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Accelerated cassava varietal turnover in Tanzania, a direct result of cassava seed system interventions

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Cassava is a vital food security crop grown in the tropics primarily for its starchy tuberous roots that play a significant role in calorie intake in Africa. The cassava seed system has been historically neglected resulting in the widespread propagation of poor quality and diseased planting materials (stems/cuttings). Recently there have been ongoing efforts to modernise cassava breeding and improve seed delivery in Tanzania which have resulted in the creation of a functional and commercially sustainable cassava seed system. This system comprises a decentralized network of seed producers in a hierarchy from early generation to community-based seed with different quality assurance requirements at each level. Seed entrepreneurs are registered on a 'SeedTracker™' database where volumes of seed produced can be tracked for each variety. In this study, we analysed SeedTracker™ data and household survey data to determine the Weighted Average Varietal Age (WAVA) of improved cassava varieties in Tanzania. We used total seed (cuttings) produced as weights for WAVA estimations. Results showed changes in WAVA from 11.3 years in 2018, 13.6 years in 2019, 13.5 years in 2020, 10.6 years in 2021, 11.4 years in 2022 to 10.1 years in 2023. This suggests that there is an accelerating turnover rate of improved cassava varieties. The findings of this study are useful to cassava seed system actors such as policymakers, quality assurance agencies, breeders, and seed businesses. This study also serves as an indicator of the positive impacts being achieved through cassava seed system interventions in the country. Furthermore, it validates the adopted cassava seed system model and suggests that the model could be readily adapted to other crop systems where varieties are being routinely monitored.

KEYWORDS

varietal turnover, Cassava seed system, WAVA, seed renewal frequency, adoption

Introduction

More of the tropical root crop cassava (*Manihot esculenta* Crantz) is produced in Africa than any other continent, however, yields in Africa are significantly below those of the other two major cassava-producing continents—Asia and South America. Tanzania is one of the largest cassava producers in Africa, however, yields are low at 6.5 t/ha [FAO (Food and Agricultural Organisation of the United Nations), 2023] which is well below its estimated potential yield of 25 to 30 t/ha (Lebot, 2019). Intense disease pressure, combined with the slow adoption of improved cassava varieties, has prevented farmers in Tanzania from achieving the potential yields. Cassava Brown Streak Disease (CBSD) and Cassava Mosaic Disease (CMD), both transmitted by the whitefly—*Bemisia tabaci* (Genn.)—significantly reduce yields when susceptible varieties are planted (Thresh et al., 1994; Hillocks et al., 2001; Ndyetabula et al., 2016; Chikoti and Tembo, 2022; Mkamilo et al., 2024). The diseases also cause important losses when farmers recycle stem cuttings of disease-tolerant improved varieties over extended periods (Shirima et al., 2019). The combined effect of CBSD and CMD on cassava yield in Africa causes an estimated financial loss of more than 1 billion USD annually (Patil et al., 2015; Legg et al., 2011).

To achieve the potential yields in cassava, farmers need to adopt the latest improved varieties and take advantage of the genetic gains resulting from enhanced disease resistance and increased yield. An effectively functioning seed system is crucial for the rapid adoption of the latest improved varieties and the swift phase-out of outdated ones. In the U.S., replacing maize hybrids typically takes 3 to 4 years; however, in developing countries, this process is typically much slower. For instance, in 2017, the 15-year-old maize cultivar SC513 was still widely cultivated in eastern and southern Africa (Atlin et al., 2017). The situation is even more challenging for vegetatively propagated crops in developing countries, as farmers often have restricted access to high-quality planting materials (Spielman et al., 2021). Slow rates of varietal turnover negatively impact yields over time, as farmers miss out on genetic advancements from breeding programs that address current biotic and abiotic stresses (Nuthalapati et al., 2024). Key factors contributing to slower varietal turnover in the developing world include issues within seed systems, such as limited commercialization of crop varieties, regulatory obstacles in seed production, and inadequate seed delivery systems.

Varietal turnover, defined as the rate at which farmers replace old cultivars, is a crucial mechanism for farmers to maintain yield gains and mitigate the impacts of evolving biotic and abiotic stresses (Witcombe et al., 2016; Veettil et al., 2018; Boddupalli et al., 2020; Delaquis et al., 2024). Varietal turnover played a key role in The Green Revolution. The yield boost characterizing The Green Revolution was not a one-time event in the 1960s but a sustained increase in productivity due to successive generations of improved varieties (Evenson and Gollin, 2003). Regular adoption of new varieties is also critical to combating resistance breakdowns, as demonstrated by the rapid loss of resistance to blackleg disease of rapeseed within just 3 years (Sprague et al., 2006).

The cassava seed system in Tanzania consists of four seed classes: pre-basic, basic, certified, and quality-declared seed (QDS). The Tanzania Agriculture Research Institute (TARI) primarily produces and sells pre-basic and basic seed through its national breeding programme and seed business unit. Meanwhile, seed companies and registered farmers manage the production and sale of certified and QDS seed classes. The registered farmers, known as Cassava Seed Entrepreneurs (CSEs) in Tanzania, form a decentralized network of suppliers across all cassava-producing districts (Legg et al., 2022).

Seed production across all classes is regulated by the Tanzania Official Seed Certification Institute (TOSCI), the government body responsible for seed quality assurance in Tanzania. TOSCI has set various regulations, guidelines, and tolerances for disease incidences according to each seed class. Seed inspectors from TOSCI use SeedTracker^{TM}, an ICT platform for electronic field registration, inspection and certification of cassava seed production fields at all levels of the seed system. SeedTracker^{TM} enables the collection and storage of detailed data which is useful for estimating varietal turnover rates, and which is gathered through the routine work of TOSCI seed inspectors.

