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Research Article

Morpho-agronomic diversity of local ABB banana 'Roid' in Jatigede, West Java

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ABSTRACT

Bananas are one of Indonesia's most important horticultural crops, valued for their adaptability and economic potential. Among them, the Roid banana (ABB) (Musa spp.) stands out as a local variety native to West Java-Indonesia, particularly the Jatigede District, Sumedang Regency where it thrives naturally without agronomic inputs. Known for its resistance to pests and diseases, long shelf life, and strong fruit attachment that reduces post-harvest losses, the Roid banana remains underutilized and understudied. Despite its advantages, research on its genetic diversity is limited, highlighting the need for characterization as a foundation for conservation and breeding. This study, conducted from October to December 2023 in the Jatigede District, aimed to analyze the distribution patterns and genetic diversity of Roid bananas. Characterization used a survey method and purposive sampling in situ. Results revealed two primary clusters dominated by accessions from Ciranggem and Jemah Villages. Key traits supported clusters were peduncle curvature, bunch length and density, number of fruit hands, male flower attitude, apex shape, skin color, plant height, and the presence of hermaphrodite flowers. The genetic diversity based on Euclidean distances was 0.47 to 11.92. The Index of Cultural Significance value was 105, implying a very high level of utilization diversity. These findings highlight the genetic richness and cultural importance of Roid bananas, offering valuable insights for future conservation and breeding programs.

Keywords: characterization; cluster analysis; exploration; Index Cultural Significance (ICS); *Musa* spp.

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INTRODUCTION

Bananas are considered one of the horticultural commodities with great potential to meet domestic and export needs, making them a priority for research and development. Bananas thrive and are widely cultivated in Indonesia for various uses. Banana contains carbohydrates, sugars, proteins, fats, vitamins A, B, and C, as well as mineral salts; the starch found in banana flesh is the largest carbohydrate in bananas, which, when the banana ripens, is converted into glucose, sucrose, and fructose, with carbohydrates ranging from 15% to 20% (Bello et al., 2005). Furthermore, Bello et al. (2005) noted that carbohydrate content decreases to 1.5-15% when bananas ripen either on the tree or during ripening, but other contents increase, such as sugars, which increase from 6% to 19%, and the protein content is only 1.2%. These various nutrients make bananas a highly beneficial plant.

In Indonesia, banana field covers the highest area and top first in production capacity as compared to other fruits (Yudha & Noerbayinda, 2023). The cultivated bananas are usually those with market value and superior characteristics. Indonesia is a country with many types of bananas spread across various regions, one of which is in Sumedang

Regency, West Jawa (Zulkarnain, 2017). West Java Province is rich in plant biodiversity. The region is an important banana producer, in 2021, banana production reached 1,649,228 tons and became top first fruit in West Java with 170,787 tons coming from Sumedang Regency (BPS, 2021).

Despite having higher productivity compared to other commodities, banana is still imported from abroad (BPS, 2024). This is likely due to the decreasing availability of agricultural land for banana cultivation as a result of infrastructure development, which has led to a decline in the quality and productivity of local bananas. Due to this rapid infrastructure development, the existence and availability of germplasm are threatened with extinction. The extinction of germplasm would be a disaster for future human life, so efforts are needed to maintain and preserve germplasm, including collecting banana germplasm. Collecting bananas to understand the diversity of banana characteristics can be done through characterization (Damayanti, 2018). If local variety germplasm is well managed, it can help increase productivity and minimize banana imports.

The rich diversity of local banana varieties in Indonesia offers significant potential; however, consumer preferences tend to be influenced by visual attributes such as uniform size and bright color, which are more commonly found in imported bananas and often align more closely with market expectations. Other common issues with local bananas include their susceptibility to pests and diseases, varied quality with relatively low productivity, and short shelf life. The problems of pest and disease susceptibility and short shelf life can potentially be addressed by a local variety in West Java, namely the Roid banana, which has advantages such as resistance to pest and disease attacks, relatively long shelf life, and low fruit drop rates (PVTPP, 2017). This banana grows without special management by farmers in Jatigede District, Sumedang Regency, West Java, without special treatment from the local community. The Roid banana is mostly utilized as a source of food and income by the local community (Masriah et al., 2019). Therefore, the Roid banana has high potential for development both as a source of germplasm and as a high-value local product.

