The diversity of local sorghum (*Sorghum bicolor* L. Moench) in Nusa Tenggara Timur province

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Abstract. Sorghum (*Sorghum bicolor* L. Moench) is an important food crop in the dry land including Nusa Tenggara Timur (NTT) Province. This plant has a high adaptability to drought, can produce on marginal land, and is relatively resistant to pests and diseases. The study aims to collect and identify the species of local sorghum being cultivated by farmers, and the purposes of cultivation. In addition, this study will preserve germ plasm of local sorghum by providing bank seeds for the next growing season. A collection of local sorghum samples was conducted in 7 districts using survey and observation method. A total of 53 species of sorghum were collected, with various characteristics and different local names. Based on the skin color of the seeds, the accessions were grouped into white groups (26.42%), light yellow (15.09%), black (20.75%), brown (24.52%), and red (13.20 %). Sorghum is used for complementary food for rice, consumption in times of food insecurity, fodder, and as a fence for corn and rice. It is necessary to characterize the type of local sorghum that has the potential to be developed for food, industrial raw materials, and for functional food.

1. Introduction

East Nusa Tenggara (NTT) province is characterized by low rainfall and prolonged drought, 8 - 10 months, and a short rainy season (3 - 4 months) to make sorghum one of the most suitable food crops to be developed. A 92.32 percent or about 1.5 million hectares of total agricultural land in NTT is dry land [1]. Sorghum (*Sorghum bicolor* L. Moench) is a subsistence crop for many farmers in the semi-arid tropics in Africa. The cropping systems based on sorghum used mainly local varieties which are part of their strategy to reduce the risks in the constraining areas. Local varieties have been defined as variable plant populations adapted to local agro-climatic conditions which are named, selected and maintained by the traditional farmers to meet their social, economic, cultural and ecological needs [2].

Sorghum is cultivated for human consumption.The production is mainly ensured by local varieties which are diversified and belong mostly to the botanical race guinea [3]. The guinea varieties are rustic, well adapted to low agronomic conditions and climatic uncertainties [4]. Moreover, their grain quality is well suited to the various local processing.

Sorghum is one type of food crops that has been well adapted and cultivated by the people of NTT, therefore, sorghum has a different local name each region. In East Flores, sorghum is known as *watablolo, solo corn,* or *wataholot*, in Sumba, it is called as *wataruhemutuji* and *watanruhemukadipta*,

in Timor known as *benwuka* or *bennina*, Rote people call it *jagung rote*, Ende people call it *watar*, in Lembata known as *watarwoloq*. However, the existence of local sorghum began to be replaced by other food crops that have a better economic value such as corn and rice. Therefore, the collection of sorghum germ plasm is an essential activity to seek and excite their genetic diversity to prevent genetic erosion of local sorghum species.

Sorghum is basically a self-pollinated plant with an open panicle form so that the possibility of cross-species cross-breeding high and producing offspring in the form of accessions or new varieties. Germ plasm diversity can be derived from wild-type relatives (wild-type), landraces, local varieties and introduced varieties and somaclonal variations. To maintain the genetic diversity of local sorghum in NTT, conservation efforts should be made, in the form of collections of species that are still cultivated by farmers, to further develop both in-situ and ex-situ. This study aims to explore local sorghum germ plasm in NTT that is still cultivated by farmers, and reproduce it ex-situ. This preliminary study aims to re-promote sorghum as a commodity that can support food security of rural communities and increase the comparative value of sorghum.

2. Materials and Methods

2.1. Collection Area

Panicles and seeds of local sorghum samples have been collected from farmers in areas that still grow sorghum both in the yard and on the land. The location of sampling include 7 (seven) districts and 15 villages, which is determined intentionally based on the criteria that the location is still cultivated sorghum. The seven sampling sites Wet Flores Timur District (1 villages), Lembata District (3 villages), Kupang District (1 village), Sabu Raijua District (1 village), Belu District (1 village), and Sumba Timur District (8 villages).

