Jurnal Budidaya Pertanian
Versi online: http://ojs3.unpatti.ac.id//index.php/bdp ***Vol. 19(2), 149-157 Th. 2023 ISSN: 1858-4322 (Print) ISSN: 2620-892X (On line)***
DOI: 10.30598/jbdp.2023.19.2.149 ***Terakreditasi RISTEKBRIN Peringkat SINTA 3, SK. 85/M/KPT/2020***

Diversity of Morphology and Reproduction Phenology of Clove Germplasm on Manipa Island, Western Seram, Maluku

Yohana Ulath[1], Asri S. Mahulette[2*], Simon H.T. Raharjo[1]

[1]Study Program of Plant Breeding, Faculty of Agriculture, Pattimura University,Jln.Ir.M Putuhena Kampus Poka Ambon 97233, Maluku, Indonesia
[2]Study Program of Agrotechnology, Faculty of Agriculture, Pattimura University, Jln.Ir.M Putuhena Kampus Poka Ambon 97233, Maluku, Indonesia
[*]E-mail Correspondence Author : mahulette230778@gmail.com

ABSTRACT

Manipa Island, in Western Seram Regency, Maluku Province, Indonesia, is one of the cloves-producing centers in Maluku. So far, the study of clove germplasm on Manipa Island is still minimal, especially studies on morphological diversity and flowering phenology. The study aimed to (1) obtain data and information on morphological characteristics of various clove germplasm on Manipa Island and (2) obtain data and information on reproductive phenology of various clove germplasm on Manipa Island. The study was carried out in two clove distribution areas on Manipa Island, namely West Tomalehu Village (altitude >600 m asl) and East Tomalehu Village (<600 m asl), from March-December 2021. Morphological investigation in this study used survey methods, whereas observations of reproductive phenology were carried out through interviewing representative farmers. The results showed three types of cloves on Manipa Island, namely Tuni, Red Zanzibar, and White Zanzibar. Based on Hierarchical Cluster Analysis (HCA), cloves in Manipa Island were divided into two large groups with a coefficient of dissimilarity of 33%, namely the Tuni clove group as the first group and the Red Zanzibar and White Zanzibar cloves as the second group. The main characterizing character based on Principle Component Analysis (PCA) indicated that the characterizing character in the Red Zanzibar and White Zanzibar cloves was the color of the shoots. In contrast, in Tuni cloves, characterizing characters were the color of the old leaves and the color of petiole tips. The phenology of clove reproduction on Manipa Island consisted of 7 stages, namely: flower induction, flower initiation, pre-anthesis, anthesis, pollination and fertilization, as well as fruit and seed formation, fruit and seed enlargement, and fruit and seed ripening. The timing of the occurrence of each of these phenological stages throughout the year in Manipa Island was determined in this study.

Keywords*: description, characterization, flowering, Hierarchical Cluster Analysis (HCA), Principle Component Analysis (PCA)*

ABSTRAK

Pulau Manipa yang berada di Kabupaten Seram Bagian Barat, Provinsi Maluku, Indonesia merupakan salah satu sentra penghasil cengkeh di Maluku. Selama ini kajian plasma nutfah cengkeh di Pulau Manipa masih minim, terutama kajian keanekaragaman morfologi dan fenologi pembungaannya. Penelitian ini bertujuan untuk (1) memperoleh data dan informasi karakteristik morfologi berbagai plasma nutfah cengkeh di Pulau Manipa dan (2) memperoleh data dan informasi fenologi reproduksi berbagai plasma nutfah cengkeh di Pulau Manipa. Penelitian dilakukan di dua daerah sebaran cengkeh di Pulau Manipa, yaitu Desa Tomalehu Barat (ketinggian >600 m dpl) dan Desa Tomalehu Timur (<600 m dpl), pada bulan Maret-Desember 2021. Penelusuran morfologi pada penelitian ini menggunakan metode survei , sedangkan observasi fenologi reproduksi dilakukan melalui wawancara terhadap petani yang mewakili. Hasil penelitian menunjukkan bahwa ada tiga jenis cengkeh yang ada di Pulau Manipa, yaitu Cengkih Tuni, Zanzibar Merah, dan Zanzibar Putih. Berdasarkan Hierarchical Cluster Analysis (HCA), cengkeh di Pulau Manipa dibagi menjadi dua kelompok besar dengan koefisien ketidaksamaan sebesar 33%, yaitu kelompok cengkeh Tuni sebagai kelompok pertama dan cengkeh Zanzibar Merah dan Zanzibar Putih sebagai kelompok kedua. Karakter penciri utama berdasarkan Prinsip Komponen Analisis (PCA) menunjukkan bahwa karakter penciri pada cengkih Zanzibar Merah dan Zanzibar Putih adalah warna pucuknya. Sebaliknya pada cengkeh Tuni, ciri khasnya adalah warna daun tua dan warna ujung tangkai daun. Fenologi perkembangbiakan cengkeh di Pulau Manipa terdiri dari 7 tahapan, yaitu: induksi bunga, inisiasi bunga, pra-antesis, antesis, penyerbukan dan pembuahan, pembentukan buah dan biji, pembesaran buah dan biji, serta pematangan buah dan biji. Waktu terjadinya masing-masing tahapan fenologi sepanjang tahun di Pulau Manipa telah ditentukan dalam penelitian ini.

