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Research Progress on Formation Mechanism of Plant Continuous Cropping Disorder

Lirong He[1, 2, 3, 4], Na Wang[1, 2, 3, 4]

[1]Shaanxi Provincial Land Engineering Construction Group Co., Ltd, Xi'an, Shaanxi, 710075, China

[2]Institute of Land Engineering Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an, Shaanxi, 710075, China

[3]Key Laboratory of Degraded and Unused Land Consolidation Engineering, the Ministry of Natural Resources, Xian, Shaanxi, 710075, China

[4]Shaanxi Provincial Land Consolidation Engineering Technology Research Center, Xi'an, Shaanxi, 710075, China

Abstract

In view of the widespread and serious situation of continuous cropping obstacle, the specific performance and harm of continuous cropping obstacle were summarized. The research progress of the formation mechanism of continuous cropping obstacle in recent years was summarized from three aspects : the change of soil physical and chemical properties, the deterioration of soil biological environment and the allelopathy. It can be seen that continuous cropping has different degrees of influence on plant morphology, leaf photosynthesis and reactive oxygen metabolism, which hinders the absorption and accumulation of various nutrients, aggravates the disease of plant roots, and leads to lower crop yield and poor quality. In the formation mechanism of continuous cropping obstacles, the changes of soil physical and chemical properties mainly include poor physical properties, secondary salinization, acidification and nutrient imbalance. The deterioration of soil biological environment refers to the decrease of soil enzyme activity, the decrease of soil microbial community diversity index, richness and evenness index, the transformation of soil microbial flora from ' bacterial type ' to ' fungal type ', and the decrease of the number of beneficial antagonistic bacteria with the increase of the number of pathogenic microorganisms. The allelopathy and autotoxicity mainly refers to the toxic effects of plant water extract, plant residue decomposition and root exudates. At present, the phenomenon of continuous cropping obstacle caused by the above mechanism is becoming more and more prominent. In the future, it is necessary to further study the relationship between bacteria and the synergistic mechanism from the perspectives of physiology, metabolism and genetics, so as to promote the development direction of the mechanism research and practical application of fungicides in the prevention and treatment of plant diseases.

Keywords

Continuous cropping obstacles; Formation mechanism; Environmental deteriorationt.

1. Introduction

After continuous cropping of the same plant or related plants, even under normal management, the phenomenon of poor fertility, serious diseases and insect pests, low yield and poor quality will occur, which is called continuous cropping obstacle [1]. Japan calls this kind of problem a taboo phenomenon, European and American countries call it replant disease or replant

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problem. Due to the development trend of intensification of modern planting industry, high multiple cropping index and single species, the continuous cropping obstacle of plants is becoming more and more prominent. This paper summarized the latest progress in the study of continuous cropping obstacles, including the hazards and main formation mechanisms of continuous cropping obstacles, especially the detailed analysis of the formation mechanism of continuous cropping obstacles caused by the deterioration of soil biological environment, and prospected the hot issues that should be paid attention to in the future, so as to provide scientific basis for the sustainable land use and plant cultivation management.

2. The Harm of Continuous Cropping

2.1. Effect of Continuous Cropping on Plant Growth and Development

Plant continuous cropping has different degrees of influence on plant morphology, photosynthetic physiological characteristics of leaves and active oxygen metabolism. Continuous cropping reduces plant height, leaf volume, chlorophyll content and photosynthetic rate [2]. Continuous cropping also led to the accumulation of reactive oxygen species and membrane lipid peroxidation damage, directly affecting its growth and development. The root growth of continuous cropping plants was affected, and the root activity decreased.

2.2. Effects of Continuous Cropping on Nutrient Characteristics of Plants

Continuous cropping has seriously affected the absorption and accumulation of various nutrients by plants. The results showed that the contents of nitrate nitrogen, available phosphorus and available potassium in soybean plants decreased significantly under continuous cropping. However, some studies have found that the absorption of nitrogen in continuous cropping soybean plants remained within the normal range, but the absorption of phosphorus and potassium significantly reduced the absorption of trace elements in soybean under continuous cropping stress, while the absorption of medium element calcium increased significantly.

