World Mycotoxin Journal, Volume 16, Issue 3, January 2023, pp. 277-238
DOI: 10.3920/WMJ2022.2827

Assessment of agricultural practices by Ethiopian women farmers: existence of gender disparities in access to mycotoxins training

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Highlights

- More than 60% of women from both Oromia and Amhara regions was illiterate.
- Women were involved in post-harvest tasks, mainly sorting (89%) spoiled crops.
- Most of women (52%) didn't know about mycotoxins and ignore their impact on health.
- Mycotoxins training was previously assessed by only 0.24% of women farmers.
- The radio seemed to be most appropriate means of training dissemination.

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ABSTRACT
Ethiopia is one of the countries with the lowest gender-equality performance in sub-Saharan Africa being ranked 121/134 in terms of the magnitude and scope of gender disparities by the United Nations Women's Organisation. Within the farming communities, women represent 70% of the labour force but they are neglected from accessing training events run by Ethiopian Universities (e.g. Haramaya University). A survey to assess the existence of gender disparities among Ethiopian women farmers with respect to agricultural labour and mycotoxins knowledge was conducted on three hundred and forty-nine women from the Oromia and Amhara regions. A higher illiteracy rate was found in women compared to men from both Oromia and Amhara regions. Women played a key role in agricultural activities while having limited access to modern technologies compared to their male counterparts. Women were mainly responsible for sorting spoiled crops. Especially in Amhara, these were intended for home consumption, representing a serious health risk for local people. Overall, women from Amhara were more aware than women from Oromia about what mycotoxins are, their impact and risk of occurrence in crops. Women in Amhara were also more intended to act towards mycotoxins in the future compared to women from Oromia. Only a small percentage of women have previously attended a training on mycotoxins. The radio seemed to be the most efficient way to deliver training to Ethiopian women farmers from these regions. Mycotoxins trainings were the second option of choice by all women surveyed. Such findings clearly stated the existence of gender inequality in the two Ethiopian regions considered. Empower women's knowledge about mycotoxins will not only benefit agricultural income and the national economy, but it will also provide women the recognition they equally deserve alongside their male counterparts in future agricultural training programs and interventions.

1. INTRODUCTION

Ethiopia is an agricultural-dependent nation providing more than 73% of the employment opportunities and contributing to 46% of the Gross Domestic Product (GDP) (Gebre *et al*., 2019; Aliyi *et al*., 2021). Despite the great importance of this sector, about 74% of the Ethiopian producers are smallholders with less than 3 hectares (ha) of land and little involvement in commercial production (Negassa *et al*., 2021). Among the wide variety of crops cultivated in Ethiopia, maize and peanuts play a key role in the Ethiopian livelihood and economy.

Maize is grown by 66% of Ethiopian farmers and is currently cultivated on 2.1 million ha with an average yield of 3.6 tonnes per ha (Ertiro *et al*., 2018). The farming household consumes 75% of all maize produced (Rosenstock *et al*., 2019). Major maize-producing regions in Ethiopia are Amhara and Oromia regions. As a result, maize is a critical crop for the country's overall food security as well as economic development (Abate *et al*., 2015).

Peanuts is the most important cash crop in Ethiopia. Ethiopia produced 157 Kilo tonnes of peanuts in 2019, a 50% increase over the previous five years (FAOSTAT, 2022). Peanut production is concentrated in the Oromia and Benishanghul-Gumuz regions (Mohammed and Chala, 2014) where climatic conditions (humid climate, temperature around 25°C, annual rainfall > 500 mm) are ideal for the cultivation of this crop. Apart from being a valuable cash crop, peanuts are known to have great beneficial effects on human health (e.g. decreasing the risk of cardiovascular disease).

Ethiopia has a great potential and capacity to produce food on a large scale, but its participation in the international markets remains very low due to the lack of systems that guarantee food safety (Teferi, 2020.). Mycotoxins, which are toxic fungal secondary metabolites, are one of the main constraints for the achievement of food safety in Ethiopia. Among these, aflatoxins produced by *Aspergillus* section *Flavi* species (mainly *A. flavus* and *A. parasiticus*) are often contaminating maize and peanuts. Aflatoxin B_1 (AFB_1) has been classified as the most potent carcinogenic (hepatocellular carcinoma) natural compound (IARC, 2002). Studies on the occurrence of mycotoxins in different crops including peanuts and maize cultivated in Ethiopia have been conducted by several authors (Worku *et al*., 2019; Ayalew *et al*., 2006; Mohammed and Chala, 2014) showing that total aflatoxins concentration could reach up to 12,000 ng/g being 3,000-fold above the maximum regulated limits (4 µg/kg) according to the EU regulation (EC, 1881/2006).

