

Research Progress on the Effects of Different Soil Methods in Orchards on Soil Nutrients and Fruit Trees

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Abstract

With the continuous expansion of the area of orchards, there are many ways of soil management among orchards. Orchard main line used at home and abroad are covered with grass cultivation, stubble cover, natural grass, fruit intercropping. Different management methods have a great influence on soil nutrient status, root distribution of fruit trees, leaf nutrient yield and fruit quality. In this paper, the main 4 management methods of orchards at home and abroad are summarized: different soil management methods have different effects on soil Nutrients, fruit trees have different effects. This paper analyzes some problems existing in these four kinds of soil management methods and puts forward the problems that need to be solved in the future so as to provide a theoretical basis for exploring suitable soil management methods in orchard of our country.

Keywords

Orchard; Soil Management Methods; Soil Nutrient; Fruit Tree.

1. Introduction

According to the National Bureau of Statistics, as of 2015, China's orchard area is nearly 13 million hectares, of which the planting area of citrus and apple reaches 2.5 and 2.27 million hectares [1]. However, China's orchard soil ploughing management method mainly uses clear ploughing system as the main system, and long-term clear ploughing between orchard rows leads to the decline of soil organic matter, soil sloughing, microbial diversity decline and other decline problems. For mountainous or hilly orchards, the terrain difference is large, rainy weather is very easy to cause soil erosion. At the same time, clear ploughing makes a large area of land between the rows of the orchard vacant, but also causes a waste of land resources and other issues. In Europe and the United States and Japan and other developed countries are generally implemented in the orchard grass system, achieved good ecological and economic benefits [2]. In the orchard grass technology, the selection of grass species is the key to success. China's green manure germplasm resources are relatively rich, but China's vast territory, climate differences, soil types are relatively rich, so the green manure is more territorial, north and south differences, planting green manure varieties there are great differences. Moreover, different orchards, due to the different characteristics of fruit trees, cultivation of different densities, different ages of trees, resulting in fruit trees between the rows of depression characteristics, thus, the appropriate green manure varieties is crucial. Northern orchards suitable grass species are: white clover, perennial ryegrass; Southern orchards: Baxi grass, broad bean, etc..

At present, domestic and foreign orchard rows mainly used soil management system are: cover cultivation, stubble cover, natural grass, fruit farmers intercropping and so on. Mulching cultivation, mainly in the orchard rows planting clover, alfalfa, hairy leaf camphor, arrow end

peas, broad beans, pulse root, rape, February orchid, purple daffodil, sagebrush, ryegrass, buxus and other green manure; stubble mulching, refers to the harvest of crops after the stalks, including cornstalks, wheat straw, rice straw, etc., but also green manure and other above-ground, wood shavings, shredded paper, etc. cover the tree plate or between the fruit row; natural grass The term "natural grass" refers to the fact that no treatment is done between the rows of the orchard to let the weeds grow naturally, and too high to be mowed with a lawnmower; and the term "inter-cropping" refers to the planting of peanuts, chilli peppers, cucumbers and green vegetables between the rows of fruit trees. Different soil management practices have different effects on soil nutrient absorption, activation of insoluble nutrients, and different impacts on fruit trees and yields. For this reason, the purpose of this paper is to describe the current research progress on the effects of soil nutrients and fruit yield and quality after planting green manure in orchards.

2. Effects of Different Soil Management Patterns on Soil Nutrients

Soil organic matter is an important source of soil nutrients, and the change of soil organic matter content is an important characterisation of soil fertility and environmental quality status [2]. At the same time, soil organic matter is also a key factor governing soil physicochemical properties such as moisture, aeration, erosion resistance, fertiliser supply and retention capacity and nutrient effectiveness. After planting green manure in the orchard, especially some green manure with large biomass, such as alfalfa, arrow end pea, dry hemp, etc., the residues such as its above-ground and below-ground parts are transformed and decomposed in the soil to form humus, which improves the organic matter of the soil, and produces some humic acid, which has a certain effect on the activation of soil insoluble nutrients [3].

