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Study on the Effect of Green Manure Return on Microenvironment of Saline-alkali Soil

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Abstract

Saline soils are important reserve arable land resources in China, and saline-alkali soil management and agricultural use play an important role in maintaining the stability of existing arable land and holding the safety bottom line of basic self-sufficiency in food, etc. Green manure return to fields has great prospects in promoting sustainable agricultural development. In this paper, we analyze the progress of research on the effects of green manure on saline soils in terms of physicochemical properties, nutrient status and microorganisms at home and abroad, and provide an outlook on the application prospects of green manure return to saline lands, in order to provide reference for ecological management of saline-alkali soil.

Keywords

Green Manure; Saline-alkali Soil; Soil Microenvironment.

1. Introduction

Saline soils are a general term for saline and alkaline soils, which have a wide distribution area of about 9.55×108 hm2 in the world, accounting for about 10% of the global land area. In China, saline soils are distributed over an area of about 9.913×107 hm2, accounting for 4.88% of the available land area. Nowadays, the problem of soil salinization has limited the sustainable development of agriculture worldwide, and the management and improvement of saline soils has been a priority in the process of agricultural development [1]. Nowadays, saline soils are mainly improved by technical measures in water engineering, chemical, biological, and agricultural aspects.

With the increasing environmental pollution and decreasing arable land area, the unexploited saline land has great potential as a reserve resource. However, saline soils have poor physical and chemical properties, and their ecological environment is very fragile. If they are not properly exploited, they will not only lead to the reduction of soil productivity, but also cause many environmental problems, which will cause great harm to the ecological environment and affect the sustainable development of agriculture. Therefore, we should start from protecting and improving saline land, improve the utilization of saline land, and increase the nutrient content of saline soil while reducing the saline ion content of soil. Green manure alkali pressure and alkali drainage is widely used as an emerging biological improvement technology, which mainly improves saline soils by changing soil fertilization, improving soil microbial structure and environment, and reducing saline ion content. At the same time, it can achieve the effect of

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nitrogen fixation and carbon absorption [2]. Therefore, this thesis attempts to summarize the improvement effect of green manure return to the field on saline soils and provide theoretical basis for the biological improvement technology of saline soils.

2. Effect of Green Manure Return on Saline Soil

2.1. Effect of Green Manure Return to the Field on Soil Nitrogen Content

Green manure is a green plant body that is returned to the soil as organic material under field production conditions by turning all or part of the green plants owned by the crop in situ, ex situ or through composting and rotting. Green manure can be used for forage, and green manure for food can also increase the land equivalent ratio and ensure national food security; green manure can replace part of chemical fertilizer and reduce costs. Green manure can replace part of chemical fertilizer and reduce cost. There are many types of green manures, and the common ones include the following [3]: Leguminous green manure has a strong root system and penetrates well in the soil, which can loosen the soil and fertilize the ground, while the root nodules have nitrogen fixation and are a great source of nutrient resources. Gramineae also has a well-developed root system and the plants themselves have high C/N, which can increase the organic matter content of the soil; Brassicaceae can promote the conversion of P in the soil; Compositae has higher economic and medicinal values than other green manures. Compositae have higher economic and medicinal values than other green manures, including endive and plane grass.

Rape green manure is cultivated and tilled into the soil as a fertilizer. It was found that oilseed rape returned to the field as green manure at full bloom had a more balanced nutrient composition and greater dry matter accumulation than other crops, while oilseed rape had the best overall plant C/N at full bloom, which was more conducive to the decomposition rate in the soil after the plants were returned to the field [4]. In a study on green manure return to the field of rape, rape green manure return to the field can increase the nutrient content in the soil, improve the physical properties of the soil, and have better soil fertilization advantages. Brassica napus belongs to the Brassica genus, and as a "cleaner" of rice fields, its plant has a large amount of sulfur glycosides, which can disinfect the soil and kill harmful bacteria, insect eggs, and weeds in the soil. Olea europaea is one of the few crops used to develop saline wastelands, and as a new type of green manure with high resistance, high nutrients, and salinity tolerance adaptation, it can efficiently uproot salinity from saline lands [5]. Planting rapeseed can improve the physicochemical properties of soil to some extent in a study of medium and heavy saline lands.

2.2. Effect of Green Manure Return on Soil Inorganic Nitrogen

Soil nitrogen, which is the inorganic and organic nitrogen pool, inorganic nitrogen (ammonium nitrogen (NH4+-N), nitrate nitrogen (NO3--N)), which is fast-acting nitrogen, is a nutrient indicator of the soil and an indicator of soil environmental assessment and is used to evaluate soil fertility and to evaluate the risk of surface source pollution. In soil, plants and fertilizers, ammonium nitrogen (NH4+-N) is preserved and circulated in the form of NH4+, which can be interconverted with other forms of nitrogen in the soil [6]. NH4+-N has high solubility and can be rapidly absorbed by plants. At the same time NH4+ is acidic and neutralizes with alkaline ions in alkaline soils thus causing volatilization of nitrogen [7].

Green manure return can improve the physical and chemical properties of saline soils thus reducing the volatilization of NH4+. Nitrate nitrogen (NO3--N), the nitrogen element in nitrate, is decomposed by water and organic matter in the soil, and the resulting ammonium salts eventually form nitrate nitrogen through oxidation reactions [6]. Like NH4+-N, NO3--N has high solubility and can be rapidly absorbed by plants, but is highly reactive in the soil and easily lost.

