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Ismail A · Pratiwi VF · Maulana H · Bari IN · Maharani Y · Kusumah FMW

In-situ characterization of Jatigede local roid banana (*Musa* spp.) based on morphological and agronomical characteristics

Abstract. Banana (*Musa* spp.) is one of the agricultural commodities that's widely cultivated and used by the local community. Currently, only 101 types of local varieties of bananas are registered in Indonesia; one of them is the Roid banana from Jatigede District. Roid bananas grow wild without any mandatory special care. Continuous use without any conservation and preservation efforts can lead to scarcity of Roid banana germplasm as a genetic resource. Therefore, it is necessary to identify the distribution and diversity of Roid bananas through *in situ* exploration and characterization activities. This study aimed to identify the potential for genetic diversity and develop conservation efforts for the local variety of Roid banana (*Musa* spp.) in Jatigede District. This research was conducted from November 2021 - March 2022 in three villages in Jatigede District: Ciranggem Village, Jemah Village, and Mekarasih Village. The research used exploratory, survey, and interview methods as data collection techniques. Based on the results of the study, Jatigede District has a wide genetic diversity and distant kinship among Roid banana accessions. Characters that contributed to genetic diversity among accessions were the width of the midrib margin, the diameter of the bunch, and the length of the pseudostem. MS1.3 was the selected accession with its potential characteristics: more combs in bunches, leaf width of 71-80 cm, leaf length of 171-220 cm, and the number of rhizomes > 5 tillers.

Keywords: Exploration · Characterization · Germplasm conservation · Index cultural significance · Principal component analysis

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Ismail A[1*] · Pratiwi VF[3] · Maulana H[1] · Bari IN[2] · Maharani Y[2] · Kusumah FMW[3]
[1] Department of Agronomy, Faculty of Agriculture, Universitas Padjadjaran, Jalan Raya Bandung Sumedang Km. 21 Sumedang 45363, Indonesia
[2] Department of Plant Protection, Faculty of Agriculture, Universitas Padjadjaran, Jalan Raya Bandung Sumedang Km. 21 Sumedang 45363, Indonesia
[3] Undergraduate Programme of Agrotechnology, Faculty of Agriculture, Universitas Padjadjaran, Jalan Raya Bandung Sumedang
Km. 21 Sumedang 45363, Indonesia
*Correspondence: ade.ismail@unpad.ac.id

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Introduction

Banana is one of the agricultural commodities widely cultivated and used by people in various circles. Bananas are a fruit crop with a high level of consumption, reaching 7.2 kg/cap/year in Indonesia. Bananas are rich in vitamins, minerals, and carbohydrates; hence, they are recommended for consumption during the COVID-19 pandemic (Marpaung and Handayani, 2020). Other than directly consumed, people often process bananas into various products such as "sale" and banana flour (Putri et al., 2015). Other parts of banana plants, such as leaves, tubers, midribs, flowers, and roots, are also utilized to benefit the community. Banana leaves can be used as food wrappers, while the cob can be processed into crackers.

Banana plants in Indonesia have a relatively high level of diversity. Currently, 101 types of banana plants have been registered as local varieties in Indonesia (PPVT-PP, 2021). This number is expected to continue to increase, considering that many local varieties of bananas have not been identified. Various types of bananas are scattered in various regions in Indonesia, one of which is in West Java Province. Some types of bananas that are recorded as local varieties in West Java include Roid Jatigede bananas, Manggala Hitam Karyamukti bananas, Kole Karyamukti bananas, and Ranggap bananas (PPVT-PP, 2021).

Roid banana is a local variety in West Java that has the potential to be developed. According to the PVTPP (2017), Roid bananas have advantages in terms of fruit storage, low fruit loss rates, and resistance to pest and disease attacks. The shelf life of Roid bananas reaches 2-3 weeks or 4-11 days longer than Kepok bananas (Ikhsan et al., 2014). These bananas are found only with wild growing in Jatigede District without any treatment from the local community. Most people use Roid bananas as a source of food and household income (Masriah et al., 2019). Continuous use and lack of efforts to preserve Roid banana can trigger a scarcity of Roid banana germplasm. Therefore, conservation and germplasm management efforts are needed to preserve and develop the potential of Roid banana.

