

# Cultural Effects on Sorghum Varieties Grown, Traits Preferred, and Seed Management Practices in Northern Ethiopia

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**Cultural Effects on Sorghum Varieties Grown, Traits Preferred, and Seed Management Practices in Northern Ethiopia.** Agrobiodiversity is fundamentally shaped by farmers' preferences and management practices, and these are again shaped by the farmers' social and cultural background. This study investigates variety preferences and seed management practices in the crop sorghum (*Sorghum bicolor*) among the Kunama and the Tigrayan ethnolinguistic groups living side by side in Northern Ethiopia. Surveys were conducted in 10 villages located in two districts inhabited by the two ethnolinguistic groups and analyzed using descriptive and multinomial analysis. We find important differences in varieties grown across the ethnolinguistic groups, but we also find that ethnicity and geographic proximity interact and affect trait preference and seed management practices. Altogether, 22 varieties are cultivated, and few farmers cultivated improved varieties, especially among the Kunama. Respondents considered use traits as important as agronomic traits when selecting sorghum varieties. Notably, preferred use traits were not limited to food (e.g., construction materials were important for the Kunama), and preferred agronomic traits were not focused on drought resistance. Timing of seed selection, seed selection criteria (e.g., panicle size and color), and seed storage practices differed among the ethnic groups. Understanding cultural and social preferences towards sorghum varieties, their traits, and the criteria used for seed management is crucial for the success of crop breeding programs, climate change adaptation policies, and development interventions.

**Key Words:** Agrobiodiversity, Culture, Ethnolinguistic groups, use trait, varietal preferences, Sorghum.

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አብ ሰሜናዊ ኢትዮጵያ ባህላዊ ረጅሙታት አብ ዚበቀላል በበይኑ ዓይነት መሸላጭ፣ዚመርጽዎ ባህርያት ፣ከምኡውን ምምሕዳር ዘርኢ ዘሕደር ጽልዎ. እተፈላለዩ ዓይነት አትክልቲ ብመሰረቱ በቲ ሓረስቶት ዚገብርዎ ምርጫታትን ምምሕዳራዊ ልምድታትን እዩ ዚቐረጽ እዚ ድማ እንደገና ብማሕበራውን ባህላውን ድሕረ-ባይታ ሓረስቶት እዩ ዚቐረጽ። እዚ መጽናዕቲ እዚ አብ ሰሜናዊ ኢትዮጵያ ጎድኒ ጎድኒ ዝክበሩ አብ መንጎ ኩናማን ተጋሩን ስነ-ምግባራዊ አተሓሳስባ ዘለዎም ጉጅለ አብ መሸላ ዘሎ እተፈላለዩ ምርጫታትን አተሓሕዞ ዘርእን ይምርምር። አብተን ክልተ ዓሌታት ዝክብሩሉን ክልተ ቀቢላታት ዝርከባ ዓሰር ተአቓቕሻት መጽናዕቲ ተገይሩ ኢዩ ። እቲ ሓበሬታ ብገላጽን ብብዙሕን መጽናዕቲ እዩ ተመርመሩ ። አብ እተፈላለዩ ጉጅለታት መጽናዕቲ እተገብረሉ እተፈላለዩ ዓይነት መሸላ ንረክብ እኳ እንተ ኹንና ዓሌትን ጂኦግራፊያውን ምቅርራብ ነቲ ናይ ባህርይ ምርጫን አተሓሕዞ ዘርእን ከም ዚጸልዎ እውን ክንፈልጥ ክኢልና ኢና። ብሓፈሻኡ 22 ዓይነታት መሸላ ይሕረስ ሓረስቶት ከአብፍላይ አብ ኩናማ ሒደት አተመሓየሽ ዓይነት መሸላ የፍረዩ። እቶም ምላሽ ዝሃቡ ሰባት እተፈላለዩ ዓይነት መሸላ ከመርጹ ኸለዉ ናይ አጠቓቕማ ባህርያት ከም ናይ ሕርሻ ባህርያት ገይሮም ኢዮም ዝርእይዎ ነይሮም። እቲ ዘገርም ከአ እቲ ዝመረጽዎ አጠቓቕማ አብ መግቢ ጥራይ እተሓጸረ ኣይነበረን (ንኣብነት ናውቲ ህንጻት ንኩናማ ኣድላዩ ኢዩ ነይሩ) ከምኡውን ናይ ሕርሻ ባህርያት አብ ድርቂ ተጻዋርነት ዘተኮረ ኣይነበረን ።። ግዜ ምምራጽ ዘርኢን መለክዒታት ምምራጽ ዘርኢን (ንኣብነት ጉምቦን ሕብርን) ከምኡውን ናይ ምዕቃብ ልምዲ ዘርኢ አብ መንጎ እቶም መጽናዕቲ እተገብረሎም ዓሌታት እተፈላለዩ ኢዩ። ብዛዕባ እተፈላለዩ ዓይነት መሸላ ባህላውን ማሕበራውን ምርጫታት ምርዳእ መደባት ምፍራይ እኸለ ፖሊሲታት ለውጢ ኸኾነታት ኣየር ከምኡውን ዕቢት ንምግባር ኣዝዩ ኣገዳሲ እዩ.

