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# Effects of Pruning on Growth, Rhizosphere Soil Physicochemical Indexes and Bacterial Community Structure of Tea Tree and Their Interaction

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**Abstract:** Pruning is an agronomic practice that contributes to tea tree yield during cultivation, but little is known about how pruning improves yield through shifting bacterial communities in rhizosphere soil. Therefore, Meizhan tea (*Camellia sinensis*) was used as the research object to analyze the effect of unpruning and pruning on the growth and rhizosphere soil physicochemical indexes of the tea tree, and sequencing technology was used to obtain the diversity of soil bacterial communities. The results showed that leaf area, hundred bud weight and yield of pruned tea trees increased by 1.32, 1.40, and 1.84 times, respectively, and pH and available N, available P, and available K contents increased by 1.10, 1.07, 1.30, and 1.07 times, respectively, compared with unpruned treatment, while total N, total P, and total K contents decreased by 1.20, 1.37, and 1.13 times, respectively. Analysis of the bacterial community structure showed that the key differential bacteria between pruned and unpruned tea trees were *Candidatus Solibacter*, *Acidibacter*, *Rhizomicrobium*, *Bryobacter*, *Solanum torvum*, *Mizugakiibacter*, *Nitrospira*, *Sphingomonas*, and *Granulicella*. Among them, the bacterial abundance of *Candidatus Solibacter*, *Bryobacter*, and *Nitrospira* showed an upward trend and the rest showed a downward trend after pruned treatment. Interaction network analysis showed that the correlation between the total key genera of microorganisms and organic matter, total N, total K, and total P content in rhizosphere soil did not reach a significant level, whereas the correlation with soil available N, available K, available P, pH, and tea tree growth indexes were all positively and significantly correlated. It can be seen that pruning changed the structure of the rhizosphere soil microbial community of tea trees, promoted soil nutrient transformation, increased the content of soil available nutrients, and promoted the growth of tea tree.

**Keywords:** Meizhan (*Camellia sinensis*); pruning; rhizosphere microorganism; soil nutrient cycling; physiological characteristics

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## 1. Introduction

Soil microorganisms, especially bacteria, are one of the important contributors to the biogeochemical cycling of nutrient elements such as carbon, nitrogen, phosphorus, and sulfur [1,2]. Complex interactions between plant roots and soil microorganisms occur mainly in the rhizosphere soil [3]. The composition and structure of microorganisms in rhizosphere soil effectively influence plant growth and development [4]. At the same time, soil environmental factors also affect the composition and activity of microbial communities [5–8]. Therefore, understanding plant–microbe interactions and the influence of abiotic factors on plant growth has become a research focus in recent years.

Pruning is an important management strategy in tea cultivation. Pruning of tea trees (*Camellia sinensis*) could stimulate the growth of lateral buds, which further improved tea yield. Meanwhile, pruning can decrease the amount of labor during tea harvesting and increase the efficiency of tea harvesting [9,10]. Current research on tea tree pruning focused on the effect of pruning degree on tea yield and quality [11,12]. It has been reported that pruning not only improves tea yield, but also slows down tea tree senescence and mitigates rhizosphere soil degradation [13]. Secondly, after pruning, the tea tree litter remains in the tea plantation, which favors the increase in soil nutrient content, promoting uptake by the tea tree [14]. Sarmah et al. found that pruning is beneficial in promoting the growth of the tea tree root system and improving the ability of the tea tree root system to absorb nutrients from the soil [15]. It was determined by Bora et al. that the process of tea tree pruning may result in alterations in the composition of the microbial community within the soil [16]. Pruning is an abiotic stress for tea trees. Tea trees undergo physiological changes in response to pruning, leading to alterations in root secretions that subsequently affect microbial community diversity and abundance in rhizosphere soil, which, in turn, affects the tea tree's own growth and function [17]. In turn, changes in microbial communities are followed by changes in their functions, which, in turn, affect nutrient cycling in the soil [18,19]. However, what kind of changes occur in the diverse soil microbial community after tea tree pruning, and what is the relationship between such changes and nutrient cycling in the soil? Few studies have investigated the mechanism of pruning-induced changes in rhizosphere soil indexes of tea trees, and gaining insight into this area is of great practical significance for the management and cultivation of tea trees.

Accordingly, this study was conducted to analyze the effects of pruning and unpruning on the growth of Meizhan (*Camellia sinensis* cv. Meizhan) tea trees. At the same time, the physicochemical indexes and microbial diversity were assessed in the tea tree rhizosphere soil to evaluate the impact of pruning on the structure of the microbial community and the nutrient cycling of the soil. On this basis, the interactions between microorganisms and soil nutrients and tea tree growth indexes were further analyzed, with a view to revealing how soil microorganisms change the nutrient transformations of soil, which, in turn, affects the growth of tea trees. The results of the study are intended to provide a reference for the cultivation and management of tea trees after pruning.

