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Adoption of Best Cultivation Practices and Post-Harvest Techniques among Maize Farmers in Anuradhapura District, Sri Lanka

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Abstract

Maize (Zea mays L.) ranks as the second most important grain crop in Sri Lanka after rice, playing a pivotal role in meeting the country's agricultural and economic needs. The rising demand for maize, driven primarily by the expansion of the livestock sector, has outpaced domestic production capabilities. This shortfall is attributed to suboptimal yields, significant post-harvest losses, and poor grain quality, often linked to mycotoxin contamination. Consequently, Sri Lanka continues to rely heavily on maize imports to bridge the supply gap. Enhancing local maize production and improving grain quality through the adoption of best management practices offers a promising pathway to achieving quality grains. Despite this potential, limited recent research has examined the current practices of the farmers in production and post-harvest handling, creating a knowledge gap. This study investigated the extent to which maize farmers in the Anuradhapura District in Sri Lanka have adapted recommended best management practices and post-harvest techniques in maize production. Data were gathered from 280 maize farmers, selected through random sampling, using structured questionnaires and key informant interviews during the 2023 Yala season. Findings reveal considerable deviations from recommended practices in critical aspects of maize production, such as land preparation, seed rate management, crop establishment, and fertilizer application. Additionally, deficiencies in post-harvest practices particularly in drying, threshing, and storage have contributed to measurable losses. According to farmers' estimates, average maize losses are 1% during drying, 1.8% during threshing, and 1.5% during storage. The deficiencies in harvest and the post-harvest losses highlight the crucial need for targeted interventions to improve the knowledge and practices of the farmers. The study emphasizes the importance of implementing robust farmer training programs focused on best management practices adoption and post-harvest handling techniques. Moreover, it recommends developing village-level infrastructure to mitigate post-harvest losses and ensure the production of high-quality maize.

Keywords: Anuradhapura, Management practices, Maize, Post-harvest losses, Sri Lanka

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Introduction

Maize *(Zea mays* L.) is a versatile cereal cultivated globally across diverse agro-ecological zones and serves as a vital component in the food and feed industries. In Sri Lanka, maize holds the position of the second most important grain crop after paddy, underscoring its agricultural and economic significance (Esham, 2014). The expanding poultry and livestock sectors have further amplified the role of maize as a primary ingredient in animal feed production.

Data from the Department of Animal Production and Health in 2020 (DAPH, 2021) indicates that 182,479 metric tons of domestically cultivated maize and 12,930 metric tons of imported maize were utilized in animal feed manufacturing, contributing to 40-50% of the total cereal content in these products. Beyond its application in feed, the growing popularity of maize-based food products such as ready-mix cereals, popcorn, boiled maize cobs, sweet corn, and baby corn has driven a parallel increase in local maize consumption in Sri Lanka (Vidanapathirana et al., 2022).

Despite the growing demand for maize in Sri Lanka, local production remains insufficient to satisfy national requirements, largely due to suboptimal yields and significant post-harvest losses. Fungal contamination, particularly during storage, is a primary contributor to the deterioration of maize quality (Kumari et al., 2020). As a result, Sri Lanka imported 184,611 metric tons of maize in 2022 at a cost of 18,306 million rupees, straining the country's foreign exchange reserves. Domestic production of maize in that year was 259,040 metric tons (DCS, 2022). To address this challenge, increasing productivity on existing maize lands is critical, given the limited scope for expanding cultivation areas (Cassman, 1999).

The current average maize yield in Sri Lanka is approximately 3.6 metric tons per hectare, far below the potential yield of 8 metric tons per hectare offered by the high-yielding imported varieties used by the majority (95%) of farmers (Abeysooriya, 2012). Factors such as limited access to water and land resources, climate variability, pest infestations, land degradation, and inadequate agronomic practices are major constraints to achieving higher yields (Pandey and Koirala, 2017). Proper agronomic practices, however, have been proven to significantly enhance yields (Aramburu-Merlos et al., 2024; Balemi, 2019; Senthilkumar et al., 2018; Malaviarachchi, 2014; Ranaweera, 1988).

Post-harvest losses remain another critical issue, occurring during harvesting, drying, storage, and transportation. Storage losses, primarily caused by high moisture content and poor handling practices, contribute substantially to the reduction in grain quality (Kumari et al., 2020; Chegere, 2018; Ngowi and Onesmo, 2019).