### Introduction

Crops are not only biological objects, but they also bear the imprint of the societies in which they are grown, seeds exchanged, and selected (Stemler et al. 1977). Some crops are so important that a society may define them as critical elements in their relationship with—and adaptation to—the local environment (Cristancho and Vining 2004). Some authors identify such crop species as “cultural keystone species” because the societies they support probably would be quite different without them (Garibaldi and Turner 2004). In general, cultural keystone species are defined as species (plants, animals) that play a key role in resource acquisition, have high use–value, have an associated naming and terminology in a local language, fulfill a psycho–sociocultural function within a given culture, and have a high level of species irreplaceability (Garibaldi and Turner 2004). The concept of keystone species has been applied to various studies; e.g., the ritual value of upland rice for the Sarangani tribal community

in the southern Philippines (Zapico et al. 2020) and the ceremonial value of Emory oak acorns for western Apache tribal communities in Arizona and Mexico (Souther et al. 2021). In the realm of research on crop genetic resources, Berg’s (2009) concept of “folk varieties” similarly emphasizes the active management and cultural significance of many farmers’ varieties. Understanding the processes that shape crop genetic diversity is crucial for sustainable management of this vital part of the planet’s biodiversity. The loss of farmers’ crop varieties is a major sustainability concern (Abdi et al. 2002; Bellon 1996; Doggett 1991; Khoury et al. 2021; Pautasso et al. 2013; Tsehaye et al. 2009). Farmers’ crop varieties, sometimes referred to as “farmer varieties”, are products of centuries of selection by farmers and the natural environment and are typically adapted to specific agro–ecological conditions and farmers’ sociocultural preferences (Cavatassi et al. 2011; Pautasso 2015; Teshome et al. 1997). Small-scale farmers often prefer farmer varieties to improved varieties because farmer varieties can be

grown with little capital inputs, such as fertilizers, pesticides, or irrigation (Cavatassi et al. 2011). In addition, farmer varieties can meet farmers' social, economic, cultural, and ecological needs (Teshome et al. 1997), and they have historical origins and cultural significance (Pautasso et al. 2013).

Sorghum (*Sorghum bicolor* [L.] Moench) is a drought-tolerant cereal crop that is important for farmers' food and livelihood security in the semi-arid tropics of Africa and Asia. In terms of area of cultivation, it is the fifth most important cereal crop worldwide and the third most important crop in Ethiopia (FAOSTAT 2019). Ethiopia is located in a center of diversity for sorghum and all of the five botanical races of sorghum are found cultivated by farmers in the country (Wondimu et al. 2021). The diversity of sorghum in Ethiopia is due to the historic movement of people and plants and the diversity of agroecological conditions in the country (Stemler et al. 1977).

In recent years, several studies have focused on evaluating sorghum diversity in Ethiopia, including genetic variability of sorghum (Gebregergs and Mekbib 2020; Mola and Ejeta 2021; Wondimu et al. 2021), on-farm sorghum landrace diversity and farmers' selection criteria (Mekbib et al. 2009; Teshome et al. 2016), the role of traditional farmers in the maintenance of sorghum landrace diversity in the north Shewa and south Welo regions of Ethiopia (Teshome et al. 1999a), a botanical classification of sorghum landraces of the north Shewa and south Welo regions of Ethiopia (Teshome et al. 1997), how agronomic traits have shaped sorghum diversity (Wubeneh and Sanders 2006), or how socioeconomic factors drive variety use, e.g., gender (Abebe et al. 2021). However, these studies focused more on the genetic diversity and botanical classification of sorghum and only to a limited extent on the sociocultural factors influencing sorghum diversity. Understanding the sociocultural factors of sorghum diversity enables the design of an effective conservation strategy for sorghum genetic resources in Ethiopia. Thus, our study aims to fill this knowledge gap by focusing on ethnicity as a sociocultural driver of sorghum diversity in the Tigray region of northern Ethiopia. We address the following research questions: Is there a difference in sorghum variety use between the two ethnolinguistic groups and can such a difference eventually be explained by sociocultural differences in variety trait preferences and/or seed management practices? We discuss the implications of the findings

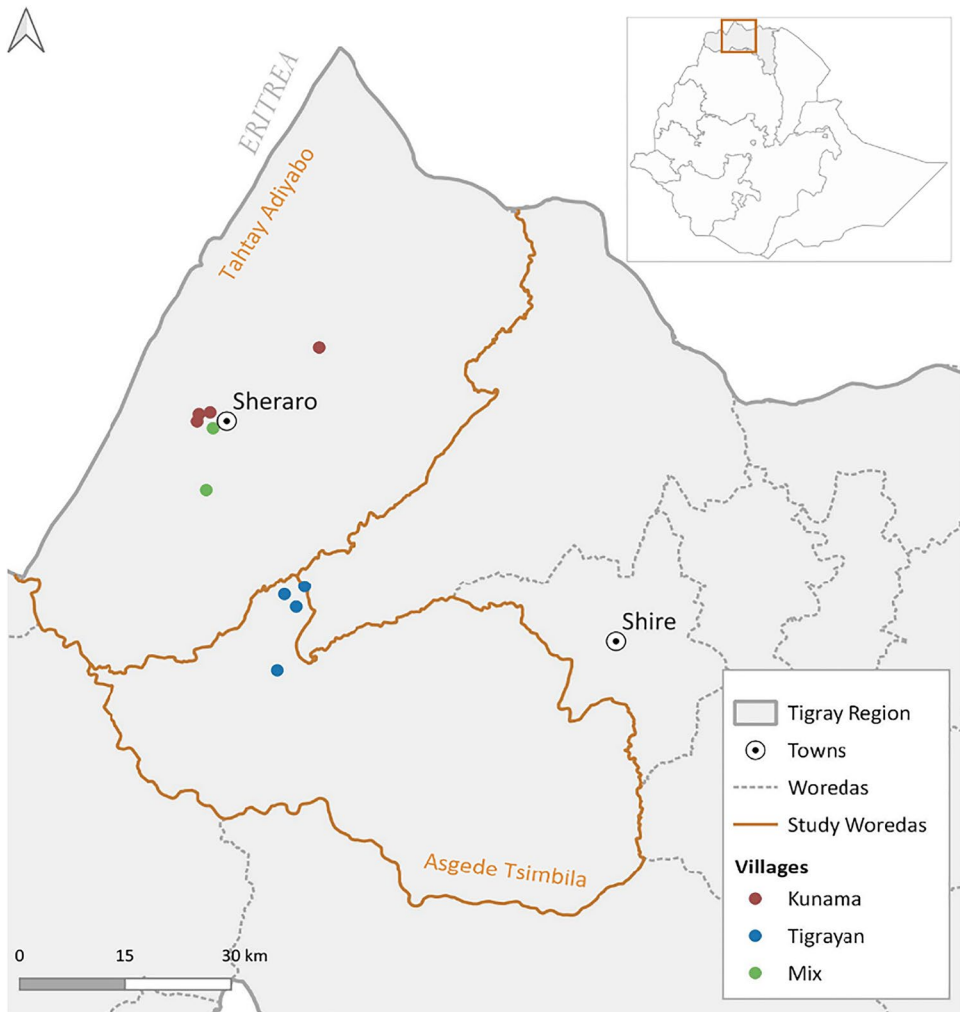
for crop breeding programs, climate change adaptation policies and development interventions.

