Future market segments for hybrid maize in East Africa

Pieter Rutsaert, Jason Donovan, Harriet Mawia, Kauê de Sousa, Jacob van Etten

Abstract

The current seed product market segmentation by the Consultative Group on International Agricultural Research (CGIAR) for maize in East Africa includes four segments, which differ by agro-ecological zone and maturity class. However, considering the lengthy period required to produce a variety, from initial design to commercial production, a critical question should be asked: what are future segments that should be considered in discussions on current breeding investments? Video-based product concept testing (VPCT) is a novel approach for gathering insights from farmers about their varietal preferences to inform future market segmentation. This brief explains the conceptual and methodological underpinnings of VPCT. We present an application of the tool in hybrid maize. Seven new product concepts (representing potential future market segments) were identified based on discussions with breeders, seed companies and farmers, which we labelled: home use, intercropping, drought avoidance, nutritious, feed (yellow), green maize and food and fodder. These future concepts, together with the resilient benchmark product concept (the current breeding target), were evaluated through triadic comparisons with 2400 farmers in Kenya and Uganda. In Uganda, the drought avoidance concept ranked high, while in Kenya the intercropping concept stood out. Concept testing provides a strong case for new investments to integrate agronomic practices and preferences of farmers into breeding, on-farm testing and seed systems. Future work will estimate the implications of increased availability (and uptake) of these future segments on the current segmentation.

Key points

- VPCT is a new way to assess farmers' preferences for seed products that draws inspiration from the product innovation literature and previous work in CGIAR on using citizen science in on-farm testing of new seed varieties.
- Through multiple stakeholder engagements, seven new product concepts were identified in addition to the resilient benchmark concept: home use, intercropping, drought avoidance, nutritious, feed (yellow maize), green maize and food and fodder. Ten professionally made short videos explained the ranking exercise (two) and presented the seven new product concepts and the benchmark concept (eight) in local languages.
- VPCT was applied for hybrid maize in wet mid-altitude areas of Kenya and Uganda with 2400 farmers, with each respondent evaluating three out of seven new concepts or the benchmark concept.
- Two high-priority future market segments were identified—stress tolerant, early maturity maize in Uganda and maize tailored to intercropping in Kenya.
- Neither yellow nor orange maize were considered priority concepts by farmers; consideration of these concepts as future market segments will require external drivers to trigger interest.
- This application of VPCT shows its potential to support evidence-based dialogues with breeding programs to confirm current strategic investments versus alternative priorities and new potential directions.

INITIATIVE ON
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This Initiative aims to maximize CGIAR and partners' returns on investment in breeding, seed systems and other Initiatives based on reliable and timely market intelligence that enables stronger demand orientation and strengthens co-ownership and co-implementation by CGIAR and partners.

Introduction

An important characteristic of smallholder farming is the changing need for crops and seed that serves multiple requirements related to on-farm production (e.g. low-input levels, labour saving), climate pressure (e.g. drought and disease resistance), home consumption (e.g. taste, storability) and sales (e.g. size, color, hardness). Decisions in the past 20 years on how to invest CGIAR resources in breeding have been increasingly dominated by plant resilience to biotic and abiotic stresses in response to growing pest and disease pressure and climate change (Atlin et al 2017). However, uptake and turnover of new varieties has tended to be disappointingly slower than expected. The prioritization of crop resilience may have resulted in improved varieties that are out of sync with shifting farmer priorities. A better understanding of farmer variety preferences is critical to advance effective strategies for broader and faster uptake of new varieties by smallholders.

The CGIAR has been looking to better align its breeding pipelines with current and future demand for varieties. As part of this effort, the Seed Product Market Segment Database (SPMSD) was introduced. The database contains more than 400 seed product market segments (SPMS). Each segment represents a group of farmers with common variety requirements. These requirements consider grower requirements (where and how the crop is grown) and end-user requirements (what the crop is used for). For each market segment, a unique Target Product Profile (TPP) exists that provides the blueprint for the 'ideal' product.[1] Looking ahead, three critical questions must be addressed:

- How should investments in breeding and seed systems development be prioritized across market segments in SPMSD?
- What missing segments might exist, i.e. segments that exist but, for whatever reason, were not included in the current version of SPMSD?
- What are potential future segments, i.e. segments for which neither growers, processors nor consumers have identified a current requirement but which might be required in the future based on changes in the context?