Addressing these challenges requires a thorough understanding of farmers' current crop and post-harvest management practices. This study aims to bridge the research gap by evaluating the level of adoption of best management practices in maize production and post-harvest handling among Sri Lankan farmers. It compares these practices with government-recommended practices to identify critical intervention points for improving maize productivity and quality.

Methodology

Study area and duration

The study was conducted in the Anuradhapura District, chosen for its extensive maize cultivation area during the Yala season (from May to August) in Sri Lanka, making it a representative location for the research. The target population comprised farmers who cultivated maize in this district during the Yala season of 2023. The sampling unit included individual maize farmers from this area. A total sample size of 280 farmers was determined using Cochran's formula, with a 6% margin of error and a 94% confidence level (Piran-Qeydari et al., 2022).

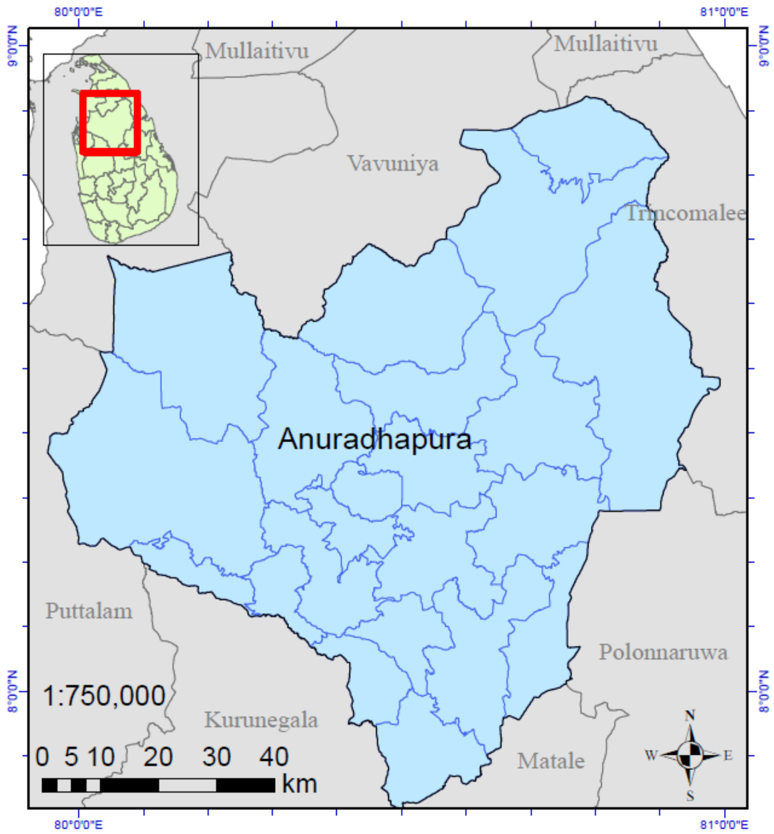

Figure 1. Map of the study location - Anuradhapura district

Sampling

Multi-Stage Random Sampling approach was employed to ensure representative sampling. In the first stage, the Anuradhapura District was selected due to its prominence in maize cultivation and diverse irrigation systems, including major irrigation schemes, minor irrigation schemes, and the Mahaweli system. In the second stage, three irrigation systems; Major, Minor, and Mahaweli were identified as stratification criteria. Subsequently, in the third stage, 11 Agrarian Services Centers (ASCs) were selected across the district. These centers were chosen based on their significant contribution to maize cultivation, collectively covering 50% of the maize cultivation extent in the Anuradhapura district. Finally, the sample was proportionally distributed among the selected ASCs, and individual farmers were randomly selected from each ASC for data collection.

The study utilized both primary and secondary sources of data, with data collection conducted in October 2023. Primary data were gathered through a structured questionnaire survey and Key Informant Interviews (KIIs). The questionnaire, pre-tested for reliability and validity, captured detailed information on farmers' demographic profiles, maize cultivation practices, and post-harvest handling methods. Key Informant Interviews with agricultural officers provided additional insights, complementing the survey data. All primary data were collected through face-to-face interviews with farmers to ensure accuracy and clarity in responses. Prior to data collection from farmers and officers, a clear explanation was provided to all participants regarding the purpose of the research. The participants were informed that the data collected would be used only for academic and research purposes. Respondents were assured that their identities would remain anonymous and that no personal information would be disclosed in any part of the analysis or reporting and that they can withdraw from participation at any time during the study without any consequences. Further, all enumerators involved in data collection were instructed to maintain strict confidentiality regarding any information they learned or observed during interviews. Informed consent was obtained prior to commencing data collection. Secondary data were obtained from various reliable sources, including records from the Department of Agriculture (DOA), the Department of Census and Statistics (DCS), and the Central Bank of Sri Lanka (CBSL), as well as published research articles, reports, and online databases.