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After green manure is returned to the soil, the majority of nutrients within the plant will enter the soil through decomposition. The nitrogen that enters the soil undergoes a mineralization and decomposition process under the combined action of soil nitrogen conversion enzymes and microorganisms, and eventually most of the nitrogen exists in the soil as inorganic nitrogen [4]. A part of NH4+-N and NO3--N will be absorbed and assimilated by microorganisms and plants in the soil, and then become a component of the plant organism; another part is abiotic fixation, and the colloids in the soil itself are negatively charged and can adsorb and fix the positively charged NH4+-N in the soil, so that a part of the ammonium nitrogen in the exchangeable state can be preserved in the soil This allows part of the exchangeable ammonium N to be stored in the soil and then converted into immobilized ammonium, which temporarily loses its biological effectiveness [8]. The return of green manure to the soil can enhance the nitrogen content in the soil, which is one of the essential massive elements for plant growth, and increasing the nitrogen level in the soil can alleviate the toxic effects of salt stress on plants and enhance the salt tolerance of plants.

2.3. Effect of Green Manure Return on Soil N Conversion Enzyme Activity

Soil N-converting enzymes promote the conversion of organic N into active N that can be directly used by crops and are highly catalytic and specific proteins, mostly from the apoplast of the above-ground part of the plant, the root system of the below-ground part, and microbial and animal residues in the soil. In saline soils, soil nitrogen converting enzyme activity is inhibited. The vast majority of soil microorganisms have difficulty surviving in heavily saline environments, and the soil contains only a very small number of microorganisms, which in turn reduces the secretion of enzymatically active substances in the soil [9]; urease is an extracellular enzyme, and sucrase is mainly present in the form of bound cellular components, usually combined with organic matter and mineral colloids in the soil, but in saline soils the organic matter content is not high, which inevitably brings lower soil microbial activity [10]. The high content of salt ions in saline soils leads to particle dispersion in the soil and reduces the number of soil aggregates compared to other cations, so that extracellular enzymes can lose protection and denature due to protein hydrolysis; at high salt content in the soil, the salting effect from salt ions, the change in soil infiltration potential and other harmful ions in the soil toxic effects of other harmful ions in the soil make the enzyme activity in the soil inhibited. Soil enzymes affect the material cycle and energy flow of the soil ecosystem, and they also characterize soil biological properties and quality conditions, and saline soils warm slowly and low temperatures inhibit soil enzyme activity [11]. Increased alkalinity of forest soils can reduce urease activity, and nitrate reductase activity decreases with increasing salinization. The number of microbial communities in the inter-root soil increased substantially after green manure was planted and returned to the field, which led to an increase in the secretion of soil microorganisms and brought about an enhancement of soil enzyme activity.

2.4. Effect of Green Manure Return on Soil Microbial Community Structure

As an important component of the ecosystem, when the structure of saline soils is changed, the types and numbers of microbial communities in the soil will change accordingly, and the structure of soil microbial communities and the performance of ecological functions will be affected accordingly [12]. Some researchers found that salinization of soil is closely linked to soil microorganisms, and the number of microorganisms (fungi, bacteria, and actinomycetes) in soil gradually decreases with increasing salinization and reaches highly significant levels. Researchers have conducted numerous studies on microbial communities in saline soils, and most of them concluded that salt stress adversely affects the microbial community structure and microbial activity in soil, inhibiting the growth of microorganisms in soil, reducing microbial biomass, and decreasing soil respiration and enzyme activity [13]. Salt stress not only affects crop growth, but salt chelation in the soil also affects soil microbial activity. Soil pH value

also directly affects microbial life activity, and it was found that the highest microbial activity was found at pH value of 4.5 in tea plantation soil. Proper salinity in the soil will promote microbial growth, while high salinity will disrupt the osmotic pressure of microbial cells and inactivate them. The abundance (S), diversity (H) and evenness (J) of microbial communities in saline soils can reflect and influence soil physicochemical properties and soil fertility status. Bacteria are numerically dominant in saline soils, followed by fungi and actinomycetes. In terms of numbers, actinomycetes, fungi and bacteria show a decreasing trend with increasing salinity of the soil [14]. Compared to common agricultural soils, the number of soil microorganisms in saline soils is relatively low. Studies have shown that for in large fields with high soil salt content and soil pH, actinomycetes are highly tolerant, and salt-tolerant actinomycetes are most abundant in heavily saline soils [15]. Soil microorganisms are more sensitive and responsive to changes in the survival environment, and therefore are often used as a measure of saline soil improvement.

3. Conclusion and Prospect

Green manure plants not only supply macro and micronutrient elements needed during the reproductive period of crops, but also have an impact on soil temperature, water content, fertility, and biological, physical, and chemical properties. Plant return can significantly increase the peroxidase activity, urease activity, and alkaline phosphatase activity of the soil, and with the increase of soil nitrogen and organic matter, the nutrients of the soil are subsequently increased, and the quality of the soil is improved more obviously (Zhang Qi et al., 2019). Throughout the improvement technology of domestic green manure plants on saline soils, it mainly focuses on the planting improvement mechanism of green manure plants, and it is necessary to continue to strengthen the research on the effect of green manure to improve saline soils, such as rape, in order to provide a scientific and theoretical basis for the biological improvement of saline soils.

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