Planting green manure between orchard rows can significantly increase soil nutrients such as total nitrogen, effective nitrogen, effective phosphorus and total potassium [1]. Duan Shunshan et al [4] reported that the total soil N increased by 25.53% after intercropping Lychee with *Columnaris* for 3a. Chen Qingxi et al.[5] concluded that total N and quick-acting nitrogen in the soil increased by 17.4%-27.5% and 189.3%-217.1%, respectively, compared with the pre-grassing period. Huizhumei et al. [6] concluded that grassing of orchards could increase soil total N and quick-acting N content after planting grasses in wine vineyards. Yang Guiying et al. [7] planted duckweed and hawkweed in an apple orchard, the soil total N content increased compared with the control; quick-acting nitrogen content increased significantly in the second year after planting forage, but quick-acting nitrogen was significantly lower than the control in the third year after planting duckweed.

Stubble mulching is an ideal soil management system for orchards, which can effectively reduce the ineffective evaporation of soil moisture, thereby increasing soil moisture content, which is a very important way to mulch stubble between orchard rows in some rain-fed agricultural areas, such as orchards in arid and water-scarce areas of Northwest China, as well as orchards in mountainous and hilly areas of South China, which are not irrigated and lead to summer-seasonal drought. Li Huaiyu [8] conducted a pilot study on the soil management system of orchards in the high loess gully area and showed that mulching can stabilise the ground temperature and increase soil nutrients, and each kilogram of straw can be converted into 8.5g of organic matter after rotting, and at the same time, increase the content of effective phosphorus and quick-acting potassium. Yin Xiaoning et al [9] on the apple orchard of different mulching materials research found that mulching can significantly improve the orchard, especially the top soil organic matter content, increase a variety of nutrients, especially quick-acting potassium content, but the first two years of mulching, the 0-20cm layer of alkaline dissolved nitrogen significantly reduced.

Cao Baoqin et al.[10] found that in the natural grassing experiment in red Fuji apple orchard, planting 4 a (year) white clover orchard, 0-20 cm and 20-40 cm soil layer, organic matter content increased by 0.36% and 0.21% respectively, alkaline dissolved nitrogen increased by 20 mg/kg and 17 mg/kg, quick-acting phosphorus increased by 9 mg/kg and 8 mg/kg, quick-acting potassium increased by 14 mg/kg and 6 mg/kg, quick-acting potassium increased by 6 mg/kg. In addition, clover is a leguminous plant, the root system has a certain nitrogen fixation function; the ability of grass roots to absorb iron, calcium, zinc and boron is stronger than that of the root system of fruit trees, and it can be converted into the absorbent state of the fruit trees to be utilised, thus improving the soil fertility. Huang Yan and et al [11] also have similar conclusions, orchards of different grassing methods to improve the soil fast-acting nutrient content, different grassing methods of fast-acting nutrients on the impact of the difference is reflected in the magnitude of its improvement. Among them, the alkaline dissolved N increased the most with the whole orchard mulching, amounting to 30.2%, followed by strip mulching and dressing cover, and the increase of strip mulching was smaller; the quick-acting P increased the most with the strip mulching and dressing cover, amounting to 152.1%, followed by strip mulching and the increase of the whole orchard mulching was smaller; and the quick-acting K also increased the most with the strip mulching and dressing cover, amounting to 114.2%, followed by whole orchard mulching and the increase of the strip mulching was smaller.

At present, the country is vigorously implementing land transfer, some areas, farmers' land is basically leased to fruit producers, farmers in order to meet the daily needs of the phenomenon of planting vegetables between the rows of the orchard is common. Han Bing [6] found that intercropping of citrus and crops can significantly increase the soil alkaline dissolved nitrogen content, and at the same time, after intercropping crops, the soil nitrogen activation increased, and the proportion of effective soil nitrogen increased. However, among them, vegetables such as cabbage and cucumber, which have a high demand for soil nitrogen, did not produce competition with citrus for effective nitrogen.

3. Effects of Different Soil Management Patterns on Roots and Leaves of Fruit Trees

The root system as an important organ of fruit trees to absorb nutrients and water, has an important role in ensuring the nutritional balance of fruit trees. Fruit trees as perennial plants, in the process of their growth and development, the root system is also growing. A. E. Klodd et al [19] found that shallow rooted perennial herbs will lead to vertical distribution of grape roots, and reduce the total length of the root system, and the control compared to the orchard mulching cultivation root system total length reduced by 63.88%; and that promote the root system of the fruit tree downward rooting. Atkinson [20] found that in herbicide-treated areas (clearcutting), 75% of adult apple roots were located below the topsoil, and in mulch-cultivated areas, fruit tree roots were distributed under 10 cm and were able to promote the growth of short lateral roots. E. E. Sánchez et al. [21] found that, following planting of alfalfa and white clover in an apple orchard, compared to clearcutting, leaf nitrogen, phosphorus, potassium, calcium, magnesium, and iron were all increased; mulching cultivation affected the net accumulation of magnesium in apple leaves in four seasons of the year, while potassium produced net accumulation in only three seasons.

