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Research Paper

The Existence of Zingiberaceae Plants Under Forest Garden Stands in the Wan Abdul Rachman Grand Forest Park, Indonesia

Indriyanto
Department of Forestry, Faculty of Agriculture, Universitas Lampung, Indonesia
Corresponding Author

ABSTRACT: *Zingiberaceae plants have varying tolerance to shade from the canopy of forest garden stands. It is important to know about the existence of Zingiberaceae plants under forest gardens stands because these plants have important functions, both ecological functions in the ecosystem and economic functions for humans. This research aims to determine the species of Zingiberaceae plant, population density, distribution area, and level of dominance of each plant species. The data was collected through vegetation surveys using nested rectangular plots with a sampling intensity of 2.5%. The data collected includes the species of Zingiberaceae plants, the number of individuals for each species, and the species of trees as components of forest garden stands. Data were analyzed by calculating density (D), frequency (F), and importance value index (IVI). The results showed that the composition of forest garden stands consisted of 25 tree species, dominated by 7 species, namely langsat, durian, rubber, candlenut, nutmeg, stink bean, and jointfir. Under the forest garden stands, 16 species of Zingiberaceae plants consisting of 6 genera were found. The species of Zingiberaceae plants found include javanese turmeric, galangal, fragrant ginger, ginger, lempuyang emprit, tepus, shampoo ginger, zedoary, forest galangal, crepe ginger, temu giring, purpel ginger, cardamom, torch ginger, wresah, and turmeric. There are 2 dominant species of Zingiberaceae plants, namely lempuyang emprit and galangal. Lempuyang emprit has IVI of 27.90%, density of 1,583.3 individuals/ha, and frequency of 0.63. Galangal has IVI of 24.17%, density of 1,416.7 individuals/ha, and frequency of 0.53.*

KEYWORDS: *Composition, Dominance, Forest garden, Zingiberaceae*

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I. INTRODUCTION

Botanical Characters of Zingiberaceae Plants

Zingiberaceae is the name of a plant family from the order Zingiberales (Tjitrosoepomo, 1989) which is generally known by Indonesian people as ginger plants (Windarsih et al., 2021) or empon-empon (the Indonesian term) (Andini et al., 2020). Zingiberaceae consists of 53 genera and more than 1,200 species (Arviani et al., 2024; Silalahi, 2023). Tjitrosoepomo (1989) stated that Zingiberaceae plants are estimated to include 1,400 species. It is estimated that the number of Zingiberaceae plant species could include 1,600 species (Pitopang et al., 2019; Saensouk, P. & Saensouk 2021) some of which are native to tropical regions (Tjitrosoepomo, 1989).

The species of Zingiberaceae plant has many relatives that live and grow wild in the tropical forests of Indonesia (Kinho, 2014). Several countries that are rich in species of Zingiberaceae plant include Indonesia, Malaysia, Brunei, Singapore, Thailand, Philippines, and Papua (Andini et al., 2020). It was estimated that the species of Zingiberaceae plant found in tropical and subtropical regions are mostly found in Southeast Asia, especially in Malaysia and Indonesia (Hutasuhut & Tambunan, 2018). Large areas in Indonesia such as Kalimantan and Sumatra have not yet been identified and studied in more depth regarding the existence of the diversity of Zingiberaceae plant species (Hutasuhut & Tambunan, 2018). In fact, the exact number of species of Zingiberaceae plant in Indonesia is currently not known (Windarsih et al., 2021).

The habitus (life form) of Zingiberaceae plants is perennial herbaceous plants (Tjitrosoepomo, 1989). This herbaceous plant lives for years and is unique in its rhizome because it has rhizomes which contain volatile and aromatic oils (Hutasuhut & Tambunan, 2018). Apart from rhizomes, the leaves of Zingiberaceae plants are also aromatic, so Zingiberaceae plants are called aromatic herbaceous plants (Silalahi, 2023).

The stem of Zingiberaceae plants is a pseudostem formed from a collection of leaf sheaths (Silalahi, 2023), often short and only supporting many flowers (Tjitrosoepomo, 1989). Below the base of the stem there are organs that develop in the soil called rhizomes or rimpang (the Indonesian term) that enlarge in the shape of tubers (Hutasuhut & Tambunan, 2018; Tjitrosoepomo, 1989). Rhizome is a modified stem that grows below the surface of the soil and in the rhizome there are parts that contain aromatic oils. Rhizome nodes can grow shoots and thick roots (Hutasuhut & Tambunan, 2018).

The leaf is a single leaf which sometimes has 3 components consisting of the leaf blade (lamina), leaf stalk (petiolus), and sheath (vagina), as well as the tongues (ligula). The main leaf vein is large, the branches of the leaf spine are parallel and close together in an oblique direction towards the tip of the leaf (Tjitrosoepomo, 1989). The leaf blades are lanceolate or elliptical, and the leaf edges are flat (Silalahi, 2023).

Flowers (flos) are arranged as compound flowers located at the tip of the shoot. Flowers grow directly from rhizomes without leaves (Tjitrosoepomo, 1989). Flowers are epigynous (inferous), bisexual, and zygomorphic/monosymmetric (Silalahi, 2023). The flower decoration is clearly visible and consists of three petals and three crowns whose bases are attached to form a reed with a striking color (Tjitrosoepomo, 1989). Flowers have one functional/fertile stamen which is located in the middle, then two sterile stamens, and several reduced stamens which are located in the outer circle (Silalahi, 2023). The sunken ovary has three chambers.

The fruit (fructus) of Zingiberaceae plants is a type of kendaga fruit (rhegma) which has 3 valves, or a type of fleshy fruit that does not open (Tjitrosoepomo, 1989). However, there are also Zingiberaceae plants that have capsule type fruit, for example galangal. The fruit is round or ellipsoid in shape and contains 2-3 seeds. Seeds have a seed coat, and contain a lot of endosperm (Tjitrosoepomo, 1989).

Species of plants in the Zingiberaceae family live in various tropical and subtropical climates, from lowland areas to highlands with elevations of more than 2,000 m above sea level (m asl.) (Erwinsyah, et al., 2022), but are very rare in mountainous areas (Hutasuhut & Tambunan, 2018). The suitable habitat environment for Zingiberaceae plants is moist and shady (Arviani et al., 2024), especially in areas with high rainfall (Andini et al., 2020). Thus, many Zingiberaceae plants grow wild and cultivated in forests, gardens and forest gardens. However, there are several species of Zingiberaceae plants that can live in open areas with full sunlight (Erwinsyah, et al., 2022).

Use of Zingiberaceae Plants

Species of Zingiberaceae plant are multipurpose or multi-use plants (Kinho, 2014) because all plant organs can be used (Saensouk, P. & Saensouk 2021). Plants in the Zingiberaceae family have unique characteristics because their rhizomes contain extractive substances in the form of essential oils, so they can be used for various uses such as spices/flavoring for cooking, traditional medicines, cosmetic ingredients, and beverage ingredients (Andini et al., 2020), for food ingredients and as an ornamental plant (Lianah et al., 2020). In fact, many people use Zingiberaceae plants for hair care or hair tonic (Hamidi et al., 2022), for vegetable ingredients (Hutasuhut & Tambunan, 2018), dyes, fragrances, and ritual ingredients (Saensouk, P. & Saensouk 2021), as well as for biopesticides or vegetable pesticides (Nufus, 2020).

