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Research Article

Diversity and Phenetic Relationship of Mountain Papaya (*Vasconcellea Pubescens*) in Dieng Plateau Based on Morphological Marker

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ABSTRACT
Vasconcellea pubescens A. DC., commonly referred to as mountain papaya, belongs to the Caricaceae family and is native to the Andean highlands. In Indonesia, mountain papaya can be found on the Dieng Plateau and has become one of the typical processed products from the Dieng area. The aim of the study is to explore the diversity and phenetic relationship of mountain papaya from the Dieng Plateau based on morphological markers. This study is important to provide information in guiding future conservation efforts. 18 samples were collected from three areas with different altitudes in the Dieng Plateau. In addition, it proved valuable results by elucidating patterns of variation, enabling the identification of distinct groups. A total of 18 samples were collected from three areas with varying altitudes in the Dieng Plateau. Morphological analysis used 22 characters with The Clustering Analysis Method, Principal Component Analysis (PCA), and Diversity Analysis using Multivariate Statistical Package (MVSP) software version 3.1A. The results of cluster analysis showed that mountain papaya accessions were grouped into two main clusters and five sub-clusters. Cluster grouping based on sex distribution characters, flower stalk length, and inflorescence density; there is no grouping based on geographical location or altitude. The Shannon's Index Value (H') for mountain papaya shows moderate phenetic diversity. This suggests that the mountain papaya community remains stable within its substrate and its environmental parameters.

INTRODUCTION
Vasconcellea pubescens A. DC., also known as mountain papaya, is a species of the genus *Vasconcellea* of the family Caricaceae. This plant flowers and bears fruit throughout the year. Mountain papaya usually grows well at an altitude of 1500 meters above sea level (Prabhukumar et al. 2018). Since mountain papaya originates from the highlands and has similarities with the species *Carica papaya* L., it is often referred to as "highland papaya". This species originating from the Andean Highlands that has an untapped potential that can be developed. For instance, the use of mountain papaya, which has a good taste and high quality and can be reproduced and commercialised. In addition, the genetic heritage of mountain papaya that has resistance to cold temperatures can be transferred to ordinary

papaya to add to the adaptability of ordinary papaya in subtropical regions (National Research Council 1989).

Mountain papaya in Indonesia can be found in the Dieng Plateau area, which is included in the Wonosobo and Banjarnegara Districts, Central Java. In addition, mountain papaya can also be found in the Bromo and Cangar areas of East Java (Laily et al. 2021). The people of the Dieng Plateau area call the mountain papaya tree "Carica". In the Dieng area, mountain papaya fruit has become one of the leading consumption products by being processed into candied carica, and it is now a typical souvenir product from the Dieng Plateau area (Sarno 2018).

Research on morphological characterisation is one of the most important basic rules in the identification of phenetic and genetic diversity in plants, especially in mountain papaya (Martiwi et al. 2020). Morphological characterisation of plant accessions provides several advantages, including revealing the environmental factors underlying changes in plant conditions, providing an indication of physiological status, and providing predictions of future plant population status (Buckley et al. 1997). Previous research conducted by Kyndt et al. (2005) on relationships in the genus *Vasconcellea* (mountain papaya) based on molecular and morphological evidence resulted in relationships based on morphological characters that only show external similarities and are not directly related to genetic relationships or taxon validity. Phenetic inter compatibility and plasticity among mountain papaya species tend to confuse morphological boundaries in each taxon.

Morphological markers have been the primary markers for classification for centuries. Early classifications were based on macroscopic morphological characters. Over the past two centuries, more and more microscopic morphological characters have been included. Although flower morphology has been the main material for classification, other morphological characters also contribute to specific plant groups (Singh 2019). A study conducted by Laily et al. (2022) on macromorphological characters in three sex types of mountain papaya in Java showed varied leaf and flower characters. Likewise, the micromorphological characteristics of mountain papaya show great differences in the trichomes of female and monoecious plants. As a foundation for determining the phenotypic and genotypic diversity within a species, research on morphological characterisation in plants with great morphological variation is crucial. In cultivated plants like mountain papaya, information on phenotypic and genotypic variety is particularly important (Ayana & Bekele 2000).

Phenetic classification groups species into higher taxa based on the overall similarity of observable characters, regardless of their phylogeny or evolutionary relationships. Similarity coefficients are used to create similarity matrices and generate phenograms, which are tree-like networks that express phenetic relationships (Chouduri 2014). Phenetic analysis methods can generally be classified into methods that produce tree-like diagrams (clustering) and methods that produce scatter diagrams on two or more axes (Nixon 2013). In this study, the method used for clustering is the UPGMA (Unweighted Pair Group Method with Arithmetic Average) or average linkage method, which is a direct approach to reconstructing phylogenetic trees using distance matrices (WeiB & Goker 2010). The UPGMA method gives equal weight to each OTU (Operational Taxonomic Unit) and calculates the average similarity or difference between OTUs in cluster formation (Singh 2019).

