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DATABASE, DIVERSITY AND POTENTIAL USE OF LOCAL CLOVE (*Syzygium aromaticum* (L) Merry and Perry) AT MALUKU ISLAND

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CONTENT

TABLE

FIGURES

1. Introduction

1.1. Background

Maluku Islands are known as "the center of origin" of cloves in the world (Alfian et al. 2019). It has a high diversity of clove germplasm. According to Ditjenbun data (2019), Maluku is the largest clove producing province in Indonesia since 2015, with an average contribution of 15.37%. The total area was recorded at 43620.3 ha then increased to 43780.1 in 2017 with total production from 20805.6 tons in 2016 increased to 21 159.6 in 2017 (BPS, 2018). It caused the high diversity of superior clove germplasm and is supported by agro-climatic suitability.

Based on data from Ditjenbun (2020), the total production of cloves in Maluku in 2020 amounted to 20 001 tons with the following details: Central Maluku Regency (9215 tons), Eastern Seram Regency (4763 tons), South Buru Regency (2 226 tons), West Seram Regency (2879 tons), Buru Regency (412 tons), Southwest Maluku Regency (49 tons), Southeast Maluku Regency (4 tons), Ambon (404 tons), and Tual (9 tons).

There have not been many reports of complete information on the types of local cloves in Maluku. Maluku has the potential to find various types of local cloves. It needs to be compiled in a clove database to facilitate its development in the future. According to Suparman et al. (2017), a database of cloves can be obtained by identifying the diversity of types of cloves found in the field. The existence of cloves in Maluku regions makes it possible to find cloves' diversity at the morphological and DNA levels. Maluku consists of small islands with various agro-climatic conditions so that it is possible to find various types of cloves with distinctive characteristics.

The high-quality germplasm in Maluku provides opportunities for the industrial utilization of this commodity in the future. Cloves are classified as essential oil-producing plants reported having potential biological activities, including antibacterial, antiviral, antifungals, insecticidal, defense against herbivores, as attractant pollinators and pest repellents, etc. (Bakkali et al. 2008). Clove essential oil is reported to be widely used in medicine, as a food preservative, aromatherapy, cosmetics, and other industries (Jentzsch et al. 2017; Kamatou et al. 2012; Rathinam and Viswanathan 2018).

So, it is currently necessary to collect data on all local clove varieties in Maluku. This database can be used as a reference for restoring the richness of spices, especially cloves in Indonesia. The data collected are local names or varieties, morphological characters,

agronomic characters, distribution, ecology, genetic diversity, and potential use, leading to the identification of essential oils content.

The clove database in Maluku can be obtained through the identification of the diversity of cloves scattered in the distribution area in Maluku. Characterization of cloves is essential to see the important character of plants, such as potential production. The morphological variations can be shown by making a dendogram of the percent similarity followed by a Principle Component Analysis to determine each type of clove's characters and make a clove plant descriptor.

The morphological diversity of various clove germplasm needs to be supported by analyzing at the DNA level to describe plants' diversity. DNA bands will help make genetic distances followed by DNA barcoding to prove the parent of origin. The study of clove germplasm in Maluku needs to be supported by information on potential future development uses. The study of potential utilization includes a complete analysis of essential oil components and essential oils' quality (Physico-chemical properties). Information on essential components is useful for evaluating each clove germplasm's potential utilization, while information on the quality of essential oils is important for clove oil trading purposes. The gas chromatography-mass spectro (GC-MS) can provide complete information on the cloves' essential components.

1.2. Objectives

The objectives of the research are:

a. To compile a database of clove varieties, distribution, and ecology in Maluku
b. To obtain data on the morphological and agronomic character of local clove in Maluku
c. To analyze the genetic diversity of cloves in Maluku, followed by SSR marker.
d. To find potential use of local clove in Maluku through analyzing of essential oils component

1.3. Expected Output

After the research finished, the output and outcomes we expect are:

a. At least two articles submitted to a scientific journal (Biotropia)
b. Research report
c. Clove database on website
d. New information on variety and essential oils of clove
e. The future outputs: Book (Clove of Maluku)

2. Benefits and Importance of Conducting Research

This study uses two main parts of the state of the art in the literature review, namely: (1) previous research on morphological and genetic characters, as well as clove essential components, (2) the stages of research that have been carried out and will be carried out on local cloves in Maluku. State of the art can be presented in Figure 1.

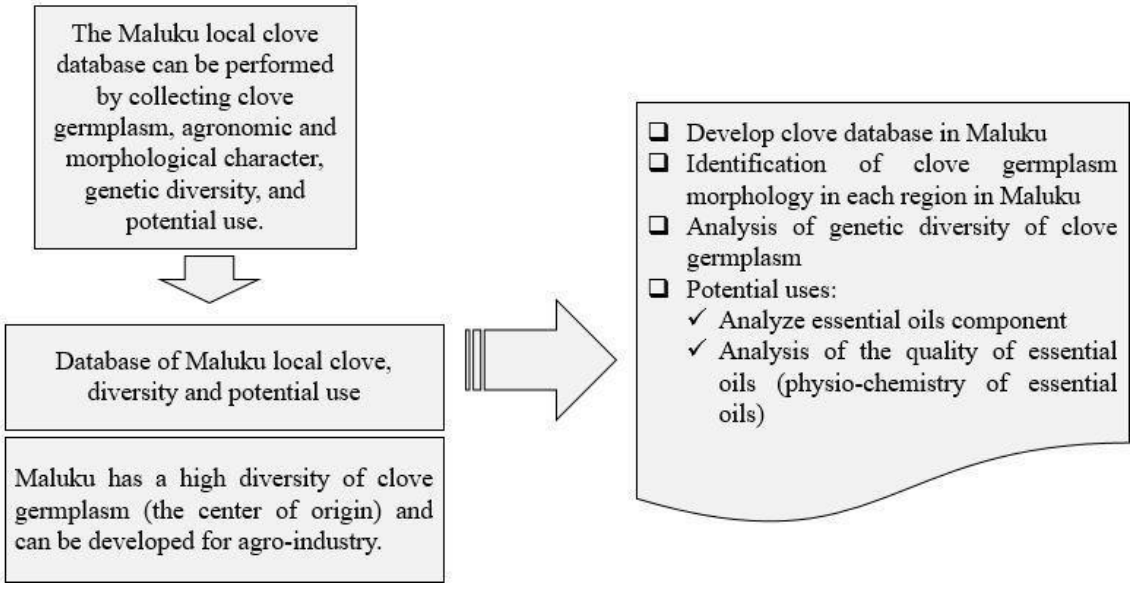

Figure 1. State of the art of the research

The characterization activity is the first step in compiling the clove database. Characterization can be carried out at the morphological or genetic level. Characterization of germplasm accessions can provide information in the development of breeding programs for superior genotype selection (Nascimento et al., 2011). The main characters obtained from the results of plant morphological grouping can be used as a reference for making plant descriptors that can be used in identifying plants (Purnobasuki et al., 2014). Furthermore, plant genetic characterization can be used to see plant diversity at the DNA level. Cloves are classified as plants with cross-pollinating properties so that their diversity can be observed at the DNA level. Genetic markers (molecular markers) can help analyze genetic variation between plants and within clove plant species. Simple sequence repeats (SSR) or microsatellite markers can be used as markers to see genetic diversity (Lee et al., 2007). SSR is classified as a molecular marker that is very effective and codominant with a high level of heterozygosity so that it has a very high degree of differentiation between individuals, and its location can be found in DNA so that it can detect allele diversity at high levels.

The variety of cloves can be evaluated on their potential use based on the essential components. Besides being used as a spice, clove plants can be developed into various

products such as aromatherapy, perfume, flavor, and aroma in food, cosmetics, and various other industrial product. This potential use is because cloves are a plant that produces essential oils. Clove oil is an essential oil that can be extracted from the flowers, leaves, and stalks (Riyanto et al., 2016; Widayat et al., 2014), producing bud oil, leaf oil, and stem oil (Alma et al., 2007; Kamatou et al., 2012; Milind and Deepa, 2011; Nejad et al., 2017; Uddin et al., 2017). The demand for clove essential oil from the distillation of flowers, leaves, and flower stalks is very high in the market (Jentzsch et al., 2017; Milind and Deepa, 2011) because it is widely used in the fields of pharmacology, agriculture, as a flavor and aroma giver in food, cosmetics and various other industries (Bendre et al., 2016; Milind and Deepa, 2011). The production of clove essential oil in Indonesia is considered good quality with high levels of eugenol, which is around 70-90% (Atanasova-Pancevska et al., 2017; Nejad et al., 2017; Uddin et al., 2017). According to Bendre et al. (2016) and Nejad et al. (2017), the quality of clove oil is primarily determined by its eugenol content. The higher the eugenol content, the higher the selling value. Eugenol and its derivatives are useful in various industries such as cigarettes, health, food and beverage, cosmetics, vegetable pesticides, fisheries, active packaging, and others (Towaha, 2012).

Eugenol is a phenylpropanoid with a 164.2 g / mol molecular weight, dissolves in organic solvents, pale yellow, and has a spicy aroma (Kurniawan et al., 2017; Nejad et al. 2017). Eugenol is widely used in pharmacology as an antimicrobial, antioxidant, anti-cancer, while in agriculture, it is used as a food preservative, pesticide, and fumigant; giving aroma and taste to food, cosmetics, and other industries (Bendre et al. 2016; Kamatou et al. 2012; Nejad et al. 2017). Sesquiterpene components found in the wild type clove group are widely used as a phytoalexin, an antibiotic compound for plant protection against microbes and herbivores (antifeedants) (Thelen et al. 2005).

Research Roadmap

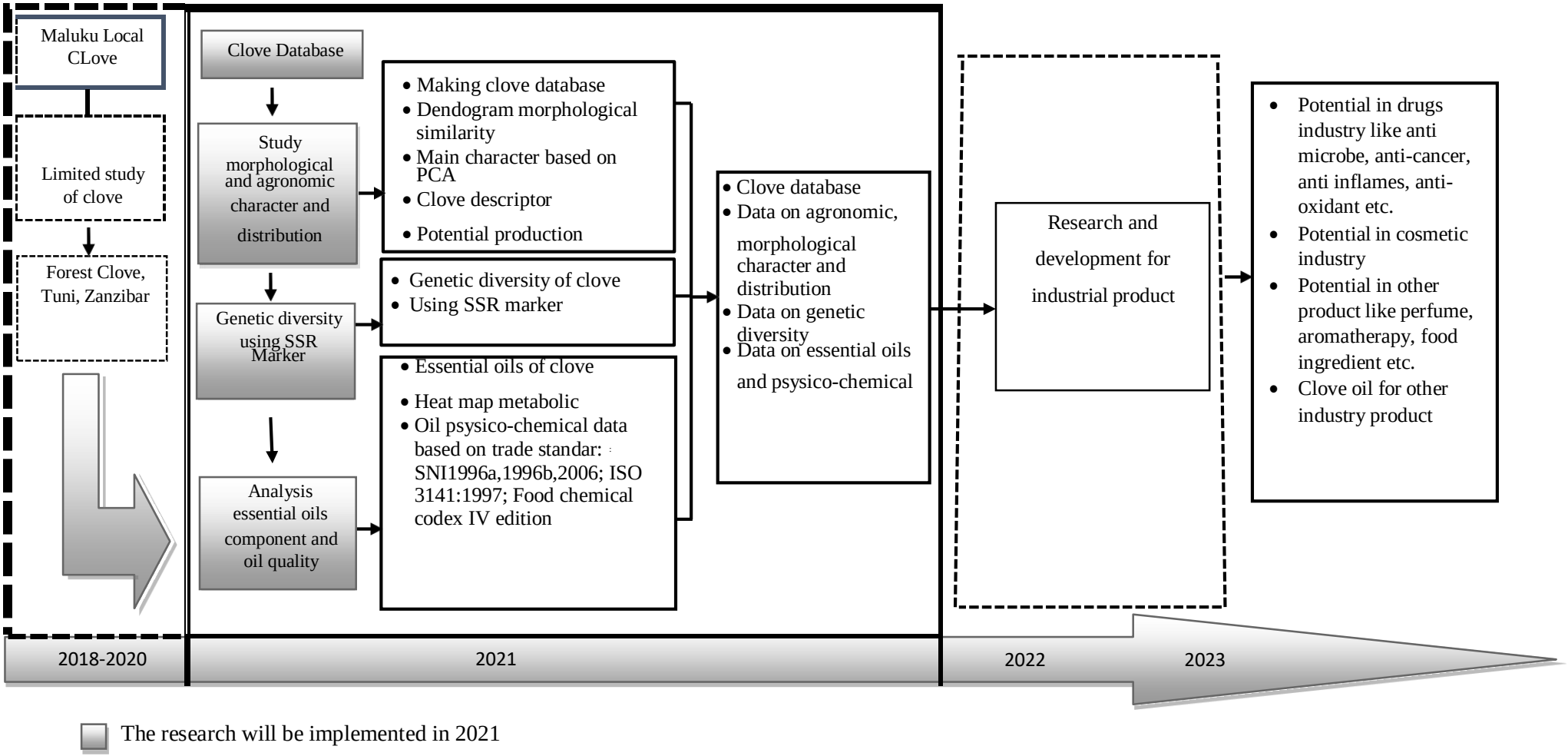

Figure 2. Research roadmap

3. Metodology

Time and Location

The research carried out for nine months, which includes two stages, namely: (a) Compilation of a clove database in the Maluku region, which includes morphological characterization activities, DNA analysis of clove germplasm, and (b) Study of potential utilization which includes activities identification of essential components and quality of essential oils (physico-chemical oil) for development towards agro-industry. Research on the preparation of a clove database in Maluku was carried out by identifying clove germplasm in its distribution area. Research on potential utilization in essential oil studies is planned to be carried out using Gas Chromatography-Mass Spectrometry (GC-MS) at Pattimura University Chemistry Laboratory, Maluku Province

Tools and Materials

The tools include morphological characterization tools (haga meter, meter, caliper, digital balance, ImageJ software, RHS color chart 2015 color scale); equipment for DNA analysis; essential component analysis tools in the form of Gas Chromatography-Mass Spectrometry (GC-MS), namely Agilent Technologies 7890; analysis tools for physico-chemical properties of the oil, namely pycnometer, refractometer, gas chromatography (GC) Agilent Technologies 6890N).

The materials used in the research consisted of trees for morphological characterization in the form of cloves belonging to farmers > 20 years old; material for DNA analysis (sample of clove plant leaves for DNA extraction purposes), 10 SSR primers, according to Risterucci et al. (2005): (mPgCIR01, mPgCIR04, mPgCIR05, mPgCIR07, mPgCIR08, mPgCIR09, mPgCIR14, mPgCIR16, mPgCIR25, Ssa-423); ingredients for essential oil analysis (flowers, stalks, and clove leaves).

Research Implementation

a. Analysis morphological and agronomic character, ecology, and distribution

The compilation of a clove database in the distribution area in Maluku will be carried out by identifying plants in the field. Identification is carried out by characterizing the morphological and genetic characters of clove plants. The location includes three areas that have high clove diversity, namely Central Maluku Regency, West Seram Regency, and Ambon City. Each location will be taken 4 sample villages. Ten plants for each type of clove will be taken, and ten samples of leaves, flowers, fruit and seeds from each plant.

The collection of potential biomass, carbon storage and carbon sequestration was carried out during field measurements in the form of diameter at breast height (dbh) and tree height. Measurements were carried out using a non-destructive approach as proposed by Brown (1997). The selection of sample plots was carried out by purposive sampling, where for each type of clove used 3 replications. The plot used is square with reference to SNI: 7724-2011 (BSN 2011), where the size is 20 mx 20 m for the tree level (diameter >10 cm/around >31 cm), the plot size is 5 mx 5 m for the saplings level (diameter 5 cm – 10 cm / circumference 15-31 cm), plot size 2 mx 2 m for seedlings level (diameter < 5 cm / circumference < 15 cm).

The allometric model for estimating clove biomass used follows the universal allometric equation proposed by Ketterings et al. (2001) namely:

$$w=0.11\ \rho\ D^{2.62}$$

Explanation:

W = biomassa (kg pohon^{-1})

ρ = plant density (g cm^{-3})

D = diameter

Calculation of carbon storage from above ground clove biomass uses the biomass conversion formula that refers to SNI: 7724 – 2011 (BSN 2011):

$$Cb = B \times \%\, C\ organik$$

Explanation:

Cb	= Carbon content of biomass (kg)
B	= Total biomassa (kg)
% C organic	= Carbon content percentage value (0.47) (IPPC 2006).

Calculation of CO2 absorption using the formula (Murdiyarso 1999):

$$W_{CO_2} = C \times FK_{CO_2}$$

Explanation:

W_{CO_2}	: Amount of CO2 absorbed
C	: Carbon (ton ha^{-1})
FK_{CO_2}	: Carbon conversion factor (C) to CO_2 = 3.67

Data on clove morphological characterization was analyzed by Hierarchical Cluster Analysis (HCA) and Principle Component Analysis (PCA) using R Stat 3.1.0 software. To see differences in agro-morphological characters between areas of distribution, Student's t-test was used. Also, soil samples was taken to observe the content, and ecological conditions was observed at the clove location.

b. Genetic diversity

All types of cloves found in the field are genetically grouped through DNA analysis, followed by an SSR marker. DNA isolation of cloves using modified CTAB (Cetyl Trimethyl Ammonium Bromide) (Doyle and Doyle, 1990). DNA was then analyzed using Simple Sequence Repeats (SSR) molecular markers. DNA amplification using 10 primers according to Risterucci et al. (2005) namely mPgCIR01, mPgCIR04, mPgCIR05, mPgCIR07, mPgCIR08, mPgCIR09, mPgCIR14, mPgCIR16, mPgCIR25, Ssa-423.

DNA bands are processed using Gel Analyzer software. Band scoring results are analyzed using Popgene 32 and GenALEx 6.51 programs to obtain data on allele frequency, heterozygosity, and Polymorphic Information Content (PIC). The genetic distance dendogram is made using the Sequential Agglomerative Hierarchical and Nested (SAHN) -UPGMA (Unweighted Pair-Group Method with Arithmetic) program in the NTSYS software version 2.1 (Rohlf, 2000).

c. Analysis essential oils component

Analysis of the essential components of cloves using Gas Chromatography-Mass Spectrometry (GC-MS) in the Agilent Technologies 7890 Gas Chromatograph with Auto Sampler equipped with 5975 mass selective detectors and chemo station data system. The GC-MS clove essential oil components are determined based on comparing the mass spectrum from the NIST 2005 v.2.0 literature and the Wiley 7 library 2003 (Hossain et al., 2012; Wenqiang et al., 2007).

The analysis's component data was processed using R Stat 3.1.0 software to produce a heat map profile for essential oil grouping. The packages used are metabolomics, heat map, shiny heat map, and shiny using the complete linkage agglomeration method and the Euclidean distance matrix.

Oil quality analysis is carried out through physico-chemical analysis of clove oil. The oil's physicochemical analysis parameters include color, specific gravity, refractive index, refractometer, ethanol solubility 70%, and total eugenol. Analysis of the physicochemical properties of clove oil is carried out descriptively.

The physicochemical properties from the flowers, flower stalks, and leaves were compared with the Indonesian National Standard (SNI): 06-4267-1996 for clove flower oil, SNI: 06-4374-1996 for clove flower oil.), and SNI: 06-2387-2006 for clove leaf oil, as well as with International Standards (ISO) 3141: 1997 (E) and Food Chemical Codex Edition IV.

d. Research flow chart

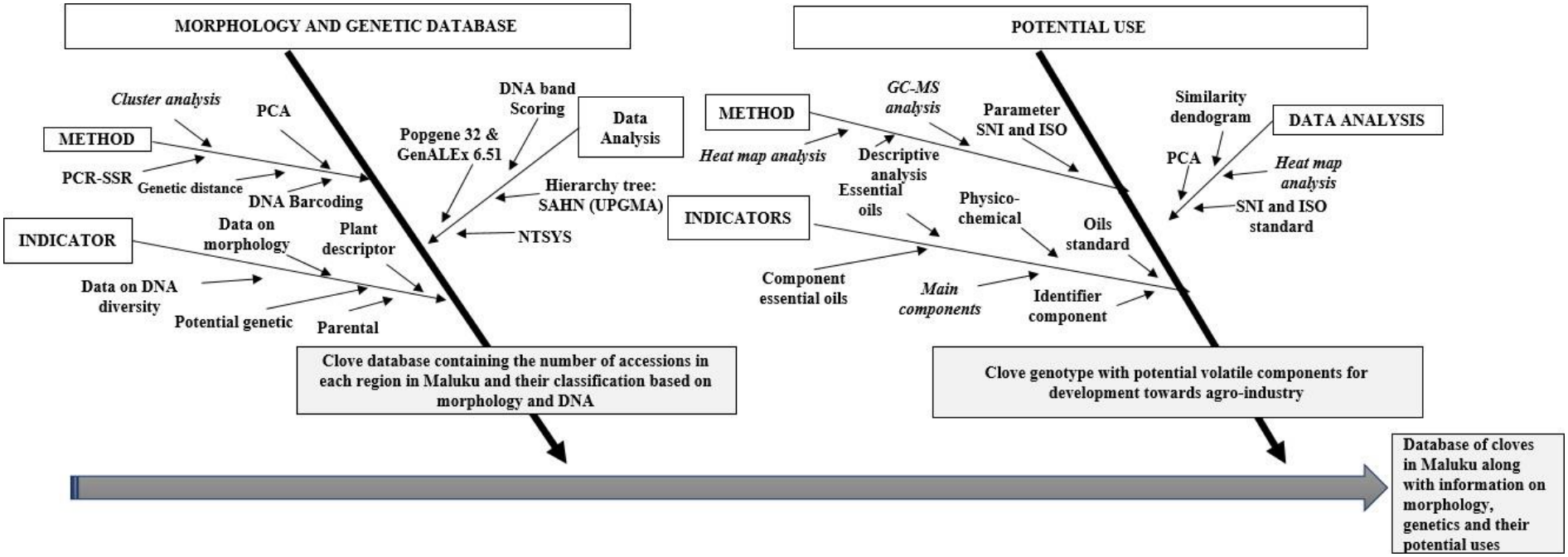

Figure 3. Research flow chart

4. Result and Discussion

A. Database, Morphological Character, Ecology, and Distribution

a. Database Maluku Local Clove

Local cloves in Maluku are spread in several districts and cities in Maluku, including Eastern Seram Regency, Central Maluku Regency, South Buru Regency, Western Seram Regency, Buru Regency, Southwest Maluku Regency, Southeast Maluku Regency, Ambon, and Tual. From these distribution locations, it was identified that the highest local clove diversity was in Central Maluku District and West Seram District, thus becoming the focal point of the research location. The local clove accessions identified in the study included Tuni cloves, Hutan (group I, II, III), Raja (group I and II), Boiselang, Zanzibar (red and white), Bogor, Jinten, Tae, Damar (Table 1). The local clove accession of Tuni is dominantly distributed throughout the Maluku region, while other local clove accessions are concentrated in Central Maluku Regency, especially on Ambon Island and other islands such as Tae cloves on Haruku Island, Central Maluku Regency, and Damar cloves on Seram Island, West Seram Regency.

Table 1. Maluku local clove variety

Clove Variety	Varian	Distribution Area	Type	Status
Tuni	*	All Maluku area	Cultivated/aromatic	Released as a superior variety (SK No.4964/Kpts/SR.120/12/2013)
Forest Clove	Group I (large leaf)	Ambon and Seram Island	Wild type/non-aromatic	Registered
	Group II (medium leaf)	Ambon and Seram Island	Wild type/non-aromatic	Not registered
	Group III (small leaf)	Ambon and Seram Island	Wild type/non-aromatic	Not registered
Raja	Group I (large leaf)	Ambon Island	Wild type/non-aromatic	Not registered
	Group II (small leaf)	Ambon Island	Wild type/non-aromatic	Not registered
Zanzibar	Red shoots	Ambon and Seram Island	Cultivated/aromatic	Not registered
	White shoots	Ambon and Seram Island	Cultivated/aromatic	Not registered
Bogor Clove	*	Ambon and Seram Island	Cultivated/aromatic	Not registered
Boiselang	*	Ambon Island	Wild type/non-aromatic	Not registered
Jinten	*	Ambon and Seram Island	Wild type/aromatic	Not registered

Tae	*	Haruku Island	Wild type/non-aromatic	Not registered
Damar	*	Seram Island	Wild type/non-aromatic	Not registered

Note:* No variant

Of all the clove accessions found, it was identified that there were several variants of the clove accessions found, such as Forest cloves with three variants, Raja with two variants, and Zanzibar with two variants. All of the clove accessions found were partly cultivated clove species, and some were wild-type clove species. The two cloves found are partially aromatic or have a strong aroma, and some are less aromatic (non-aromatic).

The local cloves of Tuni, Zanzibar (red and white), Bogor, and Tae in the study were identified as cultivated cloves from the aromatic group, while the Forest cloves (group I, II, and III) and Raja (group I and II) were wild-type cloves from the non-aromatic group. The Boiselang, Jinten, and Damar cloves found in the study were identified as wild-type cloves but had strong aroma properties similar to cultivated cloves, so they were classified as aromatic wild-type cloves.

From all accessions of local Maluku cloves found, it is known that only Tuni local cloves have been released as superior varieties based on Decree No. 4964/Kpts/SR.120/12/2013, while other local clove accessions are still in the limited assessment stage.

b. Differences in Morphological Characters of Maluku Local Cloves

The Maluku clove accessions had specific characters that differentiated them from other clove accession groups. The measurement of the agro-morphological characters showed significant differences in morphological characters, especially the lower branch height and leaf characters (Table 2). Significant differences in morphological characters were observed in the height of the lowest branch, leaf size (index), leaf length, leaf width, leaf area, and petiole length. The overall agro-morphological characters of Maluku local cloves are presented in Table 2.

