Forage hybrid market segmentation in East Africa

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Key messages

- East Africa presents some adverse conditions related to cattle farming, in particular desertification of soils and climate change. In this regard, improved forages that adapt to these environments are essential for the productivity and sustainability of the region's cattle sector.

- In addition to productivity and quality gains, improved forages generate positive environmental impacts, for example through increasing the nitrogen-use-efficiency or mitigating cattle-related greenhouse gas emissions.

- The identification of market segments for Africa, especially East Africa, is developed within the CGIAR crop improvement programs. From a global perspective, this responds to several Sustainable Development Goals, such as no poverty (SDG-1), zero hunger (SDG-2), and climate action (SDG-13), among others.

- According to pilot tests conducted by these programs, the forages developed for the market segments in East Africa have superior characteristics compared to the existing commercial offer on the market. They thus have the potential to increase adaptability to the environmental and productive conditions of the region, and to facilitate producer awareness regarding the advantages of technology adoption.

Introduction

The purpose of this brief is to provide an overview of the potential forage market segments for East Africa. This work was conducted as part of the OneCGIAR Initative on Market Intelligence, which seeks to expand the social impact of crops in areas such as nutrition, gender equality, and climate change (CGIAR, n.d.). From a global perspective, this responds to several Sustainable Development Goals, such as no poverty (SDG-1), zero hunger (SDG-2), and climate action (SDG-13), among others. The segments have been identified within the CGIAR EiB (Excellence in Breeding) and BPAT (Breeding Program Assessment Tool) programs. EiB aims to promote the modernization of crop improvement programs for farmers in low- and middle-income countries (EiB, 2021). For its part, BPAT is a tool that allows a structured review of technical aspects, capacities, and components of crop improvement programs, with the purpose of increasing the rate of genetic gain (McHugh et al., 2021).

In East Africa, the cattle sector is strategic in the fight against hunger and poverty. It contributes to the livelihoods of about 70% of the rural population in the dry areas of West and East Africa, which means of about 110 to 120 million people. Cattle farmers in these drylands only have 1-1.2 TLUs (Tropical Livestock Units) per capita, exposing their livelihoods to vulnerability related to climatic events such as droughts, diseases, or any other type of unforeseen event (de Haan, 2016). For people's livelihoods, the sale of milk is the predominant way of obtaining benefits from cattle farming, since it generates cash flow that covers family expenses, such as for food and medicine. Cattle slaughter is less frequent and thus, cattle are a means of savings for people, which generate income in the short term (milk) and can be used in difficult periods or when important expenses occur (slaughter) (Felis, 2020). Regarding the production system, Gonzalez et al. (2016) highlight that most of the farms in the region have an area smaller than what is necessary to maintain a cow and her calf, making cut-and-carry the predominant practice of animal feeding.

Scarcity and low quality of forage are typical in the region, which is accentuated during dry seasons (Ohmstedt et al., 2019). This lack of quality, low production efficiencies, and low levels of sustainability are manifested in poor supply levels of animal protein. This is, according to the United Nations World Food Program (2022), one reason why food security in East Africa has worsened over the last years. Between March and July 2022, in Kenya, Somalia and Ethiopia, the number of children suffering from acute hunger, malnutrition, and thirst grew from 7.25 million to nearly 10 million. The droughts and the price increases in the recent months exacerbate a problem that has historically characterized the region. However, Creemers et al. (2021) show that in countries like Kenya there are efforts to strengthen the commercialization of higher quality forages, for example of *Urochloa* hybrids (syn. *Brachiaria*) and *Megathyrsus maximus* (syn. *Panicum maximum*) varieties such as Mombasa and Siambaza. They also highlight that the public and private sectors and research make efforts to promote the adoption of these materials among cattle producers.

Under this scenario, an important potential market can be observed. The superior characteristics in terms of productivity, environmental adaptability, and nutritional quality of the new improved materials facilitate producer awareness regarding the advantages of technology adoption. The improved forages developed by the International Center for Tropical Agriculture (CIAT) can increase the productivity and quality of the cattle sector, thus improving the incomes and livelihoods of cattle and dairy farmers (Ohmstedt et al., 2019). On the other hand, Paul et al. (2020) highlight that in addition to achieving this primary objective, the adoption of these technologies generates positive environmental externalities. The reduction in greenhouse gas emissions is only one example. Despite these advantages, the adoption process faces challenges and is affected by factors such as a lack of knowledge, low levels of public investments, and an underdeveloped market for forage seeds, other productive, and end-products.

