

Article

Tobacco/*Salvia miltiorrhiza* Intercropping Improves Soil Quality and Increases Total Production Value

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Abstract: Unreasonable cultivation methods and management measures have led to widespread obstacles in tobacco continuous cropping in planting areas, resulting in reduced tobacco yield and soil degradation. Therefore, intercropping tobacco with other crops is an effective strategy to improve continuous cropping barriers. In this study, flue-cured tobacco NC102 and conventional planting varieties of *Salvia miltiorrhiza* were used as materials, and four treatments of flue-cured tobacco monoculture (CK), flue-cured tobacco, and *Salvia miltiorrhiza* at a ratio of 1:1 (TS11), 2:2 (TS22), and 2:3 (TS23), respectively, were set up to study their effects on soil microorganisms, physical and chemical properties, and yield and quality of flue-cured tobacco. The results showed that intercropping *Salvia miltiorrhiza* increased the number of soil bacteria and actinomycetes, decreased the number of fungi, and increased the activity of urease and sucrase. The content of available nitrogen and available phosphorus in intercropping *Salvia miltiorrhiza* soil was significantly higher than that of the flue-cured tobacco monoculture, while the content of available potassium was lower than that of the flue-cured tobacco monoculture. The soil environment was more conducive to the growth of flue-cured tobacco. Compared with the flue-cured tobacco monoculture, the proportion of superior tobacco in intercropping *Salvia miltiorrhiza* increased by 2.2–3.4%, and the ratio of potassium to chlorine in leaves of different parts of flue-cured tobacco increased by 12.3–75.0%. The content of total sugar and soluble sugar in middle and upper leaves of intercropping flue-cured tobacco was higher than that of the flue-cured tobacco monoculture, which improved the quality of flue-cured tobacco. From the analysis of the chemical composition of tobacco leaves, TS11 (flue-cured tobacco and *Salvia miltiorrhiza* intercropping row ratio of 1:1) had the best treatment effect, potassium content, total sugar, reducing sugar content, and potassium chloride ratio of flue-cured tobacco were the highest, the chlorine content was the lowest, and the quality was better than other treatments. From the analysis of total output value, the total output value of TS22 (flue-cured tobacco and *Salvia miltiorrhiza* intercropping row ratio of 2:2) was higher than that of other intercropping treatments. In 2018 and 2019, the total output value increased by 21.3% and 22.4%, respectively, compared with the flue-cured tobacco monoculture. The intercropping advantage was obvious, and the treatment effect was the best.

Keywords: tobacco; *Salvia miltiorrhiza*; intercropping; soil microorganisms; soil physico-chemical properties; yield quality



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1. Introduction

Flue-cured tobacco belongs to Solanaceae crops, avoiding continuous cropping. Due to the suitable environmental conditions for tobacco planting and the limited area of cultivated land, there is a phenomenon of continuous cropping of flue-cured tobacco in the main tobacco areas [1]. Especially in recent years, vegetables, flowers, medicinal materials,

fruits, and other industries have continued to grow and develop. The basic tobacco fields with good infrastructure are occupied year by year, and continuous cropping of flue-cured tobacco has become a common phenomenon [2,3]. Increasing investment, disease aggravation, yield decline, quality deterioration, and benefit decline are common problems in the continuous cropping of tobacco fields. According to statistics, the continuous cropping area of tobacco planting in China accounts for 30–60% of the total planting area of tobacco planting, and the economic losses are as high as billions [4], affecting the sustainable development of tobacco agriculture. Therefore, it is of great significance to explore a new planting mode to solve the continuous cropping obstacle of flue-cured tobacco and improve the economic benefits of tobacco farmers.

Salvia miltiorrhiza has high medicinal value. As a typical representative of Labiatae medicine, it has strong ecological adaptability. The roots of the underground part of *Salvia miltiorrhiza* and the stems of the aboveground part can be used as medicinal materials for the treatment and prevention of cardiovascular diseases, liver diseases, and diabetes. It has the effects of promoting blood circulation and removing blood stasis, protecting myocardium, anti-thrombosis, and anti-inflammation. As one of the most demanded Chinese medicinal materials in China, and even in the world, the economic benefit of planting *Salvia miltiorrhiza* is obviously higher than that of planting crops, but the continuous cropping cultivation and continuous cropping obstacles of *Salvia miltiorrhiza* are widespread [5].

Studies have shown that intercropping increases crop species, and the types of root exudates in the intercropping system are significantly more than those in the monoculture, which correspondingly changes the types and quantities of soil microorganisms and is conducive to restoring soil ecological balance [6]. Reasonable intercropping to reduce the continuous cropping obstacles of *Salvia miltiorrhiza* and tobacco, and improve the planting efficiency, has been confirmed in the intercropping of *Salvia miltiorrhiza* with mint and perilla [7], *Salvia miltiorrhiza* with maize [8], and flue-cured tobacco with soybean and mung bean. For example, flue-cured tobacco soybean intercropping reduces the incidence of tobacco black shank [9], flue-cured tobacco sweet potato intercropping improves the planting efficiency of the intercropping system [10], flue-cured tobacco ginger intercropping improves the economic benefits, yield, and quality of flue-cured tobacco [11], and flue-cured tobacco Pinellia intercropping improves soil yield and quality [12]. As two important economic plants in China, the intercropping of flue-cured tobacco with *Salvia miltiorrhiza* has not been reported. *Salvia miltiorrhiza* plant height ranges from 40 to 50 cm, whereas flue-cured tobacco plant height ranges from 130 to 160 cm; growth peak period for *Salvia miltiorrhiza* is from August to November, whereas the growth peak period for flue-cured tobacco is from May to July. *Salvia miltiorrhiza* and flue-cured tobacco affect the plant shape and growth and development characteristics with obvious differences; flue-cured tobacco *Salvia miltiorrhiza* intercropping may produce an intercropping advantage.

Therefore, in this study, the intercropping of flue-cured tobacco and *Salvia miltiorrhiza* was used for the improvement of continuous cropping obstacles. The main objectives were to study the effects of intercropping of flue-cured tobacco and *Salvia miltiorrhiza* on the soil as follows: (1) evaluate the effects of different interplant methods on the microbial population in soil; (2) investigate the effects of different interplant methods on soil properties and enzyme activities; (3) examine the predictive changes in the quality and total output value after intercropping.

2. Materials and Methods

2.1. Experimental Site

The experiment was conducted in 2018 and 2019 at the cultivation base for tobacco in Liancheng Township, Linyi, Shandong Province. The region has a warm temperate monsoon continental climate. The overall climate characteristics are four distinct seasons, suitable temperature, sufficient light, abundant precipitation, rainy and hot seasons, and long frost-free period. The altitude is 452 m. The annual mean temperatures, maximum and minimum temperatures for 16 consecutive years from 2001 to 2016, were 12.7 °C, 40 °C, and

−21.1 °C, respectively, with an annual frost-free period of 200 d and an annual precipitation of 827 mm. During the test period, the temperature change characteristics of Liancheng Town were obvious (e.g., Table 1). April to May is the stage for preparing seedling beds and the transplanting period. The temperature changes greatly, and the average temperature is more than 14 °C, which ensures the normal growth and development of tobacco seedlings. From June to August is the stage of flue-cured tobacco from vigorous growth to maturity. The overall temperature is high, the monthly average temperature is between 24.0 °C and 27.0 °C, and the precipitation is large, which is conducive to promoting the vigorous growth of flue-cured tobacco stems and leaves, and does not burn tobacco leaves to reduce their quality. There was no extreme special weather situation on the whole, which was basically consistent with the comprehensive data of 16 consecutive years, and was more suitable for the growth and development of flue-cured tobacco [13]. After drying, the soil samples from 0–20 cm of the ploughed layer were taken to determine the soil organic matter content of 6.14 g·kg^{−1} by the five-point sampling method. The content of total nitrogen (TN) along with the total phosphorus (TP) and total potassium (TK) contents were 43.55 g·kg^{−1}, 34.29 g·kg^{−1}, and 474.99 g·kg^{−1}, respectively, and the available nitrogen, available phosphorus and available potassium were 10.39 mg·kg^{−1}, 51.75 mg·kg^{−1}, and 98.16 mg·kg^{−1}, respectively. The physical and chemical properties of the soil were determined according to the ‘soil survey laboratory analysis method’ [14]. According to the ‘World Reference Base for Soil Resources 2014’, the soil type of the test area was determined to be Eutric Planosols [15].