Table 2. Comparison of morphological characters of Maluku local cloves

Clove Variety	Lowest Branch Height	Leaf Size (Index)	Leaf Length	Leaf Width	Leaf Area	Leaf Stalk Length
Tuni	4.00±0.22a	2.67±0.16ab	9.46±0.26h	3.55±0.16h	21.26±6.91e	1.50±0.07d
Forest Clove group I	1.388±0.75cde	2.06±0.12f	20.67± 1.60a	9.85±0.80a	180.93±29.86a	2.09±0.39b
Forest Clove group II	2.058±0.52bc	2.07±0.20f	17.89± 1.83b	8.61±0.75b	130.28±28.08b	1.88±0.30bc
Forest Clove group III	0.968±0.40e	2.16±0.11ef	15.13± 1.10c	6.99±94.03c	97.56±22.57c	1.95±0.27bc
Raja group I	2.47±0.78b	2.51±0.06bc	13.39±0.17d	5.33±0.16d	56.74±7.13d	2.00±0.03b
Raja group II	4.10±1.29a	2.89±0.20a	11.15±0.47efg	3.87±0.25fgh	35.54±4.80e	1.50±0.07d
Boiselang	4.0±0.16a	1.77±0.08g	10.14± 0.26gh	5.73±0.15d	37.28±5.24de	1.50±0.05d
Red Zanzibar	1.0±0.20de	2.21±0.14def	10.14± 0.26e	5.31±0.31d	28.27±4.04e	2.00±0.07b
White Zanzibar	1.0±0.16de	2.33±0.11cde	12.20± 0.34de	5.24±0.20d	36.05±5.66de	2.00±0.11b
Bogor	1.0±0.12de	2.42±0.13cd	10.50±0.22fgh	4.35±0.15efg	36.05±5.66e	3.00±0.08a
Jinten	1.50±0.24cde	2.51±0.21bc	9.48± 0.62h	3.79±0.21gh	23.84±4.15e	2.15±0.21b
Tae	0.73±0.14e	2.52±0.22bc	11.38± 0.40ef	4.54±0.30e	32.93±5.95e	1.66±0.19cd
Damar	1.76±0.21bcd	2.54±0.10bc	11.15±0.44efg	4.39±0.11ef	19.30±1.53e	1.66±0.34cd

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Table 3. Agro-morphological character of Maluku local clove

Cove Variety	Varian	Agro-morphological Character	Parameter							Warna*
			Height (m)	Shape	Length (cm)	Width (cm)	Area (cm^2)	Weight wet (g)	Number	
Tuni	-	Tree	10±0.49	Cylinder	-	-	-	-	-	-
		Lower branch	4.00±0.22	Angle 90°	-	-	-	-	-	-
		Leave	-	*Eliptical*	9.46±0.26	3.55±0.16	21.26±6.91	-	-	Old leaves: 141B/deep yellowish green/green group (yellow), spicy aroma
		Flower	-	Funnel	1.95±0.15	0.49±0.03	-	0.37±0.03	15.80±3.79	2D/pale greenish yellow/yellow group
		Flower stalk	-	Lenght	5.05±0.20	-		1.42±0.45	-	141B/deep yellowish green /green group
		Fruit	-	Conical	2.61±017	1.31±010	-	2.76±0.49	-	79A/dark purple/purple group
		Seed	-	Conical	1.94±0.10	0.92±0.06	-	1.14±0.18	-	75B/light purple/purple group
Forest Clove	Group I	Tree	18±0.32	Rounded	-	-	-	-	-	-
		Lower branch	1.388±0.75	Angle 90°	-	-	-	-	-	-
		Leave	-	*Elliptical*	20.67± 1.60	9.85±0.80	180.93±29.86	-	-	Old leaves: 141A/deep yellowish green/green group, the size of the leaves is very large and thick like guava and does not have a spicy aroma.
		Flower	-	Round funnel	2.50± 0.10	0.64±0.05	-	0.86±0.12	17.82± 4.83	154D/light yellow green/yellow green group
		Flower stalk	-	Lenght	6.04± 1.18	-	-	3.88±1.45	-	141A/deep yellowish green/green group
		Fruit	-	Conical	3.24± 0.25	1.70±0.27	-	6.14±2.27	-	59A/dark red/red purple group
		Seed	-	Conical	2.26± 0.29	0.98±0.15	-	1.62±0.50	-	59D/ strong purplish red/red purple group
	Group II	Tree	20±0.67	Rounded	-	-	-	-	-	-
		Lower branch	2.058±0.52	Angle 90°	-	-	-	-	-	-
		Leave	-	*Obovate*	17.89± 1.83	8.61±0.75	130.28±28.08	-	-	Old leaves: 144A/strong yellow green/yellow green group, the size of the leaves is medium and thick and does not have a spicy aroma
		Flower	-	Round funnel	2.21± 0.15	0.56±0.09	-	0.65±0.10	12.35± 3.18	154D/light yellow green/yellow green group
		Flower stalk	-	Lenght	5.25± 0.63	-	-	2.40±0.94	-	144A/strong yellow green/yellow green group
		Fruit	-	Conical	3.23± 0.29	1.90±0.17	-	6.71±2.11	-	59A/dark red/red purple group
		Seed	-	Conical	2.29± 0.23	1.13±0.10	-	2.04±0.51	-	134B/strong yellowish green/green group
	Group III	Tree	15±0.70	Rounded	-	-	-	-	-	-
		Lower branch	0.968±0.40	Angle 90°	-	-	-	-	-	-
		Leave	-	*Elliptical*	15.13± 1.10	6.99±94.03	97.56±22.57	-	-	Old leaves: 143A/strong yellow green/green group, small and thick leaves, not spicy
		Flower	-	Round funnel	2.32± 0.17	0.58±0.05	-	0.57±0.11	13.88± 3.24	154D/light yellow green/yellow green group
		Flower stalk	-	Lenght	5.13± 1.23	-	-	1.93±0.70	-	143A/strong yellow green/green group
		Fruit	-	Conical	2.75± 0.45	1.40±0.27	-	3.72±2.18	-	59A/dark red/red purple group
		Seed	-	Conical	1.95± 0.43	0.89±0.25	-	1.26±0.91	-	59D/strong purplish red/red purple group
Raja	Group I	Tree	16±0.32	Cylinder	-	-	-	-	-	-
		Lower branch	2.47±0.78	Angle 90°	-	-	-	-	-	-
		Leave	-	*Eliptical*	13.39±0.17	5.33±0.16	56.74±7.13	-	-	Old leaves: 131B/dark green/green group, slightly larger in size, morphology similar to cultivated cloves but less spicy aroma
		Flower	-	Funnel	2.3±0.17	0.6±0.04	-	0.50±0.03	15.00±3.89	154D/light yellow green/yellow green group
		Flower stalk	-	Lenght	5.05±0.20	-		1.42±0.45		154D/light yellow green/yellow green group
		Fruit	-	Conical	3.7±017	1.50±010	-	2.57±0.49	-	53C/strong red/red group
		Seed	-	Conical	1.90±0.10	0.90±0.06	-	0.86±0.18	-	47D/deep pink/red group

	Group II	Tree	18±0.67	Cylinder	-	-	-	-	-	-
		Lower branch	4.10±1.29	Angle 90°	-	-	-	-	-	-
		Leave	-	*Eliptical*	11.15±0.47	3.87±0.25	35.54±4.80	-	-	Old leaves: 131B/dark green/green group, leaf size is slightly narrower, lower branch height is higher, and has a morphology similar to cultivated cloves but less spicy aroma
Zanzibar	Red Shoot	Tree	10±0.67	Piramidal	-	-	-	-	-	-
		Lower branch	1.0±0.20	Angle 45°	-	-	-	-	-	-
		Leave	-	*Elliptical*	11.70± 0.71	5.31±0.31	28.27±4.04	-	-	Old leaves: 131B/dark green/green group; shoots: 180B/moderate red/grayed red group; petiole tip:180B/moderate red/grayed red group (shoot and petiole are red)
		Flower	-	Funnel	1.89± 0.09	0.50±0.01	-	0.38±0.02	22.30±10.15	49A/strong pink/red group
		Flower stalk	-	Lenght	4.95± 0.80	-	-	2.15±0.99	-	141B/Deep yellowish green/green group
		Fruit	-	Conical	2.18± 0.10	1.34±0.10	-	2.51±0.32	-	79A/dark purple/purple group/purple group
		Seed	-	Conical	1.47± 0.09	0.73±0.19	-	0.62±0.12	-	75B/light purple/purple group
	White Shoot	Tree	10±1.07	Piramidal	-	-	-	-	-	-
		Lower branch	1.0±0.16	Angle 45°	-	-	-	-	-	-
		Leave		*Elliptical*	12.20± 0.34	5.24±0.20	36.05±5.66	-	-	Old leaves: 131C/moderate green/green group; shoots: 179C/moderate reddish orange/grayed-red group; petiole tip: 180B/moderate red/grayed red group (similar to Zanzibar red but has shoots and petioles that are not red)
Bogor	-	Tree	10±0.67	Piramidal	-	-	-	-	-	-
		Lower branch	1.0±0.12	Angle 45°	-	-	-	-	-	-
		Leave	-	*Elliptical*	10.50± 0.22	4.35±0.15	27.56±1.90	-	-	Old leaves: 131B/dark green/green group; shoots: 180A/moderate red/grayed-red group; petiole tip: 180A/moderate red/grayed red group (top color and petiole color are redder than Zanzibar red)
Boiselang	-	Tree	15±0.97	Slightly rounded	-	-	-	-	-	-
		Lower branch	4.0±0.16	Angle 90°	-	-	-	-	-	-
		Leave	-	*Obovate*,	10.14± 0.26	5.73±0.15	37.28±5.24	-	-	Old leaves: 132B/strong green/green group; very thick leaves; blunt leaf tip, roudend leaf base, flat leaf edge, fragrant and spicy aroma
Jinten	-	Tree	16±0.32	Cylinder	-	-	-	-	-	-
		Lower branch	1.50±0.24	Angle 90°	-	-	-	-	-	-
		Leave	-	*Elliptical*	9.48± 0.62	3.79±0.21	23.84±4.15	-	-	Old leaves:N134B/Deep yellowish green/green group; shoots: N170C/moderate yellowish pink/grayed-orange group; the size of the flower is very small, has a very fragrant and very spicy aroma.
Tae	-	Tree	18±0.97	Cylinder	-	-	-	-	-	-
		Lower branch	0.73±0.14	Angle 90°	-	-	-	-	-	-
		Leave	-	*Elliptical*	11.38± 0.40	4.54±0.30	32.93±5.95	-	-	Old leaves: N134B/Deep yellowish green/green group; thin leaves with prominent and wavy veins.
Damar	-	Tree	20±0.67	Piramidal	-	-	-	-	-	-
		Lower branch	1.76±0.21	Angle 45°	-	-	-	-	-	-
		Leave	-	*Elliptical*	11.15± 0.44	4.39±0.11	19.30±1.53	-	-	Old leaves:139B/moderate yellowish green/green group; lush leaves like a resin tree

***** Color standards based on 2015 RHS color chart criteria

Based on the measurement results, it can be seen that Tuni cloves, Raja cloves group I, and cloves Boiselang have the highest and shortest lower branch height in red Zanzibar, white Zanzibar, Bogor, and Jinten cloves. Raja group I. Based on the measurement results, Raja group IIII had the highest and lowest leaf index in the Forest clove group, but the Forest clove group I, II, III, and cloves Raja group II has the largest length, width, and leaf area of all local Maluku clove accessions. The longest petiole length of all local Maluku clove accessions was shown in Bogor cloves and the shortest in Tuni local cloves, Raja group II, and Boiselang.

c. Grouping of Maluku Local Cloves Based on Hierarchical Cluster Analysis (HCA)

Morphological characterization in the local Maluku clove population was carried out on 13 clove accession groups and their variants, where each accession was represented by ten plants so that there were 130 plants in total. The characterization results show that there is diversity among local clove accession groups in Maluku. The results of Hierarchical Cluster Analysis (HCA) on all local clove accessions of Maluku are presented in Figure 4, while the characterizing characters based on Principle Components Analysis (PCA) are presented in Figure 5.

Based on the results of Hierarchical Cluster Analysis (HCA) it shows that local cloves in Maluku are divided into two large groups with 57% agro-morphological differences, namely the Forest clove accession group (group I, II, III) and Boiselang as the first group and the local clove group. Others as the second group (Tuni, Jinten, Red Zanzibar, White Zanzibar, Bogor, Damar, Tae, Raja group I, and Raja group II). Forest Cloves (group I, II, III) and Boiselang showed 73% similarity in agro-morphological characters based on groupings. The results of further analysis divided the Raja cloves (group I and II) with other local clove groups (Tuni, Jinten, Red Zanzibar, White Zanzibar, Bogor, Damar, and Tae) into two large groups with a morphological difference of 27%.

Group I

This group consisted of accessions of Forest cloves (groups I, II, III) and Boiselang cloves with a morphological difference of 57% with other Maluku local clove groups, while the morphological difference between Forest cloves (groups I, II, III) and Boiselang cloves was 27%. The Forest Cloves in the grouping consisted of 3 variants (group I, II, III), where each variant was represented by ten plants, while the Boiselang clove accession group also consisted of 10 plants. The morphological characters of the Forest and Boiselang clove groups are as follows:

1. Forest Cclove

***Forest Clove group I*:** The first group of this Forest clove had a similarity rate of 88%. Forest clove group I was characterized by the largest leaf and flower morphology but slightly smaller fruit and seeds than group II accessions. Forest clove group I had the longest leaves (20.67 cm), the widest (9.85 cm), and the largest leaf area (180.93 cm2), as well as deep yellow-green leaf color (141A/deep yellowish-green/green group). The flower buds belonging to this group are the longest (2.50 cm), the widest diameter (0.64 cm), the heaviest weight (0.86 g), and the highest number of flowers in each arrangement (17.82 flowers). The color of the ripe flower buds is bright yellow-green (154D/light yellow-green/yellow-green group). The flower stalk is 6.04 cm long, weighs 3.88 g, and is slightly yellowish green (141A/deep yellowish-green/green group). The harvest time of the ripe flowers and the blooming time of this group was one week earlier than the other forest clove accession groups. This group has a fruit length of 3.24 cm, a diameter of 1.70 cm, weight 6.14 g, fruit color is dark red (59A/dark red/red-purple group). The seeds of this group have a length of 2.26 cm, a diameter of 0.98, a weight of 1.62 g, a firm red-purple seed color (59D/strong purplish red/red-purple group).

***Forest Clove group II*.** This second group of forest clove population consists of 90% similarity. Forest Clove group II has a medium leaf size but has the largest fruits and seeds of the other accession groups. The forest clove accessions of this group had leaves with a leaf length of 17.89 cm, a width of 8.61 cm, and a leaf area of130.28 cm2. Leaf color is a firm yellow-green (144A/strong yellow-green/yellow-green group). The ripe flower bud has a length of 2.21 cm, a width of 0.56 cm, a weight of 0.65 g. The color of the ripe flowers is bright yellow-green (154D/light yellow-green/yellow-green group). In addition, the number of flowers in each arrangement of members of this group is, on average, the least among the forest clove group, which is about 12.35 flowers. The longest flower stalk is 5.25 cm, weighs 2.40 g, and has a firm yellow-green color (144A/strong yellow-green/yellow-green group). Fruits and seeds of members of this group are the largest and slightly rounded from other accession groups. Fruit length 3.23 cm, diameter 1.90 cm, weight 6.71 g, fruit color is dark red (59A/dark red/red-purple group). The seeds of this group have a length of 2.29 cm, a diameter of 1.13 cm, a weight of 2.04 g, a firm yellow-green color (134B/strong yellowish green/green group).

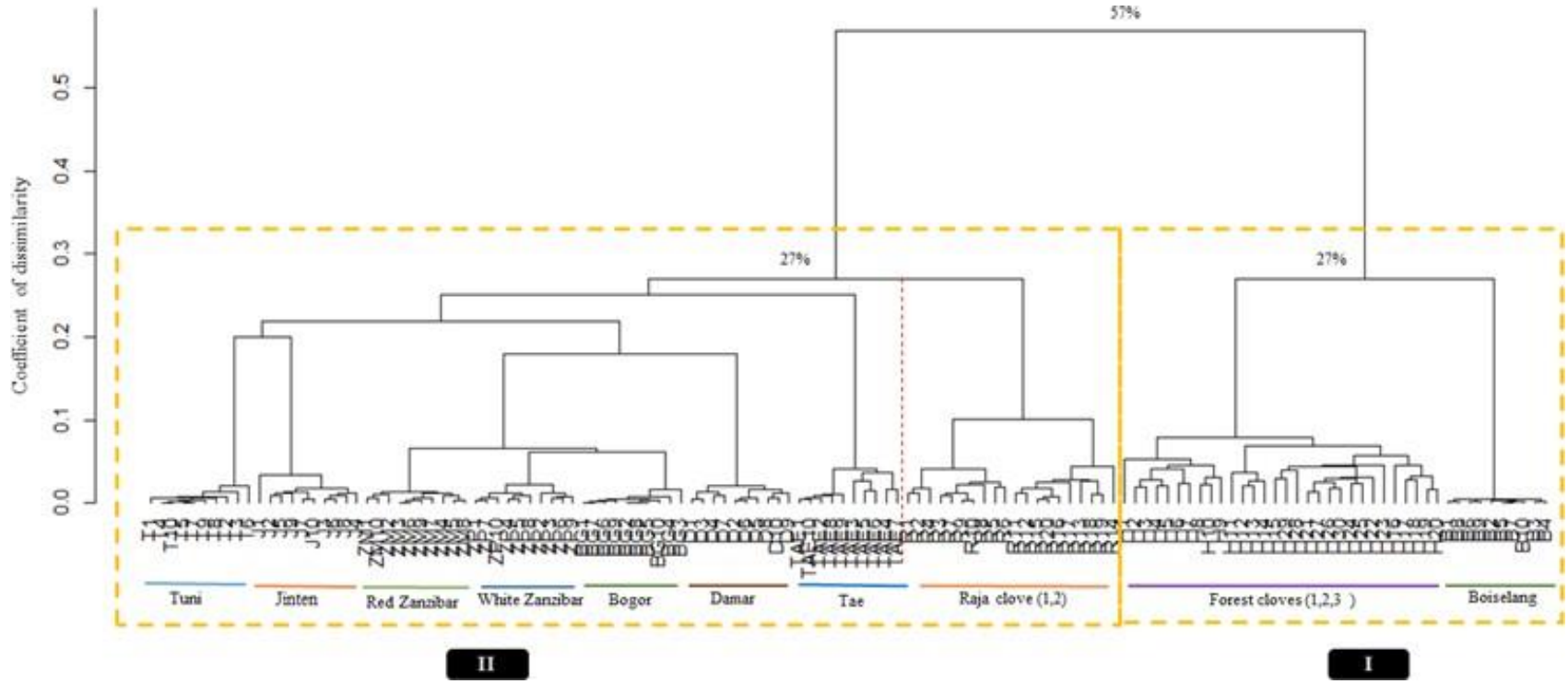


Figure 4. Dendrogram of 13 Maluku local clove Maluku based on morphological characters. Tuni (T1-T10), Jinten (J1-J10), Red Zanzibar (ZM1-ZM10), White Zanzibar (ZP1-ZP10), Bogor (BGR1-BGR10), Damar (D1-D10), Tae (T1-T10), Raja (R1-R10), Forest Clove (H1-H30), Boiselang (B1-B10).

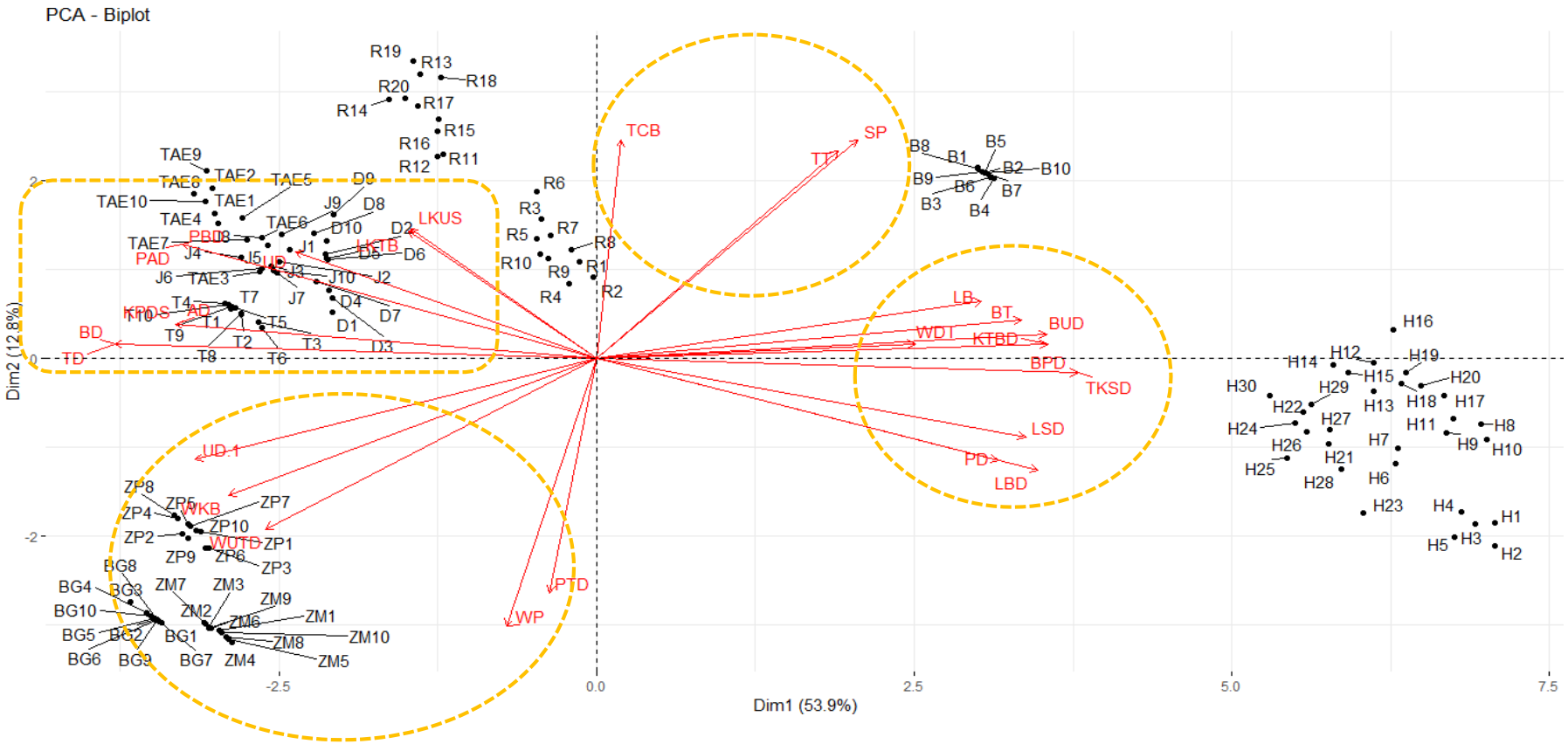


Figure 5. Principle Component Analysis (PCA) 13 Maluku local clove with 32 morphological character.

TT= plant height, LB= stem circumference, WKB= bark color, BT= canopy shape, LKUS= north-south canopy thickness, LKTB= east-west canopy width, SP= branching angle, TCB= lowest branch height, UD= leaf size, PD= leaf length, LBD= leaf width, LSD= leaf area, PTD= petiole length, BD= leaf shape, BUD= leaf tip shape, BPD= leaf base shape, PAD= leaf top surface, TD= edge leaf, UD = leaf veins, KTBD = leaf thickness, TKSD = leaf texture, WDT = dark leaf color, WP = shoot color, WUTD = leaf tip color, AD = leaf aroma, KPDS = leaf spiciness. Tuni (T1-T10), Jinten (J1-J10), Red Zanzibar (ZM1-ZM10), White Zanzibar (ZP1-ZP10), Bogor (BGR1-BGR10), Damar (D1-D10), Tae (T1 -T10), Raja (R1-R10), Forest Cloves (H1-H30), Boiselang (B1-B10).

Forest Clove group III. The last group of Forest clove population consisted of 10 accessions with a 92% similarity level. The most prominent character of the population members of this group was the smallest leaf, flower, fruit, and seed size of the whole forest clove access group. Forest Clove group III had the shortest leaves (15.13 cm), the narrowest leaf width (6.99 cm), the smallest leaf area (97.56 cm^2), and firm yellow-green leaf color (143A/strong yellow-green/green group). . The flower buds belonging to this group were the shortest (2.32 cm), the smallest flower diameter (0.58 cm), the lightest flower weight (0.57 g), but the number of flowers was more than the group II accessions, namely 13.88 flowers. The color of the ripe flowers is bright yellow-green (154D/light yellow-green/yellow-green group). The flower stalk of this group has a length of 5.13 cm, a weight of 1.93 g, and the color of the flower stalk is a firm yellow-green (144A/strong yellow-green/yellow-green group). The harvest time of ripe flowers and blooming time of flowers in this group is also the slowest of all Forest clove groups but has the fastest physiological fruit ripening time of all Forest clove groups. The harvesting time of ripe flowers for members of this group accession is two weeks compared to group I accessions and one week compared to members of group II accessions. In addition, members of this group had the shortest average fruit length (2.75 cm), the smallest fruit diameter (1.40 cm), and the lightest fruit weight (3.72 g) and dark red color (59A/dark red/red-purple group).). The seeds of this group are, on average, the shortest (1.95 cm), the smallest diameter (0.89 cm), and the lightest weight (1.26 g) and have a firm red-purple color (59D/strong purplish red/red-purple group).

Figure 6. Forest Clove group I (A, B, C, D), group II (E, F, G, H), groupIII (I, J, K, L).

