The Study on Tomato with Different Planting Patterns in Coastal Saline-Alkali Land

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Abstract: In this paper, the plants' height, yield of tomato and soil surface conductivity were studied under drip irrigation conditions in greenhouses, with three planting patterns: root-limiter planting, ridge planting without film, and ridge planting with film-mulching. The result showed that the planting pattern had a significant impact on the height and yield of tomato. Comparing to the ridge with non-film planting，the plants of ridge with film-mulching were 6.5 cm taller. The average yield per plant with root-limiter was 1018.0g, and the ridge without film was 650.0g barely. The root-limiter was better than the ridge-planting as a whole. Compared with the soil surface conductivity before planting, the root-limiter, ridge with film-mulching, as well as ridge without film increased the conductivity of the soil by 2.0%, 5.2%, and 22.0%, respectively. In summary, ridge with film-mulching could achieve higher yields with the use of drip irrigation for greenhouses with mild salinization. Root-limiter with off-soil could maximize the overall benefits for greenhouses with more severe salinization.

1 INTRODUCTION

Saline-alkali land is widely distributed in China, and it has weak environmental carrying capacity. These factors limit the sustainable development of economic, social, and ecological environment. At the same time, saline-alkaline soil is an important reserve resource of arable land in China. Saline-alkaline soil management and agricultural utilization play an important role in ensuring the absolute safety of rations, maintaining the stability of existing arable land, and adhering to the safety bottom line of basic food self-sufficiency (Liu et al., 2021; Liu, 2021).

In recent years, facility agriculture has been greatly developed, among which facility vegetables represented by greenhouses have developed the fastest (Qiao & Wang, 2021; Gao & Lu, 2021; Zhang, 2011). However, it has brought increasingly serious soil problems with the long-term relatively closed production environment. The soil salinization has become most apparent with the using of greenhouses. It was mainly composed of coastal saline soil, tidal saline soil, and fluvo-aquic soil in coastal saline-alkali land.

With the high groundwater level and high salt content, it has led to the salinization of greenhouse soil, and appeared massive, quick and harmful. Some greenhouses have been invalid and unsuited to planting only 1 to 2 years (Lu et al., 2009). There was little effect to inhibition the raise of the groundwater level and salt-accumulation, with the traditional fresh-water irrigation (Li & Wang, 2007). Therefore, the appropriate planting method was of great significance to alleviate the salinization of greenhouses planting areas in the coastal area.

The drip irrigation has the characteristics of high frequency, small flow and long time, among many planting methods. It could leach soil salinity, and then enhance the absorption of water by plant roots, which effectively preserves moisture, and improve saline-alkali land (Dou & Kang, 2010). The film-mulching planting could effectively reduce soil surface evaporation, maintain soil moisture and inhibit the accumulation of salt to the soil surface (Jiao et al., 2008). The root-limiting cultivation has been a trial to introduce in the saline-alkali cultivation. The ridge cultivation with root-zone

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restriction cultivation could effectively improve the survival rate of seedlings of *Chinese wolfberry* in medium-to-severe saline-alkali soils (Jin et al., 2021). In the light of the soil salinization, it has a great significance in the choice of suitable planting method in the coastal soil salinization areas.

In this paper, we have studied the effect on tomato growth and soil surface conductivity with three planting method under drip irrigation conditions. The structure of the paper is as follows. Materials and Methods are described in Section 2. Results are discussed in Section 3. Section 4 contains concluding remarks.

2 MATERIALS AND METHODS

2.1 Experimental Site

The experiments were conducted in the greenhouse of the coastal experiment base of Jiangsu hydraulic research Institute in 2020, Jiangsu. The annual average temperature was 14.5℃, wind-speed was 3.3 m/s, and the annual average sunshine-hour was 2231.9 h. There was a large disparity in rainfall during the flood season and non-flood season, 733.4 mm in the flood season and 331.8 mm in the non-flood season. It was prone to drought and flood disasters. The soil in the experiment area belonged to coastal siltation sandy soil with light saline-alkaline and strong water permeability, which was easy to reach saturation during precipitation.

2.2 Experimental Material

The tested crop was tomato, and the variety was Cooperative 903 Royal Scarlet. It was planted on April 8, 2020, harvested began in mid-June, and pulled up straw in late August.

2.3 Experimental Setup

The experiment was carried out in a glass greenhouse, and the temperature was strictly controlled to reduce the influence of uneven temperature. There were three planting methods (Figure 1), including root-limiter, ridge with film-mulching, and ridge without film. The fertilization and irrigation conditions were the same in the three planting methods. The isolation belts and protection lines were set up between the plots.

Root-limiter planting: The high of root-limiter was 40 cm and the diameter was 30 cm. The root-limiter was filled with 1 kg rice husk at the bottom, and non-saline alkaline soil was loaded on the rice husk. The spacing between rows of plants was 80 cm, and the spacing between plants was 50 cm.

