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## A MORPHOLOGICAL STUDY OF GENETIC VARIABILITY IN WEST JAVA "MULI" BANANAS

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**Abstract:** West Java, Indonesia, stands out as a hub of banana diversity, serving as the national center for banana cultivation and seed production. This province boasts an extensive array of banana genotypes, including banana muli, king, kepok, horn, and more, with over half of the region dedicated to banana production. Despite this rich diversity, many banana genotypes remain poorly characterized, leaving a vast potential genetic resource untapped. Among these diverse banana varieties, banana muli stands out for its myriad benefits. Notably, it serves as an excellent energy source due to its high-calorie content, rapidly absorbed by the body. Additionally, banana muli varieties are rich in essential minerals, vitamins, iron, and folic acid. Furthermore, they possess significant levels of resistant starch, classified as prebiotics, which remain undigested and promote the growth of beneficial gut bacteria. This study aims to shed light on the genetic diversity of banana muli in West Java, providing valuable insights into its potential applications and benefits. By characterizing this banana genotype, we contribute to the broader understanding of this vital crop's genetic resources and its potential for various uses, including as functional food.

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**Keywords:** West Java, banana genotype, genetic diversity, banana muli, resistant starch, functional food.

### Introduction

West Java is one of the provinces where there is a high diversity of banana genotype. This is evidenced by West Java which became the center of banana planting and became the region with the national banana seed producer (West Java Food Crops Agency, 2012). In addition, in West Java, the types of bananas are also very diverse, ranging from banana muli, king, kepok, horn and many more scattered in banana production centers, and more than half the area in West Java is a banana-producing region (Suyanti and Supriadi, 2008 ). This has led to many genotypes that have not been characterized so that many sources of potential genetic diversity of bananas are not yet known.

Banana muli is one of the many bananas spread in West Java. But until now unknown information related to genetic diversity. Though the benefits of banana muli varieties very much. Banana muli varieties can be used as a good source of energy because it contains calories quickly absorbed by the

body. In addition to this banana muli varieties contain minerals, vitamins, iron, Fe and folic acid are quite high. Banana muli varieties can also be said as functional food because it has resistant starch (resistant starch). Potential resistant starch as prebiotics (Haralampu, 2000 in Mustita, 2009) is undigested food and serves as a substrate for growth or selection of beneficial bacteria growing in the human gut.

In general, differences in environmental conditions of an area with other areas may have an effect on the genotype seen in phenotypic appearance. The phenotypic appearance of a character is an expression that is influenced by genetic, environmental, and interaction between the two (Cardenas et al., 1972). Characterization activities can be an initial basis before further research is undertaken. In germplasm management, characterization activities are used to construct descriptions of a variety in the selection of elders. Characterization on banana plants not only identifies species or varieties, but determines the genetic or kinship relationship between the banana accession and aims to obtain a picture of the accessions tested (Sukartini, 2008). The purpose of this research is to identify muli banana based on agronomic and morphological character in three ecosystems in West Java as the basis for the development of muli banana breeding in the next effort to breed banana plant to get superior seeds.

### **Materials and Methods**

**Data Collection:** Survey and characterization were conducted in 10 regencies in West Java, among others Sukabumi, Cianjur, Garut, Ciamis, Banjar, Tasikmalaya, Pangandaran, Purwakarta, Sumedang and West Bandung. The study was conducted on November 2018 until April 2019. Characterization was carried out at the location of banana plantations in West Java grown in all environments, both in smallholder plantations, fields, homegarden, and intercropping areas, representing lowland, medium land, and high land. Location of characterization is listed in Table 1. There are 72 points of observation location spread over 10 regencies in West Java. Total banana plants observed were 726 accessions.

**Plant material:** The materials used in this study are various types of *Musa acuminata cola* (the local name is Muli) that have been fruitful found in the district of observation location (in situ characterization). The tools used include Global Positioning System (GPS) to know the coordinates and altitude, IPGRI banana descriptor (International Plant Genetic Resources Institute, 1984) to find out the characters of agronomy and morphology (Table 2), digital cameras for documentation and stationery.

**Statistical and Data Analysis:** This research was conducted by descriptive research using survey method. Sampling is determined by purposive sampling. The purposive sampling technique is one of the sampling technique that is done to choose the location that will be used to do the research intentionally and determine the samples taken by themselves (Tongco, 2007). Vegetation analysis was conducted to obtain information on the distribution of bananas in a region so as to obtain Important Value Index (IVI). The result of this research data is qualitative and quantitative data of vegetative and generative character. The data were analyzed using NTSYS PC 2.1. software to calculate the genetic distance based on similarity between the objects studied, then compiled in one unit (cluster analysis). The end of this analysis will form a dendrogram depicting the extent to which the relationship between the genotypes is observed. PCA (Principal Component Analysis) analysis using NTSYS PC 2.1. software,

is used to determine the extent of the contribution of a character to the banana appearance of the multi varieties found. The PCA (Principal Component Analysis) analysis results are displayed in the form of a biplot graph that connects the component scores as axis, then arranged in a single (cluster analysis) on the types of bananas of multi varieties found. The analysis results are presented in the form of dendrogram (Rohlf, 2001).

