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# Species composition, structure, and management in gayo coffee-based agroforestry system: the case of Mude Nosar Village, Central Aceh Regency

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***Abstract.*** *Gayo coffee has been the main commodity of the Gayo tribe, including the Mude Nosar, as local farmers. One of the ways to cultivate Gayo coffee is through an agroforestry system. However, limited reports on the tree species composition and its management in Gayo coffee-based agroforestry need to be explored. This study aims i) to identify the tree species composition and structure, as well as 2) to analyze the management of Gayo coffee-based agroforestry system in Mude Nosar Village. The method used plot establishment for vegetation analysis and interviewed the Gayo coffee farmers. The results showed that the number of tree species at all growth stages was 26 species. The highest Important Value Index (IVI) at the understory and sapling level in order was rumput kerbau* (Paspalum conjugatum) *and Gayo coffee* (Coffea arabica), *while at the seedling, pole, and tree levels were dominated by lamtoro* (Leucaena leucocephala). *The local farmers often use lamtoro as a shade tree for Gayo coffee in the agroforestry system. The species diversity index (H') showed low values at all tree growth levels. The horizontal structure of the tree stand showed an inverted J curve, meaning that the regeneration rate was normal. The vertical structure of the tree stand belongs to strata C and D. The local farmers have applied good Gayo coffee management practices through an agroforestry system, including land and seed preparation, planting, maintenance, and harvesting techniques. The management of Gayo coffee using an agroforestry system impacts the ecological, economic, and social aspects.*

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## INTRODUCTION

Indonesia is rich in biodiversity consisting of various flora and fauna. Many plant species are widely used as vital cultural species. According to Faluthi (2021), the critical culture species are various plant species with multifunctionality in cultural activities. One of the vital species of culture is coffee due to economic, environmental, and cultural benefits. Based on the economic aspect, coffee can improve welfare, while in the environmental aspect, it can conserve biodiversity, soil, and water. In the cultural aspect, coffee can be used as a preservation that adheres to various social values and norms as the formation of the identity of a tribe.

One of the tribes that live side by side with coffee (co-exist) is the Gayo Tribe. The variety of Gayo coffee is Arabica coffee (*Coffea arabica*). According to Khalisuddin et al. (2012), the Gayo tribe believes that Gayo coffee is "the life and death of Gayo people". Furthermore, Gayo people who do not have coffee plantations are not considered Gayo people. Gayo coffee has become a superior commodity for the Gayo Community, especially the people of Mude Nosar Village. Gayo coffee has been traded in domestic and international markets. The way to cultivate Gayo coffee people of Mude Nosar Village is through an agroforestry system. Mayrowani and Ashari (2011) explain that agroforestry is developed to improve community welfare, optimize land use, and increase ecological carrying capacity, especially in rural areas. Hakim (2021) states that agroforestry is a form of local community wisdom in managing land.

The people of Mude Nosar Village, who cultivate the Gayo coffee-based agroforestry, indirectly conduct environmental conservation efforts. According to Atangana et al. (2014) and Hartoyo et al. (2022), agroforestry plays a role in conserving biodiversity because it integrates the commonly found plants, namely local and semi-natural introduced species. Coffee agroforestry practices have also been widely applied by local communities in Indonesia, such as in West Lampung (Maharani et al. 2013; Lumbanraja et al. 2020), Malang Regency (Hidayat et al. 2021), Jambi Province (Meiln et al. 2017), and the province of Aceh (Pramulya 2021; Fauzi 2019). However, limited reports on the tree species composition and its management in Gayo coffee-based agroforestry system need to be explored. This study aims i) to identify the tree species composition and structure, as well as 2) to analyze the management of the Gayo coffee-based agroforestry system in Mude Nosar Village.

## METHOD

### Research Location

This study was conducted in Mude Nosar Village, Bintang District, Central Aceh Regency, Aceh Province, in 2021. The research location is presented in Figure 1.