Table 1. Monthly statistics of average temperature and precipitation in Liancheng during the test period (April–November 2018, April–November 2019).

Year	Month	4	5	6	7
2018	monthly average temperature (°C)	15.1	20.2	24.6	26.5
	monthly precipitation (mm)	57	63	132	246
	Month	8	9	10	11
	monthly average temperature (°C)	26.2	20.3	13.9	7.6
	monthly precipitation (mm)	180	76	12	34
	Month	4	5	6	7
2019	monthly average temperature (°C)	14.5	22	25.5	28
	monthly precipitation (mm)	50	43	120	231
	Month	8	9	10	11
	monthly average temperature (°C)	25.5	22	15	10.5
	monthly precipitation (mm)	153	66	13	34
	Month	4	5	6	7

2.2. Experimental Design

According to the local production system and management mode, the experiment was set up as three intercropping modes of flue-cured tobacco and *Salvia miltiorrhiza* with an intercropping row ratio of 1:1 (TS11), 2:2 (TS22) and 2:3 (TS23), with the flue-cured tobacco monoculture (CK) as the control. Each treatment was repeated three times, with a total of twelve plots. Each plot area was 222.3 m², and placed in a random arrangement on the field. The flue-cured tobacco monoculture had a row spacing of 110 cm, and a plant spacing of 50 cm; when flue-cured tobacco and *Salvia miltiorrhiza* were intercropped, the row spacing of flue-cured tobacco and *Salvia miltiorrhiza* was 75 cm, the row spacing of flue-cured tobacco was 110 cm, the plant spacing was 50 cm, the row spacing of *Salvia miltiorrhiza* was 35 cm, and the plant spacing was 20 cm. The specific distribution was as shown in Figure 1.

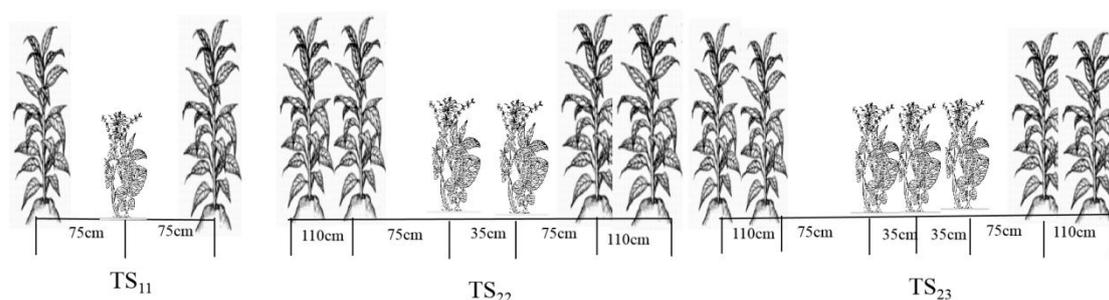


Figure 1. Intercropping modes of flue-cured tobacco *Salvia miltiorrhiza*. Note: T and S mean tobacco and *Salvia miltiorrhiza*. TS11: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 1:1, TS22: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:2, TS23: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:3.

In CK, 9 rows of flue-cured tobacco were planted in each replicate plot, with about 390 plants in total; TS11 was planted with 7 rows of flue-cured tobacco and 6 rows of *Salvia miltiorrhiza* in each replicate plot, with about 300 flue-cured tobacco and 650 *Salvia miltiorrhiza* plants in total. TS22 was planted with 7 rows of flue-cured tobacco and 6 rows of *Salvia miltiorrhiza*, with about 300 flue-cured tobacco, about 650 *Salvia miltiorrhiza* plants in total; TS23 was planted with 6 rows of flue-cured tobacco and 9 rows of *Salvia miltiorrhiza* in each replicate plot. There were about 260 flue-cured tobacco and 950 *Salvia miltiorrhiza* plants in total.

In order to make full use of the growing season, flue-cured tobacco and *Salvia miltiorrhiza* were raised in small sheds, about 20 days in advance. Transplanting was carried out on 27 April 2018 and 29 April 2019. The fresh weight of *Salvia miltiorrhiza* and flue-cured tobacco seedlings was 6.0 ± 0.5 g and 15.0 ± 1.0 g, respectively, and the fresh seedlings without water loss and pests and diseases were selected as seedlings. The tested flue-cured tobacco variety was NC102, the base fertilizer was the special base fertilizer for flue-cured tobacco ($N:P_2O_5:K_2O = 10:10:25$), and the application rate was $750 \text{ kg}\cdot\text{ha}^{-1}$. The ridge was double-ditched for strip application. After 30 days of transplanting, the special topdressing fertilizer for flue-cured tobacco ($N:K_2O = 13:26$) was applied to the root (20 cm from the root), and the application rate was $225 \text{ kg}\cdot\text{ha}^{-1}$. The variety of *Salvia miltiorrhiza* was Shandong *Salvia miltiorrhiza*. The rotten organic fertilizer $22.5\sim 30.0 \text{ t}\cdot\text{ha}^{-1}$ and compound ($N:P_2O_5:K_2O = 12:15:18$) $450\sim 750 \text{ kg}\cdot\text{ha}^{-1}$ were applied as base fertilizer. *Salvia miltiorrhiza* did not have fertilizer applied during the whole growth period.

After transplanting, the soil was loosened 2–3 times to maintain loose soil between rows. Combined with the soil conditions, the hole irrigation method was used to irrigate the appropriate amount at the right time (1 time each at transplanting stage, rosette stage, and mature stage, and 3 times at vigorous growth stage). The prevention and control of diseases and insect pests was given priority along with strict regulation of farming operations, elimination of diseased leaves in a timely manner, focusing on tobacco black shank disease (with 25% Ruidumei wettable powder 400–500 times liquid control), ordinary tobacco mosaic disease (with 0.1% zinc sulfate prevention), flue-cured tobacco, and control of common pest aphids afflicting *Salvia miltiorrhiza* (with 4000 times liquid control). The top of the tobacco plant was removed when the leaf length was about 15 cm. When topping, 2–4 leaves in the lower part and 3–4 leaves in the upper part were removed, and the number of effective leaves was 21–23. Bud removal was not carried out on *Salvia miltiorrhiza*. After a mature harvest, the tobacco leaves were cured in a curing barn according to the three-stage curing process.

Samples were collected at transplanting stage (29 April), rosette stage (24 May), vigorous growth stage (27 June), squaring stage (22 July) and mature stage (25 August) of flue-cured tobacco. Soil samples from the 0–20 cm soil layer were taken using the five-point sampling method in the inter-row soil of the flue-cured tobacco intercropping area, the inter-row soil of flue-cured tobacco and *Salvia miltiorrhiza*, and the inter-row soil of the

flue-cured tobacco monoculture area. After removing gravel and plant residues, they were brought back to the laboratory with ice bags. Some of them were naturally dried for the determination of soil available nitrogen, phosphorus, potassium, and soil enzymes, and some were stored at 4 °C for the determination of soil microorganisms.

2.3. Measurement Items and Methods

2.3.1. Determination of Chemical Composition and Quality Evaluation of Tobacco Leaves after Flue-Curing

Flue-cured tobacco was harvested at the mature stage. The lower leaves were harvested on 26 and 27 August 2018 and 26 and 27 August 2019, the middle leaves were harvested after 15 days, and the upper leaves were harvested after 25 days. Flue-cured tobacco leaves were cured in a curing barn, and the dry yield and quality of flue-cured tobacco leaves were determined. The rhizomes of *Salvia miltiorrhiza* were harvested by digging on 15 and 16 November 2018 and 2019, respectively. After natural drying, the yield was measured. After the experiment, the rhizomes of *Salvia miltiorrhiza* were directly sold as a technical drug. The cured tobacco was graded according to the national standard GB 2635-92 [16], and the proportion of top-quality tobacco in different treatments was counted. The contents of total sugar, reducing sugar, total nitrogen, total alkaloid, potassium, and chlorine in 2–5 kg representative flue-cured tobacco samples B2F, C3F, X2F (B2F, C3F, and X2F mean the representative tobacco grades of all parts of flue-cured tobacco, with the second orange in the upper leaf, the third orange in the middle leaf, and the second orange in the lower leaf, respectively.) were determined, which were used for quality evaluation and internal chemical composition analysis of tobacco leaves [17]. The contents of total sugar and reducing sugar were determined according to the YC/T 159-2002 study 'Determination of water-soluble sugar in tobacco and tobacco products was done by continuous flow method' [18], and the total alkaloid content was determined according to the YC/T 160-2002 study 'Determination of total alkaloid in tobacco and tobacco products was done by continuous flow method' [19]. The total nitrogen content was determined according to the YC/T 161-2002 study 'Determination of total nitrogen in tobacco and tobacco products was done by continuous flow method' [20]. The potassium content was determined according to the YC/T 217-2007 study 'Determination of potassium in tobacco and tobacco products was done by continuous flow method' [21]. The chlorine content was determined according to the YC/T 162-2002 study 'Determination of chlorine in tobacco and tobacco products was done by continuous flow method' [22]. The sugar–nicotine ratio (reducing sugar/nicotine), nitrogen–nicotine ratio (total nitrogen/nicotine), and potassium–chlorine ratio (potassium/chlorine) were calculated.

