Effect of light on soil microstructure and soil elements

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Abstract. Light has certain energy, so it can change the soil microstructure and the elements in the soil when it radiates the soil. In this paper, the changes of total nitrogen and organic carbon in the soil under white light were studied. The results showed that: the light had an activation effect on the organic carbon in the soil; the light exposed the organic matter in the soil, accelerated the decomposition of organic matter, and reduced the total content of organic carbon. The results show that the infrared light has no effect on the soil structure, and the ultraviolet light can change the soil structure.

1. Introduction

With the development of human and society, the contradiction between human and land becomes more and more prominent with the acceleration of development speed, among which the problem of cultivated land is a strategic and important problem in the process of modern development \cite{[1,2]}. The problem of cultivated land is more and more serious because of the small per capita cultivated land area in China. In order to improve the grain yield, a large number of pesticides and chemical fertilizers have become the main means to increase the crop yield \cite{[3,4]}. In the process of using chemical fertilizer, N element is the most needed element for crops at present. However, in addition to being absorbed and utilized by crops, there are also microbial fixation, mineral absorption, nitrogen volatilization, and denitrification. Finally, a large amount of nitrogen remains in the soil in the form of NO\textsubscript{3}-N \cite{[5]}. Carbon in soil is also an important factor affecting crop growth. Plants usually absorb carbon dioxide from the air through photosynthesis, which can generally meet the basic needs of crops. However, it is also an important process for crop growth to absorb water-soluble organic carbon from soil by roots. Soil carbon pool is the largest carbon pool in the terrestrial ecosystem at present. Research shows that the global soil organic carbon pool is about 1500-2000 PG, and the inorganic carbon pool is about 700-1000 PG \cite{[5]}. Based on this, there are a lot of organic carbon in the soil. However, how to effectively utilize the organic carbon in the soil has become an important research issue.
Light is indispensable for plant growth. However, in addition to the use of light in photosynthesis, the soil is also affected by light radiation. Photoexcitation can realize the transformation from the stable state such as molecular state to the active state such as ionic state, which makes the elements activate from the original inert state to the active state, and this activity enhances the interaction between the advantageous elements and the outside world [7]. For example, ultraviolet light can promote the photochemical transformation of nitrogen. Zhang [8] and others found that ultraviolet light can promote the transformation of inorganic nitrogen, and the higher the light intensity, the more significant the transformation of inorganic nitrogen. Therefore, it is of great practical significance to study the influence of light on soil microstructure and soil elements.

2. Materials and methods

2.1. Test materials
The test soil samples were taken from the surface layer of Fuping County (109°12′10″ e, 34°42′31″ n) in Shaanxi Province (0-15cm). Five sampling points were randomly selected for each soil sample according to the S-shaped line. The soil samples were evenly mixed and spread on the clean ground. The air dried soil was screened for 1mm by indoor natural air drying in dark, and the obtained soil was used for the determination of basic physical and chemical properties of soil and indoor light Experiment. The initial physical and chemical properties of the experimental soil are as follows: total nitrogen content 0.6g/kg, available potassium 4.08mg/kg, available phosphorus 3.94mg/kg, organic carbon 3.22g/kg.

2.2. Test method
This experiment was carried out in cartons with the size of 65 × 65 × 50 (cm). All around the cartons were covered with thickened aluminum foil to prevent other environmental light from entering the box. LED lamp is placed in the carton, the light intensity is 1.14 × 106 w m\(^{-2}\), and the temperature in the light reaction box is maintained at 28 ± 1.5 ° C. The soil sample is placed in a culture dish with a diameter of 10cm, and the height of the culture dish is 3cm. The filling height of the experimental soil should be controlled to be equal to the height of the culture dish, so as to prevent the thickness from affecting the test results.

2.3. Test method
Sampling method: the sampling time is from January 25 to April 19, 2018, once a week for a total of 10 weeks. Take out the experimental soil from the culture dish and put it into a sealed bag for preservation.

Sample test: the total nitrogen content of soil was extracted with 2 mol/L KCl solution (the ratio of water and soil is 5:1), and determined by full-automatic discontinuous chemical analyzer (cleverchem 200, Germany). Soil organic carbon was determined by heating oxidation method. The soil microstructure was determined by environmental scanning electron microscopy.

3. Results and discussion

3.1. Effect of light on total nitrogen
The results show that both NO\(_3^-\) and NO\(_2^-\) in water have photochemical activity, and NO\(_3^-\) and NO\(_2^-\) can photolysis to generate hydroxyl (•OH) and nitrogen oxides (NO\(_2\), no) and other active substances under sunlight radiation[9], which can react with most organic substances rapidly, thus significantly affecting the organisms of earth C, N and heavy metals.