To support the development of Roid bananas, understanding their distribution patterns and genetic diversity in the region is very important. Analysis to determine the distribution pattern is conducted based on morpho-agronomic characteristics (Maxiselly et al., 2016). The analyzed morpho-agronomic characteristics will provide data on the distribution of Roid banana locations in the field. The distribution results will also indicate the diversity of this banana type. Distribution patterns are closely related to the genotypic diversity of Roid bananas in the area. These traits, which include bunch size, fruit hand numbers, plant height, and sucker count, not only highlight the physical diversity of Roid bananas but also suggest distinct genetic variations. Compared to other local banana varieties, such as Apuy, Latundan, and Raja Bulu, Roid bananas differ in several key characteristics, including their leaf blade dimensions, number of hands per bunch, and plant height. These differences reflect Roid bananas' unique genetic makeup, which sets them apart from other varieties in terms of growth patterns and agronomic traits. This diversity is crucial for breeding and conservation efforts aimed at improving local banana production and ensuring the sustainability of these unique varieties.

Studies on the genotypic diversity of Roid bananas are still limited, leaving many genotypes uncharacterized. Characterization is an essential step for understanding the potential diversity of a plant species, in this case, the Roid banana (Kusumah et al., 2020). Information on the diversity of Roid bananas becomes a crucial foundation for developing new superior banana varieties to improve the quality of bananas in Indonesia. This study aimed to analyze the distribution patterns and genetic diversity of Roid bananas.

MATERIALS AND METHODS

The research was conducted from October to December 2023 in Jatigede District, Sumedang Regency, West Java, Indonesia. The site was recognized as one of the prominent banana-producing areas in the region. The study encompassed eight villages within the district, namely Cijeungjing, Cipicung, Ciranggem, Cisampih, Jemah, Kadujaya, Karedok, and Mekarasih. These eight villages were then classified based on elevation. Jatigede District falls into the low elevation category with an altitude of less than 500 meters above sea level (masl) and a temperature range of 27-34°C (BPS, 2015). The elevation was classified into three categories to observe the distribution pattern of the Roid banana (<170 m, 170-340 m, and 341-500 m above sea level) as shown in Table 1.

Table 1. Study site and number of accessions according to site elevation at Jatigede District, Sumedang Regency, West Java.

Village	Number of accessions			
	< 170 m asl	170-340 m asl	341-500 m asl	Total number
Kadujaya	1	11	-	21
Cijeungjing	-	8	16	24
Mekarasih	-	19	-	19
Ciranggem	-	29	-	29
Cisampih	-	-	20	20
Jemah	-	19	3	22
Karedok	20	-	-	20
Cipicung	-	15	1	16
Total	21	101	40	162

The plant material used in this study consisted of Roid banana accessions (*Musa acuminata* × *Musa balbisiana*, ABB genome) naturally growing (in situ) at each site. This study employed a survey method combined with field exploration using purposive sampling. Sampling sites were selected based on their representativeness of the Roid banana population and alignment with the study objectives (Abubakar, 2021). Observations were conducted at 162 observation points spread across 8 villages.

Equipment employed included a Global Positioning System (GPS) for recording coordinates and elevation, a measuring tape for assessing plant height and pseudostem diameter, a hand counter for population quantification, and a digital camera for documentation purposes. Supporting materials included standardized banana descriptors (PVTPP, 2014), character observation sheets, questionnaires, and stationery for conducting farmer interviews.

Morphological and agronomic data were collected from individual plants based on standardized descriptors. Observed traits included both qualitative and quantitative characters such as pseudostem height and pigmentation, number of suckers, leaf blade dimensions, petiole canal morphology, inflorescence type, male flower characteristics, bunch orientation and compactness, number of hands per bunch, number of fingers per hand, finger curvature, apex shape, skin and pulp color, and fruit taste. Quantitative traits were measured using field instruments, while qualitative traits were evaluated visually and compared against reference descriptors.