**Table1. Banana Sample Collection/Characterization Sites**

| Banana No. | Growing Code | Name of Village/Places where specimen were investigated/collected | Number of banana cultivars collected |
|------------|--------------|---|--------------------------------------|
| 1          | SB1          | Sukabumi Cijabun Sidangresmi                                      | 18                                   |
| 2          | SB2          | Ciasahan Jampang Tengah   | 21                                   |
| 3          | SB3          | Tegal Buleud  | 19                                   |
| 4          | SB4          | Argabinta   | 20                                   |
| 5          | SB5          | Wangunjaya  | 20                                   |
| 6          | SB6          | Sukamaju Sukalarang   | 4                                    |
| 7          | CR1          | Cianjur Ciranjang   | 8                                    |
| 8          | CR2          | Naringgul   | 22                                   |
| 9          | CR3          | Cidaun  | 18                                   |
| 10         | CR4          | Sindangbarang   | 10                                   |
| 11         | CR5          | Cikadu  | 10                                   |
| 12         | CR6          | Rajamandala   | 5                                    |
| 13         | CR7          | Cicanglek   | 7                                    |
| 14         | CR8          | Cipanas   | 4                                    |
| 15         | GR1          | Garut Cibat   | 10                                   |
| 16         | GR2          | Majasari  | 11                                   |
| 17         | GR3          | Cibiuk  | 12                                   |
| 18         | GR4          | Limbangan Tengah  | 17                                   |
| 19         | GR5          | Sukamerang  | 23                                   |
| 20         | GR6          | Wanaraja  | 22                                   |
| 21         | GR7          | Bojong Pameungpeuk  | 16                                   |
| 22         | GR8          | Mancagahar Pameungpeuk  | 13                                   |
| 23         | GR9          | Karyamukti Cibalong   | 10                                   |
| 24         | GR10         | Karyasari Cibalong  | 15                                   |
| 25         | GR11         | Mekarsari Cibalong  | 9                                    |
| 26         | GR12         | Cikelet   | 5                                    |
| 27         | GR13         | Rancamaya   | 10                                   |
| 28         | GR14         | Karamatwangi Cisurupan  | 8                                    |
| 29         | GR15         | Bungbulang  | 6                                    |

|    |      |               |                       |    |
|----|------|---------------|-----------------------|----|
| 30 | GR16 | Caringin      | 20                    |    |
| 31 | GR17 | Rancabuaya    | 5                     |    |
| 32 | CS1  | Ciamis        | Sukanagara Lakbok     | 4  |
| 33 | CS2  | Jagabaya      | Panawangan            | 8  |
| 34 | CS3  | Bangunjaya    | Panawangan            | 6  |
| 35 | CS4  | Rajadesa      | 8                     |    |
| 36 | CS5  | Rancah        | 5                     |    |
| 37 | CS6  | Cirahong      | 9                     |    |
| 38 | BJ1  | Banjar        | Langensari            | 11 |
| 39 | BJ2  | Banjarsari    | 15                    |    |
| 40 | BJ3  | Karyamukti    | Pataruman             | 20 |
| 41 | BJ4  | Karangmulya   | Padaherang            | 15 |
| 42 | BJ5  | Sindangwangi  | Padaherang            | 6  |
| 43 | TM1  | Tasikmalaya   | Sukaharja Singaparna  | 8  |
| 44 | TM2  | Sindangkerta  | Cipatujah             | 7  |
| 45 | TM3  | Cikawung      | Ading Cipatujah       | 6  |
| 46 | TM4  | Sukamulih     | Singaparna            | 10 |
| 47 | PD1  | Pangandaran   | Parigi                | 5  |
| 48 | PD2  | Cijulang      | 8                     |    |
| 49 | PW1  | Purwakarta    | Kertajaya             | 10 |
| 50 | PW2  | Pasawahan     | 6                     |    |
| 51 | PW3  | Sawit         | 4                     |    |
| 52 | PW4  | Wanayasa      | 7                     |    |
| 53 | PW5  | Parakan Salam | 15                    |    |
| 54 | SM1  | Sumedang      | Pasirbiru Rancakalong | 11 |
| 55 | SM2  | Rancakalong   | 5                     |    |
| 56 | SM3  | Lamping       | Rancakalong           | 8  |
| 57 | SM4  | Sukasirna     | Rancakalong           | 6  |
| 58 | SM5  | Sukamaju      | Rancakalong           | 9  |
| 59 | SM6  | Cibungur      | Rancakalong           | 16 |
| 60 | SM7  | Cileleus      | Pamulihan             | 12 |
| 61 | SM8  | Ciptasari     | Pamulihan             | 10 |
| 62 | SM9  | Mekarsari     | Tanjungsari           | 6  |
| 63 | SM10 | Jatiroke      | Jatinangor            | 8  |
| 64 | SM11 | Ciparanje     | Jatinangor            | 5  |
| 65 | SM12 | Cijengjing    | Jatigede              | 7  |
| 66 | SM13 | Cipicung      | Jatigede              | 4  |
| 67 | SM14 | Cintajaya     | Jatigede              | 6  |
| 68 | BB1  | Bandung Barat | Parongpong            | 7  |

|                            |     |                      |   |
|----------------------------|-----|----------------------|---|
| 69                         | BB2 | Citatah Cipatat      | 3 |
| 70                         | BB3 | Mandalawangi Cipatat | 3 |
| 71                         | BB4 | Mekarwangi Lembang   | 5 |
| 72                         | BB5 | Cikahuripan Lembang  | 4 |
| Total Sample Characterized |     | 726                  |   |