Agricultural production is strongly influenced by the availability and access to education and training programs on farming systems by the farmers. The lack of access to these services represents a limiting factor for farmers, especially for small-scale producers in rural areas. Within the farming communities, it should be considered that women account for about 70% of the Ethiopian agricultural workforce (Doss *et al*., 2018). They participate in farming activities such as raising seedlings in nurseries, transplanting and weeding. Women are also involved in post-harvest tasks like shelling, sorting, packaging, and processing that are directly related to their household commitments (Aregu *et al*., 2010). However, their active engagement in these agricultural activities does not result in their equal recognition as farmers with men (Gella and Tadele, 2015). Extension services that provide new agricultural technologies and training to farmers are mainly accessed by men. Married women are particularly disadvantaged as it is assumed that they will be receiving training via their husbands (Ministry of Agriculture and Natural Resources, 2017). Due to the lack of recognition, female farmers are denied access to the use of new agricultural products and technology, as well as access to loans and extension services. Achieving strong economic development, food security and food safety through a reduction in post-harvest losses due to fungal spoilage and mycotoxin contamination, therefore, requires women to be integrated into specific training programs. This study aimed to first characterise the socio-demographic framework of Ethiopian women surveyed with a focus on their religious beliefs, education level and marital status. Then, to assess their perception of

gender equality with respect to agricultural labour, access to modern agri-technologies and mycotoxins knowledge. Finally, to identify future training preferences and ways to efficiently deliver them to rural women in Ethiopia.

2. MATERIALS AND METHODS

Study areas and survey design

The survey was developed using Qualtrics^{XM} (Qualtrics, Provo, UT) by the Applied Mycology Group at Cranfield University (United Kingdom). The questionnaire was organised into the following five sections: i) socio-demographic characteristics, ii) agriculture resources and practices, iii) gender equality perception within farming practices, iv) knowledge of mycotoxins, v) previous access to training and future preferences (Table S1).

Ethical approval

Prior to starting the survey, ethics approval was obtained through the Cranfield University Research Ethics System. Briefly, the interviewees consent was taken before collecting sensitive data. Interviewees were made aware to refer to privacy policy and data were collected in accordance with General Data Protection Regulation (GDPR) (EU, 679/2016). The survey was conducted on password-protected tablets by the interviewers to protect both the interviewers and the interviewee data collected as per GDPR.

Data collection

The survey was loaded in Samsung Galaxy Tab 3 tablets that were then sent to Haramaya and Debre Berhan Universities staff. An additional Qualtrics ^{XM} offline tool was used to allow data collection without internet connection while conducting the interviews. Interviews were conducted in the local language by local academics and responses were transcribed to English within the survey. The survey for the Oromia region which included the Babile, Fedis, and Midhaga Tola districts was conducted by Haramaya University staff. Debre Berhan University did the same in the Amhara region including the Shewa Robit, Kewet and Tarma Ber districts. Overall, the total number of seven districts was surveyed. For all the survey, only women living in Kebeles (equivalent to villages) were selected. For Oromia region, five villages were selected per district and ten women belonging to independent households were selected per village. Similarly, in the Amhara region, five villages were selected per district and ten women belonging to independent households were selected per village except for Shewa Robit district. Due to Shewa Robit being the most productive region for maize staple food, fifteen villages instead of five were chosen for this district. The survey was performed from February to July, 2021. For each region, the gender of the interviewer was recorded. A total of 349 women were interviewed including 149 women from Oromia and 200 women from Amhara regions. The villages for each district were randomly selected independently of stunting prevalence, mycotoxin exposure, or other potential factors. All the interviewed women (≥ 15 years old) were confirmed to be engaged in agricultural activity.

Data analysis

The datasets recorded offline were transferred to Qualtric^{XM} (Qualtrics, Provo, UT) when internet connection was available. Descriptive statistics were used to represent and analyse the data. Results from Babile, Fedis, and Midhaga Tola and from Shewa Robit, Kewet and Tarma Ber were processed to represent Oromia and Amhara regions results, respectively.

3. RESULTS

Socio-demographic characteristics

Out of 349 Ethiopian women respondents, 197 (56.5%) of women were orthodox, followed by Muslim (151, 43%) and protestant (1, 0.3%). A different predominant religious belief was observed among the two regions, with 100% of women from Oromia being Muslim and 98.5%

of women from Amhara being Orthodox (Figure 1a). Most of the respondents were illiterate (216, 62%) followed by 114 (32.7%) that have not completed school and 19 (5.4%) that have received a religious education.
The proportion of illiteracy was >60% both in Oromia and Amhara regions. Moreover, in Oromia, a higher prevalence of women with religious education was observed compared to Amhara (12% vs 0.5%) (Figure 1b).
With respect to their marital status, 295 (84.5%) were married, 23 (6.6%) were divorced, 16 were widowed (4.6%) and 11 were separated (3%). Only 4 (1.15%) women were never married. At a regional level, being married was the predominant marital status of the interviewed women from both Oromia (93.96%) and Amhara (77.5%) regions (Figure 1c).

