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Understanding seed selection decisions among small-scale maize farmers in Machakos County, Kenya: the dominance of market leader varieties

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Introduction: The maize seed market in Kenya is highly competitive, yet older varieties dominate smallholder farmers' preferences. The current study aimed to identify the key drivers of maize seed selection by examining trait priorities, prior experience, purchase behavior, and sociodemographic profiles of farmers across different seed variety groups.

Methods: Farmers were categorized into three groups based on their preferred maize varieties: market leader, competitor, and low-cost. A multinomial logit model was used for inferential analysis.

Results: The results revealed that 70% of the farmers preferred market leader varieties, while 21% preferred competitor varieties and 7% chose low-cost varieties. Drought tolerance emerged as the most valued trait, reported by 72% of farmers. In addition, farmers reported little experience with different maize seed varieties and hybrids. Trait preferences, previous knowledge and farm size primarily significantly influenced seed selection. Regarding purchasing behavior, most farmers made quick decisions at a mock agro-dealer store, often disregarding price offers and informational posters when their preferred variety was available.

Discussion: This study provides a basis for developing strategies that encourage and influence farmers to broaden their maize seed choice considerations which will ultimately improve domestic maize production as climate change continues. It aimed to understand better the factors influencing farmers' loyalty to market leader maize varieties in Machakos County, Kenya.

KEYWORDS

agro-dealer, competitor, low-cost, multinomial logit, varietal turnover

1 Introduction

Smallholder farmers often face significant challenges when selecting which seed to plant due to the wide variety of available seed options. Farmers must navigate this complex decision by evaluating many of seed traits and understanding the diverse seed options on offer (Wheatley et al., 2021). Therefore, the decision-making process for farmers is a time-consuming cognitive activity that depends on a combination of knowledge, experience, intuition (Martin-Clouaire, 2017), and social networks, which take time to develop. Furthermore, each farmer brings unique experiences, farm conditions, and constraints, which shape their seed choices. Local seed availability, pricing, and regional factors also influence what farmers seek each planting season (Atieno et al., 2023; Waldman et al., 2017).

Farmer seed choice is influenced by various contextual factors, including trait preference, which is one of the key reasons farmers choose to cultivate specific maize varieties (Marenya et al., 2022). Lunduka et al. (2012) found that although farmers valued hybrid maize for its yield potential and drought tolerance, they rated local open-pollinated varieties higher for their storability and certain consumption traits in Malawi. Similarly, in Kenya, studies have shown that adoption rates of improved maize seeds vary, with estimates ranging from 40 to 70% (Odame and Muange, 2011; Simtowe et al., 2019; Simtowe et al., 2021). While other studies report 80% coverage of improved varieties (Smale and Olwande, 2014; Walker and Alwang, 2015).

Despite these adoption rates, there is a noticeable gap in varietal turnover among smallholder maize farmers in Kenya. Many farmers continuing to rely on familiar, older varieties which dominate the markets rather than newer improved options (Rutsaert et al., 2021). The current study explored reasons for the continued dominance of market leader varieties in the Kenyan maize seed market. By segmenting farmers based on their varietal preferences, the study was to uncover the factors that drive the persistent popularity of older maize varieties and assess whether these preferences are linked more to the traits of the varieties or other factors such as farmer characteristics and decision-making processes. Additionally, the study examined the seed choice behavior of farmers and the factors that influence the selection of maize varieties. This study provides a basis for developing strategies that encourage and influence farmers' maize seed choice consideration which will ultimately improve domestic maize production as climate change continues.

1.1 Background

Maize is a vital pillar of food security in Kenya, underpinning both national well-being and rural livelihoods, while making a substantial contribution to the country's Gross Domestic Product. In 2023, approximately 2.55 million hectares were dedicated to maize cultivation, an 18% increase from the 2.17 million hectares recorded in 2022 (Stats Kenya, 2025). Despite this expansion in cultivated area, overall maize production has trended downward in recent years.

Production dropped from 3.795 million metric tonnes to 3.304 million metric tonnes in 2021, representing a 12.8% decline (Mutiso and Kimtai, 2022). During the same period, total domestic consumption rose from approximately 4.005 million metric tonnes in 2020 to 4.212 million metric tonnes in 2021 (KNBS, 2022). To bridge the demand, maize imports surged from 273.5 thousand metric tonnes in 2020 to 486.5 thousand metric tonnes in 2021 (KNBS, 2022).

More recent data reflect lingering challenges as maize production declined by 6.1%, dropping from 47.6 million 90 kg bags in 2023 to 44.7 million bags in 2024, a decline attributed to erratic short rains during the year (KNBS, 2025). As climate variability continues to threaten maize yields in Kenya, deploying the right seed varieties becomes ever more critical. Breeders have introduced climate-smart maize, including drought-tolerant, pest-resistant, and fast-maturing hybrids, to help farmers adapt to changing conditions (Maina, 2024). However, adoption of these recently improved maize seeds remains low, consenting low varietal turnover.

Previous research on adopting agricultural innovations suggests that farmers adopt new technologies when they perceive benefits, although these benefits vary by individual and context (Feder et al., 1985; Sunding and Zilberman, 2001; Chavas and Nauges, 2020). Rapid varietal replacement plays a critical role in climate change adaptation and ensuring food security (Smale and Olwande, 2014; Abate et al., 2017; Rutsaert and Donovan, 2020). Regular varietal replacement improves productivity, helps mitigate the impact of pests and diseases (Cairns and Prasanna, 2018; Prasanna et al., 2020), and supports the adaptation of crops to changing climate conditions (Ray et al., 2012).

Additionally, newer varieties respond better to fertilizers, boosting yields (De Groote and Omondi, 2023). The consequences of slow varietal turnover are significant, affecting not only farmers' productivity but also the viability of seed companies. When farmers continue using outdated varieties, it can lead to stagnating or declining yields, poor adaptation to climate change, and greater vulnerability to pest and disease outbreaks (Chivasa et al., 2022). Moreover, continued reliance on old varieties can result in customer dissatisfaction, reduced sales, and decreased seed companies market share, ultimately affecting farmers brands perception (Chivasa et al., 2022).