This brief presents a new methodology to test whether the current segments are in line with farmer preferences or whether there are alternative SPMSs that could better suit varietal requirements of farmers. We do this by using product concepts, defined as descriptions of actual or hypothetical varieties and their potential uses and benefits for farming, processing and end use. The case we present here is that of segmentation for hybrid white maize in the western part of Kenya and central part of Uganda—areas traditionally considered to be part of the 'intermediate maturity' market segment.

Hybrid maize market segments

[2]The SPMSD includes four maize market segments for East Africa. Each segment was identified based on eight criteria:

- crop
- material type
- subregion
- end use
- color
- production environment
- production system
- maturity

These criteria as applied to maize in East Africa are presented in table 1. The first three criteria form the basic building blocks of the segmentation: crop, material type and subregion, which are similar for the maize market segments in East Africa. Currently, the SPMSD only includes hybrid maize as 'material type' in the database. Neither end-use requirements (feed, processing) nor production system were considered to be a differentiating factor: all segments featured white color, for human consumption, grown in rainfed conditions. The key differentiating factors in the current maize market segments were the production environment and the corresponding maturity level required, respectively, intermediate maturity for wet mid altitude, early maturity for dry mid altitude, late maturity for wet upper-mid altitude and late and very late maturity for highland environments.

Table 1. SPMSs for maize in East Africa, as presented in current version of SPMSD

Criteria	Market segment 1	Market segment 2	Market segment 3	Market segment 4
Hybrid	Yes	Yes	Yes	Yes
Subregion	East Africa	East Africa	East Africa	East Africa
End use	Food	Food	Food	Food
Color	White	White	White	White
Production environment	Wet mid altitude	Dry mid altitude	Wet upper-mid altitude	Highlands
Production system	Rainfed	Rainfed	Rainfed	Rainfed
Maturity	Intermediate	Early	Late	Late/Very late

[1] See Market Intelligence Brief 1 for further details on the segmentation approached taken by the CGIAR Initiative on Market Intelligence.

[2] The SPMSD also has two market segments on High Zinc and Provitamin A. As these are currently not commercially available in Uganda or Kenya, we focus on the four main segments.

Figure 1 shows the distribution of the four SPMS for maize in Uganda and Kenya based on the key differentiating factor: maturity level. The size of the market segments was calculated based on the production environment, i.e. the biophysical conditions under which the crop is grown, estimated through geospatial data. Most maize cultivated areas in both countries are estimated to fall under the intermediate and late market segments because these are deemed most suitable for the production environment, which is predominantly wet mid altitude and wet upper-mid altitude. Looking through a product concept lens, the question arises as to whether the preference for maturity is dependent only on the production environment. What about farmers' requirements for early-maturity maize because it provides grain earlier in the season to meet family needs or to sell at a higher price before bumper harvests? Or are climate change pressures and erratic rainfall patterns pushing farmer maturity preferences?

Another question is whether our assumptions about farmers' end-use requirements are correct. Is maize dominantly used as a food crop or is there a need for maize as animal feed? What about dual-purpose use of grains for food and biomass for fodder? And should all maize be white or is there farmer appetite for exploring yellow maize for feed or orange maize containing provitamin A? This invites the question, are there future market segments that should be addressed by breeding pipelines?