To evaluate the efficiency of Tanzania's cassava seed system and assess the impact of interventions done in the country, it is crucial to understand the adoption rate of improved cassava varieties and the varietal turnover rate. Currently, there are no reliable estimates of these metrics for cassava in Tanzania. To address this, we analyzed 6 years of data (2018–2023) obtained through SeedTracker^{TM} (2018–2022) and a household survey (2024) to determine the varietal turnover rate by using the Weighted Average Varietal Age (WAVA) method. Additionally, we used the household survey data to estimate the adoption rate of improved cassava varieties and seed renewal frequency among the interviewed farmers. The findings of this study provide an assessment of the impact of cassava seed system interventions in the country and offer valuable insights for seed system actors and policymakers in Tanzania and elsewhere in sub-Saharan Africa.

Methodology

Data sources

To determine the cassava varietal turnover rate in Tanzania's cassava seed system, this study employed the WAVA method using seed volumes as weights. Two key assumptions were taken, first, we assumed all seeds produced were planted, and second, we assumed farmers applied a uniform cassava seed rate of 10,000 stem cuttings per hectare. WAVA estimations were done utilizing six years of data (2018–2023) from two different sources. The first source was SeedTracker^{TM} (www.seedtracker.org), which provided 5 years of data (2018–2022). SeedTracker^{TM} data for the period of this assessment were collected by TOSCI seed inspectors.

The second source was a 2024 household survey ($n = 326$) conducted across twelve regions in Tanzania's Lake and Coastal Zones, the country's primary cassava-producing areas (Figure 1), but which recorded information for varieties planted in 2023. These regions collectively accounted for over 70% of Tanzania's total cassava production in 2018/2019 [National Cassava Development Strategy (NCDS), 2020–2030]. The survey employed a combination of purposive and random sampling techniques. At the regional

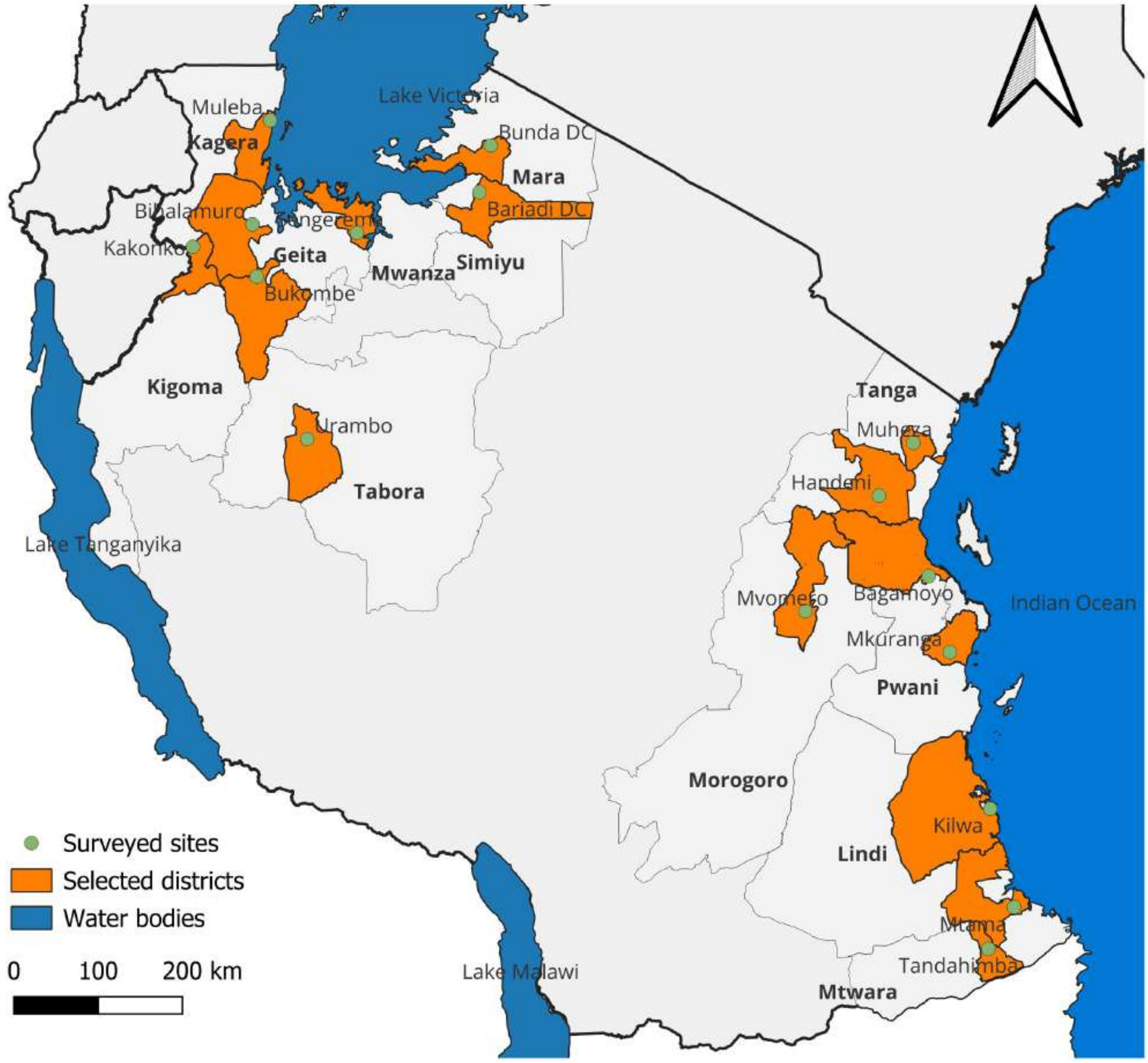

FIGURE 1
Map of Tanzania showing the Weighted Average Varietal Age (WAVA) household survey regions.