Kata kunci: deskripsi, Hierarchical Cluster Analysis (HCA), karakterisasi, pembungaan, Prinsip Komponen Analisis (PCA)

PENDAHULUAN

Clove (*Syzygium aromaticum* (L.) Merril. Perry.), a member of the genus *Syzygium* with about 500 species mainly in Asian tropics, is indigenous to the Moluccas, which include the region of Maluku Province. It was an important trade commodity in the past to the level that it had a very significant influence to the history of Eastern Indonesia, in relation to China, India, Middle East and Europe, and especially the Netherlands. The importance of

clove historically and commercially during the colonial time has been described in details by Rumphius, a German botanist living in Ambon Island in the 17th century (Beekman 2011). Weiss (2002) also discusses the history of trade and the use of cloves starting long before the spice exploration of Arabs and Europeans to Maluku, during the colonial era as well as the present time.

Clove (*Syzygium aromaticum* (L.) Merril. Perry.) is currently one of the essential plantation commodities in the Indonesian economy because 99% is cultivated by farmers (Alfian *et al.* 2019; Mahulette *et al*. 2020a, 2022). Cloves are widely used as raw materials for 'kretek' cigarettes and as spices. In addition, it is commonly used in the pharmaceutical and cosmetic industries as raw material for making vanillin and in food technology as a natural anti-microbial agent.

According to data from the Ditjenbun (2020), from 2018 to 2020, the area of cloves in Indonesia increased from 569 052 ha to 570 353 ha. Clove production in Indonesia in 2018 was recorded at 131 014 tons, then increased to 134 792 tons in 2019 and to 137 758 tons in 2020. The increased area and clove production nationally have not met the growing demand for cloves. To meet the shortage of supply, clove has been imported from overseases, sung as Madagaskar. According to data from the Ditjenbun (2020), the volume of Indonesian clove imports from 2015 to 2018 increased from 11 tons in 2015 to 13 373 tons in 2018. To overcome this problem, it is necessary to increase clove productivity. One of the ways is through the use of clove germplasm in its distribution area. Increasing plantation acreage should also be strived to increase clove production in Indonesia.

Maluku is known as a clove-producing center with a relatively high clove germplasm diversity. According to (Ditjenbun 2020), Maluku has been the largest clove-producing province in Indonesia since 2015, with an average contribution of 15.37% to the national production. According to Statistic Center Bureau or BPS Maluku Data 2018, the area of clove plantations in Maluku in 2016 was recorded at 43 620.3 ha, subsequently increased to 43 780.1 in 2017, with total production increasing from 20 805.6 tons in 2016 to 21 159.6 in 2017. Like other provinces in Indonesia, however, clove productivity in Maluku is higher, which affects the production quantity. One of the causes of high clove productivity in Maluku is the high diversity of superior clove germplasm and supported by agro-climatic suitability.

Manipa Island, located in the Western Seram Regency, is one of the clove-producing centers in Maluku. This region has a relatively high diversity of clove germplasm. However, so far, the study of clove germplasm on Manipa Island is still minimal, especially information on the diversity of plant morphology and flowering phenology. According to Nascimento *et al*. (2011), the morphological characters of germplasm accessions are essential to provide information in the development of breeding programs for the selection of superior types. In addition, to plant morphological data, the phases of flowering, especially the development of clove flowers or phenology, are also essential. According to (Alfikri *et al*. 2020; Anders *et al*. 2021; Hyles *et al*. 2020; Vârban *et al*. 2021), the study of flowering phenology has practical importance for planning breeding programs, especially if breeding of superior clove varieties is to be achieved in the future. Observation of reproductive phenology can be done by observing flower age, seed formation and harvest time (Rehnus *et al*. 2020; Schmidt *et al*. 2019; Vârban *et al*. 2021; Wicaksono *et al*. 2022). Therefore, this study aimed to describe the morphological diversity and reproductive phenology (flowering) of clove germplasm on Manipa Island, Western Seram Regency, so that it could be used as a reference in developing clove varieties for the region in the future.

MATERIALS AND METHODS

Place and Time

The study was conducted in two clove distribution areas on Manipa Island, Manipa Islands District, wertern Ceram Regency, Maluku Province, namely: West Tomalehu Village (altitude >600 m asl) and East Tomalehu Village (<600 m above sea level), in March-December 2021.

Materials and Tools

The plant material used in the morphological observations was clove plants belonging to the farmers in the study area, which were >20 years old. For each variety found, ten plants were taken as observation samples. For the observation of reproductive phenology, the tool used is a questionnaire for interview needs. Measurement and observation equiments and tools used in the observation of plant morphology were a haga-meter for measuring tree height; a metering tape for measuring the length, width and circumference of a tree trunk; measuring ruler for measuring the size of leaves, flowers, fruit, and seeds; a caliper for measuring flower, fruit, and seed diameters; Easy Leaf Area software for measuring leaf area; the 2015 RHS Color Chart for determining leaf, fruit, and seed colors; a digital camera for plant morphology documentation. The tools used for observation of reproductive phenology (flowering) are recording devices (mobile phones), digital cameras for documentation, and writing tools.

Research Methods

Morphological characterization in this study used a survey method, and the selected samples were determined randomly. Ten plants were taken as samples of each clove variety in each village. Measurement and observation of morphological characters referred to Pool and Bermawie (1986), Tropical Fruit Descriptors (IPGRI, 1980) and modified Mahulette *et al.* (2019, 2022). Observations of reproductive phenology were carried out by referring to the stages of reproductive phenology according to Mahulette *et al.* (2019a) and (Mudiana and Ariyanti 2010), namely the steps: (1) flower induction, (2) flower initiation, (3) pre-anthesis, (4) anthesis, (5) pollination and fertilization and fruit and seed formation, (6) fruit and seed enlargement, and (7) fruit and seed ripening.