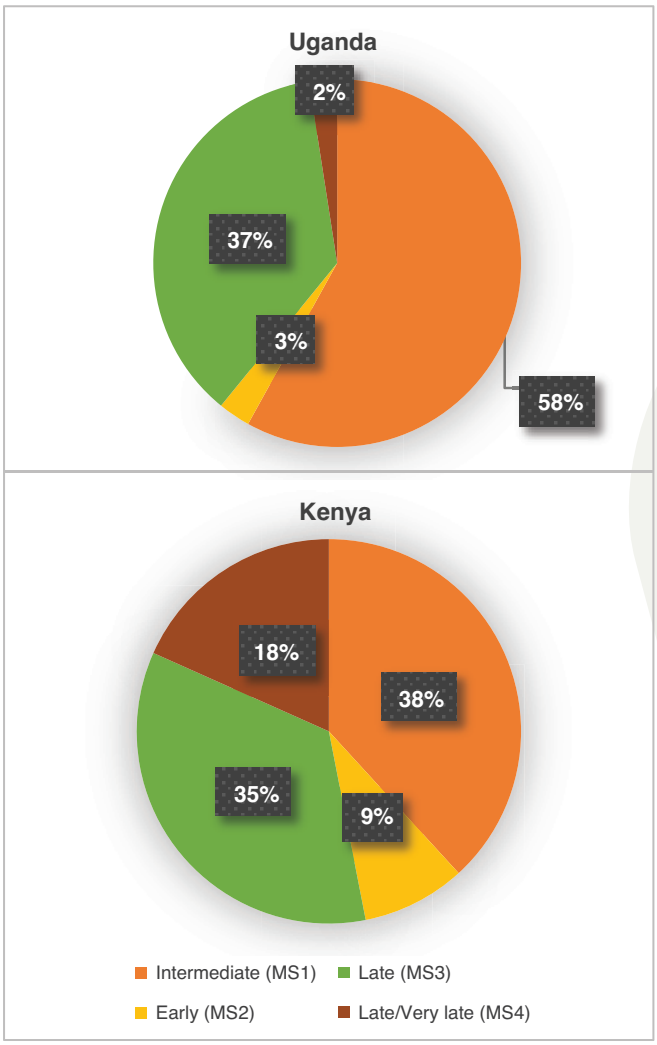

Figure 1. Estimated relative size of the early, intermediate, late and very late market segments in Uganda and Kenya

This brief proposes a novel application of concept testing to inform crop-breeding decisions by CGIAR and National Agricultural Research Systems (NARS). The application, which we refer to as VPCT, can be used to evaluate grower requirements for seed products that are currently available (actual SPMSs) or products that have yet to be developed, thus representing future SPMSs. When these are discovered, the task falls on breeding teams to select the varietal traits that need to be optimized to build the product.

Going from traits to concepts

Market intelligence to support breeding programs has focused on identifying farmers' priorities for specific traits. In the spirit of Lancaster (1966), the strong trait focus has assumed that farmers derive utility not from the seed product itself but from the attributes (traits) inherent in the seed. Long surveys are typically employed to evaluate trait preferences. These require farmers to express preferences based on irrational tradeoffs between traits, such as: would you prefer reduced plant lodging or higher yield? However, by focusing the research on a specific set of traits, we miss the broader product-relevant question: what are the motivations behind the preferences of farmers for a particular seed product? In other words, why do farmers give more weight to a product compared to others. This 'why' question, although often overlooked, is crucial for guiding investments in product development since it underpins an individual's choices and decisions (Hasselbach and Roosen 2015). History shows that adequately responding to the 'why' question and understanding customer needs has led to higher product success (Cooper and Kleinschmidt 1995).

In the larger discussion around marketing and product innovation, a well-known method used to understand customer product preferences is concept testing (Iuso 1975). Consumers are shown a product idea, or concept, through a description, picture, video or prototype, with the goal to obtain their feedback as well as their interest in purchase and or use of the product if it were to become available. The testing takes place early in the product innovation cycle before substantial amounts of development resources are committed. The insights gained should be used to guide future investment decisions. While product concept testing to guide product development has long been applied in the commercial sector, it has seen limited application in technology design by public-sector research programs. Instead, the agricultural research-for-development agenda has tended to apply 'push programs' (Kremer and Zwane 2005), where public funding is provided to do basic research and develop public goods (both products and information) that can be used by private sector partners, without a clear understanding of the preferences of end users.

In the crop-breeding context, concepts can explore the relevance of future new seed products that respond to preferences related to gender equity (e.g. crops easier to harvest), food security (e.g. grains most resistant to mold) or home consumption (e.g. 'sweet' tasting fruit). In selecting a concept, growers are, in fact, indicating their preferences for a particular seed product.

Application of VPCT

Product concepts were designed around specific smallholder preferences related to grower requirements and end-user requirements for maize to identify alternatives to the current maize SPMS for the wet mid-altitude zones of East Africa (i.e. the benchmark, corresponding to market segment 1 in table 1). The product concept development was guided by qualitative research that included focus group discussions in Kenya and Uganda with representatives from farmer organizations, seed-producing companies and retailers as well as international and national plant-breeding institutes. These discussions focused on the (changing) role of maize on their farms, growing practices, varietal preferences and key benefits sought by farmers. Discussions with technical experts focused on the technological possibilities of breeding, the new types of products companies were interested in and the suitability of other types of maize not yet grown in East Africa, such as yellow maize.

Product concepts were written, starting with the main grower or end-use requirement the product addresses. The description then included a section about why that seed effectively responds to that requirement. The third section provided additional relevant information about standardized variables such as yield potential, fertilizer needs, color, maturity period and grain usage. Table 2 lists the seven product concepts developed and the main requirement each addresses as well as on which criteria the concepts differ from the benchmark product concept, representing the current market segment. See annex 1 for a full overview of the concepts.