Figure 1. a) Religious belief b) Education level c) Marital status

Agriculture and main crops production
Among the interviewees, agriculture represented 86% of profitable sources of income for Ethiopian women farmers with an average annual revenue between the two regions of 29,485 Birr. Relatively, in Amhara it was almost the only source of revenue (99.7%) generating 43,280 Birr/year while in Oromia agriculture covered 71.66% of household income and it generated 15,689 Birr/year. Other less profitable business included non-agricultural activities (on average 3,866 Birr/year) and revenues from sales of other farm resources (e.g. livestock, machinery) (on average 2,549 Birr/year).
Out of 349 respondents, 291 (83.4%) owned the land which was on average 2.5 ha big. At regional level, women from Oromia owned bigger lands (4.2 ha) compared to Amhara's ones (0.9 ha) (data not shown).

Top four crops produced were sorghum (39.8%), maize (19.6%), teff (12.1%) and peanuts (10.8%). Overall, a higher production was observed in Amhara (87.43%) compared to Oromia (77.16%). In Oromia, maize (23.8%) and peanuts (21.6%) were the second and third most produced crops, respectively. In Amhara, teff (24.1%) and maize (15.36%) production prevailed over other crops. Peanuts production was absent in this region, except for a slight amount (0.02%) produced in Tarma Ber district only (Figure 2a).
In terms of yield, sorghum was the most profitable crop (on average, 14.1 quintal/ha) followed by maize (on average, 6.3 quintal/ha), teff (on average, 4.2 quintal/ha) and peanuts (on average, 3.4 quintal/ha), reflecting data on crops production. Overall, yield was higher in Amhara (34.9%) compared to Oromia (21.1%).
Interestingly, despite a lower production of maize in Amhara compared to Oromia, it generated a higher yield (7.5 quintal/ha) compared to that of Oromia region (5.1 quintal/ha), with maximum value observed in Shewa Robit (40 quintal/ha) district. In Oromia region, peanut was more profitable than maize (6.8 vs 5.1 quintal/ha), despite the latter was highly produced in here (Figure 2b).

Figure 2. a) Crops production b) Yield

Gender division of agricultural labour and access to modern agri-technologies
Figure 3a shows an overall linear increase of the involvement of women within the main stages of maize and peanuts production chain in Ethiopia. Women were majorly saddled with the post-harvest tasks particularly with sorting (89%), shelling (47%) and selling (59%) while their least involvement was observed during pre-harvest activities such as ploughing (16%) and watering (18%).
Most of women (180, 53%) have access to modern agricultural technologies. Pre-harvest modern technologies, which included the use of tractors, motor pump, were on average the

most selected (175, 97%) and this was similar both in Oromia (53, 100%) and in Amhara (127, 96%). However, among the women that replied to have access to modern agri-technologies 98 (55%) do not actually use them equally as their husband and this was particularly true for women from Amhara region. Figure 3b highlights relevant differences between the two regions regarding this aspect. Overall, women linked their less access to modern technologies compared to men to lack of training (81, 51%) followed by among the other reasons, too much household chores (37, 23.3%) and caring duties (19, 12%) (data not shown).

Figure 3. a) Division of agricultural labour b) Access to modern agri-technologies

Sorting of fungal-spoiled crops

Eighty nine percent of the grain sorting is handled by women. Women were asked particularly what they would do if they encountered grains with visible spoiled grains/nuts with *Aspergillus* section *Flavi*, called "green" crops (Figure 4). Overall, the "green" crops were mainly addressed for home consumption (53%) rather than to feed animals (46.3%) with differences at regional level. In fact, in Oromia green grains/nuts were mainly intended to feed animals (71.4%) while in Amhara these were addressed to home consumption (71.7%).

Figure 4. Use of sorted "green" crops

Knowledge of mycotoxins

Out of 349 responses, 182 (52%) women claimed to have never heard about mycotoxins before. Figure 5a, shows a clear different level of knowledge about mycotoxins between the two Ethiopian regions considered in this study. Indeed, most of the women from Oromia (104, 69.8%) were aware about mycotoxins while in Amhara most of them (137, 68.5%) have never heard about them. Further questions were specifically addressed to the 167 (48%) women that have previously heard about mycotoxins.

Among these, only 36 (21.5%) correctly believed that mycotoxins were chemical compounds while 131 (78.4%) of women, considered mycotoxin as living (72, 43.1%) or dead (59, 35.3%) organisms. Women from Oromia mainly considered mycotoxins as living (59, 56.7%) or dead (45, 43.3%) organisms. On the contrary, most of the women from Amhara (36, 57.14%) correctly believed that mycotoxins are chemical compounds (Figure 5b).

Furthermore, their awareness about linking mycotoxins contamination to spoiled "green" crops was evaluated. Data showed that, 86 (51.5%) women believed that mycotoxin could happen only in presence of green grains, while 57 (34%) said that green crops might be contaminated with mycotoxins and the remaining 24 (14%) considered that mycotoxins could occur regardless of the presence of spoiled green grains. Most women that linked mycotoxins to the presence of evidently spoiled grains were from Oromia (77, 74.04%) while in Amhara, majority of them correctly believed that it might be possible (36, 57.14%) (Figure 5c).