Data analysis was performed using a combination of descriptive and inferential statistical techniques. Descriptive statistics, including measures such as frequencies, means, percentages, and standard deviations, were used to summarize the dataset and provide a clear overview of key variables. Inferential analysis involved the application of t-tests to compare farmers' existing maize production and post-harvest handling practices with the recommended guidelines provided by the Department of Agriculture (DOA).

Results and Discussion

Land preparation

In the study, 62% of farmers reported that they conducted only land ploughing as their primary land preparation activity. Subsequently, 37% of farmers performed harrowing after ploughing, while only 1% practiced zero tillage. Harrowing is crucial for creating fine soil, which facilitates improved seed germination and enhanced root development (Bot and Jose, 2001). Despite government recommendations for harrowing, maize farmers have shown limited adherence to this practice mainly due to high cost of land preparation particularly for machinery.

Seed use in maize cultivation

99% of maize farmers who participated in this study relied on imported hybrid seed varieties for cultivation. The average seed rate reported by the sampled farmers was 6.1 (±4.5) kg per acre, exceeding the DOA recommended rate of 5.2 kg per acre for imported hybrid varieties (Abeysooriya, 2012). This is a 15% deviation per acre from the recommended seed rate, indicating a tendency among farmers to use an excess quantity of seeds for maize planting. Higher seed rates result in higher plant densities which adversely affect plant growth due to insufficient sunlight and carbohydrate assimilation (Timlin et al., 2014).

Furthermore, 48% of the farmers engaged in gap filling or replanting during the cultivation process. Among these, the primary reason was poor seed germination. This may be attributed to suboptimal land preparation practices or, as cited by farmers, the low quality of seeds available in the market. The importance of seed quality in determining crop yield is well-established (Sanginga & Woomer, 2009). The economic analysis showed that farmers spent an average of 21,839 Sri Lankan rupees per acre on seed procurement, reflecting the substantial financial burden associated with seed costs. These findings underscore the need for improved access to high-quality seeds and training on optimal seed rates and land preparation techniques to enhance both cost efficiency and productivity in maize cultivation.

Field establishment of maize

Most farmers (59%) cultivated maize in paddy fields, while the remaining farmers utilized upland fields during the Yala season. All farmers relied on irrigation for their maize cultivation. Proper field spacing for maize establishment was adapted by 41% of the farmers, with 45 cm × 30 cm being the most common spacing, followed by 60 cm × 30 cm (24%). Both spacing configurations align with the recommendations of the government for imported hybrid seed varieties under irrigated conditions. However, 35% of farmers implemented spacing practices that deviated from these guidelines. Numerous studies have consistently demonstrated that proper spacing is essential for achieving optimal plant density, which is critical for maximizing the yield in maize (Zamir et al., 2011; Sangoi, 2001). These findings highlight that more than one-third of farmers in the sample did not achieve optimal plant density, potentially limiting their crop performance and productivity.

Nutrient management in maize cultivation

Balanced fertilizer application, incorporating appropriate doses and timely methods, is essential for effective nutrient management in agriculture (Prasad, 2009). The government recommends applying Urea, Muriate of Potash (MOP) and Triple Super Phosphate (TSP) as basal dressing before planting or within one week after field establishment to provide Nitrogen (N), Potassium (K) and Phosphorous (P) nutrients for maize. According to the results, 99% of the farmers in the study population applied basal dressing after planting. Among these, the majority (55%) applied it 14 - 20 days (2 - 3 weeks) post-planting. This was a significant deviation from the timing of basal dressing application recommended by DOA Sri Lanka. Figure 2 presents the extent of adherence to government recommendations for basal dressing under irrigated conditions.

