Vegetable and food crop production with micro climate modification

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Abstract. Vegetable and food crops generally require optimum light intensity so that most of these plants are cultivated monoculture. This research has tried to produce food and vegetable crops in the planting system with a perennial crop. This might be a solution to land limitations, and opportunity modification for the cultivation of food crops and vegetables in sites that tend to be shaded and less light intensity. This research was carried out in Nokilalaki Subdistrict which is directly bordered with the conservation area, i.e. Lore Lindu National Park. The study was designed in factorial design method of randomized block design, that consists of two factors, such as food crop species (tomatoes, chilies, sweet potatoes, taro) and pruning degrees of perennial crops (low pruning /25% of light intensity, moderate pruning/50% of light intensity, and heavy pruning/75% of light intensity. The results showed that the highest crop production was provided on sweet potatoes yield of 18.5 tons ha$^{-1}$ at 50% of light intensity, but was not significant different in 75% of light intensity (17.1 tons ha$^{-1}$). Tomato and taro yield was not significantly different between all light intensity. So tomatoes and taro might be introduced into a variety of microclimate conditions.

1. Introduction
The most basic needs for humans are food, either carbohydrate (rice, corn, tubers) and fibre (vegetables, fruit). The availability of food in sufficient quantity and quality is needed in achieving food security which is influenced by the availability and distribution of food that is affordable in terms of price and safe for consumption by the community to meet energy needs in daily activities [1]. Maintain stability, availability and resilience of food, the government launch several superior programs, including agricultural intensification and extensification.

One of the agricultural technologies which have opportunity to be developed and have not been paid much attention by various stakeholders, including the main actors in agricultural sector and other stakeholders, namely multiple cropping by introducing food and vegetable crops in the annual cropping system. Borchers states that the agriculture intensification technology through multiple cropping of two species of crops (soybean and wheat) might increases production to meet the global demand and contributes to an increase in production 2% of total agricultural land production in the United States [2]. Various agricultural products are obtained through multiple cropping. The ratio of land equality, the total relative yields and the ratio of income equality could be increased, as result of the agricultural production, livelihoods and income increases. This implies the importance of multiple cropping for small scale farmer, which is the majority in developing countries [3].
Multiple cropping technology might combine the program of intensification and diversification, it might be expected to become an alternative solution in the potential land scarcity for crop production and increase in the productivity of limited land through the effectiveness and efficiency of the land resources and the use of growth and production factors.

Indrawan said that climate is one of the factors affect the growth and production of plants [4]. The climatic factors which significantly affect the growth of the plant are the solar radiation, temperature, and rainfall.

Energy of solar radiation that enters the ecosystem is only small partially absorbed by autotrophic organisms and converted into chemical energy [5]. Whereas the autotrophic organisms only utilize 50% of the radiation received to achieve the 1% of net primary productivity [6].

The utilization efficiency of the solar radiation and the optimalisation of the climate condition by agricultural commodities might be improved by modifying the micro climate through a physical action, such as branch pruning of the annual tree crops to provide space for the food and vegetable production. Therefore, this research intends to improve the production of vegetable and food crops through the modification of micro climate as a manifestation of the efficiency and effectiveness of the utilization of growth factors in order to increase the crop production and land productivity.

2. Research Methode
This research was carried out on the cacao based land in Nokilalaki District, Sigi District, which was directly bordered with the Lore Lindu National Park, in April-November 2018. Data collection was carried out by using a 1m x 1m tile plot which was repeated 3 (three) times to accommodate the cultivated commodities.

Data collected were designed and analyzed using a factorial randomized block design that consis of two factors: firstly, food crop species (chili, tomatoes, sweet potato, taro) and pruning level of annual tree crops: (light pruning/25% of light intensity, moderate pruning/50% of light intensity, and heavy pruning/75% of light intensity). The effect of crop species variation and pruning level would be tested using the Honestly Significant Difference Test [7, 8].

3. Result and Discussion
Crop production is affected by genetic factors and hormones and crop response to the environment. The yield of crops could be ecologically shown from the total biomass produced, and economically, the crop production is measured by fruits or seeds that could be consumed by humans.

Every crop species requires different environmental conditions, including light intensity, temperature, rainfall and nutrients in their growth process. In general, food and vegetable crops requires an optimum light intensity, therefore they are cultivated on monoculture. By the way, the presence of shade trees would affect the crop production.