level, purposive sampling was conducted in collaboration with Regional Agriculture Officers and key seed system stakeholders to identify districts where Cassava QDS farmers were located. Although the survey targeted cassava root farmers, it was reasoned that proximity to Cassava QDS farmers would positively impact the adoption of improved varieties and increase the likelihood of encountering root farmers cultivating these varieties.

At the village level, random sampling was used to select twenty cassava root farmers. These farmers participated in a questionnaire survey which asked, among other questions, which variety they plant for the current season and what was the area under cultivation of the variety (see Supplementary Questionnaire survey tool). Surveyors also inspected the cassava farms to assess farm area under cassava cultivation and to identify the cultivated cassava varieties. The questionnaire tool is provided as Supplementary Data. Statistical analyses were done using Microsoft Excel and R. Results from the household survey were used to validate the WAVA estimations made using SeedTracker™ data.

Empirical WAVA method

The empirical strategy used to estimate WAVA follows the approach of Brennan and Byerlee (1991). This strategy has been widely used to determine varietal turnover across a wide range of crops such as wheat (Krishna et al., 2014), maize (Abate et al., 2017; De Groote and Omondi, 2023), soybean (Nuthalapati et al., 2024), and potato (Sharma et al., 2024).

$$A_t = \sum_{i=1}^{n} P_{it} \quad (t - y_i) \tag{1}$$

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TABLE 1 Weighted Average Varietal Age (WAVA) for cassava in Tanzania in 2018 (SeedTracker™ Data).

Variety	Year of Release	2018			
		Age	Seed volume	% seed volume	WAVA
Chereko	2014	4	50,000	5.6%	0.2
Kipusa	2014	4	4,300	0.5%	0.0
Kiroba	2004	14	610,100	68.8%	9.6
Kizimbani	2014	4	5,700	0.6%	0.0
Mkombozi	2009	9	16,000	1.8%	0.2
Mkumba	2012	6	0	0.0%	0.0
Mkuranga1	2014	4	171,100	19.3%	0.8
Mumba	2003	15	30,000	3.4%	0.5
TARICASS4	2020	N/A	N/A	N/A	N/A
TOTAL			**887,200**		**11.3**

TABLE 2 Weighted average varietal age (WAVA) for cassava in Tanzania in 2019 (SeedTracker™ data).

Variety	Year of Release	2019			
		Age	Seed volume	% seed volume	WAVA
Chereko	2014	5	27,000	1.2%	0.1
Kipusa	2014	5	47,397	2.0%	0.1
Kiroba	2004	15	1,475,000	63.1%	9.5
Kizimbani	2014	5	0	0.0%	0.0
Mkombozi	2009	10	476,000	20.4%	2.0
Mkumba	2012	7	0	0.0%	0.0
Mkuranga1	2014	5	40,975	1.8%	0.1
Mumba	2003	16	270,847	11.6%	1.9
TARICASS4	2020	N/A	N/A	N/A	N/A
TOTAL			**2,337,405**		**13.6**

A_t = Weighted Average Varietal Age in year *t*.

P_{it} = Proportion of the quantity of seed volume in the seed system (total of cuttings planted for all seed classes) for a given variety '*i*'.

y_i = Year of release of variety '*i*'.

Results

WAVA estimations

There are currently twenty-five officially released cassava varieties in Tanzania (TOSCI). However, data from SeedTracker™ indicates that only nine of these varieties hold significant economic importance within the formal cassava seed system based on the seed volumes produced (Tables 1–5). Among these, Kiroba, released in 2004, is the oldest popular variety in Tanzania's cassava seed system. Between 2018 and 2020, Kiroba accounted for over 60% of the total seed produced. However, by 2022, its share had declined to 32.2% (Table 5).

The latest cassava varieties released in 2020 include TARICASS1, TARICASS2, TARICASS3, TARICASS4, and TARICASS5. Among these, data show that only TARICASS4 has gained significant importance within the cassava seed system, driven by strong demand in the Lake Zone. Just 4 years after its release, TARICASS4 constituted 38% of the total seed volume planted in 2023, highlighting its success as a variety and the efficiency of the cassava seed system pipeline in the speedy delivery of new varieties from breeders to farmers.

Cassava seed production was highest in 2020 in which about 4 million cuttings of different varieties were produced across all seed classes (Table 3). Production was least in 2018 when less than a million cuttings were produced (Table 1). According to the SeedTracker™ data, the average figure for cassava seed production for the 5 years (2018–2022) is about 2.7 million stem cuttings. The weighted average varietal age (WAVA) of cassava in Tanzania over the years 2018 to 2022, as calculated from SeedTracker data, was as follows: 11.3 years in 2018, 13.6 years in 2019, 13.5 years in 2020, 10.6 years in 2021, and 11.4 years in 2022. For 2023, the WAVA calculated from household survey data was 10.1 years (Table 6).

TABLE 3 Weighted average varietal age (WAVA) for cassava in Tanzania in 2020 (SeedTracker™ data).

