions of biotechnology (Torres *et al.,* 2006; Kagai, 2011). In fact, socio-demographic characteristics have been reported in different parts of the world to influence the acceptance GM technology. Studies found that sex, age, occupation and education varyingly influence the acceptance of GM Crops (Henry *et al*., 2010; Buah, 2011). However, Hossain *et al.* (2002) found that the significance of socio-demographics was dependent on an individual's perceived applications. Policies and legislations have also been reported to enhance the public's perception of benefits or risks and their attitudes towards GM foods (Zhenhuan *et al.,* 2004).

Research Gap

Based on the literature reviewed, there is evidence in a few studies, which involved the broad spectrum of modern agricultural biotechnology key stakeholders to establish the perception and factors influencing them. Despite the ongoing debates on modern agricultural biotechnology and public investment in capacity-building on the use of this technology, the first published study on the perceptions of GM crops and foods in Tanzania was carried out by Lewis *et al.* (2010). The study revealed that farmers in Tanzania were interested in the potential application of GM technology to increase crop productivity for food security and enhanced household income. However, this qualitative study was limited in scope and involved only 20 smallholder cassava farmers.

Methodology

The study used both qualitative and quantitative approaches to collect data. A cross-sectional survey targeted three groups of agricultural stakeholders: Farmers (who are expected to adopt GM crops), journalists (who collect, write, or distribute news or other current information on GM crops, as facilitators of controversy debates) and agricultural scientists (who are searching for technological solutions in the agricultural industry). Participants (n=265) were drawn from Dodoma, Morogoro and Dar es Salaam regions of Tanzania using a combination of both probability and non-probability sampling techniques. The three regions were purposively chosen because of agricultural biotechnology expertise, infrastructure and knowledge systems.

Data were collected using questionnaires with both closed and open-ended questions. The criteria for participation were either being farmer, journalist, or scientist aged 16 and above. The questionnaire survey data was complemented by focus group discussions (FGDs) and discussion sessions involving experts. The inclusion criteria for FGDs were an individual's knowledge on genetic modification work for scientific and technological input, farming practices, socio-economic and technological challenges of farming. The first FGD (6 males and 2 females) was held at Mikocheni Agricultural Research Institute in Dar es Salaam, and the second FGD (3 Males and 3 Females) was held at Makutupora Agricultural Research Institute in Dodoma. In May 2016, discussion sessions for experts were held at the Sokoine University of Agriculture (SUA) in Morogoro, which brought together 40 scientists and research managers drawn from all agricultural research institutes operating in Tanzania.

Results and Discussion

Status of Agricultural Biotechnology in Tanzania

The experts' discussion session revealed that Tanzania is considering the application of GM in agriculture, industry, environment and health sectors. Yet, the pace of GM technology uptake is slow (Ndunguru, 2016). It was further established that Tanzania has the policy, laws, regulations and guidelines for applying GM technology in the agricultural sector. According to Zhenhuan*et al.* (2004), policies and legislations play a critical role in the development and deployment of GM crops in any particular country, and enhance the public's perception towards GM crops. There is evidence that countries which have in place policies and legislations that are tolerant of GM crops are the ones that are leading in the development of GM crops and their widespread adoption. South Africa presents a good example in Africa. It was able to plant its first GM crop in 1998 because of the enabling Biotechnology related Act of 1997 (Aerni, 2005).

Tanzania's national policy on biotechnology (2010) emphasises the technology's potentiality in enhancing the country's food security and trade position. The broad objective of the policy is to ensure that Tanzania has the capacity to capture the benefits arising from the application of biotechnology in health, agriculture, industry and environment while protecting and sustaining the safety of the community and environment. In addition, Tanzania's agriculture policy is one of sectoral policies which clearly stipulate the demand for the technology. The National Agriculture Policy (2013:13) stipulates on biotechnology:

> *Development and application of agricultural biotechnologies that address national priorities shall be promoted in line with the National Biotechnology Policy and Bio-safety Framework; New and emerging research areas that promise to mitigate low production and productivity in agriculture shall be promoted; these include the development of Genetically Modified Organisms; public awareness on biotechnology applications, benefits, risks and environmental implications shall be enhanced; and the Government shall protect in a sustainable way the productivity potential of crop germ-plasm and related biodiversity in the existing agro-ecosystem such that it is not endangered by the introduction of genetically engineered plants.*

In general terms, the policy presents agricultural biotechnology as one of the tools the country intends to use in an appropriate context to improve agricultural productivity.