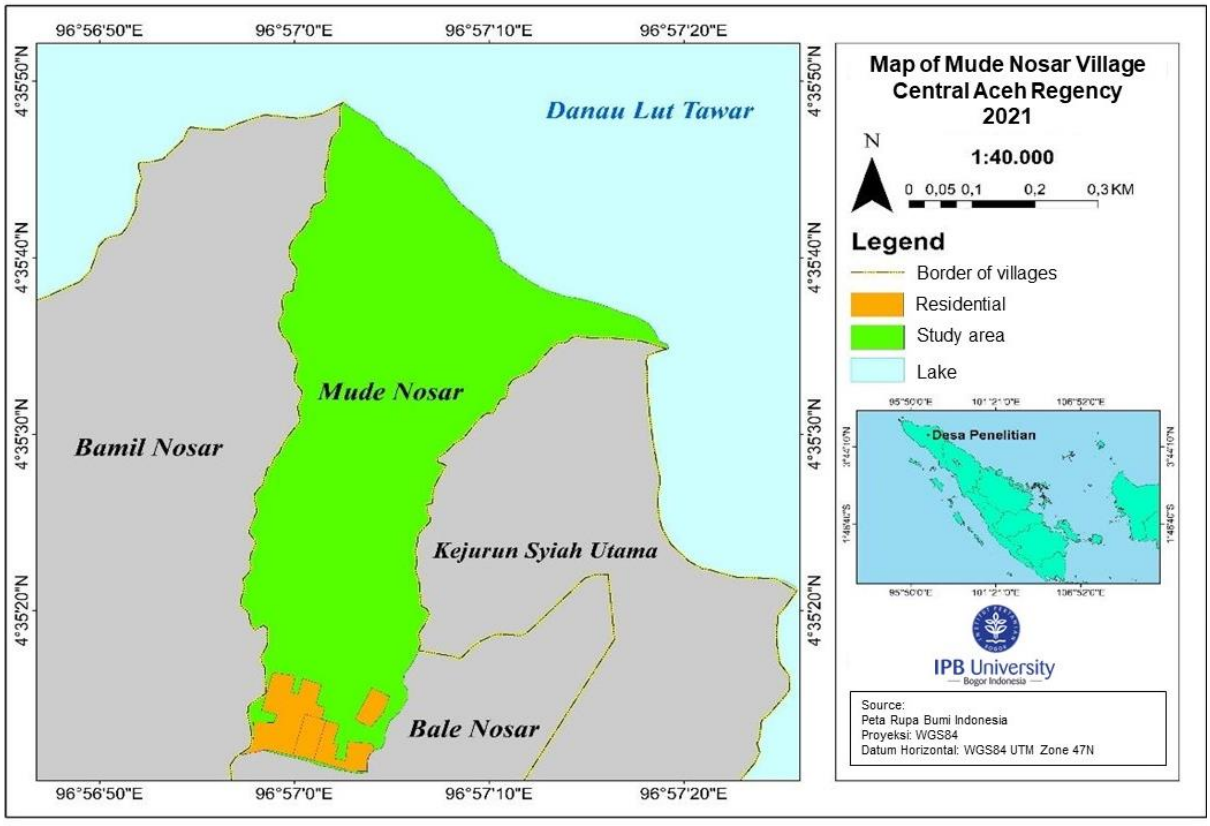



Figure 1 Map of Mude Nosar Village

**Tools and Objects**

Tools and materials used in this study were binoculars, meters, tape meter, hypsometer, thermohygrometer, GPS (Global Positioning System), paper, stationery, voice recorder, camera, interview questionnaire, and microsoft office. The object of this research is the Gayo coffee-based agroforestry area in Mude Nosar Village, Bintang District, Central Aceh Regency.

**Research Procedure**

Data collection includes tree diameter, tree height, and the number of plants to determine the composition, structure, and diversity of vegetation, as well as the results of interview questionnaires with coffee farmers in Mude Nosar Village to analyze the management of Gayo coffee-based agroforestry systems.

***Interview Respondents***

Respondents were the landowners of the 15 plots built, members of farmer groups and coffee businessmen. Interviews were conducted to analyze the Gayo coffee-based agroforestry system management in Mude Nosar Village.

***Plot Establishment***

The research plots were selected by purposive sampling, namely establishing research plots by determining specific criteria (Sugiyono 2008). Selected the criteria based on the condition of the existing agroforestry system in Mude Nosar Village, Central Aceh. The number of plot establishments was 15 plots with a plot size of 20 m x 20 m and consisted of a 10 m x 10 m subplot, a 5 m x 5 m subplot, and a 2 m x 2 m subplot. Soerianegara and Indrawan (1988) stated a 20 m x 20 m plot to identify trees, a 10 m x 10 m subplot to identify poles, a 5 m x 5 m subplot to identify saplings, and a 2 m x 2 m subplot to identify seedlings and understory.