**Table 2. Morphological Traits used in Characterization of Banana Accessions**

| No | Code | Characters                  | Character States   |
|----|------|-----------------------------|--|
| 1  | A    | Leaf habit                  | 1 Erect, 2 Intermediate, 3 Drooping, 4 Other   |
| 2  | B    | Leaf blade: shape of base   | 1 Both sides rounded, 2 One side rounded, one pointed, 3 Both sides pointed  |
| 3  | C    | Leaf blade length [cm]      | Measured at its maximum point: 1 <170 cm, 2 171 to 220 cm, 3 221 to 260 cm, 4 >261 cm  |
| 4  | D    | Leaf blade width [cm]       | Measured at its maximum point. 1 <70 cm, 2 71 to 80 cm, 3 81 to 90 cm, 4 >91 cm  |
| 5  | E    | Pseudostem colour           | 1 Green-yellow, 2 Medium green, 3 Green, 4 Dark green, 5 Green-red, 6 Red, 7 Red-purple, 8 Blue, 9 Chimerical, 10 Other  |
| 6  | F    | Petiole length [cm]         | Recorded from the pseudostem to the lamina. 1 <50 cm, 2 51 to 70 cm, 3 >71 cm  |
| 7  | G    | Petiole width [cm]          | 1 <1 cm, 2 >1 cm, 3 Cannot be defined  |
| 8  | H    | Petiole margin color        | 1 Green, 2 Pink-purple to red, 3 Purple to blue  |
| 9  | I    | Pseudostem height [m]       | 1 <2, 2 2.1 to 2.9, 3 >3   |
| 10 | J    | Male inflorescence: shape   | Should be assessed in cross section at harvest time. Only for varieties with "Male inflorescence: persistence: present". 1. Lanceolate, 2. narrow ovate, 3. medium ovate, 4. broad ovate |
| 11 | K    | Diameter Male inflorescence | Length and maximum diameter of male bud at harvest. 1 <20 cm, 2 21 to 30 cm, 3 >31 cm  |
| 12 | L    | Number of suckers           | Record the number of suckers from soil level to point of emergence of the last leaf (>30 cm height). Recorded only if no desuckering has taken place                                     |
| 13 | M    | Number of fruits            | Observed on the mid-hand of the bunch: 1 <12, 2 13-16, 3 >17   |
| 14 | N    | Number of bunch             | Record the number of bunch   |
| 15 | O    | Fruit length [cm]           | Measured as the internal arc of the fruit, without pedicel: 1 □15 cm, 2 16- 20 cm, 3 21- 25 cm, 4 26- 30 cm, 5 □31 cm  |
| 16 | P    | Dwarfism                    | 1 Normal: leaves not overlapped and leaf ratio inferior to 2.5, 2 Dwarf type: leaves strongly overlapped and leaf ratio superior   |
| 17 | Q    | Pseudostem appearance       | 1 Dull (waxy), 2 Shiny (not waxy)  |

- 18 R Wax on leaf sheaths 1 Very little or no visible sign of wax, 2 Very few wax, 3 Moderately waxy, 4 Very waxy
- 19 S Development of suckers 1 Taller than parent plant, 2 More than 3/4 of the height of the parent plant, 3 Between 1/4 and 3/4 of the height of the parent plant, 4 Inhibited
- 20 T Position of suckers 1 Far from parent plant (emerging >50 cm from parent plant), 2 Close to parent (vertical growth), 3 Close to parent (growing at an angle)
- 21 U Blotches at the petiole base 1 Sparse blotching, 2 Small blotches, 3 Large blotches, 4 Extensive pigmentation, 5 Without pigmentation
- 22 V Blotches colour 1 Brown, 2 Dark brown, 3 Brown-black, 4 Black-purple, 5 Other
- 23 W Appearance of leaf upper surface 1 Dull, 2 Shiny
- 24 X Colour of leaf lower surface (Wax removed). 1 Green-yellow 5 Blue  
2 Medium green 6 Red-purple  
3 Green 7 Other
- 25 Y Appearance of leaf lower surface 1 Dull, 2 Shiny
- 26 Z Wax on leaves Recorded on the lower surface. 1 Very little or no visible sign of wax, 2 Few wax, 3 Moderately waxy, 4 Very waxy
- 27 AA Peduncle length [cm] Measured from the leaf crown to the first hand of fruit. 1 <30 cm, 2 31 - 60 cm, 3 >61 cm
- 28 AB Peduncle width [cm] Recorded at mid-length. 1 < 6 cm, 2 7 - 12 cm, 3 >13 cm
- 29 AC Peduncle colour Descriptor state 4 (red/or pink-purple) is green homogeneously tinged with red (purple green appearance). When pigmentation is scattered, use state 5. 1 Light green, 2 Green, 3 Dark green, 4 Red or pink/purple, 5 With purplebrown to blue blotches, 6 Other
- 30 AD Peduncle hairiness 1 Hairless, 2 Slightly hairy, 3 Very hairy, short hairs (similar to velvet touch), 4 Very hairy, long hairs (>2 mm)
- 31 AE Bunch position (Position of the fruit-bearing part). Angle from vertical to the general axis of the bunch. 1 Hanging vertically, 2 Slightly angled, 3 Hanging at angle 45°, 4 Horizontal, 5 Erect
- 32 AF Bunch shape 1 Cylindrical, 2 Truncated cone shape, 3 Asymmetric - Bunch axis is nearly straight, 4 With a curve in the bunch axis, 5 Spiral (all fruit is attached to a unique crown coiled around the stalk)
- 33 AG Bunch appearance 1 Lax (one can easily place one's hand between the hands of fruit), 2 Compact (one can place one's finger, but not one's hand, between the hands of fruit), 3 Very compact (one cannot place one's finger between the hands of fruit)
- 34 AH Rachis type 1 Truncated, no bract scar below the last hand of fruit, 2 Present and male bud may be degenerated or persistent
- 35 AI Rachis position 1 Falling vertically, 2 At an angle, 3 With a curve, 4 Horizontal, 5 Erect
- 36 AJ Male bud shape Note the general shape of the male bud at harvest. 1 Like a top 4 Ovoid, 2 Lanceolate 5 Rounded, 3 Intermediate



