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# Phenotypic Variation of Fei Banana (*Musa Troglodytarum* L.) Originated from Maluku Islands.

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**ABSTRACT**

The study aims to determine the phenotypic variation of Fei banana from the Maluku islands. Exploration was conducted at the island of Ambon, Saparua, Nusalaut, Haruku, Seram, Dobo, Wokam, Tual, Elat, Tobelo, Jailolo. Phenotypic characterization of vegetative and generative organs of Fei banana (*Musa troglodytarum* L.) was done using the reference of the International Plant Genetic Resources Institute (IPGRI). Variation of the phenotypic character of the samples were detected and used to create a dendogram and analyzed using the software NTSYSpc V2.02i. At the similarity value of 69.3 the dendogram divided into two branches, a small branch consisted of Fei banana from Ambon (Ambon 1 and Ambon 2), and one big branch consisted of the remaining sample. This big branch divided into two branches, which the first branch consist of Fei banana originated from Saparua and Seram and the second branch consisted of Fei banana collected from Nusalaut, Haruku, Dobo, Wokam, Tual, Elat, Tobelo, Jailolo. Bananas population collected from Ambon (AMB2 and AMB3) seem had an special characters different from thats collected from other places in Maluku, however one type of Fei banana collected from Maluku (Amb1) showed similar character with Fei banana collected from Wokam.

**Keywords:** Maluku, *Musa troglodytarum* L, phenotypic, variation.

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## INTRODUCTION

Maluku is an archipelago comprises of 632 large and small islands. The total area of Maluku is 581,376 km2 consists of 527,191 km2 ocean (90%) and 54,185 km2 land area. The land area of Maluku province has a variety of topography, edaphic and climate. In this area grows tongkat langit bananas or Fei banana, a unique local Maluku banana, which is known by it is scientific name, *Musa troglodytarum* L. Simmonds[1]. It has been investigated that Fei banana is a specific type banana of eastern Indonesia, Maluku and Papua [2]. This species was locally named tongkat langit (tongkat= stick; langit = sky) banana because it has a unique shape of fruit bunches which face up to the sky, not like most bananas fruit [2].

Fei banana was believed to belong to the section Australimusa [3], but the exact origin is still unclear. The chromosome number of Fei banana is x = 10 [3, 4].

Fei bananas spreads from the Maluku to the south including New Guinea, New Ireland, New Britain, Salamon Island, New Herbrides, New Seledonia, Fiji, Samoa, Tonga, Cook Island, Society Island and Marguesas and to the north to the Hawaiian Island [5] (Figure 1). In the Maluku islands, Fei banana was distributed at Ambon, Saparua, Nusalaut, Haruku, Seram, Dobo, Wokam Tual, Elat, Tobelo, Jailolo. Although Fei banana is found spread across the islands in Maluku, however studies on the biology, taxonomy, agronomy and ecologi are limited.

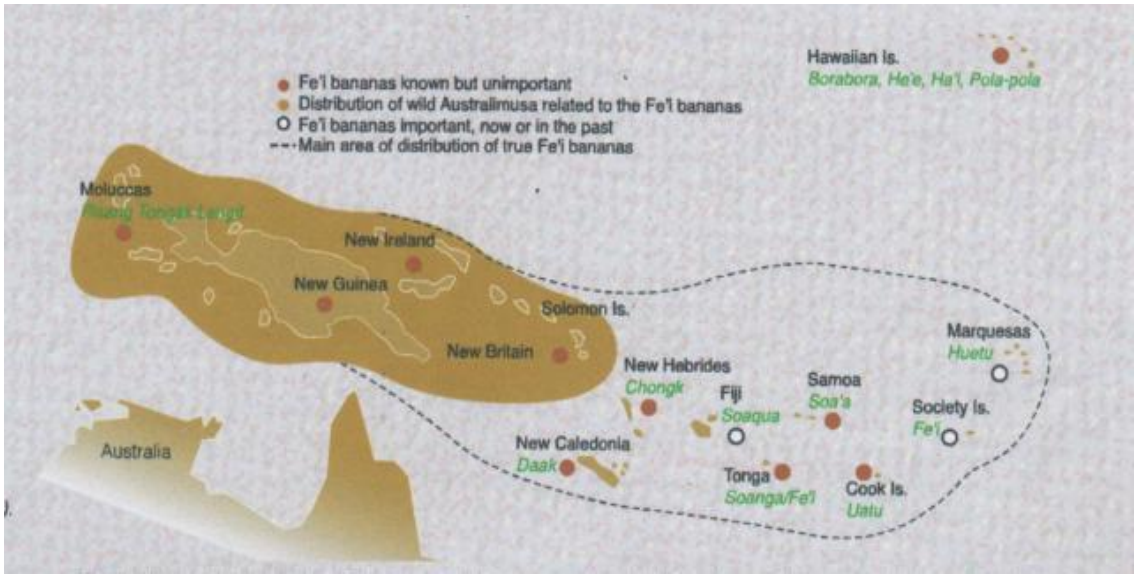


**Figure 1: Distribution maps of Fei bananas (red dot) in Pacific (Mac Daniels, 1947 in Sharrock, 2001)**

The distribution of Fei banana at different islands which is separated by ocean may gave rise to genetic variation. The first study on genetic variation of Fei banana populations [6] only covered four islands in Maluku. More information of genetic variation in other islands showing association between phenotypic variation and their habitats (pH, soil texture, temperature, humidity) were needed.