**Data Analysis**

***Analysis of Gayo Coffee Agroforestry System Vegetation***

Tree species composition analysis was carried out by calculating the Relative Density (RD), Relative Frequency (RF), Relative Dominance (Dm), and Important Value Index (IVI). The calculation of the IVI formula followed Soerianegara and Indrawan (1988) formula. The species diversity index (H') and species richness index (Dmg) were calculated using the Reynold and Ludwig formula (1988), the evenness index (E) was calculated using the Magurran formula (1988), and the dominance index (D) was calculated using the Odum formula (1993).

***Descriptive Qualitative Analysis Descriptive Qualitative Analysis***

The results of interview questionnaires with coffee farmers in Mude Nosar Village were used to analyze the management of Gayo coffee-based agroforestry system. According to Nugrahani (2014), descriptive qualitative is a method for understanding and assembling the data collected to describe the object being studied in depth and its entirety related to the study. Data analysis begins by making a transcript of the questionnaire results by playing back the recording, grouping the same answers, and ignoring unnecessary data. The data is then presented in a narrative equipped with tables or figures to facilitate analyzing the data, then verifying and drawing conclusions from the data by the research objectives.

## RESULTS AND DISCUSSION

### Characteristics of Respondents

Interviews were conducted to analyze the Gayo coffee-based agroforestry system management in Mude Nosar Village. Eight characteristics were recorded: ethnicity, age, length of stay, education, length of visit, side work, land area, and income level. Characteristics of respondents can be seen in Table 1.

Table 1 Characteristics of respondents

| Characteristics of respondents | Category | Percentage (%) |
|---|---|---|
| Tribe | Gayo Lut | 80 |
| | Gayo Lues | 20 |
| Age (Mahyuda et al. 2018) | Medium age (33 - 45 years) | 20 |
| | Old age (46 - 58 years) | 80 |
| Length of Stay | 1 - 5 years | 20 |
| | 16 - 25 years | 20 |
| | > 35 years | 60 |
| Education (Mahyuda et al. 2018) | Low (Elementary school/equivalent) | 20 |
| | High (Senior high school/equivalent) | 80 |
| Main occupations | Farmers | 100 |
| Side jobs | Entrepreneurial | 20 |
| | Businessman | 40 |
| | Fishermen | 40 |
| Land area (Mahyuda et al. 2018) | Narrow (≤ 1.5 ha) | 60 |
| | Medium (1.5 - 3 ha) | 40 |
| Income Level | < 500,000 | 40 |
| | > 7,000,000 | 60 |

Table 1 shows that the most ethnic group of respondents in Mude Nosar Village, Central Aceh Regency is the Gayo Lut Tribe (80%). Sukiman (2020) states that the Gayo Lut tribe is mostly domiciled in Central Aceh District and Bener Meriah District. The most dominant respondents were in the age category 46 - 55 years (80%), and the longest length of stay was more than 35 years (60%). The education level of most respondents was Senior High School (80%).

The main occupations of respondents were farmers (100%). Farmers in Mude Nosar Village mostly cultivate Gayo coffee and have traded it to the international market. The largest land area is 1.5 ha (60%). The land area in Mude Nosar Village tends to be narrow (≤ 2 ha), but farmers own more than two farms in different places. Agricultural land (rice fields, fields, and gardens) managed by farmers comes from family inheritance, purchased by themselves, and land for profit sharing. The most dominant side jobs were businessmen and fishermen (40%). Side jobs as fishermen were highly supported because Mude Nosar Village is close to Lut Tawar Lake, which can be used to increase the income of the local community. In addition, the community also increases their income in animal husbandry, namely goats and cows. The highest income level is >Rp7,000,000.00 (60%). BPS (2013) states that the income level > Rp3,500,000.00/month is in the very high category. It can assume that the profession of a farmer, especially a Gayo coffee farmer, is quite promising and combines with the lake products and livestock which can increase the income of the people of Mude Nosar Village.

