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Effects of Sod-culture on the Soil Properties in Apple-alfalfa System

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Abstract:

It is important to understand the influence of sod-culture on orchard soil. In this study, the physical and chemical properties of the sod-culture's soil of the apple-alfalfa of four-year old was studied. The results showed: the bulk density of the soil decreased by 5.61% and the total porosity increased by 6.38%; the sod culture played an important role in the transformation of the soil's large conglomeration. The soil aggregate with a diameter of 0.25mm-2mm at 0cm-20cm of the soil surface was reduced by 3.6% compared with the control; the grain diameter greater than 0.25mm of each layer at soil surface of 20cm-60cm in the sod-culture orchard was higher 5.5% than that of monoculture. The soil pH decreased by 0.2, showing that the orchard sod-culture could adjust the soil pH to be neutral. This study provides an important reference for orchard soil management.

Keywords*: sod-culture, Apple-alfalfa, conglomeration, Soil pH*

I. INTRODUCTION

Orchard sod culture is an ecological culture mode of orchard in which herbaceous plants are planted between rows of fruit trees or in the whole orchard as soil cover. Before 1939, some orchards in southern Ukraine adopted to sod cover. After World War II, sod culture developed rapidly. At present, the area of sod-culture orchards in Europe, America and Japan accounts for more than 55%-70% of the total orchard area [1]. In fact, planting and utilizing green manure is one of the traditional experiences of agricultural production in China. As early as the 6th century AD, people realized that it was beneficial to plant legumes in orchards. It was not until the 1960s that green manure was widely popularized and applied in orchards, especially in 1970s and 1980s, when experiments and demonstrations were carried out in various places [2]. In 1998, China listed orchard sod-culture as an ecological orchard construction for promotion, but the area of monoculture orchard still accounts for more than 90% of the total area, and orchard sod-culture is only in the stage of experiment and small-area application [3].

The sod culture can promote the growth and development of fruit trees, and improve the yield and quality of fruits[4-10]. However, the literature at home and abroad shows that most of the research in this

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area focuses on the intuitive investigation and determination of some trees and varieties[11,12]. The research on the mechanism of this effect is rare. Therefore, it is of great significance to study soil, which is the basic condition of compound effect of orchard sod-culture, especially the soil properties, for optimizing orchard sod-culture mode and strengthening orchard sod-culture management[13,14].

II. MATERIALS AND METHODS

2.1 Study Site

This study was conducted in Peicun, Jiyuan, China(35° 11′, 112° 03′). the annual average temperature of 14.3℃, the annual average rainfall of 641mm, the annual accumulated temperature of 5262℃(≥0℃), the annual accumulated temperature of 4639℃(≥10℃), the total solar radiation of 494.1kJ/㎡, and the frost-free period of 262 days. The study site is located on a gentle slope terrace composed of diluvial fans and slope deposits, with the soil layer thickness of about 1m, the gravel content of 15%, the PH value of 8.3, the organic matter content of 0.69%-1.14%, the available nitrogen of 21.4mg/kg-80mg/kg, the available phosphorus of 5.416mg/kg and the available potassium of 61103.4mg/kg.

2.2 Materials and Methodology

The sample is quadrennial *Maluspumila*.cv. 'RedFuji', and the rootstock is *Malus sieversii*, with a row spacing of 3m×4m, the trees' average basal diameter of 3.9cm, the average tree height of 251cm and the average crown width of 298cm. High-position open-center tree shape is adopted, with the trunk height of 1.2m-1.5m, the central trunk height of about 2.5m-3m, the tree height of 2.5m-3m, the single crown and the leaf curtain layer thickness of about 2m. There are 3-4 main branches growing in the center. They are scattered up and down and horizontally extending in different directions, and the opening angle of the main branches is 70°-80°. The main branches were covered with drooping bearing branches and medium and small bearing branches. Falfalfa was biennial *Medicago sativa* 'Algonguin', which was sown between rows, 50cm away from the center of the trees compared with monoculture.

Within each standard, 0cm-60cm soil samples were collected by five-point method in layers (20 cm for each layer). The soil bulk density and field water-holding capacity were measured by cutting ring soaking, and the PH value was measured by titration.