## MATERIALS AND METHODS

Twenty-one samples were collected From ten islands in Maluku province (Figure 2, Table 1). The morphology of vegetative and generative organs of Fei banana was visually observed and scored based on banana descriptors guide from the International Plant Genetic Resources Institute [7]. Scoring data of 100 morphological characters were analyzed using the NTSYSpc V2.02i software to create phylogenetic trees (dendogram).

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**Figure 2: Location for sample collection**

| No. | Island population | Sample code |
|---|---|---|
| 1. | Ambon | AMB 1, AMB2, AMB3 |
| 2. | Saparua | SPR 1, SPR2, SPR3 |
| 3. | Nusalaut | NSL 1, NSL2 |
| 4. | Haruku | HRK1, HRK2, HRK3 |
| 5. | Seram | SRM1, SRM2, SRM3 |
| 6. | Dobo | DBO1, DBO2 |
| 7. | Wokam | WKM |
| 8. | Tual | TL |
| 9. | Elat | ELT |
| 10 | Halmahera | TBLO, JLO |

**Table 1: The Origin of Samples Collection and Sample Codes**

## RESULT AND DISCUSSION

The vegetative and generative organs of Fei banana collected from 10 sites in the Maluku islands showed a various appearance. The variation was showed by the morphology of stem, leaf, the morphology and number of tillers flower and fruit.

Similarity analysis based on 100 phenotypic characters of vegetative and generative organs using NTSYSpc V2.02i software resulted in a dendogram showing two separate groups with shared character of 69.3 %. The first group consist of Fei banana populations of AMB2 and AMB 3 which has similarity value of 74% and the second group consist of AMB 1, WKM, DBO, HRK, NSL, TL, TBLO, ELT, JLO, SPR and SRM which has similarity value of 70.1%. However the two groups share several similar characters (Figure 3).

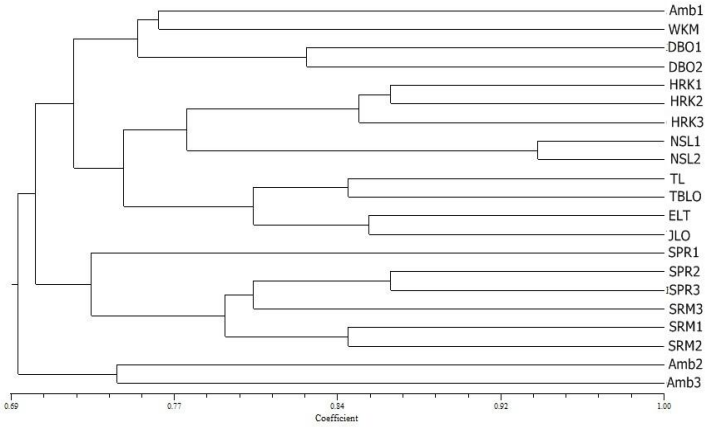


**Figure 3: The dendogram based on morphological characters of Fei banana Maluku Islands population with the UPGMA algorithm.**

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The shared characters possessed by the first group (AMB 2 and AMB 3) were: 2 characters of the rod, 4 characters of leaf, one character of petiole, 3 characters of seedling, 5 characters of flowers and fruit, whilst the shared characters possessed by the second group were 7 stems characters, 24 leaves and petiole characters, 4 seedling characters, and 10 flowers and fruit characters.