Variety	Year of Release	2020			
		Age	Seed volume	% seed volume	WAVA
Chereko	2014	6	45,000	1.1%	0.1
Kipusa	2014	6	50,000	1.2%	0.1
Kiroba	2004	16	2,849,700	69.8%	11.2
Kizimbani	2014	6	18,000	0.4%	0.0
Mkombozi	2009	11	240,000	5.9%	0.6
Mkumba	2012	8	326,000	8.0%	0.6
Mkuranga1	2014	6	486,500	11.9%	0.7
Mumba	2003	17	40,000	1.0%	0.2
TARICASS4	2020	0	28,000	0.7%	0.0
TOTAL			**4,083,200**		**13.5**

TABLE 4 Weighted average varietal age (WAVA) for cassava in Tanzania in 2021 (SeedTracker™ data).

Variety	Year of Release	2021			
		Age	Seed Volume	% seed volume	WAVA
Chereko	2014	7	282,000	7.3%	0.5
Kipusa	2014	7	59,000	1.5%	0.1
Kiroba	2004	17	1,153,000	29.8%	5.1
Kizimbani	2014	7	0	0.0%	0.0
Mkombozi	2009	12	502,500	13.0%	1.6
Mkumba	2012	9	663,000	17.2%	1.5
Mkuranga1	2014	7	959,800	24.8%	1.7
Mumba	2003	18	0	0.0%	0.0
TARICASS4	2020	1	245,700	6.4%	0.1
TOTAL			**3,865,000**		**10.6**

Figure 2 illustrates the combined WAVA of cassava in the seed system of Tanzania for each of the 6 years from 2018 to 2023.

Adoption of improved cassava varieties

A total of 326 households participated in the household survey, collectively cultivating 267 hectares of cassava. About 22% of this area was planted with improved cassava varieties, while the remaining 78% consisted of local landraces. The average cassava farm size was 0.8 hectares. Among the surveyed farmers, 73 households (22%) were female-headed, while 253 households (78%) were male-headed. Overall, 25% of the respondents had adopted at least one improved variety of cassava. Chi-square analysis revealed that there was no significant difference in adoption rates between male-headed and female-headed households ($\chi^2 = 1.784$, $p = 0.18$) (Table 7).

In the Coastal Zone, Kiroba was the dominant variety, accounting for 67% of the area under improved varieties, followed by Mkuranga1 at 10% (Table 8). In the Lake Zone, TARICASS4 led with 60%, followed by Mkumba and Mkombozi at 12% each (Table 8). TARICASS4, Mkumba, and Mkombozi were very popular among farmers in the Lake Zone, while Kiroba and Mkuranga1 were favored in the Coastal Zone.

Seed renewal frequency

This refers to the frequency at which farmers renew their seed stock with fresh seed to ensure that they are using seed with optimal genetic and physical quality. Frequent seed renewal is important for preserving the vigor and health of the crop. The seed renewal rate varied more between adopters and non-adopters of improved varieties than between different zones. A clear distinction was noted between adopters and non-adopters of improved varieties. The majority of adopters of improved varieties (60.7%) sourced new planting materials every 1 to 3 seasons (1 to 3 years) while the rest (39.3%) did so at intervals greater than three seasons. In comparison, only a small portion of non-adopters (38.4%) acquired new planting materials within 3 years or less while 61.7% sourced

TABLE 5 Weighted average varietal age (WAVA) for cassava in Tanzania in 2022 (SeedTracker™ data).

Variety	Year of Release	2022			
		Age	Seed Volume	% seed volume	WAVA
Chereko	2014	8	113,500	4.8%	0.4
Kipusa	2014	8	14,000	0.6%	0.0
Kiroba	2004	18	765,500	32.2%	5.8
Kizimbani	2014	8	4,000	0.2%	0.0
Mkombozi	2009	13	116,000	4.9%	0.6
Mkumba	2012	10	197,500	8.3%	0.8
Mkuranga1	2014	8	927,700	39.0%	3.1
Mumba	2003	19	51,000	2.1%	0.4
TARICASS4	2020	2	191,500	8.0%	0.2
TOTAL			**2,380,700**		**11.4**

TABLE 6 Weighted average varietal age (WAVA) for Cassava in Tanzania in 2023 (household survey data).

Improved Variety	Year of Release	Age in 2023	Area (ha)	Seed (stem cuttings)*	% Proportion	WAVA
TARICASS4	2020	3	22.30	222,982	38%	1.15
Kiroba	2004	19	15.05	150,543	26%	4.92
Mkumba	2012	11	4.49	44,920	8%	0.85
Mkombozi	2009	14	4.25	42,492	7%	1.02
Mkuranga1	2014	9	2.93	29,340	5%	0.45
Chereko	2014	9	1.82	18,211	3%	0.28
Kibaha	2003	20	1.82	18,211	3%	0.63
Pwani	2012	11	1.82	18,211	3%	0.34
Rangimbili	2009	14	1.21	12,141	2%	0.29
TARICASS3	2020	3	1.21	12,141	2%	0.06
TARICASS1	2020	3	0.81	8,094	1%	0.04
TARICASS2	2020	3	0.40	4,047	1%	0.02
		Total	**58.13**	**581,331**	**WAVA**	**10.1**

*Seed rate = 10,000 stem cuttings per hectare.