2. Boiselang

The Boiselang clove accession group consisted of 10 accessions with 99% similarity. The most prominent character of the population members of this group is the shape and thickness of the leaves, which are similar to forest cloves but have a spicy aroma similar to cultivated cloves. Accession members of this group have an average tree height of 15 m, the shape of the crown is slightly rounded, the branching angle is 900, the lowest branch height is 4 m, the leaves are very thick, the leaf shape is obovate, the leaf tip is blunt, the leaf base is rounded, the leaf edge is flat with leaf veins very prominent. This group has a leaf size (index) of 1.77, an average leaf length of 10.14 cm, a leaf width of 5.73 cm, a leaf area of 37.28 cm2, a petiole length of 1.50 cm, the color of the tip of the petiole is brownish yellow (165B/brownish-orange/grayed orange group). , firm dark green leaf color (132B/strong green/green group), firm yellow shoot color (132B/strong yellow/yellow-green group), fragrant and spicy leaf arom.

Figure 7. Boiselang

Group II.

The second group consisted of Tuni, Jinten, Red Zanzibar, White Zanzibar, Bogor, Damar, Tae, and Raja. The second group has the most prominent differences from the first group in leaf shape and aroma. This group has an elliptical leaf, is relatively thin, and has a spicy aroma compared to the first group. However, each of these accession groups has a distinguishing morphological character among the others.

1. Tuni

Tuni belongs to the aromatic group of cloves and has been released as a superior variety based on the Decree of the Minister of Agriculture No. 4964/Kpts/SR.120/12/2013. The most prominent character is the elliptical leaf shape, dark yellow-green leaf color (141B/Deep yellowish green/green group), and has a distinctive aroma of fragrant leaves and spicy flowers. Tuni had a leaf size (index) of 2.67, an average leaf length of 9.46 cm, a leaf width of 3.55 cm, a leaf area of 21.26 cm2, a petiole length of 1.50 cm, the color of the tip of the petiole yellowish pink, dark yellow-green leaf color, yellowish-green shoot color and fragrant and spicy leaf aroma.

Figure 8. Tuni

2. Jinten

Jinten is an aromatic clove with the most prominent characteristics of this group is its narrow leaf size and the smallest flower bud of all Maluku local cloves and has a very fragrant leaf and flower aroma. Jinten had a leaf size (index) of 2.51, an average leaf length of 9.48 cm, a leaf width of 3.79 cm, a leaf area of 23.84 cm2, a petiole length of 2.15 cm, the color of the petiole tip yellowish pink, leaf color is deep yellowish-green, yellowish-pink shoot color and the aroma of the leaves are very fragrant and spicy.

Figure 9. Tae

3. Zanzibar

Zanzibar cloves are classified as cultivated cloves from the aromatic group. The Zanzibar clove accession group was divided into two variants, namely red Zanzibar and white Zanzibar. The two variants have a similarity of 93%, with a difference of 7%. The primary difference between the two variants lies only in the color of the old leaves and the color of the shoots. Red Zanzibar has dark green leaves with medium red shoots, while white Zanzibar has medium green leaves with medium yellowish-red shoots.

Red Zanzibar: The red Zanzibar clove accession group consisted of 10 accessions with a 98% similarity level. Accession members of this group have an average tree height of 10 m, pyramidal crown shape, branch angle of 450, lowest branch height 1 m, medium leaf thickness, elliptical leaf shape, sharp leaf tip, acute leaf base, wavy leaf margin, and leaf veins not stand out. This group had leaf size (index) 2.21, average leaf length 11.70 cm, leaf width 5.31 cm, leaf area 28.27 cm2, petiole length 2 cm, leaf tip medium red (180B/moderate red/grayed red group). , leaf color is dark green (131B/dark green/green group), the shoot color is medium red (180B/moderate red/grayed red group), and the aroma of the leaves is fragrant and spicy. Red Zanzibar cloves have an average flower length of 1.89 cm, flower diameter 0.50 cm, flower weight 0.38 g, and flower bud color is strong pink (49A/strong pink/red group). The fruit is 2.18 cm long, 1.34 cm wide, weighs 2.51g, conical in shape, and has a dark purple color (79A/dark purple/purple group). Red Zanzibar clove seeds have an average length of 1.47 cm, diameter of 0.73 cm, the weight of 0.62 g, conical in shape, and light purple (75B/light purple/purple group).

White Zanzibar: The white Zanzibar clove accession group consisted of 10 accessions with a 96% similarity level. Accession members of this group have an average tree height of 10 m, pyramidal crown shape, branch angle of 450, lowest branch height 1 m, medium leaf thickness, elliptical leaf shape, sharp leaf tip, acute leaf base, wavy leaf margin, and leaf veins. not stand out. This group had leaf size (index) 2.33, average leaf length 12.20 cm, leaf width 5.24 cm, leaf area 36.05 cm2, petiole length 2 cm, petiole tip color medium red (180B/moderate red/grayed red group). Medium-dark green leaf color (131C/moderate green/green group), medium yellowish-red shoot color (179C/moderate reddish orange/grayed-red group), and fragrant and spicy leaf aroma.

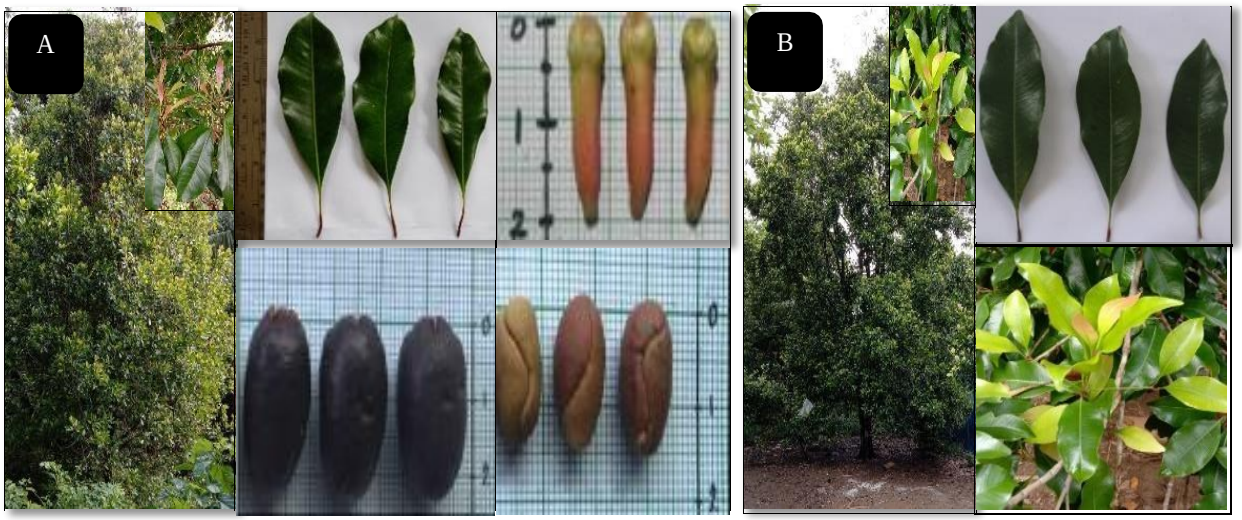


Figure 10. Red Zanzibar (A) and White Zanzibar (B)

4. Bogor Clove

The Bogor clove accession group consisted of 10 accessions with a 97% similarity level. Bogor cloves are almost similar to red Zanzibar cloves, but the most prominent differences are the shoots and petioles that look redder, and the leaf size is slightly smaller with slightly longer petioles than red Zanzibar cloves. Accession members of this group have an average tree height of 10 m, pyramidal crown shape, branch angle of 450, lowest branch height 1 m, medium leaf thickness, elliptical leaf shape, sharp leaf tip, acute leaf base, wavy leaf margin, and leaf veins not stand out. This group has a leaf size (index) of 2.42, an average leaf length of 10.50 cm, a leaf width of 4.35 cm, a leaf area of 27.56 cm2, a petiole length of 3 cm, the color of the tip of the petiole is medium red (180A/moderate red/grayed red group), dark green leaf color (131B/dark green/green group), medium red shoot color (180A/moderate red/grayed-red group), and fragrant and spicy leaf aroma.

Figure 11. Bogor Clove

5. Damar Clove

Damar is classified as an aromatic clove with the character of a tall tree with lush leaves and a dark color similar to a Damar tree. Damar has a leaf size (index) of 2.54, an average leaf length of 11.15 cm, a leaf width of 4.39 cm, a leaf area of 19.30 cm2, a petiole length of 1.66 cm, the color of the petiole tip reddish-orange, dark green leaves, moderate orange shoot, fragrant and spicy leaf.

Figure 12. Damar Clove

6. Tae

The Tae clove accession group consisted of 10 accessions with a 95% similarity level. Tae local cloves are aromatic with prominent characters, namely a tall tree with thin leaves and prominent and wavy leaf bones. Accession members of this group have an average tree height of 18 m, cylindrical crown shape, branch angle of 900, lowest branch height 0.73 m, thin leaves, elliptical leaf shape, sharp leaf tips, acute leaf bases, and wavy leaf edges. This group had a leaf size (index) of 2.52, an average leaf length of 11.38 cm, a leaf width of 4.54 cm, a leaf area of 32.93 cm2, a petiole length of 1.66 cm, the color of the tip of the petiole dark reddish-orange (178B/dark reddish-orange/grayed red group), dark green leaf color is dark yellow (N134B/Deep yellowish green/green group), shoot color is medium yellowish pink (179D/moderate yellowish pink/grayed red group). The aroma of the leaves is fragrant and spicy.

Figure 13. Tae

7. Raja

Raja was classified as non-aromatic cloves with morphological characters similar to cloves cultivated in the aromatic group, but the leaves and flowers do not smell like forest cloves. The Raja accession group was divided into two variants with 90% similarity. The difference between the two variants is 10%. The primary difference between the two variants lies only in the size of the leaves and the height of the lowest branches. Cloves of the first group had slightly larger leaf length and width, but the first branch height was slightly lower than the second group.

Raja group I: This group consisted of 10 accessions with 95% similarity. Accession members of this group have an average tree height of 16 m, cylindrical crown shape, branch angle of

900, lowest branch height 2.47 m, thick leaves, elliptical leaf shape, sharp leaf tips, acute leaf bases, wavy leaf margins, and leaf veins. Currently, this group has a leaf size (index) of 2.51, an average leaf length of 13.39 cm, a leaf width of 5.33 cm, a leaf area of 56.74 cm2, a petiole length of 2 cm, the color of the tip of the petiole reddish-orange (173B/moderate reddish orange/grayed orange group), dark green leaf color (131B/dark green/green group), strong yellow-green shoot color (142A/strong yellow-green/green group), and leaves and flowers with no spicy aroma. Flower members of this group have an average length of 2.3 cm, flower diameter 0.60 mm, flower weight 0.5 g, and flower bud color is bright yellow-green (154D/light yellow-green/yellow-green group), concave fruit circumference with bright red fruit color similar to guava fruit. The fruit has an average length of 3.7 cm, width 1.5 cm, weight 2.57 g, conical shape, and a dark purple color (53C/strong red/red group). Seeds have an average length of 1.9 cm, diameter 0.9 cm, weight 0.86 g, conical in shape, and dark pink in color (47D/deep pink/red group).

Raja group II: This group consisted of 10 accessions with 95% similarity. Accession members of this group have an average tree height of 18 m, cylindrical crown shape, branch angle of 900. The lowest branch height is slightly higher at 4.10 m, with thick leaves, elliptical leaf shape, sharp leaf tips, acute leaf bases, wavy leaf edges, and medium leaf veins. This group has a slightly smaller leaf size than the first group. Members of this group have a leaf size (index) of 2.89, an average leaf length of 11.15 cm, a leaf width of 3.87 cm, a leaf area of 35.54 cm2, a slightly shorter petiole length of 2 cm, the color of the tip of the petiole reddish-orange (173B/moderate). reddish-orange/grayed orange group), dark green leaf color (131B/dark green/green group), strong yellow-green shoot color (142A/strong yellow-green/green group), and leaves and flowers with a less spicy aroma.

Figure 14. Raja group I (left) and group II (right)

d. Analysis Main Character using Principle Component Analysis (PCA)

Principle Component Analysis (PCA) results on 32 agro-morphological characters in 130 local clove accessions of Maluku. The analysis results describe the total diversity of 66.7%, and there are four groups of characters based on the grouping. Based on the grouping, the main characterizing character is indicated by the character with the longest vector. The first group consisted of leaf length, leaf width, leaf area, leaf thickness, leaf texture, leaf tip shape, leaf base shape, old leaf color, stem circumference, and crown shape. This character is indicated to be a character that characterizes local forest cloves. The second group consisted of plant height and branching angle, which were the characteristics of local cloves of Boiselang. The third group was the character of leaf shape, leaf aroma, leaf spiciness, leaf index, upper and lower leaf surfaces, north-south canopy thickness, east-west canopy width. The character is indicated as a character that characterizes local cloves Tae, Jinten, Damar, Tuni, and Raja. The fourth group is shoot color, petiole tip color, leaf veins, stem bark color, and leaf stalk length. These characters are indicated as characterizing local cloves of red Zanzibar, white Zanzibar, and Bogor cloves.

e. Ecology, distribution and potential of local clove biomass, carbon storage and carbon sequestration in Maluku

1. Ecology of Maluku Local Clove

Local cloves in Maluku grow in various agro-climatic conditions. Forest Cloves Group I, II, III, Boiselang cloves, Tuni, Jinten, red Zanzibar, White Zanzibar, Bogor, Raja (group I, II) and Tae research results are in Central Maluku Regency, while Damar cloves are on Seram Island, Seram Regency West Region. The agro-climatic conditions at local clove distribution locations in Maluku are presented in Figure 15.

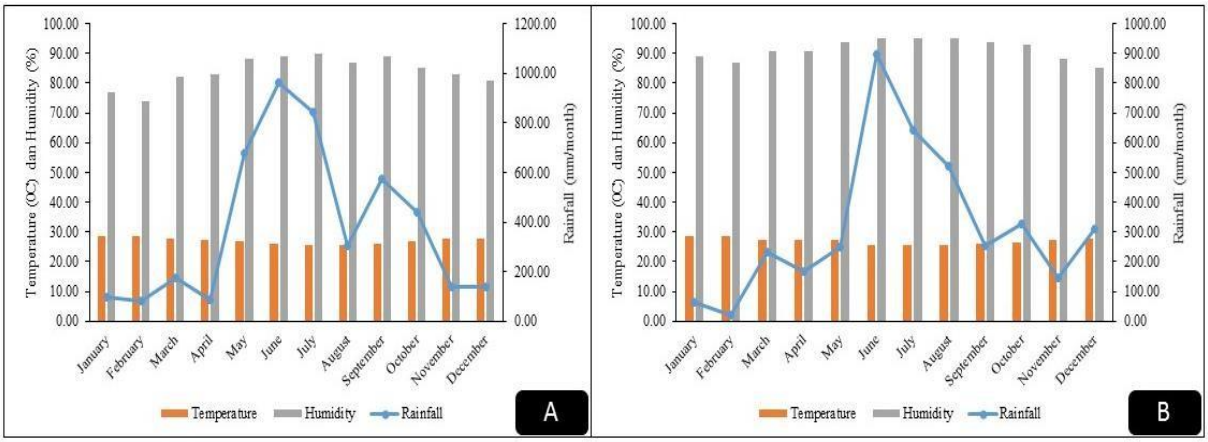


Figure 15. Climatic conditions in the local clove distribution area in Maluku; Central Maluku Regency (A), West Seram Regency (B) (BMKG Maluku 2020)

Based on climate data in 2020, Central Maluku Regency where the distribution of Forest cloves Group I, II, III, Boiselang cloves, Tuni, Cumin, red Zanzibar, White Zanzibar, Bogor, Raja groups I, II, and Tae cloves has higher annual rainfall which is 4516 mm per year with an average monthly rainfall ranging from 376.33 mm per month. Central Maluku Regency has an average monthly air temperature of 27.06 ^{o}C with an average humidity of 84% (BMKG Maluku 2020).

The Damar clove distribution area in West Seram Regency has a slightly lower rainfall of 3 833.40 mm per year with an average monthly rainfall of 319.45 mm per month. West Seram Regency has an average air temperature of 26.92 ^{o}C with an average humidity of 91.42% (BMKG Maluku 2020).

In addition to the agro-climate, local Maluku cloves in their distribution area are also affected by edaphic (soil) conditions (Table 4). The results of soil analysis informed that the soils in the distribution areas of Forest cloves (groups I, II, III), Boiselang cloves, Tuni, Jinten, red Zanzibar, White Zanzibar, Bogor, Raja (groups I and II), and Tae cloves in Central Maluku Regency has a sandy loam texture, the pH is close to neutral (6-7), except for Tae cloves located on Haruku Island, Central Maluku Regency with a clay texture with a slightly acidic soil pH (5.89). The distribution area of Forest cloves (groups I, II, III), Boiselang cloves, Tuni, Cumin, red Zanzibar, White Zanzibar, Bogor, Raja (groups I, II), and Tae cloves in Central Maluku Regency has a moderate total N content (0.18-0.28%), moderate to high P2O5 content (5.20-29.87). The Damar clove distribution area in West Seram Regency has a sandy loam soil texture, pH close to neutral (6.32), moderate N-total content (0.20%), very high P2O5 content (31.07 ppm).

Table 4. Results of soil analysis of local clove distribution in Maluku

Parameter		Unit	Location					
			Hitulama-Hitumesing Village	Mamala Village	Wakasihu Village	Seith Village	Oma Village	Loki Village
C organic (%)		%	2.38	2.19	4.48	4.04	4.20	3.06
N-Total (%)		%	0.25	0.18	0.28	0.24	0.25	0.20
C/N ratio		-	10.00	12	16	17	17	15
Available P_2O_5 ppm		ppm	29.87	9.93	5.20	7.50	4.78	31.07
Potential P_2O_5		mg/100 g	12.27	9.75	11.07	13.34	45.92	89.96
Potential K_2O		mg/100 g	50.53	119.41	115.08	239.63	117.05	457.47
Cations are interchangeable	K+ (cmol/kg)	cmol/kg	0.49	0.85	0.84	0.84	0.13	0.34
	Na+ (cmol/kg)	cmol/kg	0.22	0.11	0.40	0.28	0.08	0.08
	Ca++ (cmol/kg)	cmol/kg	3.10	5.70	27.82	27.66	12.29	11.35
	Mg++ (cmol/kg)	cmol/kg	0.29	1.84	25.72	18.35	1.26	1.41

Acid	Al-d (cmol/kg)	cmol/kg	0.00	0.40	0.46	0.38	0.67	0.26
	H-dd (cmol/kg)		0.46	0.01	0.16	0.11	0.06	0.18
KTK (cmol/kg)		cmol/kg	15.01	9.44	43.37	36.12	15.39	11.16
Base saturation		%	27.35	90.04	100	100	89.41	100
pH	H2O	-	6.56	6.75	6.76	6.62	5.89	6.32
	KCl		4.80	5.44	5.25	5.34	4.76	3.06
Texture of 3 fractions	Sand (%)	%	48.85	78	22	47	28	60
	Dust (%)	%	33.84	15	31	32	11	23
	Clay (%)	%	17.31	17	47	21	61	17

2. Distribution of Maluku Local Clove

Local cloves in Maluku are scattered in several districts and cities in Maluku. The study results found a high diversity of cloves in the Central Maluku District and West Seram District (Figure 16). In the Central Maluku district on Ambon Island, local cloves were found, Tuni cloves in Seith Village, Forest cloves (groups I, II, III) and Boiselang cloves in Hitulama and Hitumesing villages, Raja cloves (groups I and II), red Zanzibar and Bogor cloves in Mamala, while white Zanzibar and Cumin in Wakasihu Village. Tae local cloves are also found in Central Maluku Regency but are in Oma Village, Kec. Haruku Island, Maluku Regency. In the western part of Seram Regency on Seram Island, precisely in Tanah Goyang Hamlet, Loki Village, local cloves of Damar were found.

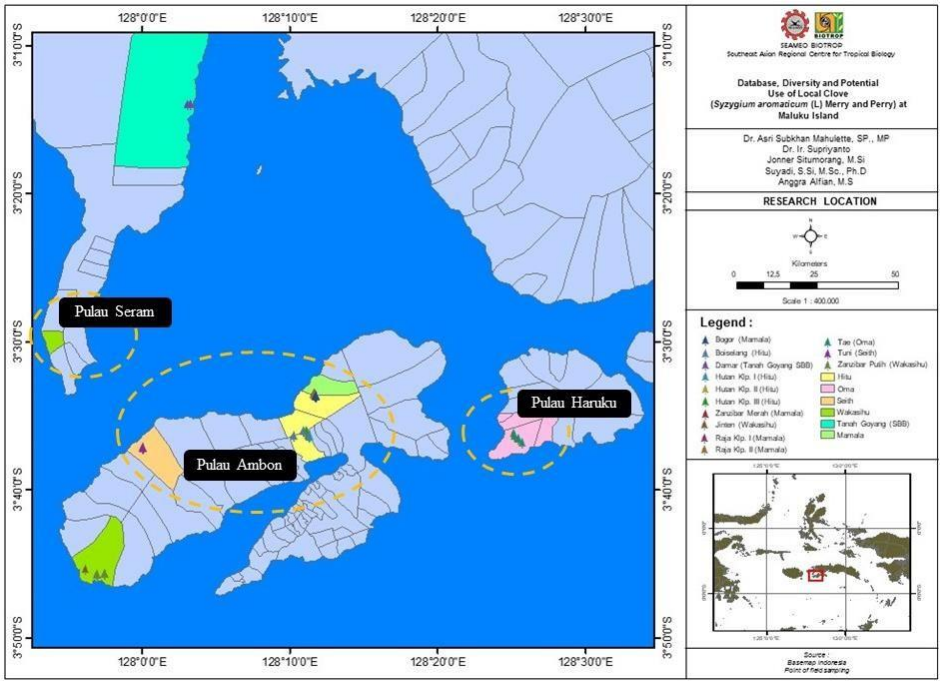


Figure 16. Location of Maluku Local Clove. Forest cloves (group I, II, III), Boiselang, Tuni, Jinten, Zanzibar, Bogor, Raja (group I, II) (A), Tae cloves (B), Damar cloves (C)

3. Potential Biomass, Carbon Storage, and Carbon Sequestration of Local Cloves of Maluku

a. Potential biomass, carbon storage and carbon sequestration in Maluku's local clove cultivation system

Estimation of individual above-ground clove forest biomass in this study followed the allometric equation proposed by Ketterings et al. (2001), plant carbon storage followed the biomass conversion formula SNI: 7724 – 2011 (BSN 2011), and the estimation of carbon absorption was based on the Murdiyarso formula (1999).

The results of observations of biomass content, carbon storage, and carbon sequestration of the Maluku local clove cultivation system in the entire observation plot are presented in Table 5. Measurements were carried out on 13 local clove cultivation systems, where the location of each clove type consisted of 3 measurement plots (Figure 17). , following the carbon measurement standard, namely SNI: 7724 – 2011 (BSN 2011)

The table also compares the biomass content, carbon storage, and carbon sequestration between various local Maluku clove cultivation systems. Furthermore, the biomass in the local Maluku clove cultivation system was compared with the percentage of land cover (Figure 18).

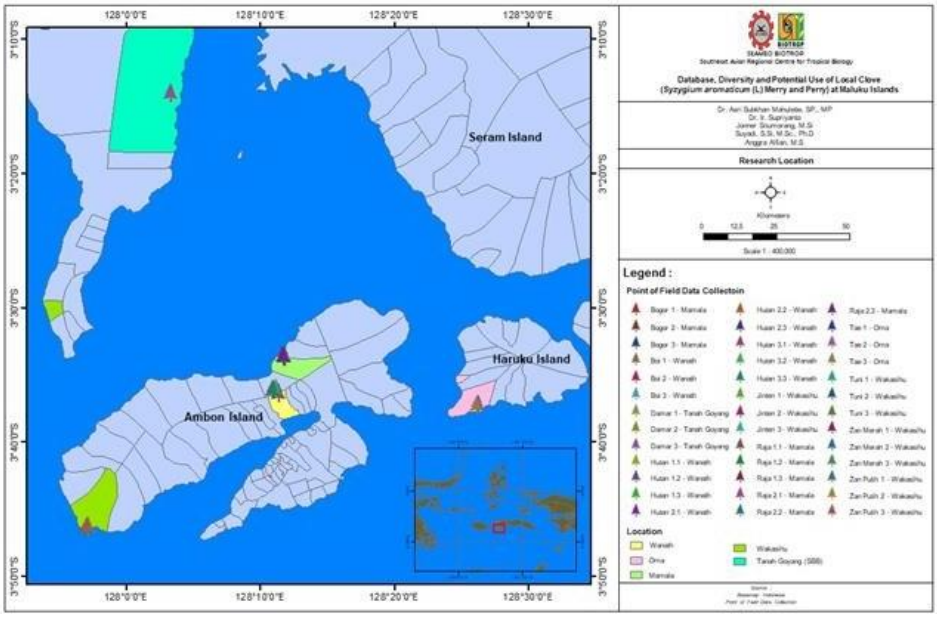


Figure 17. Location of carbon measurement in local clove cultivation system in Maluku

The overall measurement of the local Maluku clove cultivation system showed that the Raja group I clove cultivation system with other plant compositions consisting of coconut, walnuts, durian, and mangosteen had the highest average biomass content of 403.71 tons ha-1, carbon storage 189.74 tons ha. -1, and carbon sequestration of 696.36 tons ha-1. The Damar clove cultivation system had the second-highest measurement yield even without other plant

compositions, where the average biomass content was 310.71 tons ha-1, carbon storage was 146.03 tons ha-1, and carbon uptake was 535.94 tons ha-1. Although Damar cloves are grown without any other plant composition, they have a large biomass content, carbon storage, and carbon uptake because they have the characteristics of large stem and crown diameters and lush plant leaves similar to the Damar tree.

The Bogor clove cropping system in the study had the lowest mean measurement results for the whole clove cultivation system. This is because the age of the Bogor clove plants analyzed is on average > 15 years old, and there is no other vegetation. The average biomass content of the Bogor clove cultivation system obtained was 72.08 tons ha-1, carbon storage 33.88 tons ha-1, with carbon sequestration 124.34 tons ha^{-1}.