## Materials and Methods

### STUDY AREA

This research was conducted in two districts (Woredas) of the Tigray region of northern Ethiopia: Asgede Tsimbila and Tahtay Adiyabo (Fig. 1). Both districts have three agroclimatic zones: the warm semi-arid lower elevations, the warm sub-moist mid elevations, and the cool sub-moist higher elevations (Tsfay et al. 2016). Both districts have a unimodal rainfall regime of 513–910 mm, with a rainy season (*kiremti*) from June to September (Zenebe et al. 2012). According to the National Metrological Agency (NMA), the mean annual temperature ranges from 25°C to 28°C (National Metrological Agency 2015). The dominant farming system is mixed crop-livestock production, with sorghum being the main staple and sesame the main cash crop.

This research focused on two ethnic groups: Tigrayan and Kunama. There are about 7 million Tigrayan people in Ethiopia, most of them inhabiting the Tigray region (International Federation of Red Cross and Red Crescent Societies 2020). The Tigrayans comprise a sedentary farmer ethnic group indigenous to the Tigray region, but they specifically moved to Asgede Tsimbila district in the 1970s when looking for more land to farm. The Kunama, of Nilo-Saharan origin, are also considered indigenous to the Tigray region (Woldegiorgis 2018). The majority of the Kunama (about 64,000) live in Eritrea (Woldemikael 2003) while 4,800 Kunama live in Ethiopia (Federal Democratic Republic of Ethiopia Population Census Commission 2008). Currently, they are sedentary farmers, but some argue that in the past they were nomadic pastoralists rearing camels, cattle, and goats, and that the Kunama experienced a major sociocultural transformation from a nomadic pastoralist livelihood strategy to a sedentary farming way of life (Woldegiorgis 2018). On the contrary, oral sources contend that they were among the first indigenous peoples of Ethiopia and that they have always practiced sedentary agriculture (Woldegiorgis 2018).



**Fig. 1.** Map of the villages sampled in the two districts (or Woredas) studied.

#### DATA COLLECTION

A structured questionnaire was administered to 300 randomly selected households in 10 villages located in both districts between November 2019 and October 2020. In Asgede Tsimbila district (four villages), 180 respondents identified as Tigrayan (M=147, F=33) and in the Tahtay Adiyabo district (six villages), 83 identified as Kunama (M=55, F=28) and 37 as Tigrayan (M=21, F=16). The questionnaire had four sections.

- Section 1: respondents were asked to list all sorghum varieties they had grown during the previous crop growing season.
- Section 2: respondents were asked to score the sorghum varieties they have grown from 1 up to 3 (where 1 = poor, 2 = average, and 3 = good) in relation to a range of use and agronomic traits. The use traits (n = 9) included injera quality (a sour fermented flatbread eaten for lunch/dinner), kicha quality (a nonfermented thick

bread mostly consumed for breakfast/snacks), daga/siwa quality (traditional beers), sorghum use as livestock fodder, and sorghum use for construction, availability, storability, medicinal value, and ritual value. The agronomic traits ( $n = 5$ ) included early maturity, high yield, drought resistance, pest resistance, and resistance to hawi-ayna (witchweed, *Striga* spp.).

- Section 3: respondents were asked to rank their preferred traits in order of importance from 1st up to 3rd in relation to a range of agronomic and use traits. The agronomic traits ( $n = 5$ ) included early maturity, high yield, drought resistance, pest resistance, and resistance to hawi-ayna (witchweed, *Striga* spp.). The list of both uses and agronomic traits was based on interviews with 50 key informants (25 per ethnic group) carried out previous to the household survey.
- Section 4: farmers were asked to identify their seed selection practices, including selection criteria, selection methods and timings, storage techniques, and measures against pests from the alternatives provided. Ethnicity, gender, and asset status of each respondent were also recorded. All interviews were carried out in the Tigrigna language by seven enumerators trained by the first author. The Kunama also speak Tigrigna. Additionally, we surveyed and recorded the average price of the different sorghum varieties in the largest urban markets near the studied villages—Sheraro and Shire. (Fig. 1).