The morphological characteristics of mountain papaya used in this study included qualitative and quantitative characters. These morphological characters are represented in the form of nominal, ordinal, or binary data. Samples were taken from the Dieng plateau area, which is divided

into two districts, which are the east Dieng and the west Dieng. East Dieng is administratively included in the Wonosobo District area. While West Dieng is administratively included in the Banjarnegara District. Research on diversity and relationships of mountain papaya in the Dieng Plateau area is important to provide information for future conservation. In addition, information on phenetic diversity of mountain papaya is useful in providing patterns of variation so that it can make it possible to identify different groups that can be classified as species. Therefore, the objective of this study is to explore and to uncover phenetic diversity and relationships of mountain papaya from the Dieng Plateau based on morphological markers.

MATERIALS AND METHODS

Mountain papaya

In this study, from August to October 2022, a total of 18 mountain papaya accessions were collected from three locations at different altitudes (Table 1). The sampling locations were carried out in three villages: Kejajar, with an altitude of 1400 masl; Sembungan, with an altitude of 2200 masl; both areas are in Wonosobo District; and Kepakisan, with an altitude of 1800 masl, in Banjarnegara District (Figure 1). Sampling was conducted by purposive sampling using the Explore Method (Rugayah et al. 2004).

Methods

Morphological analysis of mountain papaya was carried out by observing 22 characters (Table 2) using references from the Descriptor of Papaya

Table 1. Location, altitude, and sex distribution of mountain papaya accessions.

Code	Collection Site			Altitude (masl)	Sex Distribution
	Sub-district	Regency	Province		
KJ1	Kejajar	Wonosobo	Central Java	1579	Female
KJ2	Kejajar	Wonosobo	Central Java	1567	Female
KJ3	Kejajar	Wonosobo	Central Java	1567	Female
KJ4	Kejajar	Wonosobo	Central Java	1376	Hermaphrodite
KJ5	Kejajar	Wonosobo	Central Java	1425	Hermaphrodite
KJ7	Kejajar	Wonosobo	Central Java	1579	Hermaphrodite
SB1	Sembungan	Wonosobo	Central Java	2227	Female
SB2	Sembungan	Wonosobo	Central Java	2223	Female
SB3	Sembungan	Wonosobo	Central Java	2224	Female
SB6	Sembungan	Wonosobo	Central Java	2185	Hermaphrodite
SB7	Sembungan	Wonosobo	Central Java	2224	Hermaphrodite
SB8	Sembungan	Wonosobo	Central Java	2223	Hermaphrodite
PK1	Kepakisan	Banjarnegara	Central Java	1887	Hermaphrodite
PK3	Kepakisan	Banjarnegara	Central Java	1899	Female
PK4	Kepakisan	Banjarnegara	Central Java	1921	Female
PK6	Kepakisan	Banjarnegara	Central Java	1921	Hermaphrodite
PK7	Kepakisan	Banjarnegara	Central Java	1884	Female
PK8	Kepakisan	Banjarnegara	Central Java	1899	Hermaphrodite

(IBPGR 1988) and data from UPOV (Union for the Protection of New Varieties of Plants) (2014). Morphological characters analyzed include the vegetative and generative organs of mountain papaya. Morphological character analysis was carried out by analysing the data obtained qualitatively and descriptively. Quantitative analysis was also carried out using the cluster analysis method.

