Exploration and collection of sugarcane germplasm in Southeast Sulawesi and its importance

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Abstract. One of the major constraints in improving sugarcane productivity to achieve national self-sufficiency in sugar has been the low crop productivity and sucrose content. To alleviate the problem of high yielding variety with high sucrose content is imperative. To develop high-yielding sugarcane varieties germplasm with sufficient genetic variability is needed. At present, sugarcane germplasm collection at ISFCRI is very limited and hence needs to be broadened through exploration and collection mission to the center of diversity of the crop and its development areas. Based on the literature studies, information gathered from the local estate government and funding availability collection were focused in Kendari municipality, Muna district, and Buton district. The exploration mission successfully collected 66 sugarcane germplasm, consisting of 59 clones derived from local seed, 3 clones derived from seed originated from outside Southeast Sulawesi Province (South Sulawesi, Moluccas, and West Nusa Tenggara Provinces), and 4 wild Saccharum clones (Saccharum spp). Morphological variabilities were seen in terms of stem color, stem wax, and eye-bud shape. The importance of the collected germplasm is discussed.

Keywords: center of diversity, accession, wild species, potential genotype, breeding

1. Introduction
Sugar is one of the important commodities in the international market. The largest sugar-producing countries in the world are Brazil, India, the United States, Western Europe, Australia, and Thailand. On the other hand, Indonesia, China, and several countries that were part of the Soviet Union used to be the main importing countries for sugar. Currently, to meet domestic sugar needs, Indonesia imports about 2 million tons of sugar every year with a value of around US$ 900 million. With the tendency of the import value of sugar to continue to increase, it is feared that this could result in a depletion of the country's foreign exchange. To meet national sugar needs and at the same time anticipate the country's foreign exchange depletion, the Indonesian government through the Ministry of Agriculture has declared sugar self-sufficiency in 2024.

One of the main problems to increase national sugar production to achieve self-sufficiency is the low productivity of sugar cane and sugar yield. To overcome this obstacle, the use of high-yielding sugarcane varieties is necessary. To develop these HYV varieties, genetic resources are needed, in the form of germplasm, which has high genetic diversity. One of the efforts to increase the genetic diversity of the germplasm collection is by conducting exploration and collection, especially from the center of sugarcane genetic diversity (Papua, Sulawesi) and sugarcane development areas such as Gorontalo, Lampung, West Nusa Tenggara, etc.
The success of developing high-yielding sugarcane varieties is largely determined by the availability of adequate genetic sources from germplasm. Currently, ISFCRI has only a limited collection of sugarcane germplasm. Therefore, it is necessary to enrich it through exploration and collection of germplasm to areas that are centers of genetic diversity the plants, followed by continuous conservation and evaluation of germplasm to identify potential accessions.

The center of diversity of sugarcane species is located between mainland Southeast Asia and Papua New Guinea [1]. While India is the center of diversity of glagah (Saccharum spontaneum) a relative species of sugarcane (Saccharum officinarum). Other researchers [2] stated that S. officinarum originated from Indonesia, precisely east of the Wallace line which includes Sulawesi, Moluccas, and Papua, then spread to Fiji, India, and China in prehistoric times.

In Indonesia, attempts to collect sugarcane germplasm and its relatives were carried out from 1916 to 1995 [3-5]. The exploration results are conserved in the collection garden belonging to P3GI Pasuruan. After 1995, exploration could not be carried out due to a lack of funds. According to [6] in the year 2007, as much as 5,308 accessions of Saccharum germplasm were collected, but in the year 2007/2008, the number of collections decreased by 118 accessions due to environmental influences and cultivation techniques. Meanwhile, with the increasing exploitation of forest areas for mining and industry as well as the conversion of land into buildings, the threat of genetic erosion in nature is increasing, so P3GI recommends that exploration be carried out to sugarcane diversity centers, especially in Papua, Sulawesi, and Moluccas as well as in untouched areas by the previous explorer.