Figure 5d shows that 118 (71%) women believed that mycotoxins do not have any health impact, which was followed by a 27 (16%) associating them with death, 12 (7%) with cancer and remaining 10 (6%) with other health diseases including growth retardation or higher risk of infertility. No women were able to identify that mycotoxins (especially, aflatoxins) could increase baby jaundice and can worsen acquired immune deficiency syndrome (AIDS) or Hepatitis C nor favour animal anorexia. Most of women from Oromia (97, 93.27%) replied that mycotoxins do not have any health impact. Majority of women from Amhara associated mycotoxins with death (27, 42.86%) although a considerable number of them (21, 33.3%) also believed that mycotoxins have no impact on health.

Finally, it was asked whether Ethiopian women could act to control mycotoxins contamination in crops. Eighty-five (51%) believed that they cannot play an active role in reducing mycotoxins contamination. At regional level, 71 (68.27%) of Oromia respondents believed

they could not act on mycotoxins contamination while only 14 (22%) of Amhara respondents answered the same as shown in figure 5e.

Figure 5. a) Previously heard about mycotoxins b) What are mycotoxins c) Do mycotoxins occur only in "green" crops d) Impact of mycotoxins on health e) Acting towards mycotoxin reduction

Previous access to training and future preferences

Figure 6a shows that mycotoxin training was the lowest accessed versus six categories of training choices provided to the interviewees. In fact, only two people (0.24%) from Oromia region have previously attended training on mycotoxins which was delivered by a development agency. The most attended trainings were related to health management (e.g. Wash Sanitation and Hygiene (WASH)) (224, 26.5%), sex education (212, 25%) and agricultural practices (164, 19%). Figure 6b illustrates the mode of previous training accessed by Ethiopian women. Women were mainly trained via radio (30, 38%), followed by the head of the village (13, 16.5%) and by male family members (11, 14%). Other less used means of training were represented by television (5, 6.3%) and mobile phone (2, 2.5%). It is worthy to notice that none of the women have ever been trained by an extension worker. Finally, Figure 6c shows women interest for future training. Women from Oromia expressed their preference to be trained on agricultural practices (62.4%) followed by mycotoxins management (30.5%). In Amhara, women would like to be trained on household management (39.5%) followed by, on a par, training on health management and mycotoxins management (22%).

Figure 6. a) Attendance to previous trainings b) Mode of access to past trainings c) Future training preferences

4. DISCUSSION

A preliminary socio-demographic characterisation of women surveyed from Oromia and Amhara was conducted to provide a detailed background framework. Our evaluation included questions on women's religious belief, literacy rate and marital status. With respect to religious belief, various religions are adhered in Ethiopia. According to the International Religious Freedom Reports (U.S. Department of State, 2021), an estimated 40-45% of Ethiopian population belongs to the Ethiopian Orthodox Church (EOC) which is predominant in the Northern regions, including Amhara. Islam is most prevalent in the Eastern Somali and Afar regions, as well as in many parts of Oromia. Results from the survey supported such data and evidenced that all women from Oromia (100%) were Muslim while in Amhara they were prevalently (98.5%) Orthodox.

Adult literacy rate is the percentage of people ages 15 and above, who can both read and write with understanding a short simple statement about their everyday life (UNESCO - Institute of Statistics, 2022). Education in Ethiopia is compulsory for children between the ages of 5-16 years, but with poor facilities and underprivileged backgrounds, many children don't get a high quality, full-time education in Ethiopia. Ethiopia has an adult literacy rate of 51.77% which increased of 12.78% compared to 2007 (Macrotrends, 2022). Although education in Ethiopia has improved over past years, there are still many difficulties existing there. One of these is the gender gap related to education's access. The Ethiopian gender survey of women aged 15-49 years found among the reasons of women less attendance to school, family disapproval and early age marriage (Erulkar and Amdemikael, 2010). A study by Emirie, 2005 pointed out the effects of early marriage on girls' education in rural Ethiopia in some specific areas of the

country, including Amhara region. Overall women get married at 14 years and an unmarried girl over that age is stigmatized. Access to school is considered a priority for boys while girls must be just wives and mothers. Data from our study evidenced that women surveyed, aged 15 years and above, from both regions were prevalently married (84.5%) or have been previously married (15.5%). Also, their illiteracy rate was more than 60% which was higher compared to the one of their husbands (52%) (data not shown) confirming the educational gender inequality existing in Ethiopia. The Berhane Hewan package of interventions, a 2-year pilot project (2004-2006), demonstrated that girls' school attendance could be improved by increasing the age of marriage. By providing incentives to both girls and their parents (e.g. goat at the end of the program, school materials) it was possible to increase school attendance and to delay marriage for girls between 10-14 years.