Forage hybrids market segments

Potential markets for new hybrid materials of *Urochloa* and *Megathyrsus maximus* species are analyzed in this section (Simon & Jacobs, 2003; Soreng et al., 2015). Hybrids are the product of genetic improvements and combine the superior traits of different materials. CIAT started this line of research in 1987 with *U. brizantha* (CIAT-6294 cv. Marandú), *U. decumbens* (CIAT-0606, cv.

Basilisk) and *U. ruziziensis* (BR4X-44-2) (Enciso et al., 2020; 2022). This research in joint efforts with the private sector, has led to the formal release of several hybrids: *U.* hybrid cv. Mulato I and Mulato II, *U.* hybrid cv. Cayman, *U.* hybrid cv. Camello and *U.* hybrid cv. Cobra (Papalotla, n.d.; Pizarro et al., 2013). All these *Urochloa* hybrids are interspecific, which means that different species of the same genus were crossed to obtain improved materials (Wrigley et al., 2004). In East Africa, the commercialization began with Mulato I and Mulato II in 2005; Cayman and Cobra in 2019, and Camello in 2020 (Papalotla 2022, personal communication). There are no hybrids of *Megathyrsus maximus* on the market yet, but they are under development. Hybrids of *U. humidicola* are also being developed, however, they are intended for soils with higher levels of moisture (Cook et al., 2020), and are thus not adapted to the East African conditions.

The predominant characteristics of the soils, the climate, and the agricultural practices are the key elements for the identification of potential forage markets. The information for the forage materials derives from field measurements conducted in pilot experiments in Colombia. The Alliance of Bioversity International and CIAT's forage breeding program identified areas with similar geographic and environmental characteristics to those present in East Africa and applied initial trials accordingly. The large number of trials required made it unfeasible to develop the initial experiments in Africa (Oliphant et al., 2019; V. Castiblanco, personal communication, June 13, 2019). The subsequent methodology section delves into some technical details of this procedure, since it is also part of the technique used to estimate the size of potential forage markets.

The market for *Urochloa* interspecific hybrids is oriented to sub-humid tropical savannahs with low fertility and acid soils in eastern and southern Africa. An important feature of African soils is desertification. Desertification leads to declining crop yields and undermines the resilience of agriculture and pastoralism, fundamental foundations of subsistence in Africa (African Group of Negotiators Experts Support (AGNES), 2020). Forage is used for grazing, where the cattle roam freely, and for cut-and-carry, where it remains in stables. Forage characteristics have been grouped mainly into yield, agronomic characteristics, response to diseases and insects, production systems, and seed production/multiplication. The projected performance of the hybrid materials, based on initial testing of the breeding program, is described below. Regarding seed production, it is expected that under optimal conditions it will be at a production level equal to or above the existing commercial offer on the market (Table 1). This result is also expected for other environmental conditions such as drought, acid soils, waterlogging, and heat. Seed production is of vital importance because higher yields translate into higher efficiency, allowing new products to be competitive when it comes to market prices. Likewise, superior results are expected regarding nitrogen use efficiency (NUE). NUE is essential to optimize productivity levels and contributes to sustainable development of cattle farming by reducing the use of fertilizers. This makes it a key element for areas with low availability of inputs such as Africa (Rosegrant et al., 2014).

Regarding forage quality, the trials showed a crude protein (CP) content superior or equal to 10.5% and an in vitro dry matter digestibility (IVDMD) superior or equal to 62%. The CP reflects the percentage of protein in feed and its presence in forages is essential for animals that are in the growth and production stage (Instituto Nacional de Investigación Agropecuaria INIA, 2018). IVDMD is a measure of feed quality (Martínez et al., 2014). Regarding shade tolerance and palatability, measured on a scale of 1 to 9, materials are expected to range between an intermediate to high level. Shade tolerance is important for silvo-pastoral systems (Navas, 2010), however, they are still scarce in the region of interest. On the other hand, Heady (1964) defines palatability as the particularities of a plant that encourage its selection by animals.

Disease risk, measured on a scale of 1 to 5, is ranked equal to or less than two for *Rhizoctonia* leaf blight. Studies such as those by Alvares et al. (2013) indicate that up to 50% of the *Urochloa* production in tropical areas is affected by this disease. The analysis of resistance to pests, however, is still in the development stage. Existing hybrids show a good response to spittlebug (Hemiptera: Cercopidae), but not so much to *Tetranychus urticae*, known as red spider mite. This pest has occurred in some areas of Kenya, such as Busia and Bungoma, affecting especially Mulato II and Basilisk (Mwendia et al., 2019).