#### ETHICS STATEMENT

A research permit was obtained from the Mekelle University Office of Research and Community Service. A permission letter was also obtained from the local administrators of the two districts and from the Office of Agriculture and Rural Development. We followed recommendations of the International Society of Ethnobiology Code of Ethics (ISE 2006), and the involvement of local team members ensured that local procedures, rules, and customs were respected, and that authorizations were granted from legitimate authorities. First, government administrative and local community representatives were informed and kept updated of the activities, and their

consent was sought before conducting the research. Then, the study objectives and future data utilization were explained to study participants and their written prior informed consent was obtained before undertaking interviews and seed collection. The seed samples collected were deposited at the Mekelle University gene bank. All study participants were selected on a voluntary basis. Research activities were not conducted where such consent was not granted.

#### STATISTICAL ANALYSIS

First, to explore the effects of ethnicity and location (district), we grouped respondents into three groups: Kunama ( $n = 83$ ) living in Tahtay Adiyabo district, Tigrayan living in Tahtay Adiyabo district (hereafter Tigrayan-T), and Tigrayan living in Asgede Tsimbila district ( $n = 180$ ) (hereafter Tigrayan-A). Descriptive statistics were used to examine differences among these three groups on i) sorghum varieties grown, ii) use and agronomic traits preferred, and iii) seed management practices. A one-way ANOVA was performed to assess differences related to household age, household size, years lived in a village, farm size, average number of crops, average number of sorghum varieties per household, Simpson's Diversity Index (SDI), average yield per year (see the Electronic Supplementary Material—ESM 1). A multinomial logistic regression analysis was performed on the total sample to assess the relative contribution of different sociodemographic independent variables in explaining the type of sorghum varieties grown (dependent variable): ethnicity, location (district), village, age, area of cultivation, wealth status (principal component analysis was used to group households into four wealth groups based on binary coding of ownership of 18 assets), farming experience, year of producing sorghum, and educational status. The dependent variable was constructed by categorizing sorghum varieties into six groups (*Mereway*, *Dagnaw*, *Melkam*, *Tsa'da chumurey*, *Wediaker*, and "Others"). One variety (*Mereway*) was chosen to be the "reference category" (see ESM 2). All analysis were performed in SPSS version 27.

The average price of each variety was calculated based on data from the market. Prices in Ethiopian birr (ETB) per quintal were converted to USD/kg using USD 1 = 29 ETB and 1 quintal = 100kg.

## Results

### VARIETIES GROWN

An overview of farmers' characteristics can be found in ESM 1. Overall, respondents reported having cultivated 22 varieties of sorghum: 16 farmer varieties and 6 improved varieties (Table 1). While the Kunama reported 13 varieties, the Tigrayan-T (living in same district as the Kunama) reported 10, and Tigrayan-A reported 16 (Table 1). Three and nine varieties were only grown by the Kunama or Tigrayan-A, respectively, while Tigrayan-T was not growing any unique variety. Only seven varieties were

cited by all groups. The main varieties grown by the Kunama were *Dagnev* (72% of Kunama respondents), *Wediaker* (36%), and *Tsa'da chumurey* (27%). For the Tigrayan-T (living in the same district) these were: *Dagnev* (54%), *Tsa'da chumurey* (27%), and *Mereway* (24%). For the Tigrayan-A these were: *Mereway* (86%), *Melkam* (28%), and *Wedisibush* (7%) (Table 1).

Most farmers cultivated only two varieties (average being 1.53 varieties), but some cultivated up to three, and one farmer grew four. More Tigrayan-A farmers (30%) cultivated improved varieties compared to Kunama (17%) or Tigrayan-T (24%) respondents. Most farmers considered farmer varieties as less risky than

TABLE 1. SORGHUM VARIETIES GROWN BY STUDY RESPONDENTS.

Sorghum varieties	Botanical races	Type of variety *	Kunama <sup>***</sup> (n=83)	Tigrayan-T <sup>***</sup> (n=37)	Tigrayan-A <sup>***</sup> (n=180)
<i>Dagnev</i> (Amharic)	Caudatum	FV	<b>72.3%</b>	<b>54%</b>	1.6%
<i>Fkrey</i> (Tigrigna)	Caudatum	FV	0	0	2.2%
<i>Getsharas</i> (Tigrigna)	Durra	FV	0	0	0.5%
<i>Keyih chumurey/ Bazenay</i> (Tigrigna)	Durra	FV	2.4%	5.4%	0
<i>Keyih mereway</i> (Tigrigna)	Durra	FV	2.4%	0	0
<i>Keyih meshela</i> (Tigrigna)	Durra	FV	2.4%	2.7%	0.5%
<i>Mereway</i> (Tigrigna)	Durra	FV	10.8%	<b>24.3%</b>	<b>85.5%</b>
<i>Tsa'da chumurey/ Chumurey/Zeriege-bru</i> (Tigrigna)	Durra	FV	<b>26.5%</b>	<b>27%</b>	0.5%
<i>Tsa'da meshela</i> (Tigrigna)	Durra	FV	9.6%	2.7%	2.2%
<i>Wediaker</i> (unknown)	Caudatum	FV	<b>36.1%</b>	8.1%	1.6%
<i>Wedisibuh</i> (Tigrigna)	Durra	FV	0	0	<b>7.2%</b>
<i>Akoma</i> (unknown)	Durra	FV	2.4%	2.7%	0
<i>Gehateni</i> (Tigrigna)	Durra	FV	0	0	0.5%
<i>Kemkem</i> (unknown)	Durra	FV	0	0	0.5%
<i>Shulkuut</i> (Tigrigna)	Durra	FV	0	0	0.5%
<i>Tewzale</i> (Amharic)	Durra-bicolor	FV	0	0	0.5%
<i>Argeti</i> (unknown)	Durra	Improved	0	0	0.5%
<i>Deber</i> (unknown)	Durra	Improved	2.4%	0	0
<i>Dekeba</i> (unknown)	Durra	Improved	2.4%	13.5%	0
<i>Gambela</i> (Tigrigna)	Durra	Improved	6.02%	0	0
<i>Melkam</i> (Amharic)	Durra	Improved	0	0	<b>27.7%</b>
<i>Mruts zerie</i> (Tigrigna)	Durra	Improved	8.4%	10.8%	1.6%