Orchard stubble mulching, in the early spring can increase the orchard soil temperature, improve soil humidity, enhance the root system vitality, so that the root system vitality is enhanced, so that the root system early activities, promote the growth of above-ground branches and leaves and light and leaf curtains are built early, which is conducive to the tree as early as possible for photosynthetic accumulation [23]. At the same time, the fruit tree

backbone root increase, improve the fruit tree absorption capacity, make the grape plant performance of thick stems and leaves, leaf colour green [24].

Natural grass treatment, generally mainly weeds, the main root is short, the lateral roots are more developed, most of the root system is distributed in the 0-20cm soil layer, while the root system more than 20cm weeds are less. At the same time, the root system of different fruit trees is distributed at different levels. The study by He Yansen et al [22] found that the weed root system was not distributed at the same level as the honeydew root system, i.e., there was no competition between the weed and honeydew root systems. Yao Qing et al. [25] studied nutrient competition between Luo Gang orange and *Columnaris* in a root box with Luo Gang orange and *Columnaris* as the test material, and concluded that mowing mainly reduces or eliminates the nutrient competition between fruit trees and forage grasses through the effect on the root system, and presumed that the root distribution of forage grasses is at the same level as that of fruit trees, which means that there is no competition between weeds and honeydew root system. It is assumed that the root distribution of pasture grasses plays an important role in the nutrient partitioning in the fruit tree herbaceous system.

Planting green manure between rows of orchards can affect the growth and development of fruit trees, increase fruit tree yield and improve fruit quality, although there is a gap between the conclusions of different studies, most of the studies show that green manure in orchards can increase fruit tree yield and improve fruit quality. Li Huike [12] found that planting white clover and perennial ryegrass in the orchard significantly improved fruit quality, and with the increase in the number of years of grass production, fruit quality continued to improve. Cao Baoqin et al. found that planting clover could improve the yield and quality of apples. Moreover, different green manure varieties have different impacts on the yield and quality of fruit trees, and the planting of green manure in the orchard can increase the single fruit weight, soluble solids, fruit hardness, fruit shape index, and yield per unit area of apples, but the increase is related to the grass species[10].

Liang Xiaoyu et al[14] found that after 1 year of planting chicory in citrus orchards, the fruit yield of the treatment group was 3.225t/ha, while the clear-tillage treatment was 3.663t/ha, i.e., after planting chicory, the yield was nearly 12% compared to clear-tillage. Huizhumei [15] reached similar conclusions in vineyards, where Cabernet Sauvignon grape yields, compared to clear-tillage, decreased by 41.17%, 29.41%, and 5.88%, respectively, after planting white clover, alfalfa, and perennial ryegrass in vineyards.

Sheni Du et al [16] studied on apple orchards on the Loess Plateau covered with *Zygomyrna* residue and found that fruit yield and single fruit weight increased by 16.9% and 7.9%, respectively, after 4 years of covering *Zygomyrna* residue compared to clear ploughing. Eugene J et al [17] also found that residual stubble mulching had a significant effect on cumulative yield of fruit trees during the 5-year period of the fruit tree's yield-forming stage, but with the increase of mulching years, this benefit would be reduced by 4.7% and 5.5%, respectively, as the number of years of mulching increased. However, as the number of years increased, this benefit gradually disappeared. Mulching between rows of orchards not only suppresses weeds, but also improves soil nutrients, thus increasing the yield and improving the quality of fruit trees. Shi Jin et al [13] found that natural grass treatment fruit yield and single fruit weight and clear ploughing treatment reached a significant level at 0.05 level, natural grass can effectively improve the single fruit weight of dress apple, thus increasing the yield, and at the same time reduce the hardness of the fruit flesh and pH value, improve the taste of the fruit.

Due to the lack of rural labour, the orchard rows do not take other measures, let it be overgrown with weeds, or mowed with a lawnmower mowing mode is also very common, especially in the hills, mountain orchards, the terrain is complex, weed mowing difficulties, often are used throughout the garden natural grass. The effect of natural grass on the yield and quality of fruit trees has been the subject of different studies with varying results. Huang Yanhe et al [11] found

that the whole garden grass has a greater impact on fruit yield, from the 2-year average, its yield is only 48% of the clear-cutting treatment, and the banded grass and mulch and banded grass fruit yield is also only 76% and 81% of the clear-cutting treatment, respectively. It is believed that there is a certain effect of grassing on fruit trees.

