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GROWTH AND PRODUCTION OF TEA PLANT (*Camellia sinensis (L.) O Kuntze*) AFTER PRUNING WITH BIO-ORGANOMINERAL AMELIORANT

PENGUJIAN AMELIORAN BIO-ORGANOMINERAL TERHADAP PERTUMBUHAN DAN PRODUKSI TANAMAN TEH (Camellia sinensis (L.) O Kuntze) SETELAH PANGKAS

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ABSTRACT

Tea plant (*Camellia sinensis (L.) O Kuntze*) is one of the important plantation commodities that has long been cultivated in Indonesia. Mineral based ameliorant fertilization is one of the important factors to produce high productivity and maintenance of healthy plants. Ameliorant bio-organomineral (BIOM) is a fertilizer that utilizes mineral resources, potential microbes, and organic matter. This study aimed to determine the effect of BIOM's ameliorant on plant health and tea productivity after pruning. The Randomized Block Design (RBD) was accomplished by 8 treatments and three replications (100% conventional fertilizer, 100% BIOM, 80% single fertilizer + 100% BIOM, 80% conventional fertilizer + 80% BIOM, 80% conventional fertilizer + 60% BIOM, 60% conventional fertilizer + 100% BIOM, 60% conventional fertilizer + 80% BIOM, and 60% conventional fertilizer + 60% BIOM). The results showed that there was a significant effect of the combination of conventional fertilizer and BIOM ameliorant on shoot production and pekoe percentage, but not significantly different in tipping production, pekoe shoot ratio and banji shoots. The combination of 60% conventional fertilizer and 60% BIOM showed the highest total production of 31.81 kg/plot. Shoot production in the BIOM treatment was 17.36% higher than that of the conventional fertilizer application. The application of BIOM ameliorant was able to improve the plant health after pruning on the GMB 7 clone.

Keywords: bio-organomineral, plant health, shoot production, tea plant, West Java

ABSTRAK

Tanaman teh (Camellia sinensis (L.) O Kuntze) adalah salah satu komoditas perkebunan yang telah lama diusahakan di Indonesia yang memiliki peranan cukup penting. Pemupukan amelioran berbahan dasar mineral merupakan salah satu faktor penting untuk menghasilkan produktivitas dan pemeliharaan yang tinggi tanaman sehat. Amelioran bio-organomineral (BIOM) adalah pupuk yang memanfaatkan sumber daya mineral, mikroba potensial, dan bahan organik. Penelitian ini bertujuan untuk menguji pengaruh amelioran BIOM untuk kesehatan tanaman dan produktivitas tanaman teh setelah pangkas. Metode penelitian menggunakan Rancangan Acak Kelompok (RAK) yang terdiri dari 8 perlakuan dan diulang 3 kali, yaitu:100% pupuk tunggal, 100% BIOM, 80% pupuk tunggal + 100% BIOM, 80% pupuk tunggal + 80% BIOM, 80% pupuk tunggal + 60% BIOM, 60% pupuk tunggal + 100% BIOM, 60% pupuk tunggal + 80% BIOM, dan 60% pupuk tunggal + 60% BIOM. Hasil penelitian menunjukkan bahwa terdapat pengaruh nyata pada kombinasi pupuk tunggal dan amelioran BIOM terhadap produksi pucuk dan persentase peko, namun tidak berbeda nyata pada produksi teh setelah pangkas, rasio pucuk peko dan pucuk

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burung. Kombinasi 60% pupuk tunggal dan 60% BIOM menunjukkan total produksi tertinggi sebesar 31,81 kg/plot. Produksi pucuk pada perlakuan BIOM lebih tinggi 17,36% dibandingkan aplikasi pupuk tunggal. Pemberian pupuk BIOM mampu meningkatkan kesehatan tanaman setelah pangkas pada petikan medium klon GMB 7.