\*Tigrayan-T: Tigrayan living in Tahtay Adiyabo district (nearby Kunama); Tigrayan-A: Tigrayan in Asgede Tsimbila district; FV: farmer variety

\*\* Percentage of respondents within that group

\*\*\* The numbers in bold indicate the varieties grown by the majority of respondents in that group, the variety names separated by slash are synonyms

improved varieties (the latter being mostly grown on a small portion of their fields).

The multinomial logistic regression analysis showed that the sorghum variety grown was associated with both ethnicity and district (see ESM 2). Area of cultivation, age, farming experience (all crops), farming experience (sorghum), and wealth status also significantly affected variety grown (see ESM 2).

### PREFERRED TRAITS

With regard to preferred use traits, high quality sorghum for *injera* preparation (a traditional fermented flatbread) was considered the most important use trait for sorghum variety selection among most farmers from all groups studied (Table 2). The varieties most commonly cultivated by farmers reflect these use preferences; e.g., *Mereway* and *Dagnev* (most widely cultivated by the Tigrayan-A and Kunama, respectively) are considered to produce high quality *injera* (see ESM 3 and ESM 7). Some differences were also observed across groups, with, e.g., more Kunama respondents highlighting the use of sorghum for construction materials (to make fences and small sheds). Some examples of distinct uses include, for example, *Melkam* (to feed cattle only by Tigrayan-A due to its soft sugary

straws); *Mereway* (boiled grains used to treat hepatitis only by Tigrayan-A), and *Dagnev* (boiled grains used to treat malaria only among the Kunama).

With regard to preferred agronomic traits, three agronomic traits were ranked as most important by all groups (high yield, early maturing, and resistance to *Striga*), but the percentage of respondents emphasizing each trait was slightly different across groups (Table 2). The varieties most commonly cultivated by farmers reflect these agronomic trait preferences; e.g., *Mereway* and *Dagnev* (most widely cultivated by the Tigrayan-A and Kunama, respectively) are considered as high yielding (see ESM 4 and ESM 8). Remarkably, drought tolerance was not ranked among the top three agronomic traits by any ethnic group, perhaps because most respondents mentioned that local varieties are believed to be more adapted to drought than improved ones.

Respondents mentioned that market price was also an important trait to be considered. The most expensive varieties for the Kunama and Tigrayan-T were *Mereway* (USD 0.46/kg), *Dagnev* (\$0.46/kg), and *Tsa'da chumurey* (USD 0.44). For the Tigrayan-A, these varieties were *Wedisibuh* (USD 0.43/kg), *Mereway* (USD 0.42/kg), and *Melkam* (USD 0.41/kg). For an overview of varieties' prices, see ESM 9.

Notably, the name given to some farmer varieties refers to their traits (see Table 3). For

**TABLE 2.** RANKING OF PREFERRED USE AND AGRONOMIC TRAITS BY EACH GROUP STUDIED.

	Use traits				Agronomic traits		
	Injera	Kicha Bread	Livestock Fodder	Construction Material	Early Maturing	High Yield	Striga Resistance
Ranking	1st	1st	1st	1st	1st	1st	1st
Kunama	72%	18%	35%	36%	36%	24%	18%
Tigrayan-A*	77%	19%	28%	6%	25%	33%	18%
Tigrayan-T*	76%	19%	27%	5.0%	27%	19%	14%
Ranking	2nd	2nd	2nd	2nd	2nd	2nd	2nd
Kunama	27.7 %	81.9%	62.7%	60.2 %	63.9 %	60.2%	72.3 %
Tigrayan-A*	22.8%	71%	66.7%	33.9%	64.4 %	61.1%	80.6%
Tigrayan-T*	24 %	81%	73%	27%	73%	73 %	81%
Ranking	3rd	3rd	3rd	3rd	3rd	3rd	3rd
Kunama	0.3	0%	2.4%	3.6%	0	15.7%	9.6%
Tigrayan-A*	0.2 %	10%	5.4 %	60%	10.6 %	5.6 %	1.1%
Tigrayan-T*	0	0	0	67.6%	0	8.1 %	5.1%

\*Tigrayan-T: Tigrayan living in Tahtay Adiyabo district (nearby Kunama); Tigrayan-A: Tigrayan in Asgede Tsimbila district

