

Morphological Identification Characteristics of Basil (*Ocimum Spp.*) in Tabanan Regency, Bali, Indonesia

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Abstract: Basil (*Ocimum spp.*) is an aromatic plant and is the wealthiest essential oil-producing generate from the *Lamiaceae* family. Due to the various phytochemical compounds or secondary metabolites, basil has the potential of medicinal plant germplasm as a source of biopharmaceuticals. Several types of basil grow in Bali, especially in Tabanan Regency, Bali Province, Indonesia but their morphological characteristics have yet to be identified. This study aims to identify the morphological characteristics of the four types of basil found growing at that location: *Kecarum*, *selasih*, *tulasi*, and *ruku-ruku*. This research was conducted by characterizing the characteristics of the parts of the basil plant, including the morphology of the crown (*botany*), stem (*caulis*), flowers (*flos*), leaves (*folium*), and fruit (*fructus*). The results of the characterization showed that there were similarities between the four types of basil and differences in the crown shape, plant height, the direction of branch growth, type of branching, leaf shape, color (leaves, stems, flowers, fruit), leaf tips, leaf layout, and the base of the leaf. Based on the morphological identification, *Kecarum* and *selasih* have similar morphology to *Ocimum americanum L* and *Ocimum basillicum*. *Tulasi* and *ruku-ruku* are morphologically identical to *Ocimum sanctum var. Rama* (red holy basil) and *Ocimum campechianum*.

Keywords: biopharmaceuticals, basil, *Lamiaceae*, morphology, *Ocimum spp.*

1. Introduction

Basil (*Ocimum spp.*) is an aromatic plant and one of the important genera in the most affluent essential oil-producing plant family from the *Lamiaceae* family (Tangpao et al., 2022). Basil is known to come from tropical Asia and islands in the Pacific region, and was first discovered and processed in India. The *Ocimum* is recognized as one of the most prominent genera in the family *Lamiaceae* and currently comprises more than 150 species. Basil has been used commercially for nutritional, aromatic, ornamental, culinary, religious, and medicinal purposes. This plant has been cultivated worldwide as an herbal, culinary, and essential oil.

Basil's remarkable adaptability allows it to thrive in various climatic conditions across Indonesia—from the highlands to the lowlands up to an altitude of 1100 meters above sea level. Typically, this plant is characterized as

a woody shrub, ranging from 30 to 150 cm in height, with a grooved, hairy, and branched stem structure. The plant produces flowers that vary in color from green and white to purplish, all known for their pleasant fragrance. The flowers are green and white, purplish, and smell good (Kumalasari & Andiarna, 2020, Ha, et al., 2024). The stems and branches are green, and there are purplish ones in other types. The tree trunks are a little stiff and have the same color as old plants. Basil flowers are located on the upright flower stalks.

Basil is reported to have acted as anti-diabetic, antibacterial, and antihyperglycemic and has anti-inflammatory activity and antioxidant activity (Idrus A. et al., 2013). The content of flavonoids such as orientin and vicenin in basil is known to protect the body from the adverse effects of radiation based on the mechanism of antioxidant activity, which protects lipids from oxidation (Singh et al., 2012). In the agricultural sector, especially in controlling pests and plant diseases because they are toxic to insect bodies, the bioactive compounds found in basil, such as methyl eugenol, are also attractants, especially fruit flies (Balittra, 2022).

Basil has yet to be used according to its potential due to a lack of information about the types of basil and its morphological characteristics. This plant can grow in various environmental conditions, which also affects its phenotype or morphological characteristics that grow in specific locations. This study aims to characterize the morphological characteristics of the four types of basil found growing in three locations in Tabanan Regency. This is an initial process to identify the type of basil that can be classified into suitable species so that this research can increase the plant's utilization following its potential.

2. Methodology

2.1 Research Location

This research is a descriptive observational study in morphological identification. The research was conducted in Tabanan Regency, and four types of basil as samples were obtained from three growing locations in Tabanan Regency, Bali. *Kecarum* and *selasih* were collected from Senganan Village (8°21'59.8"S 115°09'18.1" E) at an altitude of 1,032 masl, *tulasi* from Wongaya Gede Village (8°23'31.1"S 115°06'42.5"E) at an altitude of 835 masl, and *ruku-ruku* from Marga Village (8°28'47.5" S 115°10'13.5"E) at an altitude of 450 masl. Figure 1 shows the sampling location.