Agriculture in Ethiopia is the economy's most important sector. Results from the survey indicated that agriculture was the most profitable source of income (86%) in both Amhara and Oromia regions. Ethiopia's crop agriculture is complex and differs importantly across the country due to different climatic and agro-ecological conditions. Five major cereal types (teff, wheat, maize, sorghum, and barley) are mainly produced in Ethiopia, accounting for about three-fourths of the total area cultivated, 29% agricultural GDP and 64% calories consumed (Taffesse *et al*., 2012). Different biophysical conditions (e.g. climate, agroecology) may be responsible for this variable trend of crop production in different areas of Ethiopia. Teff, sorghum, and maize constitute the staple foods of Ethiopian diet while peanuts are an important cash crop. Maize is grown under diverse agro-ecologies, usually under rain-fed conditions. More than 60% of maize production comes from Oromia region, followed by Amhara with about 20% of total production. Similar trend was observed in our study were women from Oromia produced higher amount of maize (~ 24%) compared to those from Amhara region (15%). Peanut production is favoured by most restrictive conditions such as lowland areas (< 1500 m above mean sea level), sub-humid to humid climate, the average temperature of 25ºC and average annual rainfall > 500 mm. The targeted study areas in Oromia region matches the optimum climatic conditions for peanut production explaining the extensive production of this crop here. Women represent a tremendous productive resource in the agricultural sector despite being more committed to household chores than to farming activities compared to their husbands (data not shown).

It is possible to make some broad generalization regarding the typical division of labour between women and men in crop production. Men are usually responsible for heavier manual tasks such as land preparation and tillage with oxen or human labour. Also, they play a dominant role in seed selection, reflecting the fact that have better access to information. On the contrary, women are often involved with activities that require dexterity and attention to detail, such as shelling and sorting (Aregu *et al*., 2010). Results from our study agree with such findings being women majorly saddled with responsibilities of sorting the grains, shelling, and selling while men were mainly involved during pre-harvest tasks requiring physical effort (e.g. ploughing, cultivations, weeding). Because of their different roles and activities men and women may be differently exposed to mycotoxin risk. For instance, peanuts are usually hand-shelled by women, beating the pods with a wood stick, or using the teeth, after soaking the peanuts with water to soften the pods. Hand-shelling, apart from being time consuming, is extremely dangerous leading women to increased risk of exposure to aflatoxin (Cervini *et al*., 2022). Sorting of peanuts after harvest and before storage is extremely important to avoid the spread of aflatoxins-producing fungi. Usually, sorting it is done manually or electronically by colour sorting machines. Electronic colour sorting would be particularly indicated for developed regions that have the infrastructure to support it, while hand sorting would be adequate for rural subsistence farming communities, owing to its low cost and simplicity. Studies have shown that hand-sorting as an intervention can reduce up to 43% of aflatoxins in

peanuts (Xu *et al*., 2017). Therefore, standards on hand sorting or physical separation procedure can be taught to women farmers through training. A prototype sorting device "DropSort" was tested for its efficiency to reduce mycotoxins contamination in maize kernels based on kernel bulk density (KBD) and 100-kernel weight (HKW). It was found to be more effective to reduce fumonisins than aflatoxins (Aoun *et al*., 2020). They also showed that size and visual sorting were much more effective to reduce aflatoxins contamination in peanuts than using the "Dropsort". Based on our findings, women from Amhara would importantly need to be training on sorting procedures as they address most of the sorted spoiled crops to home consumption rather than not using them or feeding animals.

Overall, crop production depends on the supply of inputs and new agricultural technologies. which should be typically transferred by NGOs (Aregu *et al*., 2010). Results from the survey evidenced that farmers women have access to modern agricultural technologies, especially pre-harvest ones, but they don't use them as men. This was particularly evident in Amhara region, where 75% of surveyed women do not have access to agricultural tech as their men. Reasons behind this underlies in the fact that they haven't been trained or that they have to deal with too much household chores and caring duties. Aregu *et al*., 2010 stated that the adoption of improved technology in agriculture would benefit both women and men but men tend to use them more than women. Also, this may vary depending on the household's wealth. Usually, the rich and middle wealth farmers derive the most benefit from the new technologies compared to poorer households. The latter are denied from using them due to limited economic availability or lack of awareness (Aregu *et al*., 2010). Therefore, attention is required to ensure women and the poor are neither left out nor disadvantaged by these agri-technological improvements.

Mycotoxins represent a food safety concern and also a food security issue, the latter especially in developing countries due to the fact that some of them (e.g. AFB_1) may exert a deleterious effect (e.g. carcinogenic) on human/animal health. Mycotoxins production is influenced by several abiotic factors and is not always linked to the presence of mouldy food (Garcia-Cela *et al*., 2021). Kernel discoloration and/or evident signs of damage by insect are some of the key indications that are also linked to mycotoxin accumulation (Lavkor and Var, 2017; Dorner, 2008).

Our results showed that 68.5% vs 30% of women surveyed from Amhara and Oromia, respectively have never heard about mycotoxins before. Overall, the remaining 31.5% of women from Amhara region that have previously heard about them was way out more aware about what they are, their occurrence and their impact on health than 70% of women from Oromia. Some studies reported that both high education level (Udomkun *et al*., 2017), high-income level (Redzwan *et al*., 2012) may positively correlate with higher cognizance about mycotoxins occurrence in food and feed.