Recent data underscores the persistence of older maize varieties in the Kenyan seed market. In 2019, the average age of popular maize varieties in Kenya was 19 years, with some varieties being as old as 33 years (Mabaya et al., 2021). In 2021, the most sold maize varieties ranged between 15 and 35 years old (Mabaya et al., 2021). Despite advances in breeding programs (Prasanna et al., 2020), market leader varieties that are old in the market continue to hold a dominant position in the market, raising the question: Are these new varieties not meeting farmer's needs, or are farmer's choices driven by factors beyond just seed traits?

A few newer improved maize seeds have been made available in the market such as P3812W offered by Pannar, which is considered a better choice than older varieties like Pannar 691. It exhibits better uniformity, higher yields, and excellent grain quality, making it a competitive option for farmers seeking improved performance. These new varieties such as SAWA (DSLH103) and WE1101 were introduced less than 10 years ago (Appendix Table S1) offer promising traits such as disease resistance and higher yields; their performance can vary based on agroecological conditions, disease pressures, and management practices.

The existing research on seed choice has focused on comparing farmers who adopt stress-tolerant varieties with those who do not (Fisher et al., 2015; Lunduka et al., 2019; Simtowe et al., 2019). However, this focus does not fully capture the broader traits and factors influencing farmers' decisions each season. On the supply side, the seed industry plays a critical role in providing diverse, locally adapted, and high-quality seeds, which help farmers increase agricultural productivity and conserve natural resources (Singh et al., 2013; Massresha et al., 2021). In Kenya, the maize seed market has seen the release of numerous varieties, with 63 varieties of maize seed being introduced between 2017 and 2019 and about 65 maize seed varieties available for sale by 2021 (Mabaya et al., 2021).

The Kenyan public-sector maize breeding programs have succeeded since the 1960s and 1970s Green Revolution by expanding hybrid and improved seed availability (De Groote et al., 2002). The seed sector in Kenya operates through two main delivery systems: the formal system, which includes certified seeds from multinational and domestic seed companies, as well as public and donor investment programs, and the informal system, which involves farmer-saved seeds (Rutsaert and Donovan, 2020). About more than 10,000 agro-dealers in Kenya, are crucial in distributing these seeds to small-scale farmers (Rutsaert et al., 2021).

Despite the efforts of breeding programs and numerous seed varieties, the Kenyan maize seed market remains dominated by a few market leader varieties, primarily those from the Kenya Seed Company, which holds about 70% of the market share. Van Dycke et al. (2024) indicates that the Kenyan maize seed sector, although much more -'developed'- than many of its African peers, remains remarkably undynamic. This scenario persists despite increasing demand for maize as Kenya's population grows. The population is projected to double by 2058 by UN World Population Prospects (2019), further pressuring smallholder agriculture to provide larger volumes of nutritious food (Giller et al., 2021). In recent years, Kenya has struggled to achieve maize self-sufficiency, with production consistently lagging consumption (Kenya National Bureau of Statistics (KNBS), 2023). Between 2020 and 2021, maize production declined by 12.8%, while consumption increased, leading to a rise in imports (Kenya National Bureau of Statistics (KNBS), 2023). To close this demand–supply gap, the benefits of improved maize seed varieties must be fully realized through increased adoption and varietal turnover (Veettil et al., 2018).

2 Methodology

2.1 Sample selection

The study was conducted in Machakos County Kenya between February and March 2021. A follow-up study with the same group of farmers was carried out between April and May 2023. Machakos County is a semi-arid area that has registered declining yields for maize in the previous decade due to drought and overall climate change with high temperatures and low rainfall (Omoyo et al., 2015; Nyamai David et al., 2024). Multistage sampling was applied, and three of the eight sub-counties of Machakos were randomly selected: Mwala, Matungulu, and Kangundo. Villages were stratified by sub-county, and 20 were randomly selected; thus, seven villages in Mwala and Matungulu and six villages in Kangundo, Figure 1. A farmer was eligible to participate in the study if the following conditions were met: (i) the household must have purchased hybrid maize seed at least once in the last 3 years, and (ii) they must be involved in decision-making on maize seed purchase either alone or jointly. The target respondent was smallholder farmers engaged in maize production. Up to 32 farmers per village were randomly selected among those eligible and invited to participate in the study. The study aimed at a 50/50 gender split for farmer selections. Overall, men had a higher percentage of no-shows, leading to a higher percentage of women participating in the study.

2.2 Study design

A mock agro-dealer store was built in each selected village where nine commercially available, improved and hybrid maize seeds were presented on shelves (Appendix Table S1). These hybrids were selected