2.3.2. Soil Biological Shape Determination

The activities of soil urease, alkaline phosphatase, invertase, and polyphenol oxidase were determined by indophenol blue colorimetry, disodium phenyl phosphate colorimetry, 3,5-dinitrosalicylic acid colorimetry, and the pyrogallol method, respectively [23]. Soil microorganisms were counted by plate culture. Bacteria, fungi, and actinomycetes were cultured in beef extract peptone, and Martin's and modified Gause's medium, respectively [24]. Soil alkali-hydrolyzable nitrogen content was determined by the alkali solution diffusion method; the available phosphorus content was determined by the 0.5 mol/L NaHCO₃ extraction-molybdenum antimony colorimetric method. The content of available potassium was determined by the 1 mol·L⁻¹ NH₄OAc extraction-flame photometer method [25].

2.4. Data Processing

All experimental data were processed and analyzed using Microsoft Excel 2019 and SPSS 26.0 statistical software. Excel processed the original data to obtain histograms and standard deviation; one-way analysis of variance and the LSD test were used to test the significance of the differences between the treatments.

3. Results

Considering that the data of the second year of intercropping can better illustrate the impact of intercropping on crops, the soil and quality data of 2019 were analyzed.

3.1. Effect of Intercropping of Flue-Cured Tobacco and *Salvia miltiorrhiza* on Soil Microbial Population

With the growth period of flue-cured tobacco, the number of soil bacteria, fungi, and actinomycetes in each treatment increased first and then changed (Figures 2–4). The highest numbers of bacteria, fungi, and actinomycetes were found in each treatment at the squaring stage. Intercropping of *Salvia miltiorrhiza* increased soil bacterial counts by 48.50–82.78%, 83.11–104.48%, 25.37–39.30%, 40.33–54.32%, and 31.67–40.72% at the transplanting, rosette, vigorous growth, squaring, and mature stages, respectively, compared with that of the flue-cured tobacco monoculture. The number of soil bacteria in TS22 treatment at transplanting stage and rosette stage was the highest, and the order of vigorous growth to mature stages was TS23, TS22, and TS11. The intercropping of *Salvia miltiorrhiza* reduced the number of soil fungi, and the number of soil fungi in the transplanting stage, rosette stage, vigorous growth stage, squaring stage, and mature stage decreased by 40.13–44.91%, 46.06–50.23%, 34.77–49.35%, 33.16–41.60%, and 18.75–24.29%, respectively, compared with the flue-cured tobacco monoculture. The number of soil fungi in the intercropping of flue-cured tobacco and *Salvia miltiorrhiza* consistently showed the highest TS11, TS22, and the lowest TS23 during the reproductive period of flue-cured tobacco.

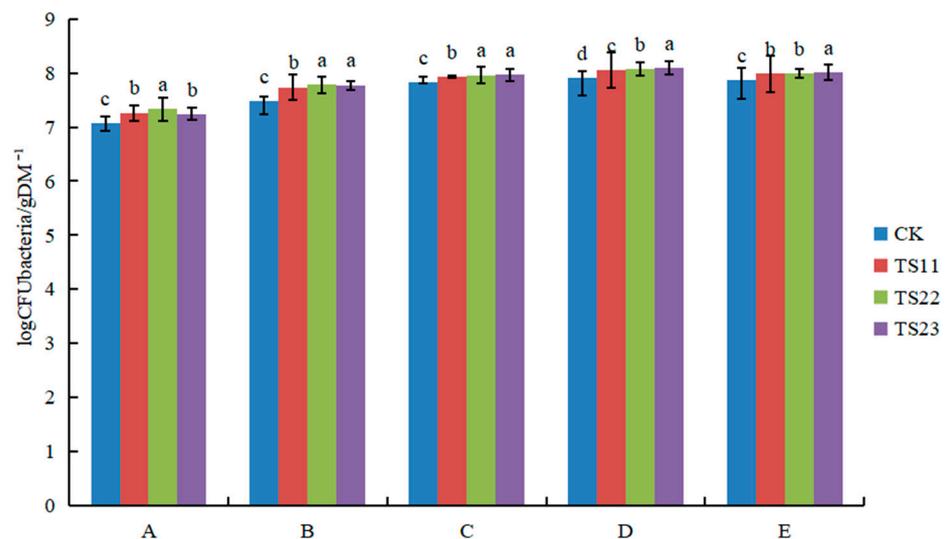


Figure 2. Effect of intercropping of flue-cured tobacco and *Salvia miltiorrhiza* on bacterial population. Note: A: transplanting stage; B: rosette stage; C: vigorous growth stage; D: squaring stage; E: mature stage; CK: flue-cured tobacco monoculture; TS11: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 1:1; TS22: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:2; TS23: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:3; logCFUbacterial: a log of bottom 10 with the parameter number of colony-forming units of the bacterial; gDM⁻¹: the amount per gram of dry substance. Different letters on the bar graphs indicate significant differences in the mean of each treatment at $p \leq 0.05$.

The number of actinomycetes in flue-cured tobacco monoculture soil was more than that in flue-cured tobacco and *Salvia miltiorrhiza* intercropping soil from the transplanting stage to vigorous growth stage, while the number of actinomycetes in flue-cured tobacco and *Salvia miltiorrhiza* intercropping soil was more than that in flue-cured tobacco monoculture soil from the squaring stage to mature stage. There was no significant difference in the number of soil actinomycetes between TS11 and TS22 at the transplanting stage, rosette stage, and vigorous growth stage. The number of soil actinomycetes in the transplanting

stage and rosette stage was slightly lower than that in TS23, and the number in the vigorous growth stage was significantly higher than that in TS23. The number of soil actinomycetes from the squaring stage to the mature stage was the highest in TS22 and the lowest in TS23.

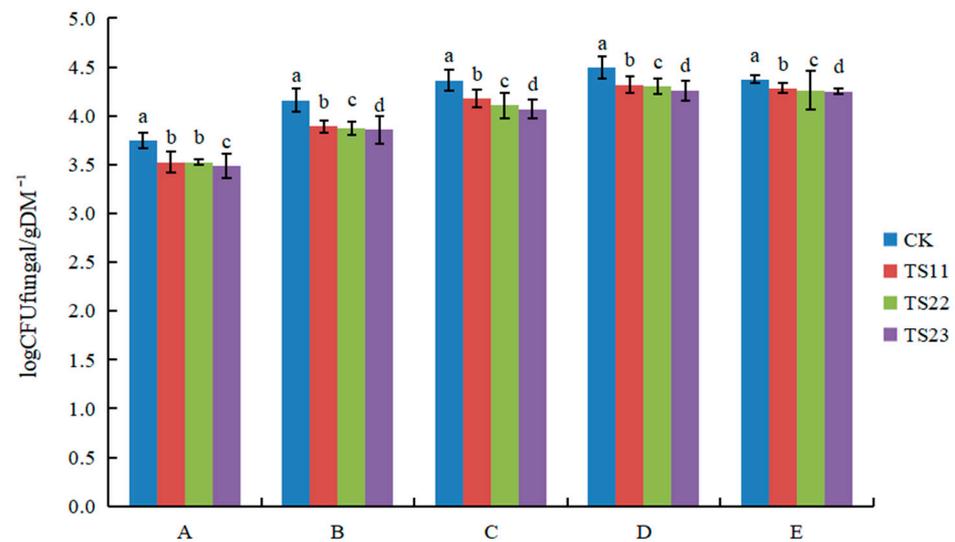


Figure 3. Effect of intercropping of flue-cured tobacco and *Salvia miltiorrhiza* on fungal populations. Note: A: transplanting stage; B: rosette stage; C: vigorous growth stage; D: squaring stage; E: mature stage; CK: flue-cured tobacco monoculture; TS11: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 1:1; TS22: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:2; TS23: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:3; logCFUfungus: a log of bottom 10 with the parameter number of colony-forming units of the fungus; gDM⁻¹: the amount per gram of dry substance. Different letters on the bar graphs indicate significant differences in the mean of each treatment at $p \leq 0.05$.