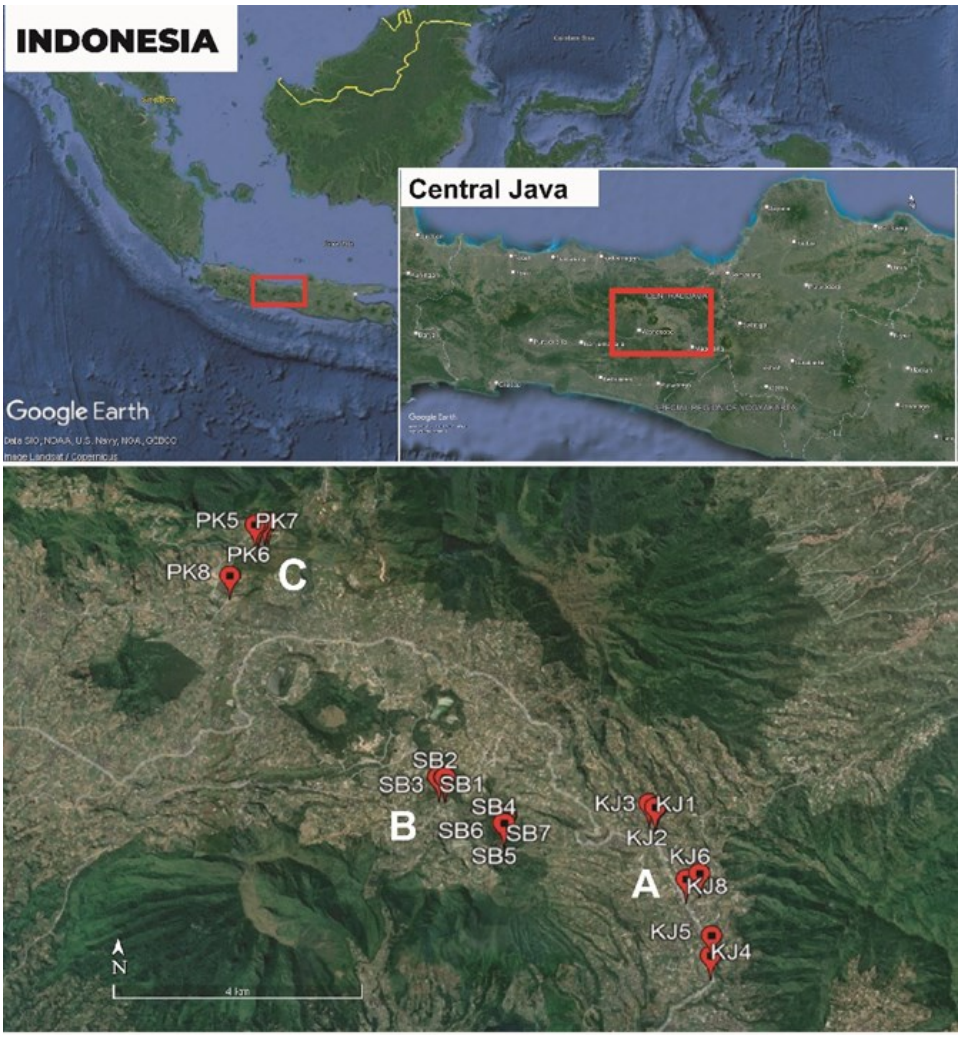

Figure 1. Mountain papaya's sampling location in the Dieng Plateau. **A**. Kejajar, Kejajar, Wonosobo. **B**. Kepakisan, Batur, Banjarnegara. **C**. Sembungan, Kejajar, Wonosobo (Google Earth 2023).

Each mountain papaya sample found is considered a separate operational taxonomic unit, or OTU. Morphological character data totaling 22 characters, both in the form of qualitative and quantitative data, were converted into numerical data in the form of two-state and multi-state data. Then the data were transformed to approach a normal distribution, the transformation was carried out using the standardisation method. Based on the transformed data, the distance index is calculated. The distance index between OTUs is calculated using the Gower General Similarity Coefficient (Sneath & Sokal 1973), which is (1):

$$Sm = \frac{m}{(m+v)} \quad (1)$$

Description:
m= a character shared by a pair of OTUs
v = a character that belongs to only one of the pair of OTUs

Index values between OTUs based on morphological character data were then used to reconstruct dendrograms using UPGMA (Unweighted Pair Group with Arithmetic Average) group analysis (Sneath & Sokal 1973) with the Multivariate Statistical Package (MVSP) version 3.1A program. The resulting dendrogram based on cluster analysis is used to present phenotypic similarity in a group. Cluster analysis is a multivariate statistical technique that has been developed for biological classification. Cluster analysis can be used to efficiently classify data sets of relevant organism characteristics (Saracli et al. 2013). Cluster analysis in this study was conducted using the UPGMA or average linkage method, which is a direct approach to reconstructing phylogenetic trees using distance matrices (WeiB & Goker 2010). Principal component analysis (PCA) was used to determine the role of each morphological character in grouping accessions. PCA will map the distribution of characters into two principal component axes. PCA analysis of data was previously carried out using log transformation and then standardised. Cluster analysis and PCA were conducted using MVSP version 3.1A program (Kovach 2007) to see the relationship between mountain papaya OTUs.
Determination of the diversity level of mountain papaya utilizing the Shannon-Wiener Diversity Index (Fachrul 2008), which is (2):

$$H' = -\sum_{i=s}^{s} pi \ln pi \quad (2)$$

Description:
H' = Shannon-Wiener Diversity Index
Pi = $\frac{ni}{N}$
ni = Total individuals of each i-th character
s = Total number of observed plant samples

There are three classifications of diversity levels based on the Shannon Wiener Diversity Index: (i) H'<1, indicating low diversity, (ii) 1< H'<3, indicating medium diversity, and (iii) H'>3, indicating high diversity.

RESULTS AND DISCUSSION

Morphological character observations of mountain papaya on the Dieng Plateau were carried out using 22 morphological markers. These morphological characters include quantitative and qualitative characters (Table 2). Based on these morphological characters, observations were made on 18 samples of mountain papaya in the Dieng area (Table 1). Mountain papaya in the Dieng Plateau has an overall medium (>1 m) to high (>2 m) stem height with single and multiple stem branching (Figure 2). In their description, Prabhukumar et al. (2018) mentioned that the stem length of mountain papaya ranges from 3.5–5 m, while Paniagua-Zambrana et al. (2020) mentioned that mountain papaya has a height of only up to 4 m. This shows that mountain papaya has a wide range of stem heights. However, compared to the stem height of carica papaya species, which reaches 2–10 meters (Wadekar et al. 2021), the height of mountain papaya is lower.

