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AWARENESS OF AFLATOXIN AND WILLINGNESS TO PAY FOR AFLASAFE TECHNOLOGY AMONG MAIZE FARMERS IN CIBITOKE, MAKAMBA AND BUJUMBURA PROVINCES IN BURUNDI

[1*]Divine NDUWIMANA, [2]Dr. Gabriel MWENJERI, [3]Dr. Eric BETT & [4]Dr. Joseph ATEHNKENG

[1]Student, Department of Agricultural Economics, Kenyatta University

[2&3]Lecturer, Department of Agricultural Economics, Kenyatta University

[4]Plant Pathologist, IITA

Author's Corresponding Email: nduwidiv2016@gmail.com

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ABSTRACT

Purpose of the Study: This study aimed to assess the awareness of aflatoxin among maize farmers in Burundi and their willingness to pay for Aflasafe technology, with a focus on the provinces of Bujumbura, Cibitoke, and Makamba.

Methodology: The study combined qualitative and quantitative techniques. Data collection involved households selected with the assistance of local administration, targeting male and married farmers with primary education and incomes below 100,000 Burundian Francs. Econometric software was utilized to analyze the data, and the contingent valuation method (CVM) was employed to capture farmers' willingness to pay.

Findings: The study found that most maize farmers in the designated provinces married, and primarily educated, with incomes under 100,000 Burundian Francs. Many belong to organizations, are middle-aged, and support households of six. Despite limited knowledge of aflatoxin, there is a notable willingness to invest in Aflasafe technology.

Conclusion: The study concludes that there is a notable lack of awareness among maize farmers in Burundi regarding aflatoxin contamination and its associated risks.

Recommendation: The study recommends that the government develop and implement awareness programs to educate maize farmers about aflatoxin and promote the adoption of Aflasafe technology.

Keywords: *Social-economic characteristics, awareness on aflatoxin, Willingness to Pay, Aflasafe technology*.

INTRODUCTION

The production of maize (Zea mays), commonly known as corn, is crucial to Burundi's agricultural sector and food security system. Maize stands out as a primary cereal crop with its significant contribution to both commercial and subsistence farming. It provides essential nutrients and a crucial source of carbohydrates, serving as a fundamental part of the diet for the majority of Burundians. After cassava, bananas, sweet potatoes, beans, and potatoes, maize production in the country produced a harvest of more than 260,000 tons in 2020, placing it as the sixth most important crop (FAO, 2022). According to Nsabiyumva et al. (2023), small-scale farmers in Burundi grow maize mostly for home consumption on an average of 0.5 hectares of land per farm.

The prevalence of aflatoxin contamination, which impacts crop output and food safety, remains a persistent challenge in maize production. This pollution not only jeopardizes consumer health due to stringent international quality standards but also restricts market access (Ayeni et al., 2020). Aflatoxins are associated with various acute and long-term health issues, including liver damage, weakened immune systems, and an elevated risk of cancer (Sansi, 2018). Among vulnerable populations, such as children and the elderly, these health risks are particularly pronounced (Wang et al., 2018). Gong et al. (2016) also highlight the adverse effects of aflatoxin contamination on child growth and development, leading to long-term health implications and societal challenges. Additionally, crops contaminated with aflatoxins often experience diminished marketability, leading to lower prices and the cost of disposing of tainted produce (Guchi, 2015). Furthermore, export restrictions are commonly imposed on contaminated agricultural goods, limiting opportunities for international trade and impacting the overall economy (Ajmal et al., 2022).

Furthermore, maize agriculture is vulnerable to climate change and fluctuating weather patterns because of how heavily the country depends on rainfall for its agriculture. Crop productivity maybe impacted by changes in rainfall patterns and extended dry spells (FAO, 2016).