- 37 AK Male bud size [cm] Length and maximum diameter of male bud at harvest. 1 <20 cm, 2 21 to 30 cm, 3 >31 cm
- 38 AL Bract base shape 1 Small shoulder, 2 Medium, 3 Large shoulder
- 39 AM Bract apex shape Flatten the apex of the bract to observe its shape. 1 Pointed, 2 Slightly pointed, 3 Intermediate, 4 Obtuse, 5 Obtuse and split
- 40 AN Male inflorescence: persistence 1 Absent, 2 present
- 41 AO Fruit: persistence of floral organs 1 Absent, 2 present
- 42 AP Fruit shape (longitudinal curvature) 1 Straight (or slightly curved), 2 Straight in the distal part, 3 Curved (sharp curve), 4 Curved in „S“ shape (double curvature), 5 Other
- 43 AQ Fruit apex Observed at the distal end of the fruit: 1 Pointed, 2 Lengthily pointed, 3 Blunt-tipped, 4 Bottle-necked, 5 Rounded
- 44 AR Fruit pedicel length [mm] 1 <10 mm, 2 11 to 20 mm, 3 >21 mm
- 45 AS Fruit pedicel width [mm] 1 <5 mm, 2 5 to 10 mm, 3 >10 mm
- 46 AT Pedicel surface 1 Hairless, 2 Hairy
- 47 AU Male inflorescence: opening of bracts 1 closed or slightly open, 2 moderately open, 3 very open

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## Results and Discussion

Based on the analysis of vegetation on each plain obtained the results as in Figure 1. Division based on the height shows in the lowlands there are 20 types of bananas where Ampyang banana has the lowest important value index of 3.14% and Nangka has the highest Important Value Index (IVI) of 59.90% . The medium plain area shows there are 23 types of bananas where Jambe banana has the lowest IVI value of 3.07% and the highest IVI is owned by Ambon Kuning with IVI value of 43.95%. Bananas that have the lowest IVI value in the highlands are Lalay and Hurang with IVI value of 1.67% and the type that has the highest IVI value in the highlands is Ambon Kuning with 109.27% value. High IVI values indicate that the status of the species in an environment has a high degree of spread.

Result of analysis of lowland banana vegetation (Figure 1a) shows that Nangka has the highest IVI with value 59,90%. The second IVI was occupied by Ambon Kuning with a value of 26.17%, and the third IVI value is the Raja Sere which is 24.94%. Based on vegetation analysis on each plain, the result shown in Figure1. Distribution based on altitude shows that there are 20 types of banana in lowland area where Ampyang has the lowest IVI of 3.14% and Nangka has the highest IVI of 59.90%. The medium plain area shows there are 23 types of bananas where Jambe has the lowest IVI value of 3.07% and the highest IVI is owned by Ambon Kuning with IVI value of 43.95%. Bananas that have the lowest IVI value in the highlands are Lalay banana and Hurang with IVI value of 1.67% and the type that has the highest IVI value in the highlands is Ambon Kuning with 109.27% value. High IVI values indicate that the position

of the species in a community has a high magnitude. The result of analysis of lowland banana vegetation (Figure 1a) shows that Nangka has the highest IVI with value 59.90%. The second IVI was occupied by Ambon Kuning with a value of 26.17%, and the third IVI value is the Raja Sere Banana which is 24.94%. The value of IVI Nangka and Ambon Kuning are high because each has a relative density and high relative frequency. The frequency indicates the distribution of a species within an area. The high frequency values indicate that the distribution of the species is more evenly distributed.

