Performance and utilization of local sorghum (*Sorghum bicolor* L.) in West Nusa Tenggara

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**Abstract.** Sorghum was seen as one of the crops best suited to future climate change due to its ability to adapt to conditions, such as drought, salinity and high temperatures. This study was aimed to know the performance and utilization of local sorghum in West Nusa Tenggara especially in Bima District. 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 plant and panicle. In addition, interviews were conducted on farmers using questionnaires to obtain data on harvested area, planting location, harvest time, and sorghum utilization. Qualitative data obtained were analyzed descriptively and presented in tables and figures, while quantitative data were analyzed using ANOVA test continued by BNJ/Tukey at 0.05 level of significant. There are six (6) local sorghum varieties whose appearance are very different from one another namely gando bura, gando keta, gando keta 2, latu kala, latu keta, and latu keta 2. Varieties had effect on plant height, diameter of stem, leaf size and panicle length. Apart from being distinguished by the color of the husk, they are also distinguished from the shape and presence of fur at the tip seed. Specifically **gando bura** variety has the ability producing until 12 tillers. Sorghum has been consumed by Bima community as a main food mixed with rice, as well as processed food such as **dodol** sorghum and sorghum porridge.

1. **Introduction**

Sorghum crop is a plant of the family graminae are physiologically classified to C4 plants. Cereal crops included sorghum (grain) is a plant that has been long known in Indonesia, especially in Java, NTB and NTT. Sorghum (*Sorghum bicolor* L.) is a staple food for the most of local community. Sorghum (*Sorghum bicolor* L.) is a cereal plant that has the potential to be cultivated and developed, especially in marginal and arid regions in Indonesia. The advantage of sorghum is in its broad adaptability to agroecology, resistance to drought, high production, less input required and more resistance to pests and diseases compared to other food crops. In addition, sorghum plants have high nutritional content, so it is best used as an alternative food source and animal feed.

Sorghum crops once actually pretty satisfying in Indonesia including NTB. Sorghum in Lombok called as **buleleng**, while in Bima called as **gando**. Sorghum not only be used as food but also used as fodder and as a source of renewable energy alternative. Sorghum has so many varieties, multifunctional and zero waste because almost all parts of the plant can be utilized, for example as food, feed, and industry [1]. Sorghum also can be used as raw materials board particles [2]. 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. 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 [3]

The main problem of development of sorghum are the comparative and competitive value of sorghum which is relatively low and sorghum farming at the farm level not intensive yet. To solve the problem, the overall management system is needed, sorghum production (holistic) through four dimensions, i.e. region (sorghum planting area), economy (the value of comparative and competitive sorghum to other commodities), social (attitudes and perceptions of producers towards sorghum as part of his farming business), and industry (value of sorghum benefits as food and feed industry raw materials livestock) [4].

To maintain the genetic diversity of local sorghum in West Nusa Tenggara, 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 was aim to know the performance and utilization of local sorghum in West Nusa Tenggara especially in Bima District.

2. Methodology

2.1 Collection Area
Panicles and seeds of local sorghum samples have been collected from farmers in areas that still growing sorghum both in the yard and on the land in Bima.

2.2 Germplasm 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, and the presence or absence of feather on seed. In addition, interviews were conducted on farmers using questionnaires to obtain data on harvested area, planting location, plant characteristics, harvest time, and sorghum utilization. To find out the climate in Bima as the origin of sorghum, rainfall data is also collected.

2.3 Data Analysis
Qualitative data obtained were analyzed descriptively and presented in tables and figures, while quantitative data were analyzed using Annova test. For mean comparison were separated using BNJ/Tukey at 0.05 level of significant.

3. Results and Discussion

3.1 Bima Geographic Conditions, Climate and Weather
Bima is one of the Autonomous Region in West Nusa Tenggara province, located at the eastern end of the island of Sumbawa. Topographically the district of Bima majority (70%) is textured mountain plateau while the remainder (30%) are plains. About 14% of the proportion of the lowland rice cultivation and more than half the dry land. Because of the limitations of such agricultural land and associated population growth in the future, will lead to the carrying capacity of the land is getting narrower. Consequently the necessary transformation and reorientation of the economic base from traditional agriculture to agricultural entrepreneurs and small industry and trade.