Roid banana conservation and preservation activities can optimize the use of germplasm in West Java. The purpose of germplasm is as a genetic resource that has use and economic value, as well as a means to trace the origin and authenticity of species (Sumarno and Zuraida, 2008). Conservation and preservation activities can minimize genetic erosion or species extinction rate (Pusponegoro et al., 2018). Conservation activities can be carried out in their natural habitat (*in situ*) and outside their natural habitat (*ex situ*). Research related to the Roid banana in Jatigede district has not been carried out widely , hence, any information that be obtained from the results of this study can be used to support the success of conservation efforts for Roid bananas.

Distribution identification and Roid banana's diversity are the initial actions in developing a strategy for conserving and preserving Roid bananas. These efforts can be carried out through *in situ* exploration and characterization activities. Exploration activities aimed to collect the best accessions as genetic resources to assemble new superior varieties (VUB) (Maskrono et al., 2017). Roid bananas were identified and *in situ* characterized based on their morphological and agronomical appearance. Indigenous knowledge is also needed to support the exploration and *in situ* conservation of Roid bananas. Indigenous knowledge was obtained from the questionnaires and interviews regarding the character and importance of Roid bananas for the local community. The results of this activity will show the kinship between accessions and the potential for Roid bananas in several locations (Lesta et al., 2018). In addition, indigenous knowledge also provides an overview of *in situ* conservation techniques that are appropriate to the local culture.

This research is a follow-up of the registration of local plant varieties. The existence and potential of Roid bananas, which have not been widely published, provide a great opportunity for distribution mapping of superior accessions and analysis of conservation strategies for Roid bananas in Jatigede. The potential of produced Roid bananas would be in line with the quality of the identified accessions. The information collected is useful for completing a comprehensive data collection on diversity of banana germplasm in West Java. The complete data is expected to support engineering and plant breeding activities to improve the quality of bananas in Indonesia.

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Materials and Methods

Observation of morpho-agronomy characters and economic potential of Roid banana plants (*Musa* spp.) based on indigenous knowledge carried out in November 2021 - March 2022. This research was conducted in three villages in Jatigede District: Ciranggem Village, Jemah Village, and Mekarasih Village. The material used in this research is the population of Roid bananas (Musa spp.). The tools used in this study include the Global Positioning System (GPS), banana descriptors (IPGRI, UPOV, PPU), and devices for data processing (Laptop, GraphPad Prism 9 software, Origin Pro, and Plantix).

This descriptive study uses exploratory and survey methods as data collection techniques. The exploratory method is aimed at obtaining characteristic data of superior accession candidates for Roid bananas. While the survey method is intended to determine the scope of indigenous knowledge of the local community on the important value of the existence of Roid bananas. The descriptors and the attached questionnaire guide the exploratory and survey methods.

Collected data will be analyzed descriptively for further interpretation. Observation of Roid banana characters in the field refers to the list of characters listed in the descriptors (UPOV, 1989; IPGRI, 2006) and Guidelines for Implementation of Uniqueness, Uniformity and Stability Tests (PPU). Purposive sampling technique determined the sample exploration locations and sources of indigenous knowledge survey. Purposive sampling or judgment sampling is a technique that deliberately selects and determines the sampling locations according to the research needs (Tongco, 2007).

Results of data analysis obtained from exploration and survey at each location were carried out through quantitative analysis of vegetation and diversity levels. Vegetation analysis was conducted to determine the dominant vegetation type in a community. The parameter of Important Value Index (INP) can be used to express a measure of dominance by adding up the values of Specific Density (K), Relative Species Density (KR), Frequency (F), Relative Species Frequency (FR), Dominance (D) and Relative Dominance (DR). The formula used in calculating INP according to (Muller-Dombois and Ellenberg, 1976) is as follows: The seven arithmetic components are interrelated and have different functions. According to Prayoga et al. {2011), the function of each component is to describe the level of dominance of local bananas (*Musa* spp.) in an area. Analysis of the diversity level of the population of banana species was calculated using the Shannon-Wieners diversity index. According to Magurran (1988), an analysis of the level of biodiversity at the ecosystem level with the Shannon-Wieners diversity index was calculated using the following formula:

$$H = -\sum \frac{ni}{N} ln \frac{ni}{N} \text{ or}$$
$$H = -\sum pi \ln pi$$

description:
ni = Importance value of each type (individuals number of each type)
N = Total importance value (sum of all individuals)
Pi = Odds of interest for each type (ni/N)