Product concepts were presented to farmers in a video format. Videos effectively deal with

- farmer illiteracy,
- reducing cognitive efforts of participants,
- avoiding interviewer bias, and
- easily implemented at scale.

All videos were shot in a studio (in Nairobi for the Kenyan sample and in Kampala for the Ugandan sample) and were recorded in the local language. The setup of the videos was built around a farmer visit to the agro-dealer. In the five videos shown, the participant saw an actor posing as an agro-dealer representative dressed in a white lab coat standing behind a counter and in front of various bags of maize seed. Between the introductory and closing video, three product concepts were described to the participant by the agro-dealer host. Product concept descriptions lasted approximately two minutes, with a similar script and acting employed in each video. All videos were made with a male and female actor acting as the agro-dealer and farmers were randomly given the male or female videos (figure 2).

The concept evaluation was done through household surveys in Kenya and Uganda, involving 1200 farmers in each country. After each video, the participant responded to questions regarding the viewed concept, including similarity with variety currently grown and interest in trying and in replacing currently grown varieties. After the three videos, the participant selected his/her most and least preferred product to purchase if it were available in the local agro-dealer shop. The ranking exercise took inspiration from the tricot approach, which stands for triadic comparisons of technology options, commonly used in on-farm trials and consumer testing (van Etten 2011, van Etten et al 2019). The participants compared the video-based product concepts options in randomized subsets of three, or 'triads,' and in incomplete randomized blocks. Data collection and analysis were done through the ClimMob software (https://climmob.net) and its supporting tools (de Sousa et al 2022, Turner et al 2020).

Results of VPCT

Farmer evaluation of videos

Overall, participants appreciated the use of videos in the survey. The participants found the videos easy to understand, the ranking easy to carry out and the agro-dealer (actor) a trustworthy provider of information on the product concept (figure 3).

Table 2. Eight Product concepts for hybrid maize seed in Kenya and Uganda

Concept	Main grower or end-use requirement	Market segment change
1. Resilient variety	Resistance to major stresses including drought, diseases and low soil fertility	Benchmark
2. Intercropping variety	Optimal yield when maize rows are alternated with beans	Production system
3. Food and fodder variety	Optimized for both household food and fodder for cattle	End use
4. Home use variety	Optimized for home-use traits such as taste, flour conversion and storability	
5. Green-maize variety	Needs of the fresh green-maize market met (including sweet taste and large cobs)	
6. Feed variety	Reliable feed for chicken, pigs and other animals	End use and color
7. Nutritious variety	Provitamin A-rich variety that provides a key nutrient for young children	Color
8. Drought-avoidance variety	Suitable for early harvesting, with reduced risk in production and potential for higher market prices (sale before peak harvest)	Maturity

Farmer ranking of the concepts

Across all farmers in Kenya and Uganda, three product concepts stood out: the benchmark resilient concept and two new ones—the drought-avoidance concept and the intercropping concept (figure 4). One element these three concepts have in common is that they are all focused on agronomic performance of maize, i.e. on growers' requirements. After those three, the household-use concept scored best, followed by the feed and fodder and nutritious concepts. Least performing were the concepts for green maize and feed. The dominance of product concepts focused on agronomy is also reflected by the open responses on why farmers selected their most preferred concept (figure 5). Key words such as drought, disease and resistant were most in mind when they discussed their preferred concepts.

Country and gender differences

Figure 6 presents a more detailed look at the rankings of men and women farmers in Kenya and Uganda, giving a more nuanced view on farmer priorities across countries and gender. There were differences in farmer rankings between Kenya and Uganda. In Kenya, it was the intercropping concept that outperformed all other concepts, except for the benchmark resilience concept. Although intercropping is widely practiced among maize farmers, to our knowledge intercropping as an entry point is not used by seed companies for marketing purposes, and most testing is done under monocropping systems. How this can be translated into practice deserves more attention since intercropping is relevant for a wide diversity of crops (Brooker et al 2015). In Uganda, it was the drought-avoidance concept that performed best. As Uganda is predominantly a mid-altitude area with sufficient rainfall, the focus of maize breeding programs is directed towards intermediate-maturity varieties that tend to have higher yields than early-maturity varieties.