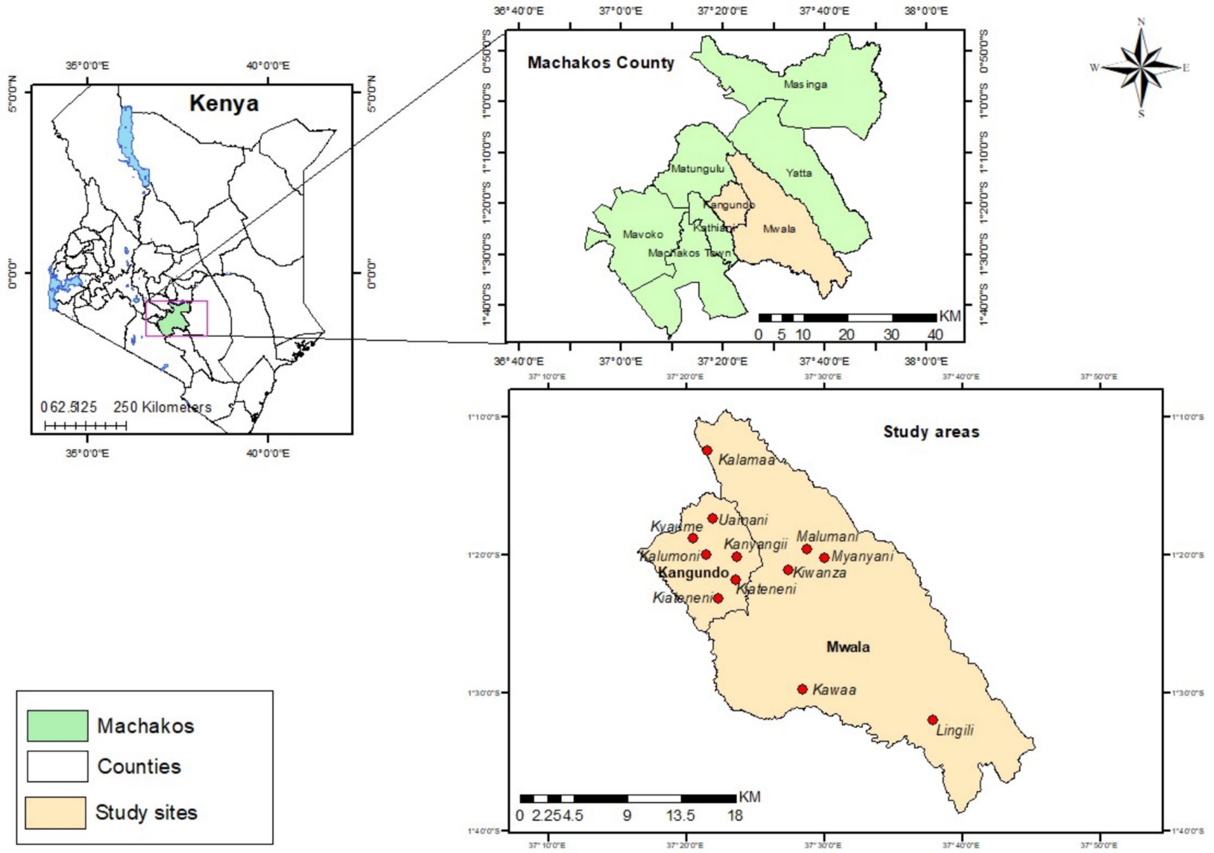

FIGURE 1
Study site in Machakos County, Kenya.

based on agro-dealer sales in collaboration with seed companies active in the study area from among those currently available in the local market and suitable for the agro-ecological zone (dry mid-altitude). Six seed companies were found to operate in the study area: SeedCo, Bayer, Kenya Seed Company, Western Seeds, Dryland Seeds, and Corteva. Two seed varieties per brand were selected from each of three seed companies namely, SeedCo, Bayer, and Kenya Seed Company, and made available in the store. For the other three companies, only one variety was included in the study. The oldest variety was DH02, which is 29 years old as indicated in Table 1, and the most recent was Sungura 301, which is 9 years old in the market.

Three variety preference categories based on farmers stated intentions to purchase specific hybrid seeds were established. The first category of varieties is the market leader category, which is comprised of farmers who planned to buy Duma 43 hybrid seed which is the most market-dominant hybrid seed in the study site. The second is the Competitor category which includes farmers that preferred to purchase Sungura 301, DK8031, DK8033 and PHB3253 hybrid seeds. DH02 and DH04, both products from Kenya Seed Company, were offered at a lower market price of KES 400 and were categorized as low-cost varieties, thus a 20% lower in price compared to other available hybrids in the study area. This lower pricing is consistent with Kenya Seed Company's parastatal pricing strategy, which sets seed prices at 2.5 times the prevailing commercial price of maize grain, thereby aligning with broader market conditions while maintaining affordability for farmers.

Among the nine varieties excluded from the study were PHB 3253 and Sawa, as they were not preferred by farmers. The market share of the respective varieties and the aggregated preference categories indicate the market leader having a market share of 69.7%, the competing varieties 22.4% and the low-cost varieties 7.1% (Table 1).

Participating farmers were randomly allocated to six different cells and assigned to select a maize hybrid from a mock agro-dealer store. In this context, a cell refers to a distinct experimental group or condition in a research study. Each cell represents a specific scenario or treatment under which participating farmers interacted with the mock agro-dealer store. In half of the cells (cell 1, 3 and 5; Table 2), participants had access to all hybrids available in the store. Participants in the remaining cells (cell 2, 4 and 6) faced an 'out-of-stock situation (OOS)' in which the hybrid they planned to purchase was not available. The OOS condition mimicked a situation that farmers would face if a seed company/brand were to replace an older product. A key question for brands is whether customers facing a stockout will delay their purchase, go to a different store (negatively affecting the retailer), select another product from the same brand, or switch to a different brand (negatively affecting the brand).

In total, 293 participated in the in-stock treatment and 294 participants in the out-of-stock treatment. The split for in-stock and out-of-stock for market leader, competitor hybrid and low-cost varieties were, respectively, 210 and 207, 60 and 68, and 23 and 19. A survey and focus group discussions data on farmers' motivations, access to information and seeds, and perceptions of risk were collected to complement the mock agro-dealer store experiment.

2.3 Data capturing

The study collected data using mixed methods, integrating both qualitative and quantitative approaches. Ethical clearance was obtained from the International Livestock Research Institute prior to data collection. Enumerators were recruited and trained intensively over 2 weeks to ensure data quality. Data collection involved face-to-face interviews, with responses recorded on tablets and audio recordings used to capture the duration of farmers' participation in the mock agro-dealer store. Before participation, the study informed participants about its purpose, ethical clearance, and guarantees of anonymity during data analysis and reporting. Informed consent was subsequently obtained from all participants. Observations were conducted alongside data collection, with contemporaneous notes taken. For the qualitative component, a checklist guided the focus group discussions, while for the quantitative component, a structured questionnaire coded in SurveyCTO was administered using tablets.

2.4 Analysis

Data analysis was carried out using STATA software. Descriptive statistics such as Chi-square association tests, independent sample t-tests, and one-way analysis of variance (ANOVA) were used to compare hybrid attributes and farmer profiles across the three categories: market leader, competitor and low-cost varieties. A multinomial logit model (MNL) was used for inferential statistics to assess the factors that influence farmer seed selection. The outcome variable was categorical for farmers who planned to purchase the market leader variety, competitor varieties and the low-cost varieties in the store.

TABLE 1 Classification of hybrid maize seed varieties that respondents planned to buy (n = 587).

Variety	Market price per 2 kg	Variety age (Years)	Seed company brand	Farmer preference (%)	Market share (%)	Category	Category (%)
Duma 43	Kes 500	20	Seed Co	69.7	40	Market leader	69.7
DK8031	Kes 500	21	Bayer	10.5	17	Competitor	22.4
DK8033	Kes 500	20	Bayer	5.9	1	Competitor	
PHB3253	Kes 500	28	Pioneer	4.0	15	Competitor	
P2809W	Kes 500	29	Pioneer	1.0	10	Competitor	
Sungura 301	Kes 500	9	Seed Co	1.0	7	Competitor	
DH02	Kes 400	29	Kenya Seed Company	5.9	8	Low-cost	7.1
DH04	Kes 400	23	Kenya Seed Company	1.2	4	Low-cost	

TABLE 2 Mock agro-dealer store design treatments.