Research Implementation

Clove plant samples to be measured for morphology are labelled. Morphological measurements and observations were carried out on characters of trees (height, habitus, canopy shape, canopy width), trunks (trunk circumference, main trunk shape (single/dividing), branches (branching direction, branching angle, lowest branch height), leaves (leaf index, leaf length and width, leaf shape, old leaf color, shoot color, leaf tip and base shape, petiole length and color, leaf top surface texture, leaf edge shape, leaf veins, leaf thickness, leaf aroma). The leaves measured consisted of 10 leaf samples taken purposively in the north and south directions on an area of 1 m^2 (Tresniawati and Randrian 2011). The criterium of leaf measurement was the 4th leaf from the shoot (Ruhnayat 2007), which was uniform in size and free from pests and diseases. The morphological measurement data were then assigned scores to facilitate quantification.

Reproductive phenology information was obtained through interviews with clove farmers. The clove farmers interviewed were selected purposively with the criteria that the farmers cultivated cloves with a clove land area of >0.5 ha. The number of farmers interviewed was 40 people, in which 20 people were from West Tomalehu Village and 20 from East Tomalehu Village. Interview questions were made referring to the stages of reproductive phenology according to Mahulette *et al.* (2019a) and (Mudiana and Ariyanti 2010).

Data Analysis

Data on the overall morphological character of the clove germplasm were analyzed with Hierarchical Cluster Analysis (HCA) and Principle Component Analysis (PCA-Biplot) using R Stat 3.1.0 software. Whereas, reproductive phenology (flowering) data were analyzed and presented descriptively.

RESULTS AND DISCUSSION

Morphological Characters Of Clove Germplasm On Manipa Island, Western Seram Regency

Clove germplasm exploration conducted on Manipa Island, West Seram Regency, found three types of cloves: Tuni cloves, Red Zanzibar, and White Zanzibar (Figure 1). Tuni and Red Zanzibar cloves were only located in West Tomalehu Village, while in East Tomalehu Village, three clove types were found, namely Tuni, Red Zanzibar and White Zanzibar. The morphological characters of the clove types found at the study site are shown in Table 1.

The Tuni clove type found in the villages of West Tomalehu and East Tomalehu has almost the same characteristics, namely elliptical leaves, old leaf color is deep yellowish-green/green group (141B), a shoot color is vivid yellowish-green/green group (140A), and the color of the tip of the petiole is dark yellowish pink/greyed red group (181D). Red Zanzibar found in both locations also had almost the same morphological characters in the form of elliptical leaf shape, leaf color is dark green/green group (131B), shoot color is moderate red/greyed red group (180B), the color of the tip of the petiole is moderate red/greyed red group (180B). White Zanzibar found in East Tomalehu Village has almost the same character as Red Zanzibar. Still, the differences can be seen in the color of the dark green leaves (moderate green/green group/131C) and the shoot color of moderate reddish orange/greyed-red group (179C), petiole tip color was moderate red/greyed red group (180B).

Clove Germplasm Grouping on Manipa Island Based on Hierarchical Cluster Analysis (HCA)

From the results of observations and analysis of 35 cloves in two research locations on Manipa Island, the results of Hierarchical Cluster Analysis (HCA) showed that there were two main groups with a coefficient of dissimilarity of 33% (Figure 2). The two groups consisted of the Tuni clove type group as the first group, whereas the Red Zanzibar and White Zanzibar as the second group. According to Hartati *et al*. (2022), HCA can classify morphological characters and yield components of plant genotypes and is widely used in plant breeding studies. The cluster analysis can evaluate plants' essential morphological characters to select high-yielding plant types (Karuwal *et al*. 2021; Rosmaina *et al*. 2021; Wang *et al*. 2014).

Figure 1. Clove type, a) Tuni-West Tomalehu Village,
b) Tuni-East Tomalehu Village, c) Zanzibar Red-West Tomalehu Village,
d) Zanzibar Red-East Tomalehu Village, e) Zanzibar White-East Tomalehu Village

