Effects of spraying Indonesian foliar fertilizer on growth and quality of tea in red soil region of southern China

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Abstract. In order to explore the application effect of BioSilAc solid foliar fertilizer and OBFs liquid foliar fertilizer produced by Indonesia Institute of Biotechnology and Bio-industry on tea plantations in red soil region, a field plot experiment was conducted to study the effects of spraying BioSilAc and OBFs on the morphological indexes of tea garden, fresh tea outputs and contents of biochemical components of tea in red soil region of southern China. Results showed that spraying BioSilAc and OBFs could increase bud density by 14.4%-24%, 100 buds’ weight of tea by 17.0%-33.9%, internode length by 9.5%-23.8% and leaf area by 6.9%-23.1%, respectively; The yield of autumn tea and spring tea increased by 2.4%-6.7% and 13.1%-24.7% respectively, and the total yield of fresh tea was increased by 7.1%-14.5%; The contents of tea polyphenols, amino acids, caffeine and water extract were increased by 8.3%-24.0%, 19.0%-47.6%, 3.5%-19.7% and 13.2%-31.3%, respectively. Among them, treatment of CF+OBFs had the best effect on improving the morphological indexes of tea gardens, promoting the yield and increasing the content of biochemical components of tea.

1. Introduction
BioSilAc solid foliar fertilizer and OBFs (Organic-based Biostimulant Formulas) liquid foliar fertilizer are developed by Indonesia Institute of Biotechnology and Bio-industry. BioSilAc is a new type of water-soluble silicon dioxide formula fertilizer enriched with silicon soluble microorganisms. It contains 17.5%-20.0% of bioavailable silicon dioxide (SiO₂), more than 5% of available silicon dioxide in H₄SiO₄, 10⁴-10⁶ propagule/tablet (4g) of non-pathogenic silicon dioxide solubilizing microorganisms, and is mixed with humic acid coating[1]. OBFs are mainly made of natural seaweed with abundant local resources in Indonesia, and are developed by unique extraction and processing technology. The preparation of the extract and formula has a unique way in terms of composition and biological activity for plant growth and development, and has obtained the national invention patent of Indonesia[2,3].

Studies in Indonesia showed that the mixed application of BioSilAc and 25%-50% reducing fertilizer could increase crop yield by 12.1% for oil palm, 35% for rice, 20% for corn, 15% for sugarcane, 26% for black soybean and 50% for potato; Compared with the control, the productivity of rice, corn, potato and onion increased by 25%, 31%, 30% and 23%, respectively; The application
results on perennial crops showed that the yield of tea and sugarcane could be increased by 48% and 50% respectively by spraying OBFs\textsuperscript{[1]}.

In order to explore the application effect of BioSilAc solid foliar fertilizer and OBFs liquid foliar fertilizer produced by Indonesia Institute of Biotechnology and Bio-industry on tea plantations in red soil region of Fujian Province, southeast coast of China, we carried out field fertilizer efficiency verification test of these two foliar fertilizer products since July 2020. The purpose is to provide a scientific basis for the introduction of these two kinds of products in Fujian and even in southern China.

2. Materials and methods
The experimental site is located in the Beifeng tea base of Fujian Man Tang Xiang Tea Co., Ltd., Huanxi Town, Jin'an District, Fuzhou City, Fujian Province. The soil type is mountainous red soil with medium basic fertility. Huanxi town is located in the northeast of Jin'an District, Fuzhou City, with an area of 133 km\textsuperscript{2} and superior geographical position. It is the nearest mountain town to the urban area and the most convenient transportation in Fuzhou City. The climate type is subtropical monsoon humid climate, with abundant sunshine, abundant rain, pleasant climate, evergreen trees and an average altitude of 500m. It is a summer resort, leisure and tourism resort, It has the reputation of "the back garden of Rongcheng" and has the unique advantages of natural geography and climate in developing green ecological tea garden in mountainous areas.