Treatments	Preferred product available	Preferred product out-of-stock
Control	Cell 1	Cell 2
Information: A poster is included in the store with technical information about the available varieties	Cell 3	Cell 4
Promotion: two randomly selected products have a price promotion of 10%.	Cell 5	Cell 6

Farmers' decisions to purchase new seed varieties are often analyzed through frameworks like the Diffusion of Innovations Theory (Rogers, 1962) and the Theory of Planned Behavior (TPB; Ajzen, 1991). These theories emphasize factors such as perceived benefits, social influence, and behavioral intentions. The current study applied TPB, which underpins the study of farmers' perceptions and drivers for varietal turnover. TPB postulates that the performance of behavior is a joint function of intentions and perceived behavioral control (Ajzen, 1991). Intentions capture the motivational factors that influence behavior; they indicate how hard people are willing to try to perform a behavior.

Overall, the stronger the intention to engage in behavior the more likely its performance is, since the likelihood of accepting it is high (Ajzen and Madden, 1986). The probability, P_{ij} , of respondents selecting a particular variety alterative depends on the characteristics of the chooser, factors that influence their choice and the choice represented by vector X_{ij} with $å_{ij}$ assuming a logistic distribution (Wulff, 2015). This is captured by the following MNL in Equation 1 (Wulff, 2015):

$$\text{where},\ldots m \qquad P_{ij} = \frac{e^{xi\,\beta'}}{\sum_j^m = 0 e^{xi\,\beta'}}. \quad j = 0 \tag{1}$$

where m = 3. The likelihood function for the multinomial logit model can be written as (Chalwe, 2011):

$$L = \prod_{i=1}^{n} P_{i0}^{y_{i0}} \ldots P_{i3}^{y_{ij}} \tag{2}$$

Equation 2 gives the density function for a multinomial logit for one observation while Equation 3 gives the likelihood function for a sample of n independent observations with j alternative options (Chalwe, 2011):

$$L_n = \prod_{i=1}^{n} \prod_{j=0}^{m} P_{ij}^{Y_{ij}} \tag{3}$$

Taking logs in Equation 4 gives the following log-likelihood function in Equation 7 (Maddala, 1999):

$$L = \ln L_n = \sum_{i=1}^{n} \sum_{j=0}^{m} y_{ij} \ln P_{ij} \tag{54}$$

where P_{ij} is a function of parameters $\hat{a}$ and regressors defined in Equation 1 with first order condition for the Maximum Likelihood Estimates of $\hat{\hat{a}}$ given by Equation 5 (Maddala, 1999):

$$\frac{\partial L}{\partial \beta} = \sum_{i=1}^{n} \sum_{j=0}^{m} \frac{y_{ij}}{P_{ij}} \frac{\partial P_{ij}}{\partial \hat{\hat{a}}} = 0 \tag{5}$$

The probability of a farmer selecting the first variety option (base category) $j = 0$ has been normalized to zero since all the probabilities must sum up to 1 (Maddala, 1999). Therefore, only two parameters will be identified and estimated from the three choices. The probability of the respondent using any of the alternatives instead of the base category is given by Equation 6 (Wulff, 2015). MNL estimates are estimated using Maximum Likelihood Estimation (MLE), which explains the variation in the dependent variable as a function of one or more independent variables.

$$P_{ij} = \frac{\exp(X_i \beta')}{1 + \sum_{j=0}^{4} \exp(X_i \beta')}, \text{where } j = 0,1,2,3 \tag{6}$$

Therefore, the estimated coefficient for each choice reflects the effect of x_{ij} on the respondent's likelihood of choosing a particular variety relative to the reference. While predicted probabilities provide us with information about the direction and magnitude of the relationship, it may be difficult to precisely determine whether a relationship can be established (Wulff, 2015). Thus, the use of marginal effects (ME) is defined as the slope of the prediction function at a given value of the explanatory variable and thus informs about the change in predicted probabilities due to a change in a particular predictor (Bowen and Wiersema, 2004). Even though marginal effects for a multinomial model may be complicated to derive, they have a quite distinctive and simple form (Wooldridge, 2010). For a continuous independent variable, Equation 7 shows the marginal effects (ME):

$$ME_{ij} = \frac{\partial P_{ij}}{\partial X_{ik}} = \frac{\partial \Pr(y - j | X_i)}{\partial X_{ik}} = P_{ij}\left(\beta_{kj} - \hat{\beta}_i\right) \tag{7}$$

where $\hat{\beta}_i = \sum_m^2 \beta_{km} \Pr(y = m | X_i)$ is a probability-weighted average of the coefficients for different choice combinations, $\hat{a}_{km}$ (Wulff, 2015). Following this the multinomial logit model will be used and fitted into the data as Equation 8 indicates:

$$\begin{aligned} Y_{ij} = {} & \beta_0 + \beta_1 \text{Gender} + \beta_2 \text{Variety Information} + \beta_3 \text{AGE} \\ & + \beta_4 \text{Education} + \beta_5 \text{Foodtraits} + \beta_6 \text{ Harvest traits} \\ & + \beta_7 \text{Maize Plot} + \beta_8 \text{Farm size} + \beta_9 \text{Yield traits} \\ & + \beta_{10} + \beta_{11} \text{Early maturing traits} + \beta_{12} \text{Disease and Pest traits} \\ & + \beta_{13} \text{Number of varieties purchased in the past} + \varepsilon_{ij} \end{aligned} \tag{8}$$

where Y_{ij} represents the probability of choosing the different varieties. The variables in Equation 8 were hypothesized to influence farmers' seed selection. The gender variable, measured as binary (male or female), was hypothesized to influence varietal preference and selection from the mock agro-dealer shop. Gender disparities in access to seeds and agricultural information often shape decision-making processes, as adopting improved seed requires both access to genetic resources and the knowledge to use them effectively (Quisumbing et al., 2014; Otieno et al., 2021).