Table 5. Average biomass content, carbon storage, and carbon sequestration of various local Maluku clove cultivation systems aged >15 years*)

Local Clove Population	**Biomass (ton/ha)**	**Carbon Stock (ton/ha)**	**Carbon Absorption (ton/ha)**
Forest Clove group I	107.711±183.81	69.21±118.09	254.01±433.40
Forest Clove group II	88.077±150.07	57.16±97.52	209.79±357.91
Forest Clove group III	51.693±87.77	49.72±85.09	182.46±312.28
Raja group I	**403.711±698.27**	**189.74±328.19**	**696.36±1204.45**
Raja group II	266.042±459.72	125.04±216.07	458.90±792.96
Tuni	114.781±194.51	53.95±91.42	197.99±335.50
Red Zanzibar	98.300±166.24	46.20±78.13	169.56±286.74
White Zanzibar	138.167±238.50	64.94±112.10	238.32±411.39
Bogor	**72.084±123.32**	**33.88±57.96**	**124.34±212.71**
Boiselang	84.476±144.33	39.70±67.83	145.71±248.95
Jinten	135.857±233.69	63.85±109.83	234.34±403.09
Tae	149.662±257.81	70.34±121.17	258.15±444.69
Damar	**310.707±536.44**	**146.03±252.13**	**535.94±925.31**

Noted: *) Not include C litter, C-humus and C-soil

According to Langi (2011), biomass will increase until a certain age (the diameter class representative expresses age), and then the increase will decrease until it finally stops productive (dead). In addition, other factors such as the diversity of tree species, soil types, and tree age and management methods also determine the amount of carbon stored (Hairiah and Rahayu 2007). The amount of biomass is determined by the diameter of the plant, which will directly determine the carbon storage and carbon uptake of the plant. Elias and Wistara (2009) suggested that the larger the diameter of the plant in the stand, the greater the carbon storage. Furthermore, it is said that the older the stand, the greater the carbon storage. This shows that the amount of carbon storage and carbon sequestration in the stand is highly dependent on the amount of biomass because biomass is composed of 45-50% carbon (Brown 1997). Therefore,

an increase in biomass is followed by an increase in the amount of carbon storage and carbon sequestration.

The results of the biomass measurement in the clove cultivation system also show the amount of land cover. The Raja group I clove cultivation system, which had the highest biomass in the study, had a land cover percentage of 62.58%. The study's highest percentage of land cover was found in the Damar clove cultivation system, which was 71.42%. The lowest percentage of land cover was found in the Tae clove cultivation system, which was 60.80%. The percentage of land cover is largely determined by other vegetation in the clove cultivation system. In addition, the spacing of cloves used and the morphological characteristics of clove plants also affected the amount of cover. The Raja group I clove cropping system in this study has other vegetation that is quite dense. The vegetation includes coconut, walnuts, durian, and mangosteen. The highest percentage of cover in the study was found in the Damar clove cultivation system, where even in the absence of other vegetation, the characteristics of the Damar clove plant were up to 20 m high, and the lush leaves produced a high percentage of land cover. Furthermore, the low percentage of cover in the Tae clove cropping system obtained in the study was more likely due to the characteristics of the Tae clove branches and leaves, which were small, and the plant crowns were not tightly packed.

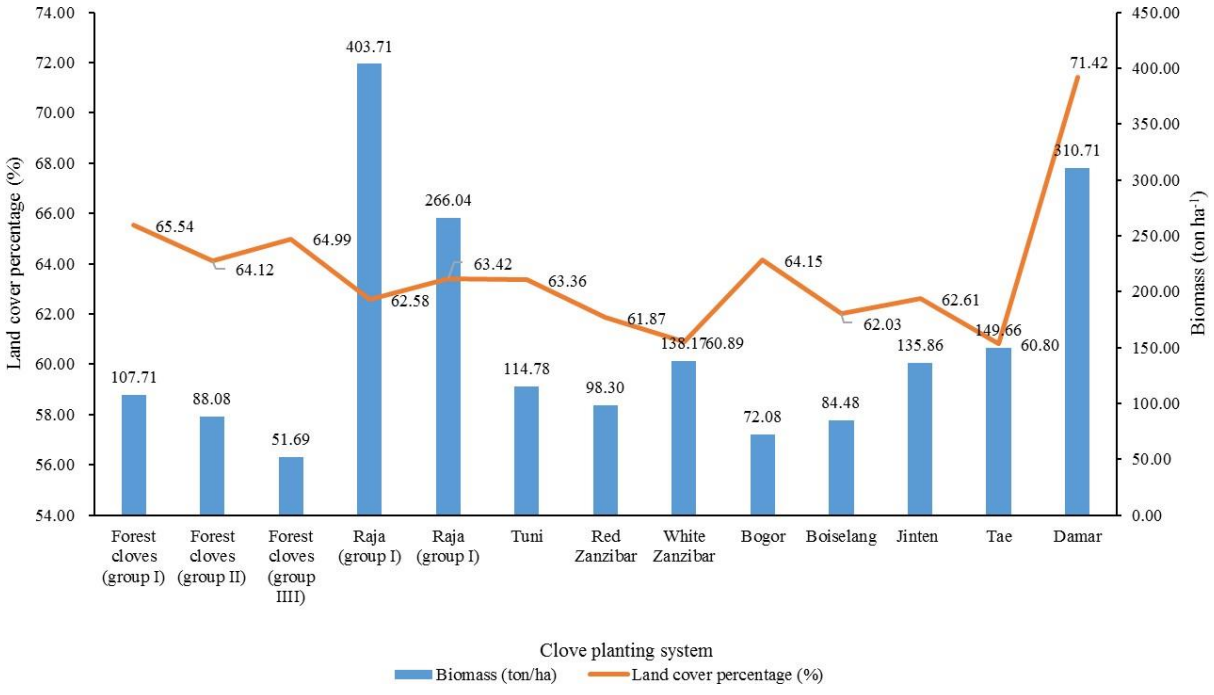


Figure 18. Percentage of land cover based on biomass in local clove cultivation systems in Maluku

b. Maluku local clove carbon stock by plant growth rate

The carbon stock in the local Maluku clove cultivation system based on the growth stage is presented in Figure 19. The estimation results show that the carbon storage in the Maluku local clove cultivation system increases with the increase in the plant growth rate.

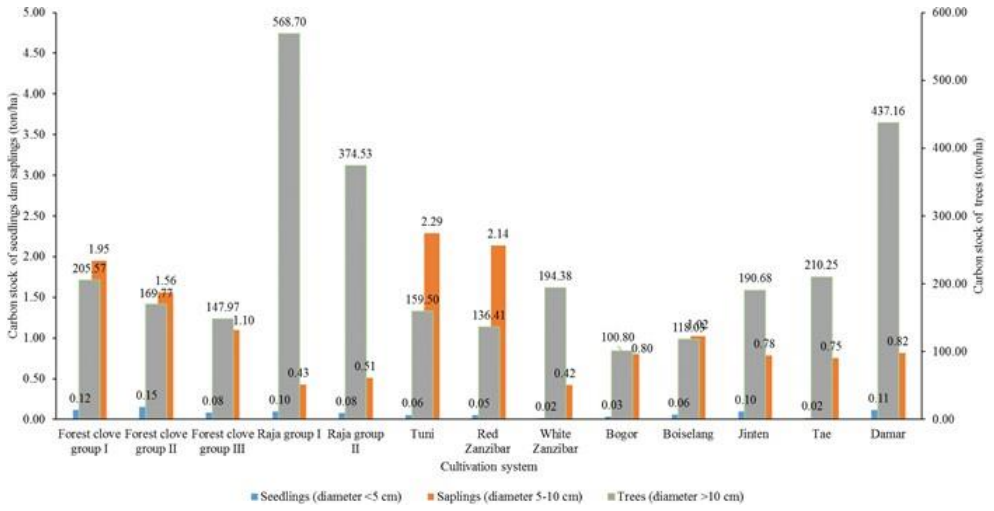


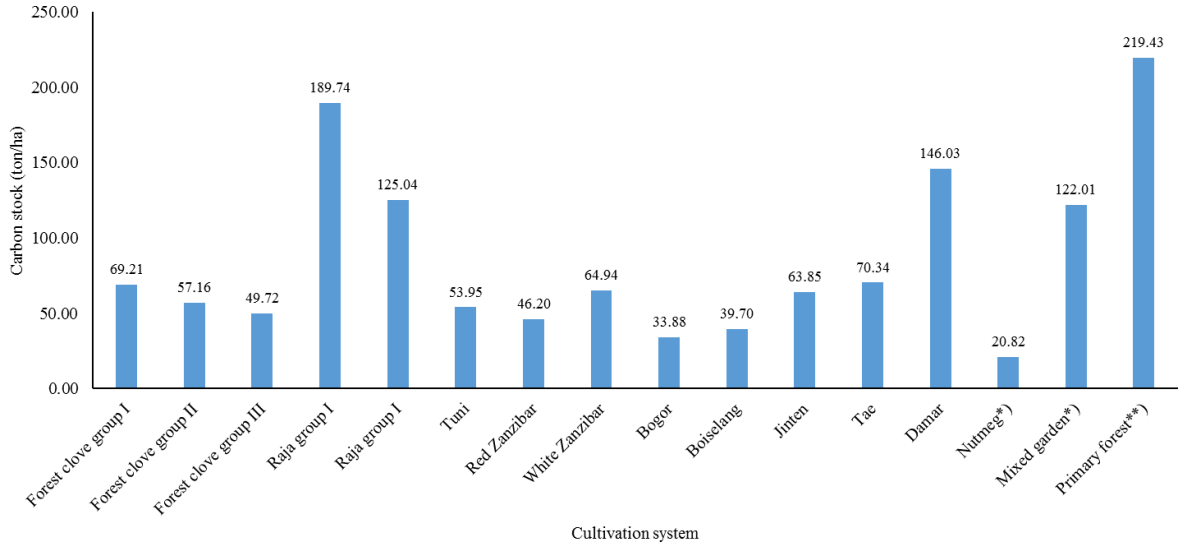
Figure 19. Average above-surface carbon storage by growth rate in the local Maluku clove cultivation system

Estimating carbon storage indicates that the carbon storage in the local clove cultivation system will increase following the level of plant growth. The highest carbon storage at the seedling level (diameter <5 cm) was found in forest clove group I (0.15 ton ha-1), carbon storage at the saplings level (diameter 5-10 cm) was found in the Tuni clove cultivation system (2.29 ton ha-1).), while carbon storage at the tree level (diameter > 10 cm) was found in the Raja group I clove cultivation system. Langi (2011) stated that biomass will increase until a certain age (diameter class representatives express age), and then the increase will decrease until it eventually ceases to be productive (died).

c. Comparison of carbon storage between local Maluku clove cultivation systems

The average carbon storage of the entire Maluku local clove plant observation plot is presented in Figure 20. The figure also shows the results of previous carbon measurements that have been achieved in nutmeg and mixed garden systems (Hariyadi et al. (2019) and primary forest (Komul 2017). The carbon storage of the local Maluku clove cultivation system, which was compared, did not include litter, humus, and soil carbon. The measurement results obtained that the highest carbon storage value was found in the Raja group I clove cultivation system (189.74 tons ha-1) and Damar cloves (146 tons ha). -1), where the carbon sequestration value is close to the carbon uptake in primary forest in the previous study by (Komul 2017) (219.43

ton ha-1). The nutmeg cropping system obtained in the previous study by Hariyadi et al. (2019) is still lower compared to the overall carbon absorption of the local clove cultivation system, where the carbon uptake obtained in the nutmeg cultivation system was only 20.82 tons ha-1.



Noted: *: results of measurements of nutmeg and mixed garden systems by Hariyadi et al. (2019); **: results of measurement of primary forest carbon storage by Komul (2017)

Figure 20. Histograms of carbon storage in various Maluku local clove cultivation systems

The comparison of carbon storage between local clove cultivation systems in Maluku is presented in Table 6. The overall carbon storage of the local clove cultivation system is compared with primary forest carbon storage obtained by Komul (2017). When comparing carbon stocks of various types of local Maluku cloves to carbon stocks in primary forest systems, information is obtained that Raja group I clove carbon stores with other plant populations such as coconut, walnuts, durian, and mangosteen have carbon stores of only 86.47% compared to primary forest. . The Damar clove cultivation system without other plant compositions was 66.55% compared to primary forest. The Bogor clove cultivation system with the lowest carbon storage in the study only obtained a carbon stock of 15.44% compared to primary forest. Besides having economic benefits as a commercial dried clove flower-producing plant, the local Maluku clove cultivation system also has the potential to develop C sequesters and carbon conservation for environmental sustainability.

Table 6. Comparison of carbon storage of various local Maluku clove cultivation systems*)

Clove population	Carbon stock (ton/ha)	% to													
		Primer Forest*	Forest Clove I	Forest Clove II	Forest Clove I	Raja I	Raja II	Tuni	Red Zanzibar	White Zanzibar	Bogor	Boiselang	Jinten	Tae	Damar
Forest Clove I	69.21	31.54	**100.00**	121.08	139.21	36.48	55.35	128.29	149.80	106.58	204.29	174.32	108.39	98.39	47.39
Forest Clove II	57.16	26.05	82.59	**100.00**	114.98	30.13	45.72	105.96	123.73	88.03	168.72	143.97	89.52	81.27	39.14
Forest Clove III	49.72	22.66	71.83	71.83	**100.00**	26.20	39.76	92.16	107.61	76.56	146.74	125.22	77.86	70.68	34.04
Raja I	189.74	86.47	274.15	331.94	381.66	**100.00**	151.75	351.72	410.69	292.19	560.06	477.90	297.16	269.75	129.93
Raja II	125.04	56.98	180.66	218.74	251.51	65.90	**100.00**	231.78	270.64	83.07	369.07	314.93	195.83	177.76	85.62
Tuni	53.95	24.59	77.95	94.37	108.51	28.43	43.14	**100.00**	116.77	83.07	159.23	135.87	84.49	76.69	36.94
Red Zanzibar	46.20	21.05	66.75	80.82	92.93	24.35	36.95	85.64	**100.00**	71.15	136.37	116.36	101.70	65.68	31.64
White Zanzibar	64.94	29.59	93.83	113.60	130.62	34.22	51.93	120.37	140.56	**100.00**	191.68	163.56	101.70	92.32	44.47
Bogor	33.88	15.44	48.95	59.27	68.15	17.86	27.09	62.80	73.33	52.17	**100.00**	85.33	53.06	48.16	23.20
Boiselang	39.70	18.09	57.37	69.46	79.86	20.92	31.75	73.60	85.94	61.14	117.19	**100.00**	62.18	56.44	27.19
Jinten	63.85	29.10	92.26	111.70	128.44	33.65	51.07	118.36	138.21	98.33	188.47	160.82	**100.00**	90.78	43.73
Tae	70.34	32.06	101.63	123.05	141.49	37.07	56.25	130.39	152.25	108.32	207.62	177.16	110.16	**100.00**	48.17
Damar	146.03	66.55	211.00	255.47	293.73	76.96	116.79	270.69	316.08	224.88	431.04	367.81	228.70	207.61	**100.00**
Primer Forest**	219.43	**100.00**	317.04	383.87	441.37	115.65	175.49	406.75	474.95	337.90	647.68	552.67	343.65	311.95	150.26

Noted: *) excluding C litter, C-humus and C-soil; **) primary forest measurement results by Komul (2017), including including litter C, C-humus and C-soil.

B. Maluku Local Clove Genetic Diversity

a. Maluku Local Clove DNA

DNA analysis was carried out on Maluku cloves, where the three accession groups of Forest cloves and Raja cloves represented Maluku local cloves from the wild type (wild type) and non-aromatic group. Tuni and Red Zanzibar represent Maluku local cloves from the cultivated type and aromatic. DNA extraction of local clove access groups was carried out on young leaves and in fresh conditions. The DNA isolated from all samples was tested for DNA quantity using a nanodrop spectrophotometer. The results of the DNA concentration and purity test are presented in Table 7.

Table 7. DNA quality of the Maluku local clove

Genotype	Type	Concentration DNA (ng/µl)	DNA Purity	
			260/280	260/230
Forest Clove Group I	Wild type	4470.4	1.11	0.58
Forest Clove Group II	Wild type	4848.3	1.12	0.62
Forest Clove Group III	Wild type	3474.7	1.09	0.54
Raja	Wild type	2724.2	1.15	0.53
Tuni	Cultivated	2937.3	1.05	0.57
Red Zanzibar	Cultivated	3713.4	1.13	**0.68**

The analysis showed that the accession of Forest Clove group II had the highest DNA concentration at 4848.3 ng/µl followed by Forest Clove group I (4470.4 ng/µl). The lowest DNA concentration was found in Raja, which was 2724.2 ng/µl. The analysis of DNA purity to protein at an absorbance ratio of 260/280 was in the range of 1.05-1.15. The DNA purity of protein at 260/280 was highest in Raja (1.15) and the lowest in Tuni (1.05). The highest DNA purity for polyphenols and polysaccharides (260/230) was in Red Zanzibar (0.68), and the lowest was in Raja (0.53).

b. Level of Polymorphism and Heterozygosity

The amplification of 10 primers showed that nine primers produced bands and one primer did not produce DNA bands after PCR. 9 primers that produced bands consisted of mPgCIR01, mPgCIR04, mPgCIR05, mPgCIR07, mPgCIR08, mPgCIR09, mPgCIR14, mPgCIR16, mPgCIR25, while one band that did not produce bands was Ssa-423. According to Bhattarai et al. (2021) dan Brhane et al. (2021), simple sequence repeats (SSR) or microsatellite markers are commonly used in taxonomy and diversity studies. Also, it is the most appropriate marker to see genetic diversity. The DNA bands

from the SSR PCR results in the Maluku clove are shown in Figure 21. The DNA bands shown are represented by primers mPgCIR04 and mPgCIR05. Genetic analysis was carried out by scoring the DNA bands resulting from the amplification of SSR markers to form binary data, notation 1 for alleles with a band and 0 for alleles without bands.

Figure 21. Electropherogram of SSR primers mPgCIR04 and mPgCIR05. Tuni (1), Red Zanzibar (2), Raja (3), Forest Clove Group I (4), Forest Clove group III (5), and Forest Clove group II (6).

Polymorphism analysis used GenALEx 6.51 and popgene 32 programs. The results showed that the level of diversity based on the analysis of SSR markers was high (Table 8). According to Prasetiyono and Tasliah (2004), SSR is classified as a molecular marker that is very effective and codominant with a high level of heterozygosity. It has a very high distinguishing power between individuals and can be located on DNA. Also, it can detect allele diversity at a high level.

Table 8. The level of polymorphism and heterozygosity of SSR markers

Primer SSR	Repeat motif	Number of Allele	Allele Frequency (%)	Heterozygosity	PIC
mPgCIR01	$(GA)_{17}$	4	0.54	0.43	0.70
mPgCIR04	$(GA)_{25}$	3	0.56	0.44	0.69
mPgCIR05	$(GA)_{31}$	2	0.67	0.45	0.53
mPgCIR07	$(CA)_{13}AA(GAA)_3$	4	0.58	0.44	0.64
mPgCIR08	$(GA)_{12}$	4	0.67	**0.49**	0.56
mPgCIR09	$(GA)_{19}$	6	0.50	0.38	0.69
mPgCIR14	$(GA)_{11}$	4	0.33	0.30	0.89
mPgCIR16	$(TC)_{25}$	**9**	***0.31***	0.27	0.86
mPgCIR25	(GA)24	6	**0.69**	0.26	***0.43***
Number	-	**42**	-	-	-
Average	-	**4.67**	0.54	0.38	0.66

Noted: SSR primers developed by Risterucci et al. (2005); Polymorphic Information Content (PIC).

The analysis results showed that 42 alleles were detected in 9 SSR markers with an average of 4.67 alleles per locus. The range of allele numbers varies widely in the range of 2-9 alleles per locus. The mPgCIR16 primer was the primer with the highest number of alleles (9), and the mPgCIR05 primer was the primer with the fewest number of alleles (2). However, the mPgCIR16 primer had the lowest allele frequency (0.31%), and the mPgCIR25 primer had the highest allele frequency (0.69%). Primer mPgCIR08 was the primer with the highest level of heterozygosity (0.49). The Polymorphic Information Content (PIC) value analysis showed that only 1 primer (mPgCIR25) showed a PIC value below 0.50, while the other 8 primers had a PIC value above 0.50.

c. Phylogeny and Genetic Similarity of Maluku Local Cloves

Phylogenetic analysis was carried out based on the results of band scoring on DNA samples (Bhattarai et al. 2021; Brhane et al. 2021). The results of the dendrogram of the Maluku local clove based on the band scoring of the SSR markers are presented in Figure 2. The dendrogram of the phylogenetic analysis results in classifying the Maluku local clove genotype into 2 groups. Forest cloves group I and II, Tuni and Raja in the first group. Forest Clove group III and Red Zanzibar in the second group. The results of the analysis of the genetic distance of the two groups obtained a similarity coefficient of 0.4.

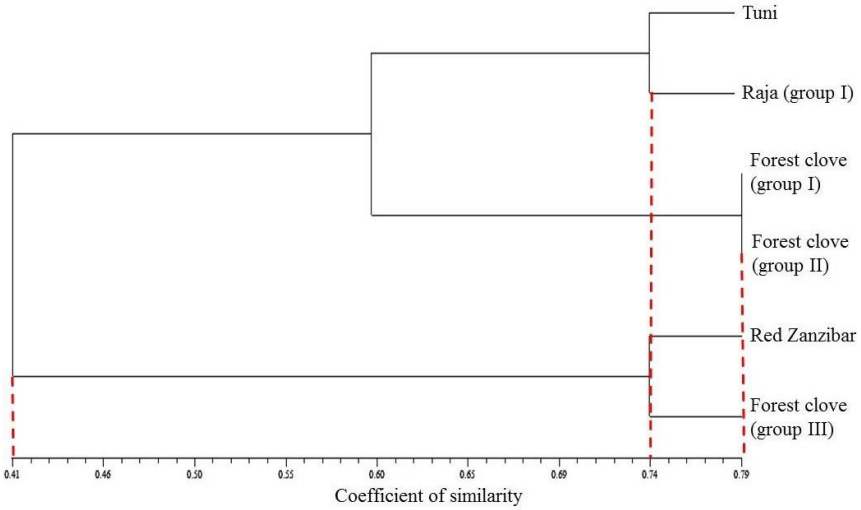


Figure 22. Phylogeny tree of Maluku local clove accession based on band scoring from SSR markers..

The value of the genetic similarity matrix shows the genetic distance between local Maluku cloves (Table 9). Close genetic distance is indicated by a similarity coefficient that is close to 1, while distant genetic distance is indicated by a similarity

coefficient of less than 0.5. The results of the analysis showed that between group I and II forest clove accessions had a close genetic distance with a similarity coefficient of 0.79 but the two accession groups had a far genetic distance from group III forest clove accessions. Forest clove accessions group I and III only had a similarity coefficient of 0.31 and between group II and III forest clove accessions only had a similarity coefficient of 0.43.

Table 9. The genetic similarity matrix of local Maluku cloves using SSR markers

Sample	Tuni	Red Zanzibar	Raja group I	Forest Clove group I	Forest Clove group III	Forest Clove group II
Tuni	1.00					
Red Zanzibar	0.55	1.00				
Raja group I	0.74	0.38	1.00			
Forest Clove group I	0.60	0.43	0.57	1.00		
Forest Clove group III	0.43	0.74	0.40	0.31	1.00	
Forest Clove group II	0.57	0.36	0.64	0.79	0.43	1.00

C. Essential Oils Analysis

a. Physicochemical chemistry of local Maluku clove oil

Clove oil color. The physical color of local Maluku clove oil, which is distilled from the bud oil, is presented in Figure 19. The color of wild-type clove oil in the non-aromatic group is represented by 3 groups of forest clove accessions (groups I, II, III), while Tuni cloves and red Zanzibar cloves represented cultivated local cloves from the aromatic group. The clove oil color is based on the oil color criteria according to the 2015 RHS color chart.

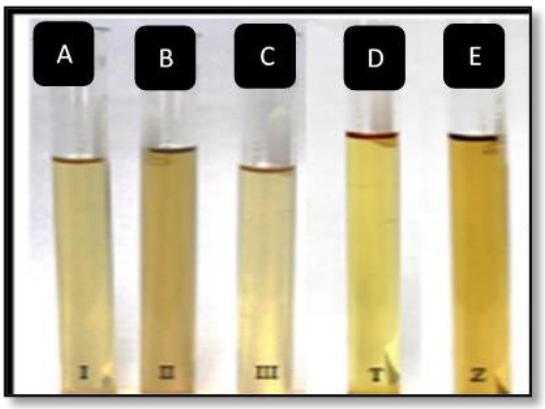


Figure 23. Physical color of local Maluku clove bud oil visually: Forest cloves group I, II, III (A-C), Tuni (D), red Zanzibar (E).

The distillation results showed that the overall physical color of wild-type clove oil represented by forest cloves was visually in the yellow to the dark brown color range. The physical color range shows the normal physical color characteristics of the oil, which is following the clove oil standard in the Indonesian National Standard (SNI): 06-4267-1996 for clove flower oil, as well as with the International Standard (ISO) 3141:1997(E) and Food Chemical Codex Edition IV.

Based on the 2015 RHS color chart standard, the flower oil (bud oil) of forest clove accessions group I and II is included in the yellow group, namely vivid yellow (9A) and brilliant yellow (8B), while group III accessions are included in the color chart in the green yellow group, namely light greenish-yellow (1C). Color standards were also achieved in local Maluku cloves cultivated in the aromatic group, namely Tuni and red Zanzibar.

Visually, the physical color of the red Tuni and Zanzibar clove oils from the distillation of the flower parts, flower stalks, and leaves is also in the yellow to the dark brown color range. The physical color of the oil is visually normal because it is in the standard range of clove oil. The color standard on the 2015 RHS color chart shows that Tuni clove flower oil is included in the yellow group, namely brilliant yellow (7A), while local Zanzibar cloves are red, the flower oil (bud oil) is included in the grayed orange group, namely brownish orange. (N1671B).