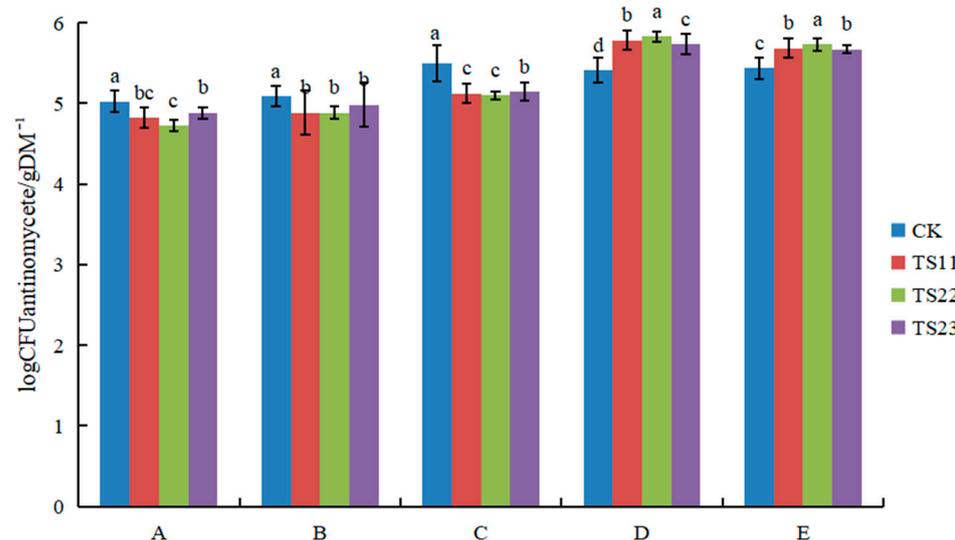


Figure 4. Effect of intercropping of flue-cured tobacco and *Salvia miltiorrhiza* on the number of actinomycetes. Note: A: transplanting stage; B: rosette stage; C: vigorous growth stage; D: squaring stage; E: mature stage; CK: flue-cured tobacco monoculture; TS11: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 1:1; TS22: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:2; TS23: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:3; logCFUactinomycete: a log of bottom 10 with the parameter number of colony-forming units of the actinomycete; gDM⁻¹: the amount per gram of dry substance. Different letters on the bar graphs indicate significant differences in the mean of each treatment at $p \leq 0.05$.

3.2. Effect of Intercropping of Flue-Cured Tobacco and *Salvia miltiorrhiza* on Soil Enzyme Activities

With the advancement of the flue-cured tobacco growth period, the soil urease and sucrase activities of flue-cured tobacco monoculture and flue-cured tobacco intercropping showed a downward trend. The soil urease and sucrase activities of flue-cured tobacco and *Salvia miltiorrhiza* intercropping were always significantly higher than those of the flue-cured tobacco monoculture (Figures 5 and 6). The soil urease activity of TS23 was the highest at transplanting stage and rosette stage, followed by TS22 and TS21, and the difference was significant. The soil urease activity of TS22 was significantly higher than that of TS11 and TS23 at the vigorous growth stage, squaring stage, and mature stage. From the transplanting stage to the squaring stage, soil sucrase activity was the highest in TS22 and the lowest in TS23. At the maturity stage, TS22 was the highest and TS11 was the lowest. Soil sucrase activity was the highest in TS22 treatment.

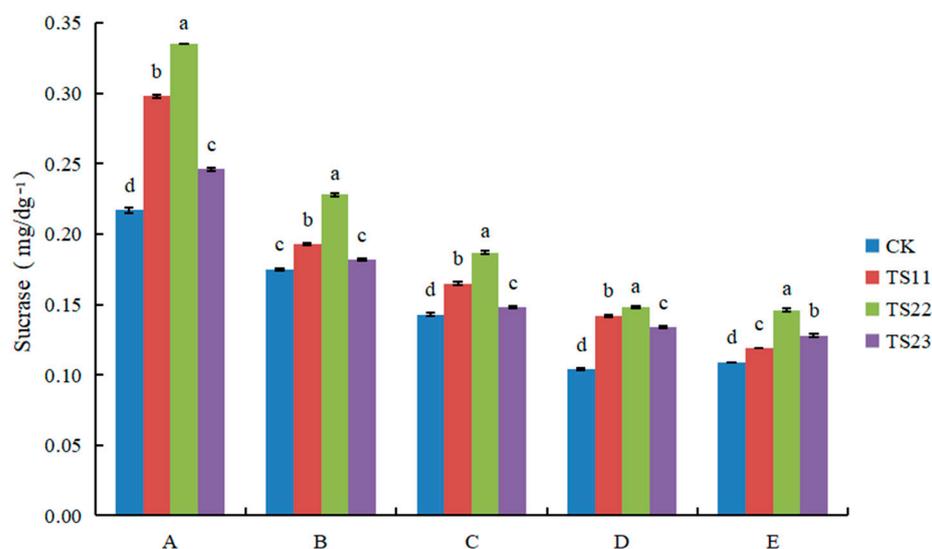


Figure 5. Effect of intercropping of flue-cured tobacco and *Salvia miltiorrhiza* on sucrase activity. Note: A: transplanting stage; B: rosette stage; C: vigorous growth stage; D: squaring stage; E: mature stage; CK: flue-cured tobacco monoculture; TS11: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 1:1; TS22: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:2; TS23: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:3; dg^{-1} : the dry weight per gram. Different letters on the bar graphs indicate significant differences in the mean of each treatment at $p \leq 0.05$.

The soil phosphatase activity of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was significantly lower than that of the flue-cured tobacco monoculture from the transplanting period to the vigorous growth period (Figure 7), and the soil phosphatase (ACP) activity of TS11 treatment was higher than that of TS22 and TS23. The soil phosphatase activity of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was significantly higher than that of the flue-cured tobacco monoculture at the squaring stage and the mature stage, and the soil phosphatase activity of TS11 treatment was higher than that of TS22 and TS23.

The soil catalase (CAT) activity of flue-cured tobacco monoculture and flue-cured tobacco intercropping decreased slightly from the transplanting stage to the rosette stage (Figure 8), and increased rapidly from the vigorous growth stage to the mature stage. The soil catalase activity of TS11 treatment was always significantly higher than that of TS22 and TS23, and there was no significant difference between TS22 and TS23.

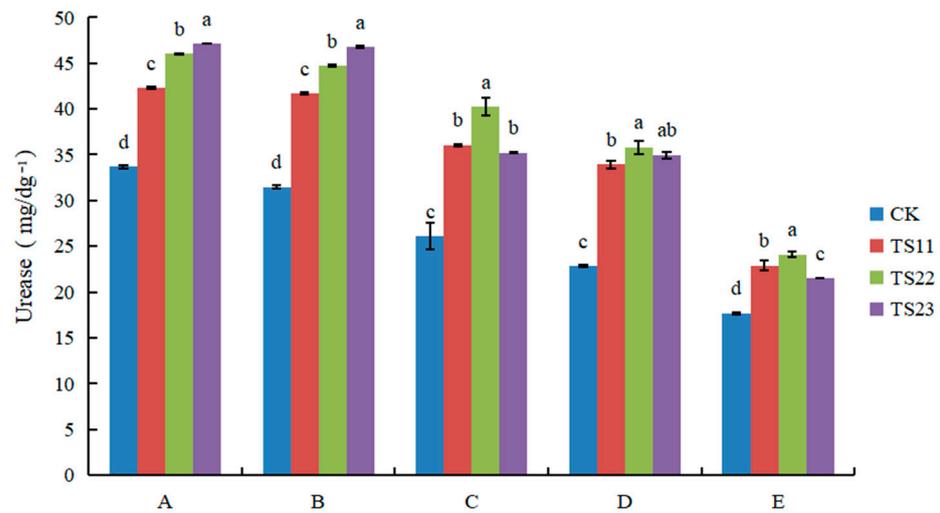


Figure 6. Effect of intercropping of flue-cured tobacco and *Salvia miltiorrhiza* on urease activity. Note: A: transplanting stage; B: rosette stage; C: vigorous growth stage; D: squaring stage; E: mature stage; CK: flue-cured tobacco monoculture; TS11: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 1:1; TS22: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:2; TS23: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:3; dg⁻¹: the dry weight per gram. Different letters on the bar graphs indicate significant differences in the mean of each treatment at $p \leq 0.05$.