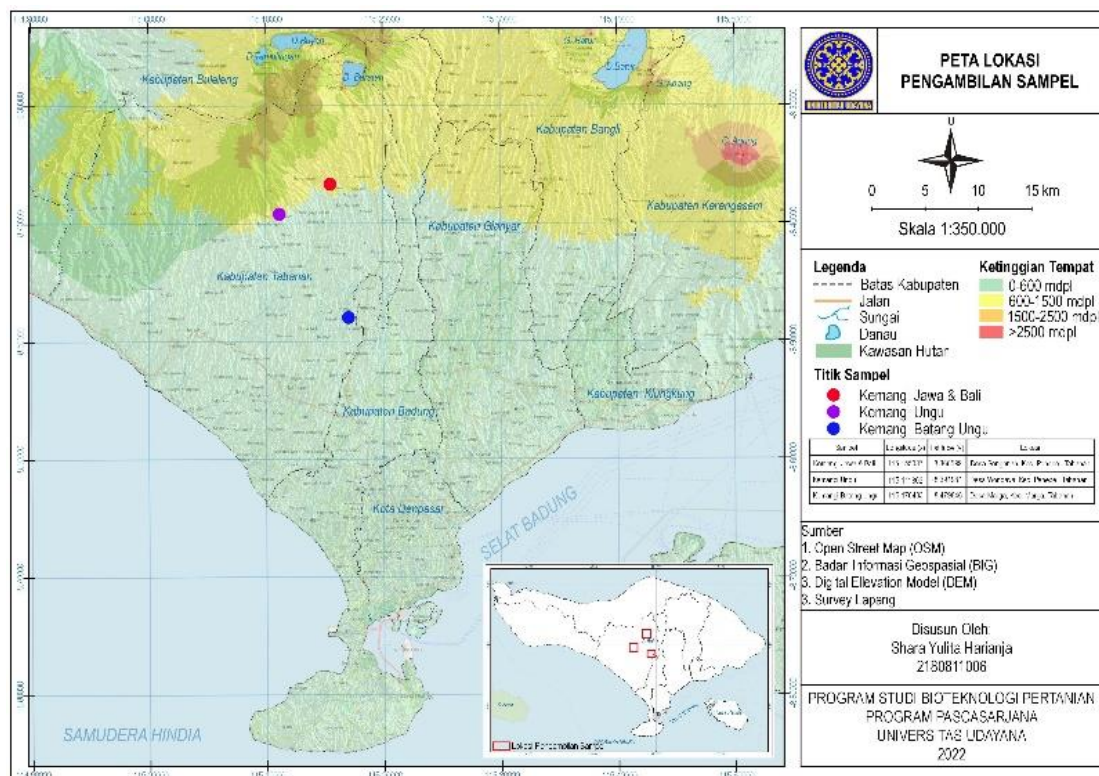


Figure 1. Map of sampling locations for four types of basil in Tabanan Regency, Bali, Indonesia

2.2 Methodology

Morphological identification was carried out by direct observation of basil to compare the differences in morphological characters by referring to Tjitrosoepomo's book on plant morphology (1985) and Indriyanto's book

on dendrology (2012). Documentation was carried out to compare the morphological characteristics of each type of basil as well as to compare them with the morphological characteristics of the basil species reported in previous studies on basil found abroad and in Indonesia to obtain provisional species estimates. Observations were carried out qualitatively by randomly selecting plants as characterization samples due to the limited number of plants of this type of basil.

The characteristics that are characterized are as follows: 1) Crown (botanical): type of growth, plant height, crown shape, and crown diameter; 2) Stem (caulis): stem type, stem shape, stem surface, stem color, stem growth direction, and stem branching type; 3) Leaf (folium): type of leaf, shape of the leaf, edge of the leaf, tip of the leaf, base of the leaf, arrangement of leaf veins, chin surface color, leaf flesh, leaf thickness, leaf area, leaf surface, and leaf layout; 4) Fruit (fructus): shape, color, and location of the fruit; 5) Flower (flos): type of flower, flower color, flower stalk, flower petals, type of inflorescence, position of stamens and pistils, and location of the flower. Figure 2 shows research flowchart.