Men and women farmers had similar rankings for most concepts, with one important exception: the home use and family consumption concept. In Uganda as well as Kenya, this concept scored at the same level as the resilient benchmark concept for women farmers, while male farmers

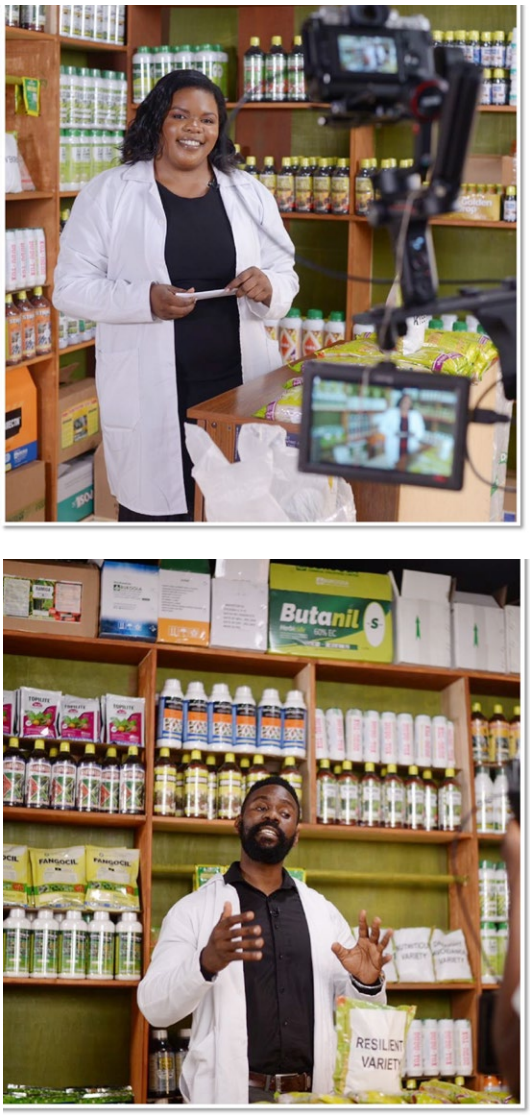

Figure 2. Actors playing the part of an agro-dealer for presenting product concepts to farmers

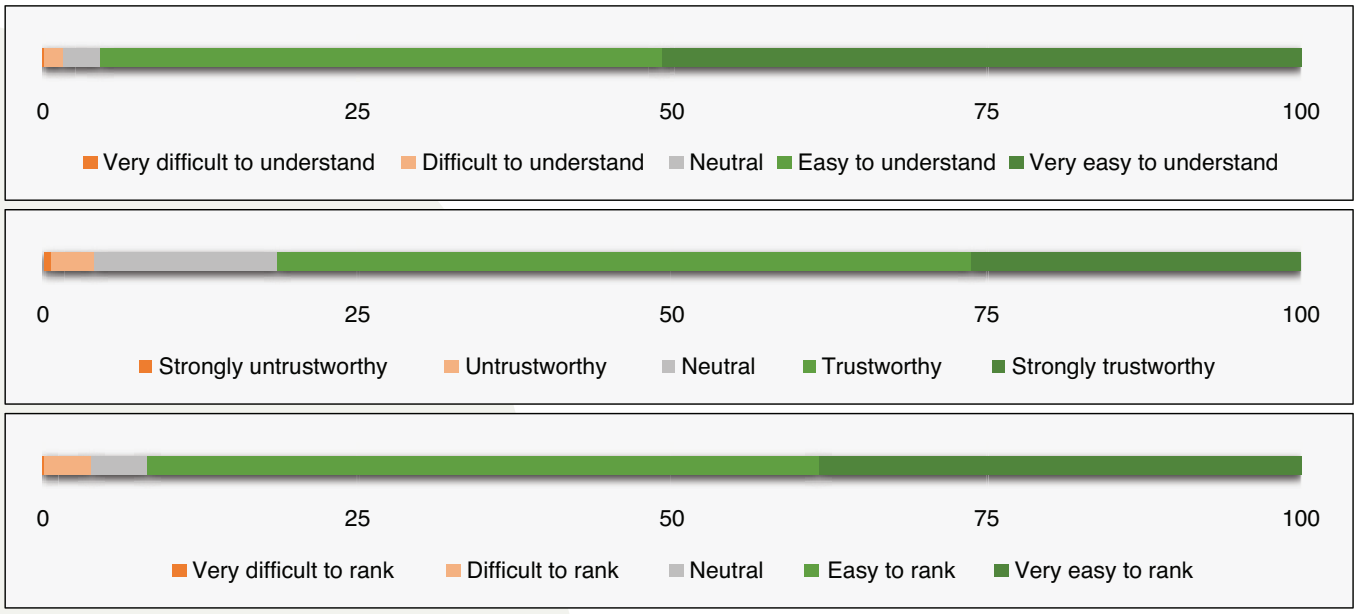

Figure 3. Farmer evaluation of difficulty in understanding the videos, trust in the agro-dealer providing the information and difficulty in doing the ranking