Previous studies have highlighted significant gender differences in seed use, particularly for climate adaptation (Doss and Morris, 2000; Doss, 2013; Colfer et al., 2015; Anderson et al., 2017). Otieno et al. (2021) found that male farmers in Lower Nyando, Kenya, and Hombolo, Tanzania, adopted improved seed varieties at higher rates than their female counterparts. Based on this evidence, it was expected that gender would influence varietal choice, with men more likely to select recently developed varieties.

The age variable, treated as a continuous measure representing the farmer's age in years, was also hypothesized to influence seed choice. Studies in Kenya indicate that many farmers are middle-aged or older, a demographic that remains engaged in enhancing farm productivity (Wawire et al., 2021; Musafiri et al., 2022). Moreover, youth involvement in seedling production has been linked to positive outcomes for both the agricultural and seedling sectors (Bannor et al., 2021).

Seed trait preferences were measured as a dummy variable to distinguish between farmers who prioritize specific seed traits and those who do not. The yield trait, for example, was hypothesized to influence the type of seed selected. Evidence from Malawi shows that farmers highly value hybrid maize for its superior yield potential (Lunduka et al., 2012). Additionally, Marenya et al. (2021) found that farmers often prioritize yield while also seeking varieties with drought and disease tolerance. Yield continues to be one of the most important traits in varietal selection (Bellon and Risopoulos, 2001; Bellon et al., 2006; Bellon and Hellin, 2011).

The preference for high-yielding varieties is also likely influenced by income and plot size, as larger plots offer greater returns, reinforcing the desire for higher yields. The income variable was hypothesized to be positively associated with seed choice, given that previous studies have shown a strong correlation between income levels and the adoption of hybrid or improved seed varieties (Smale and Olwande, 2014; Mathenge et al., 2015). For instance, Mathenge et al. (2014) reported that hybrid maize adopters had significantly higher incomes and asset values compared to those growing local or improved open-pollinated varieties. Furthermore, farm size, which is often indicative of greater resource endowment and production scale, was also hypothesized to positively influence the adoption of improved hybrid seeds (Mathenge et al., 2014).

The education variable, represented by the total number of years of formal schooling completed, was hypothesized to influence seed choice. Previous research has consistently shown that household heads with more years of formal education are more likely to adopt agricultural innovations and make informed choices regarding crop and seed investments, leading to enhanced household income (Fekadu, 2008).

These variables were incorporated into the MNL model. However, the MNL model presents the problem of Independence from Irrelevant Alternatives (IIA). This issue arises due to the assumption that the random errors of the residuals are independent and homoscedastic. Consequently, the ratio of choice probabilities between any two alternatives is influenced by other alternatives which are not present in the choice set (Luce, 2012; Ben-Akiva and Lerman, 1985). A significant implication of the IIA assumption is that the removal or addition of irrelevant alternatives in the choice set can systematically alter the relative probabilities of selecting one alternative over another, which can lead to biased parameter estimates (Hausman and McFadden, 1984). The presence of the IIA problem can be tested using either the Hausman-McFadden or Small and Hsiao tests (Hausman and McFadden, 1984). To correct for the IIA problem, alternative statistical methods that relax this assumption can be employed, such as the Multinomial Probit model, Nested Logit model (McFadden, 1981), and Random Parameter Logit (RPL) model (Train, 1998).

3 Results

3.1 Comparison of farmer characteristics

Farmer characteristics for the three categories are presented in Table 3. Overall, there were no significant differences regarding the farmer profile of those interested in the market leader, competing varieties or low-cost varieties. In terms of farm indicators, the farm size used for planting maize and the percentage of maize sold were indicative of preference for low-cost varieties. Farmers that preferred low-cost varieties had more land to make farming and sold a larger percentage of the harvest than the other two groups.

3.2 Comparison of trait priorities

The seed characteristics that farmers were looking for disaggregated by the three variety preference categories are indicated in Figure 2. Overall, the most mentioned seed characteristics were drought tolerance (72%), yield potential (70%), characteristics linked to maize consumption such as taste, sweetness and cooking quality (57%) and characteristics linked to grain quality such as kernel size and weight (55%). A comparison of farmers who prefer market leader, competitor, or low-cost maize varieties reveals differing needs and expectations from a variety. Most farmers selected varieties classified under market leader because of their consumption quality-related characteristics with resilience being ranked first besides harvest performance. This is important because majority of households produce maize for household consumption. In contrast, low-cost varieties were the top choice because of their drought tolerance and early maturity traits reported by 90 and 64% of farmers, respectively. However, fewer farmers, 36%, selected them because of consumption-related characteristics. Farmers interested in competitor hybrids were looking for a harvest performance, such as high yield potential and prioritized characteristics linked to grain quality, as indicated by 84 and 67% of farmers, respectively.

3.3 Farmer experience, attitude, and behavior during seed selection

The experience of farmers in the different segments and their attitude toward seed prices is shown in Table 4. To capture farmers' experience with hybrid seeds, each respondent was asked about the number of maize varieties grown in the past with a reference period

TABLE 3 Sociodemographic characteristics of farmers preferring the market leader, competitor and low-cost varieties.

Variable	Total (n = 587)	Market leader (n = 417)	Competitor (n = 128)	Low-cost (n = 42)	ANOVA p-value
Age (Years)	49.61	49.08	52.05	47.38	0.08
	(14.71)	(14.94)	(14.86)	(47.38)	
Gender (Male%)	42.76	42.69	44.53	38.10	0.76
Married (%)	83.82	82.97	85.16	88.10	0.62
No Education (%)	13.12	13.19	13.28	11.90	0.97
Primary Education (%)	51.79	52.28	46.88	61.90	0.22
Secondary Education and Higher (%)	35.09	34.53	39.84	26.19	0.25
Land under farming (Acres)	2.30	2.25	2.26	2.89	0.25
	(2.36)	(2.48)	(1.92)	(2.88)	
Land under maize in Coming season (Acres)	1.67	1.67	1.49	2.20	0.05
	(1.65)	(1.76)	(1.23)	(1.64)	
Income from Agriculture (%)	62.12	61.71	63.59	61.67	0.78
Income from other sources (%)	37.84	38.24	36.41	38.33	0.79
Maize consumed (%)	55.84	56.31	56.56	49.05	0.22
Maize sold to traders (%)	26.41	24.98	28.71	33.57	0.04
Maize donated (%)	13.53	14.17	11.05	14.64	0.06
Maize used as in-kind payment (%)	3.02	3.35	2.27	2.02	0.38
Maize kept as seed (%)	0.11	0.14	0.04	0.00	0.75
Maize used as livestock feed (%)	0.93	0.82	1.37	0.71	0.43

