Effect of Fermented Plant Products on Alkaline-Saline Soil and the Growth of Alfalfa Seedlings

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Abstract A pot experiment was conducted by putting ameliorants, the products of plants fermented by lactobacillus, and sandy soil into alkaline-saline soil. After such blending, the soil physicochemical properties and the growth index of Alfalfa seedlings were measured in order to explore the influence of the blending on alkaline-saline soil and the growth of alfalfa seedlings. The results showed that soil pH decreased significantly after adding ameliorant; mixing ameliorant and sandy soil into alkaline-saline soil reduced soil evaporation and increased the germination rate of alfalfa seeds and their chlorophyll content as well as the seedling height, root length of alfalfa seedlings, but it had no significant effect on alfalfa seedlings' biomass and leaf number; besides, excessive ameliorant would inhibit the growth of alfalfa seedlings.

Key words Fermented plant products, Alkaline-saline soil, Ameliorant, Growth index

1 Introduction

Soil salinization refers to the natural geological process of constant accumulation of saline matter on the soil surface to form saline soil. The soil salinization will lead to the soil compaction and fertility decline, which hampers the nutrient absorption of crops and the growth of crops, seriously affects agricultural production and even destroys regional ecological balance. The fermented plant products (such as silage straw) are used to neutralize alkaline-saline soil, improve soil quality, reduce the degree of soil salinization and effectively reduce the secondary pollution caused by the application of chemical ameliorant. In this paper, we studied the effect of applying acid fermented plant products as ameliorant in alkaline-saline soil on soil properties and crop seedlings.

2 Materials and methods

2.1 Materials The moderate and severe alkaline-saline soil sample collected from the Da'an area of western Jilin was selected as the test soil; the acid fermented plant product (silage containing lactobacillus) was used as ameliorant.

2.2 Methods Based on previous effective measures for alkaline-saline soil remediation, the orthogonal test was designed. The alkaline-saline soil and sandy soil were air-dried and sieved (alkaline-saline soil over 2 mm sieve; sandy soil over 1 mm sieve). 3 levels (0, 20%, 40%) were set in accordance with the sandy soil mass ratio. The lactobacillus fermentation products were pulverized, and 5 grades (0, 10%, 20%, 30%, 40%) were set based on mass ratio. There were a total of 15 treatments with three replicates each. The soil pH under different treatments was determined. Each pot was filled with the equal amount of mixed soil and irrigated with the volume of water equal to 20% of that of the pot. The full alfalfa seeds were selected, disinfected with 75% alcohol and cleaned for germination. After breaking the seed coat, the seeds were evenly sown in pots (consistent sowing depth, 50 seeds per pot), and put in QHX-1500 intelligent artificial climate chamber for culture. The daily statistics about emergence were gathered until there was no change for 2 consecutive days. The germination start date under each treatment was recorded, and the germination rate was recorded after 10 days. The statistical methods were as follows:

$$\text{Germination rate}\ (\%) = n/N \times 100$$

where n is the number of germinating seeds; N is the total number of test seeds. From the completion of sowing, it was weighed under each treatment for 10 consecutive days, and the water evaporation was recorded. 5 seedlings growing well were selected from each pot after 10 days, and harvested after 5 weeks, to determine the alfalfa plant height, root length, dry weight, fresh weight, leaf number, and relative chlorophyll content.

2.3 Determination of test parameters Soil pH was measured by PHS-25 pH meter; evaporation was measured by gravimetric method; plant height and root length were measured using caliper; germination rate and leaf number were measured using observation method; dry weight or fresh weight was measured using TM-B20002 electronic balance; relative chlorophyll content was measured using SPAD-502 chlorophyll determinator.

2.4 Data Processing Excel software was used for data analysis and graphing.

3 Results and analysis

3.1 Effect of applying ameliorant and sandy soil on soil pH

Soil pH is the most important chemical property of soil, having a direct impact on plant growth and soil fertility[1]. High alkalinity of alkaline-saline soil is one of the important reasons for failure of

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normal crop growth. The pH of fermented plant products used in this experiment was 4.2, the sandy soil pH was 9.5, and the pH of the alkaline-saline soil to be modified was 9.8. As shown in Fig. 1, with the increase in the application of acidic ameliorant, soil pH decreased; soil pH decreased significantly under 10% ameliorant treatment, and then as ameliorant application increased, soil pH decreased slowly; the soil pH was 7 under 40% ameliorant and 40% sandy soil treatment, having become neutral. Soil pH decreased slightly but changed little with an increase in sandy soil application. It could be seen that applying acidic fermented plant products played a significant role in reducing the alkalinity of alkaline-saline soil.