Han Bin [6] in the study of citrus and cucumber and vegetable intercropping found that, compared with citrus monoculture, intercropping cabbage can significantly improve the citrus soluble solids content, total sugar and VC increase, soluble acid decrease, solid-acid ratio, sugar-acid ratio are significantly improved, citrus taste sweet, good effect of slagging, rich flavour, fruit grade of more than one level; and intercropping cucumber after the citrus soluble solids have been reduced, and the sugar content of the fruit. After intercropping with cucumber, the soluble solids of citrus were reduced, the sugar content of fruit was too low, only 8.75g/100ml, and the acidity reached 0.955g/100ml, which was of poor quality, and it had a certain unfavourable effect on the yield of citrus.

4. Shortcomings and Prospects

Although green manure germplasm resources are abundant, the appropriate green manure varieties in specific regional orchards remain unclear. Moreover, green manure is divided into winter green manure and summer green manure, different regions of China, climate conditions vary greatly. Winter green manure should be considered both the temperature of normal growth, but also to consider whether it is safe to overwinter. Summer green manure, consider some tolerant varieties, such as less precipitation areas, should consider drought tolerance, salt tolerance, shade tolerance and other characteristics.

Orchard row planting green manure varieties root distribution status research less, and fruit tree root interactions less research. Different green manure varieties and different fruit tree varieties root system between the existence of what kind of interactions, is the future need for further research.

Different green manure varieties, the impact on the soil and fruit trees, but also very different. It is undeniable that planting green manure in orchards can significantly improve soil nutrients. It also has significant benefits in controlling soil erosion. However, Huang Yan and [11] et al. concluded that some green manure varieties have chemosensory effects on the root system, which may lead to a decrease in the root vigour of fruit trees, which may lead to fruit yield reduction and quality decline. Therefore, in the orchard, screening out suitable ones, which can improve soil nutrients, but also increase fruit yield and improve fruit quality, will be the direction of future research.

Orchard rows or tree discs covered with stubble, straw, etc., that can achieve the suppression of weeds, but also moisture retention, increase the soil's fast-acting nutrients. Reduce the effective radiation of the ground, thus reducing the near-surface temperature, improve the above and below ground environment, for the quality of the soil and the function of the play to create the amount and favourable conditions, but also for the formation of the yield to lay the foundation [18]. However, large areas of orchard rows covered with stubble, especially corn stalks, wheat straw and other crop stalks, on the one hand, can solve the problem of large-scale straw burning triggered by the lack of storage of farmland straw, on the other hand, large areas of straw mulching or hay mulching, especially in the summer high temperature weather, particularly prone to cause fires. At the same time, straw, corn stalks and other carbon and nitrogen ratio are high, cover the ground, in the microbial decomposition process, must need exogenous nitrogen inputs, if the nitrogen fertiliser is not enough in the early stage, it is likely to lead to the phenomenon of competition for fertilizer and fruit.

Orchard natural grass, is a relatively simple way, but some studies have shown that the whole orchard grass will reduce the fruit yield and reduce the quality of the fruit [11]. Moreover, the

way of natural grassing is that the weeds are constantly mowed between the rows of the orchard, so that what was a variety of weeds, only one weed with a clear competitive advantage is left. Whether this dominant weed, then, has a chemosensory effect, which can lead to fruit tree yield reduction, or cause pest and disease problems, is unclear in these respects. In addition, natural grass, the content of nutrients absorbed from the soil and the amount that can be returned to the soil after mowing is still unclear, whether it has no effect on the nutrient growth of fruit trees? But grass can increase orchard biodiversity, can reduce insect pests, increase the appearance of fruit quality research, to be further in-depth study.

Growing vegetables between the rows of orchards is a way of high land utilisation. However, the cultivation of vegetables brings a large amount of chemical fertiliser and pesticide inputs. This may lead to orchard soil acidification, soil microbial diversity disorders, soil pathogenic bacteria increase, harmful to fruit trees; pesticide inputs, which may lead to a decline in fruit quality. On the other hand, if chemical fertilisers are not applied, there may be competition for nutrients with fruit trees because vegetables are crops with high nitrogen demand. Therefore, in how to efficiently use the land between the rows of orchards, the problem still needs further research and discussion.

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