In parentheses are the standard deviations.

of 4 planting seasons or 2 years ago. The respondents were asked to recall the hybrid seeds they had planted in the most recent growing seasons. While the recall is generally considered an unreliable indicator due to potential biases, efforts were made to minimize this bias by keeping the recall period as short as possible. One-third of farmers had only grown one variety, and 27% had grown two varieties and 40% had grown more than two varieties in the past. Farmer experience with hybrid seed varied across the three categories. The market leader category showed the least experience growing different varieties, with an average of 2.51 varieties, compared to an average of 3.21 varieties in the competitor category and 3.50 varieties in the low-cost category. Of note, over 40% of farmers selecting the market leader only had experience with exclusively that variety.

Overall, approximately 67% of farmers reported that price was the most important aspect of their seed selection, while 33% reported that the seed price was unimportant. For the ones that said that price is important, there was an important distinction in what seed price represents to them, as 22% indicated that price is important and an indicator of affordability. In comparison, 40% reported that price is important and an indicator of quality. Across the three categories of farmers, those in the low-cost category registered the highest percentage of farmers (67%) who viewed price as unimportant. In contrast, farmers in the market leader and competitor categories viewed price as an important indicator of quality, 43 and 41%, respectively.

Farmer behavior during the seed selection exercise was studied by recording the real time taken to select seeds, the number of farmers that asked questions during seed selection and the attention paid to seed varieties in the mock store (Table 5). The results indicated that farmers took 78 s to select seeds if their preferred variety was out of stock but only 34 s to select a seed when their preferred variety was in stock. The difference in seed selection time between the in and out of stock condition differed greatly between the three farmer categories. Farmers preferring the market leader needed the most time to select a variety when they could not select their preferred seed, needing around 50 s more. In contrast, those choosing a competitor variety needed only around 20 s more to make their choice. The percentage of farmers asking questions was also highest within the market leader segment. Overall, very few farmers asked questions when their preferred variety was available.

3.4 Regression results

Table 6 shows the coefficient estimates for the MNL model on the factors that influence farmers' decisions to purchase specific maize varieties. The Hausman test for IIA revealed the model's validity with a p-value of 1. The variance inflation factor showed a low correlation with the independent variables. The base category is the farmers who planned to purchase low-cost varieties. According to the results, the age of the farmer variable was positively statistically significant, indicating that older farmers are more likely to purchase market leader variety and competitor varieties compared to low-cost varieties. Seed characteristics linked to food traits and consumption, such as taste, sweetness, and cooking quality,

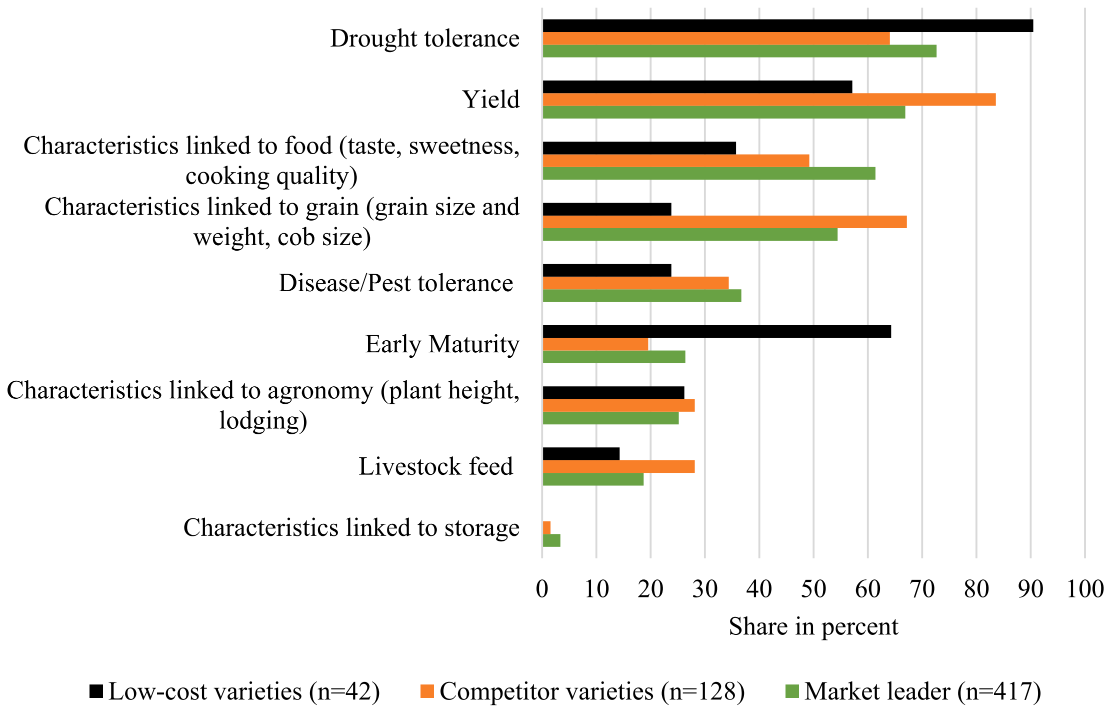

FIGURE 2
Maize seed characteristics that farmers look for by the three categories of maize seed varieties as reported by farmers during face-to-face interviews.

TABLE 4 Attitude and experience of smallholder farmers with maize seed varieties.

Variable	Total (*n* = 587)	Market leader (*n* = 417)	Competitor varieties (*n* = 128)	Low-cost varieties (*n* = 42)	ANOVA *p*-value
Attitude toward seed price					0.041
Price is not important (%)	36.04	33.68	33.88	67.57	
Price is important and an indicator of affordability (%)	22.37	22.19	23.97	18.92	
Price is important and indicator of quality (%)	40.48	42.82	41.32	13.51	
Number of different varieties grown in the past					0.003
One (%)	33.22	40.53	17.97	7.14	
Two (%)	26.92	27.1	28.91	19.05	
More than two (%)	39.86	32.37	53.13	73.81	
Number of varieties grown on average	2.73	2.51	3.21	3.5	0.006
	(1.47)	(1.38)	(1.52)	(1.58)	

In parentheses are the standard deviations.

indicated a positive association with the market leader category in reference to the low-cost varieties. Seed characteristics linked to grain (grain size and weight, cob size) and harvest traits indicate a significant positive relation between market leader and competitor varieties categories concerning the low-cost category. Both market leader and competitor varieties categories, respectively, in reference to low-cost category.