## 2. Materials and Methods

### 2.1. Site Description

The experimental site for this study was located at Foguoyan tea plantation, which is situated within the Wuyi Mountain Scenic Area (117.99° E, 27.72° N). This plantation is located at an altitude of 239 m and covers a total area of approximately 70 $m^2$. The tea cultivar grown in this area is named Meizhan (*Camellia sinensis* cv. Meizhan). The tea trees, which were eight years old, had never before been pruned. During August 2021, six distinct areas were equally separated from experimental tea plantations, of which three were subjected to tea tree pruning treatment (MP) and the remaining three areas were designated as controls (MC) and not subjected to such pruning. Three areas for each treatment were three replicates. Trimming of the tea tree canopy was carried out by removing 3–5 cm of branches, and the removed branches were left on the soil surface. In October 2021, 3.34 kg/ha of organic fertilizer and compound fertilizer (N:P:K = 21:8:16) were applied, respectively. Other management measures (weeding, pest control) were treated the same for both pruned and unpruned treatments. Soil and leaves for the experiment were obtained from the above experimental areas.

### 2.2. Determination of Physichemical Properties of Soils

Soil sampling was conducted on 28 April 2022. Due to the long tea plantation area, soil samples were collected by equidistant method. Briefly, the planting area was divided into five equal parts, and soil samples were collected within 40 cm of the four tea trees in the center of each equal part. The roots were dug out to a depth of 5–35 cm, and the soil attached to the roots was shaken off. The soil samples of the four plants were combined into a single sample, and a total of three soil samples were obtained. Each soil sample was then divided into two parts. One part was stored at −80 °C for the analysis of soil microbes and another part was air-dried, ground, and sieved for physicochemical properties' analysis.

All air-dried soil samples were crushed and passed through a 2 mm sieve for physicochemical index analysis. The physicochemical indexes included: organic matter, total nitrogen (N), total phosphorus (P), total potassium (K), available nitrogen (N), available phosphorus (P), available potassium (K), and pH [20]. Organic matter content was determined by the potassium dichromate oxidation method, i.e., the soil was decocted with potassium dichromate sulfate solution (0.4 mmol/L), cooled down, and the decoction was titrated with ferrous sulfate and then converted to obtain the organic matter content. Total N content was determined by the Kjeldahl method, i.e., the soil was decocted with concentrated sulfuric acid, the decoction was cooled and filtered, and then directly determined by Kjeldahl meter. Total P content was determined by the alkaline dissolution molybdenum antimony resistance colorimetric method, i.e., the soil was mixed with NaOH and treated at high temperature, and then dissolved using distilled water, molybdenum antimony resistance colorimetric agent was added, and the absorbance was measured at 700 nm and then converted to phosphorus content. Total K content was determined by NaOH fusion—the flame photometer method, i.e., the soil was mixed with NaOH and processed at high temperature, dissolved by distilled water, filtered, and then directly measured by flame photometer. Available N content was determined by the alkaline dissolution diffusion method, i.e., the soil was extracted with NaOH solution and the extracted solution was titrated with hydrochloric acid, and then converted to N content. Available P content was determined by the $NaHCO_3$ leaching—the molybdenum antimony resistance colorimetric method, i.e., the soil was leached with $NaHCO_3$ (0.5 mol/L), molybdenum antimony resistance colorimetric agent was added, and the absorbance was measured at 880 nm, and then converted to phosphorus content. Available K content was determined by ammonium acetate leaching—the flame photometric method, i.e., the soil was leached with 1 mol/L neutral ammonium acetate, filtered, and then directly determined by flame photometer. Soil pH was determined by the potentiometric method, i.e., leaching was carried out with distilled water as a leaching agent at a water–soil ratio of 2.5:1, and then the pH composite electrode was used directly for the determination.

### 2.3. Determination of Tea Growth Indexes

Leaf area (LA), hundred-bud weight (WHB), and tea yield in pruned and unpruned areas were measured. In brief, for LA: a random sample of 20 mature shoots was selected to measure both the length and width of their leaves, with leaf area calculated as leaf length times width times a factor of 0.7 (leaf area coefficient), and 3 replicates were conducted. WHB: 100 standard shoots with 4 leaves were randomly selected in the tea planting area and weighed, and 3 replicates were conducted. Tea yield: four rows of tea trees in pruned and unpruned areas were randomly selected for picking fresh leaves, respectively, as four replicate samples. Three leaves from standard standing buds were harvested and weighed for analysis. The tea yield was calculated by dividing the weight of the tea produced by the amount of land used, per row.

### 2.4. 16S rDNA Amplicon Sequencing Analysis

The extraction method of soil DNA and the amplification of 16S rDNA were conducted as described previously. To extract soil DNA, fresh soil samples weighing 0.5 g were used. This was conducted by following the protocol specified by the Bio-Fast Soil Genomic DNA Extraction Kit (BioFlux, Hangzhou, China). The instructions of the kit were followed accordingly. The DNA samples obtained were detected by 1% agarose gel electrophoresis.

The V3-4 hypervariable region of the bacterial 16S rRNA gene were amplified with the primers 338 F (ACTCCTACGGGAGGCAGCAG) and 806R (GGACTACHVGGGTWTCTAAT) [21]. The PCR products of each sample were subjected to deep sequencing using the Miseq platform at Allwegene Biotechnology Co., Ltd. (Beijing, China). Purified amplicons representing the bacterial 16S rDNA gene sequence reads were performed using the Illumina Analysis Pipeline Version 2.6. To minimize the impact of random sequencing errors, we screened and removed sequences with low quality scores ($\leq$20), sequences shorter than 200 bp, and sequences that did not match primers and barcode tags exactly in the raw data [22]. The purified sequences were clustered into operational taxonomic units (OTUs) at a 97% similarity level against the SILVA v128 [23]. The classifier tool of the Ribosomal Database Project (RDP) was used to classify all OTUs into different taxonomic groups [24]. Differential microorganisms were screened using volcano plots and key differential microorganisms were screened and obtained using orthogonal partial least squares discriminant analysis (OPLS-DA) [25,26].