Ridge planting: There were 20 tomatoes in each row, with single ridge and single row. The height of ridge was 20 cm, the top width of ridge was 20 cm, the bottom width of ridge was 60 cm. There was 80cm between the spacing of ridge. There was a drip irrigation tape arranged for each row of crops. The distance between the emitters was 50 cm, and the flow rate of emitter was 1.5 L/h.

2.4 Experimental Parameters and Methods

The conductivity of the lower layer soil under different planting methods was measured by a portable conductivity meter. The samples were prepared with a ring knife. The plant height of tomato was measured every 7 days with a tape measure, after tomato transplanting. The yield of plant was weighed independently at the harvest time. There were 30 plants randomly measured with each planting method.

2.5 Experimental Data Processing

The SPSS Statistics software was used to calculate the standard error and variance analysis of the experimental data. Therefore, the Origin software was used for drawing.

3 RESULTS AND ANALYSIS

3.1 The Effect of Plant Height with Different Planting Methods

3.1.1 The Effect on the Growth Rate of Plant Height

The growth regularity of tomato planted with root-limiters showed a trend of slow growth first, then rapid growth, and finally stable, in Figure 2. Within 21 days, the plant height increased rapidly, with an average increase of 22 cm and a growth rate of 0.79 cm/d. From 21 to 42 days, it was a rapid growth stage, with an average increase of 43 cm and a growth rate of 2.05 cm/d. From 42 to 70 days, the growth rate of plants tended to be stable, with an average increase of 9.1 cm, and the growth rate was 0.33 cm/d.

The growth trend of ridge-planting was basically the same as root-limiter planting. In the first 21 days, the height of tomato increased by an average of 20 cm, and the growth rate was 0.54 cm/d. From 21 to 42 days, it grew with an average increase of 42 cm and the growth rate was 2.00 cm/d. From 42 to 70 days, the growth rate of crops represented an average increase of 10.2 cm, and the growth rate was 0.36 cm/d.

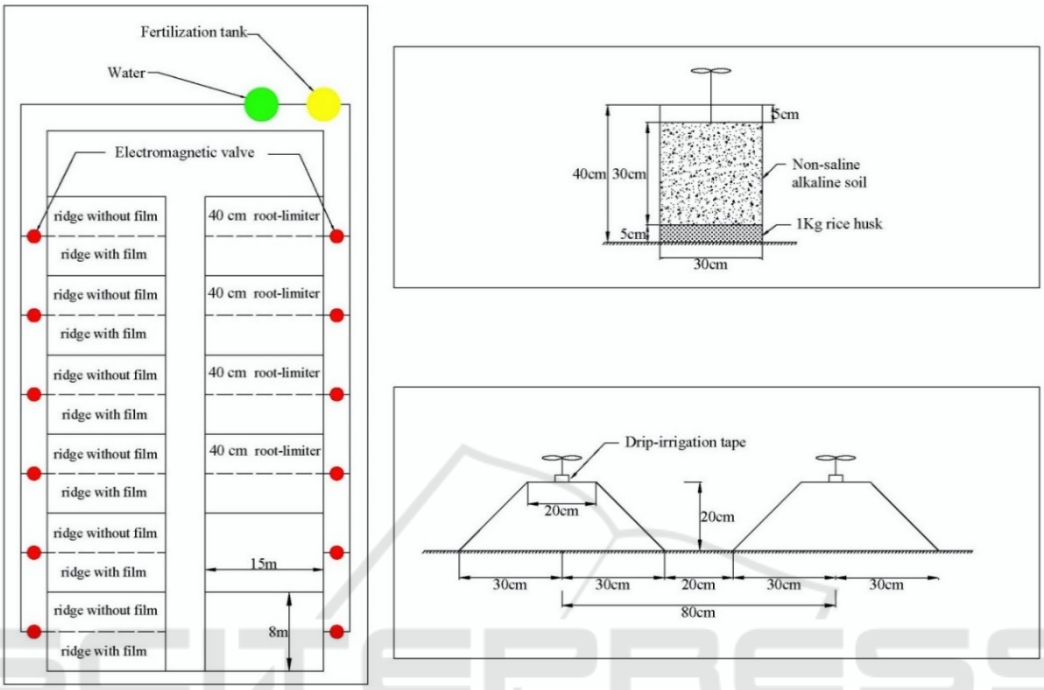

Figure 1: The layout of experimental area with different planting methods.

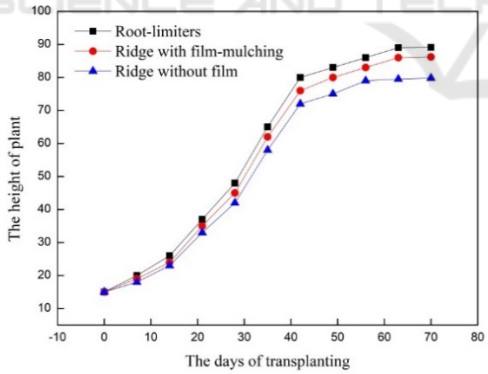

Figure 2: The influence of plant height on tomato with different planting methods.