Indonesian people have long known Zingiberaceae plants as empon-empon (term in Indonesia), namely plants with rhizome roots (Silalahi, 2023). Plants from the Zingiberaceae family are used by the community as spices (cooking spices), food ingredients, and ingredients for various traditional medicines/herbal medicine (Arviani et al., 2024; Silalahi, 2023). All plants belonging to the Zingiberaceae family have potential as ingredients for traditional medicines whose properties are recognized by the modern world and have no bad side effects (Darwis et al., 1991).

All organs of Zingiberaceae plants, from the roots, stems, leaves, and flowers, are useful for human life (Hamidi et al., 2022). The plant organs of the Zingiberaceae family contain various secondary metabolite compounds (Arviani et al., 2024). These metabolite compounds are also bioactive compounds that can be used for medicine (Windarsih et al., 2021).

Javanese turmeric (*Curcuma zanthorrhiza*), for example, this plant has long been used for its rhizomes by people in Indonesia for traditional medicine, including to treat digestive disorders, jaundice, vaginal discharge, increase endurance, and to maintain health (Syamsudin et al., 2019). Rhizome of javanese turmeric can also be used as an ingredient in traditional drinks, medicine for worms, diarrhea, diabetes, fever, and wound medicine (Silalahi et al., 2018), medicine for hepatitis, improving blood circulation, and cleansing postpartum women (Heyne, 1987).

Some examples of other species of Zingiberaceae plants that are very often used by the community include: crepe ginger (*Costus speciosus*), galangal (*Alpinia galangal*), turmeric (*Curcuma domestica*), zedoary (*Curcuma zeodaria*), torch ginger (*Eltingera elatior*), ginger (*Zingiber officinale*), shampoo ginger (*Zingiber* *zerumbet*), and temu giring (*Curcuma heyneana*). Crepe ginger generally lives in the wild, but all its organs are used by people in Indonesia to treat diuretic, diaphoretic (sweating), antidote for snake venom (antidote for snake venom), and anti-itch (anti-itch) (Aulia et al ., 2024). Crepe ginger rhizomes are also useful for treating diarrhea, flatulence and urinary tract infections (Lianah, 2020).

Galangal rhizomes can be used as cooking spices, young leaves and galangal flowers can be cooked into vegetables. Galangal rhizome can also be used to treat skin ailments, calluses, dysentery, respiratory disease, cancer, diarrhea, rheumatism, coughs, cholera and toothache (Silalahi et al., 2018). Boiled water from the young rhizomes of the galangal plant is used in baths to treat rheumatism and treat itchy skin. The juice of young galangal rhizomes can also be used to treat bronchitis, heart disease, overcome weakness, and digestive disorders (Darwis et al., 1991), as well as diabetes, kidney disease, bronchitis, glandular tuberculosis, and catarrhal infections (Mohiuudin et al., 2011).

Turmeric plants are used by the community for cooking spices, natural food coloring (Heyne, 1987), and traditional medicine (Silalahi et al., 2018). Turmeric rhizome can be used as an ingredient in medicines for headaches, stomach ulcers, stomach aches, diabetes, wounds, and malaria (Silalahi et al., 2018), medicines for smallpox, asthma disorders, liver disorders, and treating skin diseases (Rohmah, 2024). Then, zedoary rhizome can be used as traditional herbal medicine for cleansing women who are postpartum (Heyne, 1987). The benefits of plants as medicines are because they contain several secondary metabolite compounds. For example, zedoary plants contain secondary metabolite compounds including: borneol, isoborneol, benzofuran, curcumenone, curcumenol, zederone, furaniodiene, zerumbone, and others (Heyne, 1987).

Torch ginger has also been used for a long time by the people in various countries as food and medicine (Naufalin et al., 2021), to flavor dishes and curries, to cure coughs and fevers, and as a biopesticide (Silalahi et al., 2018). The stems, leaves and rhizomes of kecombrang and its flowers contain bioactive compounds such as polyphenols, alkaloids, flavonoids, steroids, saponins and essential oils which have the potential to act as antioxidants (Naufalin et al., 2021). Secondary metabolite compounds found in torch ginger plants include glycosides, diarylheptanoids, labdane diterpenoids, anthocyanins, kaempferol, quercitrin, quercetin, ergosterol 5,8-peroxide, cytostenone, isoquercetrin, kaempferol 3-glucuronide, catechin, demethoxycurcumin, decanal, dodecanal, 1 - dodecanol, dodecyl esters, dodecanoic acid, 1-tetradecane, saponins, tannins, sterols, (E)ß-farnesene, ß-cinene, 1,1-dodecanediol diacetate, cyclododecane, α-pinene, 1- dodecene, and various terpenes (Heyne, 1987). Extracts from the torch ginger plant can be used for antioxidant, antibacterial, anticancer purposes, and can be used as cooking spices and curry (Silalahi et al., 2018).

Ginger rhizomes can be used as cooking spices and traditional medicines such as coughs, fevers, and to increase appetite (Silalahi et al., 2018), to treat wounds and snake bites (Heyne, 1987). Ginger rhizomes also have high economic value as raw materials for body warming drinks (Silalahi et al., 2018). Likewise, ginger shampoo plants can be used as traditional medicine. Ginger shampoo rhizome decoction has medicinal properties for stomach aches, to cure gallbladder and kidney stones, as well as to increase appetite (Heyne, 1987), and to cure rheumatism, fever, diarrhea and digestive disorders (Silalahi et al., 2018). Meanwhile, temu giring (*Curcuma heyneana*) is useful for treating worms in children, cosmetic ingredients (for powder), softening the skin, slimming the body, treating stomach aches, improving digestion, as well as for rubbing people's faces so that blood circulation is smooth (Jalil, 2019).

It should also be noted that Zingiberaceae plants are part of the understory, namely plants that form the lower stratum in the forest ecosystem (Indriyanto & Indriyanto, 2023). Apart from being economically beneficial for society, Zingiberaceae plants have ecologically important functions as components of biodiversity in ecosystems, and function as understory plants in forest ecosystems (Indriyanto, 2024). Kinho (2014) stated that Zingiberaceae plant species have functions that are as important as other herbaceous plants in supporting the function of forest ecosystems.

The function of the species of Zingiberaceae plant is a forest soil surface cover plant (Hutasuhut & Tambunan, 2018). The function of ground cover plants, among others, is to inhibit surface flow or run-off when it rains (Kinho, 2014), so that it can suppress erosion. Thus, Zingiberaceae plants and other understory plants have the main function of conserving soil and water because of their numerous root systems and dense clusters (Indriyani et al., 2017). Another function of undergrowth is to maintain soil moisture and increase soil organic matter (Indriyanto, 2024).

The Wan Abdul Rachman Grand Forest Park

Wan Abdul Rachman Grand Forest Park (Tahura) is a type of conservation forest in Lampung Province, Indonesia. Tahura is designated by the Indonesian government as a collection of natural or artificial plants and/or animals, native and/or non-native species which are used for research, science, education, cultivation support, and utilization of environmental conditions (Pemerintah Republik Indonesia, 2024).