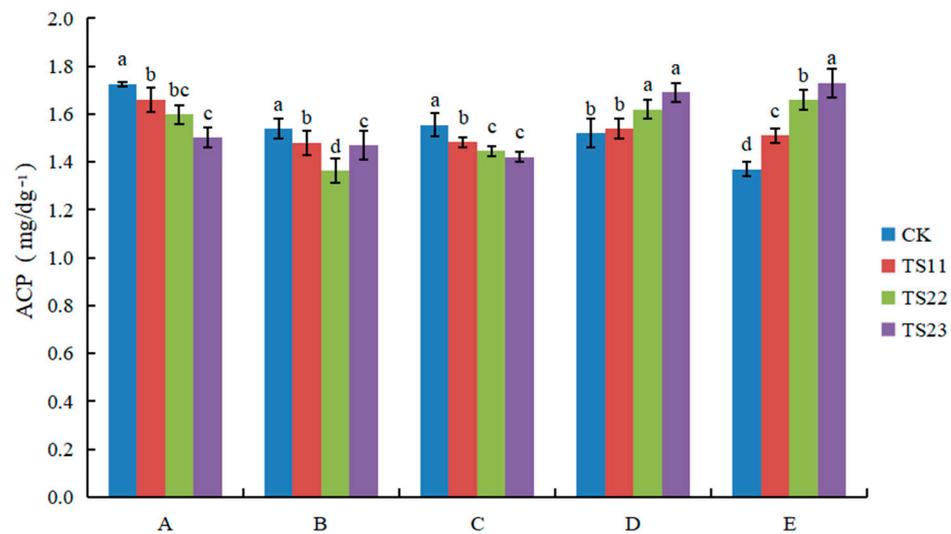


Figure 7. Effect of intercropping of flue-cured tobacco and *Salvia miltiorrhiza* on phosphatase activity. Note: A: transplanting stage; B: rosette stage; C: vigorous growth stage; D: squaring stage; E: mature stage; CK: flue-cured tobacco monoculture; TS11: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 1:1; TS22: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:2; TS23: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:3; dg⁻¹: the dry weight per gram. Different letters on the bar graphs indicate significant differences in the mean of each treatment at $p \leq 0.05$.

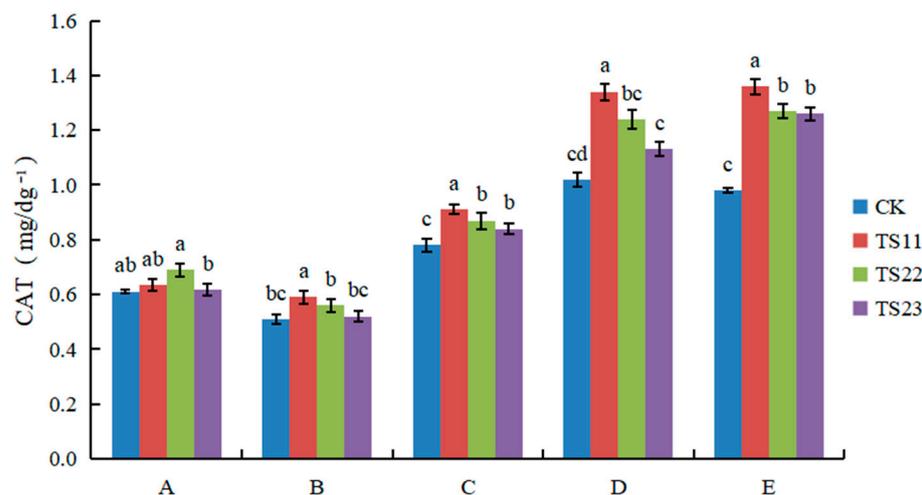


Figure 8. Effect of intercropping of flue-cured tobacco and *Salvia miltiorrhiza* on catalase activity. Note: A: transplanting stage; B: rosette stage; C: vigorous growth stage; D: squaring stage; E: mature stage; CK: flue-cured tobacco monoculture; TS11: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 1:1; TS22: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:2; TS23: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:3.; dg⁻¹: the dry weight per gram. Different letters on the bar graphs indicate significant differences in the mean of each treatment at $p \leq 0.05$.

3.3. Effect of Intercropping of Flue-Cured Tobacco and *Salvia miltiorrhiza* on Available Nitrogen, Phosphorus and Potassium Content of Soil

Intercropping *Salvia miltiorrhiza* increased the amount of soil available nitrogen (AN), available phosphorus content (AP), and decreased available potassium content (AK). With the development of flue-cured tobacco growth period, the soil available nitrogen content of the flue-cured tobacco monoculture and intercropping increased first and then decreased, and the highest value appeared in the vigorous growth period (Figure 9). The soil available nitrogen content of intercropping *Salvia miltiorrhiza* was not significantly different from that of the flue-cured tobacco monoculture at the transplanting stage, and was significantly higher than that of the flue-cured tobacco monoculture from the rosette stage to the mature stage. The order from high to low was TS23, TS22, TS11, and CK. There was no significant difference in soil available nitrogen content between flue-cured tobacco and *Salvia miltiorrhiza* intercropping and the flue-cured tobacco monoculture at the transplanting stage. The soil available nitrogen content from the rosette stage to the mature stage was significantly higher than that of the flue-cured tobacco monoculture, and the order from high to low was TS23, TS22, TS11, and CK.

The soil available phosphorus content of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was significantly higher than that of the flue-cured tobacco monoculture at the transplanting stage, rosette stage, and vigorous growth stage (Figure 10). The soil available phosphorus content of TS23 intercropping was significantly higher than that of the flue-cured tobacco monoculture at the squaring stage, and the soil available phosphorus content of flue-cured tobacco monoculture was slightly different at the mature stage.

The soil available potassium content of flue-cured tobacco and *Salvia miltiorrhiza* intercropping at the transplanting stage, rosette stage, vigorous growth stage, squaring stage, and mature stage was 13.30–23.02%, 27.10–34.15%, 28.98–36.78%, 41.27–47.77%, and 32.83–40.15% lower than that of the flue-cured tobacco monoculture, respectively (Figure 11). The difference was significant. The soil available potassium content of the flue-cured tobacco monoculture and intercropping was CK, TS11, TS23, and TS22 from high to low at the transplanting stage and rosette stage, and CK, TS11, TS22, and TS23 from high to low in the vigorous growth period, squaring period, and mature period.

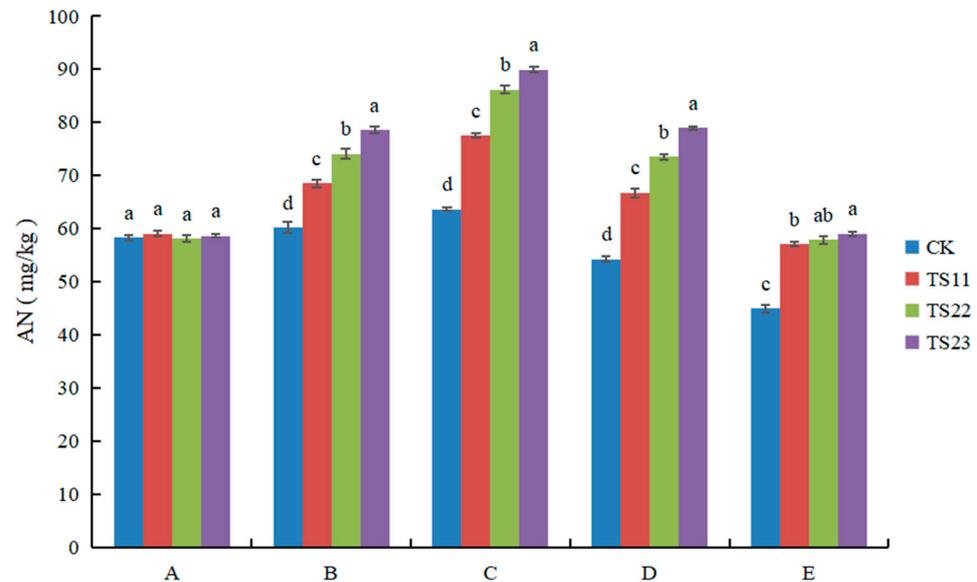


Figure 9. Effect of intercropping of flue-cured tobacco and *Salvia miltiorrhiza* on soil available nitrogen content. Note: A: transplanting stage; B: rosette stage; C: vigorous growth stage; D: squaring stage; E: mature stage; CK: flue-cured tobacco monoculture; TS11: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 1:1; TS22: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:2; TS23: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:3. Different letters on the bar graphs indicate significant differences in the mean of each treatment at $p \leq 0.05$.