Three treatments were set up and repeated for three times. The area of each plot was 66.7 m\textsuperscript{2}. The specific treatments were as follows: Treatment 1, conventional fertilization + spraying water (CK, 20 L water/666.7 m\textsuperscript{2}, time, foliar spraying); Treatment 2, conventional fertilization + BioSilAc solid flake products (i.e., 26.7 g BioSilAc solid fertilizer completely dissolved in 20 L water/666.7 m\textsuperscript{2}, time, foliar spray); Treatment 3: conventional fertilization + OBFs liquid product (133.3 ml of OBFs liquid fertilizer completely dissolved in 20 L water/666.7 m\textsuperscript{2}, time, foliar spray). Treatment 1-3 were represented by CF + W, CF + BioSilAc and CF + OBFs, respectively.

The experiment started in July 2020, and foliar fertilizer was sprayed once on July 20, 2020 and March 5, 2021 respectively. The tested crop was tea tree, the variety was Meizhan, and the tree age was 15 years old. In the experiment, fresh autumn tea and spring tea were picked from September 28 to October 10, 2020 and April 1 to 20, 2021, respectively. The yield of tea in the plot was determined, and the related agronomic traits were tested. At the same time, the biochemical components of spring tea were determined.

Observation method of tea garden shape index\textsuperscript{[4-7]}: before spring tea picking, observe the tea garden shape index of each experimental plot, randomly select three fixed points in each plot, take 0.11 m\textsuperscript{2} for each point, and calculate the number of bud heads within 0.11 m\textsuperscript{2}, which is the bud head density; Take 100 tea bud heads of 1 bud and 2 leaves at each fixed point, and weigh the fresh weight, that is 100 tea-bud weight; The internode length was measured and recorded; The length and width of the second true leaf on the base of the new shoot were measured, and the leaf area was calculated. During the tea picking period, the tea was picked according to the standard in each plot, one bud and two leaves for autumn tea and one bud and one leaf for spring tea, and the yield of fresh tea was recorded.

The methods of sample analysis and determination were as follows: the content of tea polyphenols was determined according to GB / T 8313-2018 method for the determination of tea polyphenols and catechins in tea; The total amount of free amino acids was determined according to GB / T 8314-2013 determination of total amount of free amino acids in tea; The content of caffeine was determined according to GB / T 8312-2013 determination of caffeine in tea; The content of water extract was determined according to GB / T 8305-2013 determination of tea extract.

Microsoft Excel-2003 office software was used for data processing, and SPSS10.0 statistical software was used for variance analysis and significance test.
3. Results and analysis

3.1. Effects of different fertilization treatments on morphological indexes of tea garden

Results (Table 1) showed that: compared with CF + W treatment, CF + BioSilAc and CF + OBFs treatment had a certain improvement effect on the morphological indexes (bud density, 100 bud weight, internode length and leaf area) of tea garden, in which the bud density increased by 14.4%-24%, 100 bud weight increased by 17.0%-33.9%, internode length increased by 9.5%-23.8% and leaf area increased by 6.9%-23.1%. The effect of CF + OBFs treatment on the morphological indexes of tea garden was relatively better. The results of variance analysis showed that CF + OBFs treatment had the best improvement effect on the morphological indexes of tea garden, and the improvement effect on bud head density and 100 bud weight of tea garden was significantly better than CF + W treatment ($P < 0.01$), significantly better than CF + BioSilAc treatment ($P < 0.05$), and CF + BioSilAc treatment was also significantly better than CF + W treatment ($P < 0.05$); The effect of CF + OBFs on internode length and leaf area was significantly better than that of CF + BioSilAc and CF + W ($P < 0.05$), but there was no significant difference between CF + biosilac and CF + W ($P > 0.05$).