Mountain papaya leaves are palmate compound-type leaves with 5 to 6 lobes (Prabhukumar et al. 2018). On the abaxial side of the leaf there are pubescens, or fine hairs, and palinactinodromous leaf veins. The tooth shape of mature leaves is convex, with a low to medium ratio of leaf length and width. The sinus shape of the petiole is open, slightly open,

Table 2. List of morphological characters of mountain papaya.

Character	Code	Character States
Tree habit	THB	0=single stem, 1= multiple stems
Sex distribution	SD	0=female, 1=hermaphrodite, 2=male
Color of stem (young plant)	CS	0=only green, 1=yellowish green, 2=brown, 3=green and purple, 4=only purple
Height to first fruit	HF	0=low bearing (<1.0 m), 1=intermediate, 2=height bearing (>1.5 m)
Stem colour (adult trees)	STC	0=greenish or light grey, 1=greyish brown, 2=green and shades of red purple (pink), 3=red purple (pink), 4=other (specify)
Leaf length/width ratio	LR	0=low (3:2), 1=medium (1:1), 2=height (3:4)
General shape of petiole sinus	SPS	0=open, 1=slightly open, 2=slightly closed, 3=strongly closed, 4=other
Inflorescence density	ID	0=sparse (few flowers), 1=intermediate, 2=dense (many flowers)
Colour of corolla	CC	0=white, 1=cream, 2=yellow, 3=green, 4=purple
Colour of inflorescence stalk	CIS	0=greenish, 1=purplish/pinkish, 2=dark red purple/pink, 3=other
Flower stalk length	FSL	0=short (<3 cm), 1=medium, 2=long (>5 cm)
Stalk end fruit shape	SFS	0 = depressed, 1 = flattened, 2 = inflated, 3 = pointed
Size of blossom end scar	SBS	0=small (<0.5 cm), 1=intermediate, 2=large (>1 cm)
Fruit skin texture when ripe	FST	0=smooth, 1=intermediate, 2=rough (ridged)
Ridging on fruit surface	RFS	0=absent or very weak, 1=weak, 2=moderate, 3=strong
Shape of central cavity	SCC	0=irregular, 1=round, 2=angular, 3=slightly star shaped, 4=star shaped, 5=other
Fruit shape	FS	0=ovate, 1=elliptic, 2=obovate, 3=pyriform, 4=oblong, 5=obovate waisted
Number of seeds per fruit	NSF	0=absent or very few (>50), 1=few (51-100), 2=medium (101-150), 3=many (151-200), 4=very many (<200)
Seed colour	SC	0=grey yellow, 1=grey, 2=medium brown, 3=dark brown, 4=black
Seed ratio length/width	SR	0=low (3:2), 1=medium (1:1), 2=high (2:3)
Seed position of broadest part	SPB	0=at middle, 1=slightly towards base, 2=strongly towards base
Seed shape	SS	0=generally round, 1=generally spherical or ovoid, 2=other

slightly closed, and very closed. The petiole is green with red-purple shades; there is anthocyanin coloration on the petiole (Figure 3).

a **b**

Figure 2. Stem appearance of mountain papaya: **a**. Mountain papaya with multiple stem branching; **b**. Mountain papaya with single stem branching.

Mountain papaya (*Vasconcellea pubescens*, A.DC.) is a Trioecious plant where female, male (dioecious), and hermaphrodite (monoecious) plants coexist in one species (Salvatierra-González & Jana-Ayala 2016). Flowers on mountain papaya are panicle-type flowers, which are compound flowers in the form of multiple clusters. Flowers on mountain papaya in the highlands have variations in inflorescence stalk length ranging from short (< 3 cm) to long (> 5 cm). Flower density also shows variations ranging from sparse to dense. The colour of the corolla of mountain papaya flowers is generally yellow, green, and cream (Figure 4).

The variation in fruit shape of mountain papaya found in the Dieng plateau area shows fruits with obovate, pyriform, and elliptic shapes. The fruit surface has a slightly prominent (moderate) and prominent (strong) ridge. The flesh of the fruit, when ripe, is yellow in colour with a dense texture (crunchy). The shape of the central cavity of the fruit has variations of angular, slightly starry, and rounded shapes (Figure 5). Letelier et al. (2020) mentioned in their paper that ripe mountain papaya fruits are about 8–15 cm long, 5–6 cm in diameter, and weigh an average of about 200 grams.

Variations in the shape of mountain papaya seeds in the Dieng plateau area show ovoid or spherical seeds and oval seeds. Whereas in Prabhukumar et al. (2018), the shape of the mountain papaya seeds is elliptic, oval, or fusiform. The colour of mountain papaya seeds in the Dieng plateau area is generally dark brown or light brown, with a thick layer of mucus covering the seeds. The seed surface is opaque and has no luster. The number of seeds in one fruit varies, ranging from 73 seeds per fruit to 168 seeds per fruit (Figure 6).