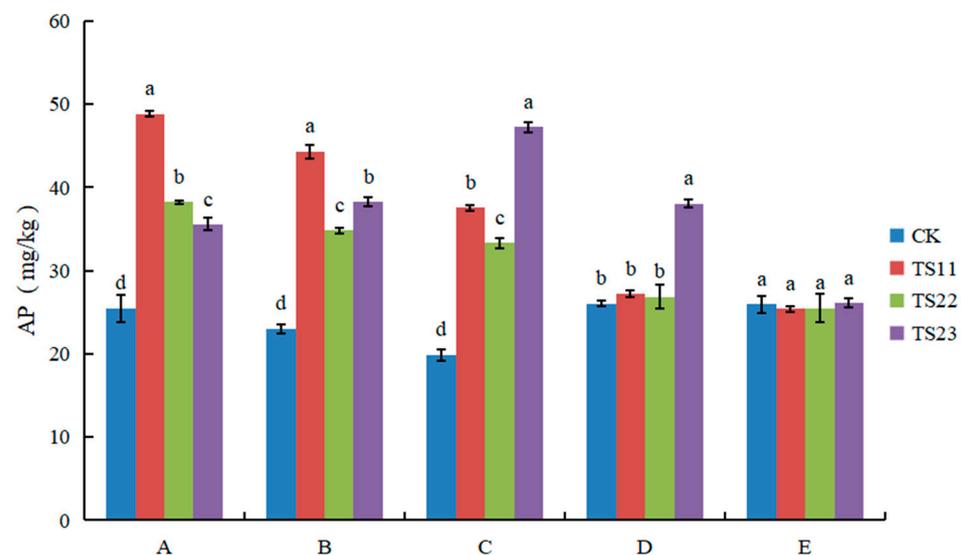


Figure 10. Effect of intercropping of flue-cured tobacco and *Salvia miltiorrhiza* on soil available phosphorus content. Note: A: transplanting stage; B: rosette stage; C: vigorous growth stage; D: squaring stage; E: mature stage; CK: flue-cured tobacco monoculture; TS11: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 1:1; TS22: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:2; TS23: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:3. Different letters on the bar graphs indicate significant differences in the mean of each treatment at $p \leq 0.05$.

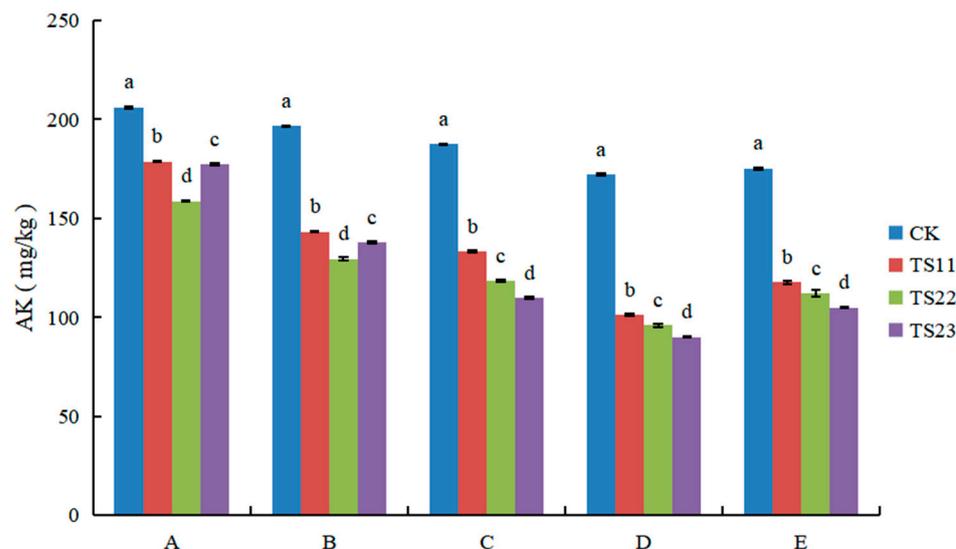


Figure 11. Effect of intercropping of flue-cured tobacco and *Salvia miltiorrhiza* on soil available potassium content. Note: A: transplanting stage; B: rosette stage; C: vigorous growth stage; D: squaring stage; E: mature stage; CK: flue-cured tobacco monoculture; TS11: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 1:1; TS22: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:2; TS23: the row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was 2:3. Different letters on the bar graphs indicate significant differences in the mean of each treatment at $p \leq 0.05$.

3.4. Effects of Tobacco-Tansy Intercropping on Yield and Quality of Flue-Cured Tobacco

Compared with the flue-cured tobacco monoculture, intercropping *Salvia miltiorrhiza* with flue-cured tobacco increased the proportion of top-grade flue-cured tobacco, but the intercropping reduced the planting density of flue-cured tobacco, and the yield was slightly reduced. In terms of total output value, intercropping *Salvia miltiorrhiza* with flue-cured tobacco significantly increased the total output value, and the TS11, TS22, and TS23 treatments increased the total output value by 8.1% and 14.1%, 21.3% and 22.4%, and 16.9% and 15.4%, respectively, compared with the CK, and the yield and total output value of the TS22 flue-cured tobacco were higher than that of TS11 and TS23 among the three intercropping modes (e.g., Table 2).

Table 2. Effect of intercropping *Salvia miltiorrhiza* on quality of flue-cured tobacco yield and total value of flue-cured tobacco field production.

	Treatment	Type	Top-Quality Tobacco (%)	Production (kg·ha ⁻¹)	Production Value (CNY·ha ⁻¹)	Total Production Value (CNY·ha ⁻¹)
2018	CK	T	48.05	2178.41	48,343.99	48,469.64
	TS11	T	49.41	1991.2	44,572.46	52,561.59
		S		826.44	7989.13	
	TS22	T	49.12	1969.47	44,769.57	58,799.49
		S		1451.52	14,029.92	
	TS23	T	49.59	1841.94	41,369.97	56,650.36
S			1591.71	15,280.39		
2019	CK	T	48.22	2140.93	47,635.68	47,635.68
	TS11	T	49.88	2106.46	47,152.13	54,367.72
		S		751.62	7215.59	
	TS22	T	49.58	2092.95	46,850.08	58,315.15
		S		1177.91	11,465.07	
	TS23	T	49.51	1870.87	42,019.64	54,985.44
S			1177.91	12,965.8		

Note: *Salvia miltiorrhiza* price 9.6, tobacco price control 22.25, intercropping according to 22.46.

In 2019, all indexes of median and upper leaves of all treatments met the standard of flue-cured tobacco quality, while total sugar, soluble sugar, and sugar–alkali ratio of the lower leaves were higher than the standard of quality flue-cured tobacco (e.g., Table 3). The total sugar, reducing sugar, nitrogen, and potassium content in each of the treated flue-cured tobacco leaves were arranged from high to low in the upper, middle, and lower parts. The total sugar and soluble sugar content of intercropping flue-cured tobacco showed that TS11 was the highest, TS22 was the second, and TS23 was the lowest. Compared with the flue-cured tobacco monoculture, intercropping flue-cured tobacco reduced the nitrogen content of upper and middle leaves and increased the nitrogen content of lower leaves. Except for the fact that the potassium content of the upper leaves of TS22 was lower than that of the flue-cured tobacco monoculture, the potassium content of each part of the flue-cured tobacco in the three intercropping modes was higher than that of the flue-cured tobacco monoculture. The nicotine content was 1.24–3.39%. The intercropping of flue-cured tobacco with *Salvia miltiorrhiza* increased the total nicotine content in the upper and lower leaves of flue-cured tobacco, and decreased the nicotine content in the middle leaves. The chlorine content was 0.12–0.18%, with the highest in the middle leaves and no significant difference between the upper and lower leaves. Except for the middle leaves of TS22, the chlorine content in all parts of intercropping flue-cured tobacco was lower than that of the flue-cured tobacco monoculture. The ratio of potassium to chlorine was 5.97–16.57, with the highest in the upper leaves, followed by the lower leaves, and the lowest in the middle leaves. The sugar–nicotine ratio was 6.90–22.09, and the sugar–nicotine ratio of the upper leaves of TS11, the middle leaves of TS11, and the middle leaves of TS22 was higher than that of the flue-cured tobacco monoculture. The chlor–alkali ratio was 0.63–1.25. The chlor–alkali ratio of the upper and middle leaves of intercropping flue-cured tobacco was slightly lower than that of the flue-cured tobacco monoculture, and the lower leaves were significantly lower than that of the flue-cured tobacco monoculture. It can be seen that intercropping *Salvia miltiorrhiza* improves the quality of tobacco leaves. Among them, TS11 treatment has the highest potassium content, total sugar and soluble sugar content, and potassium–chlorine ratio, and the lowest chlorine content. Therefore, from the analysis of the chemical composition of tobacco leaves, TS11 is the most conducive to improving the quality of flue-cured tobacco.