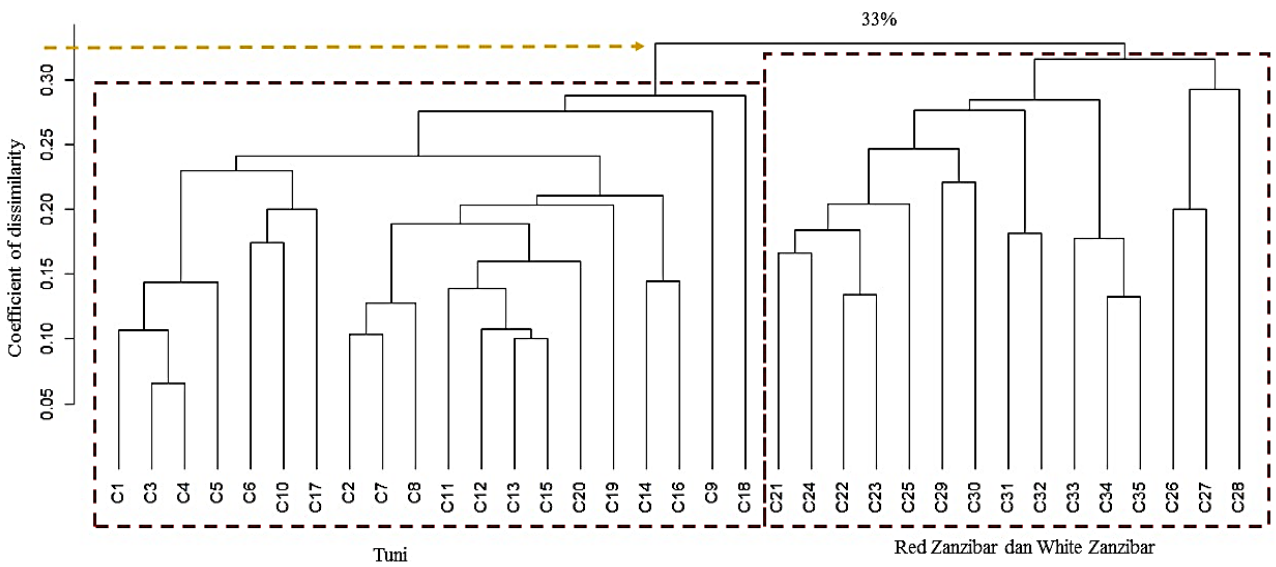


Figure 2. A dendrogram grouping 35 local clove genotype groups on Manipa Island,
West Seram Regency. Clove genotypes based on morphological characters:
Tuni-West Tomalehu Village (C1-C10), Tuni-East Tomalehu Village (C11-C20),
Zanzibar Red-West Tomalehu Village (C21-C27),Zanzibar Red-East Tomalehu Village (C28-C33),
Zanzibar White-East Tomalehu Village (C34 -C35)

Based on the grouping, the Red Zanzibar and White Zanzibar clove groups had a morphological difference of 33% from the Tuni clove group. The Red Zanzibar cloves and the White Zanzibar cloves were grouped in one group because they had more characteristics in common. The only striking difference was the old leaves' color and the shoots' color. Red Zanzibar cloves had a dark green/green group (131B) leaf color and moderate red/greyed red group(180B)

shoot color. White Zanzibar cloves had an old leaf color, moderate green/green group (131C), and a shoot color, moderate reddish orange/greyed-red group (179C).

Table 1. Morphological characters of clove type on Manipa Island, West Seram Regency

Types & location of cloves[+]	Morphological variables						Color*
	Morphological character	Height (m)	Shape	Length (cm)	Width (cm)	Wide (cm^2)	
T-TB	Tree	18.40±0.52	Cylindrical	-	-	-	-
	Bottom branch	1.90±0.37	90° angle	-	-	-	-
	Leaf	-	*Elliptical*	10.41± 1.09	3.61±0.75	35.09±10.00	Dark leaf color: deep yellowish-green/green group (141B); shoot color: vivid yellowish-green/green group (140A); petiole tip color: dark yellowish pink/greyed red group (181D).
T-TT	Tree	19.00±0.82	Cylindrical	-	-	-	-
	Bottom branch	1.61±0.31	90° angle	-	-	-	-
	Leaf	-	*Elliptical*	11.52± 3.25	4.26±0.58	49.53±12.18	Dark leaf color: deep yellowish-green/green group; shoot color (141B): vivid yellowish-green/green group (140A); petiole tip color: dark yellowish pink/grayed red group (181D). Dark leaf color: deep yellowish-green/green group (141B); shoot color: vivid yellowish-green/green group (140A); petiole tip color: dark yellowish pink/grayed red group (181D).
ZM-TB	Tree	18.71±0.49	Pyramid	-	-	-	-
	Bottom branch	1.94±0.33	45° angle	-	-	-	-
	Leaf	-	*Elliptical*	11.51± 2.48	3.76±0.61	49.09±298.80	Dark leaf color: dark green/green group (131B); shoot color: moderate red/grayed red group (180B); petiole tip color: moderate red/grayed red group (180B).
ZM-TT	Tree	18.50±1.22	Pyramid	-	-	-	-
	Bottom branch	1.90±0.30	45° angle	-	-	-	-
	Leaf	-	*Elliptical*	11.88± 1.91	4.43±0.90	50.55±15.36	Dark leaf color: dark green/green group (131B); shoot color: moderate red/grayed red group (180B); petiole tip color: moderate red/grayed red group (180B).
ZP-TT	Tree	19.50±0.71	Pyramid	-	-	-	-
	Bottom branch	2.32±0.55	45° angle	-	-	-	-
	Leaf	-	*Elliptical*	12.30± 1.41	4.55±0.21	50.12±0.62	Dark leaf color: moderate green/green group (131C); shoot color: moderate reddish orange/greyed-red group (179C/); petiole tip color: moderate red/greyed red group (180B); morphology similar to Red Zanzibar, but not red shoots).

Note: *Color standard based on 2015 RHS color chart criteria; [+]Clove type and location: T-TB=Tuni-West Tomalehu Village, T-TB=Tuni-East Tomalehu Village, ZM-TB=Zanzibar Red-West Tomalehu Village, ZM-TT=Zanzibar Red-East Tomalehu Village , ZP-TT=Zanzibar White- East Tomalehu Village