Data analysis was performed using XLSTAT version 2024.1 and PBSTAT-CL (www.pbstat.com) software packages. Cluster analysis generated a dendrogram to conduct descriptive statistics and hierarchical cluster analysis, facilitating the classification of accessions based on their morphological and agronomic similarities and diversity. Cluster analysis classifies objects based on their homogeneity within the same cluster, thereby increasing the effectiveness of selection (Yuan et al., 2016). The clustering was performed based on Euclidean distances among accessions.

RESULTS AND DISCUSSION

Species diversity and distribution

Table 1 shows that at several observation points with an elevation of <170 m above sea level, a total of 21 Roid banana accessions were found, originating from Kadujaya Village and Karedok Village. At an elevation of 170-340 m above sea level, 101 Roid banana accessions were found, distributed across all villages except Karedok Village and Cisampih Village. At an elevation of 341-500 m above sea level, 40 accessions were found, distributed in Cijeungjing Village, Cisampih Village, and Jemah Village. The majority of Roid bananas were found at an elevation of 170-340 m above sea level, suggesting that this elevation range is the most suitable for the growth of Roid bananas (Ismail et al., 2023). The Importance Value Index (IVI) is a significance index that represents the ecological importance of a vegetation type within its ecosystem (Handayani et al., 2021). The calculation of the IVI for the Roid banana was differentiated based on its location of discovery. The IVI of the Roid banana in Ciranggem Village was the highest among the villages, with an IVI of 49.57 (16%). The IVI values in other villages were as follows: Jemah Village 43.20 (14%), Mekarasih Village 38.35 (13%), Cipicung Village 38.04 (13%), Cijeungjing Village 36.15 (12%), Cisampih Village 33.84 (11%), and Kadujaya Village 22.77 (8%). Based on these data, the highest distribution of the Roid banana is in Ciranggem Village (Figure 1).

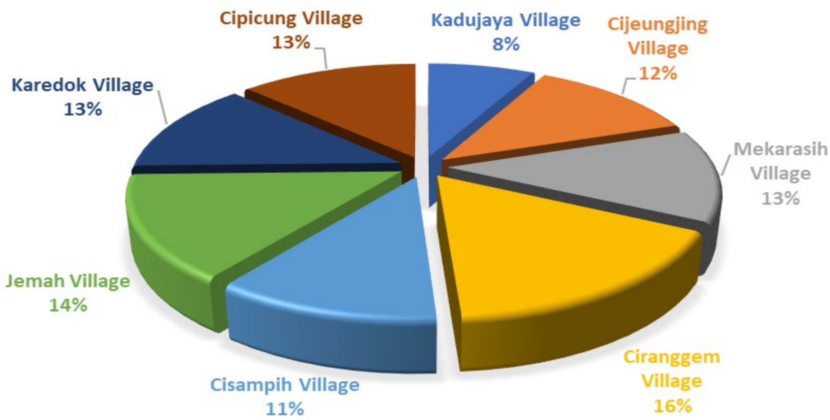

Figure 1. IVI Combination of Roid Banana in the Jatigede Sub-district Research Site.

Genetic relationship

The genetic relationship of Roid bananas in the Jatigede District was determined through cluster analysis. The dendrogram is divided into two major clusters: C1 (Red) and C2 (Green). The greatest genetic diversity of Roid bananas is found in cluster C1. The Euclidean distances among the 162 Roid banana accessions range from 0.47 to 11.92, indicating a wide variation in the local Roid bananas in Jatigede District. An Euclidean distance of more than 1 between accessions signifies a distant genetic relationship (Lestari and Julianto, 2020). The results of the cluster analysis are depicted in the dendrogram (Figure 2). This dendrogram also shows that accessions found in the same village do not necessarily have a close genetic relationship. Many factors can influence the genetic proximity of Roid bananas, with environmental factors being a major influence (Ismail et al., 2023). The accessions within the same cluster tend to have similar elevations, even if they are from different villages.