Table 3. Effect of intercropping of flue-cured tobacco and *Salvia miltiorrhiza* on the chemical composition of flue-cured tobacco leaves.

Treatment	Grade	Total Sugar	Reducing Sugar	Total Nicotine	Total Nitrogen	K	Cl	K/Cl	Glycemic Ratio	Ratio of Nitrogen to Alkali
		(%)	(%)	(%)	(%)	(%)	(%)			
CK	B2F	22.71 a	16.31 b	3.03 c	2.32 a	2.06 c	0.15 a	13.73 c	7.50 b	0.77 a
TS11	B2F	24.02 b	17.74 a	3.11 b	2.28 ab	2.21 a	0.13 ab	16.46 a	7.72 a	0.72 b
TS22	B2F	21.72 c	15.95 c	3.14 b	2.21 b	1.85 d	0.12 b	15.42 b	6.92 c	0.70 b
TS23	B2F	22.15 ab	15.46 c	3.21 a	2.18 b	2.14 b	0.14 a	15.79 b	6.90 c	0.68 b
CK	C3F	24.53 b	17.02 b	3.19 b	2.07 b	1.58 d	0.18 a	8.78 d	7.69 c	0.65 a
TS11	C3F	26.06 a	19.03 a	3.12 b	2.04 b	2.32 a	0.17 b	13.65 a	8.35 a	0.65 a
TS22	C3F	24.52 b	17.59 b	3.04 c	2.01 bc	1.91 b	0.16 c	11.94 b	8.07 b	0.66 a
TS23	C3F	23.86 c	16.47 c	3.39 a	2.12 a	1.91 b	0.18 a	10.61 c	7.04 d	0.63 a
CK	X2F	33.55 a	26.30 a	1.24 d	1.55 c	1.42 d	0.15 a	9.47 d	27.06 a	1.25 a
TS11	X2F	30.92 b	23.09 b	1.40 c	1.58 c	2.32 a	0.14 a	16.57 a	22.09 b	0.68 d
TS22	X2F	25.79 c	19.26 c	2.74 a	1.87 a	1.64 c	0.15 a	10.93 c	9.41 d	1.13 b
TS23	X2F	27.78 bc	20.68 c	2.12 b	1.75 b	1.83 b	0.13 ab	14.08 a	13.10 c	0.83 c

Note: The a, b, c, and d mean the representation of whether the difference is significant in the data analysis by the LSD method, and the difference containing the same letter is not significant.

4. Discussion

4.1. Intercropping of Flue-Cured Tobacco and *Salvia miltiorrhiza* Changed Soil Microflora

Increased bacterial population is an indication of increased soil fertility [26]. Sucrase can increase the content of soluble nutrients in soil, and its activity is often used to characterise soil fertility [27]. The number of bacteria and sucrase activity in the soil of flue-cured tobacco *Salvia miltiorrhiza* intercropping was significantly higher than that of the flue-cured tobacco monoculture, indicating that intercropping *Salvia miltiorrhiza* improves soil fertility in the flue-cured tobacco *Salvia miltiorrhiza* intercropping system. Similar results were obtained by Zhang Dongyan [28] who studied the intercropping of flue-cured tobacco and ginseng. Actinomycetes can produce antibiotics to inhibit soil pathogenic bacteria, catalase has a detoxification effect, and its activity is positively correlated with its detoxification capacity. The number of actinomycetes and catalase activity of the soil in the intercropping of flue-cured tobacco and ginseng were significantly higher than that in the monoculture of flue-cured tobacco, indicating that the intercropping of flue-cured tobacco and ginseng improved the soil microbiological environment. This was also confirmed in intercropping studies of flue-cured tobacco with garlic [29] and flue-cured tobacco with soybean [9]. The trend of catalase activity in this study was the same as that of soil actinomycetes, which implies that catalase and actinomycetes synergistically maintain soil microecological balance.

4.2. Intercropping of Flue-Cured Tobacco and *Salvia miltiorrhiza* Enhanced the Absorption of Soil Nutrients

The selectivity of plant nutrient uptake causes differences in soil nutrient uptake by different plants. The annual growth cycle of flue-cured tobacco is from April to August, and the ratio of nitrogen, phosphorus, and potassium uptake of flue-cured tobacco to nitrogen, phosphorus, and potassium is 1:0.3–0.5:2, which is relatively high [30], while the growth of *Salvia miltiorrhiza* is in the slow growth period from April to August, and the ratio of nitrogen, phosphorus, and potassium uptake is 1:0.09–0.11:0.44–0.61, which is relatively low [31]. The absorption of nitrogen and phosphorus of flue-cured tobacco is higher than that of *Salvia miltiorrhiza*, resulting in the available nitrogen and available phosphorus content of the soil of the flue-cured tobacco monoculture being lower than that of flue-cured tobacco and *Salvia miltiorrhiza* intercropping. Crops need to take up nutrients from the soil during the growth process, and at the same time transport organic compounds such as carbon, nitrogen, and other organic compounds to the soil in the form of root secretion, thus affecting the soil nutrient content. Differences in the amount and type of root secretions at different stages of crop growth cause seasonal changes in soil nutrient content. The types and quantities of root exudates in intercropping were significantly greater than those in monoculture, meaning that the seasonal variation of soil nutrients in intercropping was greater than that in monoculture. [32]. Soil urease activity was positively correlated with soil available nitrogen content, and the soil urease activity of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was higher than that of the flue-cured tobacco monoculture. In addition, the content of soil available nitrogen in the intercropping system of flue-cured tobacco and *Salvia miltiorrhiza* increased with the increase in the number of planting rows of *Salvia miltiorrhiza*, indicating that the absorption of nitrogen by *Salvia miltiorrhiza* was less than that of flue-cured tobacco. It can be seen that the soil available nitrogen content of flue-cured tobacco and *Salvia miltiorrhiza* intercropping is higher than that of the flue-cured tobacco monoculture, which is the result of the difference in nitrogen absorption of flue-cured tobacco and *Salvia miltiorrhiza* and the interaction of soil urease.

Differences in root morphology and root vigour are the main reasons for the differences in nutrient uptake in intercropping crops [33]. Root vigour of flue-cured tobacco near harvest in August declined, when *Salvia miltiorrhiza* was at the peak of nutrient uptake [34]. Soil available nitrogen content in the intercropping system of flue-cured tobacco and *Salvia miltiorrhiza* should be lower than that of the flue-cured tobacco monoculture, while the results of this study were contrary to the expectation. Fan et al. [35] found that soil

microorganisms could convert total nitrogen into available nitrogen and increase the soil available nitrogen content. Wang Shuping [36] and Wang Hua et al. [37] confirmed that soil available nitrogen content was closely related to the number of soil microorganisms. At the mature stage of flue-cured tobacco, the number of bacteria and actinomycetes in the intercropping system of flue-cured tobacco and *Salvia miltiorrhiza* was significantly higher than that of the flue-cured tobacco monoculture, which may be the main reason why the soil available nitrogen content of flue-cured tobacco and *Salvia miltiorrhiza* intercropping was significantly higher than that of the flue-cured tobacco monoculture at the mature stage of flue-cured tobacco.