The predominant production system in the region is rain-fed agriculture, where only rainwater stored in the soil is used for crop and forage production and artificial irrigation techniques are not implemented (Díaz & Gutiérrez, 2020). Therefore, *Urochloa* adapts to the characteristics of a large part of the soils in East Africa. Of the set of elements mentioned, the characteristics considered essential are seed yields, forage quality (CP and IVDMD), and resistance to pests.

The existing competitors for new interspecific hybrids of *Urochloa* are (1) Mulato II, which combines the best traits of other hybrids and is suitable for medium and low fertility soils, (2) Cayman, for areas with flooding, (3) Camello, for areas with long-lasting droughts, and (4) Cobra, for cut-and-carry (Papalotla, n.d.). Table 1 lists the main characteristics of these forage hybrids.

Table 1. Competitors of new interspecific hybrids of *Urochloa*

Characteristics	Mulato II	Cayman	Camello	Cobra
Main features	Good response to drought, acid soils, and high temperatures. Combines the best features of other hybrids	Tolerant to humidity and waterlogging	Drought tolerance, quick establishment, good for acid soils	High yield, vertical growth that facilitates cutting
Resistance to diseases and pests	Spittlebug	Spittlebug	Spittlebug	Spittlebug
Required soil fertility level	Medium, high	humidity	Medium	High (for higher yields)
Palatability	Very good	Very good	Very good	Very good
CP	14-22%	10-17%	14-16%	14-16%
IVDMD	55-66%	58-70%	62%	69%
Yield (t/ha/y)	25	Up to 24	27-30	35-40

Main use	Grazing	Grazing	Grazing	Cut-and-carry

Source: own elaboration based on Cook et al. (2020); Papalotla (n.d.); Pasturas Tropicales (n.d.); Peters et al. (2010); TropicalSeeds (n.d.).

On the other hand, the potential market for hybrids of *Megathyrsus maximus* is oriented to the sub-humid tropical savannah of eastern and southern Africa, where fertile soils of high productivity are predominant, and cut-and-carry is the main use. According to the trials carried out in Colombia, the seed yield under optimal conditions is expected to be higher than the commercial offer on the market (Table 2). This is also considering drought, acid soils, waterlogging, heat, and NUE. Regarding forage quality, CP and IVDMD levels are estimated to equal or above 10.5% and 62%, respectively. Biological Nitrification Inhibition (BNI) is estimated to be moderate to high. BNI refers to the compounds that forages generate and that inhibit nitrification in the soil, which reduces or eliminates the use of fertilizers. This generates savings in production costs as well as mitigates greenhouse gas emissions (Nuñez, 2015). The production system is rainfed. On the market, the competing products for potential *Megathyrsus maximus* hybrids are (1) *Megathyrsus maximus* cv. Mombasa, which has a good overall performance, (2) *Megathyrsus maximus* cv. Tanzania, for soils with medium to high fertility, (3) *Megathyrsus maximus* cv. Massai, with high forage production but drought sensitivity, and (4) *Urochloa* hybrid cv. Mavuno, which has good drought tolerance and high yields (Agrizon, n.d.; Cook et al., 2020; Leguminutre, n.d.; Peters et al., 2010; Saenzfety, n.d.). Table 2 summarizes the main characteristics of these forages.

Tabla 2. Competitors of new *Megathyrsus maximus* hybrids

Characteristics	Mombasa	Tanzania	Massai	Mavuno*
Main features	High regrowth rate and good stem-leaf-ratio. Medium tolerance to cold and burning. Good drought tolerance	Medium drought tolerance	Burn and shade tolerance. In the dry season its yield is reduced by 50%	Good tolerance to drought, burning, and shade. Medium tolerance to humidity
Resistance to diseases and pests	Spittlebug	Spittlebug Medium tolerance to coal in the inflorescences	Spittlebug. Sensitive to panicle rot caused by *T. ayresii* (up to 80% of inflorescences)	Spittlebug
Required soil fertility level	Medium to high, acid soils	Medium to high, acid soils	Low to medium, acid soils	Medium, acid soils
Palatability	Very good	Good	Good	Very good
CP	10-14%	10-12%	7-11%	18-21%
IVDMD	60-65%	62%	55-60%	60%
Yield (t/ha/y)	25	18-20	21	17-20

Main use	Grazing, cut-and-carry	Grazing, cut-and-carry	Grazing, cut-and-carry	Grazing, cut-and-carry