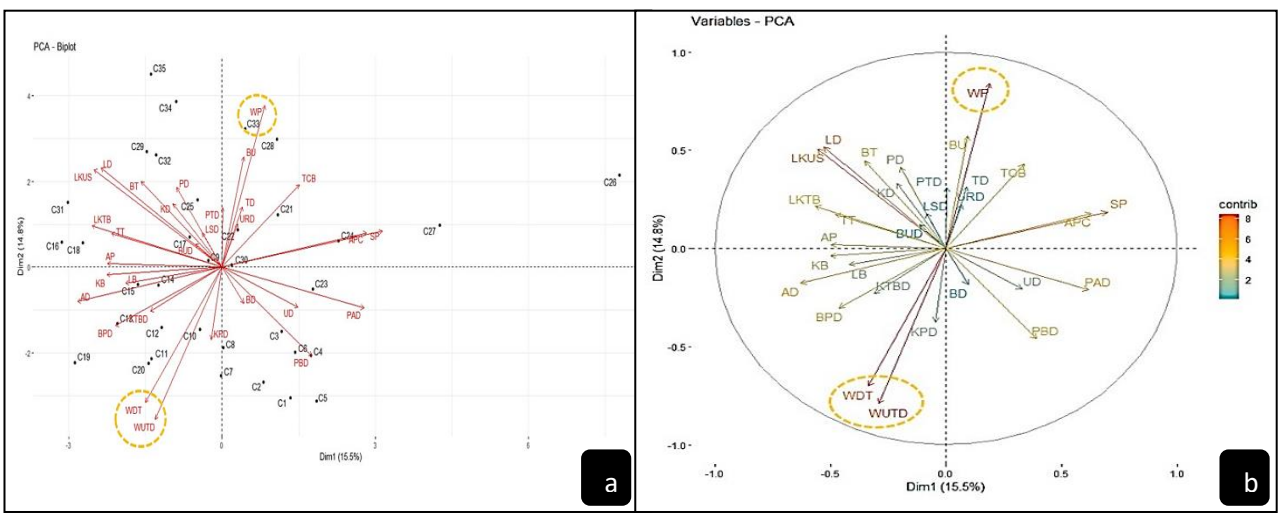
The difference between Red Zanzibar cloves and White Zanzibar cloves against Tuni cloves could be seen in the shape of the crown, branching angles, the color of the old leaves, the color of the shoots, and the color of the tips of the petioles. Tuni clove had a cylindrical crown shape, the branching angle is 90°, the color of the old leaves was deep yellowish green/green group (141B), the shoot color was vivid yellowish green/green group (140A), the color of the petiole tip was dark yellowish pink/greyed red group (181D). These results indicate that the types of cloves with many similarities in morphological characters are the types with closer kinship relationships, compared to the types with many different characters.

Although there were differences between the two groups of cloves on Manipa Island based on Hierarchical Cluster Analysis (HCA), it could be seen that between the two groups there were quite significant similarities in characters. The HCA results showed that between the Tuni clove group and the Red Zanzibar and White Zanzibar clove groups, there was 67% similarity in morphological characters. The similarity of characters was because the three types of cloves analyzed were both cultivated cloves from the aromatic group of the same species. Hence, they have many similarities in morphological characters. These results are in line with those informed by Hariyadi *et al*. (2020b, 2020a) on clove types in Maluku, where cultivated type cloves aromatic groups such as Tuni and Red Zanzibar tend to have similarities in morphology and volatile components compared to wild types clove groups, such as Forest cloves and Raja cloves (Alfian *et al*. 2019; Hariyadi *et al*. 2020a, 2020b; Mahulette *et al*. 2019a).

Differences in character within a plant population are determined by many factors, including genetics, environment, and the interactions (Amini *et al*. 2016; Hariyadi *et al*. 2019, 2020a; Mahulette *et al*. 2022, 2021). According to Mahulette *et al*. (2020b, 2022) and Hartati *et al*. (2022), morphological characterization of germplasm accessions is essential in developing breeding programs. High variability among plant accessions is also crucial in the genetic studies of plant species (Aung *et al*. 2020; Danthu *et al*. 2020).

Grouping of Morphological Characters of Clove Germplasm on Manipa Island Based on Principle Component Analysis (PCA-Biplot)

Principle Component Analysis (PCA-Biplot) was performed on 30 morphological characters on 35 clove samples from Manipa Island (Figure 3). Based on the results of PCA analysis, it was found that the shoot color character could be recommended as the main characterizing character in the Red and White Zanzibar clove descriptors. In contrast, the old leaf and petiole tip colors could be advised as characterizing characters in the Tuni clove descriptor. According to Karuwal *et al*. (2021) and Rosmaina *et al*. (2021), the characterizing characters obtained in the characterization can be used as a reference in identifying and classifying certain plant groups. Furthermore, according to Yugandhar *et al*. (2018), the principal component analysis is determined mainly by the character that contributes the most among the various characters analyzed. PCA is widely used to classify multiple variations of plant characters that have high variability. In addition, it is commonly used in preparing plant descriptors (Afuape *et al*. 2011).



Note: PCA Biplot (a), Variable PCA (b); Clove genotype, C1-C20=Tuni, C21-C33=Red Zanzibar, C34-C35=White Zanzibar; Morphological characters, plant height (TT), branching direction (AP), stem circumference (LB), bark (KB), main stem (BU), canopy shape (BT), north-south canopy width (LKUS), canopy width east-west (LKTB), branching direction (APC), branch angle (SP), lowest branch height (TCB), leaf size/index (UD), leaf length (PD), leaf width (LD), leaf area (LSD)), petiole length (PTD), leaf position (KD), leaf shape (BD), leaf tip shape (BUD), leaf base shape (BPD), leaf top surface (PAD), under leaf surface (PBD), edge leaf (TD), leaf veins (URD), leaf thickness (KTBD), dark leaf color (WDT), shoot color (WP), petiole tip color (WUTD), leaf aroma (AD), leaf spiciness (KPD)

Figure 3. Principle Component Analysis (PCA-Biplot) of 35 samples of cloves on Manipa Island based on 30 morphological characters

Reproductive Phenology of Clove Type in Manipa Island

The phenological stages of clove reproduction at the research site on Manipa Island were identified by studying the stages of flower development. The stages of flower development are known as reproductive phenology. The phenology of clove reproduction is a natural step in the clove plant flowering process. Based on the results of

interviews, the types of cloves on Manipa Island, namely Tuni, Red Zanzibar, and White Zanzibar, have stages of reproductive phenology that tend to be the same. The reproductive phenological sets of the three types of cloves on Manipa Island consist of 7 stages (Figure 4). The results obtained from this study are the same as the stages of development of clove reproductive phenology obtained in previous studies by Mahulette *et al*. (2019a) and Mudiana & Ariyanti (2010), namely the stages of flower induction, flower initiation, pre-anthesis, anthesis, pollination, fertilization and fruit and seed formation, fruit and seed enlargement, and fruit and seed ripening.