**TABLE 3.** EXPLANATIONS OF FARMERS' VARIETIES' NAMES.

Variety Names	Explanations	Ethnic Group Citing That Explanation		
		Kunama	Tigrayan-T	Tigrayan-A
<i>Mereway</i>	The name <i>Mereway</i> , means “satisfying,” referring to the high-yielding trait of the variety. It is considered as a variety of rich farmers because it is planted early and harvested late.			✓
<i>Zeriegebru</i> ( <i>Tsa'da chumurey</i> )/ <i>Chumurey</i>	The name <i>Zeriegebru</i> is coined from two words, <i>Zerie</i> and <i>Gebbru</i> . “ <i>Zerie</i> ” means seed, while “ <i>Gebbru</i> ” refers to the name of the person who is said to have selected the variety. The name “ <i>Tsa'da chumurey</i> ” is also used to refer to the same variety that means “white <i>Chumurey</i> ,” in which “ <i>Tsa'da</i> ” means “white” and “ <i>Chumurey</i> ” means ‘addition’ to refer the twin seeded trait of the variety.	✓	✓	
<i>Wedisibuh</i>	The name “ <i>Wedisibuh</i> ” means “Son of fatty.” “ <i>Sibuh</i> ” in Tigrigna means “fatty” to describe the good <i>injera</i> quality that can be prepared from the variety.			✓
<i>Dagnew</i>	It is the most cultivated variety among the Kunama. The name “ <i>Dagnew</i> ” is an Amharic term meaning “judge it” to denote the high quality of this variety in terms of quality of the <i>injera</i> and high price in the local market. It is used for malaria treatment because of its bitter taste.	✓	✓	
<i>Wediaker</i> ( <i>Wediarbe'a</i> , <i>Fkrey</i> / <i>Hishnur</i> )	The name “ <i>Wediaker</i> ” is mostly used among the Kunama. While the names “ <i>Wediarbe'a</i> ,” “ <i>Fikrey</i> ,” and “ <i>Hishnur</i> ” are used mainly by the Tigrayan to refer the same variety, the name “ <i>Wediarba'a</i> ” means “son of forty” meaning a variety that matures within forty days to show the early maturing trait of the variety.	✓	✓	✓

\*Tigrayan-T: Tigrayan living in Tahtay Adiyabo district (nearby Kunama); Tigrayan-A: Tigrayan in Asgede Tsimbila district

example, *Dagnew*, an Amharic term that means “judge it,” refers to its superior performance in terms *injera* quality and high price in local markets. *Mereway* is a Tigrayan term meaning “satisfying” and refers to the high yields one can get when cultivating this variety.

### SEED MANAGEMENT PRACTICES

Over 98% of respondents within each group practice seed selection to maintain their sorghum varieties. Most of the Kunama (48%) and Tigrayan-T (46%) select seeds during the harvesting stage, while most Tigrayan-A (74%) select seeds in the pre-harvesting stage.

While large seed size was emphasized by all groups, the Kunama also cited early maturity, the Tigrayan-T cited yield, and the Tigrayan-A cited large and long panicles (Table 4). Several similarities among the groups studied were observed in the farmers' selection environment, the selection method, and the number of panicles selected. Most farmers have no specific selection environment, use a uniform selection method (one type of variety), and select between 51–100 sorghum panicles for the next growing season (Table 4). Respondents noted that in general, they select more panicles if the harvest is good.

Modern seed and grain storage (in bags) was practiced by more Kunama respondents



**TABLE 4.** SEED SELECTION PRACTICES ACROSS THE ETHNIC GROUP.

Elements of seed practices	Parameters	Ethnic Group		
		Kunama (n = 83)	Tigrayan-T* (n=37)	Tigrayan-A* (n=180)
Seed selection	Yes	98.8%	100%	99.4%
	No	1.2%	0	0.6%
Selection method	Uniform (one type)	96.3%	97.3%	97.2%
	Mixed (more than one type)	3.7%	2.7%	2.85%
Selection criteria	Big and long panicles	20.7%	5.4%	31.3%
	Early maturing types	24.4%	10.8%	5.6%
	Long stature, straw quality	0	0	1.7%
	Good tillering capacity	2.4%	5.4%	8.4%
	Yield	20.7%	32.4%	12.8%
	Bigger seed size	31.7%	45.9%	39.7%
	Big leaf	0	0	0.6%
Number of panicles selected	<10	1.2%	0	0.6%
	10–50	26.8%	16.2%	37.4%
	51–100	46.3%	56.8%	47.5%
	>100	25.6%	27.0%	14.5%
Selection environment	Yes	34.1%	45.9%	39.7%
	No	65.9%	54.1%	60.3%
Sorghum growth stages of seed selection	Pre-harvesting	39.0%	37.8%	73.7%
	During harvesting	47.6%	45.9%	26.3%
	Post harvesting	13.4%	16.2%	0

\*Tigrayan-T: Tigrayan living in Tahtay Adiyabo district (nearby Kunama); Tigrayan-A: Tigrayan in Asgede Tsimbila district

(55% for seeds and 61% for grains) than Tigrayan-A (31% and 32%) or Tigrayan-T (0% and 0%) (ESM 10). Most likely, this is linked to limited seed production and reduced amount of seed available for storage among the Kunama (pers. obs. 2020). Modern pesticides were employed by more Tigrayan-A (59%) than Kunama (40%) or Tigrayan-T (32%) respondents. Traditionally, both ethnic groups stored sorghum seeds in *hamham* (calabash, <5 kg), when the quantity to be stored was small. When the quantity was larger, the Kunama and Tigrayan-T used *godo* (a mud granary located inside the house, <500kg) while the Tigrayan-A used *wala* (shed, <800kg), *kitsa* (small storage jar made with

*Flueggea virosa* (Roxb. ex Willd.), <800 kg), or *gotera* (large storage jars made with *Flueggea virosa* (Roxb. ex Willd.), <2,700 kg) (see Fig. 2). Traditionally, the Kunama and Tigrayan-T mixed sorghum grains with ash to protect them from insects while Tigrayan-A used *Azadirachta indica* A.Juss. Bags are now replacing the earlier storage containers and DDT or other chemical insecticides are being increasingly mixed with sorghum grain.

For the Kunama, the main factors affecting sorghum production were weeds (41%) and birds (39%), while for the Tigrayan-T these were weeds (73%) and drought (13%), and for the Tigrayan-A these were weeds (49%) and insects (30%).