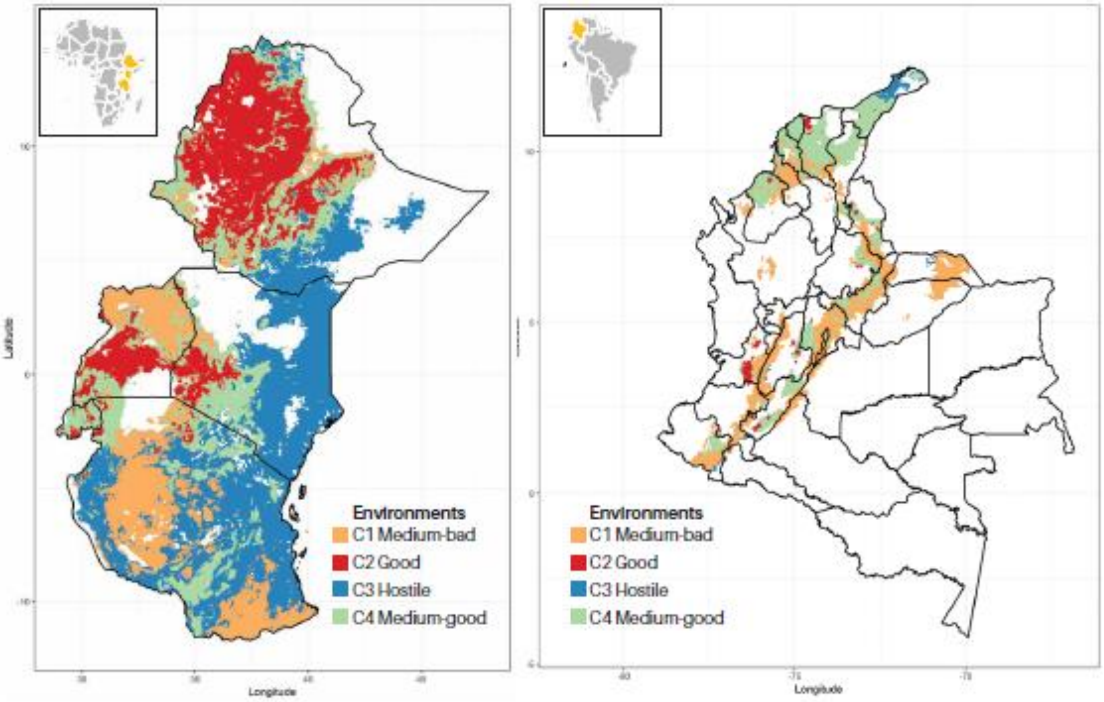
Source: own elaboration based on Agrizon (n.d.); Cook et al. (2020); Leguminutre (n.d.); Peters et al. (2010); Saenzfety (n.d.).
***Note:** Mavuno was released by Wolf Sementes from Brazil in 2013 (Cook et al., 2020). Despite being an *Urochloa* hybrid, due to its high performance it is considered a potential competitor in the *Megathyrsus maximus* market.

Methodology

This section describes the method used by the Alliance of Bioversity International and CIAT's forages breeding program to estimate potential markets for new *Urochloa* interspecific and *Megathyrsus maximus* hybrids in East Africa, particularly in Ethiopia, Kenya, Tanzania, Uganda, and South Sudan. Results are also presented for Mali and Nigeria, two West African countries. The first step is the identification of the potential hectares needed for cattle feeding. With data from the Food and Agriculture Organization of the United Nations (FAO) on cattle heads for milk production in 2018, the number of hectares devoted to forage cultivation is calculated. It is assumed that the obtained numbers are a conservative estimate, since improved forages have superior performance and require fewer hectares for the same level of production. An adoption rate of 15% per year is assumed. The second step is to assign a proportion of these hectares to each of the two materials of interest through the application of a Target Population of Environments (TPE) study (V. Castiblanco; A. Notenbaert, personal communication, June 13, 2019).

Oliphant et al. (2019), developed the TPE for this purpose through geographic information systems and a cluster-type multivariate analysis. In this way, they identified areas with similar environmental features in Africa and Colombia (Figure 1). This allowed the pilot trials referenced in the market segments section to be carried out. Likewise, the profiling formed four geographical groups with similar environmental characteristics, namely: areas of high livestock density (Ramankutty et al., 2008), qualitative soil data (Hengl et al., 2014), and different precipitation measurements (Funk et al. al., 2015; Ruane et al., 2015).

Figure 1. Identified clusters in East Africa and Colombia



Source: Oliphant et al. (2019).