III. Results

3.1 Effects of Sod Culture on Soil Bulk Density, Total Porosity and Capillary Porosity

Table I shows the investigation results of soil bulk density, total porosity and capillary porosity in quadrennial sod-culture orchard and monoculture orchard. The results show that sod culture significantly reduced the bulk density of different layers of the soils. Among it, the bulk density of 0cm-20cm soil decreased most obviously, 6.89% lower than that of the control; in the 20cm-60cm, the soil layer of sod

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culture was 4.79% lower than that of monoculture; in the 0cm-60cm, the sod planting soil layer was 5.61% lower than that of monoculture. Because of the distribution characteristics of plant roots, the residual dead roots play an important role in soil loosening, especially in the surface layer where sod roots are concentrated in the early sod culture period.

TABLE. I The main soil physical properties of two treatments

	Soil layer/cm	Bulk Density/g.cm^{-3}	Total Porosity/%	Field capacity /%
Sod-culture	0～20	1.32	56.78	20.66
	20～40	1.40	51.85	22.19
	40～60	1.51	46.28	24.63
Monoculture	0～20	1.42	50.52	19.39
	20～40	1.45	49.76	21.11
	40～60	1.52	45.28	20.52

Sod-culture increased the total porosity of soil by 6.38%. Compared with monoculture, 0cm-20cm sod culture soil layer increased by 12.42%, 20cm-40cm increased by 4.18% and 40cm-60cm increased by 2.22%. And the increase of total porosity decreased with the increase of soil level. However, the surface soil porosity of monoculture soil was low, only 49.52%, far lower than the corresponding soil layer of sod culture. The improvement of soil total porosity may be the result of the penetration of the huge plant roots of *Medicago sativa* 'Algonguin' in the soil.

The change of soil physical properties caused the change of field-capacity. It can be seen that the sod-culture obviously increased the field water-holding capacity of soil. According to the investigation, within the soil layers, the field water-holding capacity of sod-culture soil increased by 6.47% compared with that of monoculture soil.

The change of soil physical properties in sod-culture was directly affected by sod cover. The emergence and development of sod are vitally important for them. The following figure shows the change curve of soil bulk density and total soil porosity during four years of sod culture.

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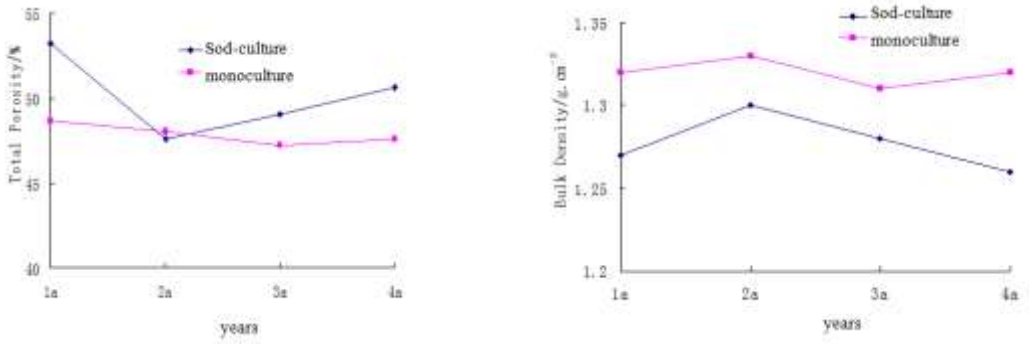

Fig 1: The annual changes on physical properties

From Figure 1, the soil bulk density gradually decreased with the increase of sod-culture years,while the soil porosity increased. However, the change was not significant compared with that of monoculture. This is because the root system of *Medicago sativa* 'Algonguin' grew bigger and bigger with the formation of sod cover. Besides, with the increase of soil animals and microorganisms, the soil porosity increased, and the soil bulk density decreased.

3.2 Effect of Sod Culture on Soil Conglomeration

Soil conglomeration plays an extremely important role in soil nutrient fixation. The results of the soil conglomeration of different soil layers in the study show that (Table II): the soil conglomeration (size 0.2mm-2mm) of the 0cm-20cm reduced by 3.6% compared with the control; in the 20cm-60cm soil layer, the soil conglomeration was improved, because sod culture promoted the transformation of soil with particle size below 0.25mm to large conglomeration. Compared with monoculture, the relative particle size of each soil layer in 20cm-60cm of sod-culture orchard increased by 5.5%, especially in the 20cm-40cm soil layer, with an average of 4.4%. This indicates that sod-culture plays an important role in the transformation of soil into large conglomeration.