Phosphorus mobility is poor, and the spatial distribution and dynamic changes in the roots are very important for phosphorus absorption. From April to August, the rapid development of flue-cured tobacco roots and the slow growth of *Salvia miltiorrhiza* roots caused the soil phosphorus absorption of the flue-cured tobacco monoculture to be greater than that of flue-cured tobacco and *Salvia miltiorrhiza* intercropping. Alkaline phosphatase is an inducible enzyme, and its activity is negatively correlated with soil available phosphorus content [38]. The soil phosphatase activity of the flue-cured tobacco monoculture was higher than that of flue-cured tobacco and *Salvia miltiorrhiza* intercropping from the transplanting period to the vigorous growth period, which just proved that the soil available phosphorus content of the flue-cured tobacco monoculture was lower than that of flue-cured tobacco and *Salvia miltiorrhiza* intercropping. The bud stage of flue-cured tobacco (22 July) coincided with the vigorous growth period of the *Salvia miltiorrhiza* root system to increase the absorption of phosphorus, so that the difference of soil available phosphorus content between the flue-cured tobacco monoculture and flue-cured tobacco *Salvia miltiorrhiza* intercropping decreased. It can be seen that the main reason for the difference in soil available phosphorus content between flue-cured tobacco *Salvia miltiorrhiza* intercropping and the flue-cured tobacco monoculture is that the root system of *Salvia miltiorrhiza* absorbs phosphorus from a range of weak to strong.

The proportion of potassium uptake by flue-cured tobacco from April to August was significantly higher than that of *Salvia miltiorrhiza*, and the available potassium content of soil in the single-crop system of flue-cured tobacco should be lower than that in the intercropping of flue-cured tobacco and *Salvia miltiorrhiza*, which was contrary to the results of this study. At the same time, we found that the potassium content of intercropping flue-cured tobacco was higher than that of monocropped flue-cured tobacco, suggesting that intercropping *Salvia miltiorrhiza* promotes potassium uptake by flue-cured tobacco (e.g., Table 2). Intercropping of flue-cured tobacco sweet potato and flue-cured tobacco peanut [39], flue-cured tobacco perilla intercropping [40], and flue-cured tobacco seed amaranth intercropping [41] also found that intercropping improved potassium uptake in flue-cured tobacco. Yang Tiezhao et al. [42] found that when the soil potassium supply was more adequate, the potassium content of flue-cured tobacco leaves is the highest, the upper leaf the lowest, and the potassium content of flue-cured tobacco leaf is the lowest when the soil lacks potassium. In this study, the potassium content of flue-cured tobacco monocropping and flue-cured tobacco intercropping was the highest in the upper leaves, followed by the middle leaves, and the lowest in the lower leaves, indicating that under the conditions of this experiment, both flue-cured tobacco intercropping and flue-cured tobacco monocropping need to increase the amount of potassium fertilizer.

4.3. Intercropping *Salvia miltiorrhiza* Increased Total Output Value and Improved the Quality of Flue-Cured Tobacco

With the increase in row ratio of flue-cured tobacco and *Salvia miltiorrhiza* intercropping, the planting area of *Salvia miltiorrhiza* increased, and the yield and output value of flue-cured tobacco decreased slightly. However, compared with the monoculture treatment of flue-cured tobacco, the intercropping treatment of flue-cured tobacco and *Salvia miltiorrhiza* could effectively increase the average price of tobacco leaves. At the same time, in addition to obtaining economic benefits through tobacco leaves, the intercropping

treatment of flue-cured tobacco and *Salvia miltiorrhiza* can also obtain benefits by planting the economic crop of *Salvia miltiorrhiza*. Therefore, the comprehensive benefits of the intercropping treatment of flue-cured tobacco and *Salvia miltiorrhiza* are higher than those of the monoculture treatment of flue-cured tobacco.

Potassium and chlorine are important elements affecting the quality of tobacco leaves. Improving the potassium content and potassium–chlorine ratio of tobacco leaves and reducing the chlorine content can improve the quality and safety of tobacco leaves [43]. Moreover, the quality of tobacco leaves is determined by the coordination of the content and proportion of chemical components in the leaves. It can be seen that the quality of intercropping flue-cured tobacco is better than that of monoculture flue-cured tobacco. Compared with the flue-cured tobacco monoculture, intercropping *Salvia miltiorrhiza* increased the potassium content and potassium–chlorine ratio of leaves in different parts of flue-cured tobacco, the total sugar and reducing sugar content of upper leaves and middle leaves, and decreased the chlorine content. Flue-cured tobacco perilla intercropping [40] and flue-cured tobacco grain amaranth intercropping [41] studies have obtained similar results.

4.4. Intercropping *Salvia miltiorrhiza* Alleviates Continuous Cropping Obstacles and Reflects Intercropping Advantages

Long-term continuous cropping of flue-cured tobacco will reduce field growth and agronomic traits, which will significantly affect the yield and quality of tobacco leaves [44]. Hao et al. [45] believed that the root cause of crop soil-borne diseases was that the directional selection of root exudates of continuous cropping crops stimulated the growth of pathogenic microorganisms in soil and inhibited the growth of beneficial microorganisms, resulting in soil microecological imbalance. The regulation of soil microbial community structure is the key to the prevention and control of soil-borne diseases, which depends on the group action of soil microorganisms. When the soil microbial community structure is richer and the diversity is higher, the comprehensive ability to resist pathogens is stronger [46]. In this study, the number of soil bacteria, fungi, and actinomycetes in each treatment increased first and then decreased with the growth period of flue-cured tobacco; however, the number of microorganisms in intercropping *Salvia miltiorrhiza* treatment was significantly higher than that in monoculture treatment, and the content of available nitrogen and available phosphorus in soil was significantly higher than that in the flue-cured tobacco monoculture. Insam et al. [47] also found that the number of soil microorganisms was positively correlated with the content of soil available nutrients. The increase in the number of soil microorganisms could enhance the conversion efficiency of soil nutrients and increase the available nutrient content of soil, which was consistent with the results of this study.

Intercropping advantage is the result of the interaction of aboveground and underground parts of intercropping plants [48]. Li et al. [49] found that the difference in plant height of intercropping crops can significantly change the light status of intercropping crops. The plant height of *Salvia miltiorrhiza* is 40–50cm, and the plant height of flue-cured tobacco is 130–160cm. Compared with the plane light receiving of flue-cured tobacco monoculture, the high and low intercropping of flue-cured tobacco and *Salvia miltiorrhiza* is beneficial to improve the light transmittance and light energy interception rate of the intercropping system, which is beneficial to increase the yield. The peak period of nutrient absorption of flue-cured tobacco (June–July) and the peak period of nutrient absorption of *Salvia miltiorrhiza* (July–November) [50] had an obvious time difference. The difference in plant type characteristics and nutrient absorption peak period between flue-cured tobacco and *Salvia miltiorrhiza* is one of the main reasons for the intercropping advantage of flue-cured tobacco and *Salvia miltiorrhiza*. After the harvest of flue-cured tobacco in August, the aboveground part of intercropping *Salvia miltiorrhiza* expanded the absorption space of light, heat, and gas resources, and the underground part expanded the absorption range of water and nutrients to promote the growth of *Salvia miltiorrhiza*. It can be seen that the main reasons for the intercropping advantage of flue-cured tobacco and *Salvia miltiorrhiza* are the difference of plant type of flue-cured tobacco and *Salvia miltiorrhiza* intercropping, the

stagger of the nutrient absorption peak period, and the expansion of the utilization space of aboveground and underground resources after flue-cured tobacco harvest. The intercropping system of flue-cured tobacco and *Salvia miltiorrhiza* not only improves soil conditions, but also helps to protect and promote the health of local organisms and the environment. However, ensuring the sustainability of this intercropping system and maximizing its potential advantages still requires in-depth research and scientific management.

5. Conclusions

Compared with the flue-cured tobacco monoculture, intercropping *Salvia miltiorrhiza* effectively improved soil nutrients, improved the soil micro-ecological environment, and contributed to the growth of flue-cured tobacco and *Salvia miltiorrhiza*. Intercropping of flue-cured tobacco and *Salvia miltiorrhiza* improves the quality of flue-cured tobacco and the proportion of superior tobacco, and increases planting efficiency. From the analysis of the chemical composition of tobacco leaves, TS11 (flue-cured tobacco and *Salvia miltiorrhiza* intercropping row ratio of 1:1), the potassium content, total sugar, and reducing sugar content of flue-cured tobacco leaves were the highest, and the quality was better than other treatments. In terms of total output value, TS22 (flue-cured tobacco and *Salvia miltiorrhiza* intercropping row ratio of 2:2) performed best, with the highest total output value and significant intercropping advantages. In summary, both TS11 and TS22 are conducive to reducing the continuous cropping obstacles of flue-cured tobacco. According to the different needs of flue-cured tobacco quality and output value, they can be selected. They are new flue-cured tobacco planting patterns worth promoting.

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