This study also provides a dendrogram illustrating the genetic relationships of local Roid bananas among the villages in Jatigede District. The dendrogram analysis results show that Roid bananas from these eight villages have significant similarities, with a dendrogram encompassing 162 accessions. Although Roid bananas in Jatigede are propagated vegetatively, genetic variation still occurs within the population. This variability can be attributed to several factors, including somaclonal variation—genetic changes that arise during clonal propagation through spontaneous mutations—and environmental influences that lead to epigenetic modifications (Pillay & Tripathi, 2007). Over time, these subtle mutations can accumulate, especially in populations that have been clonally propagated across diverse microenvironments, as is the case in Jatigede.

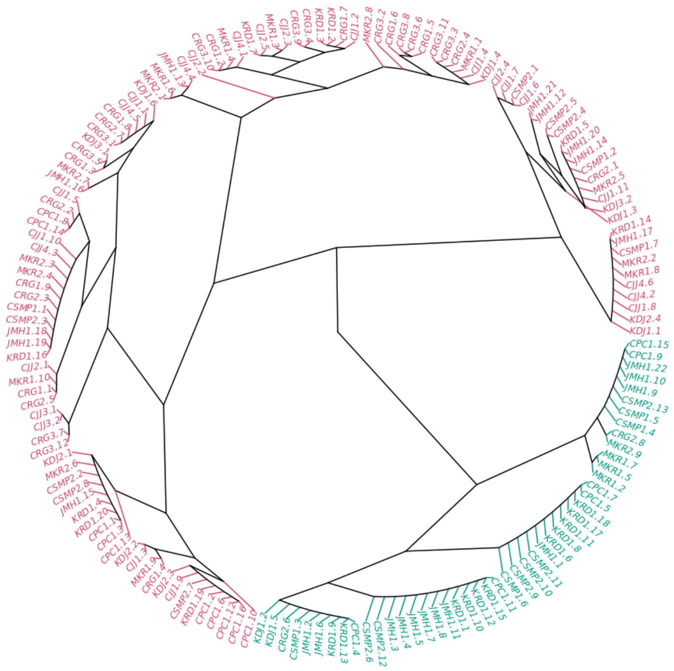

Figure 2. Clustering of Roid banana accessions existed at Jatigede District using 34 agro-morphological characters.

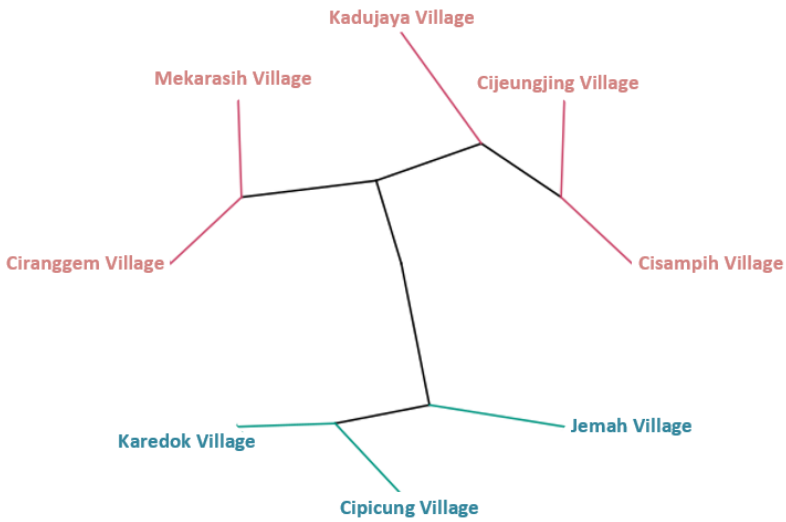

Figure 3. Clustering of villages using 34 agro-morphological characters of Roid banana.

The dendrogram analysis based on 34 agromorphological characters revealed two major clusters: C1 (Red) and C2 (Green) (Figure 3). Cluster C1, which includes Ciranggem, Mekarasih, Cisampih, Cijeungjing, and Kadujaya Villages, is more dominant, while Cluster C2 comprises Cipicung, Karedok, and Jemah Villages. The Euclidean distances among accessions ranged from 1.80 to 3.41, indicating considerable genetic divergence. Higher genetic diversity is advantageous for plant resilience, as it enhances adaptability to environmental changes and resistance to pests and diseases (D'Hont et al., 2012). These patterns suggest that despite vegetative propagation, Roid bananas in Jatigede have diversified significantly, likely due to accumulated somaclonal variations, environmental selection pressures, and possibly unintentional selection by local farmers. Such genetic diversity is crucial for resilience to biotic and abiotic stresses and provides a strong foundation for future conservation and breeding programs. Representative accessions from each cluster may serve as valuable materials for ex-situ conservation and genetic improvement initiatives.