Kata kunci: bio-organomineral, kesehatan tanaman, produksi pucuk, tanaman teh, Jawa Barat

INTRODUCTION

Degradation of soil fertility that occurs in plantations is a limiting factor in increasing productivity. Efforts to increase the carrying capacity of the land is by fertilizing. The use of chemical fertilizers in the field is often constrained by the scarcity and high price of fertilizers. In addition, chemical fertilizers have a low level of efficiency. The use of fertilizer materials derived from mineral rocks that are widely available in certain areas in Indonesia has the potential to substitute for the use of inorganic fertilizers on the market (Sudirja *et al.*, 2018). Mineral fertilizers could improve of plant growth and development so able to increase production higher both quantity and quality of plants (Constantin *et al.*, 2020).

Indonesia has abundant natural resources including mineral, potential microbes, and organic matter. Research and Development Center for Mineral and Coal Technology (*tek*MIRA) is one of the competent institutions in the field of mineral and coal research. Several minerals have potential for agriculture as a nutrient source needed by plants such as cassiterite, pyrolusite, psilomelan, braunite, manganit, feldspar, and zircon (Pranoto, Saleh and Wulansari, 2018). Bio-organomineral ameliorant (BIOM) is an ameliorant that combines mineral, organic and beneficial microorganisms-produced by *tek*MIRA and the Tea and Cinchona Research Center. Organomineral fertilizers are composed either of mixture or combination of organic and mineral fertilizers (Ayeni, 2008; Widodo, Saidi and Mulyanto, 2018; Toprak, 2019).

Organic compounds and mineral nutrients are blended to produce the organomineral fertilizers (Sá *et al.*, 2017). Compared to organic fertilizers and chemical fertilizers, the organomineral fertilizers improve better the soil physical characteristics and fertility (Olaniyi *et al.*, 2010). The mineral elements of the organomineral are potassium (K), magnesium (Mg), and phosphate (P) taken from Indonesia. While the organic comes from the animal waste and the biological content of the indigenous microbes from tea plantations was included. Mineral and organic raw materials were prepared beforehand so that the expected particle size was obtained, while microorganisms were cultured (Qiu *et al.*, 2014).

Bio-organomineral ameliorant produced by *tek*MIRA has been added in tea, rice, and corn cultivation with satisfactory results in terms of growth and production. In addition. Based on Pranoto, Saleh and Wulansari (2018) the BIOM application produced the optimal productivity of tea clone GMB 7 on three years after pruning around 93.92% and had highest production in the rainy season and the highest pekoe weight indicate the healthy of tea plant. It was reported also that the organomineral fertilizer treatments significantly increased the plant growth and development, thus the yields in tomatoes as compared to mineral fertilizers applied at the same quantities (Ayeni and Ezeh, 2017).

The presence of microorganisms in BIOM ameliorant supports the decomposition of organic matter that produces the organic acids, thereby accelerating the process of dissolving agrominerals (Widodo, Saidi and Mulyanto, 2018). Microbes play an important role in the decomposition and mineralization of organic matter and solubilizing agrominerals fertilizer with the low solubility. The phosphate solubilizing microbes in spill enable to provide available phosphorus from the phosphate rock (Sudadi, Widijanto and Putri, 2013).

According to Omueti *et al.* (2000), organomineral fertilizers increase soil nutrient contents. Slow rate of release of organomineral nutrients from organic matter allow continuous and better plant growth and development (Ipinmoroti and Adeoye, 2002). It was reported that mineral fertilizers improved phosphorus uptake efficiency with the aid of organic fertilizers and soil stabilizers (Alam *et al.*, 2007; Makinde, Ayeni and Ojeniyi, 2011).

Today, studies about organomineral fertilizers are quite limited. Therefore, further research is recommended to be conducted with different plant species and different fertilizer combinations. One of the BIOM ameliorant application was on the tea plants after pruning. The success of pruning depends on the availability of nutrient in the form of carbohydrates stored in the roots (Haq, Mastur and Karyudi, 2016). BIOM ameliorant is expected to provide substrates with sufficient plant nutrient content and release according to plant needs so that fertilization efficiency increases. This study aims to determine the effect of BIOM ameliorant on the productivity of tea plant after pruning.