**Tree Species Composition and Structure in Gayo Coffee-based Agroforestry Systemin Mude Nosar Village**

***Tree Species Composition in Gayo Coffee-based Agroforestry System in Mude Nosar Village***

Tree species composition was found at various growth stages, namely understory, seedlings, saplings, poles, and trees. The number of species at all growth levels was 26, divided into 16 species of understory, 3 species of seedlings, 3 species of the sapling, 2 species of poles, and 2 species of trees. This number is relatively low compared to natural forests due to the condition of the Gayo coffee agroforestry system is a form of forest that has been converted. The number of poles and trees has the lowest value due to its existence as a shade tree for Gayo coffee (shade tree), so the number of poles and tree growth is limited.

Important value index (IVI) was calculated based on relative density and relative frequency for the calculation of understory, seedlings, and saplings. While, IVI at the level of poles and trees was added by relative dominance. Important value index (IVI) is one of the parameters observed in analyzing the vegetation of a land. IVI values are presented in Table 2.

Table 2 Important value index (IVI) in the Gayo coffee-based agroforestry system

| Level | Local name | Latin name | IVI (%) |
|---|---|---|---|
| Understory | *Rumput Kerbau* | *Paspalum conjugatum* | 42.4 |
| | *Bandotan* | *Ageratum conyzoides* | 41.6 |
| | *Baru cina* | *Artemisia vulgaris* | 31.4 |
| | *Semanggi* | *Oxalis articulate* | 14.1 |
| | *Pegaga* | *Centela asiatica* L. | 2.8 |
| | *Daun sendok* | *Plantago major* | 7 |
| | *Rimbang* | *Solanum torvum* | 2.1 |
| | *Sirih hutan* | *Piper caducibracteum* | 2.1 |
| | *Jukut pendul* | *Kyllinga brevifolia* | 9 |
| | *Jotang* | *Acmelia ciliate* | 8.6 |
| | *Tarum* | *Indigofera tinctoria* | 5.3 |
| | *Buang-buang* | *Ludwigia palustris* | 8.7 |
| | *Sidaguri* | *Sida rhombifolia* | 4.7 |
| | *Lalampuyangan* | *Panicum repens* | 10.8 |
| | *Leluit* | *Mikania micrantha* | 7.4 |
| | *Rumput teki* | *Cyperus rotundus* | 1.9 |
| Seedling | *Lamtoro* | *Leucaena leucocephala* | 100.7 |
| | Gayo coffee | *Coffea arabica* | 87.6 |
| | *Pakis* | *Cycas rumphii* | 11.7 |
| Sapling | *Lamtoro* | *Leucaena leucocephala* | 15.7 |
| | Gayo coffee | *Coffea arabica* | 174.1 |
| | *Durian* | *Durio zibethinus* | 5.1 |
| | Avocado | *Persea americana* | 5.1 |
| Pole | *Lamtoro* | *Leucaena leucocephala* | 280.9 |
| | *Durian* | *Durio zibethinus* | 19.1 |
| Tree | *Lamtoro* | *Leucaena leucocephala* | 285.6 |
| | Mango | *Mangifera indica* | 14.4 |

The highest important value index (IVI) at the understory level was *rumput kerbau* (42.4%). This species is an adaptive weed that can live in soil conditions containing Al (Subrata and Setiawan 2018; Rumondang et al. 2016). The highest IVI value at the seedling, pole, and tree level was *lamtoro* (*L. leucocephala*), and the

highest IVI at the sapling level was Gayo coffee. Gayo coffee is the primary commodity in the agroforestry system, while *lamtoro* is a plant used as a shade for Gayo coffee (Figure 2). Sobari et al. (2012) stated that *lamtoro* is suitable as a coffee shade. *Lamtoro* also has a canopy cover that is not too tight to maintain environmental temperatures. Besides that *lamtoro* litter can be a source of soil organic matter. It is undoubtedly very beneficial for Gayo coffee in its growth.