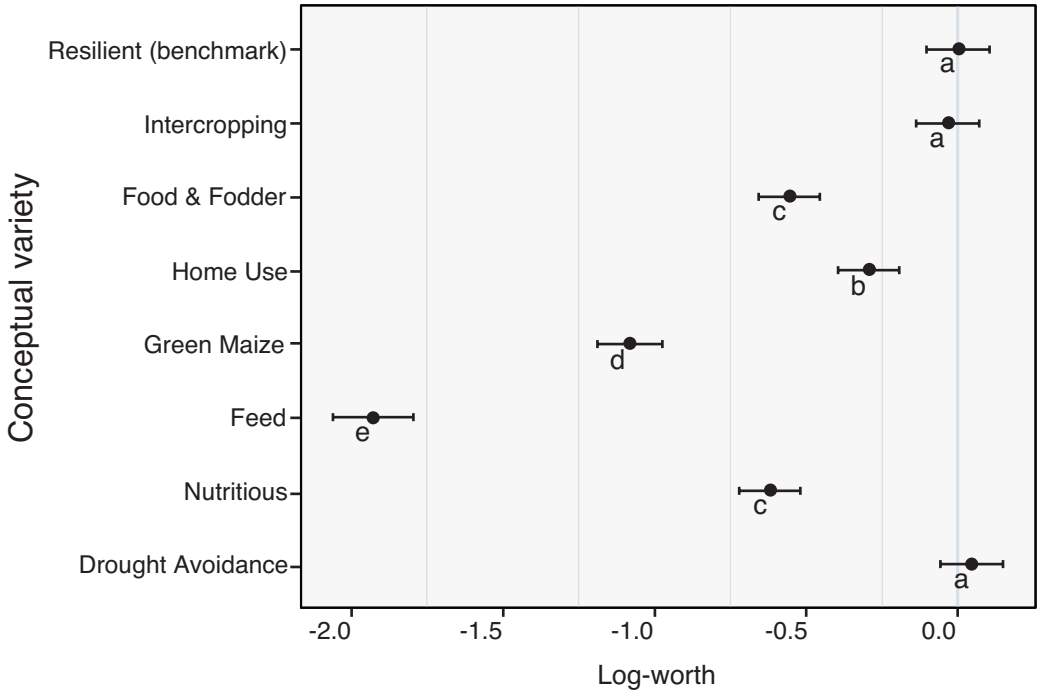

Figure 4. Overall acceptability (log-worth) of product concepts of hybrid maize presented to farmers in Kenya and Uganda

Log-worth are model coefficients derived from the Plackett-Luce model, which estimates the probability of one given concept in outperforming all the other concepts in the set. The concept 'Resilient (benchmark)' is set as a reference (log-worth arbitrarily set to zero). Different letters indicate significant differences at $p < 0.05$.

Figure 5. The most frequent words mentioned by farmers for selecting their most favored concept

rated this concept lower than the benchmark. In Uganda, the intercropping concept was also of great interest to women farmers, but less to men farmer, which is in line with the results of Cairns et al (2022) on farming practices in Zimbabwe.

Discussion and way ahead

Refining market segmentation for maize in East Africa

Using VPCT, we identified three priority market segments for hybrid maize in the intermediate-maturity zones of Kenya and Uganda, shown in table 3. First, we confirmed farmer demand for the current market segment that targets stress-tolerant, intermediate-maturity maize in wet mid-altitude areas. The high demand provides evidence for continuous investments in breeding and seed systems. Second, two near-term future market segments were identified—stress-tolerant, early-maturity maize in Uganda and maize that is tailored to intercropping in Kenya.