In summary, the plant height raised the fastest with the root-limiter planting method. During full-growth period, the law of the plant height and the growth rate with three planting methods expressed as root-limiter > ridge-planting with film > ridge-planting without film.

3.1.2 The Effect on the Final Plant Height

The growth rate of plant height with different growth stages and different planting methods was different, which resulted in different final plant heights. Comparing to ridge planting and ridge planting without film, the final plant height of tomatoes planted with root-restrictor planting during the whole growth period was the highest. The tomato with root-limiter was 4.0 cm and 9.5 cm taller than the ridge-planting with film and ridge-planting without film, respectively. The reason was that the rice husk blocked the penetration of salt and the root-limiter was filled in off-site soil with low salt content. In the first 21 days, there was little difference in plant height of tomato planted with two ridge-planting methods. The temperature was relatively low in the greenhouse, and the evaporation was small. The soil salinization was not obvious, and soil salinity has little effect on plant growth in the early stage of planting. Furthermore, the tomato plants were small, with less water required in the early stage of planting. From 21 to 42 days, the difference in plant height gradually increased between the two ridge-plantings.

The tomato plants of ridge with film-mulching were 6.5 cm taller, comparing to the ridge with non-film planting. The plant's water-demand and transpiration-evaporation were enhanced with the temperature rising in the greenhouse. Based on the same irrigation system, the water retention capacity of ridge with film-mulching was better than that of ridge without film. In summary, root-limiter planting and ridge with film-mulching could promote the growth of tomatoes, and root-restrictor planting was the more prominent among the three planting methods.

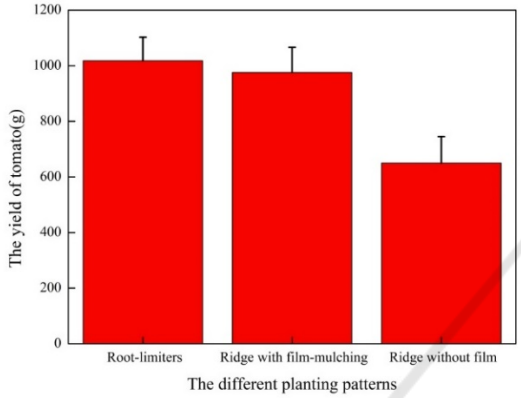

Figure 3: The influence of tomato yield with different planting methods.

3.2 The Effect on Plant Yield with Different Planting Methods

It showed that the planting method had a greater impact on yield of tomato in Figure 3. Root-limiter and ridge-mulching planting performed better than ridge without film. The average yield per plant with root-limiter was 1018.0g, which performed the highest. The average yield per plant with ridge-mulching was 976.1g, and the ridge without film was 650.0g barely.

According to one-way ANOVA(Analysis of variance) of planting method and tomato yield, the planting method had a significant impact on tomato yield($P < 0.001$, The P value is the probability, which reflects the probability of occurrence of an event). The result of analysis of variance showed that there was no significant difference between root-limiter and ridge-mulching, and it was significantly different compared to the ridge without film. The yield of plant was mainly determined by the input of water and assimilation substances. Furthermore, the accumulation of salt in the surface lowered the yield of tomato with ridge without film.

3.3 The Effect on Soil Conductivity with Different Planting Methods

The conductivity of surface soil was 315.6μs/cm with the root-limiter at the end of the growth period, and increase range was 2.0% according to non-planting (Figure 4). At the same time, the ridge with film-mulching appeared 803μs/cm and 5.2%, as well as the ridge without film appeared 803μs/cm and 22.0%. The conductivity of the surface soil had small increases during the tomato growth period with root-limiter and ridge with film-mulching. In contrast, the conductivity increased greatly with ridge without film. It showed that the difference between planting and non-planting was significant, and the salinification of soil was obvious.

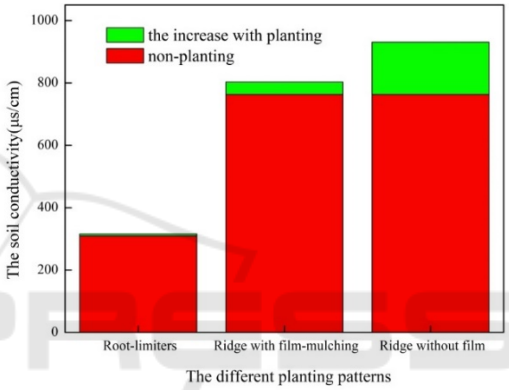

Figure 4: The effect on soil conductivity with different planting methods.

4 CONCLUSIONS

The plant's height and yield of tomato with different planting methods in coastal saline-alkali land were studied in the paper. It was concluded that the plant's height and yield with root-limiter performed the best among three planting methods, and the ridge with film-mulching was better than the ridge without film. According to the conductivity, the planting with root-limiter and ridge with film-mulching could inhibition the salinification of soil.

In conclusion, the ridge with film-mulching planting could be adopted in the greenhouse of low-salinization with drip irrigation. The root-limiter planting with external-soil could be applied in the greenhouse of heavy-salinization.

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