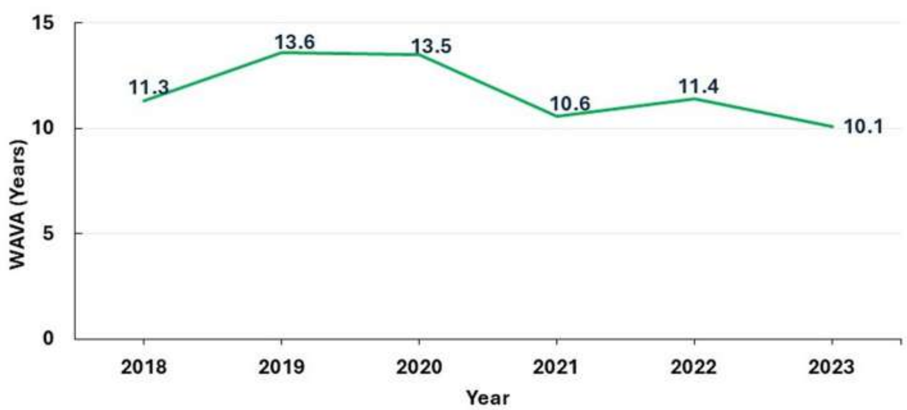

FIGURE 2
Weighted Average Varietal Age (WAVA) for cassava in Tanzania (2018-2023).

TABLE 7 Adoption rate of improved cassava varieties amongst male-headed and female-headed households.

Sex	Adopted	Not Adopted	Total	Adoption Rate (%)
Male	68	185	253	27%
Female	14	59	73	19%
Total	**82**	**244**	**326**	25%

new planting materials after more than 3 years of recycling seeds (Figure 3).

Discussion

Weighted Average Varietal Age (WAVA) requires three data points: varietal identity, year of release, and either the area planted or the seed volume produced for each variety as weights. This study represents the first instance of using SeedTracker™ data to estimate WAVA. Although household surveys provide a more direct and reliable method for estimating varietal turnover by allowing investigators to physically identify varieties and measure their cultivation areas, this study demonstrates that both approaches (utilizing SeedTracker™ data from 2018–2022 and the household survey of varieties planted in 2023) can be effectively used for assessing varietal turnover within a seed system such as that of cassava in Tanzania. SeedTracker™ has proven to be a cost-effective tool for determining varietal turnover due to the fact that data are collected as part of the normal field inspection routine of certification officers. This underscores the importance that digital tools can play in reducing the cost of agricultural interventions and expediting improvements in practice.

However, the household survey revealed that only about half of the twenty-five released cassava varieties were present in the fields of surveyed farmers. Overall, these differed somewhat from the SeedTracker™ data, as three varieties being produced by seed producers and recorded through SeedTracker™ were not grown by household survey farmers, while six improved varieties recorded in the household survey (Kibaha, Pwani, Rangimbili, TARICASS1, TARICASS2, and TARICASS3) were not recorded in SeedTracker™. The discrepancy may arise because the household survey did not cover all the cassava-growing zones in Tanzania. Also, farmers receive improved varieties directly from the national breeding programs when newly released varieties are being promoted. Nevertheless, the combined results indicate that the Lake Zone is largely responsible for driving an accelerated varietal turnover rate in the country.

This study has revealed a declining trend in the weighted average varietal age of cassava in Tanzania over six consecutive years (2018–2023). The trend reflects an accelerated turnover of cassava varieties, characterized by new adopters embracing the most recent improved varieties and former adopters transitioning to newer releases. This dynamic is supported by a robust and geographically extensive cassava seed system in Tanzania, comprised of more than 600 CSEs, which facilitates access to the newly released improved varieties (MEDA, 2022). The weighted average varietal age of cassava in Tanzania of 10.1 years in 2023 is lower than other crops in the region, such as maize, where the average varietal age is 14 years in Eastern Africa, 15 years in Western Africa, and 16 years in Southern Africa (Abate et al., 2017). These results indicate that Tanzania has benefited from interventions and investments in the cassava seed system.

Moreover, the study has found that the adoption rate of improved cassava varieties in Tanzania's major cassava producing regions is 25%. This is higher than a previous report by Walker and Alwang (2015) that estimated an adoption rate of just 14% of improved cassava varieties in sub-Saharan Africa with an average age of 14.1 years. These findings underscore the importance of continuing interventions and programmes aimed at creating and supporting a sustainable cassava seed system in the country. Literature shows that adopting improved crop varieties can increase yields by over 80%, boost farm income, enhance household consumption, promote property ownership, and ultimately reduce poverty (Asfaw et al., 2012; Walker and Alwang, 2015; Manda et al., 2019; Yabeja et al., 2025). Therefore, to better understand the long-term effects of the adoption of improved cassava varieties in Tanzania, we recommend further studies on its impact on farmers' income and nutrition.

It is important to note that in many vegetatively propagated crops (VPCs), including cassava, subjective traits such as taste significantly influence farmers' preferences. Ethnic groups in Tanzania that rely on VPCs as staples often prefer specific varieties due to their taste and cookability, which are closely linked to traditional food processing and preparation methods rather than disease resistance or yield. This phenomenon partly explains the lack of adoption in 75% of the interviewed farmers. Other factors such as insufficient local supply of high-quality improved cassava seed, poor access to information and misinformation about the improved varieties also contribute to the low adoption rates (Asfaw et al., 2012). More studies need to be conducted to identify the specific challenges associated with adopting improved crop varieties in the country.

