The Role of Tree Crops On Nutrient Availability, And production of Coffee Agroforestry

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Abstract. The Agroforestry systems require special treatment, especially in crop selection. Penaung can be a competitor for major crops such as coffee. So research needs to be conducted to examine the role of shade trees on nutrient availability and coffee crop production in the agroforestry system. The research location is community plantation land that implements an agroforestry system in Enrekang Regency. The land is determined by a Land Use System (SPL) based on the type of shade, namely SPL 1 (shade of legumes), SPL 2 (shade of plantation), and SPL 3 (shade of fruit trees). Coffee plants are mature plants between the ages of 15-17 years. The research parameters are soil nutrient content, namely C, N, C/N, P₂O₅, and K₂O, and coffee plant production. ANOVA analyzed data. The results showed that between treatments did not significantly affect all parameters. Availability of C, N, and K₂O contents with various types of shade is obtained by a low content, while the C/N, and P₂O₅ ratios are of moderate content. The highest C, and N values in shade of fruit trees. The highest C/N ratio value in shade of Leguminosae, and fruit plants. The highest P₂O₅ and K₂O content in plantations shade. The average production of coffee plants with an agroforestry system is relatively low due to high rainfall. The highest amount of production is obtained in the shade of Leguminosae, this indicates that there is no nutrient competition in the shade of Leguminosae.

1. Introduction
Coffee is one of the plantation's leading export commodities that has an important role in contributing to foreign exchange, and as a source of income for farmers [1]. Based on 2017 Ministry of Agriculture's coffee production statistics, 2017 production (637 thousand tons) has decreased compared to 2016 production (639 thousand tons), amounting to 2000 tons. Many factors cause a decrease in production, especially land, and environmental damage has an impact on the carrying capacity of land that is declining [2]

The occurrence of conversion of agricultural land raises a problem of decreasing soil fertility [3], the damage is getting more severe with the application of conventional cultivation to coffee plantations due to a decrease in soil organic matter content [4]. The use of external inputs results in dependence on synthetic compounds, so efforts need to be made to reduce external inputs, and preserve the environment. The use of local resources to implement alternative agricultural practices, and suppress external inputs with the aim of increasing production, is needed in increasing coffee production and maintaining the environment.

Existing (local) resource management aims to maintain, and enhance livelihoods for coffee farmers in the tropics [5], such as Indonesia. One of the developing systems to maintain the coffee cultivation...
environment is the agroforestry system. Agroforestry can be a practical solution to save the environment, and provide benefits as a source of community livelihood [6].

Agroforestry systems play a role in creating multispecies agroecosystems, the introduction of shade trees influences coffee adaptation to shade [7]. Costa Rica provides a good example in the implementation of agroforestry systems as an ecological, and socio-economic context, thus giving birth to management designs that can increase farmers' sources of income, and minimize environmental damage [5].

Integrating tree crops with coffee plants in agroforestry systems can increase the sustainability of coffee, both economically, and ecologically [6]. The existence of multispecies interactions in agroforestry is a key factor, whether there is competition or facilitation between plants. Mixed cropping systems allow for environmental changes in a separate way [4].

One area known for its coffee yield potential is Kabupaten Enrekang. Generally, farmers in Enrekang District have implemented agroforestry systems. The management of existing agroforestry systems in Enrekang District tends to apply based on hereditary experiences, namely agrisilviculture [7]. The use of shade is grouped into three, namely (1) shade of fruit trees, (2) shade of timber trees, and (3) ordinary shade classified as Leguminosae [8, 9].

Pattern systems in agroforestry require special treatment, especially in crop selection. Integration of components from forestry, and agriculture as complex constituents [10] characterizes adaptations between plants, especially coffee. The results of several studies found that there were negative effects resulting from shade due to improper management resulting in interference between competition between plants [11,5]. The use of shade makes it possible to become a competitor, which affects the production capacity of major crops such as coffee. Therefore, this study aims to examine the role of shade trees on nutrient availability, and coffee crop production in the agroforestry system in Enrekang District.

2. Material and Method
Determination of the study site using community coffee plantations that applied agroforestry systems in two sub-districts in Enrekang District, namely Masalle District, and Baroko District. Based on preliminary research, the Land Use System (SPL) is determined based on the type of shade used which is dominantly used by farmers, consisting of SPL 1 with shade plants of legumes (lamtoro, dadap, and gamal), SPL 2 under the shade of other plantation species (cloves, and cacao), and SPL 3 with shade plants of fruit (jackfruit, banana, durian, and avocado). Coffee plants each SPL are plants that have produced with the age of plants between 15-17 years.

This study uses two approaches to obtaining data. First, data from the results of soil analysis are taken from each SPL. The soil was analyzed to find out the nutrient content available based on SPL with the use of various shelters. Soil samples taken by Sisak consisted of 15 sample points of each SPL which were then compiled, and analyzed by the laboratory. The results of the subsequent analysis were compared with the criteria for assessing soil chemical properties based on the approach taken by [12] using a comparison table (Table 1).