The diversity index value (H) can be classified into four criteria: very high, high, medium, and low. The limits of the range of H values for each criterion according to Magurran (1988) are as follows: H> 3.0 indicates very high diversity, H 1.6 – 3.0 indicates high diversity, H 1.0 – 1.5 indicates moderate diversity, and H < 1.0 indicates low diversity.

Results and Discussion

Based on survey and exploration results Roid banana growing areas can be found in most parts of Jatigede District. Roid banana observation was conducted in six survey locations i.e. Ciranggem Village (Cikandang Hamlet and Ciranggem Hamlet), Jemah Village (Batugede Hamlet and Brujul Hamlet), and Mekarasih Village (Ciboboko Hamlet and Cihegar Mekar Hamlet). Roid banana observation sites belong to the lowland agro-ecosystem (<400 masl), with an altitude range between 295.2 masl to 364.8 masl. The range of temperature and humidity for banana planting locations in Jatigede District is 20-27^{o}C and 56-96%, respectively.

There are various types of plants in the Roid banana agroecosystem. Overall, there are 7

types of seasonal plants (rice, indigofera grass, leunca, cassava, eggplant and pumpkin) and 8 types of annual plants (mango, coconut, sugar palm, bamboo and cayenne pepper). The diversity of plant species in an agroecosystem can support the creation of a balance within an ecosystem (homeostasis). Homeostatic conditions in an area show that the ecosystem has the ability to adapt to changes that will occur in environmental conditions (Pusponegoro et al., 2018). The results of the analysis of the level of population diversity with the Shannon-Wieners index show that each village in Jatigede District has a different level of agro-ecosystem diversity. The biodiversity index of the banana agroecosystem in Jatigede District can be seen in Table 1.

Table 1. Index of diversity of banana agroecosystem species in Jatigede district

Locations	Index of Diversity	Criteria
Ciranggem Village	1.05	Medium
Jemah Village	0.50	Low
Mekarasih Village	1.48	Medium
Total	**3.03**	**High**

The index value of the diversity of agroecosystem species in Mekarasih Village and Ciranggem Village is included in the medium criteria. Meanwhile, Jemah Village has a low species diversity index. As for the whole of Jatigede District, it has a high species diversity index value of 3.03. This illustrates that the condition of the ecosystem at the observation site can support the growth of seasonal and annual plants in banana agroecosystems. Various types of plants found in banana agroecosystems will interact with each other, either directly or indirectly. According to Prayoga and Ismail (2020), most of the plant species found in the banana agro-exosystem in West Java did not have a significant negative effect on the growth of banana plants.

The diversity of Roid banana species is known by calculating the Importance Value Index (INP) which describes the position of a species relative to other species in a community. The greater the INP of a species, the higher the position and role of that species in a community. According to Safitria (2021), nine varieties of bananas were found in Jatigede District based on survey and exploration results. The nine types of bananas include Kapas, Roid, Raja Bulu, Ambon Hijau, Hurang, Nangka, Tanduk, Muli, and Raja Cere. The INP values of the nine varieties in Jatigede District can be seen in Figure 1. Roid bananas have an INP of 26.97% of all types of bananas in Jatigede District.