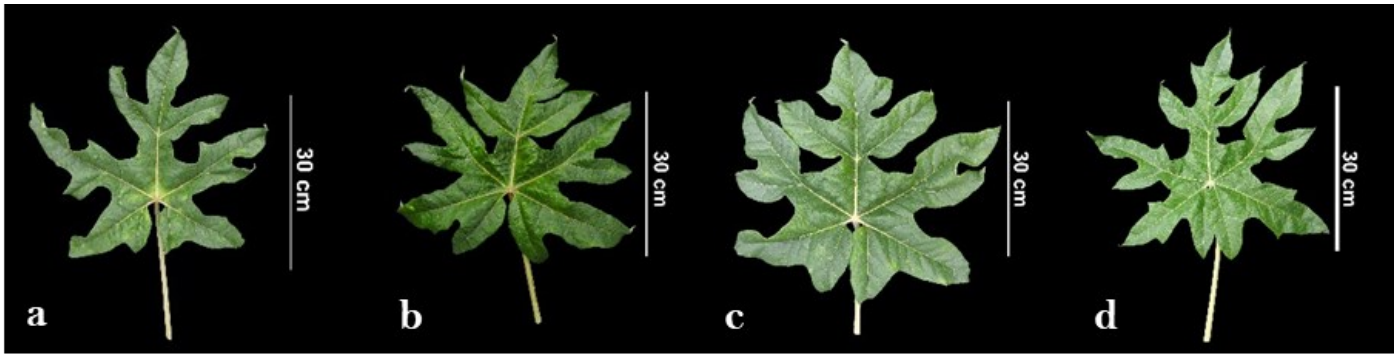

Figure 3. Mountain papaya leaf variation: **a.** Medium ratio/open stalk sinuses; **b.** Low ratio/slightly open stalk sinuses; **c.** Low ratio/slightly closed stalk sinuses; **d.** Medium ratio/closed stalk sinus.

Figure 4. Flower variations of the mountain papaya plant: **a**. Hermaphrodite flowers; **b**. Male flowers; **c**. Female flowers.

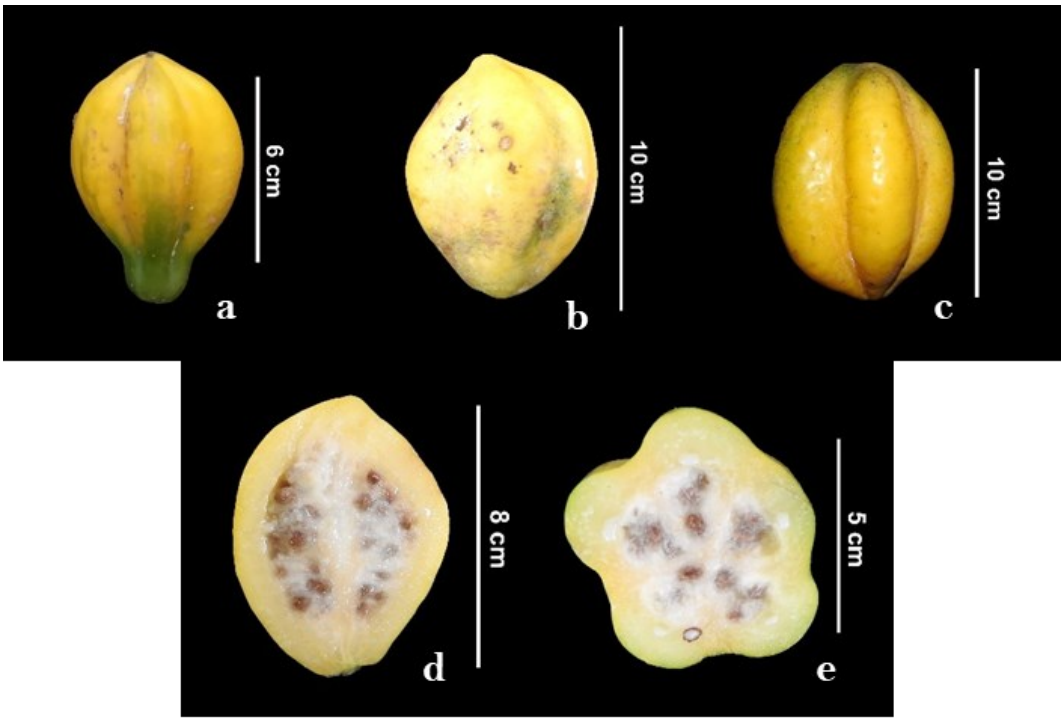

Figure 5. Variations of Mountain Papaya Fruit: **a.** Pyriform-shaped fruit; **b.** Obovate-shaped fruit; **c.** Ellyptic-shaped fruit; **d.** Longitudinal cross-section of ellyptic-shaped fruit slices; **e.** Cross-section of ellyptic-shaped fruit slices.