| No. | | OTU | Characters |
|---|---|---|---|
| 1. | Synapomorphy | Ambon I,II,III<br>Saparua I,II,III<br>Seram I,II,III<br>Dobo I,II<br>Wokam<br>Haruku I,II,III<br>Nusalaut 1,II | Stems opaque, no wax on the rod, watery sap on the trunk, there is no wax on the leaf midrib, leaf ratio ≥ 3, the leaves are opaque, does not look clear wax on the leaves, petiole angle ≤ 1, no wax on the leaf stalks, leaves opaque, wax on the leaves, tall saplings ≥ 2, no hairs on the flower stalk, stem upright position, end of bract yellow, no wax on bract, beige flowers, beige pistil, twisted ovary, green raw fruit colour and white fruit flesh, tender meat texture. the number of tillers with ≥ 30 cm height were 7. |
| 2. | Automorphy A | Ambon1 | Leaf blade width 66cm, length of petiole 55mm, the number of tillers 7, flower stalk length63cm, flowers width 4cm, fruit number 11, fruit length 12cm, fruit stalk length 5mm, fruit stalk width 10mm. |
| 3. | Automorphy B | Nusalaut I | Leaf blade length 286cm, leaf blade width 72cm, leaf number 11, petiole length 48 cm, the ratio of the number of tillers to stem 0.12, the number of tillers 8. |
| 4. | Automorphy C | Nusalaut II | Petiole length 37.5 cm, fruit length 22cm , fruit stalk length 9mm, the width of the fruit stalk 23mm. |
| 5. | Automorphy D | Ambon II | The main stem colour beige, leaf blade length 181cm, leaf blade width 47.5cm, petiole length 35mm, tilers leaf colour dark green, petiole edges dark brown colour, the ratio of the number of tillers to stem 0.3, tiller number 3, the number of tillers with ≥ 30 cm height 3, the length of flower stalks 26cm, flower colour dark green, no colour lines on bract, basic ovary yellow, fruit length 19cm, petiole width 12mm. |
| 6. | Automorphy E | Saparua I | Purple stem, without spotting, leaf blade length 221cm, shiny leaves, petiole length 28 cm, the ratio of the number of tillers to stem 0.07, tiller number 14, the number of tillers with ≥ 30 cm height 14, flower stalks length 20 cm. |
| 7. | Automorphy F | Saparua II | Leaf blade length 265 cm, blade width 64 cm, petiole length 41 cm, number of tillers25, the number of tillers with ≥ 30 cm height was 25, fruit length 25 cm, fruit stalk length 5cm. |
| 8. | Automorphy G | Saparua III | Leaf blade length 241cm, leaf blade width 70cm, flower width 7cm, fruit stalk width 18 mm. |
| 9. | Automorphy H | Seram I | Leaf blade length 254cm, leaf blade width 65cm, petiole length 49cm, number of tillers 24, flowers width 10cm, fruit stalk length 42mm, width of shaft 10cm. |
| 10. | Automorphy I | Seram II | Leaf blade length 239cm, width 51cm leaf blade, leaf length 63, width of flower stalks 5.4cm, 28.5cm length, fruit stalk length 25mm, width of shaft 34mm, fruit skin thickness 4mm. |
| 11. | Automorphy J | Seram III | Leaf blade length 199cm, leaf blade width 61cm, flower stalk length 28cm, flowers width 9 cm, fruit stalk length 3.5 mm, stalks width 24mm, fruit skin thickness 8mm. |
| 12. | Automorphy K | Haruku I | The length of the leaf blade 260cm, petiole length 39cm, the ratio of the number of tillers to stem 0.25. |
| 13. | Automorphy L | Haruku II | The length of the leaf blade 240cm, wavy leaf margins, petiole length 40cm, fruit number 6, fruit stalk length 8mm. |
| 14. | Automorphy M | Haruku III | The length of the leaf blade 205cm, petiole length 45cm, the number of tillers stem ratio 0.05, tiller number 19, the number of tillers with ≥ 30 cm height 19, fruit stalk length 19mm. |
| 15. | Automorphy N | Dobo I | The length of the leaf blade 215cm, the width of the leaf blade 45cm, the colour of upper and lower leaves yellow green, large spotting petiole, leaves bone colour yellow, tiller number 10, the number of tillers with ≥ 30 cm height 10, flower stalk length 74, flower width 3cm, fruit number 7, fruit length 10.5cm, fruit stalk length 17cm, fruit stalk width 9mm. |
| 16. | Automorphy O | Dobo II | Leaf blade length 222cm, leaf blade width 49cm, leaves number 7, petiole length 30cm, flower stalks length 60cm, fruit number 8, fruit length 9cm, fruit stalk width 6mm |
| 17. | Automorphy P | Wokam | The length of the leaf blade 176cm, the base of the leaf symmetrical, the two sides narrowed, no petiole spots, petiole edge colour brown, petiole length 21cm, flower stalk length4cm. |
| 18. | Automorphy Q | Ambon III | Plant height288 cm, main stem colour brown, leaf blade length 198cm, leaf blade width 48.5cm, bone colour green, spots colour purple brown, the number of tillers with ≥ 30 cm height 1, flower stalk length 22cm, flower width 5.5cm, anthers colour brown, fruit stalk length 2.5cm, width of fruit stalk 12mm. |

**Table 2: Synapomorphy and automorphy of Fei bananas population in the Maluku island**

Genetic variation of 76 characters each phenotypic population Fei banana Maluku Islands origin certainly influenced by many factors, both genetic and environmental. Separate populations would have different environmental conditions such as temperature, humidity, rainfall, soil pH, soil texture and fertility of the soil to allow properties to be different additives.