Bananas that have a high spread in the medium land in a row are Ambon Kuning, Nangka, and Siem with IVI values respectively are 43.95%, 40.79%, and 24.76% (Fig. 1b). The type that has the lowest IVI value in medium land is Jambe type with IVI value 2.29%. The Ambon Kuning in both the lowlands and the medium land has a high density, type, and dominance, so it has a high IVI value. Increasing IVI values indicate that the species has a larger role in a community (Kainde et al., 2011). Results of vegetation analysis in the highlands there are 20 types of bananas found (Figure 1c). The type that has the highest IVI value in the highlands is the Ambon Kuning with an IVI value of 109.27%.

Nangka has IVI value 38.89% and Muli 22.02%. Bananas that have the lowest IVI value in are Hurang and Lalay with an IVI value of 1.67%. The result of vegetation analysis showed that Nangka, Ambon Kuning, Muli, Raja Sere Banana, Siem, Kapas are banana type which can be found in all plains. However, some have a tendency to spread in certain land seen from each of the IVI values.



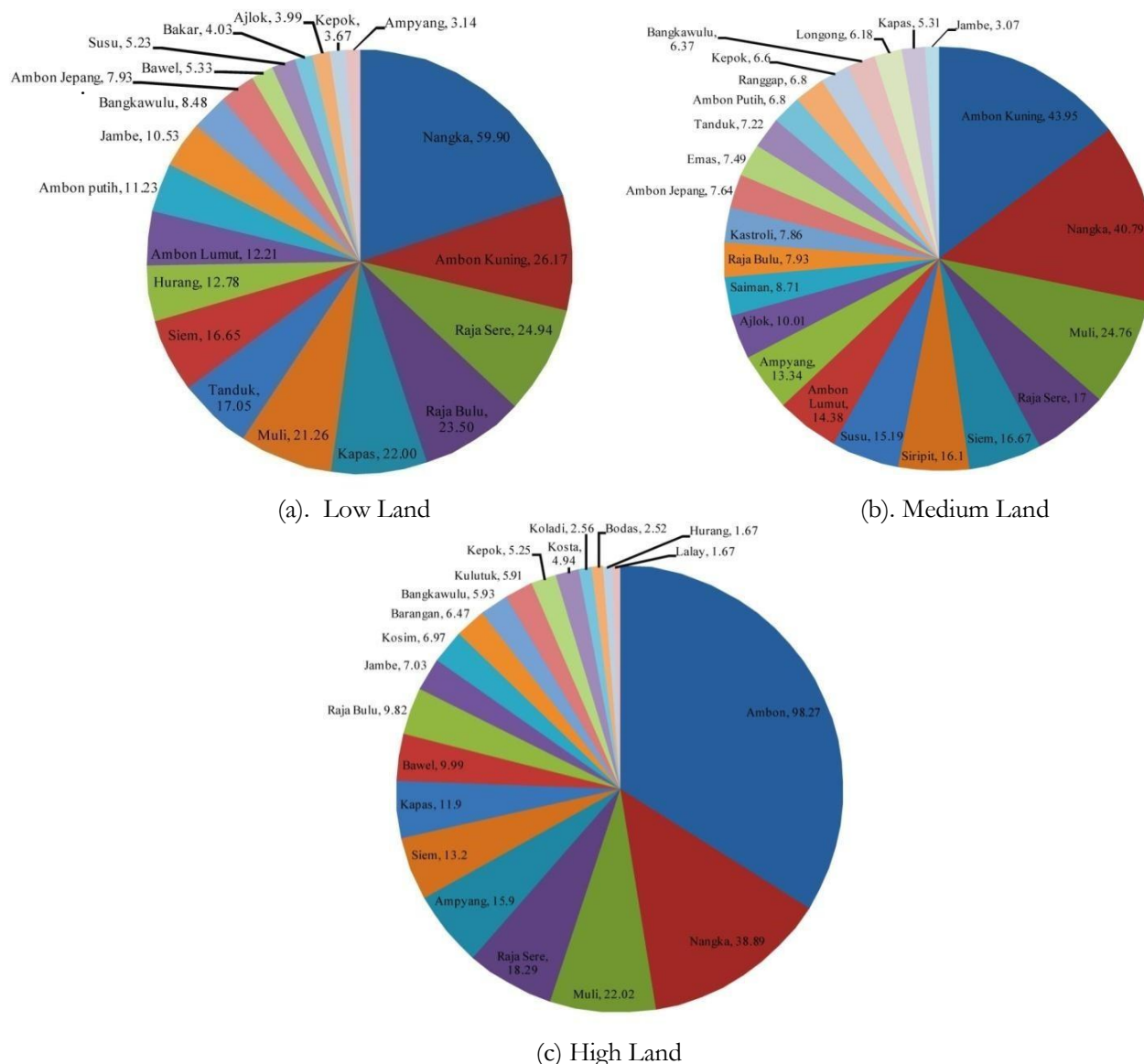


Figure1. Banana Vegetation Analysis on Three Environments

Principal component analysis (PCA) was used to find out which characters gave high contribution values and influenced variations in the types of muli bananas observed. This analysis is based on 47 morphological characters. Table 3 shows that the main component (PC1) includes 16,265% of a variation of 72 banana “muli” accessions, i.e. number of fruits, number of bunch, fruit length (cm), peduncle colour, male bud size (cm), bract apex shape, dan fruit shape (longitudinal curvature) (Table 4). In the second component (PC2) there are dwarfism characters, rachis type, position of suckers, and appearance of leaf upper surface, rachis type, and male bud shape. In the third komopnen (PC3), or fourth (PC4) there is no particular character that contributes to the variation of Muli's banana. It is possible for the magnitude of environmental influences, so it can not be explained statistically.