**Fig. 2.** Traditional seed and grain storage in our study area. From top left to bottom right: *kitsa*, *gotera*, *wala*, and *godo*.

## Discussion

### SORGHUM VARIETIES GROWN

In this study, 22 sorghum varieties were cultivated by study participants. This number is similar to other studies from Ethiopia (24 varieties

were reported from the North Shewa and South Welo regions of Ethiopia, (Teshome et al. 1999b)), but it is higher than the 9 to 14 varieties reported by three ethnic groups in the Mt. Kenya region of Kenya (Labeyrie et al. 2014), or the 16 sorghum varieties reported in 79 villages in Niger (Deu et al. 2008). On average,

the farmers in our study grew one and one-half varieties, which is similar to the three varieties grown on average in Kenya (Labeyrie et al. 2014), but lower than, for example, the six varieties reported in Niger (Deu et al. 2008).

In our study, both ethnicity and geographical location (district) significantly affected sorghum variety use. For instance, the three most frequently cultivated varieties by each group studied were not the same. Considering the ethnic identity, the most used landraces among the Kunama are *Dagneu*, *Wediaker*, and *Tsa'da chumurey*, while for the Tigrayans in the other district, the most cultivated varieties include *Mereway*, *Melkam*, and *Wedisibuh*. The Tigrayan living in the same district as the Kunama are cultivating the *Dagneu* and *Tsa'da chumurey* varieties that are grown by their neighbors while also cultivating the *Mereway* of their co-ethnics in the other district. The Tigrayan living nearby the Kunama in this case have an intermediate position between the Kunama in the same district and the Tigrayan in the other district. This was also observed in the Mt. Kenya region: three out of the five most frequently cultivated varieties differed across ethnic groups (Labeyrie et al. 2014). Similar findings have been reported for sorghum in Niger (Deu et al. 2008). Both ethnicity and geographical location have been reported to affect variety choice for other crops. For example, Perales et al. (2005) indicated that the maize variety choice in Mexico was linked to ethnicity but also to agroecological zones of the ethnic groups studied. A study in the Togo Hills also indicated that rice varietal selection is influenced not only by ecology but also by culture (Teeken and Temudo 2021).

In our study, there is seed circulation between ethnic groups: two of the most widely cultivated varieties within the Kunama and the Tigrayan-T are the same (*Dagneu* and *Tsa'da chumurey*). Studies in the Mt. Kenya region have also highlighted that seed circulation patterns are linked to reciprocal relationships among ethnic groups (Labeyrie et al. 2019). A study on traditional management of manioc agrobiodiversity in Brazil indicated that varieties are circulated and exchanged in a restricted area due to geographic proximity (Emperaire and Peroni 2007).

Most farmers in this study cultivate farmer varieties rather than improved ones, and the proportion of farmers growing improved varieties is lower among the Kunama. It could be

argued that these differences are related to the later arrival and distribution of certain improved varieties in the Tahtay Adiyabo district where the Kunama live; for example, *Melkam* was only introduced in 2019, compared to 2016 in the other district. However, culture is also likely to explain these differences. Numerous Kunama respondents highlighted that they did not believe that improved varieties were better, especially once the prohibitive cost of the inputs needed to grow them was considered. As highlighted by Deu et al. (2008), the improved varieties targeting large-scale production areas often fail to respond to the adaptive constraints in locally heterogeneous traditional agricultural systems or cannot satisfactorily fit the diversity of farmers' uses and preferences. A study on the challenges facing participatory reforms in the "Ethiopian Sorghum Improvement Program" highlights that it is likely that a more lasting impact could be achieved by involving farmers in the breeding process (McGuire 2008).

#### PREFERRED TRAITS

In this study, farmers considered use traits as important as agronomic traits when selecting a sorghum variety. Notably, preferred use traits were not limited to food, and preferred agronomic traits were not focused on drought resistance. Farmers also reported that market value was an important factor. There is increasing evidence that farmers consider both use and agronomic traits, and that local food preferences significantly affect variety choice. Farmers in Ethiopia's eastern province of Hararghe also prefer sorghum varieties based on traits such as maturity, yield potential, suitability for animal feed, and market demand (Tamiru 2021), which is similar to our study communities.

For example, sorghum farmers in Benin emphasize three sorghum traits: high quality food (dough and porridge), high yield, and high market value (Dossou-Aminon et al. 2014). Sorghum farmers in South Africa emphasize six sorghum traits: high quality *ugali* (porridge), high yield, resistance to pests and diseases, early maturing, drought tolerance, and

resistance to bird damage (Mofokeng et al. 2016). The preferred traits emphasized by Mbeere farmers in southern Kenya were these: drought tolerance, yield, taste, cooking quality, market value of the variety. However, early maturity was a less important trait, which is different from our finding (Timu et al. 2014). A study in the western Terai region of Nepal found that the main varietal attribute affecting adoption of rice varieties were easy threshability, use of grains for preparing special dish (murah fried rice and chiura–beaten rice), early maturity, and less irrigation requirement (Joshi and Bauer 2006). In Uganda, sorghum farmers also highlight use (quality *posho* or bread, quality of soft porridge) and agronomic traits (short to medium plant height with high grain yield) (Andiku et al. 2021). The same has been reported from Ghana, where farmers highlight use (high quality *tuu*, high quality of beer) and agronomic traits (yield, early maturing, drought tolerance) (Buah et al. 2010).

