The diversity of garlic bulbs and cloves quantitative characteristics of local garlic collection of East Java AIAT

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Abstract. Since 2017, garlic has received special attention from the Indonesian government considering its imbalance conditions in the domestic market. For that purpose, the government has established a self-sufficiency plan for garlic in 2045 through increased domestic production. However, the limitation of clove quality and data of the character description for garlic has become a major constraint in terms of the similarity of bulb characters and cloves between accessions. East Java AIAT has conducted an exploration of garlic germplasms to several areas of production centers as a source of planting materials for clove production. The objective of this study was to collect and to identify differentiated characters from the garlic accessions. This activity took place from 2017-2018 in four regencies, obtained the bulb of four varieties, and three garlic accessions. Each accession has its characteristics. The research result showed that Geol had the heaviest bulb weight and the highest bulb length. Regarding the ratio between the length and diameter of the bulbs, Tawangmangu Baru showed the highest ratio, followed by Lumbu Hijau and TN1. From the clove characteristics, Tawangmangu Baru showed the heaviest clove weight. Furthermore, the ratio between the length/diameter of the bulbs and cloves indicated the diversity between accessions. Also, it was potentially to be used as a differentiator between accessions.

1. Introduction

Garlic (Allium Sativum L.) is one of the widest cultivated bulb crops along with onion from the Alliaceae family. It is well known as a valuable spice and condiment around the world [1]. It has high nutritional content such as proteins (6.3 g), phosphorus (310 mg), carbohydrates (29.8 g), calcium (30 mg) as well as volatile oils (0.1%). Per 100 grams of edible portion make garlic bulbs widely utilized by the community to cause food and health purposes [2]. The results of the study of the Keusgen [3] revealed that garlic contained the compound Alliin (S-(2-propenyl) L-cysteine sulphoxide), which can be used as an antibiotic. Garlic bulbs can be used against diabetes, hypertension, cholesterol, cell platelet aggregation, viral, microbial, and cancer [4]. Since 2017, garlic has become one of the important commodities that receives special attention from the Indonesian government considering its imbalance conditions in the domestic market of garlic. Based on the data of Statistics Indonesia [5], domestic garlic production is only able to meet 5% of national needs. So, the government has established a self-sufficiency plan for garlic in 2045 through increased domestic production. As a result, national garlic production has shown an improving trend in the last five years. According to
data from the Statistic Bureau of Indonesia, garlic production in 2018 was 39.302 kg or almost two times compared with the production number in 2014, which was only 20.293 kg.

Despite garlic productivity, the breeding activity for garlic is rarely done to increase the quality of garlic variety. Especially in Indonesia, the germplasm resources of garlic decreased after local garlic was “attacked” by imported garlic, which has a bigger bulb, and the size of the cloves meets the domestic market. This phenomenon could not be separated from government policies that drastically reduced import tariffs on garlic in 1996. As a result, the price of imported garlic becomes cheaper than local garlic. So, the farmer’s passion for planting garlic is getting lower [6].

Garlic is categorized as an asexual crop that has a high morphological diversity [7]. Gayle M. Volk uses DNA markers to examine a bunch of garlic varieties and examine the genetic diversity between 211 accessions using Amplified Fragment Length Polymorphism (AFLP). The results of the study obtained many accessions that had different names, but they were very difficult to be distinguished from the morphological side. However, on the other hand, many accessions have their uniqueness [8]. The high repetition of molecular inter-sessions and the high variation of phenotype appearance may be caused by epigenetic variations of changes in expression patterns, but not in the DNA chain [9].

Furthermore, exploration, collection, and observation activity on garlic accessions were done by the team from East Java Assessment Institute for Agricultural Technology (AIAT). It was still difficult to identify garlic varieties and accessions. The descriptor could not present a specific character that can be used to differentiate among varieties. Besides that, one main problem in garlic cultivation was the descriptor availability for planting material, especially for unreleased or uncertified accessions. Planting material for a commercialized variety should have a complete published descriptor which can be used to differentiate a particular variety to other variety. Observation of morphological character is very important in recognizing certain germplasm resources. In a breeding activity, the researcher has to know the character of the prospective parents for the targeted variety’s character. So, germplasms resources which do not have a good character could not fulfill the information required for a breeding activity [10].