Third, we identified potentially long-term future market segments such as yellow maize for feed or nutritious orange maize. Those varieties are currently not available in the target countries, and they were also not in demand by

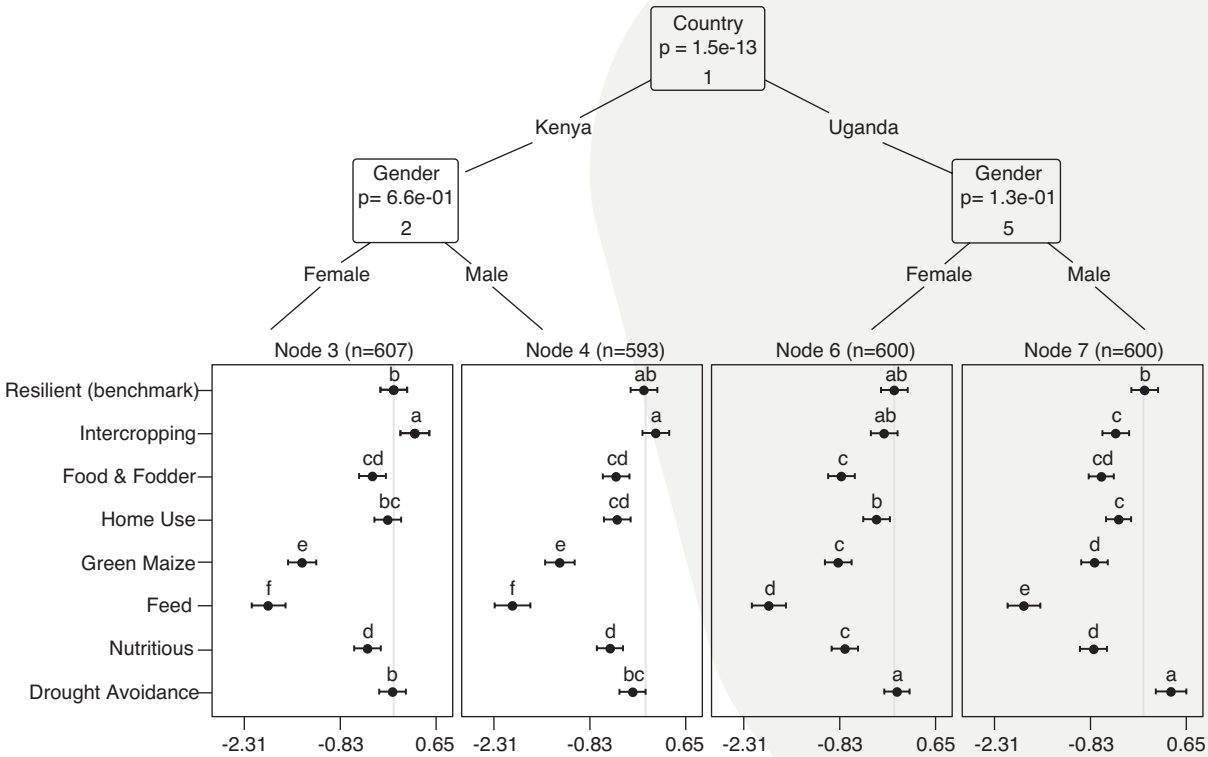

Figure 6. Plackett–Luce tree of product concept data for male and female participants in Kenya and Uganda

The horizontal axis of each panel shows coefficients derived from the Plackett-Luce model (log-worth), which estimates the probability of one given concept in outperforming all the other concepts in the set. Error bars show quasi-SEs. The gray vertical lines indicate the reference concept 'Resilient (benchmark)' (log-worth set to zero). Different letters indicate significant differences at $p < 0.05$.

Table 3: Current and future market segmentation for hybrid maize in East Africa

Types of segments	Description of segment	Implication from VPCT
Current market segment	Four SPMS, all white color, stress tolerant, hybrid, for human consumption, with maturity being the driver of segmentation (late, mid- and mid/early-maturity levels)	The mid-maturity segment was highly ranked by farmers in Uganda and Kenya relative to the other concepts presented
Future market segment—type 1 (near-term opportunity, relevant for discussions on TPP design)	Market segment for which there is no current investment in breeding or seed systems but for which there is a recognized requirement by farmers	The following two future market segments should be further explored for opportunity for impact and, based on results, considered for design of TPP • intercropping • early maturity
Future market segment—type 2 (potential long-term opportunity, dependent on changes in external environment)	Market segment that currently does not exist or show strong evidence for potential existence in the near future	The following concepts could represent an opportunity based on changes in the context: • nutritious maize • yellow maize • green maize

farmers. However, this does not mean that these should be ignored. A growing chicken industry, for which yellow maize is needed as feed, might become a driver for the demand of yellow maize and create farmer demand. School feeding programs promoting maize rich in provitamin A might spur demand for orange maize. However, without some form of demand pull, these products cannot be expected to be taken up by the farmers and potential impacts would not be in line with these breeding investments.