However, numerous studies in Ethiopia continue to focus mainly on agronomic traits and therefore do not have a “whole picture” of farmers’ preferences. For example, Belay and Wale (2021) who focused on sorghum farmers in the Amhara Region of Ethiopia, only considered seven traits: head size, panicle length, earliness, grain color, disease and pest tolerance, stalk vigor, and plant height. Similarly, the study by Mengistu et al. (2019) focused on sorghum farmers in the Oromia region and only considered disease and fungal tolerance and resistance to pests.

In our study, ethnicity and geographical location (district) interacted and affected trait preference, which helped explain which varieties were cultivated by the different groups studied. Seed management practices were also slightly different among groups, contributing to the observed differences in preferred varieties, as we discuss below.

#### SEED MANAGEMENT PRACTICES

Timing of seed selection, seed selection criteria (e.g., panicle size), and seed storage practices differed among the groups studied. The Tigrayan-A emphasized large and long panicles (typical of *Mereway*) and the Kunama

emphasized early maturing (typical of *Dagneu*). Storage techniques were also different, with the Kunama mostly using bags and storing smaller quantities of seeds.

Our findings on the timing of seed selection contrast with a previous study that found that most Tigrayan farmers conduct seed selection before harvesting and during storage (Tsehaye et al. 2009). That study focused on another district in the Tigray region, where the commonly grown farmer varieties are different (*Mereway*, *Degalit*, *Jugertie*, *Kodem*, *Dengele*), which could explain why seed selection timing is different. Notably, Tsehaye et al. (2009) highlighted that farmers visit their neighbors’ fields and identify potential sorghum fields for selection and seed exchange. This practice was also reported by our study respondents.

In terms of seed selection criteria, both ethnic groups emphasized a large seed size as a selection criterion, in agreement with previous work by Tsehaye et al. (2009). However, differences in selection criteria were observed among ethnic groups; for example, the Kunama emphasized early maturity, which also agrees with previous work on the Kunama (Kidane et al. 2004). With regard to seed storage, differences in types of containers used for large amounts of seed or grain were observed, with the Tigrayan-T using the same structures as the Kunama. This finding highlights not only seed exchange between ethnic groups, but also knowledge exchange on seed management practices. Cushitic farmers in southwestern Ethiopia also store their sorghum in *Gotera* and use ash to control storage pests similar to the study communities we analyzed (Mendesil et al. 2007). Tsehaye et al. (2009) found that farmers stored their seeds either in plastic bags, in granaries with straw roofs, in wicker storage jars, or sometimes in underground pits. Our respondents did use such underground pits, highlighting again a difference across districts within Tigray. Another study in eastern Kenya found that farmers store their sorghum grain at the fireplace and in granaries (Muui et al. 2013).

The main factors affecting sorghum production for the Kunama is weeds and birds. For the Tigrayan-T it is weeds and drought and for the Tigrayan-A it is weeds and insects. A study in southwestern Ethiopia also indicated that the major factors affecting sorghum production were insect pests caused by high temperature and

lack of storage hygiene (Mendesil et al. 2007). Similarly, in eastern Kenya, it was found that the major constraints in sorghum production were susceptibility to pests such as shoot fly, birds, ants, aphids, and borers, as well as diseases (Muui et al. 2013).

Our study has some limitations. We focused on ethnic differences, but other socioeconomic factors such as land area, age, farming experience, and wealth also influence variety use (as shown in ESM 2). Future work should explore interactions among ethnicity and such factors, and also study the effects of gender, as gender is also known to drive sorghum variety use (for example, see Abebe et al. 2021). Future work should also explore genetic differences among farmers' varieties, e.g., if the most frequently grown varieties by the Kunama belong to the botanical race *Caudatum*. According to Stemler et al. (1977), there is a deep association between speakers of Nilo-Saharan language and the race *Caudatum*.

## Conclusions

The differences in the varieties grown, traits preferred, and seed management practices between the Kunama and Tigrayan emphasize the deeper underlying association between their cultural identities and the varieties they grow. In our study area, sorghum is a key part of the culture, entangled with livelihoods practices, cuisine, medicine, and material needs and thus can be considered a "cultural keystone species" (Garibaldi and Turner 2004). At the same time, our study reveals that cultural differences are modified by geographic proximity and cohabitation, indicating that the sorghum seed network spans across ethnic groups. Our work raises questions for future research about how farmers access seeds and knowledge concerning sorghum varieties. Results indicate that the Kunama and Tigrayan in the same district exchanged seeds and knowledge to a larger degree than the Kunama and Tigrayan living in separate districts. Nuijten and Almekinders (2008) have also observed that uniformity in rice variety names in Gambia was related to the intensity of seed exchange. Indeed, the role of social networks for farmers' crop and variety change remains a

widely under-researched topic (Labeyrie et al. 2021).

By analyzing how the Kunama and Tigrayan farmers use and maintain sorghum crop diversity, this study illustrates the contribution that research on local knowledge can bring to the understanding of the concerns and priorities of smallholder farmers and offers new opportunities to better target crop diversity conservation efforts, crop breeding programs, climate change adaptation policies, and other development interventions. In Ethiopia, sorghum crop breeding mostly focuses on certain agronomic traits, overlooking important traits preferred by farmers and, therefore, some of their preferred varieties. The failure of formal breeding programs to achieve high adoption rates of improved varieties by farmers is well recognized (Sangare et al. 2020), and it is likely that this is related to a narrow "agronomic trait" focus. Our research supports the notion that participatory breeding programs (which engage with farmers to co-produce knowledge) are crucial for the successful achievement of both food security and reduced poverty in Ethiopia (McGuire 2008).

It was highlighted by Ruggieri et al. (2021) that it is necessary to understand farmers' local knowledge and practices to improve their adaptive capacity and as we show in this study, their use trait preferences should also be considered.

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