METHOD

The experiment was carried out at the Gambung Experimental Field, Research Institute for Tea and Chincona (RITC), using tea clones of GMB 7 that had one year old pruning age (TP-1) from February to August 2021. The altitude of the experimental site was 1,250 meters above sea level. Tea was grown in soil order of Andisol with a pH of 4.5 – 5.6. The research location has an average precipitation of 179 mm/month and a number of rainy days of 14,7 days (BPS-Kabupaten Bandung, 2020).

The experiment was set up in a Completely Randomized Block Design consisting of 8 treatments of application of Bio-organomineral (BIOM) ameliorant with reduced N, P, K fertilizers (conventional fertilizer). Three repetitions of each treatment were carried out to obtain 24 experimental plots with an area of 60 m^2 each. The treatment combinations are presented as:

- A0 = 100% Conventional Fertilizer (CF)
- A1 = 100% Bio-organomineral (BIOM)
- A2 = 80% Conventional Fertilizer + 100 % Bio-organomineral
- A3 = 80% Conventional Fertilizer + 80 % Bio-organomineral
- A4 = 80% Conventional Fertilizer + 60 % Bio-organomineral
- A5 = 60% Conventional Fertilizer + 100 % Bio-organomineral
- A6 = 60% Conventional Fertilizer + 80 % Bio-organomineral
- A7 = 60% Conventional Fertilizer + 60 % Bio-organomineral

Based on the results of laboratory analysis, BIOM *tek*MIRA ameliorant contains 10% P_2O_5; 23.6%; 6.0% MgO; 6.3% S; 79 ppm B; 83 ppm Zn; 76 ppm Cu; and 72 ppm Mn. (Purnomo, Wahyudi and Agung, 2010).

The dosage of conventional fertilizer was based on the RITC recommendation in Block A8 Experimental Field. The fertilizer composition was 293 N kg/ha/year, 75 P kg/ha/year, 148 K kg/ha/year and 74 Mg kg/ha/year. Bio-organomineral (BIOM) ameliorant dosages were 60% (5.4 kg/plot), 80% (7.2%) and 100% (9 kg/plot). The BIOM ameliorant consists of N-fixing *Azotobacter sp.* ($1.3x10^6$ cfu/ml), endophytic bacteria ($1.5x10^8$ cfu/ml), an average of P solubilizing bacteria ($7.5x10^7$ cfu/ml), several minerals such as rock phosphate and dolomite, and organic materials.

Fertilizer application was carried out two times during the research in the field. The plucking was carried out for the production of tipping and 4 times for shoot production. The experiment parameters are as follows:

1. Production of tipping per plot (Kg Plot-1).
   The plucking of tipping was conducted 3 months after pruning. Plucking interval 25-30 days. The production is weighed and recorded for each observation (kg/plot).
2. Shoot production per plot (Kg Plot-1).
   The shoots were medium plucked, namely pekoe + 3 leaves (p+3) or banji shoots + 3 leaves (b+3), then weighed and recorded according to each treatment.
3. Plucking analysis per plot
   The shoot sampling procedure for analysis was done by the sampling of 100 g plucked shoot with the medium plucking method in each plot. The separated shoots were then counted between the number of pekoe shoots and banji shoots. The ratio of the number of pekoe shoots and the number of banji shoots is calculated by the following formula:

$$\text{Pekoe/Banji} = \frac{\text{Number of pekoe shoot}}{\text{Number of banji shoot}}$$

Data Analysis

Data analysis was performed with the support of SPSS ver. 26 software. The data were statistically analyzed using the Analysis of Variance (ANOVA) test at a 95% confidence level, if there was a significant difference, then followed by the Duncan Multiple Range

Test significant difference test with a 95% confidence level.