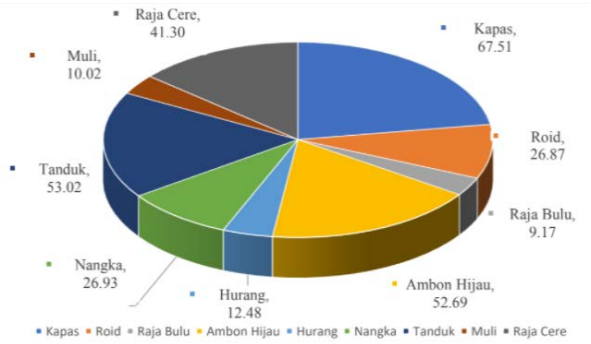

Figure 1. Combined INP of Nine Banana Varieties in Jatigede District
Source: (Safitria, 2021)

The calculation of the INP of Roid bananas at the research location is distinguished based on the location of its discovery. Ciranggem Village has the largest INP of Roid bananas among other villages, at 1.020 (34.01%). The INP of Roid bananas in Jemah Village was 1.016 (33.86%), while in Mekarasih Village, it was 0.964 (32.14%) (Figure 2). The variable that most influenced the IVI of Roid bananas in the three villages was relative density (KR). A high KR value indicates the density of Roid bananas against the density of all types of bananas in one area.

Cluster analysis classifies objects based on their homogeneity within the same cluster scope so it can increase the effectiveness of selection (Yuan et al., 2016). Cluster's formation for each group depends on the Euclidean distance. The euclidean distance from 18 Roid banana accessions results ranged from 4.5 to 7.4. This shows that Roid bananas in Jatigede District have wide variations. The kinship between accessions with an euclidean value of more than 1, shows a more distant kinship (Lestari and Julianto, 2020).

There are two parts of the dendrogram resulting from the cluster gram analysis, namely the accession dendrogram (row) and the morphological character dendrogram (column) (Figure 3). The column dendrogram depicts 38 morphological characters divided into two major

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groups with two subgroups each. Group I consisted of subgroup I with the characters of the number of rhizomes, the color of the underside of the leaf, the presence of male flowers, the position of the bunches, the diameter of the pseudostem, the diameter of the bunches, and the color of the peduncle. Subgroup II consisted of the width of the midrib, the opening of the bracts, the number of bunch combs, the curvature of the fruit, the length of the fruit stalk, the pattern of the bunches to the fruit, the width of the leaf blade, the diameter of the heart, and the number of fruits per comb. Group II consisted of subgroup I with the characters of pseudostem length, plant growth, heart shape, presence of flower organs on fruit, internal bracts color, pseudostem tapering, bunch stalk length, pseudostem anthocyanin staining, external bracts color, leaf blade length, and male flower attitude on rachis. While subgroup II consisted of pseudostem color, bunch shape, leaf base shape, bunch length, plant crown compactness, rachis: scars, bract: apex shape, inner color of the base of the pseudostem midrib, establishment of the base of the petiole wings, heart arch, and wax coating on the leaves.

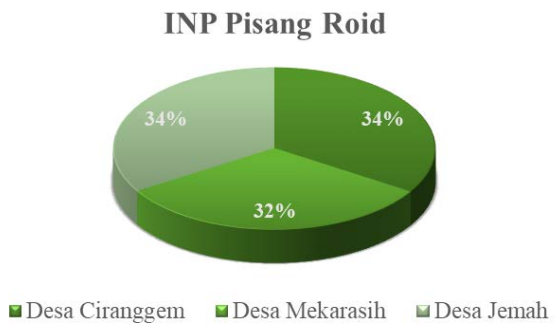

Figure 2. Combined INP of Roid Bananas at the Jatigede District Research Site

Line dendogram depicts the kinship of 18 Roid banana accessions which are divided into three major groups. Group I consisted of three accessions, namely MS1.3, MS1.2, and MS1.1. Group II consisted of 12 accessions, namely MS2.3, MS2.2, MS2.1, JM2.3, JM2.2, JM2.1, JM1.2, JM1.3, JM1.1, CGS2.3, CGS2. 2, and CGS2.1. Group III, consists of three accessions, namely CGS1.3, CGS1.2, and CGS1.1. The division of the three groups is based on the character of the establishment of the base of the petiole wings, and the male flowers: the opening of the bracts.