Distribution pattern

This PCA will identify which characteristics influence the diversity among accessions (Ismail et al., 2015). Based on the percentage of total variance from all morpho-agronomic characteristics of the Roid banana, the first principal component (PC1) accounts for 21.63% of the variance (Table 2). The loading values for each characteristic are detailed in Table 3. Grouping of accessions with similar characteristics occurs due to differences in positive and negative loading values (Karuniawan et al., 2017). According to Zubair (2004), positive loading values for a characteristic can cause grouping, whereas negative loading values can lead to separation between groups.

Table 2. Eigenvalues of four principal components of 162 roid banana accessions based on morpho-agronomy characters in Jatigede District.

	PC1	PC2	PC3	PC4
Eigenvalue	7.141	3.500	2.707	2.218
Variability (%)	21.638	10.605	8.203	6.721
Cumulative %	21.638	32.243	40.447	47.168

Note: A PC is a linear combination of several variables and corresponds to one dimension

The characteristics that significantly contribute to positive variance in PC1 include peduncle curvature (PC), bunch length (BL), bunch density (BD), number of hands per bunch (NhpB), rachis attitude of male flowers (RaMf), apex shape (AS), and fruit skin color (FsC). The second principal component (PC2) explains 10.6% of the genetic variance, with plant height (PH) being the primary contributing trait. Variations in plant height have been recognized as significant factors influencing agronomic performance and adaptability in banana cultivars (Dépigny & Damour, 2022). The third principal component (PC3) accounts for 8.2% of the genetic variance, with the presence of hermaphroditic flowers on the rachis (HfoR) contributing positively. This trait is pertinent to the reproductive biology of bananas and has implications for breeding programs (Opara et al., 2010).

Based on Table 3, there are nine characteristics that contribute to the variation among the 162 accessions of Roid banana plants. In the first principal component (PC1), these characteristics are peduncle curvature, bunch length, bunch density, number of hands per bunch, male flower attitude, apex shape, and fruit skin color. The values for these characteristics are: peduncle curvature 0.883, bunch length 0.892, bunch density 0.767, number of hands per bunch 0.758, male flower attitude 0.527, apex shape 0.959, and fruit skin color 0.961. According to Wiktorowicz (2016), a characteristic value influences variation if the discriminant is >0.5 or <-0.5. In the second principal component (PC2), the influencing characteristic is plant height, with a value of 0.520. In the third principal component (PC3), the contributing characteristic is the presence of hermaphroditic flowers on the rachis, with a value of 0.619.

The biplot graph illustrates the grouping of Roid banana accessions across the four quadrants, indicating the distribution pattern. This formation demonstrates that the distribution of the 162 Roid banana accessions in Jatigede District is extensive (Figure 4). The groups formed consist of accessions from various villages in Jatigede District. Accessions from Ciranggem Village, Kadujaya Village, Cijeungjing Village, Mekarasih Village, and Cipicung Village overall cluster into one group. Meanwhile, the second group is dominated by Jemah Village, Karedok Village, and Cisampih Village. This suggests phenotypic similarities among villages that are close to each other, either due to proximity or similar elevation. The distribution pattern is influenced by environmental factors such as soil conditions, other organisms, climate, and human intervention (Wicaksono et al., 2010). The diversity in the distribution of Roid bananas on the biplot graph is also influenced by their characteristics.

Table 3. Principal component values of 162 roid banana accessions on 34 morphological characters in Jatigede District.