In addition, it was found that only 0.24% of women have previously attended any sort of mycotoxin training. This could also explain why Ethiopian rural women almost totally ignored mycotoxins while developing agricultural tasks. The radio was the most used means of access to training which included among others, health management, sex education, and agricultural practices. It might be to the fact that the radio is an easy way to be trained while dealing with other tasks, such as household chores or caring duties. Kibret *et al*., 2019 during a study to assess knowledge, attitude, and practice of farmers towards aflatoxins in cereal crops in Wolaita zone, in Ethiopia, reported that both men and women were aware of aflatoxins and their effect on health. Such awareness was achieved through awareness creation training delivered by AMREF Ethiopia and Government agriculture workers. Finally, their future training preferences were investigated. Mycotoxins training was the second choice of interest both in Oromia and Amhara regions, followed by training on agricultural practices and household management, respectively.

5. CONCLUSIONS

This study clearly stated the existence of gender disparity with respect to agricultural labour and mycotoxins knowledge in both Oromia and Amhara regions, in Ethiopia. Women are getting married since very young age (14 years old) and this preclude their access to school. Despite being more constrained with household chores and not having equal access to modern-agri-technologies, Ethiopian women are predominant in agriculture activities and this increases towards post-harvest activities, being particularly relevant during sorting. From our results, it was clear that women did not know how to properly sort "green" commodities and that most of them consume the sorted crops at home. Moreover, most of them didn't know what mycotoxins are and ignore their negative impact on human health. Therefore, adequate training on sorting procedures and use of sorted crops should be delivered to women farmers in Ethiopia. Training these women to correctly identify and remove contaminated food would be a beneficial aflatoxins reduction strategy for the entire community. By taking into account that differences (e.g. socio-demographic, climate, crop growing) exist between different districts in Ethiopia, tailored training sessions should be organized to improve women's knowledge about mycotoxins-related issues. The radio seemed to be the most appropriate means of training dissemination. Alternatively, training can be delivered to the village heads that will later be appointed to train the women farmers across the different districts. A continuous effort must be done to ensure women recognition in farming activities likewise men. In the long term, such empowerment of women would benefit the Ethiopian economy which could rely on local crop production, reducing dependence on export, and it will also boost food safety and food security.

ACKNOWLEDGMENTS AND FUNDING

The authors acknowledge Dr. Kidane Tafa, Mr. Shegar Dawud, Mr. Nuradin Abdi for their help in data collection and Vanshika Sharma, Ajanta Mazumdar, Anurag Dhyani, Magdalena Marin-Saavedra, Olumayowa Oladipupo for their support in data analysis. This research was supported by a Global Challenges Research Fund Quality-Research (QR-GCRF) to Cranfield University.

AUTHORS CONTRIBUTION DECLARATION

Conceptualization: CVV, CC, AM[1]
Writing – original draft: CC
Writing – review & editing: CC, CVV, AM[1], AM[3], BA
Funding acquisition: CVV
Data curation: BA, RE, KG

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Figure 1. Religious belief (a), education level (b) and marital status (c) of Ethiopian women surveyed (n=349) from Oromia and Amhara regions.

Figure 2. Main crops production (a) and yield (b) of Ethiopian women surveyed (n=349) from Oromia and Amhara regions.

Figure 3. Distribution of agricultural labour within women and men (a) and access to modern agri-technologies (b) of Ethiopian women surveyed (n=349) from Oromia and Amhara regions.

Figure 4. Intended use of sorted "green" crops by Ethiopian women surveyed (n=349) from Oromia and Amhara regions.

Figure 5. Ethiopian women surveyed (n=349) from Oromia and Amhara regions that have previously heard about mycotoxins (a), knew what mycotoxins are (b), believed that mycotoxins occur in "green" crops only (c), knew the impact of mycotoxins on health (d), and women's willingness to act towards mycotoxins reduction (e).

Figure 6. Attendance to previous trainings (a), mode of access to past trainings (b) and future training preferences (c) of Ethiopian women surveyed (n=349) from Oromia and Amhara regions.

Figure 1

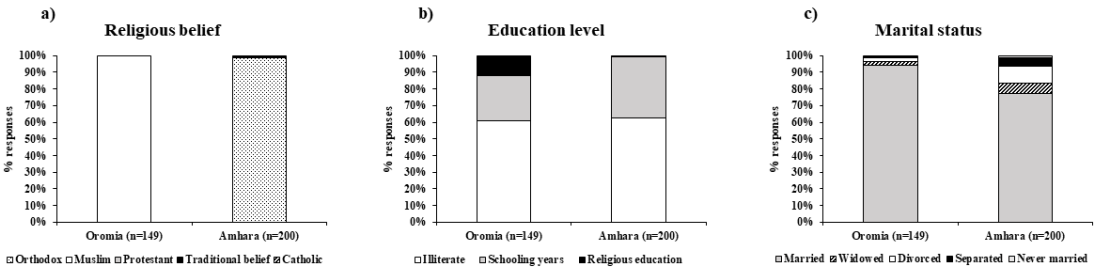

a)
Religious belief
% responses
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Oromia (n=149)
Amhara (n=200)
Orthodox
Muslim
Protestant
Traditional belief
Catholic
b)
Education level
% responses
Oromia (n=149)
Amhara (n=200)
Illiterate
Schooling years
Religious education
c)
Marital status
% responses
Oromia (n=149)
Amhara (n=200)
Married
Widowed
Divorced
Separated
Never married