Within the Tahura, 6 blocks were formed for effective management. One of the management blocks is a traditional block which is used as a place for traditional cultivation by the community (forest farmers) around the forest by applying MPTS (multipurpose trees species) agroforestry techniques (UPTD Taman Hutan Raya Wan Abdul Rachman, 2017). The application of the MPTS agroforestry technique can realize the restoration of vegetation in the form of forest garden stands from which forest farmers can harvest non-timber products, but forest farmers cannot cut down the wood (Indriyanto, 2022). In this way, vegetation cover in the form of a forest garden can be preserved.

It is hoped that the formation of a forest garden stand will create habitat conditions under the stand that will make it a suitable place for species of Zingiberaceae plant to live. Considering that the benefits of Zingiberaceae plants are broad (multi-purpose) both economically and ecologically, the presence of plants in conservation areas also needs to be considered to be preserved. Therefore, research was carried out to determine the presence of the species of Zingiberaceae plant in the areas cultivated by forest farmers in the Tahura Wan Abdul Rachman area.

II. Methods

Research Site

The research was conducted at the Talang Mulya Forest Farmer Group's cultivation area in the Traditional Block of the Bandar Lampung Resort, part of the Wan Abdul Rachman Grand Forest Park (Tahura in Indonesian), Lampung Province, Indonesia (Figure 1).

The Talang Mulya Forest Farmer Group is member of the 14 Forest Farmer Group Alliances of Wana Raya, all of whom are farmers managing cultivation areas within the Wan Abdul Rachman Grand Forest Park. They have a total of 51 active members who cultivate an area of 47.95 hectares across the Wan Abdul Rachman Grand Forest Park. In all of the cultivation areas managed by these farmers, and forest garden stands have been established, consisting of various tree species under the MPTS agroforestry program, which has been cultivated since 1998 (Gapoktanhut Wana Raya, 2019).

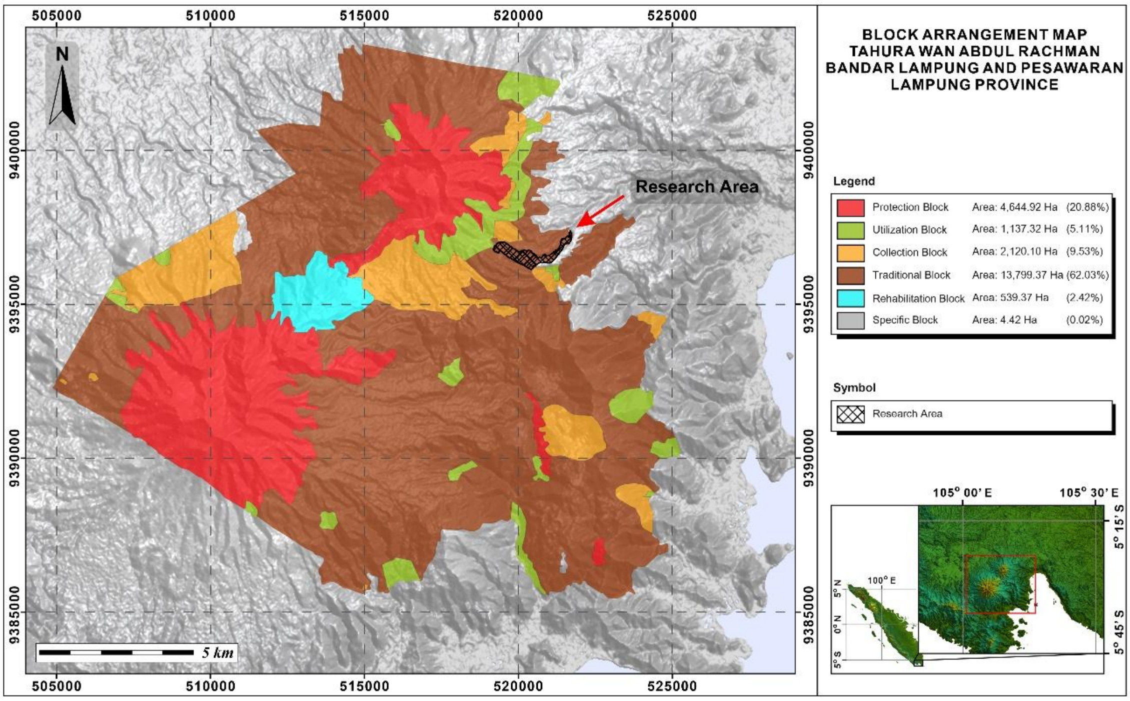

Figure 1. Map of the research site at the farmers' cultivated area of Talang Mulya Forest Farmer Group in Wan Abdul Rachman Grand Forest Park, Lampung Province, Indonesia (adapted from UPTD Taman Hutan Raya Wan Abdul Rachman, 2017).

The Talang Mulya Forest Farmer Group's cultivation area are located at elevation range of 210 to 822 m above sea level (m asl.) (Gapoktanhut Wana Raya, 2019). According to the Schmidt-Ferguson classification, Talang Mulya Forest Farmer Group's cultivation area has a wet climate condition (type B) with an average annual rainfall of 1,627.2 mm, average air humidity of 81.7%, and average air temperature of 28.1°C (UPTD Taman Hutan Raya Wan Abdul Rachman, 2017). There are three soil types composing this area, namely *Dystropepts*, *Humitropepts*, and *Kanhapludults*. However, *Dystropepts* present as predominant soil type, covering approximately 94.31% of the Wan Abdul Rachman Grand Forest Park area (UPTD Taman Hutan Raya Wan Abdul Rachman, 2017).

Equipment

The equipment used for this research consists of measuring tapes, a clinometer, a handheld GPS, measuring string, stakes, an abney level, a thermohygrometer, a lux meter, a writing board, ballpoint pens, and tally sheets.

Data Acquisition

The observation and data acquisition were conducted for five months, from August to December 2021. The data were acquired through field vegetation survey using 30 nested rectangular plots from an overall 47.95 ha survey area with 2.5% sampling intensity. Four plot types were used for observing tree species, namely: a) 2 m × 2 m for seedling phase; b) 5 m × 5 m for sapling phase; c) 10 m × 10 m for pole phase; and d) 20 m × 20 m for old tree phase. Then, a 2 m x 2 m plot was also used to observe Zingiberaceae plants. The nested rectangular plots were design following the Figure 2.

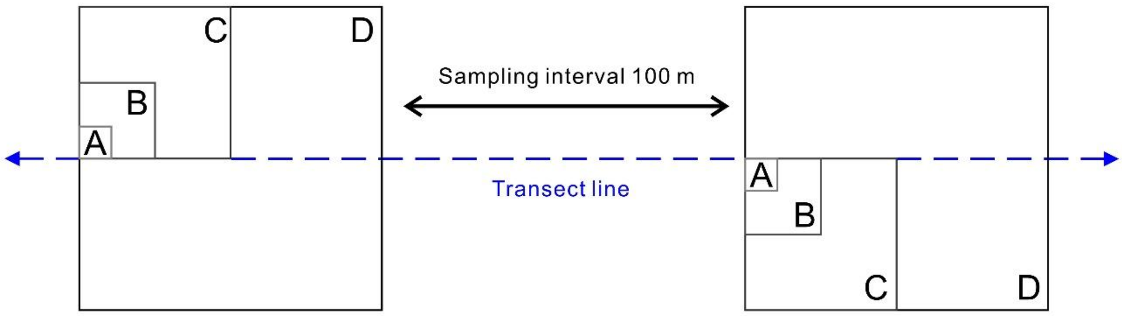

Figure 2. Design of nested rectangular sample plots used in this research.
A= 2 m x 2 m sample plot for observing trees species in the seedling phase and Zingiberaceae plants.
B= 5 m x 5 m sample plot for observing trees species in the sapling phase.
C= 10 m x 10 m sample plot for observing trees species in the pole phase.
D= 20 m x 20 m sample plot for observing trees species in the old tree phase.