TABLE. II The effects on soil conglomeration with sod-culture

	Soil layer/ cm	Soil Separate /%				
		＞2 mm	2～1 mm	1～0.5 mm	0.5～0.25 mm	＜0.25 mm
Sod-culture	0～20	0.5	0. 7	3.0	3.6	92.9
	20～40	0	0.3	2.4	4.7	92.6
	40～60	0.1	0.1	0.4	3.0	96.4
Monoculture	0～20	0.5	0.5	1.2	1.3	96.5

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20～40	0	0.1	0.5	2.4	97.0
40～60	0.3	0.3	0.6	1.3	97.5

3. 3 Effect of Sod Culture on Soil pH

The consecutive observation of the soil pH value of two types of treated orchard oil for four years shows (Figure 2): in the first year, the soil pH value of sod-culture was slightly higher than that of monoculture, but the difference was not significant; in the second year, the soil pH value of sod-culture treatment area began to decrease; in the third year, the soil pH decreased rapidly; in the fourth year of sod culture, the decrease of the pH value slowed down, and the pH value almost remained at the same level as that in the third year. The soil pH value of sod-culture orchard decreased by 0.2 in 4 years. The soil pH value in monoculture orchard showed an increasing trend, with an increase of 0.02 in four years. The maximum difference of soil pH value between sod-culture and monoculture was 0.21.

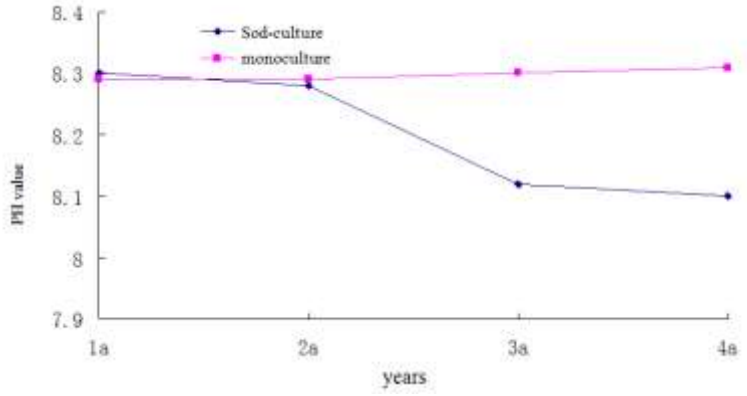

Fig 2: The annual changes on pH value

Similar research found that orchard sod culture can adjust the soil pH, and increase the pH of acid soil, while in the northern alkaline soil, it can decrease the soil pH, thus making the soil pH tend to be neutral. This is beneficial to plant growth and development.

IV. Discussion

In the four-years apple-alfalfa orchard ecosystem, the bulk density of soil decreased by 5.61% and the total porosity of soil increased by 6.38%. The increase of total porosity decreased with the increase of soil layers. In addition, sod culture increased the field capacity of soil by 6.47%. Sod culture played an important role in the transformation of soil into large conglomeration. The soil conglomeration (size: 0.25mm-2mm) of the 0cm-20cm decreased by 3.6% compared with the control. The relative grain diameter larger than 0.25mm of each layer of the 20cm-60cm soil was 5.5% higher than that of monoculture. During 4 years, the soil pH of sod orchard decreased by 0.2, while that of monoculture increased by 0.02. Similar research found that sod-culture can adjust the soil pH, and increase the pH of acid soil, while in the northern alkaline soil area, it can decrease the soil pH, making the soil pH tend to be

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neutral. In conclusion, orchard sod-culture can effectively improve the physical and chemical properties of orchard soil, which provides an important reference for green ecological management of orchards.

V. Conclusion

Statistics shows that the total apple planting area in China was 1.9425×10^6 km^2 by 2020, more than 50% of the world. Therefore, it is of great significance to strengthen apple orchard management and improve apple quality to promote the sustainable development of apple industry. Orchard sod culture is one of the effective measures to maintain the basic fertility of soil, improve the ecological environment of soil and promote the sustainable development of fruit industry. The results of this study showed that the apple-alfalfa orchard sod culture system could effectively improve the physical and chemical properties of soil. In the future, it is necessary to strengthen the research on soil fertility, microorganism and enzyme activity to accurately evaluate the system of orchard sod culture.

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