RESULTS AND DISCUSSION

Production of Tipping (kg/plot)

The plucking of tipping that begins after pruning until the production plucking stage. The plucking of tipping was carried out when the maintenance leaves the thickness of 15-20 cm, in this study the plucking of tipping started 3 months after pruning, starting from March to May 2021 with the plucking interval of 25 days, so there were three plucking times were done.

Based on the results of Anova, tipping production of all treatments was not different in any plucking time (Table 1). This condition is caused by the plucking stage; the shoot growth is not uniform and is still in the formation of the picking field until the production shoot stage. Usually, the plucking of tipping can be conducted as much as 6-10 times. The type of plucking carried out on tipping was medium plucking, namely pekoe with two leaves (p+2) or banji shoots with one/two young leaves (b+1m/b+2m) (Pusat Penelitian Teh dan Kina, 2006).

The shoot growth rate (SGR) is the accumulation of dry weight per unit time (Gardner, Pearce and Mitchell, 2010). The development of shoot growth rate at the beginning of plant growth after pruning is still quite low. This is because the plant is still in the recovery stage after pruning. Photosynthetic activity is low and the photosynthate is low as well, so that the resulting shoot production is not optimal (Anjarsari *et al.*, 2021). In addition to fertilizer application, there are other factors that influence the growth value of these shoots, including weather factors. Decreased plant growth can be caused by a decrease in the length of the growth period, low temperatures, a limited supply of water, oxygen, and nutrients to the root system from the soil, and limited root system activity. The period of plant growth is directly influenced by climatic conditions such as changes in daily maximum and minimum temperatures and rainfall levels (Koca and Erekul, 2016) (Figure 1).

Table 1. Effect of Bio-organomineral ameliorant for tipping production (kg/plot)

Treatment	Tipping Production (kg/plot)		
	1	2	3
100% Conventional Fertilizer (CF)	3.85 a	0.65 a	4.33 a
100% Bio-Organomineral (BIOM)	4.53 a	0.69 a	2.97 a
80% CF + 100 % BIOM	5.10 a	0.70 a	5.60 a
80% CF + 80 % BIOM	4.17 a	0.69 a	5.47 a
80% CF + 60 % BIOM	4.53 a	0.73 a	3.51 a
60% CF + 100 % BIOM	4.57 a	0.75 a	5.44 a
60% CF + 80 % BIOM	4.54 a	0.81 a	3.98 a
60% CF + 60 % BIOM	5.97 a	1.05 a	4.27 a

Note: Numbers followed by the same letter in the same row and column indicate that the treatment is not significantly different based on Duncan's multiple-distance test with a significance level of 0.05%.

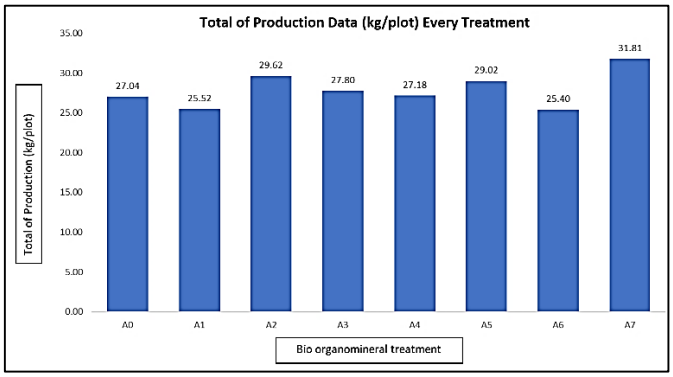

Figure 1. Total of tipping production of tea after bio-organomineral treatment

Shoot Production (kg/plot)

Based on the results of statistical tests (Table 2), it shows that there were significant differences between the 3rd and 4th of shoot plucking on all parameters, but the first and second plucks have not shown significant differences between treatments. This may occur since the first and second harvests were a transitional period after the tipping and began to increase in the 3rd and 4th. The highest shoot production in the 4th plucking was at a dose of 60% conventional fertilizer + 60% BIOM of 6.81 kg/plot with an average shoot production of 5.43 kg/plot. Figure 1 also shows the total production in the BIOM treatment (A7) at a dose of 60% conventional fertilizer + 60% BIOM had the highest total production of 31.81 kg/plot and followed by treatment (A2) 80% conventional fertilizer + 100% BIOM of 29,62 kg/plot.