Table3. Eigenvalues and Percent of Total Variation in Banana Muli Population (*Musa acuminata* Colla)

| PCi | Eigenvalue | Percent | Cumulative |
|-----|------------|---------|------------|
| 1   | 7.645      | 16.265  | 16.265     |
| 2   | 3.991      | 8.492   | 24.757     |
| 3   | 3.321      | 7.067   | 31.824     |
| 4   | 3.162      | 6.728   | 38.552     |

Table 4. Table 4. Eigenvectors 15 Characters in Muli Population (*Musa acuminata* Colla) in All Locations in West Java

| Characters                  | PC1    | PC2    | PC3    | PC4        |
|-----------------------------|--------|--------|--------|------------|
| Leaf habit                  | 0.225  | 0.135  | 0.356  | 0.087      |
| Leaf blade: shape of base   | 0.049  | -0.160 | -0.351 | -<br>0.321 |
| Leaf blade length [cm]      | -0.005 | -0.079 | -0.499 | 0.005      |
| Leaf blade width [cm]       | -0.071 | 0.161  | -0.216 | 0.167      |
| Pseudostem colour           | -0.029 | 0.088  | 0.122  | -<br>0.347 |
| Petiole length [cm]         | 0.063  | 0.124  | -0.318 | -<br>0.121 |
| Petiole widht [cm]          | 0.216  | 0.079  | -0.208 | 0.048      |
| Petiole margin color        | -0.187 | 0.270  | 0.189  | -<br>0.368 |
| Pseudostem height [m]       | 0.012  | 0.263  | -0.299 | -<br>0.120 |
| Male inflorescence: shape   | -0.130 | -0.328 | -0.401 | 0.140      |
| Diameter Male inflorescence | -0.083 | -0.370 | -0.479 | 0.148      |
| Number of suckers           | -0.014 | -0.165 | -0.131 | 0.213      |
| Number of fruits            | -0.750 | -0.029 | -0.465 | -<br>0.501 |
| Number of bunch             | 0.534  | -0.028 | -0.589 | -<br>0.356 |
| Fruit length [cm]           | 0.639  | -0.411 | -0.517 | 0.324      |
| Dwarfism                    | -0.164 | -0.682 | 0.034  | 0.135      |
| Pseudostem appearance       | 0.021  | 0.329  | -0.308 | 0.001      |
| Wax on leaf sheaths         | -0.101 | -0.004 | -0.004 | -<br>0.300 |
| Development of suckers      | -0.092 | 0.059  | -0.019 | 0.005      |
| Position of suckers         | 0.217  | 0.624  | -0.392 | 0.334      |

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|                                      |        |        |        |       |       |
|--------------------------------------|--------|--------|--------|-------|-------|
| Blotches at the petiole base         | 0.251  | -0.070 | 0.036  | -     | 0.031 |
| Blotches colour                      | 0.204  | -0.033 | -0.391 | -     | 0.595 |
| Colour of leaf upper surface         | 0.027  | -0.495 | -0.317 | 0.483 |       |
| Appearance of leaf upper surface     | -0.220 | -0.750 | 0.048  | 0.176 |       |
| Colour of leaf lower surface         | -0.057 | -0.003 | -0.410 | -     | 0.593 |
| Wax on leaves                        | -0.224 | -0.425 | 0.368  | -     | 0.380 |
| Peduncle length [cm]                 | 0.237  | -0.145 | 0.118  | 0.003 |       |
| Peduncle width [cm]                  | -0.130 | 0.090  | 0.179  | 0.077 |       |
| Peduncle colour                      | 0.985  | -0.113 | 0.045  | -     | 0.045 |
| Peduncle hairiness                   | -0.168 | -0.034 | -0.073 | -     | 0.153 |
| Bunch position                       | 0.158  | 0.314  | 0.065  | -     | 0.036 |
| Bunch shape                          | -0.078 | 0.167  | -0.136 | -     | 0.178 |
| Bunch appearance                     | 0.151  | -0.087 | -0.084 | -     | 0.053 |
| Rachis type                          | 0.119  | 0.690  | -0.288 | 0.312 |       |
| Rachis position                      | 0.160  | 0.227  | 0.169  | 0.056 |       |
| Male bud shape                       | -0.271 | -0.626 | 0.248  | -     | 0.499 |
| Male bud size [cm]                   | 0.985  | -0.113 | 0.045  | -     | 0.045 |
| Bract base shape                     | -0.035 | 0.366  | 0.362  | -     | 0.376 |
| Bract apex shape                     | 0.985  | -0.113 | 0.045  | -     | 0.045 |
| Male inflorescence: persistence      | 0.227  | 0.036  | -0.135 | -     | 0.144 |
| Fruit: persistence of floral organs  | -0.118 | 0.170  | 0.068  | -     | 0.066 |
| Fruit shape (longitudinal curvature) | 0.985  | -0.113 | 0.045  | -     | 0.045 |