Clove trees show signs of blossoming more or less eight months before they bloom. The color of the terminal bud predicts the direction of development long before any differentiation can be seen. Green buds will develop into inflorescences, whereas red buds will generate branches with immature leaves. The degree of branching of the inflorescence stalks, which appears to depend on other elements that manifest themselves in a later stage, affects the quantity of clove yield (de Wit, 1969).

Based on interviews with clove farmers in both villages on Manipa Island, information was obtained that the stage of flowering induction of the clove type on Manipa Island occurred in early June. This phase was marked by swelling at the tip of the shoot. According to Syamsuwida *et al*. (2012), the induction phase is generally characterized by an increase in sugar content which encourages flowering induction and a decrease in vegetative growth due to the reduction in gibberellins content. After the induction phase, the clove flower enters the flower initiation phase, where the swelling of the tissue looks more significant and is followed by the formation of buds. This process occurs at the end of June, and the result of the process is marked by the appearance of calyx and corolla. After passing the induction phase, the development of the clove flower enters the pre-anthesis and anthesis phases. The pre-anthesis and clove-type anthesis phases on Manipa Island lasted from July to early September. Clove frower is hermaphroditic with a fleshy hypanmthium surmounted by sepals or calyx. The hypanthium is 1-1.5 cm long, cylindrical, angled, green in young bud and flushed pink at anthesis, usually becoming reddish after the stemens fall.

Clove flowers are harvested at the end of the anthesis phase, where the harvesting is carried out before the clove flowers bloom (blooming) to ensure the cloves harvested have quality results. Therefore, the unopened petals or corolla together with enclosed stamen form the head of the dried clove. The harvest season occurs in early September which is marked by flower bud-shaped flowers. According to Hariyadi et al. (2020b) and Kembauw *et al*. (2021), the best quality of clove flower harvest is achieved when the flowers are in the form of a flower bud or before the flowers bloom, in which condition the flowers are at their maximum size with the highest eugenol content. The flower bud then blooms, and there is a process of pollination, and fertilization and continued with the formation of fruit and seeds. Based on the information, this stage takes place from mid-September to the end of October. At the end of October, fruit and seed enlargement has been maximized.

The end of the phenological phase of clove-type reproduction on Manipa Island was marked by fruit and seed ripening, which took place from early to late November. According to the research results of Alfian *et al*. (2019), Kembauw *et al*. (2021a), Mahulette *et al*. (2019a), physiologically ripe clove fruit has a blackish-red color with purplish-red seeds.

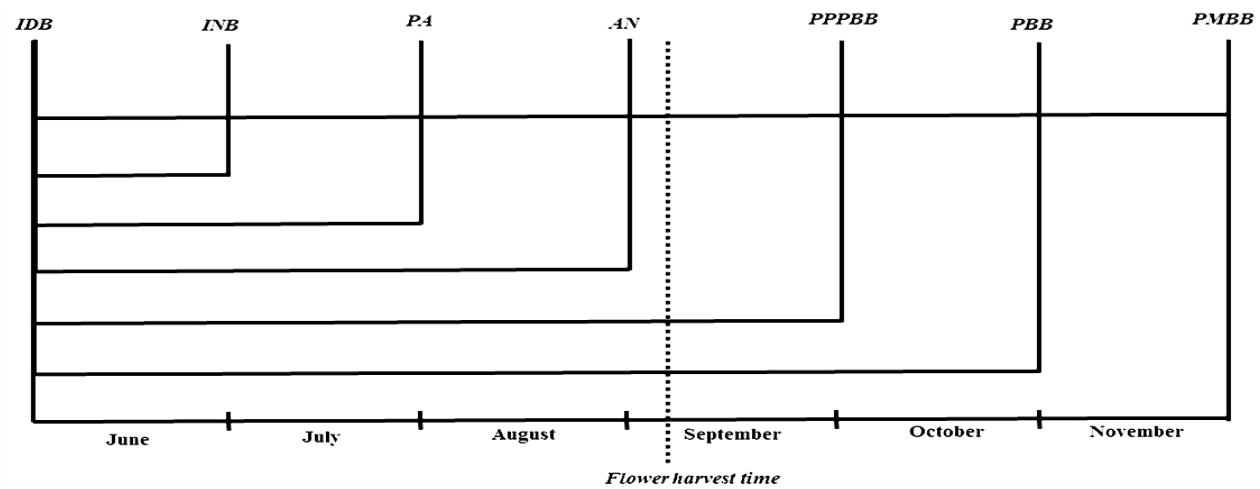


Figure 4. Stages of reproductive phenology of the Tuni, Red Zanzibar, and White Zanzibar clove types on Manipa Island, West Seram Regency.

CONCLUSION

There were three types of cloves on Manipa Island, West Seram Regency: Tuni cloves, Red Zanzibar, and White Zanzibar. The results of Hierarchical Cluster Analysis (HCA) divided these types of cloves into two large

groups with a coefficient of dissimilarity of 33%. The results of the Principle Component Analysis (PCA) obtained that the distinctive character of the Red Zanzibar cloves and White Zanzibar cloves were the color of the shoots. Meanwhile, those of the Tuni cloves were the color of the old leaves and the color of the tips of the petioles. The phenology of clove reproduction on Manipa Island consists of 7 stages, namely: flower induction, flower initiation, pre-anthesis, anthesis, pollination and fertilization, as well as fruit and seed formation, fruit and seed enlargement, and fruit and seed ripening.