The combination of 60% conventional fertilizer treatment and 60% BIOM gave positive results on a significant increase in shoot production. This is supposed to be the result of BIOM ameliorant application to increase the levels of nutrients in the soil, so increasing the ability of plants to absorb the nutrients and affecting the shoot production. The results of BIOM ameliorant content analysis showed that the available element content was relatively high. In general, the pH of the fertilizer is in the neutral range with the organic C content in the fertilizer still quite high. However, the N content in fertilizers is still very low. The P content in BIOM is very high due to the addition of phosphate rock minerals as the enrichment material. The results of the analysis of the K content available in fertilizers are quite high. This is presumably due to the addition of sources of agro mineral materials that can increase the available K in fertilizers.

The application combination of NPK and BIOM ameliorant contains elements of N, P, K and mineral materials in it as an addition to plant nutrients. Nitrogen fertilizer is applied to improve the yield and quality of tea as N is required for the production of amino acids that are a key quality indicator for tea (Oh *et al.*, 2006; Qiao *et al.*, 2018; Tang *et al.*, 2020). With the availability of chlorophyll in sufficient quantities, the process of photosynthesis increases, the carbohydrates produced increase, so that it can accelerate shoot growth. Thus, it is important to develop proper N management practices to enhance the N use efficiency, reduce the N losses, and ultimately maintain the sustainability of tea plantations (Wang *et al.*, 2020).

Shoot Quality

Shoot analysis was carried out to determine plant health by observing the comparison between pekoe shoots and banji shoots in each shoot, shoots were taken randomly in each plot. The data can be calculated by the ratio of the number of pekoe shoots to banji, and the percentage of pekoe. The comparison value (ratio) of pekoe shoots with banji shoots of tea plants with normal growth is (1.5 - 2.33), meaning that in every plucking on normal tea plants there are (60-70%) the number of pekoe shoots and (40-30%) number of banji shoot.

Healthy plants are simply indicated by the ratio of the number of pekoe shoots with a minimal number of banji shoots 2.33 and chemically analyzed at the nutrient content on mother leaves. If the mother leaves nutrient levels are at the threshold, it is indicated that the tea plant is experiencing a deficiency of nutrients, which means that the plant is unhealthy.

Table 2. Shoot production for 4 times of plucking (kg/plot)

Treatment	Shoot production (kg/plot)			
	1	2	3	4
100% Conventional Fertilizer (CF)	8.70 a	7.46 a	5.03 ab	5.85 ab
100% Bio-organomineral (BIOM)	10.35 a	4.99 a	5.19 ab	4.99 ab
80% CF + 100 % BIOM	10.54 a	6.12 a	6.86 b	6.1 ab
80% CF + 80 % BIOM	10.30 a	6.82 a	5.2 ab	5.48 ab
80% CF + 60 % BIOM	12.71 a	3.75 a	6.31 ab	4.42 a
60% CF + 100 % BIOM	11.30 a	6.87 a	6.12 ab	4.74 a
60% CF + 80 % BIOM	11.40 a	4.40 a	4.59 a	5.01 ab
60% CF + 60 % BIOM	12.78 a	5.01 a	6.25 ab	6.81 b

Note: Numbers followed by the same letter in the same row and column indicate that the treatment is not significantly different based on Duncan's multiple-distance test with a significance level of 0.05%.