Bima Regency is a tropical climate with average rainfall is relatively short Circumstances annual rainfall recorded an average of 58.75 mm, it can be concluded Bima is dry throughout the year category areas that impact on the size of the water supply and drying most of the rivers. The highest rainfall in January recorded 213 mm of rain a day for 20 days (Table 1) and the drought occurred in May, June, July, August and September.
Table 1. Monthly mean rainfall (mm) during the growing season for sorghum (November - February) in 2017 and 2018 in Bima, West Nusa Tenggara [5].

| Month    | Precipitation (mm) | Rainy Days |
|----------|--------------------|------------|
| November | 200                | 11         |
| December | 200                | 11         |
| Januari  | 213                | 20         |
| Februari | 155                | 24         |
| Total    | 808                | 66         |

Sorghum is a cereal crop that has a high adaptability to drought when compared to other cereal crops and can grow in almost any type of soil. Therefore, sorghum is a plant that has the potential to be developed in Bima as an alternative plant in meeting the needs of food, feed, and industry. An increase in population that is not balanced with an increase in the availability of food, can cause a food crisis. Physiologically, the leaf surface which contains a waxy coating and a system extensive rooting, fibrous and deep, tend to make plants sorghum is efficient in absorption and water use [6]. Among the Durra races there are varieties which has a stem with sugar content high is called sweet sorghum (sweet sorghum). While other races on commonly used as biomass and animal feed [7].

3.2 Potential of Sorghum Plants in Bima

Sorghum harvested area in the City and Regency of Bima in 2010 reached 1,500 ha. Subdistricts that cultivate sorghum in Bima City are East Rasana’e, Raba, Mpunda and Asa Kota, while in Bima Districts are Wera, Sape, Langgudu, Lambu, Wawo, Lambitu, and Soromandi. But in 2018 the area of sorghum harvest in Bima decreased dramatically until there were only about 100 ha left. This is because the sorghum commodity is displaced by corn which dominates most of the marginal land in the City and Regency of Bima.

This is also in line with the results of the Directorate of Cereals Cultivation data collection (2012) that the development of sorghum crop harvest area in Indonesia from 2005 to 2011 tends to continue to show a decline. During the period of 7 (seven) years, the harvested area decreased by an average of 1.5% per year. The harvested area achieved in 2011 was lower than in 2005. Besides decreasing the area, sorghum productivity has also declined. According to Hoeman [8], the main causes of decreased productivity of sorghum yields to date are the use of less-quality seeds and less optimal crop maintenance. Actually sorghum has a relatively higher yield potential than rice, wheat and corn. If soil moisture during growth is not a limiting factor, yield can exceed 7 t/ha.

3.3 Performance Sorghum Local Bima

The cultivation process of sorghum is easy with cost which is relatively cheap, can be planted monoculture or intercropping. Sorghum also more resistant to pest and disease attacks, so the risk of failure is relatively small [9]. There are at least six (6) local sorghum varieties found whose appearance is very different from one another namely gando bura, gando keta, gando keta 2, latu kala, latu keta, and latu keta 2. These six sorghum varieties have been registered at the Ministry of Agriculture as local Bima varieties in 2018 - 2019. Apart from being distinguished by the color of the husk, they are also distinguished from the shape and presence of fur at the tip seed (Fig. 1).
Figure 1. Six sorghum varieties of local Bima: a) Gando bura, b) Gando keta, c) Gando keta 2, d) Latu keta, e) Latu kala, and f) Latu keta 2.

Gando keta 2 and latu keta plants have height that exceeds other varieties, reaching ± 4m (Table 2). Despite having height that reaches 4m, this sorghum plant does not fall and can grow upright until harvest time arrives. These six local sorghum varieties resistant to crackers. The largest diameter of the stem is owned by gando bura, which is 3.5 cm, while the smallest diameter is owned by the Latu Keta variety, which is 2.03 cm. Leaf size also varies, where the longest leaf is found in latu keta 2 (96 cm) and the shortest leaf is owned by latu keta (61 cm). The longest sorghum panicle size is owned by latu kala variety that is 38 cm and the shortest panicle is in gando keta which is 25,67 cm.

Table 2. Plant character of sorghum local variety of Bima.

| Varieties   | Plant height (cm) | Diameter of stem (cm) | Leaf length (cm) | Leaf width (cm) | Panicle length (cm) |
|-------------|-------------------|-----------------------|------------------|-----------------|---------------------|
| Gando bura  | 190d              | 3.5a                  | 90,33b           | 11,73a          | 35ab                |
| Gando keta  | 167,67e           | 3b                    | 90,33b           | 6,03d           | 25,67d              |
| Gando keta 2| 401,67a           | 2.82bc                | 88,67b           | 8,67b           | 30c                 |
| Latu kala   | 206d              | 2.5c                  | 64,67c           | 5,50de          | 38a                 |
| Latu keta   | 374,67b           | 2.03d                 | 61,67c           | 5,13e           | 36ab                |
| Latu keta 2 | 291c              | 2.57bc                | 96a              | 7,70c           | 34,33b              |

Numbers followed by the same letter in the same column show no significant difference in the BNJ / Tukey follow-up test at a 95% confidence level (α = 0.05).

Variety had effect on plant height, diameter of stem, leaf size and panicle length. This result confirmed the results of previous studies of Abdalla [10], Bakheit [11] and Hassan [12]. They found that the cultivars of grain sorghum significantly affect the plant height. Genotype also had significant effect on number of days to 50% flowering and to 95% days physiological maturity.