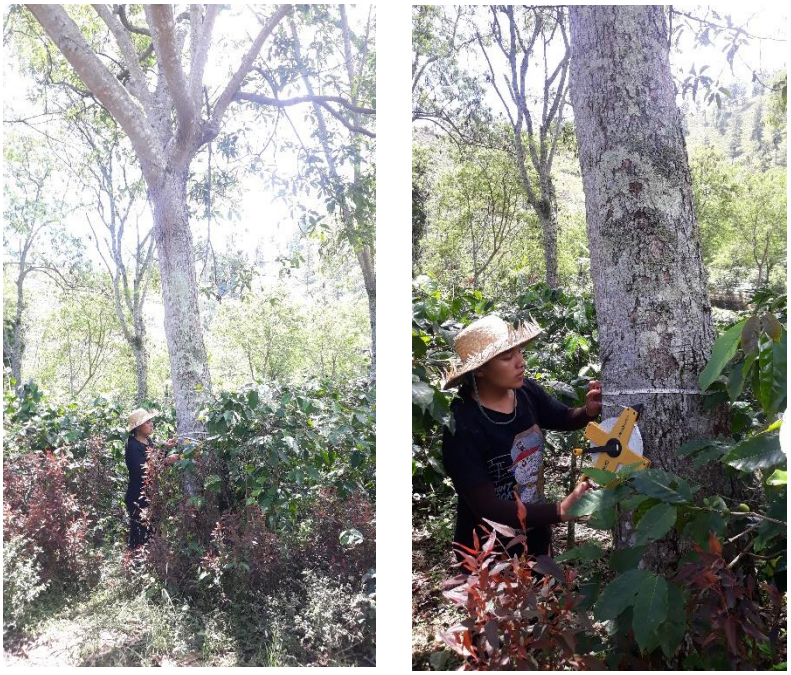


Figure 2 *Lamtoro* (*L. leucocephala*) for shading Gayo coffee

Species diversity at each growth rate of the Gayo coffee agroforestry system was calculated by the diversity index (H'), the species evenness index (E), the species richness index (Dmg), and the species dominance index (C). Data on the species diversity of Gayo coffee agroforestry systems can be seen in Table 3.

Table 3 Species diversity of Gayo coffee agroforestry systems

| Level | H’ | E | Dmg | C |
|---|---|---|---|---|
| Understory | 1.97 (S) | 0.71 (S) | 2.11 (R) | 0.2 (R) |
| Seedling | 0.78 (R) | 0.86 (S) | 0.35 (R) | 0.48 (S) |
| Sapling | 0.06 (R) | 0.04 (R) | 0.43 (R) | 0.98 (T) |
| Pole | 0.16 (R) | 0.24 (R) | 0.31 (R) | 0.93 (T) |
| Tree | 0.09 (R) | 0.13 (R) | 0.5 (R) | 0.96 (T) |

Low (L), medium (M), high (H), species diversity index (H'), species evenness index (E), species richness index (Dmg), and species dominance index (C)

The species diversity index (H') showed low values at all growth levels, except for understory plants with moderate values (1.97). Nurudin et al. (2013) stated that the characteristics of a species diversity index of less than 1 are low and a diversity index with a value of 1 - 3 is moderate. It differs from the species evenness index (E), understory, and seedling have an intermediate category value. Lower plants and seedlings have values close to 1. It is to the statement of Wahyuningsih et al. (2019) that the evenness of species with a value of 0.31-1 is moderate, and a value below 0.31 is low.

The species richness index (Dmg) of the Gayo coffee agroforestry system obtained the highest value on undergrowth, namely 2,11. The value of the species richness index is low at all growth levels. Wahyuningsih

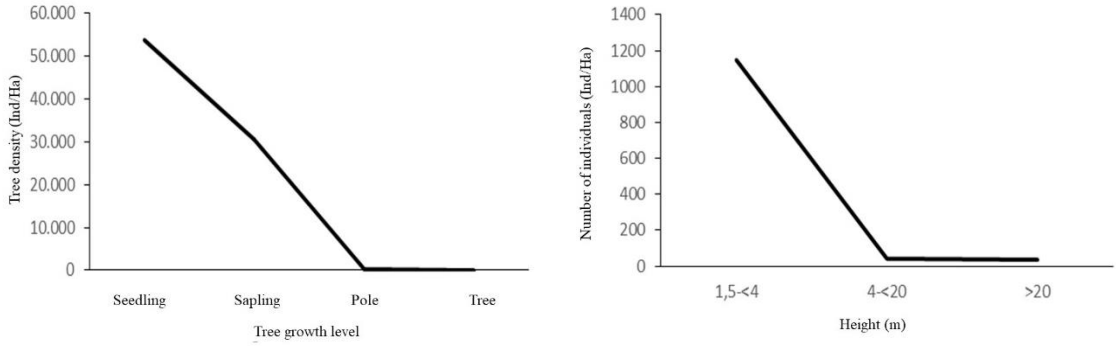
et al. (2019) stated that the species richness index below 2.5 is standard. In contrast to the species dominance index (C), the understory has the lowest value (0.2), while saplings, poles, and trees produce high values close to 1. Sirait et al. (2018) state that the dominance index has a value between 0 - 1. The dominance index will be classified as high if the value is close to 1.