Figure 2

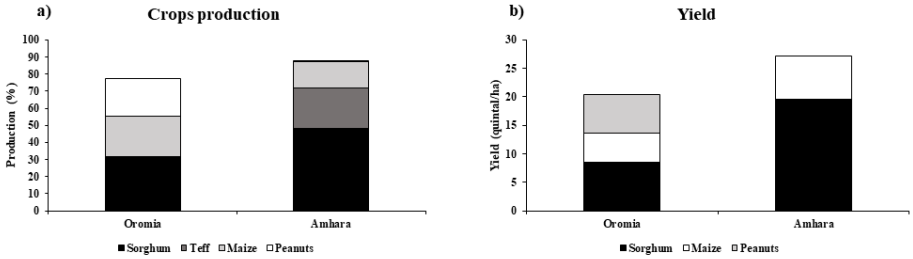

a)
Crops production
Production (%)
100
90
80
70
60
50
40
30
20
10
0
Oromia
Amhara
Sorghum
Teff
Maize
Peanuts
b)
Yield
Yield (quintal/ha)
30
25
20
15
10
5
0
Oromia
Amhara
Sorghum
Maize
Peanuts

Figure 3

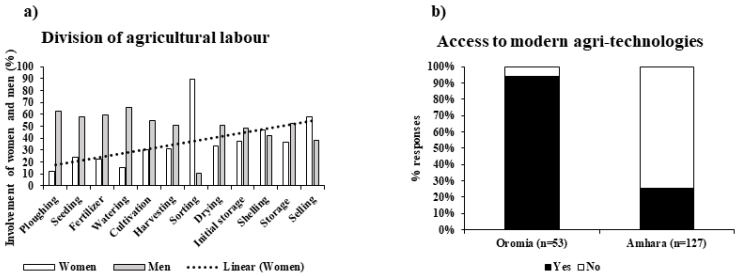

a)
Division of agricultural labour
Involvement of women and men (%)
100
90
80
70
60
50
40
30
20
10
0
Ploughing
Seeding
Fertilizer
Watering
Cultivation
Harvesting
Sorting
Drying
Initial storage
Shelling
Storage
Selling
Women
Men
Linear (Women)
b)
Access to modern agri-technologies
% responses
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Oromia (n=53)
Amhara (n=127)
Yes
No

Figure 4

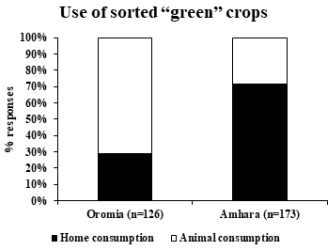

Use of sorted "green" crops
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% responses
Oromia (n=126)
Amhara (n=173)
Home consumption
Animal consumption

Figure 5

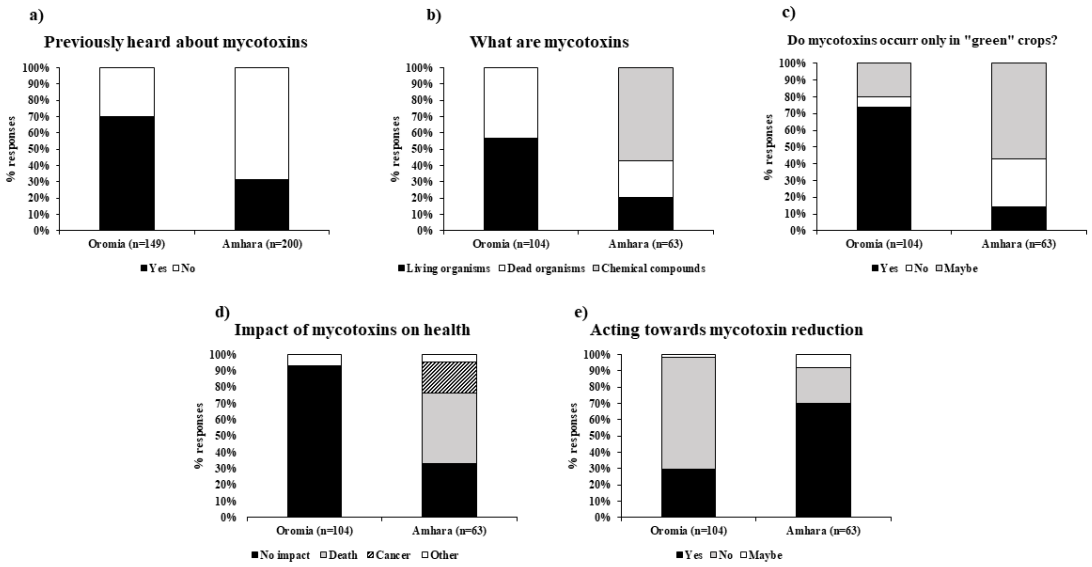
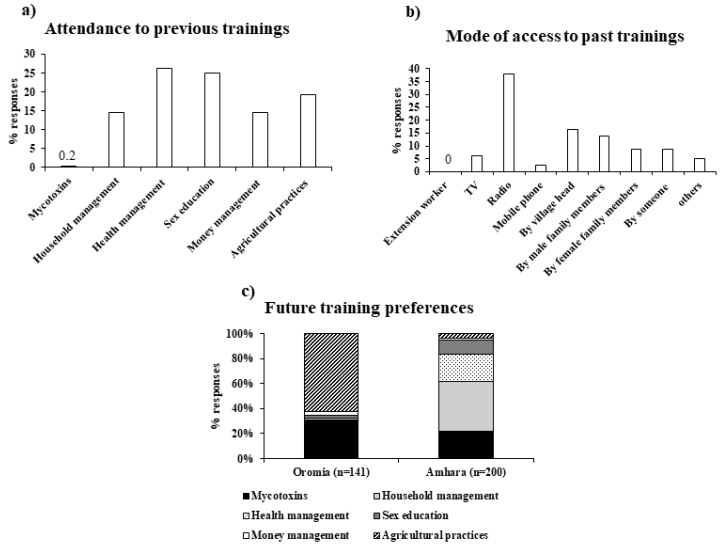