Based on the results of statistical tests (Table 3), it showed that no significant difference in the parameters of the number of pekoe shoots, number of banji shoots and shoot ratio at all treatments. From Table 3, it can be seen that the overall treatment was above the standard ratio in each plucking (1.5-2.33). The average plucking ratio in all treatments was 3.88, this condition indicated a good plant health, both in standard treatment and with BIOM ameliorant application (60-100% BIOM). The application of BIOM ameliorant was able to increase the growth of pekoe shoots compared to the growth of bird shoots. The growth of bird shoots dominant (40-30%) indicates the plant is experiencing stress caused by nutrients, environment and climate which causes an imbalance in the plant, so that shoot growth experiences dormancy and forms banji shoots.

The percentage of pekoe showed a significant difference at the 4th of plucking shoot production, with the highest percentage in the combination treatment of 80% single fertilizer + 80% BIOM of 73%, while the 100% single fertilizer treatment showed the lowest percentage of pekoe (Table 4). In all treatments, the number of pekoe shoots was in the normal range of 60-70%. The increase in the percentage of pekoe in all treatments was also in line with the increase in the average weight per shoot with the formation of pekoe shoots. This showed that the application of BIOM ameliorant was able to improve plant health in the GMB 7 clones.

The significant effect of conventional fertilizer treatment 80% and BIOM 80% on the percentage of pekoe was expected due to the nutrient content in both substrates being sufficient to meet the needs of tea plants after pruning. This is in line with the results of research (Ipinmoroti, Adeoye and Iremiren, 2007) that organo mineral fertilizers with the addition of manure showed superior results than conventional fertilizers in increasing N, P, K, Ca, Mg uptake in tea seedlings, this was due to the release of slow nutrition of organic matter, so it is easily available to plants compared to fertilizers that are easily leached from conventional fertilizers.

Table 3. The average number of pekoe shoots, number of banji and shoots ratio (%)

Treatment	Number of Pekoe Shoot	Number of Banji Shoot	Pekoe/Banji Shoot Ratio
100% Conventional Fertilizer (CF)	36.33 a	9.87 a	3.68 a
100% Bio-organomineral (BIOM)	37.30 a	9.00 a	4.14 a
80% CF + 100 % BIOM	39.57 a	9.79 a	4.04 a
80% CF + 80 % BIOM	34.97 a	9.10 a	3.84 a
80% CF + 60 % BIOM	37.20 a	9.54 a	3.90 a
60% CF + 100 % BIOM	36.57 a	8.53 a	4.29 a
60% CF + 80 % BIOM	37.33 a	10.87 a	3.43 a
60% CF + 60 % BIOM	34.90 a	9.47 a	3.69 a

Note: Numbers followed by the same letter in the same row and column indicate that the treatment is not significantly different based on Duncan's multiple-distance test with a significance level of 0.05%.

Tabel 4. Percentage of pekoe in shoot production for 4 times of plucking (%)

Treatment	Pekoe Percentage (%)			
	1	2	3	4
100% Conventional Fertilizer (CF)	66 a	69 a	61 a	57 a
100% Bio-organomineral (BIOM)	76.7 a	62 a	57.3 a	60.7 abc
80% CF + 100 % BIOM	70.3 a	55.3 a	63.3 a	62.3 abc
80% CF + 80 % BIOM	74 a	58.7 a	62 a	73 c
80% CF + 60 % BIOM	73 a	61 a	55.3 a	70 abc
60% CF + 100 % BIOM	69.7 a	63 a	64 a	58.3 ab
60% CF + 80 % BIOM	61.3 a	61 a	59.7 a	71.7 bc
60% CF + 60 % BIOM	73.7 a	59.3 a	66.3 a	67.7 abc

Note: Numbers followed by the same letter in the same row and column indicate that the treatment is not significantly different based on Duncan's multiple-distance test with a significance level of 0.05%.

CONCLUSION

The results showed that there was a significant difference effect of the combination of conventional and bio-organomineral ameliorant on shoot production and pekoe percentage. The combination of 60% conventional fertilizer and 60% BIOM showed the highest total production of 31.81 kg/plot. Shoot production in the BIOM-treated plots was 17.36% higher than the single fertilizer application. The application of BIOM ameliorant was able to improve plant health after pruning the GMB 7 clone.

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