***Tree Stand Structure of the Gayo Coffee-based Agroforestry System***

The stand structure can be seen horizontally and vertically. The horizontal stand structure is influenced by the species composition and the number of individuals per hectare (ha) on the density of each growth stage. In contrast, the vertical stand structure is influenced by the tree stand density and height. The stand structure of the Gayo coffee agroforestry system can be seen in Figure 3.

The stand structure of the Gayo coffee agroforestry system is made in a horizontal structure (Figure 3a) and a vertical structure (Figure 3b). The horizontal structure of the stand produces the highest value at the seedling level and tends to decrease successively from the sapling, pole, to tree level. The curve tends to form an inverted J which is a common shape in natural forests. Management of agroforestry systems, such as clearing natural regeneration and undergrowth that disturbs coffee plants, is contrary to regeneration. However, this research shows that the regeneration process in the Gayo coffee-based agroforestry system tends to be balanced. A similar result is also reported by Marques et al. (2022) that coffee (*Coffea arabica* L.) based agroforestry system in Liquica Regency, Timor Leste has inverse J-curve regeneration. Hartoyo et al. (2019) explained that a balanced forest regeneration power would be seen in the horizontal structure of the stand forming an inverted J-curve pattern.

The vertical structure of the stand is made up of 3 height classes, as shown in Figure 3b. Based on the high-class category, the Gayo coffee agroforestry system is included in strata C and D. Strata C is a tree canopy layer with a height of 4 - 20 m, while stratum D is a tree canopy layer with a height of 1 - 4 m (Septiawan et al. 2017). The type of plant that dominates in stratum D is Gayo coffee as the primary commodity, while *lamtoro* plants dominate stratum C as a shelter for Gayo coffee. Besides reducing the intensity of sunlight and maintaining temperature, *lamtoro* functions as a source of organic matter (Dahang and Munthe 2020). According to Bachtiar and Ura (2017), *lamtoro* provides versatile benefits, including fodder, intercrops, and wind barriers. Therefore, *lamtoro* is suitable for the Gayo coffee agroforestry system in Mude Nosar Village with windy and sloping area conditions.




(a) (b)

Figure 3 Tree stand structure of Gayo coffee-based agroforestry system, a) tree density at each growth stage, b) number of individuals per hectare (ha) in each height class

**Gayo Coffee-based Agroforestry System in Mude Nosar Village**

Management of agroforestry systems has different characteristics in each country. Honnay et al. (2019) mention that one example of agroforestry management is in Ethiopia with the Arabica coffee agroforestry system. Control of agroforestry systems in Ethiopia includes pruning, removal of epiphytes growing on stems

and branches, replacement of old or dead shrubs with locally grown coffee seedlings, and cutting of understorey seedlings and weeds once or twice per year. This is also done in managing the Gayo coffee agroforestry system in Central Aceh. The management of the Gayo coffee agroforestry system is carried out starting from land preparation, planting, maintenance, and harvesting. Management in Mude Nosar Village has been carried out organically according to market demand, starting from land preparation to the Gayo coffee harvesting process. The main types grown are Gayo coffee, *lamtoro*, and avocado. Other species are oranges, vegetables, and bananas produced at several research sites. *Lamtoro* and avocado are shade trees for Gayo coffee with different management systems. The main differences in species management in spacing, pruning, weeding, soil cultivation, and fertilization can be seen in Table 4.

Table 4 Management of the main tree species in the Gayo coffee agroforestry system

| Agroforestry management | | | | | | |
|---|---|---|---|---|---|---|
| **No** | **Main plantation species** | **Planting distance (m)** | **Pruning (times/year)** | **Loosening soil and weeding (times/year)** | **Fertilisation (times/year)** | **Pest and disease control** |
| 1 | Gayo coffee | 2.5 - 3 | 1 - 2 | 2 - 3 | 2 | Pruning the branches and burning; |
| 2 | *Lamtoro* | 6 - 8 | Optional | 2 - 3 | No fertilization | Dead plants buried; Spraying |
| 3 | Avocado | 10 | Optional | 2 | 1 | |