Despite the supportive national biotechnology and agricultural policies, the development and deployment of GM crops from research to the end-users in Tanzania still require a sustained regulatory, legal and communications strategy. The current legal regime established by the National Environment Management Act (2004), the Environment Management (Biosafety) Regulations of 2009, as amended in February 2015 still maintain a strict liability clause for commercialisation of GM products. In fact, the clause hinders the eventual deployment of GM technology and products. Additionally, the Environment Management (Biosafety) Regulations of 2009, provision 73 section (1) reads: "an application for field trials or release of GMO shall not be permitted or licensed under these regulations unless environment impact assessment under these regulations has been carried out in accordance with the Act and the Environmental Impact Assessment and Audit Regulations (2005, p..30).

Agricultural researchers during the discussion sessions of experts lamented that the environment impact assessment increases unnecessary costs for research operations in addition to delaying research undertakings such as confined field trials. The argument is supported by the late planting of the first GM maize confined field trial. The first intent to plant GM maize in the confined field was submitted in 2009, but the technology developer and project grantor withdrew their support due to prohibitive regulations. Thus, it took seven years for stakeholders to reach a consensus, which paved the way for February 2015 amendment of Environment Management (Biosafety) Regulations of 2009. Consequently, the first ever confined GM trial was planted in October 2016.

The endless public debate on biosafety legal regime in Tanzania has evidently affected research on GM crops. Presently, the GM crops researched in the country are cassava and maize presented in Table 2:

Table 2: GM Crop Research Project in Tanzania by February 2017

	GM Crop	Trait	Institutions	Stage of Development
1	Cassava	Development of varieties tolerant to Cassava Mosaic Disease (CMD) and Cassava Brown Streak Disease (CBSD)	Mikocheni Agricultural Research Institute, Ministry of Agriculture	Contained research (Genetic transformation activities in the Biosafety level II laboratory)
2	Maize	Drought tolerant	Commission of Science and Technology (COSTECH) Directorate of Research and Development, Ministry of Agriculture.	Confined Field Trial (CFT), Planted for the first season on 5th October 2016. CFT is located in Makutupora, Dodoma
3	Maize	Insect/pests Resistant	Commission of Science and Technology (COSTECH) Directorate of Research and Development, Ministry of Agriculture	Application for Confined Field trial permission to be submitted in March 2017.

Source: Field Data (2017)

The discussion sessions with Tanzania’s agricultural scientists/researchers in May 2016 revealed that the country has the policies, regulations, skills and facilities to develop and deploy GM products. The current GM crop research attests to the country’s readiness to venture into the GM crop industry.

Perception of Farmers, Journalists and Scientists of GM Crops in Tanzania

Despite the existing policies, legislations and enthusiasm of GM crops among some Tanzanians, the debate is not over. A section of the public is still pressing the government to stop research on all agricultural GM production activities in the country (Mkali, 2017). Thus, it is important to ask what Tanzanians think about GM crops.

The participants in this study were farmers, journalists and scientists. The majority of the farmers (N=175) who accepted to participate in this study were male (68%). Few farmers had post-secondary education (2.2%); the majority had attended primary education (80%), followed by those with secondary education (10.9%) and informal education (6.9%). The majority of the farmers were married (87.1%) and aged between 35 and 55 (62. 3%). Others were aged above 55 (17.1%) and those belonging to the age group of 16-35 constituted 20.6 percent. Farmers were also asked to self-rank their basic knowledge on science and technology. The majority indicated to have poor BKST (46.3) followed those who indicated to have adequate BKST (45.1), good BSK (4.6%) and not sure (4.0%). The majority of the journalists (N=24) had post-secondary education (45.8%) and first degree (54.2%), all falling in two age groups of 16-35 (62.5%) and 36-55 (37.5%). Only 4.2 percent of the journalists indicated to have poor BKST and rest indicated their BKST to be adequate (50%) and good (45.8%). The percentage of married journalists was the same as single journalists 47.8 percent, and only 4.3 percent were widows. Scientists who participated in this study (N=66) had a bachelor's degree (56.1%) and postgraduate education (43.9%). Young scientists aged 16-35 were in the majority (43.9%), followed by those in the age group of 36-55 (39.4%) and the least were those in the group aged above 55 years (16.7%). Although 86.4 percent of the scientists were male, 75.8 percent of the respondents were married and 22.7 percent single.