These findings revealed concerning trends in fertilizer application practices: 89% of farmers applied both Urea and TSP without adhering to the recommended amounts. Specifically, 81% exceeded the recommended Urea application rate (75 kg per hectare) ranging between 82 to 329 kg per hectare, while 58% used TSP below the suggested amount (100 kg per hectare) ranging from 9 to 98 kg per hectare. Similarly, 69% of farmers deviated from the recommended rate of MOP application (50 kg per acre) in both excess and below levels (Figure 2 & 3). Urea was most frequently applied in excess mainly due to farmers' assumption that applying more urea will increase the yield. The high cost of TSP relatively to other fertilizers has led to its reduced usage. These deviations suggest widespread noncompliance with the DOA guidelines.

For top-dressing applications, only Urea was used. 68% of farmers applied excess quantities of Urea ranging from 366 to 976 kg per hectare compared to the recommended rate of 350 kg per hectare under rainfed farming conditions. While 45% of farmers applied top dressing at the correct time (28–35 days or 4–5 weeks after planting), most (77%) applied it in a single blanket application. The remainder employed split applications, with 22% applying in two doses and 1% in three doses. The split application of fertilizer enhances the efficiency of nutrient use while reducing the leaching of nutrients (Fabunmi, 2009). Notably, none of the farmers utilized eco-friendly fertilizers for maize cultivation during the Yala season.

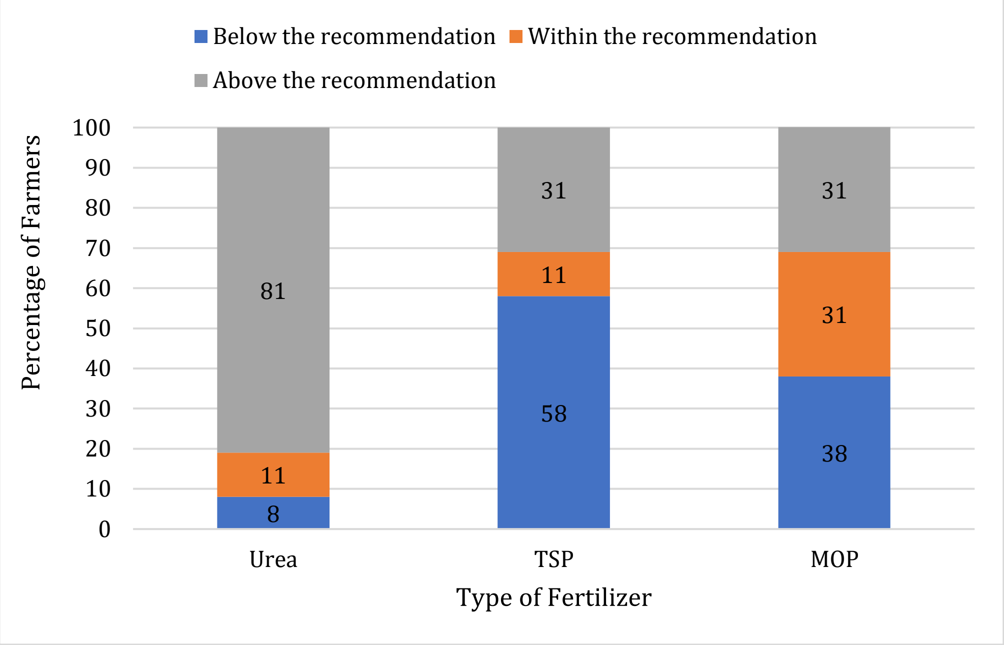

Figure 2. Percentage of farmers adhering to the recommendations of NPK fertilizers in maize cultivations