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|                                       |        |        |        |   |       |
|---------------------------------------|--------|--------|--------|---|-------|
| Fruit apex                            | -0.016 | 0.012  | -0.106 | - | 0.484 |
| Fruit pedicel length [mm]             | 0.985  | -0.113 | 0.045  | - | 0.045 |
| Fruit pedicel width [mm]              | 0.985  | -0.113 | 0.045  | - | 0.045 |
| Pedicel surface                       | -0.225 | -0.077 | 0.093  | - | 0.050 |
| Male inflorescence: opening of bracts | 0.985  | -0.113 | 0.045  | - | 0.045 |

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The results from the analysis of the main components of local banana accession in each plain were obtained characters that contributed to the variation. The value of PCi has positive and negative values, positive value (+) indicates that the relationship between the characters is closer, while the negative (-) indicates that the relationship between the characters is farther, making it profitable for the next breeding program. Based on this will facilitate the selection of characters that want to be developed in the next breeding program.

Cluster analysis is an analysis to group similar elements as research objects to be distinct and mutually exclusive clusters. Cluster analysis is included in multivariate statistical analysis of interdependent methods. Therefore the purpose of cluster analysis is not to relate or differentiate with other samples / variables. Cluster analysis is useful for summarizing data by way of grouping objects based on the similarity of certain characteristics among the objects to be studied (Sitepu, 2011). The euclidean coefficient on cluster analysis states the distance of the incapacity.

Euclidean spacing in more than one ranges represents a large non-incidental coefficient. The small inclination coefficient represents each genotype one with the other having variations that are not broad, in contrast large coefficient of non-perception states that the variation in each genotype is broad (Jamie et al., 2010). The euclidean distance of 72 muli banana accessions is in the range of 0.00 to 5.07 (Fig. 1). The range represents the euclidean distances coefficient on 46 accessions of the muli banana is large. A large inequality suggests that the variations contained in the 72 accessions are broad. Figure 1 shows that the muli banana population is divided into two large clusters. Each group has a different level of kinship with each other.

The presence of various types of muli bananas found in the same sub cluster is caused by the similarity of morphological characters in some other types of accessions. Similarly, the location of similar accessions that are not adjacent to similar accession due to the morphological disparity in accession. The accuracy of the cluster analysis is determined by the number of characters observed. The more characters observed, the more obvious the differences and similarities between the accessions of banana muli (Rohlf, 2001). The pattern of close relationship between the accession of muli banana from

various regions in West Java shown in the dendrogram image can be used for the benefit of the next breeding.

It can be seen that the results of observation and kinship analysis using the distance of incompatibility in each variety of bananas in various places in West Java showed the existence of variation. Variations that occur in each type are seen from the appearance of phenotype in each variety even there are several varieties of bananas that vary in each location. Various environmental factors greatly affect the appearance of the existing banana phenotype. There are several different varieties of the location background and the height of the place is not in one group.

Differences in the geographic background of the origin of genotypes of the existing bananas allow for variations in phenotypic appearance. Associated with this, adaptation is a long process that plays an important role in phenotypic shifts (Suzuki et al., 1989). High levels of adaptation in banana plants may cause variations in the phenotypic appearance of the plants, so that there are similar varieties but different locations have different phenotypic features. Several different varieties clustered in the same cluster / sub cluster, it is assumed that the varieties have similarities in some morphological characters. This research is an initial procedure in banana plant breeding program, so further research is required to characterize each type of banana and for higher level of kinship accuracy, it is better to analyze the kinship using molecular marker. To get the more varied types of bananas, it is necessary to scan the observation sites related to the civilization of the community, enabling the discovery of the local endemic banana species.

Based on Figure 2, the accessions from Cianjur 6, Tasikmalaya 4, West Bandung 3, Purwakarta 4, Sumedang 5, and West Bandung 2, are separate groups from other groups. The accession group has a different appearance compared to other accessions. Variations in the appearance of fruit morphology are shown in Figure 3. Each banana multi accession originating from each location has a diverse fruit appearance. Each location shows variations of fruit on the number of bunch character, number fruits of bunch, and size of bunch.