Table 1. Criteria for assessing soil chemical properties

| properties          | Very Low | Low     | Medium | High    | Sangh High |
|---------------------|----------|---------|--------|---------|------------|
| Organic C (%) *     | <1.00    | 1.00 - 2.00 | 2.01 - 3.00 | 3.01 - 5.00 | > 5.00     |
| N (%) *             | <0.10    | 0.10 - 0.20 | 0.21 - 0.50 | 0.51 - 0.75 | > 0.75     |
| C/N *               | <5.0     | 5.0 - 7.9 | 8.0 - 12.0 | 12.1 - 17.0 | > 17       |
| P<sub>2</sub>O<sub>5</sub> (me / 100gr) ** | <10 | 10 - 20 | 21 - 40 | 41 - 60 | > 60 |
| K<sub>2</sub>O (me / 100gr) * * | <10 | 10 - 20 | 21 - 40 | 41 - 60 | > 60 |

Source: [13].
Second, to find out the production based on the use of shade-based SPL, production data is primary data obtained through in-depth direct interviews with farmers. Respondents used were farmers from each sample based on the SPL used. Coffee production is the product obtained now, and the previous year using trend analysis based on [14]. To determine the relationship between the use of shade, and nutrient availability, and production of coffee plants, it was analyzed using ANOVA.

3. Results and discussion

3.1. Nutrient content

The results of the laboratory analysis of nutrient content in various systems of land use based on shade used can be seen in Table 2. The content of the percentage of availability of Carbon, Nitrogen, and K$_2$O were all low, while the C/N, and P$_2$O$_5$ ratios were moderate.

| SPL            | C   | N     | C/N | P$_2$O$_5$ | K$_2$O |
|----------------|-----|-------|-----|------------|--------|
| Leguminosae    | 1.65| 0.17  | 10.00 | 24.10  | 16.79  |
| Plantation Plants | 1.85| 0.19  | 9.50  | 25.29  | 17.50  |
| Fruit Plant    | 1.98| 0.20  | 10.00 | 16.25  | 12.09  |
| Average        | 1.82| 0.18  | 9.83  | 21.88  | 15.46  |

Description: ■ highest

Based on the results of soil chemical analysis obtained if the use of shade is not significant for soil nutrient availability of coffee agroforestry systems, but the highest C and N content is seen in the use of fruit shade. Leguminosae plants are not able to contribute high C, and N as a source of organic material, although Leguminosae is plants that can affect symbiosis with rhizobium in producing nitrogen. It is suspected that the availability of organic material from the shade of Leguminosae returned to the soil is less, because farmers tend to make leaves, and stalks of legume plants as animal feed. Leguminosae plants have the potential to be used as animal feed because they contain good nutrition [15].

Fruit plants and plantation crops contribute C, and N which are quite high. The high content of C and N in the shade of fruits is supplied from the results of litter biomass that fall to the ground. Nutrients released by plants depend on the type of plant, part of the plant, and the volume of biomass aborbed [16,12]. The number and age of shade plants greatly influence the occurrence of seizures between plants [12]. Generally, the spacing of fruit trees has a wider spacing so that the population is less than the other shade. The C/N ratio is obtained by the same value in the leguminous, and fruit shade. The availability of sufficient organic material in fruit shade has a positive effect. According to [17], the C/N ratio of land ranges from 10-12 to be used by plants. The size of the C/N ratio indicates the amount of N which decomposes less [18]. Important factors for the level of weathering of organic matter are the concentrations of C, and N, the C/N ratio, and the mass of organic matter [19].

The highest P$_2$O$_5$, and K$_2$O content, was obtained from the use of plantations shade. This shows that plantation crops can contribute to the increase of nutrient elements P, and K. Plantation crops such as clove plants generally have an older plant life of almost 20 years. Other research results show that plantation trees have a good influence on the content of P$_2$O$_5$, and K$_2$O, especially at a depth of the soil surface 0-5 cm [20,21]. Plants with a lower age have a smaller contribution to total biomass than older ones [21].
3.2. Production Average

![Production Average Chart](chart.png)

Figure 1. Average coffee crop production based on the use of shade in agroforestry systems.

Production results are not significant for the average value of each use of shade types. But the use of Leguminosae shade trees provides the highest production compared to other types of shade (Figure 1). The low production average is more likely to be influenced by climate, the high rainfall for 2 years causes a decrease in production in coffee plants at the study site. Coffee plants need a dry month period of 3 months for flower primordia formation, floretation, and pollination [22]. A long rainy season can reduce coffee production to 80% [23].

Although the C and N content is low the C/N ratio is high in the shade of Leguminosae, so the availability of nutrients in the soil can be utilized properly by coffee plants. This shows that there is no competition in absorbing nutrients between the shade of leguminous, and coffee plants. The availability of P₂O₅, and K₂O content which is high enough to use Leguminosae shade can increase production. Macronutrients such as P and K are needed for coffee plants for the development of roots, enzymatic suppression, and protein formation [24]. The use of legume shade tends to produce greater results than other shade [25] while the low N content does not affect the production of coffee plants.

4. Conclusion

Availability of C, N, and K₂O contents with shade types is low, while the C/N, and P₂O₅ ratios are of moderate content. The highest C, and N values in shade of fruit trees. The highest C/N ratio value in shade of Leguminosae, and fruit plants. The highest is P₂O₅, and K₂O in shade plantations.

The average production of coffee plants with an agroforestry system is relatively low due to high rainfall. The highest amount of production is obtained in the shade of Leguminosae, this indicates that there is no nutrient competition in the shade of Leguminosae.

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