### 2.5. Statistical Analysis

Experimental data were expressed as the mean ± standard error (SE), as per customary scientific practices. To assess the statistical significance of differences between two groups, we employed T-tests, in accordance with the methods outlined in SPSS Statistics 19 software. R version 4.2.3 software was used to produce box plots, principal component analysis (PCA, the R library was ggbiplot version 0.55), volcano plot analysis (the R library was ggplot2 version 3.4.0), orthogonal partial least squares discriminant analysis (OPLS-DA, the packages used were ropls and mixOmics), redundancy analysis (RDA, the R library was vegan version 2.6.4) and correlation matrix analysis (the R library was linkET 0.0.7.1).

## 3. Results

### 3.1. Effect of Pruning on the Growth of Tea Tree

The results of the effect of pruning on the growth indexes of tea trees showed (Table 1) that pruning favored the increase in leaf area, hundred bud weight and yield of tea trees. Compared with MC, leaf area, hundred bud weight, and yield of MP increased by 1.32, 1.40, and 1.84 times, respectively. It is evident that pruning is favorable to promote tea tree growth and increase tea yield.

**Table 1.** Effect of pruning treatment on growth index of Meizhan tea tree.

| Treatment | Leaf Area ($cm^2$) | Hundred-Bud Weight (g) | Yield (kg/ha) |
|---|---|---|---|
| MC | 20.81 ± 2.69 ns | 108.60 ± 5.24 ns | 2850 ± 72.45 ns |
| MP | 27.49 ± 3.88 * | 152.10 ± 7.81 * | 5250 ± 124.57 * |

Note: MC: Meizhan unpruned; MP: Meizhan pruned. * represents a significant difference at $p < 0.05$, and ns represents that the difference is not significant.

### 3.2. Effect of Pruning on Soil Physicochemical Properties

The analysis of the effect of pruning on the physicochemical indexes of tea tree rhizosphere soil showed (Table 2) that soil pH and the contents of available N, available P, and available K of MP were significantly increased compared with that of MC by 1.10, 1.07, 1.30, and 1.07 times, respectively, while the contents of total N, total P, and total K were significantly decreased by 1.20, 1.37, and 1.13 times, respectively. In addition, the analysis found that the difference in organic matter (OM) content in rhizosphere soil was not significant between MC and MP treatments. It can be seen that pruning treatments were favorable to increase the pH of tea tree rhizosphere soil, increase the content of available nutrients in the soil, and decrease the total amount of nutrients in the soil.

**Table 2.** Effect of pruning treatment on physicochemical index of rhizosphere soil of Meizhan.

| Soil Index | MC | MP | Soil Index | MC | MP |
|---|---|---|---|---|---|
| pH | 4.21 ± 0.01 * | 4.62 ± 0.01 * | Total N (g/kg) | 1.18 ± 0.02 * | 0.98 ± 0.02 * |
| Available N (mg/kg) | 116.67 ± 2.35 * | 124.50 ± 1.15 * | Total P (g/kg) | 0.92 ± 0.01 * | 0.67 ± 0.02* |
| Available P (mg/kg) | 11.73 ± 1.16 * | 15.20 ± 2.03 * | Total K (g/kg) | 6.78 ± 0.12 * | 6.02 ± 0.17 * |
| Available K (mg/kg) | 104.27 ± 0.62 * | 111.53 ± 1.88 * | Organic matter (g/kg) | 20.10 ± 1.25 ns | 19.24 ± 0.87 ns |

Note: MC: Meizhan unpruned; MP: Meizhan pruned. * represents a significant difference at $p < 0.05$, and ns represents that the difference is not significant.

### *3.3. Soil Bacterial Community and Diversity Analysis*

The sequencing results of the bacterial community found (Figure 1A) that a total of 2520 OTUs were detected in all of the samples, of which 1965 were detected in MC and 2111 in MP. There were 1556 OTUs shared by MC and MP, accounting for 61.75% of the overall OTUs. A total of 409 were MC-specific OTUs, accounting for 16.23% of the overall OTUs, and 555 were MP-specific OTUs, accounting for 22.02% of the overall OTUs. Further analysis of the α-diversity indexes showed that for the chao1 index, MP was significantly higher than MC (Figure 1B), whereas the shannon and simpson indexes were not significantly different between MC and MP (Figure 1C,D). It is evident that the bacterial community richness of tea tree rhizosphere soil increased significantly after MP treatment, but the difference in diversity was not significant. Further β-diversity analysis using the NMDS method to explore the extent of differences in the complexity of tea rhizosphere soil bacterial communities showed (Figure 1E) that MP and MC were significantly different (NMDS: Stress = 0.00, PERMANOVA, $p < 0.01$). The results of the PCA plot analysis of the bacterial community in tea tree rhizosphere soil showed (Figure 1F) that MC and MP could be effectively distinguished by the two principal components, and their overall contribution was 65.8%. It is evident that pruning significantly affected the richness of bacterial communities and its community structure in tea tree rhizosphere soil.