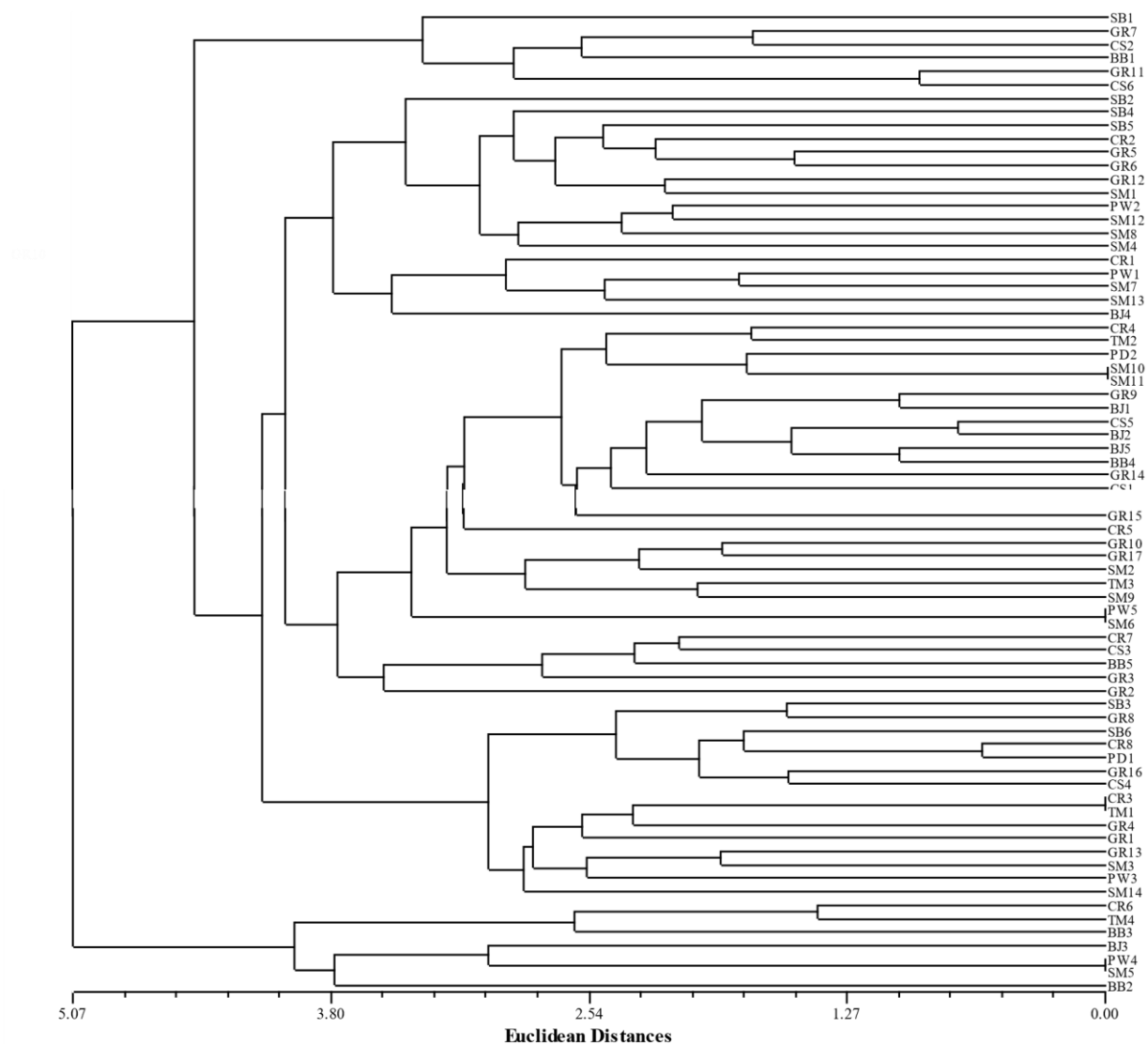





Figure 2. Custer Analysis of Muli Varieties (*Musa acuminata colla*) at All Locations in West Java Based on Morphological and Agronomic Traits





|   |   |  |   |
|---|---|--|---|
| Citatah   | Mandalawangi  | Cipatat  | Cileleus Pamulihan  |
|    |    |    |    |
| Ciptasari Pamulihan   | Sukamaju Pamulihan  | Pasawahan Purwakarta   | Sawit Purwakarta  |
|   |   |   |   |
| Lamping Rancakalong   | Tegalbuleud Sukabumi  | Jampang Tengah Sukabumi  | Tanjungsari   |
|  |  |  |  |
| Cikawung ading cipatujah  | Cipicung Jatigede   | Karyamukti Cibalong  | Karyasari Cibalong  |

|   |   |  |   |
|---|---|--|---|
|    |    |    |    |
| Cikelet   | Caringin  | Limbangan Tengah   | Limbangan   |
|   |   |   |   |
| Limbangan   | Majasari Limbangan  | Mekarsari Cibalong   | Sindangkerta<br>Cipatujah   |
|  |  |  |  |
| Banjarsari  | Langensari  | Rancah   | Argabinta<br>Sukabumi   |



### **Figure 3. Fruits Character Phenotypic of Muli (*Musa acuminata* Colla) in West Java**

#### **Conclusions**

Most characters contribute to variation with the value of the main component i.e. number of fruits, number of bunch, fruit length (cm), peduncle colour, male bud size (cm), bract apex shape, dan fruit shape (longitudinal curvature) The accessions from Cianjur 6, Tasikmalaya 4, West Bandung 3, Purwakarta 4, Sumedang 5, and West Bandung 2, are separate groups from other groups. The accession group has a different appearance compared to other accessions. Need to do the identification and characterization of *Musa acuminata* Colla var. Muli ex-situ to support plant breeding activities further.

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