The sugar palm trees were observed based on the following criteria:

1. Seedling phase: those sprout tree seeds until they reach a maximum height of 1.5 meters.
2. Sapling phase: those trees that are more than 1.5 meters in height with stem diameters of less than 10 cm.
3. Pole phase: those trees whose stem diameters are 10–19 cm.
4. Old tree phase: those trees whose stem diameters are 20 cm or more.

The sample plots were systematically arranged using 100 m interval along three transect lines in the same direction to the terrain slope or aligned with changes in elevation. The detailed configuration of the sample plots is shown in Figure 3.

The collected data include number of individuals of trees species at each growth phase, number of individuals of each species of Zingiberaceae plant, altitude and slope, intensity of solar radiation on the forest garden floor where Zingiberaceae plants grow, air temperature, and humidity.

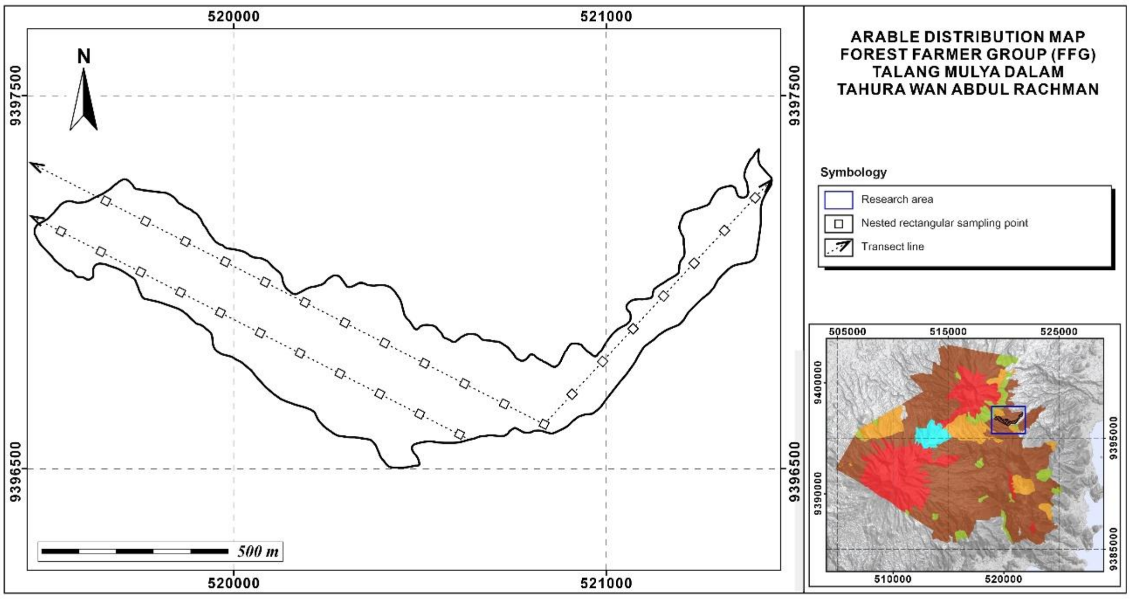

Figure 3. Layout of research sample plots at the farmers' cultivated area of Talang Mulya Forest Farmer Group in Wan Abdul Rachman Grand Forest Park, Lampung Province.

Data Processing

1. Analysis of Density

Density indicates the zise of the plant population. The density of plant population represents number of individual plant (trees and Zingiberaceae plants) per area unit, which is defined following the calculation of Indriyanto (2021).

$$\text{Density (D)} = \frac{\text{number of individuals of a plant species}}{\text{area of entire sample plot}} \quad (1)$$

$$\text{Relative Density (RD)} = \frac{\text{density of a plant species}}{\text{density of all plant species}} \text{ x } 100\% \quad (2)$$

2. Analysis of Frequency

Frequency is the intensity of finding a species of plant. Frequensy indicates the wide or narrow distribution of a plant species in the study area. The frequency of plant species was calculated using the following formula (Indriyanto, 2021).

$$\text{Frequency (F)} = \frac{\text{number of sample plots where a particular plant species is found}}{\text{number of all sample plots}} \quad (3)$$

Where F is frequency of plant (trees or Zingiberaceae plants) founded in studied area. Further, the frequency of plant is classified as follow of Indriyanto (2021).

a. High frequency if $F > 0.67$.
b. Moderate frequency if $0.33 \leq F \leq 0.67$.
c. Low frequency if $F < 0.33$.

$$\text{Relative Frequency (RF)} = \frac{\text{frequency of a plant species}}{\text{frequency of all plant species}} \text{ x } 100\% \quad (4)$$

3. Analysis of Coverage

Coverage is the ratio of the basal area to the area of entire sample plot. Basal area is the cross-sectional area of the stem at a height of 1.30 m from the base of the tree stem. Coverage is calculated using the following formula (Indriyanto, 2021).

$$\text{Coverage (C)} = \frac{\text{basal area of a tree species}}{\text{area of entire sample plot}} \quad (5)$$

$$\text{Relative Coverage (RC)} = \frac{\text{coverage of a tree species}}{\text{coverage of all tree species}} \text{ x } 100\% \qquad (6)$$

4. Analysis of Important Value Index

The important value index indicates the level of dominance of the plant species in a plant community. The important value index (IVI) for the sapling, pole, and old tree phase are calculated using the following formula (Indriyanto, 2021).

$$\text{IVI} = \text{RD} + \text{RF} + \text{RC} \qquad (7)$$

The important value index (IVI) for the seedling phase dan Zingiberaceae plant are calculated using the following formula (Indriyanto, 2021).

$$\text{IVI} = \text{RD} + \text{RF} \qquad (8)$$

The level of dominance is determined by creating a dominance class interval using the following formula (Indriyanto, 2021).

$$\text{Class interval of dominance (I)} = \frac{\text{IVI}_{\text{highest}} - \text{IVI}_{\text{lowest}}}{3} \qquad (9)$$

a. Dominant (high dominance) if IVI > (IVI_{lowest} + 2 I).
b. Moderat dominance if IVI as big as (IVI_{lowest} + I) until (IVI_{lowest} + 2 I).
c. Not dominant (low dominance) if IVI < (IVI_{lowest} + I).

III. RESULT AND DISCUSSION

The Condition of Forest Garden Stands

In each area cultivated by forest farmers who are members of the Talang Mulya Forest Farmer Group, forest garden stands have been formed as a result of forest farmers' participation in building forests using MPTS (multipurpose trees species) agroforestry techniques. The implementation of MPTS agroforestry techniques in the areas cultivated by forest farmers has been carried out since 1998 (Gapoktanhut Wana Raya, 2019).