REFERENCES

Afuape SO, Okocha PI, Njoku D. 2011. Multivariate assessment of the agromorphological variability and yield components among sweetpotato (*Ipomoea batatas* (L.) Lam) landraces. *African Journal of Plant Science* 5 (2):123–132. DOI: 10.9734/AJEA/2014/5827

Alfian A, Mahulette AS, Zainal M, Hardin, Bahrun AH. 2019. Morphological character of raja clove (*Syzygium aromaticum* L . Merr & Perry.) native from Ambon Island. In The First International Conference of Interdisiplinary Research on Green Environment Approach for Sustainable Development (ICROEST 2019), Makassar: IOP Conference Series: Earth and Environmental Science 343 (2019) 012150, pp. 1–4. DOI: 10.1088/1755-1315/343/1/012150.

Alfikri FN, Pujiarti R, Wibisono MG, Hardiyanto EB. 2020. Yield, quality, and antioxidant activity of clove (*Syzygium aromaticum* L.) bud oil at the different phenological stages in young and mature trees. *Scientific* 2020. DOI:10.1155/2020/9701701.

Amini F, Asghari GR, Talebi SM, Askary M, Shahbazi M. 2016. Effect of environmental factors on the compounds of the essential oil of Lippia citriodora. *Biologija* 62 (3):194–201. DOI:10.6001/biologija.v62i3.3372.

Anders S, Cowling W, Pareek A, Singla-pareek SL, Foyer CH, Gupta KJ. 2021. Gaining acceptance of novel plant breeding technologies. *Trends in Plant Science* 26 (6):575–587. DOI:10.1016/j.tplants.2021.03.004.

Aung EE, Kristanti AN, Aminah NS, Takaya Y, Ramadhan R. 2020. Plant description, phytochemical constituents and bioactivities of Syzygium genus: A review. *De Gruyter* 18 (1):1256–1281. DOI:10.1515/chem-2020-0175.

Beekman E.M. 2011. In G. E. Rumpf, 1741–1755. The Ambonese Herbal. 6 volumes (Author: G. E. Rumpf, 1741–1755). Vol 1. New Haven: Yale University Press and National Tropical Botanical Garden 524 p (Translation of Rumphius, G. E. 1741-1956. Herbarium Amboinense, J. Burmannus, Amsterdam.).

BPS Maluku. 2018. *Provinsi Maluku Dalam Angka*. BPS Provinsi Maluku. 745 hlm. [Indonesian].

Danthu P, Simanjuntak R, Fawbush F, Tsy JMLP, Razafimamonjison G, Abdillahi MM, M. Jahiel1 6, Penot and E. 2020. The clove tree and its products (clove bud, clove oil, eugenol): prosperous today but what of tomorrow's restrictions? *Fruits* 75 (5):224–242. DOI:10.17660/th2020/75.5.5.

Ditjenbun. 2020. *Statistik Perkebunan Indonesia 2018-2020 (Cengkeh)*. Jakarta (ID): Kementerian Pertanian. 70 p. [Indonesian].

Hariyadi, Mahulette AS, Yahya S, Wachjar A. 2020a. Morphological characters and essential oil constituents extracted of two clove varieties (*Syzygium aromaticum* (L.) Merr. & L. M. Perry.) from Ambon Island, Indonesia. Plant Archives 20 (1):2208–2214. e-ISSN:2581-6063 (online), ISSN:0972-5210

Hariyadi, Mahulette AS, Yahya S, Wachjar A. 2020b. Agro-morphologies and physicochemical properties of flower bud , stem and leaf oils in two clove varieties (*Syzygium aromaticum* L . Merr . and Perry.) originated from Ambon island. Chiang Mai University *Journal of Natural Sciences* 19 (3):516–530. DOI:10.12982/CMUJNS.2020.0034.

Hariyadi, Mahulette AS, Yahya S, Wachjar A. 2019. Measuring the potential of biomass, carbon storage, and carbon sink of forest cloves. In The 1st International Seminar on Natural Resources and Environmental Management (ISenREM 2019), Bogor: IOP Conf. Series: Earth and Environmental Science 399 (2019) 012063, pp. 1–9. DOI: 10.1088/1755-1315/399/1/012063.

Hartati S, Samanhudi, Cahyono O. 2022. Short Communication: Morphological characterization of five species of Dendrobium native to Indonesia for parent selection. *Biodiversitas* 23 (5):2648–2654. DOI:10.13057/biodiv/d230548.

Hyles J, Bloom MT, Hunt JR, Trethowan RM, Trevaskis B. 2020. Phenology and related traits for wheat adaptation. *Heredity* 125 (6):1–14. DOI:10.1038/s41437-020-0320-1.

IPGRI. 1980. *Tropical Fruit Descriptor*. Thailand: IPGRI-Southeast Asia Regional Committee, Thailand.

Karuwal RL, Suharsono, Tjahjoleksono A, Hanif N. 2021. Characterization and nutrient analysis of seed of local cowpea (*Vigna unguiculata*) varieties from Southwest Maluku, Indonesia. *Biodiversitas* 22 (1):85–91. DOI:10.13057/biodiv/d220112.

Kembauw E, Mahulette AS, Wattimena AY, Senewe E. 2021a. Analisis Rantai Pasok Komoditas Cengkih Hutan di Maluku. J*ournal of Agricultural Socio-Economics (JASE)* 2 (2):68–74. DOI: 10.33474/jase.v2i2.13083. [Indonesian]

Kembauw E, Mahulette AS, Kakisina AP, Tuhumury MTF, Umanailo MCB, Kembauw MGI. 2021b. Clove processing as a source of increasing business income in Ambon City. IOP Conf. Series: *Earth and Environmental Science* 883 (012091):1–7. DOI:10.1088/1755-1315/883/1/012091.