Based on the above information, it was decided to conduct in-country exploration and collection in the center of sugarcane genetic diversity. The exploration was divided into two phases; the first mission was sent off to Papua and has been reported elsewhere [7-8]. Later, the second mission was sent to South East Sulawesi. The reason is from the geographical point of view; Southeast Sulawesi Province is located in the southern part of the equator between 3° – 6° south latitude and 120° 45’ – 124° 60’ east longitude. Therefore, it is considered ideal for sugarcane plants to thrive.

This paper was aimed to report the results of the second exploration mission to South East Sulawesi and its potential significance to the sugarcane breeding program.

2. Material and method
Exploration was carried out in Kendari municipality, Muna district, and Buton District. Exploration took place from July 9 to July 19, 2013 (Table 1).

Transportation in the field includes land vehicles (4-wheeled and 2-wheeled vehicles) and crossing the sea by boat. The exploration strategy is determined by the presence of sugarcane in the target area. Based on the information obtained, sugar cane is widely used in traditional parties for the local people. This plant is often found in yards and fields. Thus, the exploration strategy is directed at sampling efforts in the yards of people's homes or their fields.

The sampling method was carried out randomly and selectively. If the plant population is large enough, plant samples are taken randomly [9] to represent all variations in the plants. However, if the number of plants in a place is limited, then plant samples are taken from individuals who happen to be found in the field [10] [12]. In addition, because sugarcane (Saccharum officinarum L.) is easily recognized and distinguished from each other based on the appearance of the morphotype, samples from one location can be collected in large quantities with a small risk of duplication [13] [14].

All sugarcane clones collected were visually observed for their respective morphotype descriptions, Plants are known to be infected by systemic pests, and diseases, such as stem borer, mosaic and blendok were not taken. 3-4 sets of samples in the form of cuttings of 2-3 eyes were collected from each location. Additional information such as habitat, area name, coordinates, and important general notes was added for each sample in the form of passport data.
To assess the potential value of the collected germplasm, preliminary evaluation, and subsequent evaluation was done in Muktiharjo Experimental Garden of Indonesian Sweetener and Fiber Crop Research Institute (ISFCRI), IAARD, from 2015 to 2020 growing seasons. However, in this paper, the data was not presented.

3. Results and discussion
Collection of germplasm is urgently needed for preserving the genetic diversity of a plant species and its wild relatives [15]. In addition, it is also a prerequisite for successful any plant breeding program. In the current era of modern agriculture, where intensification and extensification are carried out, and the rate of conversion of agricultural land into buildings is increasing and uncontrolled, genetic erosion vulnerability and species extinction are predicted to be higher [6]. For this reason, exploration and collection efforts followed by ex-situ conservation are the only option because it is better to keep some species than to let all of them become extinct. Ex-situ conservation techniques have the advantage of providing easy use of germplasm, and genetic material can be immediately available when needed for the development of superior species or new cultivars [16] [17].

During the exploration, the team managed to collect a total of 66 accessions taken from the people's yards or fields. Further study on morphological characteristics showed that 62 accessions could be classified as *Saccharum officinarum*, and 4 accessions belonged to *Saccharum* sp (Table 2 and 3). Intemys of seed origin, of the 62 accessions of *S.officinarum*, 59 accessions are indigenous, whereas the other three accessions came from the outside province, that are, 1 acc from Ambon, 1 acc from NTB, and 1 acc from South Sulawesi (table2). These types of local sugarcanes are generally grown for their usage. From field observations, morphological variations among collection numbers were visible from stem color, internode length, bud eye shape, and the presence of a waxy layer (Figure 2a-2i). Judging from the taste, all sugarcane collections collected have a taste range from slightly sweet, sweet to very sweet. High variability found in the collected *S. officinarum* germplasm was also reported for accessions collected from Papua [7] [8]. Further, results of preliminary study and subsequent evaluation from 2015 to 2020 (data not shown) showed that amongst 62 collected accessions, one accession (KDI-11, a red type with better yield) has emerged as a potential clone to be used in sugarcane breeding program for increasing productivity. This accession has exhibited a promising performance; under the irrigated condition it can produce up to 100 tons of cane per hectare (Figure 3) [18].