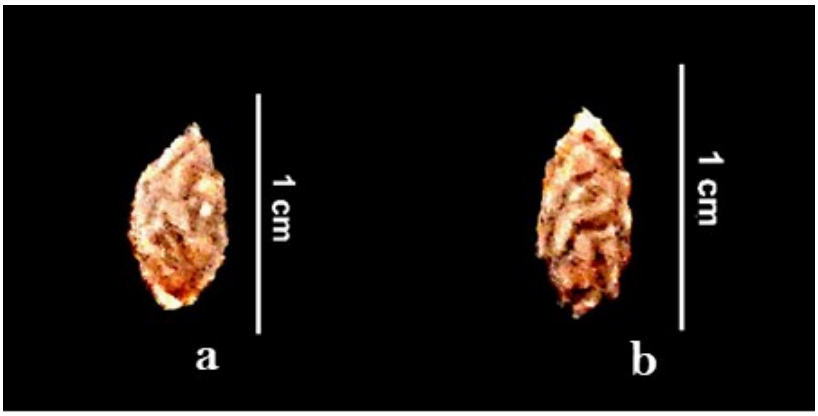

Figure 6. Seed shape of mountain papaya: **a.** ovoid or spherical; **b.** Oval.

The morphological relationship analysis of mountain papaya from the Dieng Plateau used two types of analysis methods, namely cluster analysis and principal component analysis (PCA). Kettenring (2006) states in his article that there are three main methods in multivariate analysis, which are cluster analysis (CA), principal components analysis (PCA), and discriminant analysis (DA). The results of cluster analysis on mountain papaya based on morphological characters using the UPGMA method showed similarity indices ranging from 0.631–0.945 (63.1–94.5%).

The dendrogram of the cluster analysis showed two main clusters with five sub-clusters (Figure 7). Cluster I consist of accessions that have hermaphrodite sex distribution, moderate to dense flower density, and a flower stalk length of more than 5 cm. Cluster II consists of accessions that have female sex distribution, sparse to medium flower density, and short (< 3 cm) to medium (< 5 cm) flower stalk length. Cluster I have two sub-clusters, namely sub-cluster Ia and sub-cluster Ib, with a similarity index of 78.7%. Subcluster Ia consists of accessions PK6, SB6, PK8, and PK1, which have similar characteristics, such as medium texture of

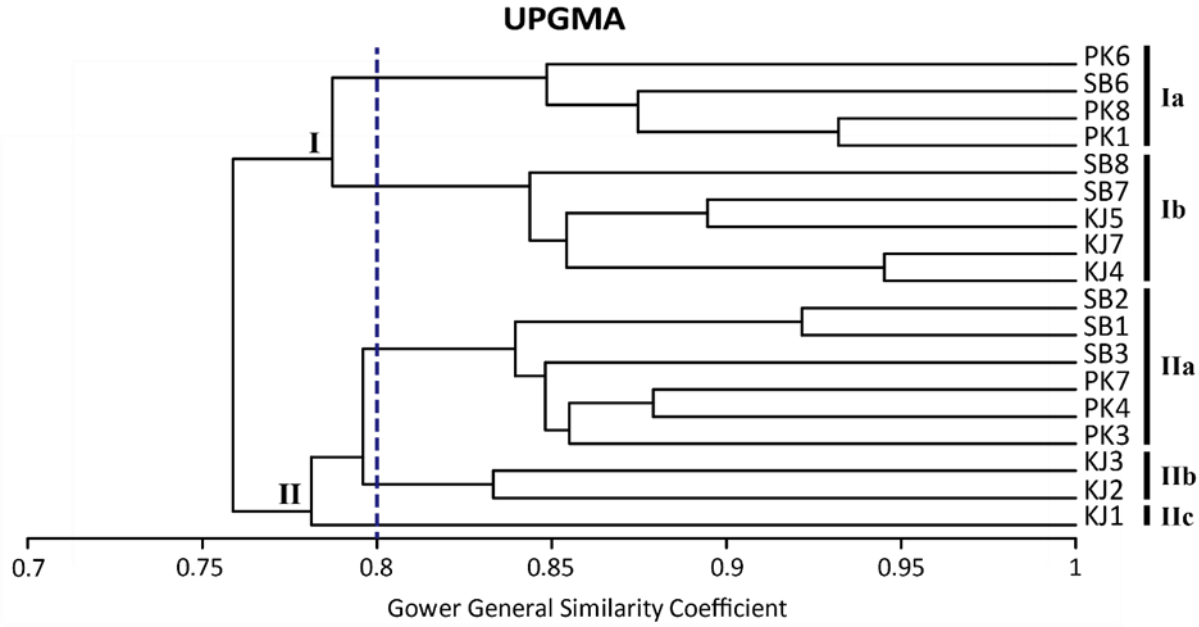

Figure 7. Dendrogram of cluster analysis results based on morphological characters of Mountain Papaya using the UPGMA method. **KJ.** Accession from Kejajar Sub-District, Wonosobo Regency; **SB.** Accession from Sembungan Sub-District, Wonosobo Regency; **PK.** Accession from Kepakisan Sub-District, Banjarnegara Regency.

the fruit skin at maturity, low seed ratio, and the position of the widest part of the seed in the centre. Subcluster Ib consists of 5 accessions, including SB8, SB7, KJ5, KJ7, and KJ4. The common characteristics of subcluster Ib are rough or prominent fruit skin texture, a high seed ratio, and the position of the widest part of the seed slightly towards the bottom.