***Land preparation***

The coffee land managed by farmers in Mude Nosar Village comes from inheritance, purchased by themselves, and ground for profit sharing. One coffee plantation area usually covers an area of 0.5 to 2 ha (Table 1), and based on the questionnaire results, farmers typically have two or more different coffee growing locations. The land preparation technique carried out by the Gayo community usually begins with clearing weeds, planting holes, and filling them with organic fertilizer. In addition, weeds that have been cut down are typically buried in the soil as bio pores holes or *rorak*. Bio pore hole (*rorak*) has a function other than fertilizing the ground because it produces compost. Bio pore holes can also be water absorption holes to prevent landslides due to rain (Dianty et al. 2022).

***Planting***

The next stage after land preparation is planting. The coffee types usually grown in Mude Nosar Village are arabica coffee. Coffee plantations covering an area of 0,5 ha are usually planted with 600 - 700 coffee. Coffee farmers in Mude Nosar Village obtain coffee seeds from natural regeneration under the coffee plant. The criteria for selecting natural regeneration seeds are the condition of all healthy plant parts. There are no defects or damage due to pests and diseases, especially on the leaves, stems, and roots. Quality coffee plant seeds are produced from old parent trees, high-yielding, aging, and healthy seeds or seeds (Aji 2016). Selected Gayo coffee seedlings are ready to be planted at a distance of 2.5 - 3 m. Planting Gayo coffee seeds requires planting holes previously filled with compost so that the nutrients needed for Gayo coffee seeds are available in the soil. The immersion process using soil is carried out until the roots and base of the stems of the Gayo coffee seeds are buried so that the seeds can withstand the flow of water when it rains.

***Preservation***

**Soil Loosening and Weeding.** Loosening soil is usually done 2 - 3 times a year before the main harvest. Loosening soil is generally done in conjunction with weeding or cleaning weeds. Weeds directly impact plants because they compete for nutrients, water, and light. In contrast, indirect impacts will hinder accessibility, affecting the efficiency and effectiveness of fertilization, the difficulty of controlling pests and diseases, and various other jobs (Anwar et al. 2021). Weed control is usually carried out 2 - 3 times a year by coffee farmers in Mude Nosar Village using brush cutting, which is considered more accessible and environmentally friendly. Weed-cutting remnants can be used as organic fertilizers for coffee plants. Another option is to use herbicides when labor is lacking and time is short. Based on the observations in the field, the type of herbicide used by coffee farmers is a systemic herbicide. Synthetic herbicides will enter the plant tissue through the leaves and be translocated to the roots, making them very effective for controlling rhizomes and stolon weeds (weeds around coffee plantations).

**Pruning.** In Mude Nosar Village, coffee pruning activities are carried out twice a year at the same time as coffee harvesting. Khalisuddin et al. (2012) explained that this saves energy (along with harvesting) and reduces production declines because there are no remaining coffee cherries. This has become the habit of coffee farmers in Mude Nosar Village until now. Pruning shade trees is not routinely done because it depends on the condition of the canopy cover. Shade pruning is done when the canopy cover begins to close so that the light intensity enters a little.

**Fertilization.** Fertilization is usually done twice a year. Fertilization is done by immersing fertilizer in the middle of the coffee plant at a distance of 0.5 meters from the coffee stem. Another method is to place the fertilizer directly on the ground at the same distance from the coffee stem. The fertilizers commonly used by coffee farmers in Mude Nosar Village are organic in manure (cows and goats) and compost derived from coffee husks, litter, and weeds from cutting weeds. Coffee husk waste can be used as a natural fertilizer for the coffee plant itself because the coffee husk contains organic matter and nutrients (Falahuddin et al. 2016). Kadir and Kanro (2006) explained that organic fertilizers not only help improve the soil's physical, chemical, and biological properties but also increase the availability of nutrients to increase the growth and productivity of coffee plants. Gayo coffee is famous for using organic fertilizers or without chemicals, so it has a distinctive aroma and taste from other coffees.