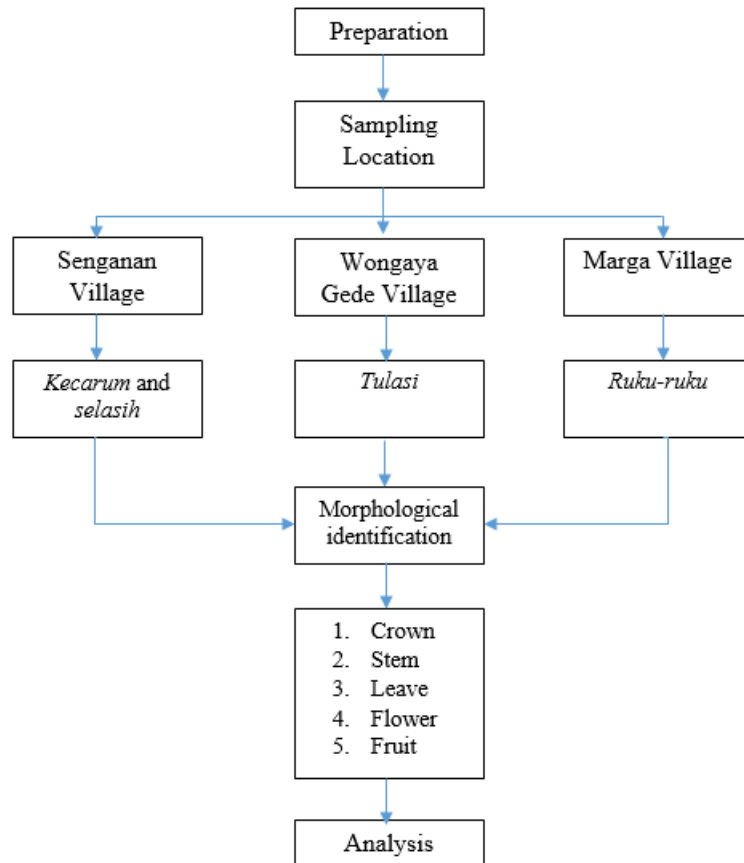


Figure 2. Research Flowchart

3. Results

Based on the results of the morphological characterization of the four types of basil, there were variations in their morphological characters, and there were some apparent similarities and differences. Figure 3 shows crown morphology of *Kecarum*, *selasih*, *tulasi*, and *ruku-ruku*. Table 1 shows crown morphological characteristics of *Kecarum*, *selasih*, *tulasi*, and *ruku-ruku*. Meanwhile Figure 4 shows the morphology of *Kecarum*, *selasih*, *tulasi*, and *ruku-ruku*. Table 2 shows the morphological characteristics of the stem of *Kecarum*, *selasih*, *tulasi*, and *ruku-ruku*. Table 3 shows the morphological characteristics of the leaf, Table 4 shows the morphological characteristics of the flower and Table 5 shows the morphological characteristics of the fruit.



Figure 3. Crown Morphology of *Kecarum* (A), *selasih* (B), *tulasi* (C), and *ruku-ruku* (D).

Table 1. Crown morphological characteristics of *Kecarum*, *selasih*, *tulasi*, and *ruku-ruku*

Characteristics	Types of Basil			
	<i>Selasih</i>	<i>Kecarum</i>	<i>Tulasi</i>	<i>Ruku-ruku</i>
Growth Type	Perpendicular	Perpendicular	Perpendicular	Perpendicular
Shape	Vertical (V-shape)	Vertical (V-shape)	Spreading	Rounded
Plant Height (cm)	± 30 – 120	± 30 - 120	± 80 - 195	± 80 -170
Diameter (cm)	± 50 -100	± 50 - 100	± 50-130	± 50-130