2.2. Germ plasm Collection

The collection was preceded by a participatory diagnostic in each village. A collection of sorghum samples was performed on a population of sorghum farmers in both small and larger planting areas. Observations were made on the characteristics of panicles and seeds visually i.e. panicle, panicle density, husk color, husk nature, presence or absence of feather on seed, seed cluster, and seed thickness. In addition, it was also measured the water content using portable water meter (hygrometer). The weights of 1000 seeds were weighed using analytic scales. In addition, interviews were conducted on farmers using questionnaires to obtain data on harvested area, planting location, plant characteristics, harvest time, and sorghum utilization.

2.3. Data Analysis

Qualitative data obtained were analyzed descriptively and presented in tables and figures, while quantitative data were analyzed using mean and standard deviation.

3. Results and Discussion

3.1. Local Sorghum Type at Farmer Level

The type of sorghum identified in the study sites were 53 samples and 31 species based on the color of panicles and seeds (Table 1). It proves that the diversity of local sorghum species is quite high, although the farmers are less interested in cultivating sorghum. The results of interviews with farmers revealed that the lack of interest of farmers to grow sorghum due to post-harvest technology and complicated processing compared with other foodstuffs.

The highest diversity of local sorghum was found in East Sumba Regency which was 8 species, followed by Sabu Raijua Regency with 5 types. Variations of panicle/seed color were also varied, namely white, light yellow, brown, red, black, and mix between colors. This indicates that crossbreeding between species of sorghum produces new genotypes increasing the diversity of

sorghum germ plasm. Sorghum is basically a self-pollinated plant with high cross-pollination levels due to its open-air panicles [5]. In order to maintain the genetic diversity of the collection, conservation measures are necessary, both *in-situ* and *ex-situ*. Such genetic diversity can be utilized as genetic material and gene donors for the improvement of various plant characters in breeding programs. Breeding programs are impossible without high genetic diversity, so the availability of germ plasm collection is a critical stage of breeding programs [6].In terms of its utilization, sorghum as a staple food can also be used as a functional food ingredient, especially red and black sorghum type. It has been reported that phenol compounds contained in sorghum such as phenol, flavonoid, and tannin are antioxidant compounds that play an important role in overcoming oxidation-related diseases such as cancer, diabetics, cardiovascular disease, and obesity.The sorghum phytochemicals show high antioxidant activity against different free radicals in vitro relative to fruits and vegetables and may offer similar benefits attributed to fruits and vegetables. However, overall epidemiological evidence suggests sorghum has anti-carcinogenic properties when consumed regularly in diet [7]. The red and black sorghum contains tannins and anthocyanins 10 times higher than the white sorghum [8-9].

Table 1. Collected local sorghum during the study

Sample Origin	Number	Color of panicle/seed	No. of sample	Type	Local's name
Lembata	5	Reddish brown	3	Local	Watarwoloq
		Light yellow	3	Kawali	
		White	1	Numbu	
		Black-spotted white	1	Local	
		White, the bottom is red	1	Local	
Flores Timur	4	Light yellow	2	Kawali	-
		White	1	Numbu	-
		Black	1	Local	Watablolong hitam
		Reddish brown	1	Local	Watablolong merah
Sumba Timur	8	White, ½ the base of the seeds is brown	3	Local	Wataruhemu
		Maroon	1	Local	
		Red	2	Local	
		Brownish yellow	2	Local	
		Dark black	3	Local	
		Black	1	Local	
		White	2	Numbu	
		Reddish brown	1	Local	
Rote Ndao	3	Black	2	Local	Beladai hitam
		White with black spot	4	Local	Beladai putih
		Brownish red	1	Local	Beladai merah
Kab. Kupang	3	Reddish brown	4	Local	benwuka
		Dark black	1	Local	bennina
		Light yellow	3	Local	
Belu	3	White	1	Local	-
		Reddish brown	2	Local	
		Black	1	Local	
SabuRaijua	5	Reddish black	1	Local	Jagung rote
		Red	1	Local	
		Brown	1	Local	
		Black	1	Local	
		White	1	Local	
Total	31		53		

Local sorghum has a specific name at each location, indicating that sorghum has been known by the community for a long time and has adapted well to local conditions.