Gender intentionality in concept testing

VPCT provides a new method suited to improve gender intentionality in breeding. Concept development allows development of new concepts directly focused on the challenges women face in agriculture, including labour challenges such as weeding, planting (in the case of rice) or harvesting (in the case of groundnut). Although these challenges might not be a priority in current breeding pipelines, future concepts could be described around those challenges, and concept testing allows comparison of these potential future breeding priorities with current breeding directions.

The concept involving maize for home use and family consumption was drafted around postharvest use, which is often considered linked more to women's variety requirements (Weltzien et al 2020). The strong women's interest for this concept might not necessarily warrant a separate market segment since the current mid-maturity resilient segment already targets food as the end use. However, it would be worth looking closer at the TPP for that market segment and how much consumption traits are specified in it.

Expanding concept testing in market intelligence

Changing dynamics in public sector breeding and the push towards more demand-driven breeding requires new method and tools. Social scientists need to develop new field-tested tools that strike a balance between ease and cost of deployment and robustness of evidence. The brief has discussed what concept testing is and why it is relevant for SPMS. Once future market segments (type 1) are identified, important questions arise related to the implications of these segments for the current set of segments. Estimates are needed on both the actual (potential) crop area that would be covered by the market segments and the reduction of crop areas of the current set of market segments. Among the factors to be considered are potential for seed production, distribution systems (speed, price, coverage) and farmer access to information on new varieties. Estimation approaches may be qualitative in nature or based on geospatial analysis and modelling.

Further development and testing will be needed to refine this methodology. Nevertheless, first results looked promising, and the method delivered on its goals:

- being a cost-efficient and swift methodology that can be rolled out easily with partners,
- being intuitive for farmers to understand,
- comparing current and potential future priorities in breeding, and
- providing practical insights to breeding programs.

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Annex 1: Product concept information

Name	Main grower or end-use requirement	Supporting information	Additional information				
			Grain yield	Fertilizer needs	Stress tolerance	Color	Use
1. Resilient variety	Resistance to some major stresses, including drought, diseases and low soil fertility	Higher maize yield than your neighbors' when there is little rain or when diseases are present in the area	Medium	Medium	High	White	Food / Sales
2. Intercropping variety	Optimal performance when maize rows are alternated with beans	Benefits from the wider spacing and gives bigger plants that often grow double cobs and need less fertilizer	Low	Low	Medium	White	Food / Sales
3. Food / fodder variety	Provides both food needs as well as the needs of dairy animals such as cows	Besides maize yield, provides excellent fodder with high fiber content	Low	Medium	Medium	White	Feed / food / Sales
4. Home-Use variety	Focuses on home use and feeding the family	Allows household storage for up to six months with low postharvest losses, good taste and excellent flour conversion	Medium	Medium	Medium	White	Food / Sales
5. Green-maize variety	Meets the needs of the fresh green maize market	Combines a sweet taste with long cobs and good grain filling, making it a fitting variety for the fresh market	Medium	Medium	Medium	White	Food / Sales / fresh market sales
6. Feed variety	Provides great feed for animals such as chicken and pigs	Very high nutritional value, which gives the maize a yellow color but makes it better than white maize for animal feed	High	High	Low	Yellow	Sales / Feed
7. Nutritious variety	Healthy variety that provides a key nutrient for young children	Bright orange in color, which comes from beta-carotene—good for overall health and tastes the same as white maize	Medium	Medium	Medium	Orange	Food / Sales
8. Drought-avoidance variety	Suitable for early harvesting	Can harvest after 3 1/2 months or 110 days—harvesting early results in a lower yield than average but reduces the danger of losing a harvest to drought	Low	Medium	High	White	Food / Sales

Acronyms used in this brief

CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
NARS	National Agricultural Research Systems
SPMS	Seed product market segment
SPMSD	Seed Product Market Segment Database
TPP	Target Product Profile
VPCT	Video-based product concept testing

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About this series

The *Market Intelligence Brief* offers evidence-based insights into the potential for increased impact towards the CGIAR Impact Areas from investments in crop breeding and seed systems development. This peer-reviewed series brings together voices from diverse fields, including marketing and agribusiness, gender, plant sciences and climate change to inform debates on future priorities and investments by CGIAR, NARS, the private sector and non-governmental organizations (NGOs). This series is a collaborative effort of the CGIAR Initiative on Market Intelligence. For more information, including potential submissions, please contact Meliza Peña, editorial assistant, at <c.pena@cgiar.org>.

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