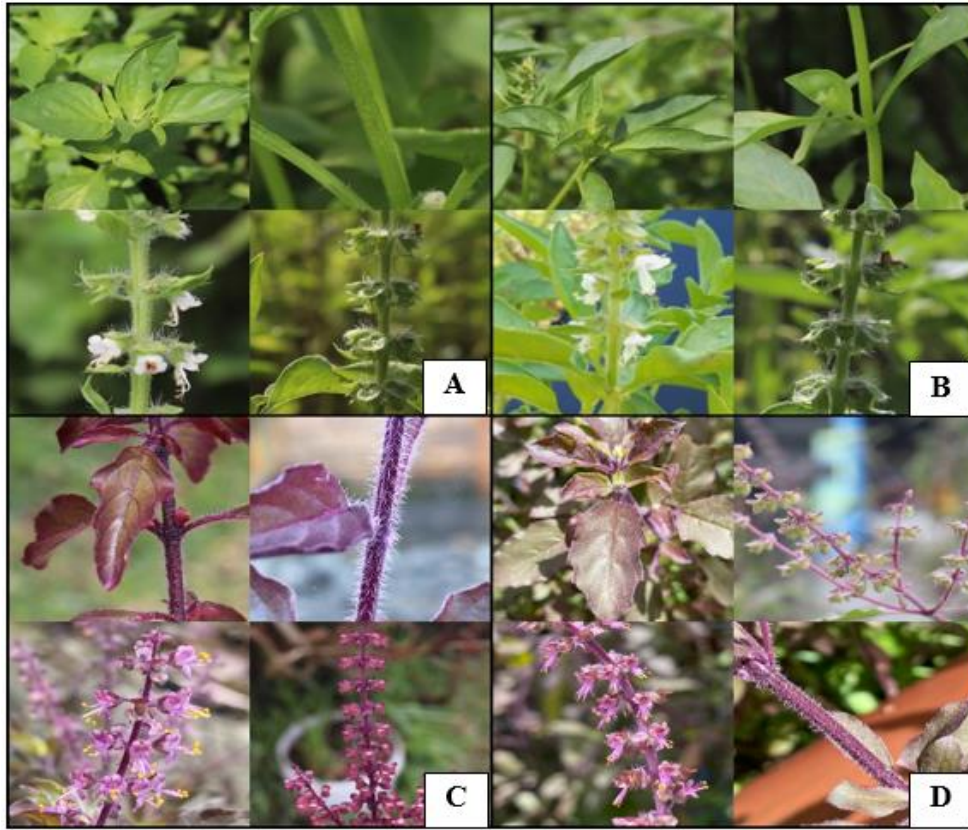


Figure 4. The Morphology of *Kecarum* (A), *selasih* (B), *tulasi* (C), and *ruku-ruku*(D).

Table 2. The morphological characteristics of the stem

Morphological Characteristics	Types of Basil			
	<i>Kecarum</i>	<i>Selasih</i>	<i>Tulasi</i>	<i>Ruku-ruku</i>
Type	Woody (<i>lignosis</i>)	Woody (<i>lignosis</i>)	Woody (<i>lignosis</i>)	Woody (<i>lignosis</i>)
Shape	Round (<i>teres</i>)	<i>Quadraangularis</i>	<i>Quadraangularis</i>	<i>Quadraangularis</i>
Structure	Grooved (<i>sulcatus</i>)	Grooved (<i>sulcatus</i>)	Grooved (<i>sulcatus</i>)	Grooved (<i>sulcatus</i>)
Surface	Smooth haired (<i>pylosus</i>)	Coarse-haired (<i>pylosus</i>)	Coarse-haired (<i>pylosus</i>)	Coarse-haired (<i>pylosus</i>)
Stem Growth Direction	Perpendicular (<i>erectus</i>)	Perpendicular (<i>erectus</i>)	Perpendicular (<i>erectus</i>)	Perpendicular (<i>erectus</i>)
Growth direction	Upright	Upright	Leaning up	Leaning up
Branches	(<i>fastigiatus</i>)	(<i>fastigiatus</i>)	(<i>patens</i>)	(<i>patens</i>)
Color	Green	Green	Deep Purple	Purple
Branch Type	Sympodial	Sympodial	Dichotomes	Sympodial