However, the limitation of clove quality and the limited data of the character description for garlic accessions have become a significant constraint on itself in terms of the similarity of bulb characters and cloves between accessions. East Java AIAT has conducted an exploration of garlic germplasms to several areas of production centers as a source of planting materials for clove production. The objective of this study was to collect and identify differentiated quantitative characters among collected garlic accessions.

2. Material and method
The exploration activity for garlic germplasms was conducted in several areas of garlic production center in East and Centre Java as the source of planting materials for clove production. The exploration areas in East Java were Batu, Malang, and Probolinggo Regency, while in Center Java was Temanggung Regency. The activity was conducted from August 2017 to March 2018. The collected materials were local garlic bulbs. In this case, farmers stored garlic planting resources in bulb form for the planting season, which happens from May to December. We collected the garlic accession and did measurement and observation for eight parameters of the collected bulbs and cloves. For bulbs characters, we observed 15 bulbs, while, for the cloves characters, we observed 30 cloves for each accession. Thus, parameters were bulbs weight, bulbs diameter, bulbs length, the ratio between bulbs length and diameter, cloves weight, cloves diameter, cloves length, and the ratio between bulbs length and diameter. The measurement results were recapitulated and analyzed descriptively.

3. Results and discussion
Base on the field study, the garlic team from East Java AIAT obtained the results in the form of four varieties of bulbs and three accessions of garlic (Table 1). The first varieties were collected from Kalisoro Village, Temanggung District, Karanganyar Regency, named Tawangmangu Baru, which was released in 1989 through The Decree from The Minister of Agriculture Number 771/Kpts/TP.240/11/2019 in November 1st, 1989 [11]. According to the decree, this variety originates from Tawangmangu, Karanganyar. The second was Lumbu Hijau varieties, which were released on
November 12th, 1984, through The Minister of Agriculture decree number 894/Kpts/Tp. 240/11/1984 [12]. The third variety found was Lumbu Kuning. Lumbu Kuning was released by The Minister of Agriculture Decree number 895/Kpts/TP. 240/11/1984 on November 12th, 1984 [13]. Both Lumbu Hijau and Lumbu Kuning originate from Batu City, East Java. Although both varieties are from similar regencies but based on the variety description, they have specifications in cultivated area adaptation. Lumbu Kuning is suitable to be cultivated in 600-900 masl location, while Lumbu Hijau is suitable to be cultivated in a place located above 1000 masl. The last variety found was Lumbu Putih. As its name, it has a white-color-bulb without any other combination or stripes. Through The Minister of Agriculture Decree number: 273/Kpts/TP.240/4/1988, Lumbu Putih was released on April 21st, 1988. This variety is a lowland-specific variety (suitable to be cultivated in 6 – 200 masl) and from Yogyakarta, Central Java [14].

Table 1. The exploration accessions result from each location.

| Production center                              | Accession/Varieties collected |
|------------------------------------------------|-------------------------------|
| Kalisoro Village, Temanggung District, Karanganyar Regency | Tawangmangu Baru              |
| Madiredo Village, Pujon District, Malang regency          | Lumbu Hijau                  |
| Sapikerep Village, Sukapura District, Probolinggo Regency | Lumbu Hijau                  |
| Sumber Brantas Village, Bumiagi District, Batu City, East Java | Lumbu Kuning                  |
| Ngantang District, Malang Regency, East Java              | Kayu                         |
| Temanggung, Center Java                                | Lumbu Putih                  |
| Temanggung, Center Java                                | TN1                          |
| Temanggung, Center Java                                | Geol                         |

Meanwhile, besides the varieties, accessions were found as well. The first accession named Kayu. Kayu in Indonesian means wood, which reflects the hard texture of its bulb. Besides, there were TN1 and Geol accessions found in Temanggung, West Java. The collected bulbs can be seen in Figure 1.