Table 10. The local Maluku clove oil color standard is based on the 2015 RHS color chart

Maluku variety	*bud oil*			SNI1996a,1996b,2006; ISO 3141:1997(E); Food chemical codex IV edition
	Code	Color	Color group	
Forest Clove group I	9A	Vivid yellow	Yellow group	Yellow to dark brown (visual method)
Forest Clove group II	8B	Brilliant yellow	Yellow group	Yellow to dark brown (visual method)
Forest Clove group III	1C	Light greenish yellow	Green yellow group	Yellow to dark brown (visual method)
Tuni	7A	Brilliant yellow	Yellow group	Yellow to dark brown (visual method)
Red Zanzibar	N1671B	Brownish orange	Grayed orange group	Yellow to dark brown (visual method)

Physico-chemical properties of flower oil (bud oil). The physicochemical properties of wild type clove flower oil in the non-aromatic group were represented by 3 groups of forest clove accessions (groups I, II, III), while Tuni cloves and red Zanzibar represented local cloves cultivated from the aromatic group. . The standard of Physico-chemical quality of clove flower oil used refers to the Indonesian National Standard (SNI): 06-4267-1996) and International Standard (ISO) 3141:1997(E) as well as the Food Chemical Codex Edition IV (Table 9). The physical results of local Maluku clove oil obtained in the study are presented in Table 10. The physico-chemical properties of clove oil described in this study were specific gravity, refractive index, solubility in ethanol 70%, total eugenol, and caryophyllene.

The physico-chemical results of local Maluku clove oil showed that the wild-type clove flower oil represented by 3 groups of Forest cloves (group I, II, III) did not meet the standards on the parameters of specific gravity, refractive index, solubility in ethanol. 70%, and total eugenol, while the levels of -caryophyllene meet quality standards. Specific gravity at a temperature of 20°C obtained in the whole Forest clove accession group was in the range of 0.9559-1.1091 g ml-1. Likewise, the refractive index parameter at a temperature of 20°C, where the overall clove oil of the forest clove accession group was in the range of 1.5075-1.5467. The solubility properties in 70% ethanol and total eugenol also showed that all the Forest clove accession group oils had insoluble oil properties in 70% ethanol (1:10) and had low total eugenol content (20-28%). The content of -caryophyllene meets quality standards because it does not exceed 17%.

The physico-chemical results of cultivated clove oil from the aromatic group represented by Tuni cloves and red Zanzibar showed different results from forest cloves. The results of physico-chemical analysis of Tuni and Zanzibar red cloves have specific gravity, refractive index, solubility in ethanol 70%, and total eugenol, which are in the overall range of clove oil standards, except for the -caryophyllene content of the red Zanzibar variety which is slightly above the standard set.

The results of the analysis showed that Tuni clove flower oil at 20oC had a specific gravity of 1.0443 g ml-1, a refractive index of 1.5350 at 20oC, soluble in 70% ethanol (1:2), the highest eugenol content (84%), and -caryophyllene does not exceed 17%, i.e., 12.68%. The same standard is achieved with red Zanzibar cloves. Clove flower oil of the Zanzibar variety at a temperature of 20oC has a specific gravity of 1.0327 g ml-1, a

refractive index of 1.5263 at a temperature of 20oC, is soluble in ethanol 70% (1:2), the eugenol content is slightly lower than the Tuni cloves, namely 76% and the content of -caryophyllene slightly higher at 19.03%.

Table 11. Physico-chemical standards of cultivated clove bud oil (*Syzygium aromaticum* (L.) Merr. & L. M. Perry.)

No.	Test	SNI: 06-4267-1996 (Bud Oil)	ISO: 3141:1997 (E) and *Food Chemical Codex* IV edition.
1.	Specific weight (20°) (g ml^{-1})	1.04-1.07	1.0355-1.0455
2.	Index Bias (20°)	1.529-1.537	1.5260-1.5330
3.	Solubility in ethanol 70%	1 : 2 clear	1 : 2 clear
4.	Total Eugenol (%)	80-95%	80-82%
5.	β-caryophyllene (%)	-	4-17%

Table 12. Physico-chemistry of Maluku local clove bud oil

No.	Test	Clove variety				
		Forest Clove I	Forest Clove II	Forest Clove III	Tuni	Red Zanzibar
1.	Specific weight (20°) (g ml^{-1})	0.9987	1.0221	0.9559	1.0443	1.0327
2.	Index Bias (20°)	1.5173	1.5283	1.5075	1.5350	1.5263
3.	Solubility in ethanol 70%	1 : 10 (Not dissolved)	1 : 10 (Not dissolved)	1 : 10 (Not dissolved)	1 : 2 (Dissolved)	1 : 2 (Dissolved)
4.	Total Eugenol (%)	20	26	23	84	76
5.	β-caryophyllene (%)	5.30	11.79	6.40	12.68	19.03

b. Maluku local clove essential oils components

1. The volatile components bud oil and stem oil of Maluku local cloves

Gas Chromatography-Mass Spectrometry (GC-MS) analysis of essential oil components from flower parts and flower stalks was carried out on local Maluku cloves. Local Maluku cloves wild type (wild type) from the non-aromatic group were represented by the group I, II, III, and Raja cloves group I, while local Tuni cloves and red Zanzibar represented cultivated cloves from the aromatic group.

The results of the GC-MS analysis on the group I, II, III forest clove essential oil obtained information that group I forest clove accessions identified 13 components in flower oil and 11 components in flower stalk oil. Group II identified seven components in flower oil and 11 components in flower stalk oil. Group III forest cloves identified 11 components in flower oil and 14 components in flower stalk oil. Clove Raja group I was identified as having 5 components in flower oil, where the components were indicated to be a combination of wild-type cloves and cultivated cloves. The results of the analysis of volatile components in all forest clove oil (groups I, II, III) and Raja cloves group I

showed that there were differences in components with aromatic cloves from the Tuni and Zanzibar red varieties.

The results of the GC-MS analysis on Tuni and Zanzibar cloves identified 5 volatile components in flower and flower stalk oil, respectively, while in the Zanzibar variety, 6 volatile components were identified in flower oil and flower stalk oil. Tuni and Zanzibar cloves are aromatic cloves with higher levels of eugenol than wild-type cloves such as forest cloves (groups I, II, III) and Raja cloves group I.

2. Essential oils component of Maluku Local Cloves

Gas Chromatography-Mass Spectrometry (GC-MS) analysis of leaf oil was carried out on all local Maluku cloves. The results of the GC-MS analysis identified volatile components in some aromatic and non-aromatic wild-type cloves and aromatic clove cultivation. Forest cloves group I, II, III, and Raja cloves groups I and II are wild-type cloves of the non-aromatic group. This local clove group is indicated to have different components from cultivated cloves, where the main character is the low eugenol content. The results of GC-MS indicated that there were 6 components in the leaf oil of group I forest clove accessions and 13 components in group II and III forest clove accessions. The results of the GC-MS analysis of leaf oil on two accessions of clove king also showed the same 7 components with varying concentrations.

Wild type cloves (wild type) aromatic group consists of cloves Boiselang, cumin, and resin. Boiselang cloves are indicated to have 4 components, where the volatile components show a combination of non-aromatic wild type cloves and aromatic cultivated cloves. Therefore, boiselang cloves are classified into wild type cloves (wild type) aromatic group. Cumin cloves and Damar cloves are also classified as wild type cloves, but have high levels of eugenol so they are classified as aromatic wild type cloves. Both local cloves were indicated to have the same 4 volatile components with varying concentrations.

Cloves of the Tuni, red Zanzibar, white Zanzibar, and Bogor clove varieties are cloves cultivated from the aromatic group with high eugenol content. The results of the GC-MS analysis on cloves of Tuni and Zanzibar red varieties identified each of 5 volatile components in leaf oil. White Zanzibar cloves and Bogor cloves were identified as having the same 4 volatile components but varying concentrations.

The heatmap for grouping local cloves of Maluku volatile components is presented in Figure 24. The heatmap profile describes the differences in the volatile components of all plant parts, namely flowers, flower stalks, and leaves. Forest cloves groups I, II, III on the heatmap profile due to GC-MS analysis represent wild type cloves (wild type) non-aromatic group, while Tuni cloves and red Zanzibar represent cultivated cloves of the aromatic group. The main components identified in the clove plant were analyzed both on the flower, flower stalk, and leaves. The main components are visible in bright green in the heatmap profile. The heatmap profile resulting from the GC-MS analysis shows that the major components of non-aromatic wild-type cloves consist of, germacrene-D, -cubebene, eugenol, -cadinene, -copaene, methylenegenol.

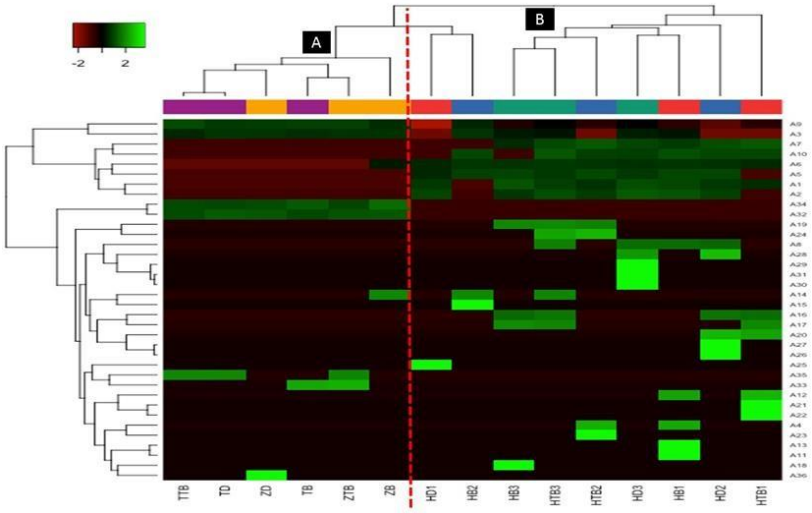


Figure 24. Heat map of grouping the volatile components of wild type clove oil (wild type) non-aromatic group (forest cloves group I, II, III) (A) and cultivated cloves aromatic group (Tuni and zanzibar cloves) (B). Types of volatile components (A1-A36); chch flowers. Forest-group I (HB1), flower stalk ckh. Forest-group I (HTB1), ckh leaves. Forest-group I (HD1), flower ckh. Forest-group II (HB2), flower stalk ckh. Forest-group II (HTB2), ckh leaves. Forest-group II (HD2), flower ckh. Forest-group III (HB3), flower stalk ckh. Forest-group III (HTB3), ckh leaves. Forest-group III (HD3); Flowers, flower stalks, chch leaves. Tuni (TB, TTB, TD), red Zanzibar clove (ZB, ZTB, ZD).

Non-aromatic wild-type cloves represented by forest cloves (groups I, II, III) have different main components from cultivated-type cloves of the aromatic group, namely Tuni cloves and red Zanzibar. The results of the analysis showed that the volatile components of cultivated cloves in the aromatic group were composed of the main components in the form of eugenol, caryophyllene, eugenyl acetate, and –humulene. These main components were found in all parts of the analyzed plant and were in high concentrations.

Table 13. Essential Oils Component of Maluku local cloves

Clove Variety	Bud oil					Stem oil				
	Component	Class	RT	Q	Cons. (%)	Component	Class	RT	Q	Cons. (%)
Forest Clove group I	Germacrene-D	S	34.116	99	15.49	Ageratochromen	S	56.430	90	30.67
	Ageratochromen	S	56.421	90	12.58	Methyleugenol	PP	47.787	98	23.34
	α-cubebene	S	21.149	99	12.42	Germacrene	S	34.078	99	15.12
	Eugenol	PP	50.059	98	10.60	Eugenol	PP	50.059	99	11.35
	δ-cadinene	S	36.830	99	9.85	δ-cadinene	S	36.835	99	5.14
	α-copaene	S	23.006	99	9.40	trans-Caryophyllene	S	28.144	94	2.45
	4,11-Dioxa-3,5-dimethyl-3-methoxytetracycloundecane Cage Compund	A	56.588	90	9.62	α-cubebene	S	21.120	99	2.13
	Caryophyllene	S	28.225	99	4.30	α-cadinol	S	51.211	99	1.96
	α-cadinol	S	51.211	91	3.45	γ –Muurolene	S	33.216	99	1.59
	Methyleugenol	PP	47.764	98	3.30	Myristcin	A	51.564	99	1.30
	α-amorphene	S	33.216	99	2.64	Cadina-1,4-diene	S	48.787	95	1.18
	Naphtalene, 1,2,3,4,4a,7-hexahydro-1,6-dimethyl-4-(1-methylethyl)	S	48.792	84	2.07					
	4,10 (14)-Muuroladien-8.beta.-ol	S	53.273	48	1.47					
Forest Clove group II	Eugenol	PP	50.030	98	42.79	Methyleugenol	PP	47.787	98	22.97
	Caryophyllene	S	26.959	99	29.37	Germacrene-D	S	28.187	93	18.21
	δ-cadinene	S	35.625	99	10.00	Methyl 4,47-trimethyl-4,7-dihydroindan-6-carboxylate	A	56.421	83	14.93
	Germacrene-D	S	32.811	99	9.54	Eugenol	PP	50.059	98	11.82
	t-Muurolol	S	50.959	90	4.02	δ-cadinene	S	36.864	99	9.47
	α-cadinol	S	50.297	90	2.21	2'-3',4' Trimethocyacetophenone	S	56.578	83	5.88
	Copaene	S	50.478	96	1.52	α-amorphene	S	33.216	99	3.14
						α-cubebene	S	21.125	99	2.94
						5-ethyl-3,12-dioxatricyclo[4.4.2.0(1,6)]dodecan-4-one	A	48.126	90	2.07
						α-copaene	S	22.973	99	1.95
						α-cadinol	S	51.211	95	1.41
	α-cubebene	S	21.187	99	27.83	Eugenol	PP	50.064	98	24.26
	Eugenol	PP	50.059	98	12.90	δ-cadinene	S	36.859	99	12.60
	Germacrene-D	S	34.097	98	11.26	Methyleugenol	PP	47.773	98	8.91
	δ-cadinene	S	36.816	98	8.58	2'-3',4' Trimetho cyacetophenone	S	56.578	87	8.79
	2'-3',4'Trimethocyacetophenone	S	56.573	90	8.44	α-cubebene	S	21.125	99	6.74
	Caryophyllene	S	28.225	99	5.87	Methyl 4,47-trimethyl-4,7-dihydroindan-6-carboxylate	A	56.407	83	6.53

Clove Variety	Bud oil					Stem oil				
	Component	Class	RT	Q	Cons. (%)	Component	Class	RT	Q	Cons. (%)
Forest Clove group III	α-copaene	S	23.044	99	17.49	α-copaene	S	22.982	99	6.28
	Geraniol	S	40.473	87	1.40	Germacrene-D	S	34.063	98	5.79
	Cadina-1,4-diene	S	38.068	97	1.36	Naphtalene, 1,2,3,4,4a,7-hexahydro-1,6-dimethyl-4-(1-methylethyl)	A	31.740	89	5.41
	γ-Muurolene	S	33.216	99	1.28	α-cadinol	S	51.211	95	4.65
	Methyleugenol	PP	47.764	98	1.08	Caryophyllene	S	28.230	99	3.86
						γ-Muurolene	S	33.197	99	2.40
						Copaene	S	50.726	95	1.23
						Cadina-1,4-diene	S	38.044	97	1.02
Raja group I	Eugenol	PP	50.035	98	59.85	-	-	-	-	-
	Caryophyllene	S	26.973	99	18.21	-	-	-	-	-
	Germacrene-D	S	32.816	99	11.92	-	-	-	-	-
	δ-cadinene	S	35.606	99	5.48	-	-	-	-	-
	α-cadinol	S	50.965	99	3.61	-	-	-	-	-
Tuni	Eugenol	PP	50.0	98	67.85	Eugenol	PP	50.0	97	80.60
	Caryophyllene	S	26.9	99	21.05	Caryophyllene	S	26.9	99	13.02
	Eugenyl acetate	PP	51.3	99	6.23	Eugenyl acetate	PP	51.3	99	2.51
	α-humulene	S	30.7	98	1.26	α-humulene	S	30.7	99	1.60
	Pathchouli alcohol	A	50.2	99	1.16	Cryophyllene oxide	S	46.2	91	1.18
Red Zanzibar	Eugenol	PP	50.0	98	47.36	Eugenol	PP	50.0	98	67.46
	Caryophyllene	S	26.9	99	25.34	Caryophyllene	S	26.9	99	24.78
	Eugenyl acetate	PP	51.3	99	19.13	α-humulene	S	30.7	98	2.73
	α-humulene	S	30.7	98	3.25	Eugenyl acetate	PP	51.3	99	1.76
	δ-cadinene	S	35.6	99	1.93	Pathchouli alcohol	A	50.2	99	1.49
	Copaene	S	21.6	99	1.52	Cryophyllene oxide	S	46.2	94	1.01

Description: (RT) retention time (retention time); (Q) quality (quality); S=sesquiterpenoids, PP=phenylpropanoids, A=aliphatic, M=monoterpenoids.

Table 14. Essential oils component of Maluku Local cloves leaves

Clove Variety	leaf oils				
	Component	Class	RT	Q	Cons. (%)
Forest Clove group I	2,3',4-Trimethyldiphenylmethane	A	56.706	90	80.39
	α-cubebene	S	21.144	99	4.24
	δ-cadinene	S	36.821	99	4.19
	α-copaene	S	23.020	99	3.65
	Germacrene-D	S	34.063	99	1.79
	Eugenol	PP	50.059	99	1.29
Forest Clove group II	2',3',4' Trimethocyacetophenone		56.602	90	26.02
	Germacrene-D	S	34.083	99	13.40
	Methyleugenol	PP	47.773	98	11.45
	3-(2,2-dimethylpropylidene) bicyclo [3.3.1] nonane-2,4-dione	A	56.411	90	9.70
	trans-Caryophyllene	S	28.187	96	5.28
	Eugenol	PP	50.054	99	5.03
	δ-cadinene	S	36.844	99	7.76
	β-Bourbonene	S	24.278	98	4.65
	α-cubebene	S	21.116	99	4.13
	α-copaene	S	22.987	99	2.84
	α-cadinol	S	51.211	98	2.20
	γ-Muurolene	S	33.187	99	2.15
	Naphtalene, 1,2,3,4,4a,7-hexahydro-dimethyl	A	48.783	99	1.41
Forest Clove group III	Eugenol	PP	50.059	98	22.83
	α-cubebene	S	21.149	99	17.62
	α-copaene	S	23.006	99	13.00
	δ-cadinene	S	36.854	99	7.03
	Caryophyllene	S	28.202	99	6.90
	Methyleugenol	PP	47.768	98	6.35
	3,4-Dihydro-1-hydroxy-5,8-dimethoxy-1,3-dimethyl-1H-2-benzopyran	A	56.402	78	6.09
	Germacrene-D	S	34.054	99	5.71
	2',3',4' Trimethocyacetophenone	S	56.569	83	4.35
	1S, Cis-Calamenene	S	40.464	96	3.24
	Naphtalene, 1,2,3,4,4a,7-hexahydro-1,6-dimethyl-4-(1-methylethyl)	A	48.7	70	1.98
	α-cadinol	S	51.1	98	1.25
	Humelene	S	31.8	78	1.18
Boiselang	Eugenol	PP	49.4	98	37.09
	α-cubebene	S	19.4	96	2.20
	Caryophyllene	S	24.9	99	39.40
	Methyleugenol	PP	46.6	98	13.40

Clove Variety	leaf oils				
	Component	Class	RT	Q	Cons. (%)
Tuni	Eugenol	PP	50.0	98	60.45
	Caryophyllene	S	26.9	99	32.18
	α-humulene	S	30.7	99	3.54
	Eugenyl acetate	PP	51.3	99	2.08
	Cryophyllene oxide	S	46.2	94	1.00
Red Zanzibar	Eugenol	PP	50.0	98	63.51
	Caryophyllene	S	26.9	99	29.13
	α-humulene	S	30.7	98	3.23
	Eugenyl acetate	PP	51.3	99	2.78
	Caryophyllene oxide	S	46.2	95	1.03
White Zanzibar	Eugenol	PP	49.3	98	69.48
	Caryophyllene	S	24.8	99	25.85
	α-humulene	S	28.5	98	2.87
	Caryophyllene oxide	S	44.0	91	1.02
Bogor	Eugenol	PP	49.4	98	75.95
	Caryophyllene	S	24.8	99	18.31
	Humulene	S	28.5	98	2.15
	Caryophyllene oxide	S	44.0	91	2.01
Raja group I	Eugenol	PP	49.3	98	22.10
	Caryophyllene	S	24.9	99	58.30
	Humulene	S	28.5	97	6.75
	Copaene	S	19.4	99	1.73
	Cryophyllene oxide	S	44.0	91	3.45
	α-cubebene	S	17.8	98	1.19
	Bicyclo [3.1.1.] hept-2-ene,2,6-dimetil 1-6-(4-methyl 1-3-pentenyl)	A	33.4	87	1.91
Raja Group II	Eugenol	PP	49.3	98	22.10
	Caryophyllene	S	24.9	99	58.30
	Humulene	S	28.5	97	6.75
	Copaene	S	19.4	99	1.73
	Cryophyllene oxide	S	44.0	91	3.45
	α-cubebene	S	17.8	98	1.19
	Bicyclo [3.1.1.] hept-2-ene,2,6-dimetil 1-6-(4-methyl 1-3-pentenyl)	A	33.4	87	1.91
Jinten	Eugenol	PP	49.4	98	59.88
	Humulene	S	28.5	97	3.67
	Cryophyllene oxide	S	44.0	91	1.33
	Caryophyllene	S	24.9	99	33.79
Tae	Eugenol	PP	49.4	98	67.23
	Caryophyllene	S	24.8	99	23.81
	Humulene	S	28.5	96	2.60
	Cryophyllene oxide	S	44.0	91	1.38
	Lauric anhydride	A	54.4	58	2.90
Damar	Eugenol	PP	49.4	98	74.67
	Caryophyllene	S	24.8	99	19.50
	Humulene	S	28.5	97	2.20
	Cryophyllene oxide	S	44.0	91	1.32

Description: (RT) retention time (retention time); (Q) quality (quality); S=sesquiterpenoids, PP=phenylpropanoids, A=aliphatic, M=monoterpenoids.

5. Conclusions

1. Local cloves in Maluku were identified in 2 groups with an agro-morphological difference of 57%, namely the Forest clove accession group (group I, II, III) and Boiselang as the first group and other local clove groups as the second group (Tuni, Jinan, Zanzibar Red, White Zanzibar, Bogor, Damar, Tae, Raja group I, and Raja group II).
2. The Principle Component Analysis (PCA) results of 32 agro-morphological characters in 130 local clove accessions of Maluku obtained a total diversity of 66.7% with four groups of characters based on grouping.
3. The Raja group I clove cultivation system had the highest average biomass content, while the highest percentage of land cover in the study was found in the Damar clove cultivation system.
4. The accession of wild-type cloves to the non-aromatic group represented by forest cloves group III has a close genetic distance to cloves cultivated from the red Zanzibar aromatic group, while cultivated cloves from the aromatic Tuni group have a genetic distance closer to wild-type cloves. type) non-aromatic Raja group.
5. The Physico-chemical properties of non-aromatic wild-type clove oil represented by three accession groups of forest cloves in Maluku did not meet the oil Physico-chemical standards. In contrast, the cultivated type cloves of the Tuni and Zanzibar aromatic groups as a whole met all Physico-chemical standards for clove oil.
6. Non-aromatic wild type cloves represented by three accession groups of forest cloves in Maluku have major components, namely germacrene-D, -cubebene, eugenol, -cadinene, -copaene, methyleugenol, while cloves cultivated from the aromatic groups of Tuni and Zanzibar red in the form of eugenol, caryophyllene, eugenyl acetate, and -humulene.