Additionally, we noted that preferences for improved cassava varieties differed greatly between the Coastal Zone and the Lake Zone. The top three varieties in the Lake Zone are virtually absent in the Coastal Zone, and vice versa. This difference may be due to the adaptation and performance of varieties in different agroecological zones, as well as distinct uses for cassava in these areas. Farmers in the Lake Zone tend to cultivate less sweet, late-maturing varieties best suited for preparing "*Udaga*", a traditional starchy meal made from a mix of maize and cassava flour, popular in the Lake Zone. In contrast, farmers in the Coastal Zone, especially on the northern coast, primarily cultivate cassava for fresh consumption; frying, and selling in urban markets where there is high demand for cassava snacks. When other things remain constant, it is expected that the two zones will have different popular varieties based on farmer and market preferences. We recommend further studies to assess farmers' preferences as well as market preferences in traits such as cookability, sweetness, flour conversion rate and starch content. Understanding these preferences is crucial for developing policies that support strategic breeding for specific market segments and ensuring the rapid uptake of market-preferred varieties.

Also, it has been noted that the use of clean seeds and the practice of frequent seed renewal are essential in mitigating yield

TABLE 8 Improved cassava varieties in the Coastal and Lake Zones.

Improved variety	Coastal zone (ha)	% in coastal zone	Lake zone (ha)	% in lake zone
TARICASS4	0.61	3%	21.69	60%
Kiroba	14.85	67%	0.20	1%
Mkumba	0.00	0%	4.49	12%
Mkombozi	0.00	0%	4.25	12%
Mkuranga1	2.23	10%	0.71	2%
Chereko	0.81	4%	1.01	3%
Kibaha	1.82	8%	0.00	0%
Pwani	1.82	8%	0.00	0%
Rangimbili	0.00	0%	1.21	3%
TARICASS3	0.00	0%	1.21	3%
TARICASS1	0.00	0%	0.81	2%
TARICASS2	0.00	0%	0.40	1%
Total	**22.14**		**36.00**	

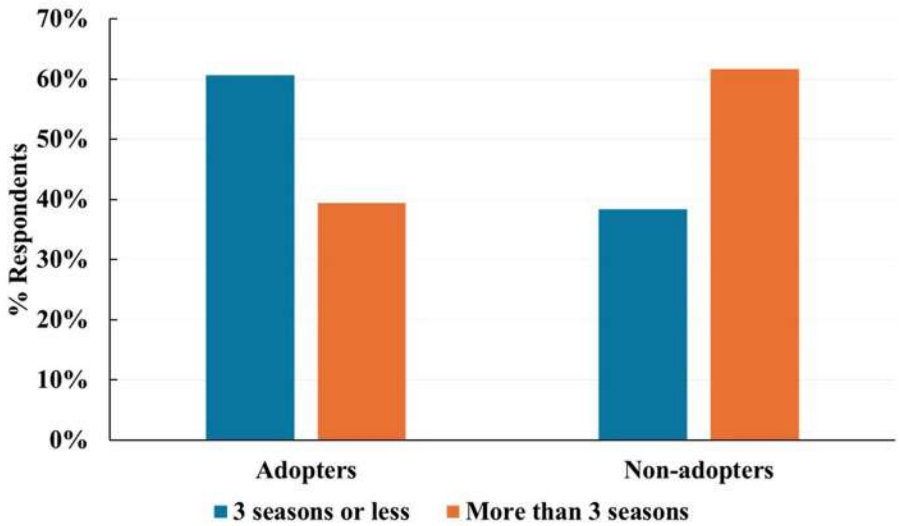

FIGURE 3
Seed renewal frequency among adopters and non-adopters of improved cassava varieties in Tanzania.

losses due to diseases and seed degeneration in cassava cultivation. Clean seeds that are free from pathogens and pests ensure healthy crop establishment and vigorous growth, reducing the incidence of disease outbreaks and subsequent associated yield penalties (Akanbi et al., 2024; Yabeja et al., 2025). Frequent seed renewal refreshes the genetic vigor and health of the crop, preventing the accumulation of viral and bacterial infections that can decimate yields over successive planting cycles (Thomas-Sharma et al., 2017; Shirima et al., 2019; Onofre et al., 2021). It is therefore advised to recycle clean cassava seed for a maximum of three seasons when planting during the long rains in Tanzania (Shirima et al., 2019). The current study revealed that a significantly higher proportion of adopters of improved cassava varieties in Tanzania (60.7%) renew their seed frequently (every 3 years or less) compared to non-adopters (38.4%). This is unsurprising, as early adopters of improved varieties are also more likely to have access to information highlighting the benefits of high quality seed and are typically more commercially focused.

Conclusion

This study successfully estimated the Weighted Average Varietal Age (WAVA) for cassava in Tanzania using SeedTracker™ data as well as household survey data. Both datasets provided broadly comparable results, although they each applied a slightly different approach to WAVA estimation. The most recent weighted average varietal age of 10.1 years (2023) is comparably lower than other more commercialized crops in the region, which highlights the positive impact of interventions and investments in the cassava seed sector. With an adoption rate of 25% and the declining trend of varietal age for improved cassava varieties, there is progress, but also a need for continued support and development of the cassava seed system. Further research into the impacts of improved cassava variety adoption on farmers' income and nutrition could provide valuable insights. Additionally, the study revealed a quicker seed renewal rate for adopters of improved varieties, which is essential for maintaining crop health and productivity. We recommend that seed system actors should ensure that farmers who adopt improved varieties also receive training in good agronomic practices, so that the benefits from the adoption of the technology are maximized. Addressing the preferences and practices of the 75% of farmers who are yet to adopt improved varieties is crucial. Factors such as access to the supply of high-quality seeds, as well as taste and suitability for traditional food preparation methods, play significant roles in farmers' varietal adoption. Tailored policies to support strategic breeding for specific market segments and enhancing farmer education will therefore be vital for the sustainable adoption of improved cassava varieties in Tanzania, as well as in other countries in sub-Saharan Africa where cassava is important.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author/s.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the [patients/ participants OR patients/participants legal guardian/next of kin] was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