Table 1. Effects of different fertilization treatments on morphological indexes of tea garden

| Treatment   | Bud density (Pcs/0.11m²) | Fresh weight of 100 buds (g) | Internode length (cm) | Leaf area (cm²) |
|-------------|--------------------------|------------------------------|-----------------------|-----------------|
|             | Increasing rate (%)      | Increasing rate (%)          | Increasing rate (%)   | Increasing rate (%) |
| CF+W        | 146Bc                    | 66.3Bc                       | 2.1Ab                 | 36.0Ab          |
| CF+BioSilAc | 167Ab                    | 77.6Ab                       | 2.3Ab                 | 38.5Ab          |
| CF+OBFs     | 181Aa                    | 88.8Aa                       | 2.6Aa                 | 44.3Ab          |

3.2. Effects of different fertilization treatments on the yield of tea

Table 2. Effects of different fertilization treatments on fresh tea yield

| Treatment    | Autumn tea Increasing rate(%) | Spring tea Increasing rate(%) | Total output Increasing rate(%) |
|--------------|-------------------------------|-------------------------------|-------------------------------|
| CF+W         | 5.5 a                         | 4.2b                          | 9.7b                          |
| CF+BioSilAc  | 5.7 a                         | 4.8b                          | 10.4b                         |
| CF+OBFs      | 5.9 a                         | 6.7a                          | 11.1a                         |

In Table 2, results showed that: compared with CF + W treatment, CF + OBFs and CF + BioSilAc treatments showed a certain increasing trend on the yield of fresh tea, among which the increasing ranges of autumn tea and spring tea were 2.4%-6.7% and 13.1%-24.7% respectively; The total yield of fresh tea was increased by 7.1%-14.5%. The results of variance analysis showed that there was no significant difference in the yield of fresh autumn tea among different treatments; For spring tea and the total yield of spring and autumn tea production, CF + OBFs treatment was significantly better than CF + BioSilAc and CF + W treatment ($P < 0.05$), but there was no significant difference between CF + biosilac and CF + W ($P > 0.05$).

3.3. Effects of different fertilization treatments on biochemical components of tea

Results (Table 3) showed that: compared with CF + W treatment, CF + BioSilAc and CF + OBFs treatments increased the content of biochemical components in tea to a certain extent, and the contents of tea polyphenols, amino acids, caffeine and water extracts increased by 8.3%-24.0%, 19.0%-47.6%, 3.5%-19.7% and 13.2%-31.3%, respectively. Among them, CF + OBFs treatment had the best effect on improving the content of biochemical components in tea. The results of variance analysis showed that CF + OBFs treatment was significantly better than CF + BioSilAc and CF + W treatment ($P <
0.01), and CF + BioSilAc treatment was also significantly better than CF + W treatment ($P < 0.01$); Compared with CF + BioSilA treatment and CF + W treatment, CF + OBFS treatment could significantly improve the contents of tea polyphenols, caffeine and water extract ($P < 0.01$), but there was no significant difference between CF + biosilac treatment and CF + W treatment ($P > 0.05$).

Table 3. Effects of different fertilization treatments on biochemical components of tea green

| Treatment   | Tea polyphenols Content(%) | Amino acid Increasing rate(%) | Caffeine Content(%) | Water extract Increasing rate(%) |
|-------------|-----------------------------|-------------------------------|---------------------|-------------------------------|
| CF+W        | 19.2Bb                      | \                             | 4.0Bb               | 28.1Bb                        |
| CF+BioSilAc | 20.8Bb                      | 2.1Cc                         | 4.2Bb               | 31.8Bb                        |
| CF+OBFS     | 23.8Aa                      | 24.0                          | 3.1Aa               | 13.2                          |

4. Conclusion
The results showed that: compared with CF + W treatment, CF + BioSilAc and CF + OBFS treatment increased bud density by 14.4%-24%, 100 bud weight by 17.0%-33.9%, internode length by 9.5%-23.8% and leaf area by 6.9%-23.1%, respectively; The yield of autumn tea and spring tea increased by 2.4%-6.7% and 13.1%-24.7% respectively, and the total yield of fresh tea was increased by 7.1%-14.5%; The contents of tea polyphenols, amino acids, caffeine and water extract were increased by 8.3%-24.0%, 19.0%-47.6%, 3.5%-19.7% and 13.2%-31.3%, respectively. Among them, CF + OBFS treatment had the best effect on improving the morphological indexes, promoting the yield of tea and increasing the content of biochemical components.

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