Phenotypic analysis of 100 characters produced dendogram with the first branching to form two sub-branches with each - each have different similarity values. The first sub-branch has a similarity value of 72.8 consists of SPR and SRM populations and sub-branches both have a similarity value of 71.9 consists of a population AMB1, WKM, DBO, HRK, NSL, TL, TBLO, ELT, JLO.

The results show the lowest level of similarity comprises 69.3% of the population AMB, WKM, DBO, HRK, TL, TBLO, ELT, JLO, SPR and SRM. Whilst, the NSL population showed the highest similarity level of the entire population in the Maluku Islands to the value of 94% similarity (Figure 3). Characterization of the population with the highest similarity value have a variation in the phenotypic characters including the length of leaf blade, the width of leaf blade, the colour of the lower surface of the leaf, the colour of the edge of the base of the leaf, the number of leaves, petiole length, leaf edges colour, stem colour, the ratio of stem and number of tillers, the ratio of seedling height and the number of tillers which froms synapomorphy and automorphy of Fei bananas population in the Maluku islands (Table 2).

## DISCUSSION

Based on the descriptors of bananas from International Plant Genetic Resources Institute [7] there were 106 organ characters of banana, however in this research there were only 100 characters of Fei banana was observed because the male generative organ of interest was not found and the female generative organs found were only flowers and fruits without seeds. In general Fei bananas do not have seeds [8]. Bananas without seeds could occur because most of the regeneration of banana was occured by vegetative propagation [3].

The development of a wild banana without seed is an important step in the evolution [9]. *Musa acuminata* Colla and *Musa balbisisana* Colla are diploid with AA and BB genome [10]. Those species were characterized by the wild nature of high fertility and the formation of seed which are able to change over time. During the evolution some even lose the entire crop from the nature or lose both the anthers and the ovule, so that all cultivated bananas clones are sterile and do not have seeds.

From 100 organ characters observed there are 76 characters that varies along the banana sample collected with the value of scoring varies between 0-4. Indonesia has a very large banana germ plasm include wild and cultivated banana (cultivate variety) indicated by large variations in shape, flavour, and colour of the fruit [9]. Variation based on 60 characters was found in Fei banana from the four islands in the Maluku [6]. Phenotypic appearance is the result of the interaction between genetic factors (genes) with the environment [11].

Possible differences of Fei banana variety from Maluku Islands suspected of being influenced by environmental factors pH, temperature, moisture, soil texture and fertility. Populations in different locations are not the same and have different variations. Rastali banana accessions grouped into 7 groups and each group is different from the endemic area [12]. Each individual in the population has a different response to the influence of environmental factors and the interaction of genetic factors with the environment. This causes the phenotypic and genotypic variation exhibited by individual species within populations and among populations. A plant population has a variation for various characters. Populations which have a large phenotypic variation was not always has a large genotypic variation even may not have a genotypic variation.

Similarity coefficient value of phenotypic characters in ten populations of Fei banana Maluku Islands origin varies between 69.3% - 94.% with the highest similarity coefficient showed between population from Saparua with Haruku and Seram II with Seram III (Figure 3).This is in accordance with the finding found by other researcher that Fei banana collected from five islands in Maluku showed similarity coefficient values ranged between 0.64-0.92 [6]. Furthermore phenotypic characterization using 72 character of 27 banana accessions results in similarity coefficient values between 31-34% [13]. Other researcher found that based on 35 characters of 26 accessions of banana she produced a dendogram with similarity values ranged from 83-94

% [14]. On determining the character of the phenetic numerical taxonomy, a minimum number of characters that are tested should not less than 60 characters, so the use of 100 characters in this study had fulfill the requirement to collect a valid data [15].

Phenotypic variations in vegetative and generative organs are taken from different populations, different locations and a variety of quantitative and qualitative character. Qualitative character development is controlled by genes that have a powerful effect called major genes or controlled by a simple genes like the gene for colour, flower shape, fruit shape, leaf shape and resistance to pathogenic organisms while plant height, number of grains, seed protein content, fat content in seeds and seed yield were included into quantitative character which controlled by many genes that each gene contributes to the appearance or expression of certain quantitative characters and each contribution is not large, but the sheer numbers are additive and can be expressed as phenotypic that can be distinguished with other populations [16].

## CONCLUSION

Fei banana (*Musa troglodytarum* L.) population from the Maluku Islands have a phenotypic variation in vegetative and generative organs. Those populations formed two groups at 69.3% similarity coefficient thatsharing twenty-one phenotypic characters of vegetative and generative organs.

The similarity coefficient value in this study associated with phenotypic characters shared among the population. The higher the value the smaller the variation of characters among populations, conversely the lower the value the greater the variation of characters among populations.

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