For the purpose of analysis, two of the four identified clusters are relevant. Cluster 2 (good), colored red on the maps, is characterized by higher precipitation and better rainfall distribution throughout the year. It provides the conditions for the adoption of potential hybrids of *Megathyrsus maximus*, which have high forage quality and production, but require good environmental conditions. This cluster represents 28% of the potential area. Cluster 3 (hostile), colored blue on the maps, has low rainfall and poor distribution of rainfall throughout the year, making it more suitable for new interspecific hybrids of *Urochloa*, which have medium to high forage production and are very adaptable to difficult environments. This cluster represents 27% of the potential area (V. Castiblanco, personal communication, June 13, 2019). Applying these percentages to the hectares calculated in the first step, the potential markets for the new materials are obtained. This is done for each of the countries of interest. Although some data sources are not recent, the TPE provides valuable geospatial information by incorporating a large number of variables, which allow for segmentation with a good level of certainty.

The segmentation of these two potential markets for improved forage hybrids responds to the environmental and production characteristics present in the countries of East Africa. This environment requires materials with agronomic and performance traits that exceed the conditions currently available on the market.

Market Segmentation Results

The results of the estimation of the potential market for new *Urochloa* interspecific hybrids can be seen in Figure 2. The biggest potential markets in East Africa are found in Ethiopia, Kenya, Tanzania, and Uganda. Other representative countries outside the region are Nigeria and Mali in

West Africa. In terms of numbers, Ethiopia ranks first with 174,924 hectares, followed by Kenya and Tanzania with 103,679 and 101,926 hectares, respectively. Uganda and Nigeria are in the middle range with 58,316 and 32,589 hectares, respectively, and Mali shows the smallest market potential with 25,879 hectares.

Figure 3 shows the results for the potential market for *Megathyrsus maximus* hybrids. The most relevant country is Ethiopia with 181,403 hectares, followed by South Sudan with 113,150, Kenya with 107,519, Tanzania with 105,701, and Uganda with 60,476 hectares, respectively. Nigeria is the only country outside East Africa and has a market potential of 33,796 hectares.

Figure 2. Potential market for new *Urochloa* interspecific hybrids

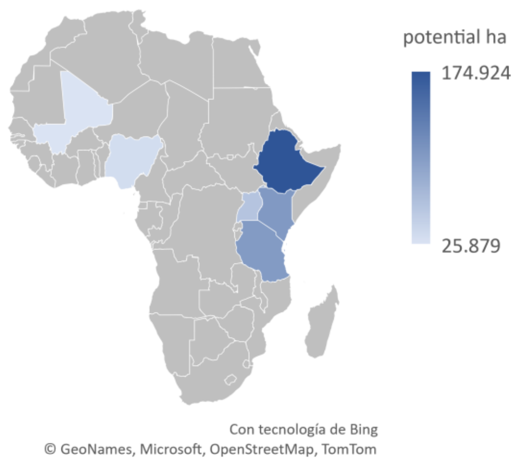
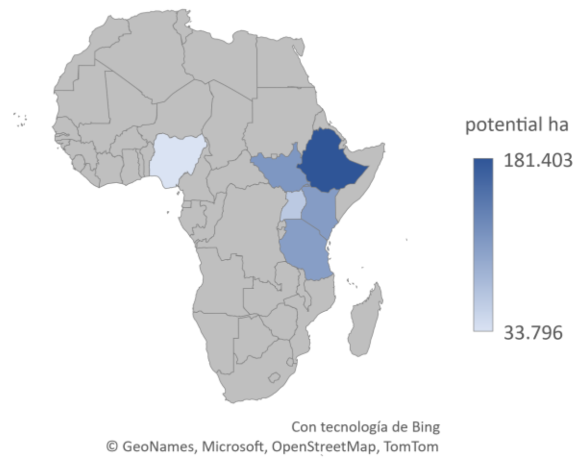


Figure 3. Potential market for new *Megathyrsus maximus* hybrids



Source: own elaboration based on V. Castiblanco and A. Notenbaert (personal communication, Junio 13, 2019) and Oliphant et al. (2019).

Policy recommendations

- Consolidate relationships between public entities, private sector, and research to sensitize the rural population about the productivity, cost, and sustainability advantages of new forage technologies. The superior characteristics of these materials must be assertively conveyed to producers to obtain higher adoption rates.
- Strengthen the accompaniment of the public and private sectors, research, and development institutions to the producers to guarantee their access to technical, administrative, and commercial training and knowledge, which allows a sustainable adoption of new forage technologies.
- Generate a favorable commercial and institutional environment for the adoption of improved forages. This element is key since it will provide the necessary incentives for producers to make the decision to generate a change in their production system.
- Promote communication between the various actors to identify the advances and difficulties that arise with the adoption of new technologies. An adequate information system is essential for decision makers to establish policies and implement timely actions according to each local context.

- Support the development of a competitive forage seed market so that promising materials can be registered properly and made accessible to the producers.

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