2.3. Effect of Continuous Cropping on Plant Diseases

Continuous cropping aggravated plant diseases, especially root diseases. The incidence of black shank and brown spot increased after continuous cropping of flue-cured tobacco; after continuous cropping of carrot in spring and autumn, root-knot nematodes and black rot occur seriously and spread year by year [3].

2.4. Effects of Continuous Cropping on Plant Yield and Quality

Under continuous cropping conditions, plant growth and development are affected, resulting in a decrease in yield. The biological yield of continuous cropping soybean decreased by 7.2 %~14.5 %, and the yield of soybean decreased by 12.1 %~14.5 % at harvest time. In addition to reducing the yield of plants, continuous cropping can also deteriorate their quality. With the extension of continuous cropping years, the contents of soluble solids and vitamin C' in cucumber decreased, but the nitrate content increased [4].

3. Main Mechanism of Continuous Cropping Obstacle Formation

On the formation mechanism of continuous cropping obstacles, the ' toxin theory ' was first proposed, and later was considered to be the phenomenon of ' mutual generation and mutual restraint ' between organisms. In 1983, Long Island of Japan proposed the ' five factors theory ' of continuous cropping obstacles. Throughout the research results of scholars at home and abroad, combined with our scientific research practice, the main mechanisms for the formation of plant continuous cropping obstacles can be summarized as follows.

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3.1. Changes of Soil Physical and Chemical Properties

2.1.1 Poor soil physical properties

The results showed that with the increase of planting years, 0.25~2mm water-stable aggregates in protected soil increased, capillary pores developed and water-holding capacity was good. However, salt accumulation caused by continuous cropping would make soil hardening, so that the proportion of soil inactive pores was relatively reduced, and the ventilation and permeability became worse.

2.1.2 Soil secondary salinization and acidification

Continuous fertilization under continuous cropping conditions, resulting in increasing soil salinity, resulting in soil secondary salinization, thereby affecting plant growth and development. The study found that long-term continuous cropping can cause significant decline in soil yang value, causing soil acidification [5], and ultimately related to the change of soil nutrient availability, resulting in abnormal nutrient absorption of plants, thereby affecting growth and development.

2.1.3 Soil nutrient imbalance

Long-term continuous cropping of the same plant will inevitably result in the deficiency of one or several nutrient elements in the soil, while other nutrient elements are increasingly accumulated, resulting in soil nutrient imbalance. For example, the available phosphorus in carrot continuous cropping land was seriously exceeded; however, after continuous cropping of cucumber, there is excess phosphorus in the soil and excessive consumption of potassium, resulting in nutrient imbalance [6]. When the lack of nutrients in the soil is not timely and reasonable supplement, it will cause deficiency and affect the normal growth of plants.

3.2. Deterioration of Soil Biological Environment

Continuous cropping worsened the biological environment of soil, resulting in changes in soil enzyme activity and soil microbial status, thereby affecting the growth and development of plants.

3.2.1 Changes of soil enzyme activity1.1.1 Inorganic Stimulation

Soil enzyme is an important biological indicator of soil quality. The results showed that with the increase of continuous cropping years, the activities of soil acid phosphatase, invertase and vein enzyme decreased, and the activity of catalase increased gradually [7]. However, some studies have found that most of the changes in soil enzyme activity showed an inverted ' saddle ' shape. Different researchers have different conclusions, indicating that soil enzyme activity may be affected by soil geological background, fertilizer, plants and other factors.

3.2.2 Changes of soil microorganism

Soil microorganisms, including bacteria, fungi, actinomycetes, algae, protozoa, etc., play a very important role in the degradation of plant residues, the formation of humus, and nutrient transformation and circulation [8~9]. This important physiological function has attracted wide attention of scholars.

3.2.2.1 Changes of soil microbial community structure

Studies have shown that the diversity index, richness and evenness index of soil microbial community decrease with the increase of continuous cropping years [10].