The condition of forest garden stands in the areas cultivated by forest farmers belonging to the Talang Mulya FFG is presented in Table 1.

Table 1. Tree species as component of forest garden stands and condition of each tree population at forest farmers' cultivated area, members of Talang Mulya Forest Farmer Group in Wan Abdul Rachman Grand Forest Park

Number	Tree species		Density (Individual/ ha)	Frequency (F)	Important Value Index (%)
	Local name in Indonesia	Botanical name			
1.	Alpukat	*Persea americana* Mill.	36.3	0.57 mf	12.49 md
2.	Aren *)	*Arenga pinnata* Merr.	94.8	0.37 mf	16.47 md
3.	Binjai *)	*Mangifera caesia* Jack.	4.6	0.17 lf	6.37 ld
4.	Bisoro *)	*Ficus hispida* L.	4.3	0.23 lf	6.47 ld
5.	Cempaka	*Michelia champaca* L.	5.6	0.27 lf	7.05 ld
6.	Cengkeh	*Eugenia aromatica* O.K.	10.6	0.40 mf	7.11 ld
7.	Dadap srep *)	*Erythrina lithosperma* Miq.	4.6	0.30 lf	7.01 ld
8.	Duku	*Lansium domesticum* Correa	64.3	0.97 hf	20.90 hd
9.	Durian	*Durio zibethinus* Murr.	98.8	0.97 hf	25.10 hd
10.	Jengkol	*Pithecellobium lobatum* Benth.	34.3	0.70 hf	12.81 md
11.	Kakao	*Theobroma cacao* L.	55.2	0.53 mf	14.18 md
12.	Karet	*Hevea brasiliensis* M.A.	79.2	0.97 hf	21.61 hd

13.	Kecrutan *)	*Spathodea campanulata* P.B.	4.6	0.13	lf	6.15	ld
14.	Kemiri	*Aleurites moluccana* (L.) Willd.	60.4	0.93	hf	20.11	hd
15.	Manggis	*Gancinia mangostana* L.	12.8	0.37	mf	7.52	ld
16.	Nangka	*Artocarpus heterophyllus* Lamk.	10.5	0.30	lf	6.34	ld
17.	Pala	*Myristica fragrans* Hout.	79.4	0.93	hf	21.23	hd
18.	Petai	*Parkia speciosa* Hassk.	60.8	0.97	hf	20.47	hd
19.	Pinang sirih	*Areca catechu* L.	5.3	0.30	lf	6.81	ld
20.	Randu	*Ceiba pentandra* Gaertn.	4.6	0.17	lf	6.02	ld
21.	Salam	*Eugenia polyantha* Wight.	5.3	0.37	mf	7.63	ld
22.	Sonokeling *)	*Dalbergia lathifolia* Roxb.	4.6	0.23	lf	6.55	ld
23.	Tangkil	*Gnetum gnemon* L.	66.2	0.97	hf	20.87	hd
24.	Tisuk *)	*Hibiscus macrophyllus* Roxb. ex Hor.	4.6	0.23	lf	6.51	ld
25.	Weru *)	*Albizzia procera* Benth.	4.6	0.23	lf	6.17	ld
Total			816.3	12.57		300.0	

Remark: Calculated based on the formula for determining the level of frequency and dominance (Indriyanto, 2021).
Dominat (high dominance) (hd) that is IVI> 18.78
Moderate dominance (md), that is IVI 12.47–18.78
Not dominant (low dominance) (ld), that is IVI< 12.47
High frequency (hf), that is F> 0.67
Moderate frequency (mf), that is F 0.33–0.67
Low frequency (lf), that is F< 0.33
*)= trees grow naturally; not planted.

Based on Table 1, in forest garden stands there are 25 species of trees, 17 species of trees planted by forest farmers and 8 species of trees that live naturally. The dominant tree species in the forest garden stands are 7 species, namely langsat (*Lansium domesticum*) with an IVI of 20.90%, durian (*Durio zibethinus*) with an IVI of 25.10%, rubber (*Hevea brasiliensis*) with an IVI of 21.61%, candlenut (*Aleurites moluccana*) with an IVI of 20.11%, nutmeg (*Myristica fragrans*) with an IVI of 21.23%, stink bean (*Parkia speciosa*) with an IVI of 20.47%, and jointfir (*Gnetum gnemon*) with an IVI of 20.87%. The number of tree species categorized as moderate dominance is 4 species, while those categorized as not dominant (low dominance) are 14 species. Dominant tree species are those that generally have greater density, frequency, and coverage than other tree species in forest garden stands (Indriyanto, 2021). Viewed from the perspective of the preferences of forest farmers who plant tree species, the dominant tree species describes the species most preferred by forest farmers compared to other species (Indriyanto & Asmarahman, 2019; Indriyanto, 2022).

The number of tree species whose presence is most widely distributed in the areas cultivated by forest farmers is indicated by frequency (Indriyanto, 2021; Indriyanto, 2024). Based on Table 1, there are 8 species of trees whose presence is most widely distributed in the areas cultivated by forest farmers, namely langsat, durian, dogfruit, rubber, candlenut, nutmeg, stink bean, and jointfir.

In the forest garden stands, durian trees have the largest density. The population density of durian trees is 98.8 individuals/ha, this is the largest tree population compared to other tree populations which vary in size from 4.3 individuals/ha to 98.8 individuals/ha. Meanwhile, the tree population with the lowest density is hairy fig (*Ficus hispida*) at 4.3 individuals/ha.

Forest garden stands with a total density of 816.3 individuals/ha and an average distance between trees of approximately 2.99 m≈ 3 m enable the creation of habitat conditions for the life of Zingiberaceae plants. Zingiberaceae plants are a group of undergrowth plants, most of which are tolerant of shade from tree crowns (Indriyanto & Indriyanto, 2023).

The Condition of Zingiberaceae Plants Population

Under the stands of mixed forest gardens there are 16 species of Zingiberaceae plants consisting of 6 genera. Condition of the population of Zingiberaceae plant under forest garden stands in the area cultivated by forest farmers who are members of Talang Mulya FFG is presented in Table 2.

Table 2. Species of plants belonging to the Zingiberaceae and condition of the population of each plant species at farmers' cultivated area, members of Talang Mulya FFG in Wan Abdul Rachman Grand Forest Park, Lampung Province, Indonesia