Cluster II has sub-clusters IIa and IIb that cluster at a similarity index of 79.6%. It then regroups with sub-cluster IIc at a similarity index of 78.1%. Sub-cluster IIa consists of six accessions (SB1, SB2, SB3, PK3, PK4, and PK7) with multiple stem characters, a low seed ratio, and the position of the widest part of the seed in the middle. While sub-cluster IIb consists of two accessions, KJ2 and KJ3, which have single stem characters. While cluster IIc, which consists of one accession, KJ1, has a moderate ridge character on the fruit surface, the other sub-clusters have a strong ridge on the fruit surface.

The results of cluster analysis on mountain papaya in the Dieng Plateau area based on morphological characters showed no grouping based on geographical location or altitude. In contrast to the mountain papaya research conducted by Carrasco et al. (2008) in Chile, which clustered based on the location of growth. Cluster grouping of mountain papaya in the Dieng Plateau is mainly influenced by the characters of sex distribution, stalk length, and flower density. Moore (2013) mentioned that the most distinctive and significant phenotypic traits of papaya varieties are related to flower and fruit characteristics. The form of morphological variation in flowers and inflorescences in papaya varies based on the sex of the tree.

Principal component analysis (PCA) is used to determine the source and structure of variation and the contribution of the observed characteristics to total variability (Glogovac et al. 2012). The results of principal component analysis of morphological characters of mountain papaya in the Dieng plateau showed an eigenvalue of 5.22 on the first axis to 1.80 on the 6th axis (Table 3).

According to Jeffers (1967) in his article, there is a practical and useful role in determining components that have a significant value,

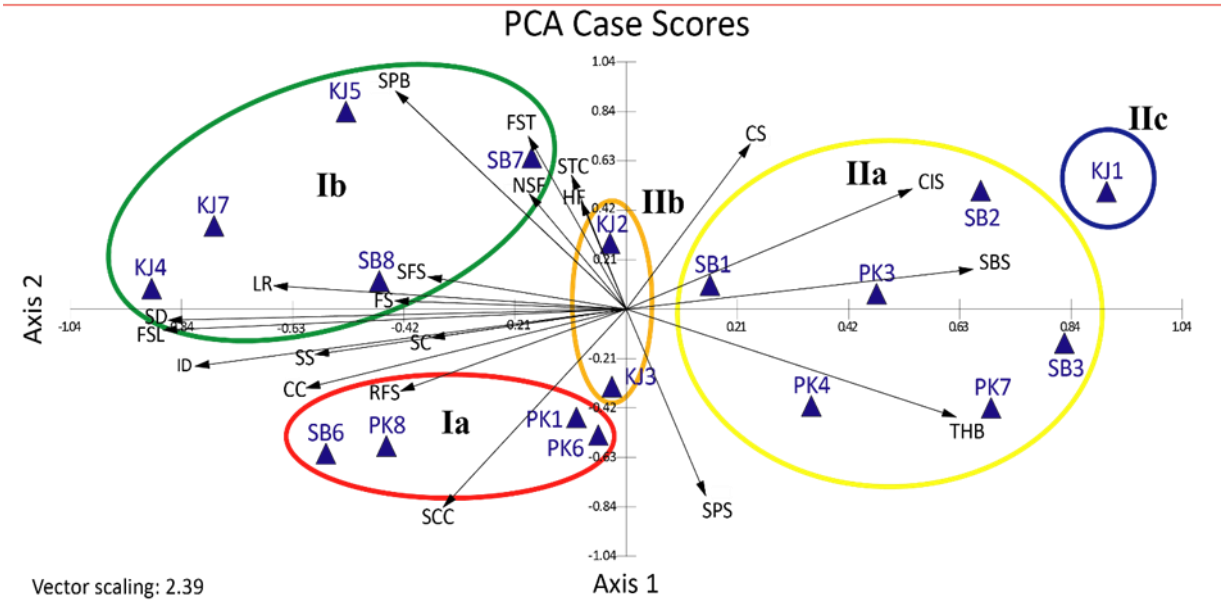

Figure 8. Scatter plot of mountain papaya grouping based on 22 morphological characters.

which is to only consider components with an eigenvalue equal to 1.000 or greater. The grouping of mountain papaya accessions based on principal component analysis is shown in the scatter plot image (Figure 8); the length of the arrow indicates the role of the character in the grouping.