Initiating measures to increase maize output is therefore a responsibility of the Burundian government. These initiatives include the adoption of disease-resistant maize cultivars and the promotion of better agricultural practices (World Bank, 2017). The sensitivity of disease-resistant maize varieties to fungi is decreased, which lowers the possibility of aflatoxin development during growth and storage (Donald et al., 2005). The necessity for continued monitoring and enforcement of mitigating measures, as well as limited farmer knowledge and resource availability, continue to be problems despite these efforts (Meijer et al., 2021). Enhancing post-harvest procedures is another essential option. This include using the right dry, storing, and transportation techniques to avoid moisture buildup, which can be a favor environment for the production of aflatoxin (Niyongabo et al., 2023). Programs for farmer education are essential for spreading information about these practices (Johnson et al., 2015)). Aflasafe technology, a bio control technique created to reduce aflatoxin contamination in maize, is yet one viable solution (Migwi et al., 2020). In order to reduce contamination levels Aflasafe introduces non-toxic strains of Aspergillus flavus into the soil (Senghor et al., 2020). These strains compete with and inhibit the dangerous strains that produce aflatoxin (Atehnkeng et al., 2022).

In light of these challenges and potential solutions, it is evident that addressing aflatoxin contamination in maize production in Burundi necessitates a concerted effort from both the government and agricultural stakeholders. Enhancing post-harvest procedures and educating farmers on proper storage and transportation techniques are essential steps in reducing aflatoxin contamination. The biocontrol technique Aflasafe offers a promising solution. By implementing these strategies and supporting research and education, Burundi can improve maize production, ensure food safety, and enhance its food security system, ultimately benefiting the health and well-being of its population and contributing to its economic growth.

PROBLEM STATEMENT

Aflatoxin contamination, a recurring issue in the global agricultural landscape, imposes significant threats to both public health and agricultural sustainability. It is a concern that affects various staple crops, with maize being particularly vulnerable. In Burundi, where maize holds a pivotal role in food security and the economy, the challenge of aflatoxin contamination is especially pertinent. Contaminated maize, when consumed, elevates the risk of aflatoxin-related diseases, with liver cancer being a primary concern. Additionally, the presence of aflatoxin-contaminated maize in local markets results in the rejection of crops in both domestic and international trade, compounding economic hardships for farmers.

In the context of aflatoxin contamination in Burundi, one of the central issues is the low awareness among maize farmers regarding the presence of aflatoxins, the associated health risks for consumers, and the adoption of best agricultural practices to reduce contamination levels. This lack of awareness perpetuates the cycle of contamination from field to market, posing a silent but severe threat. Despite promising innovations like Aflasafe technology that have the potential to significantly reduce aflatoxin contamination, its adoption among maize farmers in Burundi remains limited. This limited adoption rate exacerbates the contamination problem, as the full benefits of these innovative solutions are yet to be realized. Achieving a sustainable reduction in aflatoxin contamination necessitates a multifaceted approach, including addressing knowledge gaps, promoting the adoption of mitigation strategies like Aflasafe, and fostering collaboration among stakeholders. These efforts are integral components of sustainable aflatoxin control.

RESEARCH OBJECTIVES

i. To establish social and economic characteristics of maize farmers in Burundi.

ii. To assess maize farmers' awareness on aflatoxin.

iii. To determine the farmers' WTP for Aflasafe technology in controlling Aflatoxin.

EMPIRICAL LITERATURE REVIEW

Aflatoxin contamination in crops

Aflatoxin are fungi that infect several crops, such as maize and groundnuts. The predominant fungi in agriculture is the Aspergillus flavus, which is the most fascinating and has an effect on both crops and livestock (Caceres et al., 2020). Aspergillus, flavus, and toxin are three words that make the name "aflatoxin"; the "a" comes from the Aspergillus genus, "fla" from the Flavus species, and toxin from the last two (Yu et al., 2004). There are 33 different species of aflatoxins, of which 18 are considered to be aflatoxigenic and 16 are considered to be the most interesting in terms of public health and the economy due to their prevalence and toxicities (Shephard et al., 2008). According to Tao et al. (2018), the 18 species generate the four main aflatoxins: aflatoxin B1, aflatoxin B2, aflatoxin G1, and aflatoxin G2.

The growth of aflatoxin is encouraged by many factors including abiotic factors including temperature, water activity, pH, carbon and nitrogen. Aflatoxin contamination is mainly caused by high T^0 between 29^0 C and 30^0 C and water activity of $0.99a_w$ approximately.