Characteristics of panicle such as shape, density, color, and nature of husk are specific features to identify the type of sorghum (Table 3). Three local Bima sorghum varieties have dense panicle forms (gando bura, gando keta, and gando keta 2), while the other three varieties have panicle shapes that spread like a short broom. The colors of this sorghum husk vary from gray, maroon, black reddish, red, and purplish black. There are two types of seed closure, they are all seed covered and ¾
of seeds covered. These five types of sorghum have no hair on seeds except for the type of latu keta 2. The six varieties have panicles that do not fall off easily.

Gando bura variety also has another advantage where this variety in one plant can produce up to 12 tillers which all produce panicles with successive maturity levels, while other varieties produce only one tiller with one panicle per plant. 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 [13].

### Table 3. Panicle character of sorghum local variety of Bima.

| Genotype      | Density and shape of panicle | Husk color         | Seed closure       | Presence of fur | Panicle loss |
|---------------|------------------------------|--------------------|--------------------|-----------------|--------------|
| Gando bura    | Rather compact, oval         | Grey               | All seeds are covered | Hairless        | Not fall out |
| Gando keta    | Rather compact, oval         | Maroon             | All seeds are covered | Hairless        | Not fall out |
| Gando keta 2  | Rather compact, oval         | Black reddish      | ¾ of seeds covered | Hairless        | Not fall out |
| Latu kala     | Like a short broom           | Red                | ¾ of seeds covered | Hairless        | Slightly     |
| Latu keta     | Like a short broom           | Purplish black     | ¾ of seeds covered | Hairless        | Slightly     |
| Latu keta 2   | Like a short broom           | Purplish black     | All seeds are covered | Hairy           | A little     |

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 hetero genetic patterns and the genetic distance of accession [14]. 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. 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 [15].

### 3.4 Utilization of Local Sorghum in Bima

Considering its utility that is so widely known as the concept of 5F (Food, Feed, Fiber, Fuel and Fertilizers) then the economic potential for the development of sorghum is promising as processed commodities in small or large industrial scale [16]. Sorghum has important potential as a source of carbohydrates for food, feed and export commodities. However, this potential cannot be fully utilized due to various obstacles both in terms of understanding the benefits of sorghum and in terms of the application of cultivation technology. Judging from its chemical content, sorghum seeds (whole) contain 9.01% protein, 3.6% fat, 1.49% ash, 2.5% fiber [17].

Sorghum can be said to be a zero waste plant because besides its seeds can be used as human food, sorghum stems can also be used as feed ingredients. All of local Bima sorghum varieties have stems that stay green until the sorghum harvested, making them very suitable for use as an alternative feed, especially in the dry season where other fresh forages are no longer available. In Bima, since several decades ago, sorghum was used as an alternative food. Sorghum is usually made into sorghum rice, porridge, dodol, and various other types of wet food. Currently processed sorghum begins to develop into processed foods such as tortillas, pop sorghum, and various pastries (Fig. 2).
Public interest in the preparation of sorghum is increasing along with the increase in people's understanding of health, which is known that sorghum has nutritional value that is not inferior to other food ingredients such as rice, corn and wheat. 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.

Sorghum (*Sorghum bicolor* (L) Moech) is a potential source of carbohydrate commodity because the carbohydrate content is quite high, which is about 73 g / 100 g of material [7], [18]. Sorghum is a food ingredient which also contain carbohydrates like rice, wheat and corn [19]. Sorghum is a food ingredient potential for flour substitution and rice because it's still a family with wheat and rice, only different subfamilies, so the characteristics of the flour are relative better than tuber flour. Therefore sorghum can be used as a substitute for alternative carbohydrates [20]. 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 [21]. The red and black sorghum contains tannins and anthocyanins 10 times higher than the white sorghum [22].

Functional food elements in sorghum seeds include a variety of antioxidants, elements minerals, especially iron, food fiber, oligosaccharides, β-glucans including non-starch carbohydrate components polysaccharide (NSP), and others. Functional food beneficial for preventing diseases associated with immune system, endocrine, nervous, system digestion, circulatory system, and others [23]. Sorghum starch content is relative height that has the potential to be a plastic base material can decompose naturally so it is environmentally friendly [24], [25].

4. Conclusion
Variety had effect on plant height, diameter of stem, leaf size and panicle length. Based on the density and shape of panicles, the local sorghum from Bima divided into two types namely rather compact or oval and like a short broom. The colors of the sorghum husk varies from gray, maroon, black reddish, red, and purplish black. There are two types of seed closure, they are all seed covered and ¾ of seeds
covered. These five types of sorghum have no hair on seeds except for the type of latu keta 2. The six varieties have panicles that do not fall off easily. Sorghum has been consumed by Bima community as a main food mixed with rice, as well as processed food such as dodol sorghum and sorghum porridge.

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