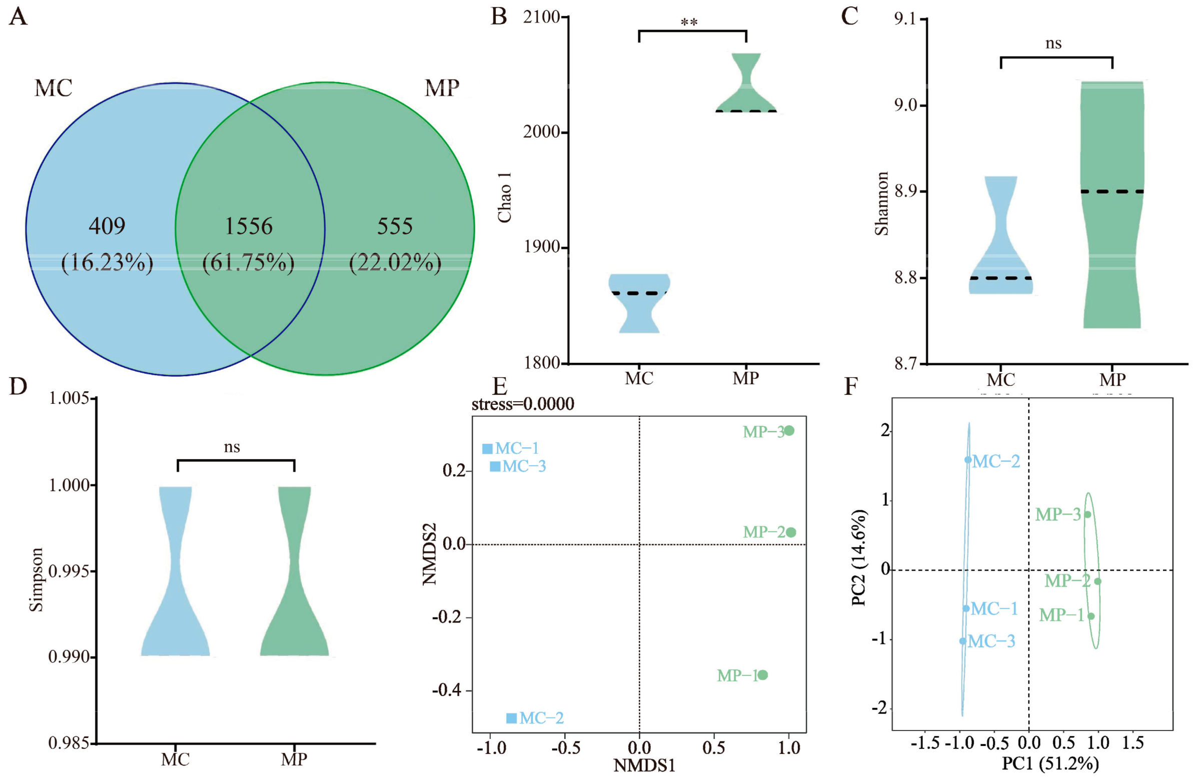

**Figure 1.** Bacterial community diversity in tea rhizosphere soils. Note: MC: Meizhan unpruned; MP: Meizhan pruned. (**A**) Analysis of the number and similarity of OTUs detected in the rhizosphere

soils of tea trees with different pruning treatments; (**B**) Analysis of the chao1 diversity index of rhizosphere soil OTUs of tea tree with different pruning treatments; (**C**) Analysis of the shannon diversity index of rhizosphere soil OTUs of tea tree with different pruning treatments; (**D**) Analysis of the simpson diversity index of rhizosphere soil OTUs of tea tree with different pruning treatments; (**E**) NMDS analysis of the β-diversity index of rhizosphere soil OTUs of tea tree with different pruning treatments; (**F**) PCA analysis of rhizosphere soil OTUs of tea trees with different pruning treatments. ** represents a significant difference at $p < 0.01$, and ns represents that the difference is not significant.

### *3.4. Screening of Key Differentiating Microorganisms*

A volcano plot and OPLS-DA model based on the abundance of rhizosphere soil bacterial OTUs were used to screen for key bacteria with significant changes in MC and MP. The results of the volcano plot analysis showed (Figure 2A) that there were a total of 413 bacterial OTUs that were significantly different in MC and MP, of which 197 were significantly increased and 216 were significantly decreased after pruning. On this basis, this study further screened key differential bacteria by the OPLS-DA model. For the OPLS-DA model of MC and MP, the goodness-of-fit ($R^2Y = 1$, $p < 0.005$), and predictability ($Q^2 = 0.994$, $p < 0.005$) of the model reached a significant level after 200 randomized simulations (Figure 2B). It can be seen that the OPLS-DA model constructed by MC and MP met the requirements and could effectively distinguish between different samples, which could be utilized for further analysis. The results of the OPLS-DA plot analysis showed (Figure 2C) that MC and MP could be effectively differentiated in two different regions, with a 2.87% within-group and 87.8% between-group difference. It is evident that a significant difference was between MC and MP, and high reproducibility between replicates. The constructed OPLS-DA model was further analyzed with S-Plot to obtain the variable importance projection values (VIP values) for different OTUs, resulting in 246 key difference OTUs (Figure 2D).