Mahulette AS, Hariyadi, Yahya S, Wachjar A, Alfian A. 2019a. Morphological traits of Maluku native forest clove (*Syzygium aromaticum* L. Merr & Perry) *Journal of Tropical Crop Science* 6 (2):105–111. DOI: 10.29244/jtcs.6.02.105-111

Mahulette AS, Alfian A, Situmorang J, Matatula AJ, Kilkoda AK, Nendissa JI, Wattimena AY. 2022. Type and morphological character of local clove (*Syzygium aromaticum*) from Maluku, Indonesia. *Biodiversitas* 23 (3):1301–1309. DOI:10.13057/biodiv/d230314.

Mahulette AS, Hariyadi, Yahya S, Wachjar A, Marzuki I. 2019b. Morpho-agronomical diversity of forest clove in Moluccas, Indonesia. *Hayati Journal of Biosciences* 26 (4):156–162. DOI:10.4308/hjb.26.4.156.

Mahulette AS, Alfian A, Zainal M, Nendissa JI, Wattimena AY, Tanasale VL, Makaruku MH, Laisina JKJ. 2020a. Growth of forest clove seedlings at different concentrations of paclobutrazol. In The 2nd International Conference of Interdisciplinary Research on Green Environmental Approach for Sustainable Development, Makassar: IOP Conf. Series: Earth and Environmental Science 575 (2020) 012081, pp. 1–7. DOI:10.1088/1755-1315/575/1/012081.

Mahulette AS, Riry J, Kesaulya H, Kembauw E, Lawalata IJ, Wattimena AY, Makaruku MH, Alfian A. 2021. Essential oil components of forest clove variants from Ambon Island, Maluku. In International Seminar on Agriculture, Biodiversity, Food Security and Health, Ambon: IOP Conference Series: Earth and Environmental Science, pp. 1–8. DOI:10.1088/1755-1315/883/1/012002.

Mahulette AS, Hariyadi, Yahya S, Wachjar A. 2020b. Physico-chemical properties of clove oil from three forest clove accession groups in Maluku. In 1st International Conference on Sustainable Plantation (1st ICSP 2019), Bogor: IOP Conf. Series: Earth and Environmental Science 418 (2020) 012028 IOP, pp. 1–8. DOI: 10.1088/1755-1315/418/1/012028.

Mudiana D, Ariyanti EE. 2010. Flower and fruit development of *Syzygium pycnanthum* Merr. & L.M. Perry. *Biodiversitas* 11 (3):124–128. DOI:10.13057/biodiv/d110304.

Nascimento D, Ferreira W, Silva EF da, Veasey EA. 2011. Agro-morphological characterization of upland rice accessions. Sci. Agric. (Piracicaba, Braz.) 68 (6):652–660. DOI: 10.1590/S0103-90162011000600008.

Pool P, Bermawie N. 1986. *Kriteria Seleksi Pohon Induk Cengkih*. Bogor (ID): Balittro. [Indonesian]

Rehnus M, Pelaez M, Bollmann K. 2020. Advancing plant phenology causes an increasing trophic mismatch in an income breeder across a wide elevational range. *Ecosphere* 11 (6):1–11. DOI:10.1002/ecs2.3144.

Rosmaina, Elfianis R, Almaksur A, Zulfahmi. 2021. Minimal number of morphoagronomic characters required for the identification of pineapple (*Ananas comosus*) cultivars in peatlands of Riau, Indonesia. *Biodiversitas* 22 (9):3854–3862. DOI:10.13057/biodiv/d220931.

Ruhnayat A. 2007. Aplikasi model pemupukan berimbang pada tanaman cengkeh (*Syzigium aromaticum*). *Bul. Littro* 18(2):149–158. [Indonesian]

Schmidt L, Rustiami H, Theilade I. 2019. Local monitoring of flowering and fruiting of Jernang, Daemonorops species in Sumatra, Indonesia. *Biodiversitas* 20 (1):118–125. DOI:10.13057/biodiv/d200114.

Syamsuwida D, Palupi ER, Siregar IZ, Indrawan A. 2012. Flower initiation, morphology, and developmental stages of flowering-fruiting of Mindi (*Melia azedarach* L). *Jurnal Manajemen Hutan Tropika* 18 (1):10–17. DOI:10.7226/jtfm.18.1.10.

Tresniawati C, Randrian E. 2011. Uji kekerabatan aksesi cengkeh di Kebun Percobaan Sukapura. *Buletin Plasma Nutfah* 17 (1):40–45. DOI: 10.21082/blpn.v17n1.2011.p40-45

Vârban R, Ona A, Stoie A, Vârban D, Cris I. 2021. Phenological assessment for agronomic suitability of some agastache species based on standardized BBCH scale. *Agronomy* 11:2280. DOI:10.3390/agronomy11112280.

Wang H, Li X, Shen D. 2014. Diversity evaluation of morphological traits and allicin content in garlic (*Allium sativum* L .) from China. *Euphytica* 198:243–254. DOI:10.1007/s10681-014-1097-1.

Weiss EA. 2002. Spice Crops. CABI Publishing. New York, USA. 411 p. ISBN: 0-85199-605-1

Wicaksono FY, Sinniah UR, Ruminta, Sumadi, Nurmala T. 2022. Characteristics of physiology, phenology, and drought susceptibility index of two varieties of Job's tears under water deficit stress. *Biodiversitas* 23 (1):381–387. DOI:10.13057/biodiv/d230139.

Wit F. 1969. The clove tree, *Eugenia caryophyllus* (Sprengel) Bullock et Harrison. *In*: F.P. Verwerda and F. Wit (Eds) Outlines of Perennial Crop Breeding in the Tropics, p. 163-174. H. Veenman and Zonen N.V., Wageningen, The Netherlands.

Yugandhar R, Kota S, Kiran U. 2018. Principal component analysis for agro-morphological and quality characters in germplasm of rice (*Oryza sativa* L.). *IJABR* 8(2):268–273.