JM: Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. MN: Data curation, Investigation, Writing – review & editing. JoN: Formal analysis, Writing – review & editing. MA: Data curation, Investigation, Writing – review & editing. JaN: Data curation, Investigation, Writing – review & editing. NM: Data curation, Investigation, Writing – review & editing. AM: Data curation, Investigation, Writing – review & editing. DM: Data curation, Investigation, Writing – review & editing. PK: Data curation, Resources, Software, Writing – review & editing. JL: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2025.1564907/full#supplementary-material

References

Abate, T., Fisher, M., Abdoulaye, T., Kassie, G. T., Lunduka, R., Marenya, P., et al. (2017). Characteristics of maize cultivars in Africa: how modern are they and how many do smallholder farmers grow? *J. Agric. Food Secur.* 6, 11–17. doi: 10.1186/s40066-017-0108-6

Akanbi, S. U. O., Mukaila, R., and Adebisi, A. (2024). Analysis of rice production and the impacts of the usage of certified seeds on yield and income in Côte d'Ivoire. *J. Agribus. Dev. Emerg. Econ.* 14, 234–250. doi: 10.1108/JADEE-04-2022-0066

Asfaw, S., Shiferaw, B., Simtowe, F., and Lipper, L. (2012). Impact of modern agricultural technologies on smallholder welfare: evidence from Tanzania and Ethiopia. *Food Policy* 37, 283–295. doi: 10.1016/j.foodpol.2012.02.013

Atlin, G. N., Cairns, J. E., and Das, B. (2017). Rapid breeding and varietal replacement are critical to adaptation of cropping systems in the developing world to climate change. *Glob. Food Sec.* 12, 31–7. doi: 10.1016/j.gfs.2017.01.008

Boddupalli, P., Suresh, L., Mwatuni, F., Beyene, Y., Makumbi, D., Gowda, M., et al. (2020). Maize lethal necrosis (MLN): efforts toward containing the spread and impact of a devastating transboundary disease in Sub-saharan Africa. *J. Virus Res.* 282:197943. doi: 10.1016/j.virusres.2020.197943

Brennan, J. P., and Byerlee, D. (1991). The rate of crop varietal replacement on farms: measures and empirical results for wheat. *Plant Varieties Seeds* 4, 99–106.

Chikoti, P. C., and Tembo, M. (2022). Expansion and impact of cassava brown streak and cassava mosaic diseases in Africa: a review. *Front Sustainable Food Syst.* 6:1076364. doi: 10.3389/fsufs.2022.1076364

De Groote, H., and Omondi, L. B. (2023). Varietal turn-over and their effect on yield and food security-Evidence from 20 years of household surveys in Kenya. *Global Food Secur.* 36:100676. doi: 10.1016/j.gfs.2023.100676

Delaquis, E., Slavchevska, V., Almekinders, C. J., Newby, J. C., Sareth, C., Tanthapone, C., et al. (2024). Increased farmer willingness to pay for quality cassava (Manihot esculenta Crantz) planting materials: evidence from experimental auctions in Cambodia and Lao PDR. *J. Food Secur.* 16, 571–594. doi: 10.1007/s12571-024-01453-0

Evenson, R. E., and Gollin, D. (2003). Assessing the impact of the green revolution, 1960 to 2000. *Science* 300, 758–762. doi: 10.1126/science.1078710

FAO (Food and Agricultural Organisation of the United Nations) (2023). FAOSTAT: online statistics database. Available at: https://www.fao.org/faostat/en/#data/QCL (accessed February 18, 2025).

Hillocks, R. J., Raya, M. D., Mtunda, K., and Kiozia, H. (2001). Effects of Brown Streak virus disease on yield and quality of cassava in Tanzania. *J. Phytopathol.* 149, 389–394. doi: 10.1111/j.1439-0434.2001.tb03868.x

Krishna, V. V., Spielman, D. J., Veettil, P. C., and Ghimire, S. (2014). An empirical examination of the dynamics of varietal turnover in Indian wheat. *IFPRI Discussion Paper* 01336. doi: 10.2139/ssrn.2417342

Lebot, V. (2019). *Tropical Root and Tuber Crops: Cassava, Sweet Potato, Yams and Aroids. Crop Production Science in Horticulture Series 17*. Wallingford, UK: CABI. doi: 10.1079/9781789243369.0000

Legg, J. P., Diebiru-Ojo, E., Eagle, D., Friedmann, M., Kanju, E., Kapinga, R., et al. (2022). "Commercially sustainable cassava seed systems in Africa" in *Root, Tuber and Banana Food System Innovations*, editors G. Thiele, M. Friedmann, H. Campos, V. Polar, J. W. Bentley (Berlin: Springer), 453–482. doi: 10.1007/978-3-030-92022-7_15

Legg, J. P., Jeremiah, S. C., Obiero, H. M., Maruthi, M. N., Ndyetabula, I., Okao-Okuja, G., et al. (2011). Comparing the regional epidemiology of the cassava mosaic and cassava brown streak virus pandemics in Africa. *Virus Res.* 159, 161–170. doi: 10.1016/j.virusres.2011.04.018

Manda, J., Alene, A. D., Tufa, A. H., Abdoulaye, T., Wossen, T., Chikoye, D., et al. (2019). The poverty impacts of improved cowpea varieties in Nigeria: a counterfactual analysis. *World Dev.* 122, 261–271. doi: 10.1016/j.worlddev.2019.05.027

MEDA (2022). *Building a strong distribution model for cassava seed in Tanzania*. Available at: https://www.meda.org/marketplace/building-a-strong-distribution-model-for-cassava-seed-in-tanzania/ (accessed January 14, 2025).