Based on the key difference OTUs obtained, the corresponding bacteria were found and analyzed for the classification found (Figure 2E), removing those that could not be matched (others), and the bacteria obtained could be classified into 10 phyla as Proteobacteria, Acidobacteria, Chloroflexi, Actinobacteria, Gemmatimonadetes, Firmicutes, Verrucomicrobia, Cyanobacteria, Bacteroidetes, and Nitrospirae. Among them, three phyla showed an increasing trend in bacterial abundance after pruning treatment, namely Acidobacteria, Chloroflexi, and Nitrospirae, while the rest showed a decreasing trend. Further categorization at the genus level revealed (Figure 2F) that 11 key genera of microorganisms were obtained: *Candidatus Solibacter*, *Acidibacter*, *Rhizomicrobium*, *Bryobacter*, *Solanum torvum*, *Mizugakiibacter*, *Nitrospira*, *Sphingomonas*, *Granulicella,* and others (unmatched bacteria) and unidentified bacteria. Among them, 3 genera showed an increasing trend in bacterial abundance after pruning treatment, namely *Candidatus Solibacter*, *Bryobacter*, and *Nitrospira*, and the rest showed a decreasing trend. It is evident that the abundance of bacterial communities in the rhizosphere soil changed significantly after pruning, which, in turn, may affect tea tree growth.

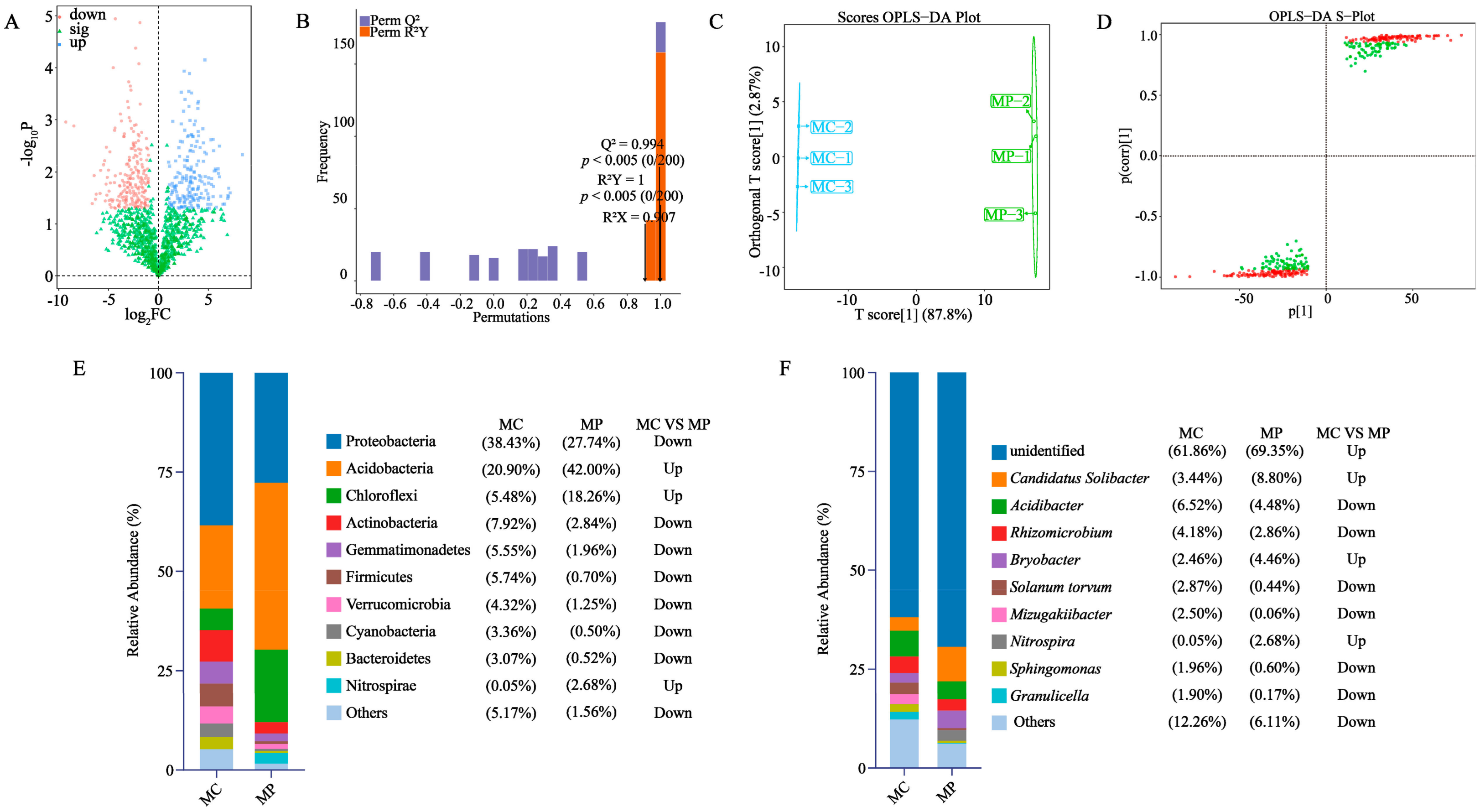

**Figure 2.** Screening of key differential bacteria in rhizosphere soil of tea tree under different pruning treatments. Note: MC: Meizhan unpruned; MP: Meizhan pruned. (**A**) Volcano plot analysis of rhizosphere soil differential OTUs of tea trees with different pruning treatments; (**B**) Test plot of OPLS-DA model for rhizosphere soils of tea tree with different pruning treatments; (**C**) Scores OPLS-DA plot for analysis of within- and between-group differences in rhizosphere soils of tea trees with different pruning treatments; (**D**) OPLS-DA S-Plot for screening of key differential OTUs in rhizosphere soils of tea trees with different pruning treatments, Green indicates that the vip absolute value is less than 1, and red indicates that the vip absolute value is greater than 1; (**E**) Abundance analysis of bacteria matched by key differential OTUs at the phylum level; (**F**) Abundance analysis of bacteria matched to key differential OTUs at the genus level.