6. Principal Investigator and Other Researcher

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Appendices

Research documentation

Figure 1. Activities for characterizing the agro-morphology, distribution, ecology and carbon storage of local Maluku cloves

Figure 2. Analysis of local Maluku clove DNA samples

Figure 3. Distillation activities, physico-chemical analysis and gas chromatography mass spectro (GC-MS) of local cloves in Maluku

CURRICULUM VITAE

ASRI SUBKHAN MAHULETTE

Curriculum Vitae

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PERSONAL INFO

Name	: Dr. Asri Subkhan Mahulette, SP, MP
Date of Birth	: 23 July 1978
Place of Birth	: Ambon
Address	: Jl. Baru SK8 No 43, Honipopu, Sirimau, Ambon City
Sex	: Male
Department	: Agrotechnology, Faculty of Agriculture, Pattimura University

EDUCATIONAL BACKGROUND

Level	Year	University	Field of Study	GPA
Bachelor	1997-2002	Hasanuddin University	Agronomy	3.58
Master	2007-2009	Hasanuddin University	Agricultural Systems	3.80
Doctorate	2016-2020	IPB University	Agronomy and Horticulture	4.00

RESEARCH EXPERIENCES

Year	Research/Project Title	Source
2020	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	
2020	Morphological characters and essential oil constituents extracted of two clove varieties (*Syzygium aromaticum* (L.) Merr. & L. M. Perry.) from Ambon Island, Indonesia.	
2019	Physicochemical Characterization and Essential Components of Forest Clove Oil	Indonesia Endowment Fund for Education (LPDP)
2019	Genetic Diversity of Clove (*Syzygium aromaticum*) from Ambon Island Revealed by SSR Marker	
2019	Potential of biomass, carbon storage, and carbon absorption of forest cloves	
2018	Agro-morphological characterization of forest cloves in Maluku	
2018	Study on the Utilization of Arbuscular Mycorrhizal Fungi (FMA) for Forest Clove Plant Nursery	

2018	Study on Increasing Productivity of Forest Clove Plants Through Paclobutrazol Application	
2014	UPT Research Year I: Increasing Productivity of of Nutmeg Plant (*Miristica* sp.) In Central Maluku District as the Leading Commodity of Maluku Region, 2014	
2015	UPT Research of Year II: Increasing Productivity of Nutmeg Plant (*Miristica* sp.) In Central Maluku District as the Superior Commodity of Maluku Region, 2014	DIPA 2015 Pattimura University
2014	Characterization of *Salaca zalaca*, Soya variety	DIPA 2014 Pattimura University
2014	Analysis and Preparation of Consumption Patterns and Food Supply 2014	APBD 2014 Buru Selatan Regency
2012	Analysis of Food Availability and Consumption and Mapping of Food Insecurity Condition of Buru District in 2012	APBD 2012 Buru Regency
2010	Preparation of Basic Data of Household and Mapping of Food Insecurity Kab. South Buru Year 2010	APBD 2010 Buru Selatan Regency

TRAINING AND WORKSHOP

Training/Workshop	Organizing Institution	Date
Training on Drafting of Plant Variety Protection Rights Application Documents	Ministry of Agriculture (Center for Plant Variety Protection and Agricultural Licensing)	July 3, 2020
Seed Quality Inspector Competency training	National Agency for Professional Certification (BNSP)	July 21 2019
Competency Certification for Generative Seedlings	National Agency for Professional Certification (BNSP)	July 20, 2019
Liquid Sugar Making Training	Sago Indonesia Society (MASSI)	March 14, 2017
Good Laboratory Practice (GLP) Training	Department of Food Science and Technology of IPB University	April 5, 2017
Training of Textbooks	University of Pattimura	September 29 – October 2, 2015
International Workshop Towards a World Class University and Teaching Methodology	Asian Law Group – UIN Syarif Hidayatullah – IAIN Ambon	August 27 – 28, 2014
Workshop on “How To Write The Proposal and Studi Objectives”	University of Pattimura – AMINEF	November 6, 2014

Workshop of Synchronization of Study Materials by Subject and RPKPS in KBK Study Program	Faculty of Agriculture Pattimura University - Agri 4 Nuffic	January 29-31, 2013
Workshop of Quality Assurance System of Faculty of Agriculture Pattimura University	Faculty of Agriculture Pattimura University	Febuary 7, 2013
Training Blog Design	Computer Training Center Pattimura University	September 3-4, 2013
Socialization / Training of Writing Proposal of Community Service for Lecturer of Higher Education	Pattimura University - Ditlitabmas Dikti	October 3-4, 2013
Workshop Facilitator "Local Ethnomedicin and Medicinal Research Exploration	Research and development of Health Agency, Ministry of Health (Balitbangkes)	October 16-20, 2012
Workshop on Writing Scientific Articles for Publication	Faculty of Agriculture Pattimura University-Agri 4 Nuffic	April 11-12, 2012
Workshop : Integration of Entrepreneurship into Courses	Faculty of Agriculture Pattimura University-Agri 4 Nuffic	Febuary 9-10, 2012
English Language Training for University Lecturers in Supporting the Development of Academic Qualifications (IELTS Preparation Course)	General Directorat of High Education, Ministry of Research Technology and High Education	April-Agustus 2011)

SEMINAR

Year	Activity	Organizer	Participation
2020	National Seminar of Indonesian Agronomic Association (PERAGI)	Indonesian Agronomic Association (PERAGI)	Speakers
2019	The First International Conference of Interdisiplinary Research on Green Environment Approach for Sustainable Development (ICROEST 2019)	Hasanuddin University	Speakers
2019	The 8th International Conference of The Indonesian Chemical Society (ICICS 2019)	Indonesian Chemical Society	Speakers

2019	1st International Conference on Sustainable Plantation	Agricultural Research and Development (IAARD) and IPB University	Speakers
2019	The 1st International Seminar on Natural Resources and Environmental Management, 2019	IPB University	Participants
2018	International Confrence on Genetic Resources and Biotechnology (ICGRB 2018)	Ministry of Agricuture	Speakers
2017	Indonesia Resource Efficient and Cleaner Production (RECP)	Ministry of Environment and Forestry	Participants
2015	Seminar on Role of Livestock Sector in Supporting Agricultural Development in Maluku	Faculty of Agriculture Pattimura University	Participants
2015	Guarding Food Safety Toward a Free Market 2015	Faculty of Agriculture Pattimura University	Participants
2014	National Seminar and Workshop "Generating Agricultural Patriotism: A Hope to the New Government"	Indonesian Agricultural Communication Forum and Andalas University	Speaker
2014	National Seminar of Agroforestry	University of Pattimura	Speaker
2014	National Science Basic VI Seminar: "Science Building a Critical Thinking Character for People's Welfare"	Faculty of Mathematics and Natural Sciences Pattimura University	Participants
2013	Seminar on "The Meaning of Food Security for Rural Households"	Faculty of Agriculture Pattimura University	Participants
2013	Seminar on "Sago Forest Land Ownership"	Faculty of Agriculture Pattimura University	Participants
2013	Scientific Seminar on Agricultural Development of Islands in the Framework of 50th Anniversary of Faculty of Agriculture, Pattimura University	Faculty of Agriculture Pattimura University	Committee
2013	International Spices Conference in Ambon, Indonesia	Pattimura University - Indonesian Spice Board	Participants
2012	National Conference and Seminar "Restoring the Glory of the Nutmeg and Cloves for People's Welfare"	University - Indonesian Spice Board	Participants
2011	International Humanosphere Science School: The Development of Science and Technology for Sustainable Human sphere	Kyoto University-Indonesian Institute of Sciences (LIPI), University of Pattimura	Participants
2011	International Symposium for Sustainable Humanosphere: Wallace Ecosystem and Biodiversity in Maluku for Sustainable Humanosphere	Kyoto University-Indonesian Institute of Sciences (LIPI), University of Pattimura	Participants
2011	International Seminar: Using GIS for Sustainable Development in Maluku Province	Witteveen + Bos – University of Pattimura	Participants

2010	International Seminar on Sago and Spices for Food Security.	Local Government of Maluku	Participants
2010	Seminar on the Implementation of Agricultural Education in Maluku Maluku Fisheries and Forestry Counseling.	Coordinating Agency for Agricultural Extension of Maluku	Participants

PUBLICATION

Year	Article Title	Journal Name
2020	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, vol. 19 No. 3, 2021 (Scopus Q3)
2020	Morphological characters and essential oil constituents extracted of two clove varieties (*Syzygium aromaticum* (L.) Merr. & L. M. Perry.) from Ambon Island, Indonesia.	Plant Archives vol. 20 No. 1 Januari 2020 (Scopus Q4)
2020	Physico-chemical properties of clove oil from three wild clove accession groups (*Syzygium aromaticum* (L.) Merr. & L. M. Perry.) in Maluku.	IOP Conf. Series: Earth and Environmental Science 418 (2020) 012028
2020	Growth of forest clove seedlings at different concentrations of paclobutrazol	IOP Conf. Series: Earth and Environmental Science 575 (2020) 012081
2020	Growth of palm oil seedlings at various doses of boiler ash and tofu wastewater	IOP Conf. Series: Earth and Environmental Science 575 (2020) 012081
2019	Morphological Traits of Maluku Native Forest Clove (*Syzigium aromaticum* L. Merr& Perry)	Journal of Tropical Crop Science Vol. 6 No. 2
2019	Morpho-Agronomical Diversity of Forest Clove in Moluccas, Indonesia	Hayati, Accepted (In press)
2019	The physicochemical components and characteristic from essential oils of forest cloves S*yzygium aromaticum* (myrtaceae) in maluku province, indonesia	Plant Archive, Accepted (In Press)
2013	Effect of Intermittent Water Management and Provision of Organic Fertilizer on Some Parameters of Water Use in Rice Field Plants	Journal of Agroqua Vol. 11 No. 2 December 2013 ISSN 0216-6585 University of Prof. Dr. Hazairin, SH., Bengkulu
2013	Growth and Results of Rice Plants (Oriza sativa L.) at Various Intervals of Water Delivery Time and Organic Fertilizer Dose.	Journal of Agricultural Cultivation, Vol. 9 No. 1, July 2013 ISSN 1858-4322 Faculty of Agriculture Pattimura University
2013	Corn Plant Growth Response Against Giving Some Kind of Bokashi.	Journal of Agroqua, Vol. 11 No. June 1, 2013 ISSN 0216-6585 University of Prof. Dr. Hazairin, SH., Bengkulu

COMMUNITY SERVICE EXPERIENCES

Year	Title of Community Service	Source
2020	Bokashi Organic Fertilizer Making Training at RW 01 Lateri Village	independently
2020	Plant Cultivation Training in Yard Lands	independently
2016	Clove stem borer control in Central Maluku Regency	The local government of Maluku
2016	Counseling and Management Training of Vegetable Cultivation System System at Nania Vegetable Farmer Group	Independent
2015	Counseling of Horticultural Cultivation at Farmer Group in Kairatu Village	Independent
2014	Propagation of Epicotyl Nutmeg in Morella Village of Central Maluku District	DIPA 2014 Pattimura University
2014	Cultivation Technique of Nutmeg in Morella Village of Central Maluku District	DIPA 2014 Pattimura University
2014	Agricultural Extension Making of Bokashi Organic Fertilizer at Nutmeg Farmer Group in Lilibooy Village, Central Maluku District	Independent
2014	Agricultural Extension of Vegetative Plant Propagation in Lilibooy Village, Central Maluku District	Independent
2014	Agricultural Extension of Nursery Vegetable Techniques in Waiheru Village, Ambon City	Independent
2014	Agricultural Counseling of Bokash Organic Fertilizer at Vegetable Farmer Group in Waiheru Village	Independent
2013	Agricultural Extension of Waste Management of Nut Garden at Nutmeg Farmer Group in Hila Village	Rain Forest Alianz
2013	Agricultural Counseling Specification of Nut Trees Tree Requirement in Nursery Breeder Group in Lilibooy Village	Rain Forest Alianz
2013	Agricultural Extension Technique of Organic Fertilizer Manufacturing of Bokashi on Nursery Breeder Group in Lilibooy Village	Rain Forest Alianz
2012	Counseling and Training of Vegetable Cultivation Management at Waiheru Vegetable Farmer Group	Independent

Ambon, January 2021

Dr. Asri S. Mahulette, SP. MP

CURRICULUM VITAE

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Short description about activities & current research interest

- Biological Aspect of Silviculture
- Soil carbon management
- Mycorrhizae
- Plant Physiology
- Forest Health Monitoring
- Mutation Breeding of Sorghum for Food, Feed, Fuel, and Fibers**.**
- Farmer Energy
- Seed technology
- Essential oil from various plants for aromatherapy, perfume, and beauty.
- Forest Honey Bee in West Kalimantan as Natural Product.
- Fruit Trees

2. Education

Institutions	**Degree**	**Period**	**Field of Study**
Faculty of Forestry, Gadjah Mada University	Engineer	1981	Forest economic and Management
Faculty of Science, Nancy University, France	Doctor	1989	Plant Physiology and Forest Biotechnology

3. Trainings Workshops

Institutions	Period	Topics
Mediterranean Agricultural Institute, Montpellier, France.	1984-1985	France Language,
Association of Private Forest of Lorraine Region , Nancy, France	1986-1987	Management of Private Forest.
Compiegne University of Technology, Compiegne, France.	1987	Scientific Communication,
ASEAN Institute of Forest Management, Kuala Lumpur, Malaysia	1990	Sustainable Forest Management.
SEAMEO BIOTROP, Bogor, Indonesia.	1991	English Scientific Communication.
Faculty of Forestry and Geomatic. University of Laval, Quebec, Canada.	1991	Mycorrhizal Technology.
Bogor Agricultural University, Bogor.	1994	Research Management Enhancement
Laval University Quebec and Department of Agriculture Ottawa, Canada.	1994.	Biotechnology of Mycorrhiza
SEAMEO BIOTROP, in Cooperation with USDA- Forest Service- Ministry of Forestry, Bogor	1995	Forest Health Monitoring
Research Coordination Meeting Joint FAO – IAEA , Vienna Austria.	2012	The Use of Mutant Lines for Increased the Agriculture Production.

4. WORK EXPERIENCES		
Institutions	**Positions/Responsibilities**	**Period**
Ministry of Environment and Forestry, Republic of Indonesia	Supervisor of Center of Excellent (PUI) of Conservation of Tropical Forest Resources	2019
Ministry of Environment and Forestry, Republic of Indonesia	Supervisor of Center of Excellent (PUI) of Seed Technology of Tropical Forest Plantation.	2019
Ministry of Education and Culture, Republic of Indonesia	Coordinator of Non-seasonal Fruit Trees	2018 - 2020

	and Vegetables Development in 36 Vocational High School in Indonesia	
Ministry of Industry, Republic of Indonesia	Consultant for Forest Honey Bee as Natural Products.	2017
SEAMEO BIOTROP	Scientists	1981 - Now
Joint Director FAO-IAEA and SEAMEO BIOTROP.	Principle Investigator for Indonesia on Development of Promising Sorghum Mutant Lines for Improved Fodder Yield and Quality Under Different Soil Types, Water Availability and Agro-Ecological Zones	2012 – 2014
PT.BATAN TEKNOLOGI – SEAMEO BIOTROP	Chairman Feasibility Study of sorghum plantation in Belu, Malaka, Timor Tengah Utara dan Kupang Districts, Nusa Tenggara Timur Province.	2013
Rumpin Seed Source and Nursery Center, Ministry of Forestry and Korea-Indonesia Forestry Cooperation	Chairman for Master plan Development 2013-2017	2012
Faculty of Forestry, Bogor Agricultural University, Bogor	Chairman for the Land Rehabilitation Movement for Jakarta Flooding Awareness.	2002 - 2008
Faculty of Forestry, Bogor Agricultural University, Bogor and KOICA	Chairman for Development of Seedling Productions from Genetically Improved.	2007-2008
KOICA	Chairman on Genetic material selection and collection for potential plantation tree improvement in Indonesia,	2006
Faculty of Forestry, Bogor Agricultural University, Bogor, and The Ministry of Forestry	Chairman for Evaluation of seedling production for Land Rehabilitation in West Java and Banten Provinces.	2006-2007

SEAMEO – BIOTROP	Scientist on Biological Aspect of Silviculture	1981 – 1985
Faculty of Forestry, Bogor Agricultural University	Lecturer on Silviculture, Seed Technology, and Plant Physiology for Undergraduate, Postgraduate (Master and doctoral programs).	1992 – 2020
Wageningen University, the Netherlands	Co-Promotor for Doctoral Program .	1998- 2002
Murdoch University, Perth, Western Australia.	External Examiner for PhD Degree	2001
BPTH – Jawa Madura	Chairman, Penyususnan Rencana Umum Pembangunan dan Pengembangan Sumber Benih Wilayah Jawa Madura,	2004
DG of Land Forestation and Social Forestry, Ministry of Forestry	Chairman, Penyusunan Rencana Strategis Pembinaan dan Pengawasan Mutu Benih dan Pembibibitan Rehabilitasi Hutan dan Hutan Cadangan Pangan,	2000
DG of Forestry Planning Ministry of Forestry,	Chairman on Master Plan Reboisasi dan Rehabilitasi Hutan dan Nasional	2000
UP Diliman, the Phillippines.	Co-Supervisor for Graduate Study	2000- 2002
Faculty of Forestry, Bogor Agricultural University	Vice Dean for Student Affairs	2000- 2004
ITTO – MOFEC – USDA – Forest Service – SEAMEO BIOTROP, Bogor.	Chairman of Project Executing Agency on Forest Health Monitoring Programme ,	1998 – 2000
DG of Land Forestation and Social Forestry, Ministry of Forestry	Member on Program Nasional Sistem Perbenihan Kehutanan, Balai Teknologi Perbenihan, Departemen Kehutanan	1998
ACIAR (Australia) - RITF (China)	Project Reviewer for ACIAR (Australia) - RITF (China) Cooperation on Mycorrhizal Development Technnology for Reforestation Program in China and Australia.	1998
DANIDA (Denmark) and MOF (Indonesia)	Project Reviewer for the DANIDA (Denmark) and MOF (Indonesia) Cooperation on Indonesian Forestry Seed Project.	2000
Faculty of Forestry, Bogor Agricultural University	Director of Gunung Walat Education Forest.	2004- 2009
Ministry of Forestry	Member of National Working Group for the Project Proposal Appraisal to the ITTO	2005 – 2009

International Forestry Student Association	Counselor	2000- now
Bogor Agricultural University	Member on Planning and Development of Bogor Agricultural University	2013 - 2014

4. Research Activities

- Seedling production using mycorrhizal fungi for land rehabilitation (1997 – 2009)
- Development of Jatropha oil for simple farmer energy (2008-2009)
- Biocharcoal for soil management in seedling production (2008- 2010)
- Duabanga mollucana as Potential Lesser-Used Species in Community Forest (2010).
- Production system of 15 Sorghum mutant in Bogor (2009 – 2010)
- Indonesian mycorrhizal fungi database (2007- 2010)
- Farmer energy through pyrolysis process (2009)
- Application of biocharcoal for growing several promising sorghum mutants in sustainable agroforestry system (2010)
- Application of Biocharcoal and Boron for increased several sorghum varieties for food, feed, and energy (2011)
- Agroforestry of Sentang and Sorghum (2011).
- Production of Liquid organic fertilizer, Particle Board and Craft Paper derived from sorghum waste in ethanol production (2012).
- Development of Promising Sorghum Mutant Lines for Improved Fodder Yield and Quality Under Different Soil Types, Water Availability and Agro-Ecological Zones (2012 – 2014).
- Development of Non Season Fruits and Vegetables in 36 Vocational School in Indonesia (1918 – 2020).
- Essential oil from various plants for aromatherapy, perfume, and beauty (2017 – now)

5. Publications

Mujahidin, **Supriyanto** and L Karlinasari, 2018, The assessment of canary trees in the Bogor Botanic Gardens using forest health monitoring and sonic tomography methods, IOP Conf. Series: Earth and Environmental Science 203 (2018) 012025

Widhi Kurniawan, L.abdullah, D.M.H.Panca, Karti and **Supriyanto**. 2014. Herbage Production of Brown Midrib (bmr) and Conventional Sorghum Fertilized With Different Levels of Organic Fertilizer as Forage Source for Goat. Proceeding of the Second Asian- Australasian Dairy Goat Conference. April 25-27 th,2014, IPB International Convention Centre Bogor, Indonesia.

Apri H. Iswanto, Irawati Azhar, **Supriyanto** and Arida Susilowati. 2014. Effect of resin type, pressing temperature and time on particleboard properties made from sorghum bagasse. Agriculture, Forestry and Fisheries. Science PG. Vol.3. No.2, pp 62-66.

Arida Susilowati, **Supriyanto**, Iskandar Z. Siregar, Imam Wahyudi and Corriyanti, 2013. Genetic variation , Heritability and Correlation between Resin Production Character of *Pinus merkusii* High Resin Yielder (hry) in Cijambu Seedling Seed Orchard (SSO). Biotropia, Vo.2 No.2 , pp 122-133.

I Wayan Susi Dharmawan, Bambang Hero Saharjo, Supriyanto, Hadi Susilo Arifin dan Chairil Anwar Siregar. 2013. Persamaan Alometrik dan Cadangan Karbon vegetasi pada hutan gambut primer dan bekas terbakar. Jurnal Penelitian Hutan dan Konservasi Alam. Vol. 10 . No. 2 , 2 Agustus 2013. Pp. 175-191.

Arida Susilowati, **Supriyanto**, Iskandar Z. Siregar, Imam Wahyudi dan Corriyanti, **2012**. Keterkaitan beberapa karakter fenotipik terhadap produksi resin pada *Pinus merkusii* kandidat bocor getah. Prosiding Seminar Nasional Masyarakat Perkayuan Indonesia (Mapeki) XIV, Gadjah Mada Club, Universitas Gadjah Mada, 670-675

Henti Hendalastuti Rachmat, Iskandar Z. Siregar, **Supriyanto,** Koichi Kamiya, Ko harada. 2012. Molecular variation of some endangered species in Indonesia. Proceeding of 3rd Gen Network and 4th International Seminar Sustainable Bio-Resources for Global Welfare. Published by Department of Agroindustrial Technology, Faculty of Agricultural Technology, University of Gadjah Mada, Indonesia.

Supriyanto, 2012. Development of Sorghum in Indonesia. Makalah ini disampaikan pada Workshop on the Current Status and Challenges in Sorghum Development in Indonesia, tanggal 25-26 September 2012 di SEAMEO-BIOTROP Bogor.

Andi Rinto Prastiyo Wibowo, **Supriyanto** dan Nurheni Wijayanto, **2012**. Agroforestri SORGUM (*Shorgum bicolor* L. Moench) dan SENTANG (*Azadirachta excelsa* Jack.). Makalah ini disampaikan pada Workshop on the Current Status and Challenges in Sorghum Development in Indonesia, tanggal 25-26 September 2012 di SEAMEO-BIOTROP Bogor.

Arida Susilowati, **Supriyanto,** Iskandar Z. Siregar dan Atok Subiakto**, 2012**. Perbanyakan Tanaman Pasak Bumi (Eutocoma longifolia ac) melalui Stek Pucuk. Foresta, Indonesian Journal of Forestry, Vol. I, No. 1 Maret 2012**.**

Supriyanto dan Kaka E. Prakasa**, 2011**. Pengaruh Zat Pengatur Tumbuh Rootone-F Terhadap Pertumbuhan Stek *Duabanga mollucana* Blume Jurnal Silvikultur Tropika Vol.03 No. 01.

Supriyanto, 2012, Accelerated optimum growth untuk pengembangan HTI. Seminar Pemilihan dan Pengembangan system silvikultur di Hutan Tanaman. Bogor. 17 Maret 2012, Ashton , Bogor.

Supriyanto, 2011. Development of Sorghum for Food, Feed, and Energy. Booklet. SEAMEO BIOTROP.

Supriyanto, 2011. Application of Biocharcoal and Boron for increased several sorghum varieties for food, feed, and energy. SEAMEO BIOTROP , Research Report .

Henti hendalastuti R., Atok Subiakto, Iskandar Z. Siregar, dan **Supriyanto.** 2010. Uji pertumbuhan stek cemara Sumatra (*Taxus sumatrana (Miquel)de Laub.* Jurnal Penelitian dan Konservasi Alam. Vol.VII, No. 3, pp 289-298.

Supriyanto , 2010. Application of biocharcoal for growing several promising sorghum mutants in sustainable agroforestry system. SEAMEO BIOTROP, Research Report

Supriyanto and Fidryaningsih Fiona, 2010. Pemanfaatan arang sekam untuk memperbaiki pertumbuhan semai jabon (*Anthocephalus cadamba* Roxb. Miq) pada media subsoil.Vol 01 No.1 Des.2010

Supriyanto, 2009. Status of mycorrhizal research and its implementation in Indonesia. Paper presented in Paper presented in the FNCA WORKSHOP on Multifunctional Biofertilizer for Sustainable Agriculture, Jakarta, 23-26 February 2009.

Supriyanto, 2008. Data-Base of Potential Ectomycorrhizal Fungi in Indonesia. Research Report. SEAMEO BIOTROP (unpublished).

Supriyanto, A.Sukendro, E. Djamhuri, Iskandar Z. Siregar, P.Pamungkas, Ulfah.Y. Siregar , S.W.Budi , and R.Syafei. 2007. Selection and Collection of Mother Trees and Plus Trees of Some Potential Genetic Resources. Paper presented in Symposium on Genetic Material Collection and Nursery Establishment of Potential Plantation Tree

Species in Indonesia, conducted by the Ministry of Forestry and Korean Forestry Services (Korean International Cooperation Agency), Jakarta, 21 February 2007.

Supriyanto. 2007. Some Strategies in Rehabilitation of Degraded Production Forest Toward Sustainable Forest Management. International Workshop on Rehabilitation of Degraded Forest Using Indigenous Species through Collaboration with Local Communities in West Kalimantan. Pontianak, 28 March 2007. ITTO-UNTAN.

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E. Indra Putra and **Supriyanto,** 2001. Forest Health Monitoring Data Base (FHM D-Base) User Guide. Technical Report No. 3 PD 16/95 Rev.2 (F). ITTO – MOF-USDA Forest Service-SEAMEO BIOTROP.

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Supriyanto, Soekotjo and A. Justianto. 2001. Assessment of Production Indicator in Forest Health Monitoring to Monitor the Susutainability of Indonesian Tropical Rain Forest. Technical Report No. 13 PD 16/95 Rev.2 (F). ITTO – MOF-USDA Forest Service-SEAMEO BIOTROP.

Supriyanto. 2001. Assessment of Production Indicator in NFI-FHM Plot System at South Kalimantan. Technical Report No. 14 PD 16/95 Rev.2 (F). ITTO – MOF-USDA Forest Service-SEAMEO BIOTROP.

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Kasno and **Supriyanto**. 2001. Crown Damage due to Logging in Forest Health Monitoring. Technical Report No. 20 PD 16/95 Rev.2 (F). ITTO – MOF-USDA Forest Service-SEAMEO BIOTROP.

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Siegar, C.A. and **Supriyanto**. 2001. Site and Species Suitability Study Based on Forest Health Monitoring Activities Conducted in South Kalimantan and East Jambi. Technical Report No. 22 PD 16/95 Rev.2 (F). ITTO – MOF-USDA Forest Service-SEAMEO BIOTROP.

Supriyanto, U. S. Irawan, E. Indra Putra and I.W.S Dharmawan. 2001. Stand Structure (Status, Change, Trends). Technical Report No. 23 PD 16/95 Rev.2 (F). ITTO – MOF-USDA Forest Service-SEAMEO BIOTROP.

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Kasno, **Supriyanto**, S.T. Nuhamara, E.Indra Putra and I.W.S. Dharmawan. 2001. Assessment on Crown Indicators of Forest Health Monitoring. Technical Report No. 28PD 16/95 Rev.2 (F). ITTO – MOF-USDA Forest Service-SEAMEO BIOTROP.

Kasno, S.T. Nuhamara, **Supriyanto**, U. Sutisna and I.W.S. Dharmawan. 2001. Early Warning of Changes in Canopy Condition of Overstory Trees. Technical Report No.29 PD 16/95 Rev.2 (F). ITTO – MOF-USDA Forest Service-SEAMEO BIOTROP.

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Supriyanto, 1998. Mycorrhizae and Forest Plantation in Indonesia. International Workshop on Mycorrhizae, GuangZhou, China, 29 September-3 October 1998.