To establish the perception of farmers, journalists and scientists of GM crops, the respondents were asked whether they consider GM crops to be beneficial or harmful. Individuals, who were not sure, were considered to be neutral. To cross check the answers, the respondents were also asked to indicate whether they accept or reject the proposal to introduce GM crops in Tanzania. Considering the two factors, the respondents were further asked to state their standpoint on GM crops. The results in Table 3 show that overall 70.5 percent of the total sample had a positive perception of GM crops, whereas 23.8 percent had a neutral perception and the least 5.7 percent had a negative perception. The study found that, among scientists, 10.6 percent had a negative perception of GM crops and 15.2 percent had a neutral perception. The majority of the journalists (91.7 %) indicated being positive to

GM crops in comparison to 74.2 percent of scientists and 66.3 percent of the farmers who had positive perception of GM crops. None of the journalists had a negative perception as the remaining minority (8.3%) had a neutral perception towards GM crops. It was noted that 29.1 percent of the farmers had a neutral perception of GM crops. The results signify that 70.5 percent of the population studied consider GM crops beneficial and accept the idea of introducing the crops in the country. The finding is close to Lucht's (2015) inference that 75 percent of Europeans (N=167) agreed and/or strongly agreed that GM technology has positive effect in crop production. In Africa, Henry *et al.* (2010) reported that 58 percent of Kenyans had positive perception of GM crops whereas Buah (2011) reported that over 80 percent of Ghanaians rejected GM crops and foods.

Table 3: Farmers', Journalists' and Scientists' Perception of GM Crops

Occupation	**Perception towards GM Crops**							
	Positive		Negative		Neutral		Total	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
Farmers	116	66.3%	8	4.6%	51	29.1%	167	100%
Journalists	22	91.7%	0	0.0%	2	8.3%	13	100%
Scientists	49	74.2%	7	10.6%	10	15.2%	85	100%
Total	187	70.5%	15	5.7%	63	23.8%	265	100%

A further analysis to find out the influence of occupation on the perception of GM crops was computed using Cramer's V test. The result reveals a weak positive association between occupation and perceptions of GM crops (Cramer's V = 0.158). The statistics suggest that there is divergence in perception of GM crops among farmers, journalists and scientists, but such divergences are small and insignificant ($p = 0.012$, which is > 0.005) as Table 4 illustrates.

Factors Influencing the Perception of GM Crops in Tanzania

Studies conducted elsewhere (Henry *et al.,* 2010; Buah, 2011) established factors that influence an individual's perceptions of GM technology include gender, marital status, religion, occupation, age, education and basic knowledge on science and technology (BKST). In this study, to establish the relationship between independent and dependent variables, gender, marital status, religion and occupation were treated as independent variables measured in nominal scale, while the perception of GM crops was treated as a dependent variable, denoted as positive, negative and neutral which was measurable on an ordinal scale. Cramer's Vtest as recommended by Lund and Lund (2013), was used to determine the strength of the association. The measurement values of Cramer's V test range from 0 to 1. The 0 value is the indicator for no association and 1 for perfect positive association.

Results in Table 4 show weak positive associations between gender, marital status, religion and perception of GM crops. Neither gender, marital status nor religion could singly be used to predict with certainty the perception toward GM crops. The findings support Barker and Burnham's (2001) inference that the perception of GM products is influenced by a combination of multiple factors including preferences and events. The relationship between gender and perception of GM crops has been discussed in a number of previous studies (Henry *et al.,* 2010; Buah, 2011). This study supports their findings that males (72.1%) are more receptive to GM crops than female (66.7%). Although the relationship between individual gender and their perception of GM crops is weak and insignificant, it is worth noting that developing communication strategies for GM crops programmes requires taking this relationship on board.

Table 4: Association between Gender, Marital Status, Religion, Occupation and Perception of GM Crops in Tanzania

Variables		**Perception of GM Crops**				Cramer's V	Sig. (*p*)
		Positive	Negative	Neutral	Total		
Gender	Count	187	15	63	265	0.089	0.351
	% within	70.5%	5.7%	23.8%	100.0%		
Marital Status	Count	183	15	61	259	0.085	0.878
	% within	70.7%	5.8%	23.6%	100%		
Religion	Count	184	15	61	260	0.077	0.793
	% within	70.8%	5.8%	23.5%	100%		
Occupation	Count	187	15	63	265	0.156	0.01
	% within	70.5%	5.7%	23.8%	100%		

The association between age, education level and BKST and the perception of GM Crops in the study population was measured using Kruskal's gamma and Somers' delta/Somers'*d*. Kruskal's gamma (γ) and Somers'*d* are non-parametric measures of the strength and direction of association that exists between two variables on an ordinal scale. Somers'*d* in addition distinguishes the ordinal dependent variable from the ordinal independent variable (Lund & Lund, 2013). Both Kruskal's gamma (γ) and Somers'*d* values range between -1 and +1, and a value of 0 indicates a complete absence of an association, as +1 shows a perfect increasing relationship and -1 a perfect decreasing relationship.