### *3.5. Analysis of Interaction between Key Microorganisms, Tea Tree Growth Indexes, and Soil Physicochemical Indexes*

On the basis of the previous analysis, interactions of the key genera of microorganisms in the rhizosphere soil with tea tree growth indexes and soil physicochemical indexes were further analyzed. Redundancy analysis of key genera of microorganisms and tea tree growth indexes showed (Figure 3A) that pruning treatments were beneficial in promoting tea tree growth and increasing the abundance of *Candidatus Solibacter*, *Bryobacter*, and *Nitrospira* in the rhizosphere soil of tea trees. Secondly, tea tree growth indexes were significantly correlated with the abundance of *Candidatus Solibacter*, *Bryobacter*, and *Nitrospira* in the soil. The analysis of key microbial genera and physicochemical indexes of tea rhizosphere soil showed (Figure 3B,C) that pruning treatment was favorable to increase soil pH and promote the available nutrient cycling, but was not conducive to the accumulation of organic matter and total nutrient content. Secondly, total available nutrient content (available N, available P, available K) and soil pH were significantly correlated with the abundance of *Candidatus Solibacter*, *Bryobacter*, and *Nitrospira* in the soil, while total nutrient content (total N, total P, total K) and organic matter were significantly correlated with the abundance of *Acidibacter*, *Rhizomicrobium*, *Solanum torvum*, *Mizugakiibacter*, *Sphingomonas*, and *Granulicella* in the soil. Further, the correlation matrix analysis of the key genera of microorganisms with the growth indexes of tea trees and soil physicochemical indexes showed that (Figure 3D) the correlation between the total key genera of microorganisms and the content of total N, total P, total K, and organic matter in the soil did not reach a significant level, whereas the correlation with the available N, available P, available K, soil pH, and the growth indexes of the tea trees were all significantly and positively correlated. It can be seen that pruning resulted in significant changes in the abundance of bacterial communities in the soil, increased soil pH, enhanced soil available nutrients, and promoted tea tree growth.