The results shows that the production of vegetables (chilli and tomatoes) on land-based cocoa with a 75% light intensity/hard pruning tend to have a higher production, while the food crops (sweet potato and taro) production are higher in the 50% light intensity/moderate pruning. The results might be clearly shows in figure 1.
Figure 1 shows that the yields of sweet potato introduced into the cocoa-based land with gradual pruning having a higher yields than other crop species. This might be caused by the value of production is based on the weight that is logically of course the tubers of sweet potato heavier than the other crop species. However, the highest number of fruits/individual is provided on chillies, in which the yields is estimated to be 0.12 kg or about 50-70 fruits in one harvest. While the weight of sweet potato tubers about 0.3-0.5 kg/tuber, so that it is very reasonable if the tuber weight is heavy resulting in a higher production. In addition, the crop production usually is controlled by environmental factors. Light intensity is one of the most important environmental factors that affect the crop growth and development. The main function of light on crop growth is to drive the photosynthesis process in the carbohydrates formation.

Sunlight in the electromagnetic waves form is converted by plants through the process of photosynthesis and other various physiologies to be chemical energetic in the carbohydrate form. A part of chemical energy is reduced into a kinetic and thermal energy through respiration. Whereas the other parts are transformed into some kinds of organic compounds through several metabolic processes.

Sudomo concluded that tuber crops generally have a good ability to grow when they are under shading. The results of the research show that sweet potato and taro have a highest production in the moderate pruning/50% of light intensity. Niu said that growth of plants increases with light intensity, however, plants is less efficient in using light by decreasing or increasing intensity [10]. This may be seen in figure 1, as a result that the production of tomato and chillies decrease along decreasing light intensity.

The decrease in the production of plant due to the effect of less of light intensity caused by the shaded condition, the plant is not getting enough light in photosynthesis process. Consequently, it causes a decrease in the amount of photosynthetic supply to the plant's generative organs [11].

Pruning is done to reduce the shade effect on the crop below. Prunin of Cacao branch is aimed at providing growth space and increasing the effectiveness of light use of variety of food and vegetable crop species. The results of statistical tests show that there is a significant interaction effect between pruning level and the variations of food and vegetable crop species production.

The chili and tomato have a high production in heavy pruning systems, while sweet potato and taro in the moderate pruning systems. This could be seen in the Honestly Significant Difference Test results presented in table 1.
Table 1. The average of food and vegetable crop yields in different pruning levels

| Cultivation system | Crop Species | SHD 5%  |
|--------------------|--------------|---------|
|                    | Chili | Tomato | Sweet potato | Taro |
| Heavy pruning      | 5.7bp | 10.1aq | 17.1abr | 4.4ap |
| Moderate pruning   | 3.9abp | 9.2aq | 18.5br | 6.2ap | 2.43 |
| Light pruning      | 2.7ap | 8.5ar | 16as | 5.9aq |
| SHD 5%             | 2.43  |
| VC (%)             | 9.05  |

Table 1 shows that vegetable and food crops grown on land-based cocoa with various pruning systems produce different yields. The highest crop yields is sweet potato which was introduced to the land based cocoa, which is moderately pruning, even not significantly different with the heavy pruning system, such as chili. Tomato and taro yields is not significant differences on all pruning levels. This indicates that vegetable and food crops, especially tomatoes and taro, could be adapted to a variety of micro-conditions.

Microclimate of plant is the condition at around plant, from the depth root zone to he highest upper canopy [4]. In micro-climate, climate parameters are viewed as a process in the atmosphere around the plant and are a phenomenon that can result from combination plant in multiple cropping. Modification of microclimate is an attempt to change or control the elements of climate in micro scale, the climate is appropriate in conditions suitable for the growth of plants. In fact, all modification of climate-based products can be done with the approach of changing the heat budget or its components [12].

Modification of microclimate through pruning of cocoa trees means that vegetables and food crops can obtain an optimal weather and growing environment. Optimal production for food crops (sweet potato, taro) is achieved at a moderate pruning/50% light intensity. While vegetables (chilli, tomato) production is optimally achieved on a 75% light intensity/light pruning system. Tomatoes included as a C3 plant that was quickly exposed to light. Thus, optimum tomato growth and yield at a shade of 30% or 70% illumination. In addition, growing vegetable and food crops under cocoa with 3 m x 3 m of planting distance is intended for resource efficiency and increased productivity.

4. Conclusion
The highest vegetable and food crop production was provided on sweet potato yields of 18.5 tons ha\(^{-1}\) which was planted at 50% of light intensity/moderate pruning system, but was not significant different in 75% of light intensity (17.1 tons ha\(^{-1}\)), as well as chili yields. Tomato and taro yields was not significant different between all light intensity. Therefore it might be concluded that tomatoes and taro might be planted into a variety of microenvironmental conditions, starting from less to high light intensity.

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