The results in Table 5 show a weak negative association between age and perception towards GM Crops (γ = - 0.038 which is < -1). Somers'*d* confirmed the negative weak association indicating that the probability of using age to predict ones perception towards GM crops is 1.7%, which is statistically insignificant. The findings support observations made by Henry *et al.* (2010) that elderly people are less receptive to GM crops than the young ones. The findings further suggest that young people's positivity towards GM crops cannot be easily distinguished from the general population, because after critical analysis of the respondents with a negative perception of GM crops (N=15), 26.7 percent were young people aged 16-35 (N=80), 60 percent were in the middle aged group 36-55 (N=144) and 13.3 percent were elderly people aged above 55 years. As the percentile of elderly people who consider GM crops to have positive effects is higher than the younger ones, the majority of people who consider GM crops to have negative effects are aged above 36 years. Therefore, the majority of the people aged below 36 years had either positive or neutral perceptions of GM Crops, while people above 36 years had perceived GM crops either positively or negatively.

Table 5: Associations among Age, Education, BKST and Perception toward GM Crops in Tanzania

		Perception towards GM Crops			Total	Gamma (γ)	Somers'*d*	Sig. (*p*)
		Positive	Negative	Neutral				
Age	Count	187	15	63	265	-0.062	-0.028	0.581
	% within	70.5%	5.7%	23.8%	100%			
Education Level	Count	187	15	63	265	-0.367	-0.157	0.000
	% within	70.5%	5.7%	23.8%	100%			
BKST	Count	187	15	63	265	0.445	0.212	0.000
	% within	70.6%	5.7%	23.8%	100%			

The descriptive analysis on influence of education level on the individuals' perception of GM showed that, as education level increases, negativity towards GM Crops increases, because respondents who had informal education had either positive or neutral perception of GM crops. Five percent (N=140) of the respondents with primary education, 5.3 percent (N=19) of the respondents with secondary education, 5.8 percent (N=52) of respondents with a bachelor's degree and 13.8 percent (N=29) of the respondents with postgraduate education had perceived GM crops negatively. The trend infers that an increase in an individual's education level leads to a negative perception of GM crops. In contrast, Henry *et al.* (2010) and Buah (2011) reported the opposite findings. Hence, Somers'*d* was used to determine the strength and direction of the association. The findings in Table 5 show that there was weak negative correlation between education level and perception of GM Crops, which was statistically significant ($d = -0.157, p < 0.005$, N=265). The results using Kruskal's gamma also showed weak negative association (γ = - 0.355 which is < -1), and, thus, supporting the inference above.

According to Buah (2011), the individuals' knowledge level is the determinant factor for either accepting or rejecting GM foods. In this study, the self-rated individuals' knowledge on basic science and technology (BKST) was used to determine the association with GM crops. Results presented in Table 5 reveal a moderate positive association between BKST and perception of GM crops (γ = 0.445 which is < 1). Somers' *d* signifies that individuals BKST could be used to predict his/her perceptions of GM Crops with 21.2 percent chances of certainty (d= 0.212), which was statistically significant (p< 0.005). The results also suggest the individual's BKST can be independent of his education level.

Conclusion

This study concludes that Tanzania has been slow in adopting GM technology but it appears poised to embrace and use it. The majority (94.3%) of the population studied indicated to be either positive (70.5%) or neutral (23.8%). This study has also determined that there is no single factor, which influences an individual's perceptions of GM crops. The delay in adopting the technology could be attributed to the slow pace of having supportive policies, legislations and regulations for the development and deployment of GM crops. Indeed, it took seven years for stakeholders to reach consensus, which paved the way for the 2015 amendment of the Environment Management (Biosafety) Regulations of 2009, and subsequent first confined field GM trial in October 2016.

Recommendations

For Tanzania to feed more than 70 million people in the next decade and reduce the rates of chronic malnutrition, the need to adopt and apply advanced science innovations including GM technology is apparent. Therefore, it is recommended that the country reviews policies and legislations to cope with science advancement.

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Declaration

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