Arum S. Wulandari, **Supriyanto**, E. Guhardja, M.A. Rifai, Y. Fakuara, N. Sukarno, 1997. Effect of thermal-schock on fruiting-body induction of *Scleroderma sinnamariense* associated with *Gnetum gnemon* seedlings.International Conference on Mycorrhizas in Sustainable Tropical Agriculture and Forest Ecosystems, Bogor, Indonesia, 26-30 October 1997.

Supriyanto and Ujang S. Irawan, 1997. Inoculation Techniques of Ectomycorrhizae. Seminar of Mycorrhizae, Ministry of Forestry - Overseas Development Administration/United kingdom, 28 - 29 February 1996, Balikpapan, East Kalimantan.

Supriyanto, 1996. Conservation and utilization of mycorrhizal fungi genetic resources. SEAMEO FORUM Vol.3 No.2.

Tjitrosemito S. And **Supriyanto**. 1992.The Establishement of timber estate - transmigration scheme on areas of *Imperata cylindrica.* National Seminar on Status of Silviculture in Indonesia. Yogyakarta, 27 -29 April

Supriyanto, I. Setiawan and M. Harahap. 1992. Quality enhancement of forest tree seedlings through mycorrhizal fungi inoculation. National Seminar on Status of Silviculture in Indonesia. Yogyakarta, 27 -29 April.

Supriyanto, M. Turjaman, Suciatmih and S. Prajadinata. Status of mycorrhizal research in Indonesia . Second Asian Conference on Mycorrhiza (ACOM II), Chiang Mai, Thailand.

Setiawan , S. , M.I. Umboh and **Supriyanto**. 1991.Growth of *Accacia mangium* obtained by tissue culture. BIOTROPIA no. 4. Pp. 1-8.

Supriyanto. 1989. Micropropagation of *Pinus nigra* and *Pinus silvestris* : application to their hybride interspecific. PhD disertation on Plant Physiology and Forest Biotechnology. Faculty of Science , University of Nancy I, Nancy, France.

Supriyanto and R.Rohr. 1988.Use of selected mycorrhizal fungi to facilitate the transfer to soil of Scots pine axenic plantlets. Int. Symp. On Forest Tree Physiology. Nancy. France.

6. Professional Membership

- Mycorrhiza Network Asia
- Indonesian Mycorrhizae Association.
- Ketua FORKOMASI (Forum Komunikasi Masyarakat Sorgum Indonesia)

7. Awards/Patents

- The Third Winner of Outstanding Lecturer in Bogor Agricultural University, in 2005.
- Efficient Stove for Farmer Energy (Invention)
- Spherical densitometer.
- Ethanol distillatory
- Fellowships Joint FAO/IAEA Division.
- Lifetime Achievement Awards (2019).

8. Editors/ Mitra Bestari

1. Jurnal Penelitian Hutan Tanaman. Badan Penelitian dan Pengembangan Kehutanan (2007 – 2012).
2. Jurnal Penelitian Hutan dan Konservasi Alam. Badan Penelitian dan Pengembangan Kehutanan (2006 – 2010).
3. Jurnal Silvikultur Tropika, Fakultas Kehutanan, IPB. (2010 – Sekarang).
4. Jurnal Wallecia (2018 – sekarang).

Curriculum Vitae

Name: Jonner Situmorang M.Si.

Place/Date of Birth: Tebing Tinggi, 8 November 1963.

Formal Education:

Universitas/Institut dan Lokasi	Gelar	Tahun selesai	Bidang studi
Universitas Nasional, Jakarta	Drs.	1989	Biology
Institut Pertanian Bogor, Bogor	M.Si.	2000	Agronomy, Plant Biotechnology

Working Experience:

1997 – 2010, Research Assistant, Plant Biotechnology Laboratory, SEAMEO BIOTROP.

2010 -2013, Research Department Supervisor, SEAMEO BIOTROP.

2014 - 2015, Community Development Supervisor, SEAMEO BIOTROP.

2016 - now, Member of Researcher DIPA, Natural Product Laboratory, SEAMEO BIOTROP.

Member of researcher RUT V, SEAMEO BIOTROP, 1997-2000

Member of researcher RUT X, SEAMEO BIOTROP, 2003-2005

Member of researcher Hiba Bersaing, IPB, 2003-2004

Member of researcher RUT Dasar, SEAMEO BIOTROP, 2006-2007

Coordinator and Narasumber pada Pelatihan Nasional Budidaya dan Pengolahan Gaharu, SEAMEO BIOTROP, Bogor , 2005.

Narasumber pada Pelatihan Nasional Budidaya dan Pengolahan Gaharu, SEAMEO BIOTROP, Bogor , 2006.

Narasumber pada Pelatihan Nasional Budidaya dan Pengolahan Gaharu, SEAMEO

BIOTROP, Bogor , 2007.

Narasumber Tunggal pada Seminar Budidaya dan Industri Gaharu, Kuala Lumpur, 2008.

Koordinator dan narasumber Pelatihan Inokulasi Gaharu Bagi Dinas Kehutanan dan Masyarakat Kabupaten Tambrauw - Provinsi Papua Barat, 2015.

Koordinator dan narasumber Pelatihan Budidaya, Inokulasi Gaharu, dan Penyulingan Minyak Gaharu Bagi Dinas Kehutanan dan Masyarakat Kabupaten Asmat- Provinsi Papua, 2015.

Koordinator Program Pengembangan Sekolah Menengah Kejuruan (SMK) Pertanian Pendukung Ketahanan Pangan di Indonesia, Tahun Anggaran 2018-2019.

Narasumber dan Pendamping, Bimbingan Teknis Budidaya dan Teknik Ekstraksi Minyak Atsiri serta Produksi Aromaterapi, parfum alami dan sabun alami, Program Pengembangan Sekolah Menengah Kejuruan (SMK) Pertanian Pendukung Ketahanan Pangan di Indonesia Tahun Anggaran 2018-2019.

Speaker on The 2nd Asian Agriculture & Food Forum (ASAFF), 2020, HKTI, Jakarta Convention Centre, 12-14 March 2020.

Speaker on Community Development and Empowerment Unit, GPIB, Indonesia, Wirausaha Minyak Atsiri & Produk Turunannya, 25 June 2020.

Publications:

Situmorang, J. 1988, Perbanyakan secara vegetatif *Eucalyptus urophylla* Blake melalui teknik kultur jaringan, (Skripsi S1), Fakultas Biologi, Universitas Nasional, Jakarta.

Umboh, M.I.J. and **J. Situmorang,** 1988. Micropropagation of *E. urophylla*, BIOTROP, Internal Report, 1987-1988.

Umboh, M.I.J.; Setiawan, I., Kamil, H., Yani, S.A. and **Situmorang, J.** 1989. L'application de culture *in vitro* a'la multiplication d' especes forestieres tropicales en Indonesie, Bull. Soc. bot. Fr., 136, Actual. bot (3/4), 179-184.

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Research and Development Institute, department of Forestry, 13-15 March 1990, Jakarta.

Umboh, M.I.J., **Situmorang, J.,** Yani, S.A. and Kamil, H., 1990. Planting materials of *Acacia mangium* and *E. urophylla* from selective trees in Subanjeriji Forest Plantation, Seminar of Forest Biotechnology, PAU, Faculty of Forestry Gajah mada University, Jogyakarta, 12-13 February, 1990.

Umboh, M.I.J. and **J. Situmorang. 1990.** Somaclonal variation of *Albizia falcataria*: Development and regeneration of embrioid cells, Internal report, SEAMEO BIOTROP, 1990-1991.

Umboh, M.I.J., **Situmorang**, **J**., Yani, S.A. and Sunarni, E. 1992. Produksi bibit asal klon i*n vitro* pohon-pohon seleksi *Acacia mangium* dan hibrid *A. mangium* x *A. auriculiformis*, Prosiding Seminar Nasional, Status Silvikultur di Indonesia saat ini. Yogyakarta.p.1-14.

Umboh, M.I.J, Sulistiani, E., **Situmorang, J.,** Ilato, S., Prakasa, N., and Setyaningsih R. 1992. Micropropagation of ten selected clones of Kapok (*Ceiba pentandra* GAERTN), Report Research Project ANSAB-SEAMEO BIOTROP.

Umboh, M.I.J., G. Rahayu, H. Affandi, **J. Situmorang,** S.A Yani, Y. Isnaini and A. Nuryadin. 1998. Efforts to Improve the production of Agarwood: Micropropagation of *Aquilaria* species as well as Effort of Improvement the Bioprocess of its Agarwood. In BIOTROP Annual Report. Bogor. (Abstract).

Umboh, M.I.J., G. Rahayu, H. Affandi, **J. Situmorang,** S.A Yani, Y. Isnaini and A. Nuryadin. 1998. Upaya peningkatan produksi gubal gaharu: mikropropagasi *Aquilaria* spesies dan upaya peningkatan bioproses gubal gaharunya [laporan akhir penelitian RUT V]. Jakarta: Menristek-DRN.

Rahayu, G., Isnaini, Y., **Situmorang, J.** dan Umboh, M.I.J., 1998. Cendawan yang berasosiasi dengan gaharu (*Aquilaria* spp.) dari Indonesia. *In.* Proceedings of the Seminar Pertemuan Ilmiah Tahunan PERMI. Bandar Lampung, 16-18 Desember 1998, p.385-393.

Situmorang, J. 2000. Mikropropagasi Kayu Gaharu (*Aquilaria* spp.) Asal Riau Serta Identifikasi Sifat Genetiknya Berdasarkan Analisa Isoenzim. Thesis (S2), Program Pascasarjana, IPB, Bogor.

Umboh, M.I.J., G. Duryadi, D., Fransiska, R., **Situmorang, J.,** and Isnaini Y. 2000. Upaya Peningkatan Produksi Gubal Gaharu**:** Konservasi *ex situ* dan seleksi genotipe pohon gaharu (*Aquilaria malaccensis* Lamk. dan *A. microcarpa* Baill.) yang berpotensi menghasilkan gubal gaharu [laporan akhir penelitian RUT X]. Jakarta: Menristek-DRN.

Umboh, M.I.J., G. Duryadi, D., **Situmorang, J.,** and Isnaini Y. 2002. Penggunaan penanda mikrosatelit pada analisis genetik dan struktur pohon gaharu (*Aquilaria malaccensis* dan *A. microcarpa*) dari kebun gaharu, Riau, Laporan Penelitian DIPA 2002, SEAMEO BIOTROP, Bogor.

Situmorang, J., dan G. Rahayu. 2003. Menuju produksi gaharu secara lestari. Laporan penelitian Hibah Bersaing. Dirjen Ilmu Pendidikan Tinggi, Jakarta.

Lukman, R., **Situmorang, J.,** Isnaeni, Y., 2005. Seleksi klon unggul gaharu (*Aquilaria malaccensis* Lamk.) secara *in vitro.* Laporan Penelitian DIPA 2002, SEAMEO BIOTROP, Bogor.

Situmorang, J. 2005. Seleksi dan perbanyakan pohon gaharu (*Aquilaria* spp.) unggul secara vegetatif: Kultur jaringan dan stek. Materi Kuliah. Pelatihan Nasional Budidaya dan Pengolahan Gaharu. 28 Nopember-3 Desember 2005 SEAMEO BIOTROP, Bogor.

Situmorang, J. 2019. Program Pengembangan SMK Pertanian Pendukung Ketahanan Pangan Tahun 2019, SEAMEO BIOTROP, Bogor.

Bogor, 7 Januari 2021

Jonner Situmorang, M.Si.
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CURRICULUM VITAE (BIO-DATA)

PERSONAL DETAILS

Name : **Suyadi, S.Si., M.Sc., Ph.D.**

Sex : Male

Place, date of birth : Lampung, June, 04th 1980

Citizenship : Indonesian

NIK/ID No. : 3201290406800002

Office : Research Centre for Biology, Indonesian Institute of Sciences (LIPI)

Office address : Jl. Raya Bogor km 46, Cibinong 16911, Bogor, Jawa Barat, Indonesia

Home address : Alam Tirta Lestari, Jl. Anthorium, B4 No 3, RT 09 RW 14, Pagelaran, Ciomas, Bogor, Jawa Barat, Indonesia 16610

Expertise : Forest Ecology (Subset mangrove), Ecosystem services, and Biodiversity Conservation

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Google scholar : https://scholar.google.co.nz/citations?hl=en

Research gate : https://www.researchgate.net/profile/Suyadi_Suyadi

Sinta : http://sinta.ristekbrin.go.id/authors/detail?id=6688106&view=overview

EDUCATION

- Ph.D. in Environmental Science, Faculty of Science, University of Auckland, New Zealand (2014- 2018).
- Master of Science (M.Sc.) in Information Technology for Natural Resources Management, an International Graduate Program at the Bogor Agricultural University, Indonesia (2009 – 2011).
- Sandwich program in English and American culture at the University of Arkansas, Fayetteville, Arkansas, USA (2011)
- Short course / Certificate in Statistics and Geographic Information System at the University of Cambridge, Cambridge, UK (2010)
- Bachelor of Biology (Graduate Cum laude), Faculty of Mathematic and Natural Sciences, Pakuan University, Bogor, Indonesia (2002 – 2005).

WORK EXPERIENCE

- Researcher at Indonesian Institute of Sciences/LIPI (2008 – Present)
  Responsibilities: my responsibilities can be categorized into: research management and research activities. Research management are managing, monitoring, and evaluating research programs in the research centre. My tasks are including research program development, human resources development, research institutional strengthening, and research facilities improvement. My main activities as a researcher is writing research proposal/research design for funding, lead research groups, chief scientist for research projects, lecturing and training, reporting and publications, and conservation actions.
- Researcher at Wildlife Conservation Society (2005 – 2007)
  Responsibilities: Assist in research design and execution, lead small survey teams, data management and analysis, reporting and publications.
- General officer (part time) at Wildlife Conservation Society (2002 – 2004)
  Responsibilities: Assist database management, administration and financial task, and other jobs such as organise conferences and meetings and society services.
- Field Technician at Wildlife Conservation Society (1997 – 2001)
  Responsibilities: help build permanent field research stations, data collection, data entry, forest fire rescue, specimen collection and management, and other job in the research station such as cleaning, gardening, and shopping.

RESEARCH PROJECTS

Funding agency	**Project/ Grant type**	**Project/ grant number**	**Title**	**Start-End Date**	**Amount (US$)**	**Position**
PN DIPA IPH - LIPI	Research grant	NOMOR : B-10405/IPH/HK.01.03/XI/2020	Development of Knowledge based system of ecosystem health index and digital information system for biological resources: wood and natural fiber	2021	17,839	Leader
Kurita Water and Environment Foundation	Research grant	20Pid002-U8	The effectiveness of mangroves for ground and marine water filter in small islands	2020 - 2021	3,760	Leader
Kemenristek/BRIN	National Research Priority of Biodiversity	274/E1/PRN/2020	Development of ecological modification concept and natural products to improve ecosystem management and sustainable use	2020 - 2021	25,400	Leader
Indonesian Institute of Sciences	Research grant	N/A	Coastal ecosystem monitoring in the outer territory of Indonesia	2019	62,963	Leader

(LIPI)			(Wetar and Timor)			
Indonesian Institute of Sciences (LIPI)	Research grant	N/A	Mangrove ecosystem monitoring in small islands	2008 - 2019	66,670	Leader
First Institute of Oceanography (FIO)-China	Research collaboration	MOU	Transport Indonesia seas, upwelling and mixing physics (Triumph)	2019	592,592	Co-coordinator
Indonesian ministry of science and technology	Research grant	N/A	Tuna and ecosystem conservation	2019	33,300	Co-coordinator
New Zealand ASEAN award	Research grant	Agreement	Dynamic of mangrove ecosystem and implication to carbon stocks in Auckland Region, New Zealand.	2014-2018	131,764	Leader
Idea Wild, USA	Research grant	N/A	Biodiversity conservation and community development	2005, 2009, 2015	3,000	Leader
ILCB, Royal Dutch Shell, UK	Research grant	N/A	Tropical deforestation and ecosystem degradation	2009	3,500	Leader
WWF Russel E. Train-EFN, USA	Research grant	R550	Deforestation and implication to population ecology of Sumatran tiger	2007	14,300	Leader

RESEARCH EXPERIENCE

1. Development of Knowledge based system of ecosystem health index and digital information system for biological resources: wood and natural fiber (2021)
2. The effectiveness of mangroves for ground and marine water filter in small islands (2020 – 2021)
3. Development of ecological modification concept and natural products to improve ecosystem management and sustainable use (2020 – 2021)
4. Monitoring of coastal ecosystems in Basin Wetar and Palung Timor, Indonesia (2019)
5. Monitoring of mangrove ecosystems in Ambon, Indonesia: Condition, Threats, and Potential (2008 – Present).
6. Mangrove ecosystem dynamics and its ecosystem services (blue carbon) in Auckland region, New Zealand (2014-2017)

7. Vegetation health and potential of mangrove ecosystem in Weda Bay, Maluku (2013)
8. Deforestation in Bukit Barisan Selatan National Park, Sumatra (2005 – 2012).
9. Survey of local elite perception on wildlife and forest conservation of Bukit Barisan Selatan National Park, Sumatra, Indonesia (2006-2009).
10. Household Socio-Economic survey around forest of Bukit Barisan Selatan National Park, Sumatra, Indonesia (2005 – 2010).
11. Assistant for population and behaviour of Siamang (*Symphalangus syndactylus*) study in Bukit Barisan Selatan National Park, Sumatra, Indonesia (1999 – 2002)
12. Assistant for a research project of Sumatran tiger (*Panthera tigris sumatrae*) and other large mammals in Bukit Barisan Selatan National Park, Sumatra, Indonesia (1999)
13. Assistant for a research project of bird biodiversity and population in Way Canguk Research Area, Bukit Barisan Selatan National Park, Sumatra, Indonesia (1998 – 2001)
14. Assistant for a research project of plant penology in Way Canguk Research Area, Bukit Barisan Selatan National Park, Sumatra, Indonesia (1998 – 2001).
15. Assistant for a research project of post-forest fire forest succession in Way Canguk Research Area, Bukit Barisan Selatan National Park, Sumatra, Indonesia (1997 – 1998).
16. Help Wildlife Conservation Society established a research centre in Way Canguk, Bukit Barisan Selatan National Park, Sumatra (1997).

TEACHING EXPERIENCE

1. A lecture assistant and exam invigilator at University of Auckland, New Zealand (2015-2017)
2. A guest lecturer at Pakuan University. Bogor, Indonesia (2010, 2011, 2018).
3. A lecturer assistant at Pakuan University. Bogor, Indonesia (2006).
4. A voluntary trainer at a local NGO, Indonesian Green Club. Bogor, Indonesia (2004-2006)
5. A teacher at SIMPLE Academic. Bogor, Indonesia (2005)

LIST OF PUBLICATIONS

Suyadi; M. Link; W. M. Rombang; N. Andayani. (*in prep*). Carbon accumulation and its influencing factors in burned and unburned lowland tropical forest. *Conservation Biology.*

Suyadi; J. Gao; C. J. Lundquist; L. Scwhendennmann. (*in prep*). Belowground carbon stocks in temperate mangroves and it source and variation across vegetation and hydrodynamic conditions. *Estuarine and Coast.*

S. Mumbunan, **Suyadi**, and C. Silangen. (*in prep*). Tropical forest cover, fiscal transfers, and forested jurisdictions. *Sceintific reports*.

Suyadi, Andri Irawan, Dharma Arif Nugroho, Daniel Pelasula, Fismatman Ruli, Muhammad Masrur Islami, Robert Alik, Daniel J. Tala, La Pay, Caleb Matuankotta (*in review*). Biodiversity in the coastal ecosystems of small islands and its conservation status**.** *IOP Conf. Series: Earth and Environmental Science of ISIBIO ISE Expo 2020.*

Suyadi, Bayu Prayudha, Terry Indrabudi, Corry Yanti Manulang, Jeverson Renyaan. (*in review*). Mangrove in urban area of small islands: vegetation health, potential, and management challenges. *IOP Conf. Series: Earth and Environmental Science of ECOES ISE Expo 2020.*

Suyadi, Abraham Simon Leatemia, and Alvi Betmanto Sitepu. (*in review*). Vegetation characteristics and its utilization: case study in East Seram. *Jurnal Kelautan dan Perikanan Terapan.*

Suyadi (2020). Characteristics of mangrove ecosystems in Weda Bay: Environment, Vegetation, and Aboveground Carbon Stocks. I*OP Conf. Series: Earth and Environmental Scienc*e 618 (2020) 012021. DOI:10.1088/1755-1315/618/1/012021.

Suyadi and Corry Y. Manulang. (2020). Distribution of plastic debris pollution and it is implications on mangrove vegetasion. *Marine Pollution Bulletin.* DOI: .org/10.1016/j.marpolbul.2020.111642.

C. Damayanti, R. Amukti, **Suyadi**. (2020). Potential of mangrove forest vegetation to mitigate sea water intrusion in small island. *Oseanologi dan Limnologi di Indonesia***.** 5(2): 75-91. DOI: 10.14203/oldi.2020.v5i2.313.

Suyadi and Corry Y. Manulang. (2020). Conservation of marine biological resources: challenges and management. *Proceeding of PIT ISOI 2019.*

Suyadi; J. Gao; C. J. Lundquist; L. Scwhendennmann. (2020). Aboveground carbon stocks in rapidly expanding mangroves in New Zealand: regional assessment and economic valuation of blue carbon. *Estuaries and Coasts*. DOI.org/10.1007/s12237-020-00736-x.

Prayudha, B., Y. Tuti, R.S. Utama, U. Yanuarbi, I.B. Vimono, I. Nagib, A. Faricha, **Suyadi**, J. Renyaan, S. Rahmawati, A. Kusnadi, L. Alifatri, A. Salatalohi, T. Triandiza, A.R. Dzumalex. (2019). *Laporan: Studi Baseline Terumbu Karang dan Ekosistem Terkait di Pulau Kei Kecil dan Sekitarnya, Kota Tual dan Kabupaten Maluku Tenggara, Provinsi Maluku*. COREMAP-CTI, Pusat Penelitian Oseanografi LIPI. 121 hal.

Suyadi; J. Gao; C. J. Lundquist; L. Scwhendennmann. (2019). Land-based stressors are key drivers of mangrve cover change in the Auckland region, New Zealand. *Special issue of Aquatic Conservation: Marine and Freshwater Ecosystems with the theme "Linking land-based stressors to rates of mangrove expansion"*. DOI: 10.1002/aqc.3146.

Suyadi; J. Gao; C. J. Lundquist; L. Scwhendennmann. (2018). Characterizing changes of temperature mangroves using spatial metrics and their rekationship with environmental factors. *Estuarine, Coastal and Shelf Science*. DOI.org/10.1016/j.ecss.2018.10.005.

Suyadi; W. N. Satrioajie; A. Syahailatua; Z. Arifin. (2018). Banda deep-sea research: histroy, mission, and strategis plan. *IOP Conf. Series: Earth and Environmental Science.* 184. 012001. DOI: 10.1088/1755-1315/184/1/012001.

Satrioajie, W. N.; **Suyadi**; A. Syahailatua; Z. Arifin. (2018). The importance of the Banda Sea for tuna conservation area: A review of studies on the biology and the ecology of tuna. *IOP Conf. Series: Earth and Environmental Science.* 184. 012001. DOI: 10.1088/1755-1315/184/1/012004.

Suyadi; J. Gao; C. J. Lundquist; L. Scwhendennmann. (2018). Sources of uncertainty in mapping temperate mangroves and their minimization using innovative methods. *International Journal of Remote Sensing*. 39:1, 17-36, DOI: 10.1080/01431161.2017.1378455.

Suyadi. (2016). Membalik paradigma pembangunan kota pesisir di indonesia untuk mencapai pembangungan ekonomi yang bekerlanjugan dan berkeadilan. In Amin, B., Dako, R., Fatem, S., Zaky, A. (Ed.), *Pluralitas dan keadilan sosial-pendangan dan pengalaman dari timur indonesia* (pp. 133-156) Indonesia Social Justice Network-Ford Foundation.

Berton C. Harris; Morgan W. Tingley; Fangyuan Hua; Ding Li Yong; Marion Adeney, Tien Ming Lee; Willy Marthi; **Suyadi**; Dewi M. Prawiradilaga, Cagan H. Sekercioglu; Nurul Winarni; David Wilcove. (2016). Measuring the impact of the pet trade on Indonesian birds. *Conservation Biology*. DOI: 10.1111/cobi.12729.

Suyadi. (2013). Impact of economic development in Ambon city on the land cover and mangrove ecosystem in Ambon Bay. *Oseanologi dan Limnologi di Indonesia.* 39 (3): 369-382.

Suyadi, Y.I. Ulumudin, R. Vebriansyah. (2013). Vegetation index from ALOS to predict above ground carbon stock in mangrove forest. *Jurnal Berita Biologi.* 12(2): 249 – 258.

Suyadi, IN. Surati Jaya, Antonius B. Wijanarto & Haryo T. Wibisono. (2013). Deforestation and it is implications to the population of key species in Bukit Barisan Selatan Nationl Park, Sumatra. *Jurnal Biologi Indonesia*. 9(1):79 – 87.

Suyadi. (2013). A Resolution to the Ambiguities in Estimation Area and Rate of Mangrove deforestation in Indonesia. *Jurnal Biologi Indonesia*. 9(2): 327 – 332.

Suyadi, I N. Surati Jaya, A. B. Wijanarto, H. T. Wibisono. (2012). A Spatial Model of Tiger (*Panthera tigris sumatrae*) Potential Habitat Suitability in Bukit Barisan Selatan National Park, Sumatra, Indonesia. *Berita Biologi*. 11 (1): 93 – 102.

Suyadi and W. N. Satrioajie. (2012). A documentary film "The Last stronghold of Amboina" or "Pelindung Pantai Amboina", Eagle Institute Indonesia-MetroTV. Present at Cinema XXI 18 – 27 September 2012 and MetroTV 9 October 2012.