Number	Species of Plants Belonging to The Zingiberaceae		Density (Individual/ ha)	Frequency (F)	Important Value Index (%)
	Local name in Indonesia	Botanical name			
1.	Temulawak	*Curcuma zanthorrhiza* Roxb.	583.3	0.23 lf	10.28 ld
2.	Lengkuas	*Alpinia galanga* (L.) Willd.	1,416.7	0.53 mf	24.17 hd
3.	Lempuyang wangi	*Zingiber aromaticum* Val.	666.7	0.13 lf	8.59 ld
4.	Jahe	*Zingiber officinale* Rosc.	750.0	0.20 lf	10.85 ld
5.	Lempuyang emprit	*Zingiber amarican* Bl.	1,583.3	0.63 mf	27.90 hd
6.	Tepus	*Etlingera solaris* (Bl.) Sm.	916.7	0.20 lf	12.21 md
7.	Lempuyang gajah	*Zingiber zerumbet* Sm.	1,083.3	0.43 mf	19.09 md
8.	Temu putih	*Curcuma zeodaria* Rosc.	500.0	0.10 lf	6.45 ld
9.	Lengkuas hutan	*Alpinia malaccensis* Rosc.	416.7	0.10 lf	5.77 ld
10.	Pacing	*Costus speciosus* Sm.	1,083.3	0.43 mf	19.09 md
11.	Temu giring	*Curcuma heyneana* Val. *et* V. Zyp.	250.0	0.10 lf	4.40 ld
12.	Bengle	*Zingiber purpureum* Roxb.	333.3	0.13 lf	5.87 ld
13.	Kapulaga	*Amomum compactum* Sol. *ex* Maton	1,083.3	0.40 mf	18.30 md
14.	Kecombrang	*Etlingera elatior* Sm.	416.7	0.17 lf	7.34 ld
15.	Wresah	*Amomum dealbatum* Roxb.	916.7	0.37 mf	16.15 md
16.	Kunyit	*Curcuma domestica* Val.	250.0	0.07 lf	3.62 ld
Total			12,250.0	4.23	200.00

Remark: Calculated based on the formula for determining the level of frequency and dominance (Indriyanto, 2021).

Dominat (high dominance) (hd) that is IVI> 19.27
Moderate dominance (md), that is IVI 11.66–19.27
Not dominant (low dominance) (ld), that is IVI< 11.66
High frequency (hf), that is F> 0.67
Moderate frequency (mf), that is F 0.33–0.67
Low frequency (lf), that is F< 0.33

Based on the results of the important value index analysis, the dominant species in the Zingiberaceae plant community are lempuyang emprit (*Zingiber amarican*) with an IVI of 27.90% and galangal (*Alpinia galanga*) with an IVI of 24.17%. The importance index of the two species of plant populations, namely lempuyang emprit and galangal, is strongly influenced by their greatest density, while the frequency of these two species is not the highest compared to other species of Zingiberaceae plants. The density of lempuyang emprit is 1,583.3 individuals/ha and the density of galangal is 1,416.7 individuals/ha with variations in the density of each species of Zingiberacae plant ranging from 250 individuals/ha until 1,583.3 individuals/ha. The plants with the smallest density (250 individuals/ha) are temu giring (*Curcuma heyneana*) and turmeric (*Curcuma domestica*).

None of the species of Zingiberaceae plant found had a high frequency. A total of 6 species of plants have medium frequencies with frequency values of 0.37 to 0.63. There are 10 species of plants that have a low frequency with a frequency value of ≤ 0.23. Indriyanto (2024) stated that frequency is the intensity of finding a species of plant in the study area. The frequency of a plant species is determined based on the ratio of the number of sample plots where a plant species is found to the total number of sample plots, so that the frequency value can indicate the extent of distribution of plant population members in a study area.

The higher the frequency value of a plant species, the wider its distribution. Vice versa, the smaller the frequency value of a plant species, the narrower its distribution. Based on the results of the frequency analysis listed in Table 2, it appears that all species of Zingiberaceae plants that live under forest garden stands have medium and low frequency levels. This means that the presence of species of Zingiberaceae plant is not widespread throughout the area cultivated by forest farmers, but is spread in a limited manner in places thought to be most suitable for their habitat. One of the factors that influences the suitability of growing sites for species of Zingiberaceae plants is the shading conditions of forest garden stands (Dewy & Indriyanto, 2022).

The microclimatic conditions under the shade of forest garden stands where 16 species of Zingiberaceae plants live in the areas cultivated by forest farmers who are members of Talang Mulya FFG can be seen in Table 3.

Based on the data in Table 3, the place of existence of Zingiberaceae plants is at a elevation of 210–820 m above sea level (m asl.) According to Erwinsyah et al. (2022), this elevation is still within the range of elevation for Zingiberaceae plants to live. Most of the land slope is gentle and only some of it is quite steep. The slope of the land is still suitable for the life of Zingiberaceae plants. Zingiberaceae plants are best suited to living on flat, sloping land, but some species of plants can live on rather steep, rolling, and hilly land (Lianah, 2020).

The forest garden stands have the function to improving habitat conditions. The trees that make up forest garden stands can influence the creation of more stable local climate conditions and better soil properties (Indriyanto (2024). Air temperature and humidity conditions at the research location are still suitable for the life of Zingiberaceae plants. In general, the plants Zingiberaceae requires high humidity conditions of 60–90% with an air temperature of 20–35^{o} C (Dewy & Indriyanto, 2022). Zingiberaceae have different ranges, this depends on the species of tree and the distance between the trees that provide shade. Shade from the forest garden canopy is very much needed by species of Zingiberaceae plant which are tolerant and very tolerant of shade range of relative tolerance to environmental factors (Indriyanto (2017). If the conditions of environmental factors are in accordance with the range of relative tolerance, then this allows the life and development of a species of plant.

Javanese turmeric (*Curcuma zanthorrhiza*) is found under forest garden stands composed of durian, jointfir, stink bean, bay leaf, cocoa, jackfruit, and sugar palm trees. Javanese turmeric is planted under forest garden stands at an elevation of 480–620 m asl. Apart from the research location, javanese turmeric is found throughout Indonesia (Rahmat et al., 2021; Silalahi et al., 2018). Javanese turmeric lives naturally in lowland areas up to an elevation of 800 m (Silalahi et al., 2018), and can also grow at an elevation of 2,500 m asl. (Rahmat et al., 2021). The tolerance range for javanese turmeric to elevation is quite wide, namely 5-1,000 m a.s.l., and the optimum elevation for growth of javanese turmeric is 750 m asl. (Alqamari et al., 2017). Javanese turmeric can also grow well in places shaded by tree canopies, temperatures of 19–30^{o} C, rainfall of 1,000–4,000 mm/year, and has high adaptability to weather changes (Alqamari et al., 2017). It is often found growing naturally in riverside areas (Silalahi et al., 2018).

Galangal (*Alpinia galanga*) is found under forest garden stands at an elevation of 210–815 m asl. The species of trees that shade galangal include avocado, clove, nutmeg, jointfir, stink bean, and cocoa. Galangal is one of the dominant species in the areas cultivated by forest farmers because it is planted by forest farmers. Alqamari et al. (2017) stated that galangal lives and grows well in lowland areas to highland areas at an elevation of 1200 m asl., rainfall of 2,500–4,000 mm/year, air temperature of 29–35^{o} C, moderate air humidity, and requires radiation. However, galangal can also live in areas with elevations approaching 1,500 m asl., especially if planted (Silalahi et al., 2018). Apart from growing under forest garden stands, galangal also grows well in open places (Trimanto et al., 2021). This indicates that galangal has a wide tolerance (eury) to the need for solar radiation.

Fragrant ginger (Zingiber aromaticum) is found at an elevation of 550–650 m asl. The forest garden stands that shading the fragrant ginger consists of michelia trees, durian, candlenut, nutmeg, kapok tree, and betelnut palm. According to Aie Angek City (2019), fragrant ginger generally lives wild in lowland to highland areas with an elevation of 1–1,200 m asl., with the soil and air humid conditions. Air humidity conditions under forest garden stands are quite high, namely 80.5–81.0%. The air humidity conditions are suitable for the life of fragrant ginger.

