Effects of Straw Mulching on Microbial Quantity in Maize and Broccoli Soil in Dianchi Lake Basin

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Abstract. Field experiments were conducted in Dianchi basin to study the effects of straw mulching on the quantity of ammoniated bacteria, actinomycetes, and fungi in maize and broccoli soil, using dilution plate counting method. The results showed that: (1) Compared with bare soil and uncovered soil, plastic mulching and straw mulching could increase the number of microorganisms in Maize soil. Straw mulching could significantly increase the number of fungi in maize soil, reaching 6.5\times10^4 CFU·g\textsuperscript{-1} dry soil, which was 2.0, 1.4 and 2.7 times as much as that of plastic mulching, uncovered and bare soil respectively. The effects of straw mulching and plastic mulching on the number of other types of microorganisms in maize soils were not significantly different. (2) Compared with bare soil, straw mulching could increase the number of fungi in broccoli soil by 83\%, and plastic mulching could increase the number of actinomycetes and fungi. Straw mulching could increase the number of microorganisms in soils, which is of great significance to clarify the microbial mechanism of straw mulching to reduce non-point source pollution.

1. Introduction

Agricultural non-point source pollution is an important source of water environmental pollution. Agricultural non-point source pollution accounted for 53\% of total nitrogen and 42\% of total phosphorus in Dianchi Lake, 69.54\% of total nitrogen and 51.71\% of total phosphorus in Chaohu Lake \cite{1-2}. There were many studies on straw mulching to reduce non-point source pollution \cite{3-5}.

The important mechanism of straw mulching to reduce agricultural non-point source pollution load was the regulation of soil moisture by straw mulching and the change of soil microenvironment by straw mulching. Straw mulching changed the physical and chemical properties of soil, increased the number of microorganisms in soil, and increased the activity of microorganisms \cite{6-8}.

Previous studies had shown that the combination of straw mulching and crop intercropping had significantly reduced non-point source pollution in farmland of Dianchi Lake Basin \cite{9}. This paper studied the changes of microbial biomass in maize and blue-and-white soil in Dianchi Lake Basin, and had important theoretical value for exploring the microbial mechanism of reducing non-point source pollution by straw mulching.
2. Experimental materials and methods

2.1 Study area
The experimental site is located in the farmland of Dianchi River Basin, Kunming City, Yunnan Province (120° 45´ E, 25° 18´ N). It belongs to the low latitude plateau subtropical monsoon climate area, with an elevation of 1 916 m, an average annual temperature of 14.8°C and an average annual rainfall of 870 mm. It mainly produces rice, broad bean, maize and rap.

The experimental site is located in the farmland of 50 m East of the main road in Duanqi village. The basic physical and chemical properties of the soil were: pH 6.62, organic matter content 20.05 g·kg⁻¹, total nitrogen content 1.39 g·kg⁻¹, alkali-hydrolyzed nitrogen content 131.10 mg·kg⁻¹, total phosphorus content 4.07 g·kg⁻¹, available phosphorus content 115.51 mg·kg⁻¹, total potassium content 4.46 g·kg⁻¹, available potassium content 265.30 mg·kg⁻¹.

2.2 experimental material
Maize variety is "Haihe 28", Broccoli variety is "Youxiu".

2.3 experimental design
7 treatments were set up in the experiment, including bare soil without crop cultivation; maize without mulch; maize covered with agricultural film; maize covered with straw; Broccoli without mulch; Broccoli covered with agricultural film; Broccoli covered with straw. Straw straw was used as mulch, with an average thickness of 7.5 cm and a length of 10 cm, covering 6 000 kg·hm⁻². The area of the plot was 30 m². Each treatment was repeated three times and arranged in random groups.

2.4 sample collection
Soil samples were collected during the vigorous growth period of crops. In the process of sampling, organic impurities such as litter were removed and 500 mg of soil samples of 0-10 cm were collected.

2.5 assay method
Soil organic carbon, total nitrogen, soil alkali hydrolyzed nitrogen, total phosphorus, soil available potassium, pH value were analyzed by conventional soil chemistry method. The number of microorganisms was determined by dilution plate method.

3 Results
3.1 Effects of straw mulching on the number of ammoniated bacteria in soil of maize and broccoli
The number of ammoniated bacteria in soil of maize was 7.2×10⁶ CFU·g⁻¹, 6.8×10⁶ CFU·g⁻¹, 2.0×10⁶ CFU·g⁻¹ and 2.6×10⁶ CFU·g⁻¹ under plastic film mulching, straw mulching, bare soil and non-straw mulching, relatively. Compared with the bare soil and non-straw mulching, film mulching and straw mulching increased the number of ammoniated bacteria in soil of maize.