Mkamilo, G., Kimata, B., Masinde, E. A., Masisila, F. F., Menya, R. O., Matondo, D., et al. (2024). Impact of viral diseases and whiteflies on the yield and quality of cassava. *J. Plant Dis. Prot.* 131, 959–970. doi: 10.1007/s41348-024-00903-3

National Cassava Development Strategy (NCDS) 2020–2030. Available at: https://www.mephics.co.tz/sites/kilimo/uploads/CASSAVA_DEVELOPMENT_STRATEGY.pdf (accessed: February 20, 2025).

Ndyetabula, I. L., Merumba, S. M., Jeremiah, S. C., Kasela, S., Mkamilo, G. S., Kagimbo, F. M., et al. (2016). Analysis of interaction between cassava brown streak disease symptom types facilitates the determination of varietal responses and yield losses. *Plant Dis.* 100, 1381–1396. doi: 10.1094/PDIS-11-15-1274-RE

Nuthalapati, C. S., Kumar, A., Birthal, P. S., and Sonkar, V. K. (2024). Demand-side and supply-side factors for accelerating varietal turnover in smallholder soybean farms. *J. Cleaner Prod.* 447:141372. doi: 10.1016/j.jclepro.2024.141372

Onofre, K. F. A., Forbes, G. A., Andrade-Piedra, J. L., Buddenhagen, C. E., Fulton, J. C., Gatto, M., et al. (2021). An integrated seed health strategy and phytosanitary risk assessment: potato in the republic of Georgia. *Agric. Syst.* 191:103144. doi: 10.1016/j.agsy.2021.103144

Patil, B. L., Legg, J. P., Kanju, E. E., and Fauquet, C. M. (2015). Cassava brown streak disease: a threat to food security in Africa. *J. Gen. Virol.* 96, 956–968. doi: 10.1099/vir.0.000014

SeedTracker^{TM}. Available at: https://www.seedtracker.org (accessed: February 20, 2025).

Sharma, K., Kumar, A., and Kumar, N. R. (2024). *Varietal Turnover in Potato and its Effect on Yield: Evidence from Household Surveys in India. IFPRI Discussion Paper 2280*. Washington, DC: International Food Policy Research Institute.

Shirima, R. R., Maeda, D., Kanju, E., Tumwegamire, S., Ceasar, G., Mushi, E., et al. (2019). Assessing the degeneration of cassava under high virus inoculum conditions in Coastal Tanzania. *J. Plant Dis.* 103, 2652–2664. doi: 10.1094/PDIS-05-18-0750-RE

Spielman, D. J., Gatto, M., Wossen, T., McEwan, M., Abdoulaye, T., Maredia, M. K., et al. (2021). *Regulatory Options to Improve Seed Systems for Vegetatively Propagated Crops in Developing Countries. IFPRI Discussion Paper 02029*. Washington, DC, USA: International Food Policy Research Institute. doi: 10.2499/p15738coll2.134441

Sprague, S. J., Marcroft, S. J., Hayden, H. L., and Howlett, B. J. (2006). Major gene resistance to blackleg in Brassica napus overcome within three years of commercial production in Southeastern Australia. *J. Plant Dis.* 90, 190–198. doi: 10.1094/PD-90-0190

Thomas-Sharma, S., Andrade-Piedra, J., Carvajal Yepes, M., Hernandez Nopsa, J. F., Jeger, M. J., Jones, R. A. C., et al. (2017). A risk assessment framework for seed degeneration: informing an integrated seed health strategy for vegetatively propagated crops. *Phytopathology* 107, 1123–1135. doi: 10.1094/PHYTO-09-16-0340-R

Thresh, J. M., Fargette, D., and Otim-Nape, G. W. (1994). Effects of African cassava mosaic geminivirus on the yield of cassava. *Trop. Sci.* 34, 26–26.

TOSCI. Available at: https://www.tosci.go.tz/search-seed-varieties?_token=VPkR4i21fTE5Pep5htIoDNoimW5N04Mwx5Re9SiT&q=cassava&button (accessed: February 20, 2025)

Veettil, P. C., Devi, A., and Gupta, I. (2018). "Caste, informal social networks and varietal turnover," in *P.C. 10th International Conference of Agricultural Economists* (Vancouver, BC: Elsevier). doi: 10.22004/ag.econ.277172

Walker, T. S., and Alwang, J. (2015). *Crop Improvement, Adoption, and Impact of Improved Varieties in Food Crops in Sub-Saharan Africa*. Wallingford, UK: CABI. 450. doi: 10.1079/9781780644011.0000

Witcombe, J. R., Khadka, K., Puri, R. R., Khanal, N. P., Sapkota, A., and Joshi, K. D. (2016). Adoption of rice varieties. I. Age of varieties and patterns of variability. *Exp. Agric.* 53, 512–527. doi: 10.1017/S0014479716000545

Yabeja, J. W., Manoko, M. L. K., and Legg, J. P. (2025). Comparing fresh root yield and quality of certified and farmer-saved cassava seed. *J. Crop Prot.* 187:106932. doi: 10.1016/j.cropro.2024.106932