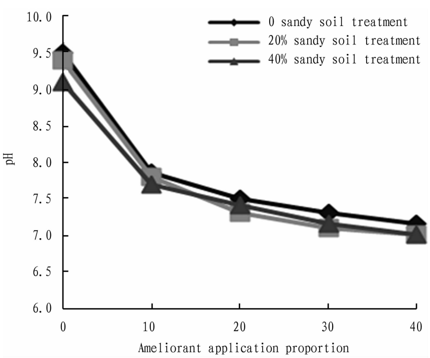

Fig. 1 Soil pH under different treatments

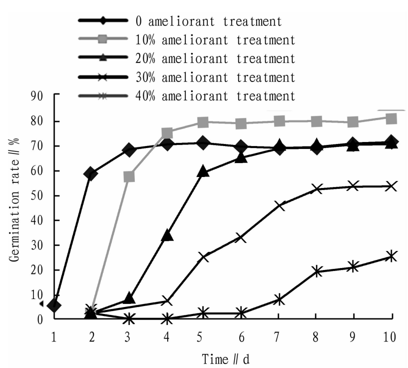

Fig. 2 Alfalfa seed germination under different treatments without applying sandy soil

3.2 Effect of applying ameliorant and sandy soil on alfalfa growth index

3.2.1 Effect on alfalfa seed germination rate. The crop seed germination rate refers to the percentage of total germinating seeds in test seeds in a given germination test time[4]. Fig. 2 showed that the initial alfalfa germination rate was slightly lower than that under the control with the ameliorant application; when the sandy soil was not applied, the final germination rate under 10% ameliorant treatment was higher than under the control; when the application proportion of ameliorant was more than 10%, the germination rate decreased with the increase in application proportion of ameliorant; when 20% sandy soil was applied, the germination rate under 10%, 20% ameliorant treatment was higher than under the control.

3.2.2 Effect on alfalfa seedling biomass. As shown in Fig. 3, when 20% sandy soil was applied, the dry weight under 20% ameliorant treatment was higher than under the control; overall, applying sandy soil and ameliorant had little impact on the fresh and dry weight of crops, and the application of high proportion ameliorant even reduced crop biomass. The reason needed further analysis.

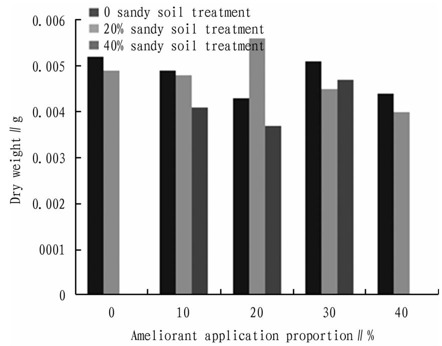

Fig. 3 Alfalfa seedling biomass under different application proportion of ameliorant and sandy soil

3.2.3 Effect on alfalfa seedling leaf number. According to Fig. 4, there was no significant difference in alfalfa leaf number after applying ameliorant and sandy soil, but the leaf number under 20% sandy soil plus 10% ameliorant treatment was larger than under the control, possibly because such application proportion was most favorable to alfalfa growth.

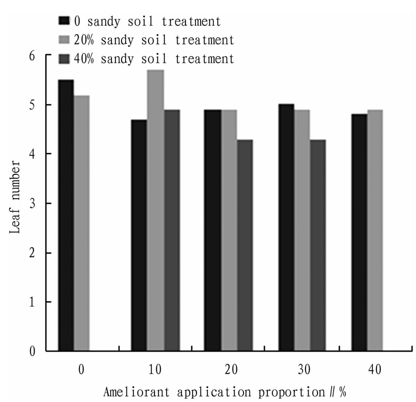

Fig. 4 Alfalfa seedling leaf number under different treatments

3.2.4 Effect on relative chlorophyll content. Chlorophyll content is an important physiological indicator of plant leaves, to a certain extent reflecting the plant quality and plant growth, as well as mineral enrichment in soil[5]. According to Fig. 5, when the sandy soil was not applied, the chlorophyll content of alfalfa seedlings under 20%, 30% ameliorant treatment was higher than under the control, and in the application proportion from 10% to 40%, the chlorophyll content increased first but then decreased; when 20% sandy soil was applied, the chlorophyll content under 0, 10%, 40% ameliorant treatment was higher than under the control; overall, the chlorophyll content first decreased with increasing application proportion of ameliorant, but when the ameliorant concentration was greater than 30%, the chlorophyll content began to rise slowly; when the 40% sandy soil was applied, the chlorophyll content under 10%, 20% ameliorant treatment was higher than under the control. Overall, applying 20% – 30%

ameliorant or a small amount of sandy soil and 0 – 10% ameliorant could improve the mineral enrichment in soil and promote chlorophyll accumulation in alfalfa seedlings.