![Figure 1](image-url) Collected bulbs from left to right: Kayu, Lumbu putih, Lumbu kuning, Lumbu hijau, Tawangmangu baru, Sembalun (left), TN1 and Geol (right).

The result showed that Geol accessions had the heaviest bulb with 33.93 grams on average, then it was followed by Tawangmangu Baru, Lumbu Kuning, Lumbu Putih, Kayu and TN1 as the lightest bulb with 3.28 gram in bulb weight average. According to Devy et al. [15], Tawangmangu Baru has a heavier bulb than Lumbu Kuning and Lumbu Hijau. Moreover, high bulb weight has a positive correlation with garlic productivity. While in bulbs’ diameter, Geol accessions have the widest size of 50.05 mm, followed by Lumbu Putih, Lumbu Kuning, Tawangmangu Baru, Lumbu Hijau, Kayu, and TN1. Sequentially the bulb diameters of the whole accessions were 3.44 cm, 3.36 cm, 3.07 cm, 2.97 cm, 2.93 cm and 2.03 cm. Moreover, the highest bulbs was shown by Geol accessions with 41.15 mm, followed by Tawangmangu Baru, Lumbu Hijau, Lumbu Kuning, Lumbu Putih, Kayu and TN1, with the bulb length size of 3.54 cm; 3.31 cm; 2.97 cm; 2.77 cm; 2.42 cm and 2.27 cm respectively. In the
case of the ratio between the bulb’s length and diameter, Tawangmangu Baru showed the highest ratio with 1.17 value, followed by Lumbu Hijau and TN1 with 1.12 ratio value. Afterwhile, other varieties/accessions showed ratio value under one value, which was 0.89 for Lumbu Kuning, 0.83 for Geol and Kayu and 0.81 for Lumbu Putih

Furthermore, for the clove’s characteristics, Tawangmangu Baru showed the biggest cloves weight with 4.89 grams. Then, it was followed with Geol, Lumbu Kuning, Lumbu Hijau, Kayu, Lumbu Putih, and TN1 with 2.46 gram, 1.68 gram, 1.03 gram, 0.8 gram, 0.77 gram, and 0.51 gram respectively. Continuously, the widest cloves diameter was shown by Geol with 2.84 cm in value. This value was followed by Tawangmangu Baru, Lumbu Putih, Lumbu Hijau, TN1, Lumbu Kuning, and Kayu. The diameter values for each variety/accession are 2.75 cm, 2.03 cm, 1.97 cm, 1.96 cm, 1.34 cm, and 0.94 cm. Then, the highest clove was shown by Tawangmangu Baru and Lumbu Kuning, which have a 2.19 cm clove’s length. After that, the cloves length characters for Kayu, Lumbu Hijau, Geol, Lumbu Putih, and TN1 were 1.81 cm, 1.45 cm, 1.44 cm, 0.9 cm and 0.81 cm respectively. Finally, for the last characters, the ratio between bulbs length and diameter, showed that TN1 had the highest value, followed by Lumbu Putih, Geol, Lumbu Hijau, Tawangmangu Baru, Lumbu Kuning, and Kayu. The quantitative characters of garlic’s bulb and clove can be seen in Table 2.