Figure 1 lists the changes of total nitrogen in different light time. It can be seen from Figure 1 that the content of total nitrogen in the soil is basically kept at about 0.9g/kg and shows a fluctuating trend, among which the total nitrogen in the third week is 1.8g/kg. Compared with 0.879g/kg in the second week, it increased significantly, which may be due to the uneven sampling or the nitrogen contained in
the collected soil samples, resulting in a significant increase in total nitrogen content. From the total nitrogen content after 10 weeks of light, it can be seen that the total nitrogen content increased by about 0.3g after light compared with that before light, indicating that the total nitrogen content in soil increased significantly under light. Among them, the fluctuation of total nitrogen content may be due to the activation of nitrogen in the soil parent material into inorganic nitrogen under the effect of light, and the unstable inorganic nitrogen decomposes continuously to form nitrogen.

![Figure 1. Effect of light on soil total nitrogen](image)

3.2. Effect of light on organic carbon
Soil organic carbon generally refers to a kind of special, complex and relatively stable polymer organic compounds formed by organic residues through microbial action [10, 11].

Under continuous light, the change of organic carbon is shown in Fig. 2. It can be seen from Fig. 2 that the organic carbon in the soil shows a downward trend at the beginning stage, which may be due to the fact that there is no litter source in the experimental soil. At the same time, before the light experiment, the ground soil sample destroys the soil aggregate structure, exposes the organic matter in the soil, and accelerates the decomposition of organic matter. After the 6th week, the content of organic matter in the experimental soil showed an upward trend. Light can make the refractory organic matter in the soil photochemical transformation, and then produce organic carbon. Therefore, the above results may be due to the degradation of residual hard to decompose humus in the soil. The decomposition of humus provides active organic carbon for the soil, thus complementing the consumption of active organic carbon produced by light. However, after the 10th week of illumination, the content of organic matter in the soil is 1.80g/kg, which is still less than 3.22g/kg of the initial soil sample, indicating that the litter and the remains of animals and plants that are difficult to decompose in the sample soil are less, so they gradually decompose under continuous illumination. However, the decomposed organic carbon can only supplement the decomposition of part of the original organic carbon, and the total organic carbon is less than the initial value after the 10th week of illumination. The reason why there are few animal and plant residues and they cannot decompose to form organic carbon under the light may be that when grinding soil samples before the experiment, the animal and plant residues are removed, resulting in the overall decline of organic carbon over time.
3.3. Effect of light on soil microstructure

Light has energy, of which the ultraviolet light is long and powerful, and its function is mainly reflected in chemical action; the infrared light has low energy, and the infrared light is overheated and radiated, which makes the thermal effect on the object. Generally speaking, the wavelength of infrared light is closest to the wavelength of Biology, which is easy to produce resonance phenomenon, thus heating the object. Therefore, it is mainly reflected in the thermal effect, its energy It plays a role of stimulating chemical bond, and can't break chemical bond. In order to study the influence of light on the soil microstructure, infrared light and ultraviolet light were used to irradiate the soil, and the changes of soil microstructure before and after the light were observed by scanning electron microscope to explore the influence of energy and heat on the changes of soil structure.

3.4. Effect of infrared light on soil microstructure

Figure 3 shows the microstructure change of soil before and after infrared light irradiation. As shown in the figure, the particle size is about 100-200 μm before and after illumination, and the particle size is basically unchanged. According to the SEM picture, the basic structure of the soil has not changed. Therefore, based on the analysis of microstructure, it can be seen that infrared light does not change the soil mass, which may be due to the fact that infrared light only provides heat radiation to the soil mass, thus increasing the temperature of the soil mass. However, this kind of temperature rise is similar to that of the nature. However, due to the lack of other functions of the nature, such as plants, wind, animals, etc., it is not enough to change the soil mass Therefore, we can draw a conclusion that infrared light can only provide heat for the soil, and its heat change is not enough to change the soil microstructure, so infrared light has no effect on the soil microstructure.
3.5. **Effect of ultraviolet light on soil microstructure**

Because of the poor UV penetration, the larger the soil particles, the weaker the UV penetration. Based on this, the influence of ultraviolet light on the microstructure of soil is studied by studying the changes of large and small particles under light. It can be seen from figure 4 that under ultraviolet light, the microstructure of soil changes, and the particle size of soil decreases. The possible reason for this is the strong UV energy, which endows the soil with energy under this light. This energy may destroy the chemical bond and change the bond angle in different minerals. Based on this change, the microstructure of the soil may change. The change of the microstructure is reflected in the change of the surface roughness and the decrease of the particle size. Therefore, based on the above analysis, it can be seen that UV light has an impact on the microstructure of soil.

4. **Conclusion**

The effects of light on total nitrogen, organic carbon and microstructure of soil were studied by indoor light experiment, and the effects of light on agricultural production except photosynthesis were discussed

1. After one week of illumination, the total nitrogen in the soil increased by 0.3g/kg, and continued to increase the duration of illumination.

2. In the initial stage, light can reduce the organic carbon in the soil, but with the increase of light time, the residue of humus and other animals and plants in the soil will decompose, part of which will increase the organic carbon in the soil, but the overall trend is still declining.

3. Infrared light has no effect on the soil microstructure due to its only thermal radiation; because of its high energy, ultraviolet light may destroy the chemical bond and change the bond angle in different minerals, thus making the soil microstructure change.
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