Table 3. Eigenvalue and variable loading of mountain papaya PCA analysis.

Eigenvalues		
	Axis 1	Axis 2
Eigenvalues	**5.22**	**3.51**
Percentage	23.73	15.98
Cum. Percentage	23.73	39.70

PCA *variable loadings*		
	Axis 1	Axis 2
Tree habit	-0.26	-0.19
Sex distribution	**0.36**	-0.02
Colour of stem (young plant)	-0.10	0.29
Height to first fruit	0.04	0.19
Stem colour (adult trees)	0.04	0.24
Leaf length/width ratio	0.28	0.04
General shape of petiole sinus	-0.06	**-0.33**
Inflorescence density	**0.34**	-0.10
Colour of corolla	0.25	-0.14
Colour of inflorescence stalk	-0.23	0.21
Flower stalk length	**0.37**	-0.04
Stalk end fruit shape	0.16	0.06
Size of blossom end scar	-0.27	0.07
Fruit skin texture when ripe	0.08	**0.31**
Ridging on fruit surface	0.18	-0.15
Shape of central cavity	0.14	**-0.35**
Fruit shape	0.18	0.02
Number of seeds per fruit	0.08	0.20
Seed colour	0.15	-0.05
Seed ratio length/width	0.18	**0.39**
Seed position of broadest part	0.18	**0.39**
Seed shape	0.25	-0.08

The results of the principal component analysis of 22 qualitative and quantitative characters of mountain papaya are shown in Table 3. The first six components accounted for 78.15% of the total variation in the data sheet. The first component (axis 1) accounts for 23.73% of the total percentage, indicating that the components on axis 1 have the most important role in clustering the other components. Variable loading in PCA relates to the correlation coefficient between the character and the derived component (Su et al. 2007). Characters with high loading are sex distribution, flower stalk length, and flower density, with loading values of more than 0.3.

The diversity analysis of mountain papaya using the Shannon-Weiner Diversity Index (H') is shown in Table 4. The average Shannon's Index in mountain papaya shows moderate genetic diversity (2.514). The lowest H' value is shown in the inflorescence stalk colour character of 0.693 and is included in the low diversity category. While the highest H' value on the ridge character on the surface of the fruit amounted to 2.889 and fell into the category of moderate diversity. According to Ortiz-Burgos (2015), the main purpose of the Shannon-Wiener Diversity Index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities in space or time. This index considers two different aspects that contribute to the concept of diversity in a communit: species richness and evenness.

Table 4. Morphological diversity of mountain papaya based on Shannon-Weiner index (H').

Character	Shannon's Index
Tree habit	2,485
Sex distribution	2,197
Colour of stem (young plant)	2,073
Height to first fruit	2,821
Stem colour (adult trees)	2,565
Leaf length/width ratio	2,398
General shape of petiole sinus	2,802
Inflorescence density	2,277
Colour of corolla	2,865
Colour of inflorescence stalk	0,693
Flower stalk length	2,468
Stalk end fruit shape	2,804
Size of blossom end scar	2,872
Fruit skin texture when ripe	2,865
Ridging on fruit surface	2,889
Shape of central cavity	2,864
Fruit shape	2,878
Number of seeds per fruit	2,856
Seed colour	2,885
Seed ratio length/width	1,946
Seed position of broadest part	1,946
Seed shape	2,869
Average	2,514

In Mountain Papaya stem characters, the diversity index value ranges from 2.073–2.821 and is included in the classification of moderate diversity index. The value of the diversity index in leaf characters ranges from 2.398 to 2.802 and is included in the medium category. Flower characters show an index ranging from 0.693 to 2.865 and are in the low to medium category. The value of the diversity index in fruit characters ranges from 2.804 to 2.889 in the medium diversity index category. In

seed characters, the diversity index value ranges from 1.946–2.885 and is in the medium category. The diversity of mountain papaya in the Dieng Plateau is based on morphological characters in the moderate category. However, based on molecular characters (internal transcribed spacer sequence), the diversity of mountain papaya is high (Rifqi & Chasani 2023). This indicates that the condition of the plant community is stable on the proponent substrate and environmental parameters (Naniu et al. 2021).

CONCLUSION

The relationship between mountain papaya accessions in the Dieng Plateau based on morphological markers is grouped based on sex distribution characters, flower stalk length, and inflorescence density; there is no grouping based on geographical location or altitude. Meanwhile, the diversity analysis of mountain papaya is classified as moderate. This is shown by the average value of the Shannon-Weiner Diversity Index (H') on mountain papaya in the medium category, which indicates that the condition of the plant community is stable. Other character studies that support identification in mountain papaya need to be carried out, especially by using more conserved character such as molecular markers.

AUTHORS CONTRIBUTION

M.S.R. designed the research, collected and analysed data, and wrote the manuscript. A.R.C. supervised all the processes.

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CONFLICT OF INTEREST

No competing interests were disclosed.

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