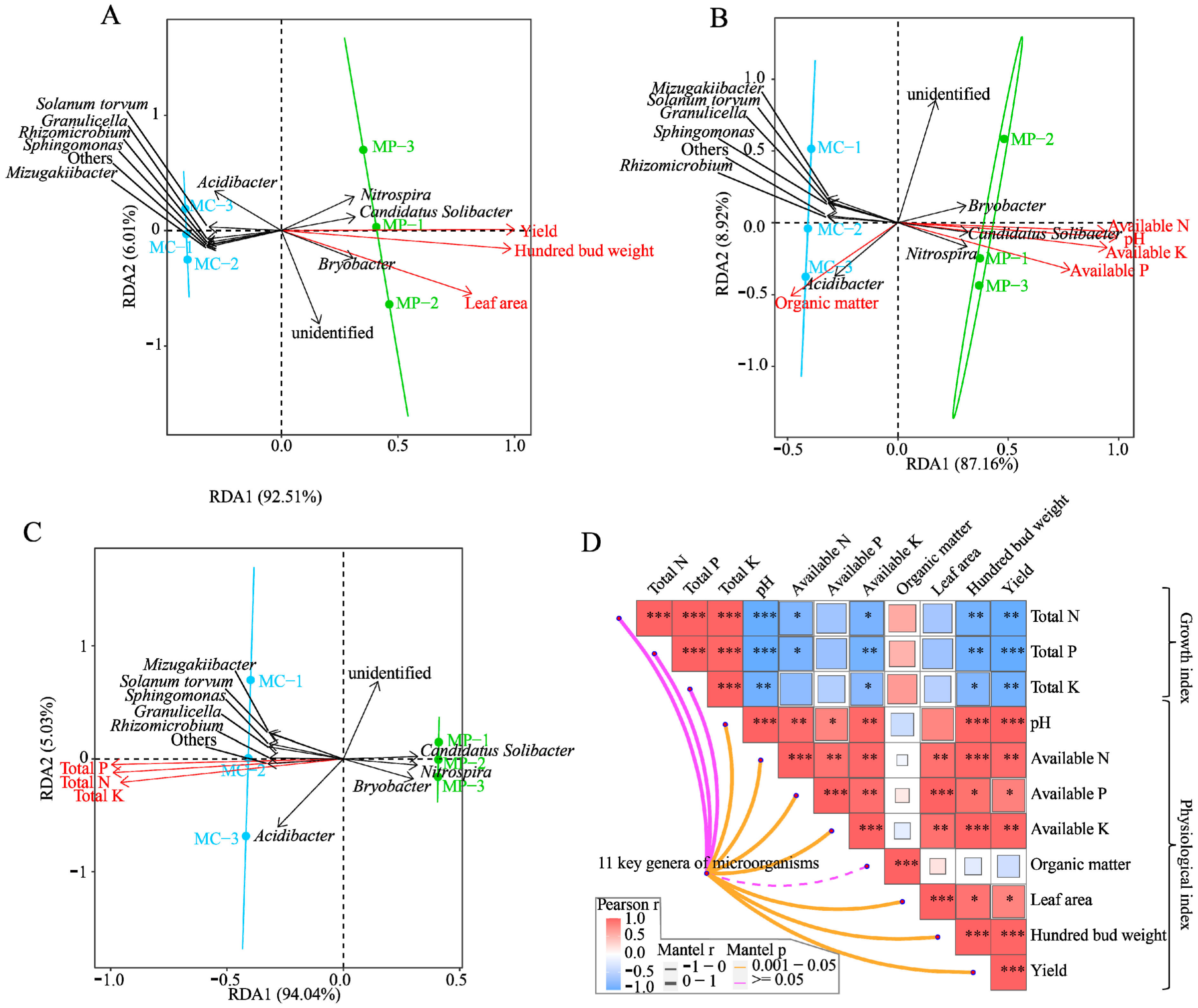

**Figure 3.** Interaction analysis of key genera of microorganisms with tea tree growth indexes and soil physicochemical indexes. Note: MC: Meizhan unpruned; MP: Meizhan pruned; (**A**) Redundancy analysis of key genera of microorganisms with tea tree growth indexes; (**B**) Redundancy analysis of key genera of microorganisms with rhizosphere soil available nutrients, soil pH, and organic matter content of tea trees; (**C**) Redundancy analysis of key genera of microorganisms and total nutrient content of tea tree rhizosphere soil; (**D**) Correlation matrix analysis of key genera of microorganisms with tea tree growth indexes and soil physicochemical indexes, * represents a significant difference at $p < 0.05$, ** represents a significant difference at $p < 0.01$, *** represents a significant difference at $p < 0.001$.

## 4. Discussion

Pruning is an important agronomic measure during tea planting and plays an important role in the growth and development of tea trees [27,28]. In this study, it was found that the leaf area, hundred bud weight, and tea yield of tea trees increased significantly after 1 year of pruning (Table 1). This result aligns with the findings of prior research [29,30]. It can be seen that pruning can indeed promote tea tree growth.

Plants need to absorb nutrients from the soil to meet their growth, especially the available nutrients of the soil, the content of which is related to the ability of plants to absorb nutrients [29]. We found that soil pH increased and the available nutrient content increased after pruning tea tree, while the total nutrient content decreased instead. It has been reported that soil pH is closely related to nutrient cycling in the soil, and increasing soil pH is favorable to increase the available nutrient content in the soil, which is conducive to promoting the growth of tea trees and increasing tea yield [31,32]. This study also found that the total nutrient content of the soil decreased after the pruning of tea trees. In this study, the same fertilization management pattern, i.e., the same amount of fertilizer was applied to both pruned and unpruned tea tree treatments. At the same time, tea tree pruning litter was also left in the tea plantation. Theoretically, the soil of a pruned tea plantation should contain more nutrients, however, this is not the case. Therefore, the authors hypothesized that the main reason for the reduction in the total nutrient content of the rhizosphere soil of tea trees after pruning was that the nutrient cycling capacity of the soil was enhanced, and the nutrients in the soil were accelerated to be converted into available nutrients for the tea tree to absorb and utilize, which, in turn, promoted the growth of the tea tree. The unpruned tea trees had a weaker soil nutrient cycling capacity, which, in turn, maintained a higher total nutrient content, but the nutrient content available for the tea tree to absorb and utilize was lower, and therefore the growth capacity of tea trees was poorer compared to that of the pruning treatment. It can be seen that tea tree pruning is conducive to rhizosphere soil nutrient cycling, increasing the available nutrient content of the soil and promoting tea tree growth.

Soil microorganisms, which are closely related to nutrient cycling in the soil, are very sensitive to changes in their surroundings and are often regarded as one of the indexes for assessing the health of the soil [33]. When a tea tree is pruned, the balance between the above-ground and below-ground parts is disturbed, prompting resources to be redistributed so that a new balance is established. Arkorful et al. [34] study showed that pruning stressed and induced changes in the types of root secretions of tea tree, which in turn affected changes in microbial diversity, abundance, etc., in the soil, which, in turn, affected its function. In this study, we found that the bacterial abundance in the rhizosphere soil increased significantly after 1 year of tea tree pruning, and the bacterial community composition changed significantly between pruned and unpruned tea trees. The key to this change was a significant increase in the abundance of *Candidatus Solibacter*, *Bryobacter*, and *Nitrospira*, which showed a significant positive correlation with soil available nutrient content and pH, and a significant decrease in the abundance of *Acidibacter*, *Rhizomicrobium*, *Solanum torvum*, *Mizugakiibacter*, *Sphingomonas*, and *Granulicella*, which showed a significant negative correlation with soil available nutrient content and pH. *Candidatus Solibacter*, *Bryobacter*, and *Nitrospira* have been reported to be associated with nutrient cycling in the soil, and an increase in their abundance is favorable for accelerating the transformation of nutrients, increasing the content of available nutrients in the soil, and accelerating the absorption of nutrients by the plants [35,36]. Secondly, *Acidibacter*, *Rhizomicrobium*, *Mizugakiibacter*, and *Sphingomonas* have been associated with plant decline diseases, and a decrease in their abundance favors the slowing of plant senescence [37]. *Solanum torvum* promotes the production of volatile substances, especially pinene, limonene and cineole [38]. However, volatiles such as pinene, limonene, and cineole have a strong inhibitory effect on plant root growth [39]. *Granulicella* reproduction is related to the carbohydrate content of the soil, and lower carbohydrate content favors its reproduction; on the contrary, *Granulicella*'s cell division is weakened and growth is inhibited [40]. It can be seen that pruning increases the abundance of *Candidatus Solibacter*, *Bryobacter*, and *Nitrospira* in the rhizosphere soil of tea tree, leading to an accelerated transformation of nutrients in the rhizosphere soil, which, in turn, enhances the content of soil available nutrients, and improves the growth of tea tree. Secondly, pruning helps to reduce the abundance of *Acidibacter*, *Rhizomicrobium*, *Solanum torvum*, *Mizugakiibacter*, *Sphingomonas*, and *Granulicella* in the soil, which reduces the production of harmful substances, and eases the senescence of tea trees.