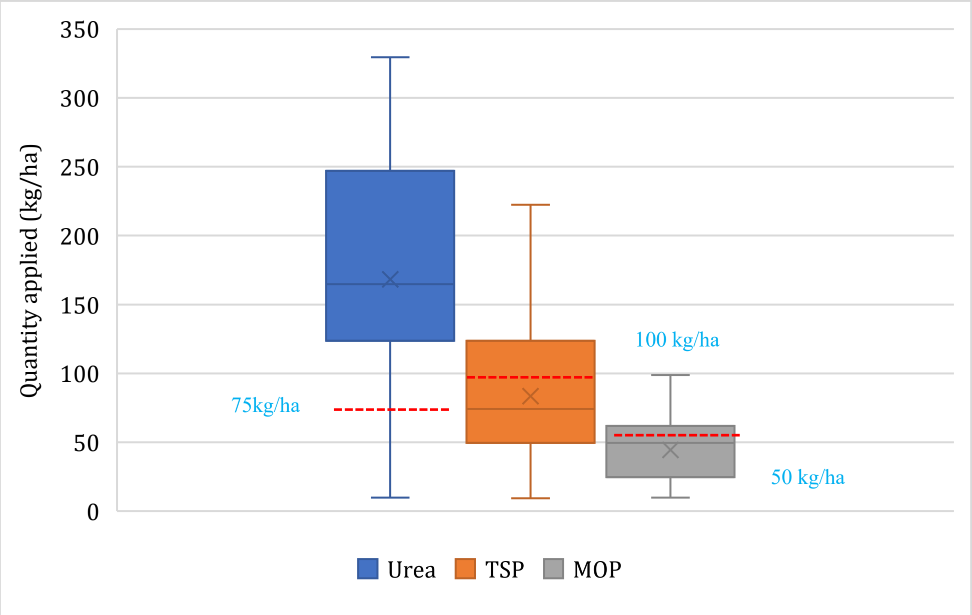

Figure 3. Box whisker plot on NPK fertilizer applied quantities and DOA recommendations

Harvesting of maize

Within the study sample, a substantial majority of maize farmers (94%) focused their cultivation efforts in the 2023 Yala season solely on grain production. In contrast, a minor proportion (6%) of farmers within the sample chose to cultivate maize for both immature cobs and grains during the specified season. The timing of maize harvesting at the correct maturity stage is crucial for reducing post-harvest losses of maize grains (Chegere, 2018).

64% of farmers harvested their maize for grains within the specified period of 105-122 days after planting (Abeysooriya, 2012). However, a notable concern arises as 36% of farmers opted to harvest before reaching the correct stage of maturity. Reasons provided for harvesting early include risks of damage from wild animals such as elephants, as well as birds like peacocks and parrots, followed by adverse weather conditions. Early harvesting of maize can indeed result in retaining more moisture in the grains, leading to a prolonged drying period. There is also a risk of maize grain contamination with fungus due to high moisture content when harvested before reaching the correct maturity stage (Serumaga et al., 2020).

Drying maize cobs before threshing

Maize harvested at optimal maturity generally contains a moisture content of 25–35%, which must be reduced to approximately 13% to minimize biological and microbial activity (Abeysooriya, 2012). Drying maize cobs prior to threshing can lower the moisture content to around 15%, thereby improving the efficiency of seed removal from the cobs (Abeysooriya, 2012). However, only 51% of farmers were found to engage in pre-threshing drying practices, while the majority proceeded directly to threshing without this step. This leads to seed damage during threshing, which consequently increases the risk of microbial contamination. 67% of farmers has used 1-3 days for drying cobs before threshing which is a 56% deviation from the duration of 4-5 days of during recommended by the DOA Sri Lanka.

Maize threshing

Removing poor-quality cobs, those that are deformed, unhealthy, pest or disease-infested, or bird-damaged before threshing is essential to maintain seed quality and prevent fungal contamination. However, the study found that none of the sampled farmers performed cob grading prior to threshing. Additionally, 92% of farmers used a harvester for threshing, despite its unsuitability for grains with a soft outer coat. Specifically, the machine, designed for paddy harvesting and threshing, was widely used for maize threshing. Furthermore, the inadequate drying of maize cobs prior to threshing exacerbates the risk of mechanical damage to the grains. According to farmers' estimates, there is a 1.8% of average loss of maize during the threshing process. Notably, no farmers utilized machinery specifically designed for maize threshing, highlighting a critical gap in the adoption of appropriate post-harvest technologies in maize production.

Post-threshing drying practices for maize grain

The post-threshing drying of maize grains is critical to reducing their moisture content to approximately 14%, ensuring safe storage and minimizing the risk of fungal contamination (DOA, 2012). The study revealed that 89% of farmers adhered to this practice, with an average drying duration of three days before storage or sale. Cement beds were the most frequently used drying method, accounting for 41%, with many farmers renting these facilities from larger-scale farmers and collectors. Tarpaulin sheets were the second most common method, used by 39% of farmers. However, 20% of farmers employed unsafe drying practices, including drying grains on tar roads, house floors, and stone floors, which pose significant risks to the quality and safety of the maize due to the increased potential for fungal contamination (Hoffmans et al., 2022).