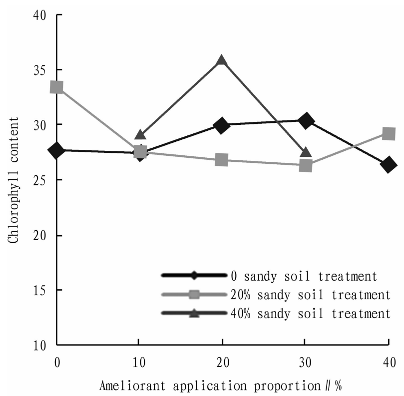

Fig. 5 Alfalfa seedling chlorophyll content under different treatments

3.2.5 Effect on alfalfa seedling plant height. As shown in Fig. 6, when the sandy soil was not applied, the alfalfa seedling plant height decreased rapidly under 10% ameliorant treatment, and the plant height decreased with the increase in ameliorant application proportion; when 20% sandy soil was applied, the plant height under all treatments except 40% ameliorant treatment was greater than under the control; when 40% sandy soil was applied, the plant height under all treatments was smaller than under the control, and decreased with the increase in ameliorant application proportion. On the whole, applying 20% sandy soil coupled with ameliorant with concentration of less than 30% or without applying ameliorant, contributed to the growth of alfalfa seedlings.

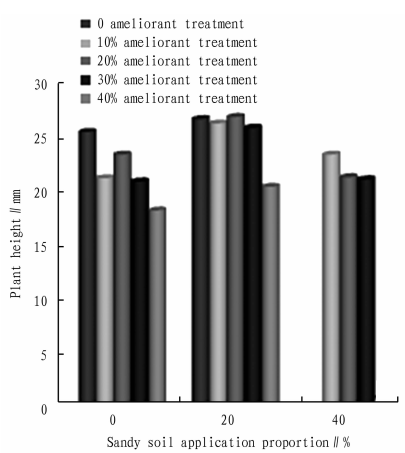

Fig. 6 Alfalfa seedling plant height under different treatments

3.2.6 Effect on alfalfa seedling root length. The plant root structure has an important impact on nutrients and water from environment and soil for plants[6]. As shown in Fig. 7, when the sandy soil was not applied, the root length under 10%, 20%, 30%, 40% ameliorant treatments was greater than under the control, and the root length under large proportion ameliorant treatment was significantly greater than under other treatments; when 20% sandy soil was applied, the root length under all treatments except 30% ameliorant treatment was greater than under the control, and the root length was the greatest under 20% ameliorant treatment; when 40% sandy soil was applied, the root length increased with the increasing ameliorant application proportion, but smaller than under the control. Clearly, applying ameliorant coupled with sandy soil with concentration of less than 20% or without applying sandy soil, was conducive to the alfalfa seedling root elongation, thereby enhancing the ability to absorb nutrients in the soil.

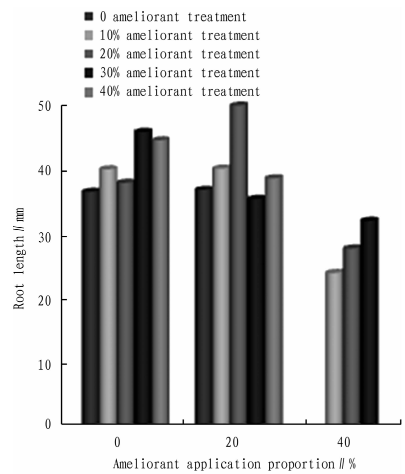

Fig. 7 Alfalfa seedling root length under different treatments

4 Conclusions

The fermented plant products were acidic, and could neutralize alkaline-saline soil and improve the soil texture. The experimental results showed that fermented plant products and sandy soil application could reduce soil pH. At the same time, applying low concentration ameliorant could improve crop germination rate, increase crop chlorophyll content, and promote the growth of crop roots and stems. However, high concentration would cause inhibiting effect, and the mechanism as well as effect was to be further verified by experiment.

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