The results further showed that the competitor variety had a positive association with yield traits in reference to low-cost varieties. Disease and pest-tolerant traits were positively associated with market leader and competitor categories. In contrast, early maturity traits indicate a significant negative association with the market leader category and competitor categories. The number of varieties purchased before had a negative association with the market leader and competitor variety categories, depicting that farmers who purchased more varieties are less likely to be in market leader and competitor categories.

The farm size and percentage of land with maize variables had a negative relationship with the competitor varieties category. Farmers that owned more than one acre of farms were unlikely to purchase competitor varieties. Additionally, 67% of smallholder maize farmers with one acre or more farm sizes showed a negative correlation with market leader and competitor varieties. This implied that the likelihood of purchasing market leader and competitor varieties decreases among smallholder farmers as farm size increases. Regarding those who planted the same variety as last season, there was

TABLE 5 Seed selection behavior of farmers.

Variable	Total (*n* = 587)	Market leader (*n* = 417)	Competitor varieties (*n* = 128)	Low-cost varieties (*n* = 42)	ANOVA *p* value
Time spent on seed selection (Real time recorded in seconds)					
Preferred variety in stock	34.95 (20.46)	33.75 (20.93)	41.18 (20.33)	29.70 (11.64)	0.02
Preferred variety out-of-stock	78.16 (69.70)	85.20 (72.57)	60.88 (64.23)	63.42 (39.19)	0.03
Difference	43.21	51.45	19.70	33.73	
Number of farmers asking questions (in %)					
Preferred variety in stock	3.07 (17.28)	4.29 (20.30)	0.00	0.00	0.16
Preferred variety out-of-stock	59.18 (49.23)	66.18 (47.42)	47.06 (50.28)	26.32 (45.24)	0.001
Difference	56.11	61.9	47.06	26.3	
Attention paid to varieties in store (*1–5 scale where 1 = No attention paid 2 = Little attention/scanned some varieties 3 = Little attentions/scanned all varieties 4 = Detailed attention to some varieties 5 = Detailed attention to all varieties*)					
Preferred variety in stock	2.63 (1.07)	2.49 (1.07)	3.20 (0.97)	2.52 (0.85)	0.002
Preferred variety out-of-stock	3.72 (1.02)	3.82 (0.99)	3.49 (1.06)	3.47 (1.12)	0.04
Difference	1.09	1.33	0.29	0.95	

In parentheses are the standard deviations.

a significant positive correlation between farmers who purchased the market leader variety category.

4 Discussion

This study identifies significant differences in farmer characteristics and preferences across maize variety categories, offering insights into seed selection behavior. These findings align with existing literature that underscores the role of education, farm size, and access to extension services in the adoption of improved varieties (Chekene and Chancellor, 2015; Chete, 2021). Farmers preferring low-cost varieties allocated more land to maize and sold a greater share of their harvest, suggesting higher economic reliance on maize (Smale et al., 2012; Setimela et al., 2017; Regassa et al., 2023).

Conversely, market leader users cultivated less maize, likely due to income diversification via off-farm employment or mixed farming, indicative of risk-averse behavior (Alene and Manyong, 2006; Asfaw and Shiferaw, 2010). Educational differences also shaped seed choices. Users of low-cost varieties had lower formal education levels, potentially limiting access to digital extension services and alternative information channels. This constrained awareness and investment capacity may influence their selection of more affordable seeds (Fisher and Kandiwa, 2014; Spielman and Ma, 2016).

Regarding seed traits, the study revealed differences in the characteristics that farmers associate with each category of maize variety. The regression analysis in Table 6 reveals that market leader adopters prioritized food and harvest quality and yield potential that directly influences household consumption and livelihoods (Asrat et al., 2009; Regassa et al., 2023). In contrast, early maturity trait, which is a key trait for food security and climate risk mitigation, was important among low-cost variety users. This divergence likely reflects socioeconomic differences whereby farmers who choose low-cost varieties prioritize traits that offer faster returns and reduce production uncertainty (Fisher and Kandiwa, 2014; Setimela et al., 2022).

During seed selection, the data revealed significant differences in decision time based on variety availability. When the preferred seed was out of stock, farmers choosing market leader varieties took longer to select an alternative (50 s) compared to those opting for competitor varieties (20 s), as shown in Table 5. This statistically significant delay indicates stronger brand loyalty and attachment to market leaders. These farmers also engaged more actively in information-seeking behavior, reinforcing their reluctance to deviate from familiar options. Such behavior aligns with the status quo bias (Samuelson and Zeckhauser, 1988) and suggests greater reliance on heuristics under perceived risk (Kahneman et al., 1991; Dhar, 1997), particularly in high-stakes agricultural decisions. This loyalty extends beyond functional traits, reflecting trust in established brands (Aaker, 1991) and a preference for varieties perceived as reliable (Rutsaert et al., 2021).

Additionally, such behavioral tendencies align with loss aversion and cognitive dissonance theory (Festinger, 1957), whereby farmers may avoid experimenting with new varieties to reduce perceived risks or reconcile with past investment decisions. In contrast to more price-sensitive or input-constrained farmers who readily shift toward low-cost alternatives, these loyal adopters may weigh perceived performance and consistency more heavily than cost. Loyalty to market leader seed varieties can present a significant obstacle to the adoption of new and improved varieties, ultimately slowing varietal turnover and hindering innovation uptake.

Furthermore, farmers' attachment to familiar, trusted brands can create inertia, making them less inclined to experiment with unfamiliar alternatives (Fisher and Kandiwa, 2014; Setimela et al., 2017). In addition, brand familiarity significantly influenced maize seed selection among farmers, with many relying on historical performance and trust in established varieties (Rutsaert and Donovan, 2020). This loyalty was reinforced by the perception that higher seed prices indicate superior quality, a common heuristic in

TABLE 6 Regression of predictors for the farmers that planned to purchase market leader variety, competitor varieties and the low-cost varieties categories.