3.2.2.2 Changes of soil microbial quantity and flora

Continuous cropping led to great changes in the number of soil microorganisms, specifically: (1) The total amount of microorganisms decreased; (2) The number of bacteria decreased significantly and the number of fungi increased, i.e. the transformation of soil microbial flora from ' bacterial ' to ' fungal '; the number of actinomycetes changed little or showed a decreasing trend.

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3.2.2.3 Changes of soil microbial physiological groups

The main physiological groups of soil microorganisms in continuous cropping were analyzed. The results showed that the number of autotrophic nitrogen-fixing bacteria and aerobic cellulose decomposing bacteria decreased significantly, the number of denitrifying bacteria increased significantly, the number of nitrifying bacteria increased or decreased, and the number of ammonifying bacteria changed little. Continuous cropping resulted in the decrease of beneficial microbial groups and the increase of unfavorable microbial groups in soil, which had adverse effects on normal life activities of plants.

3.2.2.4 Increased number of soil pathogenic microorganisms

Fusarium oxysporum is a typical soil-borne disease fungus. Studies have shown that cucumber continuous cropping can increase the number of Fusarium oxysporum in soil with the increase of continuous cropping years [11], and reduce the number of beneficial antagonistic bacteria, resulting in increased soil borne diseases and insect pests.

3.3. Allelochemical Autotoxicity

Allelopathy refers to the beneficial or adverse effects of plant or microbial metabolic activities on other plants or microorganisms in the environment. If the allelochemicals released by plants inhibit the growth of the same or similar plants in the same stubble or next stubble, this allelopathy is also known as autotoxicity [12].

3.3.1 Autotoxicity of plant aqueous extracts

Stem, leaf, root and other tissues of plants can produce chemicals that are harmful to the growth and development of plants under the flushing and leaching of rainwater, which can be confirmed by studying the autotoxicity of aqueous extracts from various parts of plants [13].

3.3.2 Toxicity of plant residue decomposition

Plant residue decomposition is one of the important ways for plants to release allelopathy and autotoxic substances. Studies have shown that soybean decomposition stubble reduces the dry weight and root activity of soybean roots, and significantly reduces soybean yield. The decomposition solution of G. radiata significantly inhibited seed germination, radicle and seedling growth [14].

3.3.3 Allelopathic effect of root exudates

3.3.3.1 Autotoxicity of root exudates

Broadly speaking, root exudates include exudate, exudates and viscose, shedding three types. Studies on watermelon, tobacco and strawberry show that root exudates of plants have a certain inhibitory effect on their own seed germination and seedling growth, and this inhibitory effect increases with the increase of root exudates concentration [15].

3.3.3.2 Indirect effect of root exudates on plants

In addition to direct autotoxicity on plants, root exudates may also indirectly affect plants by changing the physical and chemical properties of rhizosphere soil. In addition, plant root exudates can also affect the population dynamics of soil pathogenic microorganisms. It was found that the root exudates of soybean after continuous cropping could stimulate the growth of soybean root rot pathogen, promote its proliferation, and finally aggravate soybean plant diseases.

4. Summary

Continuous cropping has different degrees of influence on plant morphology, leaf photosynthesis and reactive oxygen metabolism, which hinders the absorption and accumulation of various nutrients, aggravates the disease of plant roots, and leads to reduced crop yield and poor quality. In the formation mechanism of continuous cropping obstacles, the

changes of soil physical and chemical properties mainly include poor physical properties, secondary salinization, acidification and nutrient imbalance. The deterioration of soil biological environment refers to the decrease of soil enzyme activity, the decrease of soil microbial community diversity index, richness and evenness index, the transformation of soil microbial flora from ' bacterial type ' to ' fungal type ', and the decrease of the number of beneficial antagonistic bacteria with the increase of the number of pathogenic microorganisms. The allelopathy and autotoxicity mainly refers to the toxic effects of plant water extract, plant residue decomposition and root exudates. At present, the phenomenon of continuous cropping obstacle caused by the above mechanism is becoming more and more prominent. In the future, it is necessary to further study the relationship between bacteria and the synergistic mechanism from the perspectives of physiology, metabolism and genetics, so as to promote the development direction of the mechanism research and practical application of fungicides in the prevention and treatment of plant diseases.

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