| Varieties/Accessions | Bulb’s weight (gram) | Bulb’s Diameter (cm) | Bulbs length (cm) | The ratio between bulb’s length and diameter | Clove’s weight (gram) | Clove’s diameter (cm) | Clove’s length (cm) | The ratio between Clove’s length and diameter |
|----------------------|---------------------|---------------------|------------------|-------------------------------------------|---------------------|---------------------|-------------------|---------------------------------------------|
| Tawangmangu Baru     | 22.30±5.23          | 3.07±0.56           | 3.54±0.59        | 1.17±0.16                                | 4.89±2.94           | 2.75±0.5            | 2.19±0.45         | 1.27±0.19                                   |
| Lumbu Hijau          | 7.43±1.08           | 2.97±0.54           | 3.31±0.5         | 1.12±0.1                                 | 1.03±0.48           | 1.97±0.37           | 1.45±0.26         | 1.91±0.69                                   |
| Lumbu Kuning         | 13.88±2.94          | 3.36±0.22           | 2.97±0.34        | 0.89±0.1                                 | 1.68±0.7            | 1.34±0.28           | 2.19±0.26         | 0.62±0.10                                   |
| Kayu                 | 7.85±1.34           | 2.92±0.22           | 2.42±0.18        | 0.83±0.03                                | 0.80±1.34           | 0.94±0.15           | 1.81±0.09         | 0.52±0.15                                   |
| Lumbu Putih          | 12.75±2.19          | 3.44±0.26           | 2.77±0.11        | 0.81±0.06                                | 0.77±0.24           | 2.03±0.22           | 0.90±0.16         | 2.36±0.67                                   |
| TN1                  | 3.28±1.02           | 2.03±0.25           | 2.27±0.23        | 1.12±0.11                                | 0.51±0.24           | 1.96±0.29           | 0.82±0.23         | 2.50±0.51                                   |
| Geol                 | 33.93±7.45          | 5.05±3.57           | 4.15±2.77        | 0.83±0.08                                | 2.46±1.41           | 2.84±0.45           | 1.44±0.40         | 2.07±0.62                                   |

High bulb and clove weight of garlic were identified in certain areas named Hamadan, Zanjan, Isfahan and Markazi provinces in Iran. A correlation may be intertwined between phenotypic performance and geographical origins for the majority of garlic landraces [6,16, 17]. The combination of variety and agro-ecological conditions of the plantation area has a significant impact on plant production. Proper fertilizer application has an important role in increasing the crop productivity [5]. According to Zaki et al. [18], organic manure application on garlic could increase the quantity and the quality of garlic bulbs, especially in terms of weight and essential oil content. The organic material content of the soil is very useful to increase the soil’s physical characteristics. As a result, the plant growth process can be faster and better [19].

Based on this research result, it could be said that the weight of bulb did not positively correlate with the weight of cloves. It is contrary to the results of the research by Suzan, GV [20], stating that the weight of the bulb is directly proportional to the weight of cloves. It could be linked to the number of cloves per bulb value. Garlic productivity is influenced by several productivity contributing characters [21]. The analysis of the association is to calculate the presence of a reciprocal relationship between various observational characters. It can eventually be used to determine the character of a component that can serve as a selection criterion in the Plant Properties Improvement Program. Preferred genotyping selection is usually based on results and results in components [22].

The ratio of the length/diameter of the bulbs represents the shape of bulbs, which is divided into nine types in the descriptor list for Allium,[23]. The shape number 1,2 and 3 represent the ratio value less than 1, while the shape number 4 until 9 represent ratio around one or more. There is no cloves shapes description or size in that descriptor, although identification on the ratio of the length/diameter
of garlic cloves can be used to identify garlic variety. In this research result, thus, the cloves ratio showed a certain value that could be used to reflect the clove shape. The results were following Gathala, S. et al.[24] and Singh, et al. [25], which mentioned that Garlic genetic heritability value was high in clove diameter and cloves length.

4. Conclusion
Each accession has its characteristic. This research results provide new information about local Indonesian garlic and can be used to complete the database of its character as a part of local Indonesian germplasm. From the bulb characteristic, Geol has the heaviest bulb weight and the highest bulb length. Regarding the ratio between the length and diameter of the bulb, Tawangmangu Baru shows the highest ratio, followed by Lumbu Hijau and TN1. From the clove characteristics, Tawangmangu Baru shows the heaviest clove weight. The ratio of the length/diameter of the bulbs and cloves indicated the diversity between accessions. It is potentially to be used as a differentiator between accessions. This information will be useful to increase the possibilities of its utilization, especially in breeding activity.

5. References
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