Variable	Market leader variety		Competitor variety	
	Coef.	St. Err.	Coef.	St. Err.
Gender(men)	0.024	0.428	−0.141	0.455
Age	0.027*	0.016	0.036**	0.017
Food Traits	0.825*	0.434	0.382	0.463
Harvest Traits	1.13**	0.441	1.633***	0.467
Agronomic Traits	−0.09	0.489	−0.015	0.518
Early Maturity Traits	−1.702**	0.413	−2.113***	0.456
Yield Potential Traits	0.125	0.437	1.134 **	0.487
Drought Tolerant Traits	−0.72	1.135	−1.013	1.159
Disease/Pest Tolerant	0.947*	0.5	0.892*	0.535
Stress Tolerant Traits	−0.61	1.339	−0.684	1.368
No. of varieties Purchased in the past	−0.64***	0.145	−0.301**	0.152
1 to 2 acres	−1.045	0.825	−1.791**	0.854
More than 2 acres	−1.349	0.845	−2.142**	0.879
Percentage of land with maize	−0.01	0.011	−0.027**	0.011
Highest education years	0.37	0.33	0.534	0.353
Planted same variety last season	2.31***	0.425	0.618	0.45
Constant	2.758	1.769	2.878	1.861
Mean dependent var		1.361	SD dependent var.	0.612
Pseudo r-squared		0.250	Number of obs	587
Chi-square		224.063	Prob > chi2	0.000
Akaike crit. (AIC)		740.538	Bayesian crit. (BIC)	889.289

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

markets with limited information (Wolinsky, 1983; Desai, 2019). Consequently, farmers may prioritize brand reputation over specific agronomic traits, viewing trusted brands as proxies for quality and reliability.

For the farmers selecting low-cost maize varieties, they showed greater experimentation with different maize seed varieties, with 73% having tried more than two hybrid varieties, compared to over 40% of market leader users who had only planted one. This exploratory behavior may stem from economic pressure to find affordable, high-performing options, as well as weaker brand loyalty (Fisher and Kandiwa, 2014; Spielman and Smale, 2017). This exploratory behavior may also reflect a more pragmatic, trial-based decision-making process, whereby farmers prioritize perceived performance and affordability over brand loyalty (McGuire and Sperling, 2016; Regassa et al., 2023). These findings suggest that breeding strategies must go beyond just optimizing for performance. They must also foster trust, consistency, and strong branding in seed dissemination to effectively encourage farmers to consider and explore newer options.

5 Conclusion and recommendation

This study reveals persistent loyalty to market leader maize seed varieties among smallholder farmers in Machakos County, driven by brand familiarity, past performance, and agronomic traits such as drought tolerance and grain quality. Despite the availability of improved alternatives, these farmers showed limited willingness to switch, in contrast to users of low-cost varieties who engaged in more exploratory behavior.

To improve adoption of newer varieties, seed dissemination strategies must directly address farmers' trust and performance concerns. Building transparent, long-term relationships through consistent quality assurance, open communication, and strong branding can help overcome resistance. Seed companies and extension services must engage actively with farmers, using trust-building tools such as demonstration plots, field days, and early adopter testimonials to enhance credibility and visibility of new varieties. Strategic incentives such as subsidies, targeted promotions, and performance guarantees can further encourage uptake in competitive markets. In turn, these measures can reduce market leader dominance, support varietal turnover, and promote diversity in maize seed use.

Policy support is essential. While intellectual property protections have driven innovation, regulatory frameworks should also mandate timelines for phasing out outdated varieties and introducing new ones. Regular performance assessments, transparent seed quality information, and competition among providers can enhance farmer confidence in alternatives.

A key limitation of this study is its correlational design, which constrains causal inference. Future research should employ experimental or longitudinal methods to explore causal pathways in seed choice behavior. Further investigation into gender dynamics, access to extension services, and social networks will also yield deeper insights for designing responsive, inclusive seed system interventions.

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.

Ethics statement

The studies involving humans were approved by The International Livestock Research Institute (ILRI). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

HM: Writing – original draft, Writing – review & editing, Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Visualization. JM: Methodology, Supervision, Writing – review & editing. EC: Supervision, Writing – review & editing. PR: Conceptualization, Data curation, Funding acquisition, Resources, Software, Supervision, 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.

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Publisher's note

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Appendix

TABLE S1 Maize seed products included in the study.

Variety	Company	Company category	Year released	Maturity level	Estimated market share[1]	Market price (KES)	Reported yield potential (90 kg bags)	Reported Stress tolerance	Reported agronomic/ postharvest attributes
Duma 43	Seed Co	Regional	2003	Early	40%	500	30–32	Drought, cob rot, gray leaf spot and northern leaf blight	High shelling percentage, hard dent grain texture, very white grain color
Sungura 301	Seed Co	Regional	2015	Very early	7%	500	25–30	Drought, gray leaf spot	Good husk/tip cover, semi-flint grain texture, high shelling percentage
DK8031	Bayer	Multinational	2003	Early	17%	500	28–32	Drought, Maize Streak Virus, Gray leaf spot. Ear rot	Excellent milling qualities, not sensitive to planting dates, hard-dent grain
DK8033	Bayer	Multinational	2004	Intermediate	1%	500	34–36	Drought, Leaf diseases: Gray Leaf Spot, MSV, rust	Good standability, hard dent grains, double cobbing
DH02	Kenya Seed Company	Parastatal	1995	Very early	8%	400	18	Drought, Maize Streak Virus	Plant stays green
DH04	Kenya Seed Company	Parastatal	2001	Early	4%	400	24	Drought, Leaf diseases: Leaf blight and leaf blight	Good husk cover, good standability
PHB 3253	Pioneer	Multinational	1996	Intermediate	15%	500	40	Drought, Leaf diseases: Leaf blight and rust	Good standability, white and hard flint kernel
SAWA	Dryland seed Company	Local	2015	Very early	3%	500	32	Drought, Leaf diseases: Leaf Spot and Maize Streak Virus	Good husk cover, semi-dent white grain, stay green trait, sweet taste
WH101	Western seed Company	Local	2006[2]	Early	0%	500	20–25	Drought, Leaf diseases: Gray Leaf Spot, Maize Streak Virus and Blight	Suitable for 2nd season planting, sweet grain, excellent for roasting