Table 1. The route of the exploration mission and collection of sugarcane genetic resources in Southeast Sulawesi Province, from 9 July to 19 July 2013.

| Date       | Travel schedule                                      |
|------------|------------------------------------------------------|
| 9-12 July  | Kendari, Lopo-Lepo, Puuwatu, Andadowi, aliran Sungai Sampara, Baini, Lolomerah, Wawolemo, Amesi, Lalohao, Ranoea, Wawone, Wawatobidan Tumpas. |
| 13-15 July | Raha, wali, dana, Konawe, Bungi, Mabado, Kontunaga, Lapadaku, Lahorio, Laiba |
| 16-19 July | Waruruma, Lakalogon, Liabuku, Barangka, Wakangka, Wakonthi, Kadolokatapi, Wakakili dan Karya Baru |
Figure 1. Maps of Southeast Sulawesi Province and exploration target (indicated by triangle).

Table 2. Results of *Saccharum officinarum* exploration to Southeast Sulawesi Province based on phenotypic variation and origin.

| No | Origin                | # accession Collected | Collection site        | Phenotypic variation                                                                 |
|----|-----------------------|-----------------------|------------------------|--------------------------------------------------------------------------------------|
| 1  | Local                 | 59                    | Kendari municipality   | Stem color: green, yellowish-green, red, red stripe, green stripe, red notch<br>Internode length: long, short<br>Stalk wax intensity: thick, thin<br>Eye shape: rounded, oval<br>Taste of cane juice: salty, sweet to very sweet |
| 2  | Ambon, Moluccas       | 1                     | Buton district         | Stem color: yellow<br>Taste of cane juice: very sweet                                  |
| 3  | West Nusa Tenggara   | 1                     | Muna district          | Stem color: deep red<br>Taste of cane juice: sweet                                    |
| 4  | South Sulawesi Province | 1                   | Kendari municipality   | Stem color: yellow<br>Taste of cane juice: sweet                                     |
Table 3. Results of Saccharum spp. exploration to Southeast Sulawesi Province based on morphological variation and origin.

| No. | Origin   | # accession collected | Collection site                  | Phenotypic variation                                      |
|-----|----------|-----------------------|----------------------------------|-----------------------------------------------------------|
| 1   | Local    | 4                     | Kendari municipality, Muna district | Stalk color: green, wax intensity: thin, Eye shape: oval, rounded, Cane juice: not present |

Figure 2a. Black accession.  
Figure 2b. Red stripe accession.  
Figure 2c. Green stripes accession.  
Figure 2d. Bold green accession.
Figure 2e. Green accession.

Figure 2f. Yellowish green accession.

Figure 2g. Green type with thick wax accession

Figure 2h. Red notch accession
**Figure 2i.** Green type and zig zag pattern accession.

**Figure 2j.** Yellowish type accession.

**Figure 2k.** Red type accession.

**Figure 2l.** Red type and waxy accession.
4. Conclusion
The team successfully collected 66 accessions from the farmer's yards or fields of which 62 accessions were classified as *Saccharum officinarum* and 4 accessions belonged to *Saccharum* sp. Morphological variations among the collection of *S. officinarum* are visible from stalk color, internode length, bud eye shape, and the presence of a waxy layer. The characterization and subsequent evaluations showed that KDI-11 is a promising accession to be integrated into the current breeding program.

Recommendation
The collected sugarcane accessions are recommended for further evaluation and used in the breeding program to develop sugarcane HYV with improved yield and tolerance to pests and disease.

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