The required temperature that not allows the growth of the fungi is below 25^0 C and above 37^0 C (Egal et al., 2008). According to Shabeer et al. (2022) there are two distinct phases of aflatoxin contamination, the first of which involves infection of the crop as it is growing and the second of which involves contamination levels rising as the crop matures. Significant infections develop during the first stage of contamination as a result of wounds caused by birds, mammals, insects, mechanical trauma (such as hail), or stress from hot, dry conditions on the developing crop (Cotty & Jaime-Garcia, 2008). During the second phase of contamination, toxin levels rise in both components that were infected during the first phase and those that were infected after maturation (Cotty et al., 2007). The second phase happens when crops are exposed to warm, moist conditions, whether in the field, during handling, or storage (Shabeer et al., 2022).

The high price of aflatoxin: Health and economic considerations

In 1980, the National Toxicology Program (NTP) classified aflatoxin as one of the most potent carcinogens harmful to humans, accentuating the gravity of this mycotoxin's menace to public health. Exposure to aflatoxin can transpire via various routes, encompassing the consumption of tainted foods, inhalation, and even contact with materials harboring aflatoxins, posing a considerable peril to both humans and animals, culminating in a spectrum of health adversities broadly referred to as "aflatoxicosis" (William et al., 2004).

Prolonged exposure to aflatoxins, primarily through habitual consumption of contaminated edibles, instigates a constellation of health issues. This sustained exposure can result in inhibited growth in children, compromised immunity, acute hepatitis, Reye's syndrome, and even kwashiorkor, a severe form of malnutrition (Atehnkeng et al., 2015). Aflatoxin's potency becomes glaringly evident in cases of immediate exposure, which can precipitate dire consequences. Immediate aflatoxin exposure has been definitively linked to liver cancer, one of the deadliest forms of malignancy globally. Furthermore, in the most severe instances, it can lead to fatalities (Cotty et al., 2015). The gravity of this issue is exemplified by research such as that conducted by Atehnkeng et al. (2015), which underscores the life-threatening outcomes of immediate aflatoxicosis. Expectant mothers are not exempt from aflatoxin's reach. Research by Gong et al. (2002) reveals that aflatoxin exposure during pregnancy can detrimentally affect both the developing fetus during gestation and the child through breastfeeding, potentially giving rise to a cascade of health issues that persist well beyond infancy.

Aflatoxin management with Aflasafe technology

Aflasafe is a bio control method found by the IITA in 2012 as one of the most efficient method likely to reduce aflatoxin contamination. It comprises granules applied to crops at specific growth stages. These granules contain spores of non-toxic Aspergillus strains that outcompete and displace the aflatoxin-producing strains naturally present in the environment (Atehnkeng et al., 2008). When Aflasafe is introduced into fields, the non-toxic strains within it colonize the crops, effectively reducing the likelihood of toxigenic Aspergillus species establishing and producing aflatoxins.

Aflasafe technology has undergone rigorous testing and has consistently demonstrated its efficacy in mitigating aflatoxin contamination in various crops, including maize, groundnuts, and sorghum. Numerous studies have confirmed its effectiveness under both controlled laboratory and real-world field conditions. For instance, in Nigeria, a study led by Bandyopadhyay et al. (2019) reported a substantial reduction in aflatoxin contamination levels in maize and groundnuts following the application of Aflasafe. This intervention achieved an impressive reduction of over 80%, ensuring that the crops met international safety standards. In West and Central Africa, maize genotypes that resist to aflatoxin have been identified by Brown et al. in 2001 and been used in breed programs. Kenya's experience with Aflasafe technology has also been remarkable. According to a report by the International Institute of Tropical Agriculture (IITA), the implementation of Aflasafe has lowered aflatoxin contamination in maize from an average of 20 parts per billion (ppb) to less than 10 ppb, bringing maize well within the acceptable safety thresholds for human consumption.

Review of Willingness to pay elicitation methods

The WTP (or what someone is willing to pay) is the most money a person is ready to spend on a certain amount of a product (Voelckner, 2006). When applied to the adoption of technologies like Aflasafe, WTP studies play a pivotal role in assessing the potential market for such innovations and informing policy decisions. This section reviews various WTP elicitation methods employed in research, shedding light on their strengths, limitations, and relevance in the context of Aflasafe technology adoption.