Characters	Character codes	PC1	PC2	PC3	PC4
Rhizome	Rhizom	0.010	0.284	0.010	0.013
Pseudostem: length	Pl	0.036	0.520	0.029	0.118
Pseudostem: diameter	Pd	0.019	0.451	0.000	0.046
Pseudostem: tapering	Tapering	0.015	0.201	0.020	0.027
Pseudostem: color	Pc	0.027	0.000	0.029	0.051
Pseudostem: anthocyanin coloration	Pac	0.051	0.002	0.005	0.186
Plant: compactness of crown	CC	0.092	0.170	0.011	0.049
Plant: growth habit	GH	0.005	0.016	0.226	0.036
Petiole: attitude of wings at base	AoWb	0.002	0.028	0.006	0.001
Petiole: length	PL	0.034	0.425	0.017	0.132
Leaf blade: color of midrib on lower side	LbCmls	0.000	0.004	0.043	0.024
Leaf blade: shape of base	LbSb	0.051	0.000	0.029	0.082
Leaf blade: waxiness on lower side	LbWls	0.002	0.044	0.004	0.045
Leaf blade: length	LbL	0.060	0.091	0.007	0.055
Leaf blade: width	LbW	0.038	0.001	0.056	0.001
Leaf blade: ratio length/width	LbRlw	0.003	0.061	0.077	0.040
Leaf blade: glossiness of upper side	LbGus	0.003	0.000	0.020	0.105
Peduncle: length	PeL	0.451	0.100	0.160	0.002
Peduncle: diameter	PeD	0.050	0.014	0.188	0.228
Peduncle: pubescence	PeP	0.080	0.055	0.031	0.052
Peduncle: curvature	PeC	0.883	0.001	0.034	0.003
Bunch: length	BL	0.892	0.025	0.001	0.000
Bunch: diameter	BD	0.052	0.201	0.013	0.266
Bunch: shape	BS	0.020	0.000	0.086	0.411
Bunch: attitude of fruits	BAf	0.020	0.004	0.081	0.032
Bunch: compactness	BC	0.767	0.061	0.008	0.000
Bunch: number of hands	BNh	0.758	0.003	0.000	0.016
Rachis: attitude of male part	RAmp	0.527	0.033	0.226	0.046
Rachis: prominence of scars	RPc	0.107	0.307	0.323	0.040
Rachis: persistence of hermaphrodite flowers	RPhf	0.064	0.064	0.619	0.048
Fruit: curvature	FC	0.103	0.331	0.342	0.057
Fruit: shape of apex	FSa	0.959	0.000	0.002	0.005
Fruit: color of peel	Fcp	0.961	0.000	0.001	0.001

Note: The characters that have the most influence on diversity with loading values >0.5 and <-0.5. While characters with loading values <0.5 and >-0.5 are characters that have no effect on diversity (Wiktorowicz, 2016)

The high diversity observed among Roid banana accessions is largely attributed to variations in several key morpho-agronomic traits, including peduncle curvature (PeC), bunch length (BL), bunch density (BD), number of hands per bunch (BNh), male flower attitude (MF), apex shape (AS), fruit skin color (FSc), plant height (PH), and the presence of hermaphroditic flowers on the rachis (RPhf). These characters are influenced by both genetic and environmental factors, even in vegetatively propagated crops such as bananas, where somaclonal variation and epigenetic modifications may arise over generations. Traits related to plant architecture and reproductive structures, such as plant height and bunch characteristics, tend to show high variability due to their sensitivity to local growing conditions and management practices. Additionally, correlations may exist among these traits for instance, taller plants often produce longer bunches, while higher bunch density may be associated with an increased number of hands. Such interrelated traits contribute to the observed phenotypic clustering and reflect the underlying genotypic diversity within the Roid banana population.