a)
Previously heard about mycotoxins
% responses
Oromia (n=149)
Amhara (n=200)
Yes No
b)
What are mycotoxins
% responses
Oromia (n=104)
Amhara (n=63)
Living organisms Dead organisms Chemical compounds
c)
Do mycotoxins occurr only in "green" crops?
% responses
Oromia (n=104)
Amhara (n=63)
Yes No Maybe
d)
Impact of mycotoxins on health
% responses
Oromia (n=104)
Amhara (n=63)
No impact Death Cancer Other
e)
Acting towards mycotoxin reduction
% responses
Oromia (n=104)
Amhara (n=63)
Yes No Maybe

Figure 6


a)
Attendance to previous trainings
% responses
0.2
Mycotoxins
Household management
Health management
Sex education
Money management
Agricultural practices
b)
Mode of access to past trainings
% responses
0
Extension worker
TV
Radio
Mobile phone
By village head
By male family members
By female family members
By someone
others
c)
Future training preferences
% responses
Oromia (n=141)
Amhara (n=200)
Mycotoxins
Household management
Health management
Sex education
Money management
Agricultural practices

Supplementary materials

Table S1: Data set of questions addressed to Ethiopian women based on five sections.

Questions
Socio-demographic characteristics
What is your marital status?
What is your religious belief?
What is your education level?
What is your husband education level?
Agriculture resources and practices
What is the proportion of your family income coming from agriculture?
What was the value of your total family income (in Birr) last year?
Is your household owner of the land?
What is the size of your cultivated land (ha)?
What commodities are you producing (%)?
Yield of production (quintal/ha)?
Amount consumed at home (quintal/year)?
Amount selling (quintal/year)
Gender equality perception within household and farming practices
How many hours/day you do the following tasks?
How many hours/day your husband do the following tasks?
How many hours/day your daughter do the following tasks?
How many hours/day your son do the following tasks?
Who is doing what for maize and peanuts?
Are you sorting out green grains/peanuts?
What are you doing with the green grains/peanuts?
Who is sorting the green grains/peanuts?
Are you free to change/improve your habits at home?
Is your husband letting you free to manage your timetable?
Do you have any modern agricultural technologies?
What are the modern technologies?
Do you use/have access to the modern technologies as often as the males?
Why do you have less access to the modern technologies?
Knowledge of mycotoxins
Have you ever heard about mycotoxins?
What are mycotoxins?
Which commodities could be affected by mycotoxins?
Are mycotoxins only happening if the grains/nuts are green?
What is the impact of mycotoxins (e.g. aflatoxins) on health?
Can you do something to reduced mycotoxin occurrence in your food?
Previous access to training and future preferences
How did you access your last training?
Who was the provider of the training?
What would be the training you are interested in?

	What is your education level?		
	P value	P value summary	Statistically significant
Have you ever heard about mycotoxins?	0.0013	**	Yes
What are mycotoxins?	0.0001	***	Yes
Are mycotoxins only happening if the grains are green?	0.0004	***	Yes
What is the impact of mycotoxins on health?	<0.0001	****	Yes

Table S2: Chi-square test to assess significant correlation between women education level and mycotoxins related questions.

Levels of significance (*p*-values): <0.0001: *****, 0.001: ***, 0.002: **, >0.05: ns
ns: not significant

	Do you have any modern agri-tech?		
	P value	P value summary	Statistically significant
Average income from agriculture	0.047	*	Yes
Average income from other farm resources	0.18	ns	No
Average income from other activities	>0.05	ns	No

Table S3: Chi-square test to assess significant correlation between women owning modern agriculture technologies and family income.

Levels of significance (*p*-values): <0.0001: *****, 0.001: ***, 0.002: **, >0.05: ns
ns: not significant