In Breider's work from 2006, a classification of methods for estimating Willingness to Pay (WTP) is introduced, based on their data collection techniques. These methods fall into two categories, depending on whether they employ survey methodologies, including both direct and indirect approaches, and whether they are rooted in actual price-response data. When assessing WTP, two primary methods come into play: the stated preference method and the revealed preference method. The stated preference method encompasses individual surveys wherein respondents are questioned about their willingness to pay for specific products, services, or environmental attributes (Soto et al., 2006). In contrast, the revealed preference method draws upon data obtained from real-world experiments and market observations (Hensher et al., 2010). In addition, these methodologies do not rely on direct survey responses or hypothetical scenarios but, instead, scrutinize actual consumer choices. However, the limitation of Revealed Preferences is that it can only work with observable actions, so it may not work well for figuring out preferences when there's no variety in the choices or when we can't see the attribute in question (Beshears et al., 2008).

RESEARCH METHODOLOGY

This study was carried out in three provinces of Burundi: Bujumbura, Cibitoke, and Makamba, regions where maize cultivation plays a vital role in the agricultural landscape. To gain comprehensive insights, a mixed-methods approach was employed, combining qualitative and quantitative research techniques. Data was gathered from households chosen with the assistance of the local administration. Econometric software was used to analyze data collected on farmers' awareness and farmers' WTP. The contingent evaluation method (CVM) was used to capture farmers' WTP.

RESULTS AND DISCUSSION

The study findings are discussed per section and in accordance with the objectives.

Maize farmers' characteristics

Table 1 presents maize farmers' characteristics.

Table 1: Maize farmers' characteristics

Variable	Level	Frequency (n)	Percent (%)
Gender	Male	146	51.6
	Female	137	48.4
	Total	283	100
Marital status	Single	32	11.3
	Married	251	88.7
	Total	283	100
Education level	None	28	9.9
	Informal	48	17
	Primary	141	49.8
	Secondary	58	20.5
	University	8	2.8
	Total	283	100
Income	<100.000	123	43.5
	100.000-500.000	109	38.5
	500.000-1.000.000	20	7.1
	1.000.000<	31	11
	Total	283	100
Member of an organization	Yes	148	52.3
	No	135	47.7
	Total	283	100
		Mean	Std deviation
	Age	42.4	13.4
	Household size	6.9	2.9
	Farming experience (years)	20.9	12.9
	Farm size(ha)	5.30	2.995

Results reveal that 51.6% of farmers were male while 48.4% were female. On marital status, 88.7% of farmers were married while 11.3% were single. In terms of education, 49.8% of farmers had attained primary level education, 20.5% secondary, 17% informal, 9.9% none, and 2.8% university. Further, 43.5% of farmers earned <100.000, 38.5% 100,000-500.000, 11% 1.000.000<, and 7.1% 500.000-1.000.000. In addition, 52.3% of farmers were members of an organization while 47.7% were not members.

The average age for most farmers was 42 years (M=42.4), and average household size was 6 members (M=6.9). Moreover, average farming experience for most farmers was 20 years (M=20.9), and average farm size was 5 ha (M=5.30).

Awareness of aflatoxin

Results on farmers' awareness of Aflatoxin are presented in Table 2.

Table 2: Awareness of Aflatoxin

	Frequency (n)	Percent (%)
Yes	82	29
No	201	71
Total	283	100

The findings reveal that 71% of farmers had heard about aflatoxin compared to 29% who reported to have no prior knowledge about aflatoxin.

Table 3: Farmers Awareness about aflatoxin effects on maize

	yes		**No**		**Don't know**	
	n	**%**	**n**	**%**	**N**	**%**
Can crops be contaminated with aflatoxin in the field and during storage	95	33.6 %	58	20.5 %	130	45.9 %
Poor harvesting	149	52.8 %	40	14.2 %	93	33.0 %
Handling	116	41.1 %	25	8.9%	141	50.0 %
Insects/Mold	154	54.4 %	45	15.9 %	84	29.7 %
Do food containing aflatoxin have adverse effects on human health	97	34.3 %	39	13.8 %	147	51.9 %
Are crops contaminated by aflatoxin hard to sell	208	73.8 %	51	18.1 %	23	8.2%