The number of ammoniated bacteria in soil of broccoli was 2.8×10⁶ CFU·g⁻¹, 2.1×10⁶ CFU·g⁻¹, 3.5×10⁶ CFU·g⁻¹ and 2.7×10⁶ CFU·g⁻¹ under plastic film mulching, straw mulching, bare soil and non-straw mulching, relatively. There were no significant difference the number of ammoniated bacteria in soil of broccoli among the four treatments. Compared with the bare soil and non-straw mulching, film mulching and straw mulching didn’t affected the number of ammoniated bacteria in soil of broccoli.
3.2 Effects of straw mulching on the number of actinomycetes in soil of maize and broccoli

The number of actinomycetes in soil of maize was \(3.7 \times 10^5\) CFU·g\(^{-1}\), \(7.5 \times 10^5\) CFU·g\(^{-1}\), \(7.5 \times 10^5\) CFU·g\(^{-1}\) and \(10.1 \times 10^5\) CFU·g\(^{-1}\) under plastic film mulching, straw mulching, bare soil and non-straw mulching, respectively. Compared with the bare soil, non-straw mulching, film mulching and straw mulching increased the number of ammoniated bacteria in soil of maize.

The number of actinomycetes in soil of broccoli was \(7.7 \times 10^5\) CFU·g\(^{-1}\), \(8.4 \times 10^5\) CFU·g\(^{-1}\), \(14.7 \times 10^5\) CFU·g\(^{-1}\) and \(8.5 \times 10^5\) CFU·g\(^{-1}\) under plastic film mulching, straw mulching, bare soil and non-straw mulching, respectively. Compared with the bare soil, non-straw mulching and film mulching, straw mulching increased the number of ammoniated bacteria in soil of broccoli.

3.3 Effects of straw mulching on the number of fungi in soil of maize and broccoli

The number of fungi in soil of maize was \(2.4 \times 10^4\) CFU·g\(^{-1}\), \(4.8 \times 10^4\) CFU·g\(^{-1}\), \(3.2 \times 10^4\) CFU·g\(^{-1}\) and \(6.5 \times 10^4\) CFU·g\(^{-1}\) under plastic film mulching, straw mulching, bare soil and non-straw mulching, respectively. Compared with the bare soil, non-straw mulching, film mulching and straw mulching increased the number of ammoniated bacteria in soil of maize.

The number of actinomycetes in soil of broccoli was \(6.6 \times 10^4\) CFU·g\(^{-1}\), \(9.8 \times 10^4\) CFU·g\(^{-1}\), \(9.9 \times 10^4\) CFU·g\(^{-1}\) and \(11.8 \times 10^4\) CFU·g\(^{-1}\) under plastic film mulching, straw mulching, bare soil and non-straw
mulching, relatively. Compared with the bare soil, non-straw mulching and film mulching, straw mulching increased the number of ammoniated bacteria in soil of broccoli.

![Figure 3](image_url)

**Figure 3.** The number of fungi in soil of maize and broccoli

4. Discussion

There are a lot of microorganisms living in the soil. They are the decomposers of the ecosystem. They provide nutrients for plant growth through the decomposition of organic matter, which has an important impact on the availability of plant nutrients, the circulation of nutrients in the soil and the ecological balance. The results showed that the composition, quantity and proportion of bacteria and fungi in soil could indicate the activity level of soil microorganism and measure the soil fertility.

Straw mulching changed the micro environment of the soil, and then affected the change of the number of microorganisms in the soil [12-13]. Ding et al [14] took 85 soil samples from 17 provinces as the research object, and found that straw returning can greatly stimulate the proliferation of microorganisms, and the order of increasing proportion was fungi > actinomycetes > bacteria. Straw mulching can increase the number of microorganisms in Shajiang black soil, and there are some differences in the optimal straw mulching amount corresponding to different kinds of microorganisms [8]. The number of soil nitrifying bacteria, ammoniating bacteria and phosphorus dissolving bacteria increases with the straw mulching amount, first increase and then decreases, while the number of mold increases with the straw mulching amount. Garcia-Orenes et al [7] covered straw in the Mediterranean agricultural system, increasing the content of organic matter in the soil, the number and activity of microorganisms, the abundance of fungi and the community structure of microorganisms.

In this paper, after mulching, the number of soil microorganisms in most of the treatments increased significantly, while the number of microorganisms in individual treatments did not change significantly, and the number of fungi in the soil planted with blue and white flowers increased significantly. These experimental results are consistent with the previous research results.

5. Conclusion

(1) The number of microorganisms in soil was increased significantly by crop combination.

(2) Mulching treatment can significantly increase the number of microorganisms in corn and blue and white soil.

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