Table 3. The morphological characteristics of the leaf

Morphological Characteristics	Types of Basil			
	<i>Kecarum</i>	<i>Selasih</i>	<i>Tulasi</i>	<i>Ruku-ruku</i>
Type	Pinnate compound	Pinnate compound	Pinnate compound	Pinnate compound
Shape	Ovoid (<i>ovatus</i>)	Elliptical (<i>lipticus</i>)	Obscene (<i>ovalis</i>)	Ovoid (<i>ovatus</i>)
Edge	Finely serrated (<i>serratus</i>)	Finely serrated (<i>serratus</i>)	Finely serrated (<i>serratus</i>)	Finely serrated (<i>serratus</i>)
Leaf tip	Pointed (<i>acutus</i>)	Tapered (<i>acuminate</i>)	Pointed (<i>acutus</i>)	Tapered (<i>acuminate</i>)
Reinforcement	Pinnate	Pinnate	Pinnate	Pinnate
Color	Green	Green	Purplish red- purplish green	Purplish green
Thickness	± 0.2 mm	± 0.2 mm	± 0.2 mm	± 0.2 mm
Flesh	Thin soft (<i>herbaceus</i>)	Thin soft (<i>herbaceus</i>)	Thin soft (<i>herbaceus</i>)	Thin soft (<i>herbaceus</i>)
Leaf area	± 5.8 cm	± 6 cm	± 5.4 cm	± 5.1 cm
Surface	Soft and dense hair (<i>villosus</i>)	Soft and dense hair (<i>villosus</i>)	Soft and dense hair (<i>villosus</i>)	Soft and dense hair (<i>villosus</i>)
Layout	Single faced (opposite)	Verticillate	Verticillate	Verticillate
Base	Pointed (<i>acutus</i>)	Rounded	Blunt (<i>obtusus</i>)	Blunt (<i>obtusus</i>)

Table 4. The morphological characteristics of the flower

Morphological Characteristics	Types of Basil			
	<i>Kecarum</i>	<i>Selasih</i>	<i>Tulasi</i>	<i>Ruku-ruku</i>
Flowering Type	Multiple bunches	Multiple bunches	Multiple bunches	Multiple bunches
Color	White	White	Purple	Purple
Stalk	Panicle bunch	Panicle bunch	Panicle bunch	Panicle bunch
Petals	Lipped	Lipped	Lipped	Lipped
Position	Stem tip (terminal flower)	Stem tip (terminal flower)	Stem tip (terminal flower)	Stem tip (terminal flower)
Type	Spike	Spike	Spike	Spike

Table 5. The morphological characteristics of the fruit

Morphological Characteristics	Types of Basil			
	<i>Kecarum</i>	<i>Selasih</i>	<i>Tulasi</i>	<i>Ruku-ruku</i>
Shape	Square	Square	Square	Square
Color	Green	Green	Purple	Purple
Position	Vertically attached to the axis of the wreath	Vertically attached to the axis of the wreath	Vertically attached to the axis of the wreath	Vertically attached to the axis of the wreath

4. Discussion

The four types of basil have varied morphology, and environmental and genetic factors can influence these variations. Morphological identification is carried out as an initial identification and grouping of a plant species because plants exist in nature in various types and exhibit differences. These differences can be expressed through

morphology or phenotype. The morphology of a plant species is one of the characteristics of a plant group that is easily observed. Morphological traits and characteristics are often used in taxonomic activities, such as descriptions and determinations (Jones & Luchsinger, 1986).

The morphology of *Kecarum* and *selasih* (Figure 3) is similar to that of *Ocimum americanum* L., which was identified by Akmalia (2015). However, there are differences in the tips of *Kecarum* leaves, which are pointed in shape (*acutus*). The tips of *selasih* and *Ocimum americanum* L. leaves have a tapered (acuminate) shape. *Ruku-ruku* and *tulasi* leaves have similarities with *Ocimum sanctum* var. *Rama* (red holy basil), as identified by Tangpao et al. (2022), and *Ocimum campechianum* from Argentina, as identified by Nataly (2017).