Ginger (*Zingiber officinale*) is found at an elevation of 580–695 m asl. under forest garden stands consisting of clove, langsat, durian, dogfruit, cocoa, rubber and african tulip trees. The natural habitat of ginger is lowland areas up to an elevation of 1,500 m asl. (Silalahi et al., 2018). According to Alqamari et al. (2017), ginger lives naturally in tropical and subtropical areas at an elevation of 0–2000 m asl., while in Indonesia it is cultivated at an elevation of 200–600 m asl. Ginger requires fertile soil or soil that contains lots of humus (Latifah et al., 2019), soil acidity (pH) for ginger to live in 4.3–7.4, best soil pH 6.8–7.0, rainfall 2,500–4,000 mm/yr, air temperature 20–35^{o} C, and requires an open place (Alqamari et al., 2017) or a lightly shaded place with the shade percentage is around 30% (Latifah et al., 2019).

Table 3. Conditions of the abiotic environment on the habitat of plants belonging to the Zingiberaceae famili at farmers' cultivated area, members of Talang Mulya FFG in Wan Abdul Rachman Grand Forest Park, Lampung Province, Indonesia

Number	Botanical name	Elevation (m above sea level)	Land slope (%)	Solar radiation intensity (Lux)	Air temperature (Cº)	Humidity (%)	Species of trees that provide shade
1.	*Curcuma zanthorrhiza* Roxb.	480--620	11--14	9,213--41,135	27.5--29.2	80.9--81.2	Durian, jointfir, stink bean, bay leaf, cocoa, jackfruit, sugar palm. Inter-tree spacing= 3.10 m
2.	*Alpinia galanga* Sw.	210--815	8--19	4,967--36,972	26.9--28.3	80.6--81.6	Avocado, clove, nutmeg, jointfir, stink bean, cocoa. Inter-tree spacing= 2.98 m
3.	*Zingiber aromaticum* Val.	550--650	12--14	9,324--40,352	28.2--29.0	80.5--81.0	Michelia, durian, candlenut, nutmeg, kapok tree, betelnut palm. Inter-tree spacing= 3.10 m
4.	*Zingiber officinale* Rosc.	580--695	12--14	15,450--40,405	28.0--29.0	79.2--80.5	Clove, langsat, durian, dogfruit, cocoa, rubber, african tulip. Inter-tree spacing= 3.41 m
5.	*Zingiber amarican* Bl.	450--820	14--19	9,980--45,500	27.8--29.2	80.5--81.0	Jack, dogfruit, rubber, nutmeg, jointfir, mangosteen. Inter-tree spacing= 3.15 m
6.	*Etlingera solaris*(Bl.) Sm.	510--795	14--19	2,722--19,238	26.6--28.3	81.0--81.8	Avocado, durian, candlenut, nutmeg, stink bean, jointfir, sugar palm. Inter-tree spacing= 2.94 m
7.	*Zingiber zerumbet* Sm.	715--820	11--19	8,340--38,875	27.0--28.3	80.5--81.6	Durian, cocoa, nutmeg, stink bean, tamalan tree, jointfir. Inter-tree spacing= 2.98 m
8.	*Curcuma zeodaria* Rosc.	480--600	12--13	9,495--39,321	27.8--28.5	80.6--81.5	Durian, cocoa, nutmeg, stink bean, jointfir, karoi tree. Inter-tree spacing= 2.98 m
9.	*Alpinia malaccensis* Rosc.	435--655	14--15	2,424--29,499	26.8--27.1	81.0--81.4	Sugar palm, rubber, magosteen, nutmeg, jointfir, largeleaf rosemallow. Inter-tree spacing= 2.95 m
10.	*Costus speciosus* Sm.	225--815	8--19	2,242--45,453	26.8--29.1	79.5--81.0	Avocado, durian, nutmeg, jointfir, betelnut palm. Inter-tree spacing= 3.15 m
11.	*Curcuma heyneana* Val. *et* V. Zyp.	705--810	15--19	20,997--44,223	27.8--29.2	78.5--81.0	Cocoa, nutmeg, stink bean, jointfir, mangosteen, jackfruit. Inter-tree spacing= 3.20 m
12.	*Zingiber purpureum* Roxb.	360--490	9--11	7,845--40,580	27.2--29.0	79.5--81.0	Avocado, sugar palm, durian, nutmeg, jointfir. Inter-tree spacing= 2.96 m
13.	*Amomum compactum* Sol. *ex* Maton	270--390	9--10	2,114--45,521	26.5--29.3	79.5--81.3	Durian, langsat, rubber, stink bean, nutmeg, jointfir. Inter-tree spacing= 3.15 m
14.	*Etlingera elatior* Sm.	680--795	14--17	2,240--19,982	26.7--28.3	81.0--81.8	Durian, rubber, candlenut, dogfruit, jointfir. Inter-tree spacing= 2.94 m
15.	*Amomum dealbatum* Roxb.	585--705	12--14	3,491--40,100	26.8--28.5	80.2--81.5	Cocoa, nutmeg, dogfruit, jointfir. Inter-tree spacing= 3.10 m
16.	*Curcuma domestica* Val.	540--670	12--14	29,430--45,521	28.0--29.1	78.0--80.5	Langsat, durian, dogfruit, rubber, nutmeg, kapok tree. Inter-tree spacing= 3.45 m

Lempuyang emprit (*Zingiber amarican*) is found under the shade of forest garden stands at an elevation of 450–820 m asl. Darwis et al. (1991) stated that in generally *Zingiber amarican* is found living wild in forests, gardens and fields. However, the presence of *Zingiber amarican* in areas cultivated by forest farmers is because some of it was planted by farmers, and some of it grows wild. Although its distribution in farmers' cultivated areas is still limited (F= 0.63, moderate frequency), *Zingiber amarican* is the dominant species in the research location with a density of 1,583.3 individuals/ha. The species of trees that *house Zingiber amarican* are jack, dogfruit, rubber, nutmeg, jointfir, and mangosteen.

Tepus (*Eltingera solaris*) is a plant that lives wild in the research location at an elevation of 510–795 m asl. Tepus live in the wild (not planted by forest farmers) under forest garden stands consisting of avocado, durian, candlenut, nutmeg, stink bean, jointfir, and sugar palm trees. The distribution of tepus in the areas cultivated by forest farmers is very limited with a frequency value of 0.20 (low frequency). The natural habitat of tepus is in mountain forests at an altitude of 800–1,650 m asl., and is spread throughout Southeast Asia, including Indonesia, living in Java and Sumatra (Useful Tropical Plants, 2025).

Shampoo ginger (Zingiber zerumbet) is generally planted by forest farmers under forest garden stands. Shampoo ginger lives under the shade of forest garden stands consisting of durian, cocoa, nutmeg, stink bean, tamalan tree and jointfir trees at an altitude of 715–820 m asl. Silalahi et al. (2018) stated that shampoo ginger can live in the lowlands until the highlands with an elevation of more than 1,000 m asl., in places that are shaded or slightly open. According to (Andini et al., 2020), shampoo ginger is also found in lower mountain forests up to places with an elevation of 1,300 m asl., air temperature of 25–27º C, and air humidity of 73.6–82%.