3.2. Characteristics of sorghum panicle

Characteristics of panicle such as shape, density, color, and nature of husk are specific features to identify the type of sorghum (Table 2). Sorghum with a compact panicle is preferred by farmers because it has more seeds than those with loose panicles. There are five forms of panicles: (1) inverted pyramid, (2) width at the top of the panicle, (3) symmetrical, (4) wide at the bottom of panicle, and (5) pyramid [10].Agronomic characterization can be used as a simple method to separate the accession of the cluster based on similarity or dissimilarity, then used to look at heterogenetic patterns and the genetic distance of accession [11].

Information on morphological properties of sorghum germ plasm is essential for plant breeders in the process of assembling superior varieties and improving the nature of the existing strains and varieties.

Table 2. Characteristics of Local Sorghum NTT

Sample code	Panicle shape	Panicle compactness	Grain Covered by glume	Pericarp color
Flotim 01	symmetric	compact	25% grain covered	light yellow
Flotim 02	symmetric	compact	25% grain covered	white
Flotim 03	symmetric	loose	75% grain covered	black
Flotim 04	pyramid	Semi-compact	25% grain covered	reddish brown
Kupang 01	symmetric	compact	25% grain covered	reddish brown
Kupang 02	symmetric	compact	25% grain covered	dark black
Kupang 03	pyramid	compact	25% grain covered	light yellow
Lembata 01	pyramid	loose	25% grain covered	reddish brown
Lembata 02	symmetric	compact	25% grain covered	light yellow
Lembata 03	symmetric	compact	25% grain covered	white
Lembata 04	pyramid	loose	25% grain covered	reddish brown
Lembata 05	pyramid	loose	fully covered	black
Sabu 01	*	*	75% grain covered	reddish black
Sabu 02	*	*	75% grain covered	red
Sabu 03	*	*	75% grain covered	brown
Sabu 04	*	*	75% grain covered	black
Sabu 05	*	*	25% grain covered	white
Rote 01	pyramid	loose	50% grain covered	black
Rote 02	pyramid	compact	25% grain covered	variegated
Rote 03	pyramid	loose	fully covered	brownish red
Sumba 01	pyramid	loose	75% grain covered	variegated
Sumba 02	pyramid	loose	75% grain covered	red
Sumba 03	symmetric	loose	fully covered	red
Sumba 04	symmetric	loose	75% grain covered	brownish yellow
Sumba 05	pyramid	loose	fully covered	dark black
Sumba 06	symmetric	compact	very short	white
Sumba 07	pyramid	loose	fully covered	red
Sumba 08	pyramid	loose	75% grain covered	black
Belu 01	symmetric	loose	25% grain covered	white
Belu 02	pyramid	loose	25% grain covered	reddish brown
Belu 03	pyramid	loose	75% grain covered	black

*no panicle, only seed

3.3. Seed Properties

The weight of 1000 local sorghum seeds ranges from 29 to 51 g and belongs to the category of high and very high potency of seeds. Balitsereal (1996) has classified the potency of sorghum accession by weight of 1000 seeds i.e. low (<15 g), medium (15 - 25 g), high (26 - 35 g), very high (> 36 g). The results showed that almost all species were potential to be developed into high-yielding varieties, suitable for food consumption and for food diversification. The samples namely Flotim 01, Lembata01, 02, 04, Sabu 02, 05, Rote 01, Sumba 03, 05, and 06 are the potential types used as genetic sources for developing high-yielding varieties.