Storage practices for maize grains

Studies have demonstrated that post-harvest losses of grains are particularly pronounced during the storage stage (Nelson, 2012). A significant majority of farmers (70%) in this study chose to sell their harvest immediately after drying, forgoing storage. The primary reason cited for this practice was the lack of proper storage facilities at the farmers' level. Among those who did opt to store maize at home, the predominant method involved the use of polysack bags (Figure 4). Typically, these filled sacks were stored in a room or on the porch of the house. Only 24% of farmers utilized wooden pallets to support the sacks, thereby avoiding direct contact with the floor. A small fraction (11%) allocated a separate storage room for their maize (Figure 4). Additionally, 4% of farmers stored maize directly on the floor without the use of containers (sacks). These findings underscore the inadequate adherence of farmers to proper storage techniques. According to farmers estimate on average 1.5% of maize loses during the storage. A study conducted by Kumari et al. (2020) identified that the percentage loss of maize did not exceed 5% in four divisions in Anuradhapura districts.

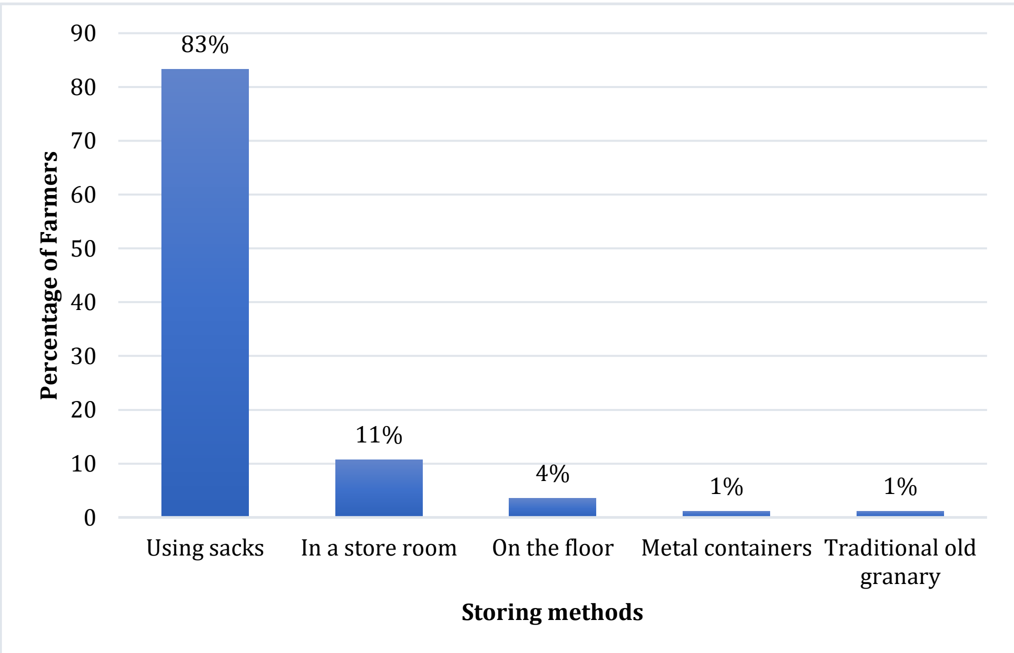

Figure 4. Percentage distribution of farmers with different storing methods of maize grains

Training and awareness programs on maize production

Study findings indicate that only 20% of farmers have engaged in training and awareness program on maize production over their lifetime. Among this, more than half have participated in only a single training session. This underscores the critical need to augment farmers' knowledge base, as it directly influences maize production outcomes.

Conclusions

This study underscores a significant disparity between recommended maize crop management practices and actual farmer practices. Despite their extensive experience in maize cultivation, farmers exhibit lower adoption of best practices, particularly in key agronomic areas such as land preparation, seed usage, field establishment, irrigation, nutrient management, and harvesting. Study findings conclude poor adherence among sampled farmers to post-harvest handling practices, including drying, threshing, and storage. This poor adherence leads to inefficient use of inputs, increased vulnerability to pests and diseases, and substantial post-harvest losses. Furthermore, inadequate post-harvest handling practices heighten the risk of fungal contamination and compromise food safety. Hence the findings highlight the necessity of raising awareness among farmers about best management practices in maize production and post-harvest handling to achieve better yield.

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Conflict of interest statement

The authors declare no conflict of interest.

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