Each major group is divided into two subgroups. Subgroups of group I were classified based on differences in the number of rhizomes, the width of the midrib, the color of the underside of the leaf, and the length of the stalk. Subgroup I consisting of MS1.3 accessions had a higher number of tillers, wider frond margins, reddish green underside surface color, and longer stalk length (31-60cm) compared to subgroup II. The accessions in subgroup II included MS1.2 and MS1.1. In group III, the subgroups were differentiated based on these characters' bunch pattern to the fruit, the width of the leaf blade, and the attitude of the male flowers to the rachis. Subgroup I in group III had a bunch pattern of fruit that did not appear much, wider leaf blades, and male flowers were curved more than subgroup II. The accessions included in subgroup I was CGS1.3, while accessions in subgroup II were CGS1.2 and CGS1.1.

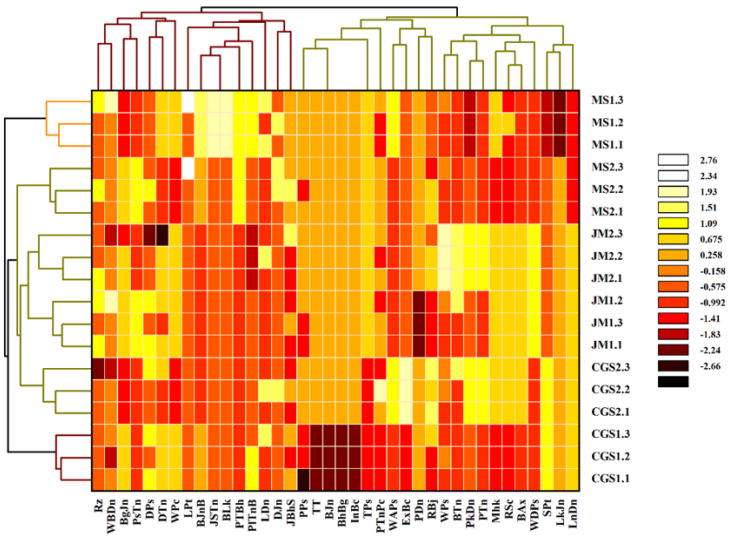

Figure 3. Clustergram Analysis with Heatmap Concepts on Morphological Characteristics of 18 Banana Roid Accessions in Jatigede District

Group II had the highest number of accessions among the other groups. Subgroups in group II were distinguished based on these characteristics: waxy coating on the leaves, compactness of the plant crown, scars on the rachis, shape of the apex on the bracts, opening of the bracts, and length of the fruit stalk. Subgroup I consisted of accessions MS2.3, MS2.2, and MS2.1 with the characters of slightly waxy leaves, looser compactness of plant crowns, weak ex scars on rachis, truncate shaped

apex bracts, fairly exposed bracts, and longer fruit stalk (≥21mm) compared to subgroup II. Sub-group II is further divided into two subgroups. Sub-subgroup I consisted of JM2.3, JM2.2, JM2.1, JM1.2, JM1.3, and JM1.1 accessions. Sub-subgroup I characters have greener inner Pseudostem, medium tapering pseudostem, petiole wings base is no deeper than Sub-subgroup II, which consists of accessions CGS2.3, CGS2.2, and CGS2 .1.

Clustergram analysis with the concept of a heat map dendrogram illustrates the influence of characters on variation between accessions with differences in color intensity. Characters that have extreme bright colors are characters that have a significant effect on the differences between accession clusters. The brighter the color of the accession group to the characters, the higher the euclidean value between the two variables (Anshori et al., 2018). Characters showing extreme color intensity on the heat map include midrib width (LPt), bunch diameter (DTn), and pseudostem length (PPs) with an average euclidean value of > 1.93 and < -2.24.

Conclusion

1. Roid bananas (*Musa* spp.) in Jatigede District have wide genetic diversity and distant genetic kinship with a euclidean value of 4.5-7.4.
2. Germplasm that has a superior potential accession for Roid banana (*Musa* spp.) based on the identification of genetic diversity and kinship is MS1.3 accession. Accession MS1.3 characters are a large number of combs, leaf blade width of 71-80 cm, leaf blade length of 171-220 cm and a number of rhizomes > 5 tillers which have potential as genetic resources to produce new superior varieties.

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