## 5. Conclusions

In this study, the effects of pruning on rhizosphere soil physicochemical indexes, the growth, and bacterial diversity of tea trees were thoroughly examined. The results indicated (Figure 4) that pruning increased the abundance of *Candidatus Solibacter*, *Bryobacter*, and *Nitrospira*, and decreased the abundance of *Acidibacter*, *Rhizomicrobium*, *Solanum torvum*, *Mizugakiibacter*, *Sphingomonas*, and *Granulicella* in tea tree rhizosphere soil, which, in turn, increased the content of available nutrients in the soil, reduced the production of harmful substances in the soil, mitigated tea tree senescence, and promoted tea tree growth. It was also found in this study that the total nutrient content in the soil of pruned tea trees was significantly lower under the same fertilization conditions. Therefore, the pruned tea trees should be supplemented with timely fertilizers several times during the management of tea plantations to safeguard the growth of tea trees. Second, pruning is a physical injury to tea trees, and pruned tea trees release secretions through the root system, which, in turn, affects rhizosphere soil microbial abundance, diversity, and their functions, and requires further study.

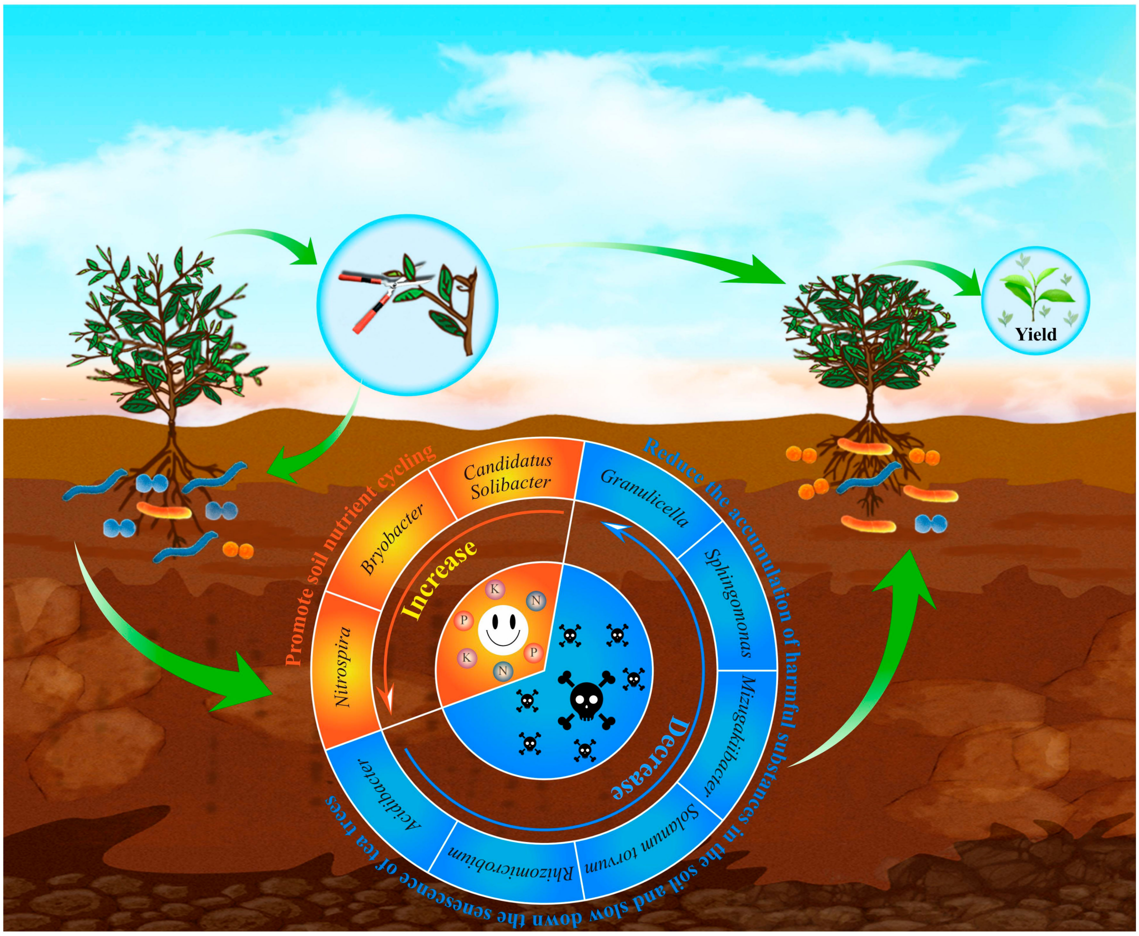

**Figure 4.** Mechanism analysis of effects of pruning on rhizosphere soil bacteria, nutrients, and tea yield of tea tree.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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