Suyadi. (2012). A Decade of Condition of Mangrove Forest in Ambon Bay, Maluku, Indonesia. *Jurnal Biologi Indonesia*. 8(1): 197 – 203.

Suyadi. (2011). Deforestation in Bukit Barisan Selatan National Park, Sumatra, Indonesia. *Jurnal Biologi Indonesia*. 7(2): 195 – 206.

Suyadi. (2009). The Condition of Mangrove Forest in Ambon Bay: Prospect and Challenges. *Berita Biologi* 9(5): 481 – 490.

Suyadi. (2009). Perception of Elite Local to Conservation of Sumatran tiger (*Panthera tigris sumatrae*) and their Prey in Bukit Barisan Selatan National Park, Sumatra. *Ekologia* 9(1): 1 - 11.

Gaveau D.L.A, M. Linkie, **Suyadi**, P. Levang, N.L. Williams. (2009). Three decades of deforestation in southwest Sumatra: Effects of cofee prices, law enforcement and rural poverty. *Biological Conservation*. 142 (2009) 597-605.

Suyadi and D.L.A Gaveau. (2007). The Root Causes of Deforestation near Pemerihan River, Bukit Barisan Selatan National Park, West Lampung. *Berita Biologi* 8(4):279-290.

Suyadi and D.L.A Gaveau. (2006). Trend and Causal Factor of Deforestation in Way Pemerihan, Bukit Barisan Selatan National Park, West Lampung. *Jurnal Biologi Indonesia* 4(1): 39-52.

Suyadi, A.S. Rohman, D.L.A Gaveau. (2006). Luas dan Laju Deforestasi di Daerah Way Pemerihan, Taman Nasional Bukit Barisan Selatan, Lampung Barat. *Ekologia* 6(1) 16 - 23.

Suyadi, A.S. Rohman, D.L.A Gaveau. (2006). Faktor Penyebab Deforestasi di Daerah Way Pemerihan, Taman Nasional Bukit Barisan Selatan, Lampung Barat. *Ekologia* 6(1) 44 – 51.

Agustina Ira, **Suyadi**, Wahyu Prihatini dan Ningrum Suhenda, (2006). Penentuan Kadar Tapioka dalam Pakan untuk Pertumbuhan dan Kelangsungan Hidup Benih Ikan Baung (*Mystus nemurus*). *Ekologia* 6(2) 1 – 8.

Suyadi. (2005). *Kebun Campur "Khepong Damar" sebagai Solusi Pegelolaan Lahan Berkelanjutan di Pesisir Krui, Lampung*. Pemenang Lomba Karya Tulis Ilmiah Nasional, Juara I Kategori Mahasiswa, Bank Rakyat Indonesia (BRI).

Suyadi. (2005). *Cara Efektif dalam Menanggulangi Kebakaran Hutan dan Lahan di Indonesia*. Pemenang (Juara 1) Lomba Karya Tulis Nasional Bidang Lingkungan Hidup. Direktorat Pendidikan Tinggi, Departemen Pendidikan Republik Indonesia.

Suyadi. (2004). *Konservasi Keanekaragaman Hayati dalam Menopang Pembangunan Berkelanjutan di Indonesia*. Pemenang (Juara I) Lomba Karya Tulis Nasional Bidang Ilmu Pengetahuan Alam. Kopertis Wilayah IV, Departemen Pendidikan Republik Indonesia.

CONFERENCES AND WORKSHOPS

1. Speaker in the 29th International Congress for Conservation Biology. Conservation beyond boundaries: connecting biodiversity with communities, government, and stakeholders. Kuala Lumpur, Malaysia, July 21-25, 2019.
2. Speaker in the 2nd International Conference on MSAT, Maritime Sciences and Technology. Makasar, Indonesia. August 7-8, 2019.
3. Speaker in the 16th annual scientific meeting of Indonesian Association of Oenologists. "Science and technology for Indonesian maritime industry development". Ambon, 7-8 November 2019.
4. Speaker and reviewer in a Policy Paper / Academic Paper of Ecological Fiscal Transfer / General Allocation Funds considering forest cover area. World Resources Institute (WRI) Indonesia, Jakarta, October 9, 2019.
5. Moderator for Konferensi nasional transfer fiscal ekologis dan peluncuran laporan dan rekomendasi kebijakan. Akademi Ilmu Pengetahuan Indonesia (AIPI), Akademi Ilmuah Muda Indonesia (ALMI), dan World Resources Institute (WRI) Indonesia. Jakarta, Indonesia. August 1, 2019.
6. Speaker in the International conference "The 55th Annual meeting of the Association Tropical Biology and Conservation, Linking Natural History and the Conservation of Tomorrow's Tropical Ecosystems", Annual meeting of the Association Tropical Biology and Conservation. Kuching, Malaysia. July 2 - 6, 2018.
7. Speaker in the International Symposium "the EFN-WWF Global meeting 2018". WWF-Education for Nature, Kuching, Malaysia. June 30 – July 1, 2018.
8. Speaker in the International Marine Conservation Congress (IMCC). Society for Conservation Biology, Kuching, Malaysia. June 23-29, 2018
9. Speaker in the International congress for conservation biology. Society for Conservation Biology, Cartagena, Colombia. July 23-27, 2017.
10. Speaker in the EFN-WWF International Workshop and Symposium. WWF-Education for Nature, Cartagena, Colombia. July 21-22, 2017.

11. Speaker in the International conference of Indonesia Marine. Title "Indonesian mangroves: Prospects and Challenges", Auckland University of Technology (AUT), Auckland, New Zealand. March 2017.
12. Speaker in the international conference of Mangrove and Macrobenthos Meeting (MMM4). University of Florida, USA. July 2016.
13. Speaker in the international conference of Conservation Asia. National University of Singapore, Singapore. June 2016.
14. Speaker in the Regional Forum on Climate Change "Low carbon and climate resilient societies: Bridging science, practice and policy". Asian Institute of Technology. Thailand, July 2015.
15. Speaker in the 2015 New Zealand Marine Sciences Society & Oceania Chondrichthyan Society Conference. The University of Auckland. New Zealand. July 2015.
16. Speaker in the Intercontinental Virtual Lecture. Polytechnic of marine and fisheries. Indonesia. April 2015.
17. Speaker in the National Conference on sustainable development and social justice "From east to Indonesia". University of Gorontalo. February 2013.
18. Speaker in the Student Conference on Conservation Science. University of Cambridge. 20 – 22 March 2012. Cambridge, UK.
19. Speaker in the Pitching Forum Eagle Awards 2012. 15 Juni 2012. MetroTV, Jakarta, Indonesia.
20. Participant in the conference on Blue Carbon. 2012. Kementrian Kelautan dan Perikanan. Jakarta, Indonesia.
21. Speaker/Trainer in the Training of Forest Conservation 2011, Pakuan University. December 18, 2011. Bogor, Indonesia
22. Speaker in the Student Conference on Conservation Science. India Institute of Science. 14-16 September 2011. Bangalore, India.
23. Comparative study in the Empala Research Center. Wildlife Conservation Society. June 17 – 23, 2011. Nanyuki, Kenya.
24. Speaker in the International Meeting of the Association for Tropical Biology and Conservation and the Society for Conservation Biology (Africa Section), "Adaptability to Climate Change and Attaining the Millennium Development Goals for Tropical Ecosystems". June 12 – 16, 2011. Arusha, Tanzania.
25. Speaker in the International Meeting of the Association for Tropical Biology and Conservation, "Tropical Biodiversity: Surviving the Food, Energy, and Climate Crisis". July 19 – 23, 2010. Bali, Indonesia.
26. Speaker in the General Lecturer in Pakuan University, "Information Technology Application to the Conservation of Medicinal plant". Pakuan University. December 12, 2009. Bogor, Indonesia.
27. Speaker in the National Conference of Science 1 "Improving of Application of Science in Agriculture and Industry". Bogor Agricultural University. November 14, 2009. Bogor, Indonesia.
28. Speaker in the 4th Asian Graduation Forum on Southeast Asian Studies. Asia Research Institute, National University of Singapore. July 15 – 17, 2009. Singapore, Singapore.
29. Participant in the Conference of Remote Sensing and GIS Applications in Global Warming Issue. SEAMEO BIOTROP. June 18, 2009. Bogor, Indonesia
30. Speaker/Trainer in the Training of Forest Conservation 2009. Pakuan University. February 2009. Bogor, Indonesia.
31. Speaker/Trainer in the Training of Forest Conservation 2008. Pakuan University. March 2008. Gunung Pangrango National Park, West Java, Indonesia.

32. Speaker/Trainer in the Training of Forest Conservation 2007. Pakuan University. January 2007. Gunung Halimun National Park, West Java, Indonesia.
33. Speaker/Trainer in the Training of Forest Conservation 2006. Pakuan University. December 2006. Gunung Pangrango National Park, West Java, Indonesia.
34. Speaker in the National Conference on Conservation of Natural Resources. University of Negeri Surabaya. July 2006. Surabaya, Indonesia.
35. Speaker in the Eco Camp of Bayer Young Environmental Envoy. PT. Bayer, United Nations Environment Program (UNEP), and Indonesian Institute of Science. June 2006. Jakarta, Indonesia.
36. Speaker/Trainer in the Training of Navigation and Mapping technique. Wildlife Conservation Society University of Negeri Jakarta, and Pakuan University. April 2005. Gunung Pangrango National Park, West Java, Indonesia.
37. Speaker in the Conference of Biological Conservation. Pakuan University. Marsh 2005. Bogor, Indonesia.
38. Speaker in the Environmental campaign for high school students. Pakuan University. April 2004. West Java and Jakarta, Indonesia.
39. Speaker/Trainer and Coordinator in the Training of Wildlife Survey in Way Canguk Research Area. Wildlife Conservation Society and Pakuan University. September 2003. Bukit Barisan Selatan National Park, Sumatra, Indonesia.

PROFESSIONAL MEMBERSHIP AND ASSOCIATIONS

1. 2016 – present: member of Asian PGPR Society
2. 2015 – present: member of the Society for Conservation Biology (SCB).
3. 2010 – present: member of the Association for Tropical Biology and Conservation (ATBC).
4. 2010 – present: member of the Indonesian Biological Society (Perhimpunanan Biologi Indonesia/PBI)
5. 2008 – present: member of Indonesia Social Justice Network (ISJN).
6. 2005 – present: coordinator of Bayer Young Environmental Envoy (BYEE) Indonesia
7. 2002 – 2006: member of the Indonesian Green Club (Klub Indonesia Hijau)
8. 2003 – 2004: Chairman of The Biology Student Association at Pakuan University
9. 2003: Coordinator of Research and Education Department, Student Council of Pakuan University
10. 1996 – 1998: Chairman of The Youth Organization of KARANG TARUNA, Desa Pemerihan, Lampung Barat
11. 1997-1998: Secretary of The Young Islamic Organization (Remaja Islam Masjid), Desa Pemerihan, Lampung Barat
12. 1988 – 1990. Member/Actor of a Traditional Theater (Ludruk Sinar Masa). Desa Pemerihan, Lampung Barat

SKILLS

Language skills: English, Bahasa Indonesia, Javanese, Lampungnese, and Sundanese

Computing: Able to operate ArcGIS, ArcView, ER Mapper, ERDAS IMAGINE, ILWIS, Global Mapper, HEC-GeoHMS, Geo Server, Quick basic, Visual Basic, MSS Office Application (Ms. Excel, Ms. Word, Ms. Power Point, Ms. Access, Ms. Visio), SPSS,

SPSS-AMOS, SigmaPlot, MINITAB, R Analysis, Corel Draw, Photoshop, and Internet.

RESEARCH GRANT, SCHOLARSHIP, AND OTHER FUNDING

Year	Name of Scholarship	Name of Institution
2021	PN DIPA IPH – LIPI 2021	IPH - LIPI
2020	Overseas Kurita Research Grant	Kurita Water and Environment Foundation, Japan
2020	LPDP PRN Mandatory	Kemensitek/BRIN & LPDP
2019	Bantuan Seminar Luar Negeri (BSLN)	Kemenristekdikti-RI
2019	ICCB Travel award 2019	Society for Conservation Biology
2018	ATBC Travel award 2018	Association for Tropical Biology and Conservation
2018	WWF – EFN Alumni Research Grant 2018	WWF - EFN
2017	SCB Travel award 2017	Society for Conservation Biology
2017	WWF – EFN Alumni Research Grant 2017	WWF - EFN
2016	Research Experience Scholarship	University of Auckland
2015	Idea Wild Fellowship 2015	IDEA WILD
2015	RFCC Conference Awards	Asian Institute
2014	A PhD scholarship of the New Zealand ASEAN Scholars Awards	New Zealand Government
2014	WWF – EFN Alumni Research Grant 2014	WWF - EFN
2013	Travel Grant to attend a National Conference from East to Indonesia	ISJN – Ford Foundation
2012	Fellowship from the Indonesian Ministry of Research and Technology for short training	Indonesian Government
2012	Eagle Award Scholarship for documentary film making	MetroTV
2012	Scholarship of the Conference on Conservation Science 2012-Cambridge, UK	University of Cambridge

2011	Scholarship of the Student Conference on Conservation Science 2011-Bangalore, India	National Centre for Biological Sciences (NCBS), Indian Institute of Science (IISC)
2011	Scholarship of the Conference of Association for Tropical Biology and Conservation 2011-Arusha, Tanzania	Association for Tropical Biology and Conservation (ATBC)
2010	Scholarship of the Conference of Association for Tropical Biology and Conservation 2010-Bali, Indonesia	Association for Tropical Biology and Conservation (ATBC)
2009	Idea Wild Fellowship 2009	IDEA WILD
2009	International Leadership and Capacity Building (ILCB) Bursary	Royal Dutch Shell
2008	Publication Fund from WWF-Riau	World Wildlife Fund-Riau Program
2007	A MSc scholarship of Ford Foundation International Fellowship Program	Ford Foundation
2007	Research Grant of Russel E. Train-EFN	World Wildlife Fund, Rusell E. Train-EFN
2006	Research Grant from WWF-Riau	World Wildlife Fund-Riau Program
2005	Research financial assistant from WCS	Wildlife Conservation Society
2005	Idea Wild Fellowship 2005	IDEA WILD
2002	Financial Assistant from WCS for bachelor degree	Wildlife Conservation Society
1999	Financial Assistant from WCS for senior high school	Wildlife Conservation Society

AWARDS

1. The third winner of Eagle Award Documentary film competition “Indonesia Tangguh” (2012).
2. The finalist of Eagle Award Documentary film competition “Cerdas Indonesiaku” (2010).
3. The best graduated award of Pakuan University, Bogor, Indonesia (2006).

4. Three years (2003, 2004, 2005) of outstanding students award of Pakuan University, Bogor, Indonesia (2003, 2004, 2005).
5. The first winner of Environmental Scientific Writing Contest for student level from Pakuan Siliwangi Foundation, Bogor, Indonesia (2005).
6. The first winner of National Environmental Scientific Writing Contest 2005 (LKTM LH Award 2005) from Department of Education, Republic Indonesia (2005).
7. The first winner of National Scientific Writing Contest, Bank Rakyat Indonesia (BRI Award), Jakarta, Indonesia (2004).
8. The first winner of National Environmental Scientific Writing Contest 2004 (LKTM LH Award 2004) from Department of Education, Republic Indonesia (2004).
9. The third winner of National Scientific Writing Contest (LKTM IPA Award 2004), Padjadjaran University, Bandung, Indonesia (2004).
10. The first winner of National Scientific Writing Contest (LKTM IPA Award 2003) from Koordinasi Perguruan Tinggi Swasta Wilayah IV, Department of Education, Republic Indonesia (2003).
11. The first winner of University Scientific Writing Contest 2004 (LKTM Award 2003) from Pakuan University, Bogor, Indonesia (2003).

CONTACT ADDRESSES OF REFEREES

1. Name: Dr. Atit Kanti, M.Sc. (Director of Research Centre for Biology - LIPI)
   Email: atityeast@gmail.com

2. Name: Prof. Luitgard Schwendennman (PhD Supervisor)
   Email: l.schwendenmann@auckland.ac.nz

3. Name: Dr. Ir. Augy Syahailatua, M.Sc. (Former Employer)
   Email: augy_lipi@yahoo.com

4. Name: Dr. Margaret F. Kinnaird (Research Advisor)
   Email: mfkinnaird@gmail.com, mkinnaird@wcs.org / mkinnaird@mpala.org

5. Name: Dr. Marion Adeney (Research Advisor)
   Email: marion.adeney@gmail.com / jma22@duke.edu

6. Name: Prof. Dr. Ir. I Nengah Surati Jaya, M.Sc. (M.Sc. Supervisor)
   Email: ins-jaya@cbn.net.id / suratijaya@yahoo.com

7. Name: Dr. David Luc Andre Gaveau (B.Sc. Supervisor)
   Email: dgaveau@yahoo.co.uk; d.gaveau@cgiar.org

THE JOURNEY OF "THE CALF" FROM THE JUNGLE

The Personal History of Suyadi (Pedhet)

My name is Suyadi but usually the others call me Pedhet, or "calf" in English. I was born in the forest of Bukit Barisan Selatan National Park (BBSNP), near Indian Ocean, Lampung. I came from a family of seven and the fourth child of a small farmer family. At five year old, I was enlisted at SDN 2 Sukamarga, the only elementary school in the region and I finished as the best graduate of the school. Having completed my elementary school, I was intending to enrol in a junior high school; but my parent did not have money for my education. One day, I walked 18 hours across the forest of BBSNP to look for job and reached the nearest junior high school. Finally, I got a job in a small tofu home industry and I managed to pursue junior high school. I graduated as a first champion at the school in 1995. Unfortunately, I could not continue to senior high school because of economic difficulties and my father suffered from chronic illness. I buried my dream to pursue high education and back to my village to help my mother work in our small farm. I felt that I was fallen down in a dark hole and my hope about education was disappeared.

I began my research and conservation journey in 1997 when a scientist from USA, Dr. Margaret F. Kinnaird (I call her Ibu Maggie), a director of an international NGO, Wildlife Conservation Society (WCS), came to the forest near my village to build a research centre. Shy, fourteen years old, with a junior high school degree, I went to her research centre and asked for a job, but Ibu Maggie told me to back home and go to school. I returned repeatedly to ask a job. Finally, she employed me as a field technician to help her in establishing the research centre. In 1999, WCS support me to study at a senior high school and I passed with flying colours. I did not stop here; I approached Ibu Maggie about opportunities to university. Shortly, the WCS provide me financial support to pursue my B.Sc. at Pakuan University. I graduated cum lauded from the university and winning awards for national scientific writing contests. In 2008, I got scholarship from Ford Foundation-International Fellowship Program to pursue master degree (M.Sc.) at Bogor Agricultural University and sandwich program at University of Arkansas, USA. My research for my M.Sc. was about deforestation and its effects on Sumatran tiger and other large mammals in BBSNP was supported by World Wild Fund-Education for Nature. I was awarded PhD in Environmental Science from the University of Auckland, New Zealand in 2018. It was supported by New Zealand – ASEAN Scholars Award. My PhD thesis was about mangrove forest ecosystem dynamics and its ecosystem services in Auckland, New Zealand.

From day one of my research and conservation journey, the unfamiliar yet fascinating world of science and conservation sparked something in me. At the research centre, I devoured books and articles, and was keen to learn scientific field skills. The more I learned, the more information I requested, and greater my work responsibilities become. In the past twenty years of my research journey, I have worked hard to gain as much knowledge and experience as possible. I conducted researches on forest and coastal ecosystems, biodiversity conservation, carbon and climate change, sedimentation, and socio-economic studies. In short, my research areas or expertise are ecology, carbon, and biodiversity conservation. During my journey, I became highly skilled in GIS and remote sensing, spatial model, sediment and elemental analysis, plant penology, wildlife occupancy survey, camera trapping techniques, line transect techniques, point samplings techniques, herbarium management, and documentary film.

Research and conservation has been in my blood since I was young and it opened my eyes to see the world. I work from the idea that scientific data should be the basis for policy making and conservation actions, unlike the rest of Indonesia where science and data are often considered irrelevant to policy making and conservation. This is an attitude that greatly handicaps conservation in Indonesia. I have a mission to convince our partners that, in fact, data and science have a role in conservation and policy making. I have dream about human are living in harmony with environment/natural ecosystems. Now, I am a member of the research and conservation community. In the future, I want to be a leader for conservation and provider scientific-base information upon which conservation and development decisions can be made. To reach my dream I work closely with partner and built close relationship with government institution, international agencies, international and local NGOs, and local communities which will allow me to contribute to sciences and conservation.

One of my achievements is I and partners established a non-profit organization, named "Bina Alam Lestari". The tagline of this organization is *harmony of people and nature*, it is to help people around forests and coastal living in harmony with their environment/natural ecosystems (e.g. forest) and biodiversity (e.g. wildlife and marine biota). I also successfully applied and received several grants for research, trainings, international conferences, and conservation actions. I was also able to participate in producing reports and documents such as maps, database, academic paper, and brief policy. Some of my articles were published in international journals and national journals. I also wrote part of book entitled *Membalik paradigma pembangunan kota pesisir di indonesia untuk mencapai pembangungan ekonomi yang bekerlanjutan dan berkeadilan*. In Amin, B., Dako, R., Fatem, S., Zaky, A. (Ed.), *Pluralitas dan*

keadilan sosial-pendangan dan pengalaman dari timur Indonesia (pp. 133-156) published by Indonesia Social Justice Network-Ford Foundation.

Clearly, Indonesia is one of the most important countries for sciences and conservation. I believe that forest and biodiversity have intrinsic value for quality of human life and main capital for sustainable development. However, my countries lack many components necessary for research and conservation actions of forest and biodiversity. I want to help strengthen two critical areas: firstly, strengthening forest and biodiversity conservation through science and conservation actions. Secondly, I want to provide scientific information (knowledge) that can be adopted into sustainable development, mitigating strategy, and providing the tools that can be use plan better forest and biodiversity management. From a humble beginning, I hope I be able to go onto doing what others dream about-being a great scientist and conservationist. And I am confident that I "the calf from the jungle" will be bullish to save forest ecosystems and biodiversity.

ANGGRA ALFIAN

Curriculum Vitae

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@anggraalfian

PERSONAL INFO

Name	: Anggra Alfian, S.Pd, M.Si
Date of Birth	: 31 March 1992
Place of Birth	: Malangke
Address	: Perumahan To'Lauro Garden Songka, Kota Palopo
Sex	: Male
Google Scholar ID	: OSI8e4UAAAAJ

EDUCATIONAL BACKGROUND

Level	Year	University	Department	GPA
Bachelor	2010-2015	State University of Makassar	Biology	3.69
Master	2016-2019	IPB University	Plant Biology	3.89

ORGANIZATION EXPERIENCE

- LPM BIOma HIMABIO FMIPA UNM Reporter (2011)
- Member of the HIMABIO FMIPA UNM Scientific Development Division (2011)
- General Secretary of HIMABIO FMIPA UNM (2012)
- Chair of HIMABIO FMIPA UNM (2013)
- Chair of the HIMABIO FMIPA UNM Consideration (BPO) (2014)
- Chair of the MAPERWA UNM Education and Training Commission (2014)
- Member of the Islamic Student Association (HMI), MIPA UNM Commissariat (2013)
- Indonesian Biology Student Association, Board of Management (2013)
- Head of Interest and Talent Division of LPDP IPB (2017)
- Members of the Think Tank Division at South Sulawesi Mata Garuda (2018)
- Member of the Indonesian lecturer association, Tana Luwu (2019)
- Member of the Indonesian Private Colleges Association, Tana Luwu (2019)
- Member of the IPB Alumni Association, Tana Luwu (2019)
- Founder and Head of Celebica (2019)
- Head of Center for Biodiversity Study, University of Muhammadiyah Palopo (2019)

PUBLICATION

Thesis (Bachelor)	The development of documentary film to improve student interest in Junior High school
Thesis (Master)	Expression of c-lysozyme gene in transgenic potatoes cv. Jala Ipam against *Ralstonia solanacearum*
Book	Indonesia Untuk Citarum Harum (ISBN 978-602-5877-24-7)
Journal	Morphological traits of Maluku native forest clove (*Syzygium aromaticum* L. Merr & Perry.)
	Morphological character of raja clove (*Syzygium aromaticum* L. Merr & Perry.) native from Ambon Island
	The diversity of mangrove forests in Kumbewaha, Buton Island, Indonesia
	The application of documentary film in improving student interest: An alternative for environmental education
	Expression of c-lysozyme Gene in Transgenic Potatoes cv. Jala Ipam Against Bacterial Wilt Disease Caused by *Ralstonia solanacearum*
	Growth of forest clove seedlings at different concentrations of paclobutrazol
	Growth of palm oil seedlings at various doses of boiler ash and tofu wastewater
Mass media (Qureta)	Melawan Krisis Pangan dengan Bioteknologi
	Di Masa Depan, Bayipun Bisa Didesain
	Manusia Pertama Penikmat Coklat
	Energi Masa Depan dari Alga

WORK AND PROJECT EXPERIENCE

2011-2014	Lab Assistant Biology Department, FMIPA UNM
2013	Olympiad Biology Teacher of Sekolah Islam Athirah
2015-2016	Teacher at Rannu Prima Coledge
2013-2014	Lab Consultant at Cv Miconos Transdata Nusantara
2017-2018	Assistant for Molecular Biology and Genetic Engineering, Biotechnology of IPB
2017	Coordinator of survey of Smart City and Community Innovation Center (SCCIC) – Pare-Pare
2018	(Project) mycorrhizal exploration of clove in Maluku
2019	(Project) Phytoplankton exploration at Lake Towuti
2019	Lecturer at Muhammadiyah University of Palopo
2019	Head of Celebica
2019	Head of Center for Biodiversity Study, Muhammadiyah University of Palopo

2020	(Project) Etlingera Exploration at Lore Lindu National Park
2020	(Project) Conservation of endangered *Magnolia sulawesiana* at Lore Lindu National Park
2020	(Project) Conservation of endemic and critically endangered *Etlingera doliiformis* at Mt. Bawakaraeng
2020	(Project) Flora expedition to the highest mountain in Sulawesi: Mt. Latimojong