As for the canopy, there are similarities and differences in the morphological characteristics. The four types of basil have the same type of crown growth, which is perpendicular. *Kecarum* and *selasih* have the same crown morphology, while *tulasi* and *ruku-ruku* have different crown shapes, and there are differences in plant height and crown diameter (Table 1). In leaf morphology (Table 3), there are apparent differences in the leaf edge, leaf size, leaf shape, leaf tip, leaf base, and leaf color. Based on the morphological characteristics, basil can come from the same species even though there are differences in some of the morphological characteristics. This can happen because of polymorphism, namely the emergence of two or more phenotypes in one species.

Ruku-ruku and *tulasi* contain an anthocyanin pigment with a purple spectrum in the leaves and stems. *Tulasi* has a more concentrated pigment than *ruku-ruku*. *Kecarum* and *selasih* also contain anthocyanin but on the green color spectrum. Anthocyanin pigments are abundant in young lateral branches and inflorescences, which are bioactive components that can provide color to plants depending on the pH of the environment in which they are located (Torskangerpoll & Andersen, 2005; Burdulis et al., 2009; Jensen et al., 2011).

The canopy morphology shows that the growth types of the four types of basil have the same characteristics, namely being perpendicular. *Tulasi* and *ruku-ruku* also have differences in crown shape (Figure 3). *Tulasi* has a spreading crown shape, while *ruku-ruku* is rounded as seen in Table 1. *Tulasi*'s crown diameter is more comprehensive compared to the diameter of other basil crowns. *Kecarum* and *selasih* have almost the same crown morphology with a V-shape. The canopy is all parts of the plant, especially trees, shrubs, or lianas, which are attached to the main stem above the ground.

According to Pollunin (1990), the parts of the plant that are most susceptible to morphological changes due to environmental influences are the leaves, stems, and flowers. Environmental factors affecting plant morphological changes include light intensity, altitude, climate, temperature, humidity, soil type, soil condition, and soil fertility (Barbour & Pitts, 1987). The samples of the four basil types came from locations with different environmental conditions, which resulted in morphological variations. At the time of morphological identification, the plant's age was unknown, so this also affected the process of identifying the morphological characteristics.

Variation due to environmental factors is referred to as plasticity. Plasticity is a plant's reaction to environmental changes, often accompanied by various organ modifications so that tolerance to these environmental factors becomes wider. These changes or modifications indicate the presence of plasticity in the organ. If conditions return to their original state, the shape of this organ will change back to its standard shape (Cartono, 2005). The genetic composition and the plasticity of the organism itself influence this resilience. This results in phenotypic or morphological diversity, especially in plants. Phenotypic diversity can be measured directly or seen visually in the characteristics observed in these plants (Prayitno et al., 2002).

A plant species with a wide distribution shows differences in its morphological characteristics according to its environmental conditions and geographical location (Hamzah, 2010). Basil is included in plants with a wide distribution because of its high adaptability. Basil grown in more excellent areas will have broader and greener leaves, while basil grown in hot areas will generally have smaller, thinner, and pale green leaves. Differences occur not only in growth and how the plant forms but will also be related to adaptations that will lead to genetics (Soerianegara, 1988 in Hamzah, 2010). Morphological identification cannot be used as a sole reference for determining species and providing accurate kinship information about basil.

5. Conclusions

The four types of basil exhibit varied morphological characteristics in their crown, stems, leaves, flowers, and fruit. There are similarities and differences in morphology, especially in the crown and leaves. Based on the morphological identification results, *kecarum* is similar to *selasih* and *Ocimum americanum* species. The morphological characteristics of *tulasi* are similar to *ruku-ruku*, and have similar morphology to the species *Ocimum tenuiflorum*, as well as *Ocimum kilimandscharicum* or *Ocimum sanctum*.

Author Contributions

Conceptualization, S.Y.H. and I.P.S.; methodology, S.Y.H.; validation, S.Y.H.; formal analysis, T.Z.; data curation, S.Y.H.; writing—original draft preparation, S.Y.H.; writing—review and editing, I.P.S.; visualization, T.Z.; supervision, T.Z.. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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