**Pest and Disease Control.** Pest and disease control is a significant activity to increase productivity and maintain the quality of Gayo. Based on field observations, the pests that usually attack coffee are fruit borers, span caterpillars, needle worms, kipat caterpillars, and jumping lice. Diseases that often attack Gayo coffee are leaf spots, fruit rust, root fungus, and shoot death. Thoriq et al. (2019); Harni et al. (2015) explained that the diseases that often attack coffee plants are diseases caused by fungi (diseases caused by nematodes, leaf rust, shoot death, leaf spot, and root fungus), while the pests that often attack coffee plants are green aphid, red stem borer, coffee berry borer, branch borer, and twig borer.

According to Erfan et al. (2019), the coffee berry borer (*Hypothenemus hampei* Ferr.) is a significant pest on coffee plants in Indonesia. Fruit borer and rot are important pests (Hindayana et al. 2002). Pests and diseases in important groups are very detrimental because they can reduce the productivity of coffee plants (Thoriq et al. 2019). A form of pest and disease control carried out by coffee farmers Gayo in Mude Nosar Village is to be left alone, burned, and in a severe enough condition will be sprayed with pesticides. Twigs that fall off and dry up due to pests and diseases are usually pruned and then burned to avoid further spread. Pests and diseases attack many agroforestry systems in sloping areas close to settlements. Several pest species attack coffee at low altitudes (below 1,200 masl) and in the dry season. Plant resistance to pests is naturally contained in plants that resist preventing or tolerating insects (Sajimin 2006).

***Harvesting***

The harvested coffee cherries are usually dark red or reddish. Mude Nosar village has an altitude of 1,300 meters above sea level, with two harvest seasons a year. Based on information from M. Khazani (Coffee farmer, October 28, 2021, personal communication), a coffee plantation *(empus)* with an area of ha can get one ton of coffee cherries in one harvest season. The coffee is then sold to collectors in the form of logs. Harvesting coffee (*ngutip kupi)* in the Gayo community is unique because women only do it, and men are usually responsible for bringing coffee cherries from the garden to the house. It is scarce to find men picking coffee. The activity of picking coffee is very suitable for women because it is considered a conscientious, gentle, and patient figure, so in the process of picking, no coffee cherries will be left behind and wasted (Khalisuddin et al. 2012). Women will pick coffee cherries while cleaning branches that are no longer productive. The price of Gayo coffee cherries is amount Rp 12,000.00/kg, while the price of Gayo coffee with the first grind is Rp 35,000.00/kg.

The management of Gayo coffee plantations using an agroforestry system is very beneficial from the ecological, economic, and social aspects. Gayo coffee combined with *lamtoro* and avocado creates a more complex canopy strata condition to have a balanced regeneration. Combining woody plants on Gayo coffee agroforestry land in Mude Nosar Village can conserve biodiversity because it is used as a habitat for various animals, such as small mammals, birds, and insects. The presence of woody plants can also save soil and water to prevent erosion and flooding and increase water availability. Atangana et al. (2014) stated that the agroforestry system has high potential in soil and water conservation and biodiversity conservation efforts because it integrates the commonly found plants, namely local and semi-natural introduced species. The function of the *lamtoro* shade is also very beneficial in the productivity of Gayo coffee. According to M. Khazani (Gayo coffee farmer, October 28 2021, personal communication), coffee production increases along with coffee plants shaded by *lamtoro*. According to Mahyuda et al. (2018), shades can suppress weed growth, reducing plant competition for nutrients. The cultivation of Gayo coffee management using an agroforestry system in Mude Nosar Village has become a culture that needs to be preserved for the next generation as the formation of identity and life philosophy of the people of Mude Nosar Village (the majority of the Gayo Lut Tribe) coexistence with Gayo coffee remains sustainable.

## CONCLUSION

The composition of the Gayo coffee agroforestry system at all growth levels was 26 species. The highest important value index (IVI) at the understory level was buffalo grass, the seedling, pole, and tree level was *lamtoro* (*L. leucocephala*), and the sapling level was Gayo coffee. Gayo coffee is the primary commodity, and *lamtoro* is a shade *tree*. The stand structure in the Gayo coffee agroforestry system formed an inverted J curve. The crown strata in the plots were observed to be in strata D, Strata C. Species diversity (H') at all growth levels was in a low category except for understory. Gayo coffee plantation management uses an agroforestry system starting from land preparation, planting, and maintenance which includes: weeding and weeding, pruning, fertilizing, and controlling pests and diseases, and an activity that is no less important is harvesting Gayo coffee. The management of Gayo coffee using an agroforestry system impacts the ecological, economic, and social aspects.

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