The findings in Table 3 shows that 45.9% of farmers did not know whether crops can be contaminated with aflatoxin in the field and during storage, 33.6% said yes while 20.5% noted no. Majority (52.8%) of farmers noted that poor harvesting results to aflatoxin contamination. Further, 50% of farmers observed that they did not know whether handling led to aflatoxin contamination. In addition, 54.4% of farmers noted that insects/mold results to aflatoxin contamination. Moreover, 51.9% of farmers did not know whether food containing aflatoxin have adverse effects on human health. Finally, 73.8% of farmers noted that crops contaminated by aflatoxin was hard to sell.

Table 4: Association between provinces and awareness about aflatoxin

		Awareness about aflatoxin		**Total**	**Chi square (p value)**
		Yes	**No**		
Provinces	Bujumbura	22	69	91	4.098 (0.129>0.05)
	Cibitoke	24	69	93	
	Makamba	36	63	99	
Total		82	201	283	

The findings in Table 4 shows that the association between provinces and awareness about aflatoxin was statistically insignificant. This is indicated by chi square of 4.098 and p value of 0.129>0.05. This suggests that type of province did not significantly determine farmers awareness about aflatoxin.

Elicitation of Maximum WTP

The farmers were asked their willingness to pay for Aflasafe and results are shown in Table 4.

Table 5: Willingness to pay for Aflasafe

	Frequency (n)	Percent (%)
Yes	273	96.5
No	10	3.5
Total	**283**	**100**

The findings showed that 96.5% of farmers were willing to pay for Aflasafe, while 3.5% were not willing to pay.

Table 6: WTP for bid prices

	Initial Bid price=3000 BIF (IBP)	IBP+500= 3500 BIF (IBP1)	IBP1+500=4 000 BIF (IBP2)	IBP-500= 2500 BIF (IBP3)	IBP3-500=2000 BIF (IBP4)
Yes (%)	254 (89.8%)	221(78.1%)	190(67.1%)	2(0.7%)	10(3.5%)
No (%)	28(9.9%)	33(11.7%)	27(9.5%)	24(8.5%)	14(4.9%)

Results in Table 6 reveal that 89.8% of farmers were willing to pay 3000 BIF, 78.1% were willing to pay 3500 BIF, 67.1% were willing to pay 4000 BIF, 3.5% were willing to pay 2000 BIF, and 0.7% were willing to pay 2500 BIF.

Table 7: Maximum WTP

Maximum WTP	Frequency (N)	Percent (%)
2000	10	3.8
2500	2	0.8
3000	33	12.4
3500	33	12.4
4000	188	70.7
Total	266	100

Results in Table 7 indicate that majority (70.7%) of respondents were willing to pay maximum 4000 BIF, 12.4% WTP maximum 3000 and 3500 BIF respectively, 3.8% WTP maximum 2000 BIF, while 0.8% WTP maximum 2500 BIF.

CONCLUSION

The study concludes that the majority of maize farmers in Burundi were male and married. A large number of farmers had attained primary level education and earned less than 100,000. The majority of farmers were members of an organization. Additionally, the study concludes that the majority of farmers were middle-aged with an average household size of six members. The farming experience for most farmers was 20 years, and the farm size was 5.3 hectares. Furthermore, the study concludes that most farmers were not aware of aflatoxin but were willing to pay for the Aflasafe technology, with farmers expressing a maximum willingness to pay (WTP) of 3727.4 BIF per kilogram of Aflasafe.

RECOMMENDATIONS

The study recommends that the government takes proactive measures by developing and implementing comprehensive programs aimed at raising awareness among maize farmers regarding aflatoxin contamination and the utilization of Aflasafe technology. These initiatives are essential for fostering improved maize production within the country while simultaneously safeguarding the health and well-being of consumers. Additionally, it is suggested that policy makers and marketers collaborate to establish an optimal pricing structure that effectively balances the needs of both producers and consumers. By determining the best price points, stakeholders can enhance the commercialization of maize products, ensuring fair compensation for farmers and stimulating market demand. These concerted efforts will not only bolster agricultural productivity but also contribute to the overall economic development and food security of Burundi.

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