Seed moisture content is one of the important factors in maintaining seed quality. The water content of sorghum at the farm level ranges from 10 to 17 percent, so it needs proper drying to achieve

ideal water content for storage of 8 to 10 percent. The main requirement for increasing the productivity of sorghum is the use of seeds quality. The three important aspects related to the quality of seeds are (1) correct seed production techniques, (2) techniques to maintain the quality of distributed seeds, and (3) seed quality detection techniques [12]. The use of superior quality seed varieties contributes significantly to phenotypic appearance and yield components of plants [13].

Availability of sorghum seed both quantity and quality at farm level have not been fulfilled. The results of studies in East Nusa Tenggara show that farmers have not been able to produce superior seeds, unavailable of storage facilities, and markets uncertain of seeds affect the success of farmers or breeders in providing sorghum seed [14].

Table 3. Water content and 1000 weight seed

Sample code	Water content (%)	1000 weight seed (g)
Flotim 01	11.07	46.00
Flotim 02	10.77	29.00
Flotim 03	10.00	34.00
Flotim 04	12.40	33.00
Kupang 01	10.50	32.00
Kupang 02	11.53	31.00
Kupang 03	12.10	36.00
Lembata 01	12.37	40.00
Lembata 02	11.97	51.00
Lembata 03	16.73	31.00
Lembata 04	12.53	40.00
Lembata 05	12.30	28.00
Sabu 01	13.93	36.00
Sabu 02	14.33	40.00
Sabu 03	12.83	38.00
Sabu 04	13.40	36.00
Sabu 05	14.13	37.00
Rote 01	13.23	40.00
Rote 02	16.67	35.00
Rote 03	15.37	38.00
Sumba 01	11.43	36.00
Sumba 02	12.50	34.00
Sumba 03	12.20	40.00
Sumba 04	14.80	38.00
Sumba 05	15.57	41.00
Sumba 06	17.23	42.00
Sumba 07	15.43	32.00
Sumba 08	14.73	43.00
Belu 01	11.20	43.00
Belu 02	11.57	37.00
Belu 03	11.73	39.00
Range	10.00 – 17.23	29 - 51

4. Conclusions

This study on local sorghum variety in the seven regency of Nusa Tenggara Timur Province has shown that the diversity cultivated sorghum in the villages is dominated by inherited varieties from parents.The local sorghum in NTT has a high diversity, with 13 collected accessions. These types have distinctive features such as color, shape, and different seed size. The colors of the seeds are white, yellow, brownish red, and black indicated that sorghums are rich in phytochemical compounds that are beneficial to human health. In addition, each type has a panicle that is also different depending on the type of sorghum. Based on the results of the interview is known that the current consumption of sorghum by the population began to decrease even some who no longer consume them. Cultivation is not intensive anymore but is cultivated for the purpose of fodder or as a fence/trap plant.The type of sorghum identified in the study sites were 53 samples and 31 species based on the color of panicles

and seeds. The highest diversity of local sorghum is found in East Sumba Regency which is 8 species, followed by Sabu Raijua Regency with 5 types. Variations of panicle/seed color are also varied, namely white, light yellow, brown, red, black, and mix between colors. This indicates that crossbreeding between species of sorghum produces new genotypes thus increasing the diversity of sorghum germ plasm. Characteristics of panicle such as shape, density, color, and nature of husk are specific features to identify the type of sorghum. The weight of 1000 local sorghum seeds ranges from 29 to 51 g and belongs to the category of high and very high potency of seeds. The results showed that almost all species were potential to be developed into high-yielding varieties, suitable for food consumption and for food diversification. The samples namely Flotim 01, Lembata 01, 02, 04, Sabu 02, 05, Rote 01, Sumba 03, 05, and 06 are the potential types used as genetic sources for developing high-yielding varieties. The water content of sorghum at the farm level ranges from 10 to 17 percent, so it needs proper drying to achieve ideal water content for storage of 8 to 10 percent.

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