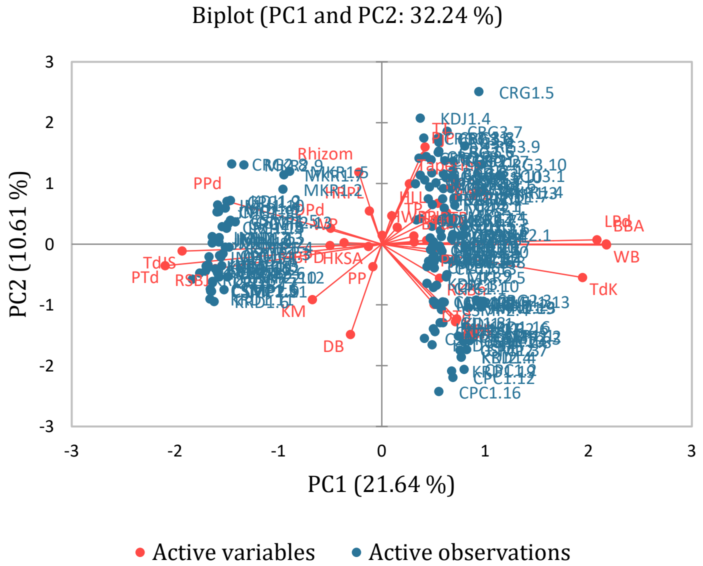

Figure 4. Plot of principal component PC1 and PC2 of 162 roid banana accessions in Jatigede District based on 34 morphological characters.

Roid banana utilization

The ICS values for Roid bananas at the research location were obtained through interviews with 37 respondents (Table 4). The majority of respondents were farmers, housewives, and traders who frequently use bananas as a primary commodity to meet their livelihood needs. Information on utilization was gathered in terms of quality, intensity, and the uniqueness of the plant species' use.

Table 4. Index cultural significance value of banana plantation in Jatigede Sub-district.

Types of banana	Utilization	ICS value
Roid Banana	Fruit: As table banana Fruit: Banana chips, dried banana slices Fruit: Banana chips Fruit: Traditional ceremony Male inflorescence: Stir-fried banana blossom Leaf: Food packaging Pseudostem: Resin as medicine Pseudostem: Tobacco wrapper Pseudostem: Chips Pseudostem: Livestock feed Stump: Crackers	105
Tanduk banana	Fruit: As table banana	12
Kapas banana	Fruit: Banana chips	15
Batu banana	Male inflorescence: Stir-fried banana blossom Leaf: Food packaging	36
Ambon banana	Fruit: As table banana Fruit: Dried banana slices	24
Muli banana	Fruit: As table banana	12

Based on the ICS analysis results in Table 4, Roid bananas in Jatigede District, Sumedang Regency, have the highest ICS value of 105, which falls into the very high category (Ismail et al., 2023). This indicates that Roid bananas are highly diverse and extensively utilized by the local community (Hidayat et al., 2018). Additionally, the intensity of Roid banana utilization was the most favored by the local community of Jatigede District. Meanwhile, bananas categorized as having moderate ICS values include

Batu bananas and Ambon bananas, with ICS values of 36 and 24, respectively. Muli bananas and Tanduk bananas belonged to the low ICS category with values of 12 each and were classified as less utilized by Permanasari (2017).

The Species Use Value provided an overview of the extent to which a plant species is utilized by the community in a given area, in this case, the Roid banana. Based on the Species Use Value calculation, the Roid banana had a value of 3.11, indicating a wide range of uses for this type of banana. The result is consistent with previous research, which found that the Species Use Value for Roid bananas in Jatigede District was 3.27, demonstrating their diverse utilization (Ismail et al., 2023). Therefore, the utilization of Roid bananas shows high diversity across various parts of the plant.

CONCLUSIONS

Cluster concluded two distinct groups of Roid banana accessions, influenced by environmental factors, particularly elevation. Significant traits contributing to the cluster included peduncle curvature, bunch length, bunch density, number of fruit hands, male flower attitude, apex shape, fruit skin color), plant height, and the presence of hermaphroditic flowers on the rachis. Roid bananas exhibit substantial genetic diversity, as evidenced by the wide range of Euclidean distances (0.47-11.92) in the dendrogram of 162 accessions. Despite being propagated vegetatively, this diversity can be attributed to several factors, including somaclonal variation, environmental influences such as microclimate, soil type, and agricultural practices, as well as human-mediated activities like selective planting and the movement of plants across regions. The broad genetic range suggests distant genetic relationships among the accessions, highlighting the richness of this local variety. Additionally, the high Index Cultural Significance (ICS) value of Roid bananas indicates their diverse utilization potential, reinforcing their importance for various applications.

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