Zedoary (*Curcuma zeodaria*) was found living under forest garden stands consisting of durian, cocoa, nutmeg, stink bean, jointfir, and karoi trees at an altitude of 480–600 m asl. The zedoary is planted by forest farmers under forest garden stands. This plant has also been widely cultivated by people in Southeast Asia. Zedoary is thought to be a species of plant that originates from the Northeastern region of India and lives well in highland areas up to an elevation of 1,000 m asl. (Silalahi et al., 2018).

Forest galangal (*Alpinia malaccensis*) lives wild under forest garden stands composed of sugar palm, rubber, magosteen, nutmeg, jointfir, and largeleaf rosemallow trees at an elevation of 435–655 m asl. According to Socfindo Conservation (2025 a), galangal forests grow well in shady places at elevation up to 1,500 m a.s.l., average annual rainfall is 800–4,000 mm/yr, and minimum temperature 2 ºC. At the research location, the galangal forest was found alive at an air temperature of 26.8–27.1º C, air humidity of 81.0–81.4%, and solar radiation varying between 2,424 lux until 29,499 lux (Table 3).

Crepe ginger (*Costus speciosus*) lives and grows wild under forest gardens at an elevatin of 225–815 m a.s.l. The species of tree that shades the ginger crepes are avocado, durian, nutmeg, jointfir, and betelnut palm. The dominance level of crepe ginger is categorized as moderate dominance with an IVI of 19.09%, has a sufficient density of 1,083.3 individuals/ha, and is categorized as moderate frequency with an F value of 0.43 (Table 2). Aulia et al. (2024) and (Wu, 2000) stated that crepe ginger requires a humid place in lowland areas up to an elevation of 1,700 m asl. At the research location, crepe ginger was found living in dry and moist soil, often found in riverside areas. Crepe ginger was found at an air temperature of 26.8–29.1º C, air humidity of 79.5–81.0%, and solar radiation varying between 2,242 lux until 45,453 lux (Table 3).

Temu giring (*Curcuma heyneana*) lives wild and some are planted by forest farmers under forest garden stands. Temu giring's living area is at an elevation of 705–810 m asl. under cocoa, nutmeg, stink bean, jointfir, mangosteen, and jackfruit trees. Jalil (2019) stated that temu giring can live and grow well in areas with an elevation of 200–750 m above sea level, annual rainfall of 1000–3,500 mm/year, air temperature of 19–30o C, and moderate air humidity. Temu giring require high intensity solar radiation (Jalil, 2019). Therefore, under shading of forest garden stands the density is very small, namely 250.0 individuals/ha. The frequency of meeting temu giring is also categorized as low frequency with an F value of 0.10 (Table 2), found in places that receive higher solar radiation between 20,997 lux until 44,223 lux (Table 3).

Purple ginger (*Zingiber purpureum*) lives wild under avocado, sugar palm, durian, nutmeg, and jointfir trees at an elevation of 360–490 m asl. Meanwhile, according to Socfindo Conservation (2025 c), purple ginger can live in lowland to highland areas with an elevation of 1,300 m asl., on soil that has good drainage and is rich in organic matter. Purple ginger likes places with sufficient intensity of solar radiation or places shaded by trees. At the research location, purple ginger was found in places with solar radiation intensity of 7,845 lux until 40,580 lux (Table 3). This indicates that the tolerance range for purple ginger to solar radiation is quite wide.

Under the forest garden stands consisting of durian, langsat, rubber, stink bean, nutmeg, and jointfir trees, there is cardamom (*Amomum compactum*). Cardamom is cultivated by forest farmers (Indriyanto, 2023). Cardamom is planted in farmers' cultivated areas, at elevations of 270–390 m asl. The natural habitat of cardamom is in medium plains and hilly areas with high humidity conditions (Ernawati et al., 2022). A suitable growing place for cardamom to live and develop is an elevation of 300–800 m asl., rainfall of 2,500–4,000 mm/year, air temperature of 20–30º C, and pH of 5–7, in a shaded place with a solar radiation intensity of 30–70% (Ernawati et al., 2022). Cardamom can also live at elevations of 1,000 m asl., and good growth of cardamom occurs at elevations of 300–500 m asl. (Abdurahim et al., 2022). Cardamom requires a solar radiation intensity of 54.0–67.0% to grow well (Indriyanto, 2023). According to Alqamari et al. (2017), cardamom requires air humidity conditions of 40–75% for optimal growth.

Torch ginger (*Eltingera elatior*) was found living wild under forest garden stands. Torch ginger is found at an elevation of 680–795 m asl. under durian, rubber, candlenut, dogfruit, and jointfir trees. According to Silalahi et al. (2018), the natural habitat of torch ginger is in lowland areas up to areas with an elevation of 1,000 m asl. Andini et al. (2020) stated that torch ginger is also found in lower mountain forests up to an elevation of 1,300 m asl. with an air temperature of 25–27º C and air humidity of 73.6–82%. In general, torch ginger is found in humid areas with forest canopy cover of around 60–70% (Kinho, 2014). At the research location, torch ginger is also found in humid places with air humidity of 81.0–81.8% (Table 3).

Wresah (*Amomum dealbatum*) also lives wild under forest garden stands. Wresah is found at elevations of 585–705 m asl. under the shade of cocoa, nutmeg, dogfruit, and jointfir trees. According to Socfindo Conservation (2025 b), wresah often live wild at an elevation of 600–800 m asl., in shady (shaded), humid places, and on soil containing humus. At the research location, wresah was found in humid places with air humidity of 80.2–81.5%, air temperature of 26.8–28.5o C, and a wide range of solar radiation intensity, namely 3,491 lux until 40,100 lux (Table 3).

Turmeric (*Curcuma domestica*) is found at elevations of 540–670 m asl. (Table 3). Turmeric is found under forest garden stands because it is planted by forest farmers, but there is also turmeric that lives wild (grows naturally). The species of trees that shading the turmeric include langsat, durian, dogfruit, rubber, nutmeg, and kapok tree. In other areas turmeric also lives in lowland to highland areas with elevations reaching 2,000 m asl. (Silalahi et al., 2018). The optimum growth of turmeric is at an elevation of 45 m asl. (Alqamari et al., 2017). At the research location, the turmeric population is very small, namely 250 individuals/ha, the presence of turmeric is very limited with an F value of 0.07 (Table 2). This is thought to be because turmeric is less tolerant of shade. Based on the conditions of solar radiation intensity at the research location, turmeric is only found in places with relatively high solar radiation intensity, namely in the range of 29,430 lux until 45,521 lux (Table 3). This indicates that turmeric tends to require a high intensity of solar radiation or even an open place.

IV. CONCLUDING REMARK

Conclusion

There are 16 species of Zingiberaceae plants found under forest garden stands, dominated by 2 species, namely lempuyang emprit and galangal. Thus, under the forest garden stands, it is possible for various species of Zingiberaceae plants to live. The level of dominance, population density, and intensity of Zingiberaceae plant species found depend on the composition of the trees that make up the forest garden stand. This is because each species of Zingiberaceae plant has different tolerance to shading conditions, although in general they are resistant to shade from tree canopies.

Recommendation

The existence of the species of Zingiberaceae plant must be protected by various parties, both by forest farmers who work on land in forest areas, and by government institutions that have authority in forest management.

Cultivation of the species of Zingiberaceae plant under forest garden stands needs to be developed in order to increase the income of forest farmers, as well as to preserve plant biodiversity.

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