Effects of Different Irrigation Upper and lower Water Limits and Covering Ways on Physiological Indicators of Jujube Seedlings

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Abstract

In order to study the effects of different irrigation upper and lower water limits on physiological indexes of jujube seedlings, The experiment started from the perspective of reducing the proportion of agricultural water use and exploring more suitable plant cover patterns, Three different irrigation upper and lower limits and three surface mulching methods were used to study the effects of different treatments on physiological indexes of date seedlings, That is, the differences in chlorophyll, leaf VC and leaf conductivity of jujube seedlings under different irrigation limits and different mulching methods. To provide theoretical and technical support for the cultivation of jujube seedlings in Hebei province. The results showed that there were significant differences in chlorophyll content, VC content and electrical conductivity of the leaves in the mature stage under different mulching methods. Among them, M2 was significantly different from other processing. During the treatment, chlorophyll content of leaves decreased with time. The content of VC in leaves increased. The electrical conductivity of the blades showed an upward trend, which was also true under the three mulching modes. Therefore, under the conditions of this experiment, when the soil moisture content remained at 65%~75% of the field moisture capacity and the covering condition was film mulching, the jujube seedlings had the best growth and each physiological index was better than other treatments.

Keywords

Jujube seedlings, upper and lower limits of irrigation, covering methods, physiological indicators.

1. Introduction

Jujube is a native tree of China. It has a history of more than 2000 years. Jujube is the main agricultural product in China. Its planting area is in the forefront of Chinese fruit tree planting. From the perspective of China's foreign trade, jujube products occupy a high position. From the point of view of domestic trade, jujube in dried fruit ranking first[1].From the perspective of nutrition, jujube is rich in a variety of nutrients required by the human body. It is often used as a traditional Chinese medicine for tonifying qi and relieving the effects of medicine. It is a high quality tonic integrating nutrition and medical care[2].The planting area of jujube trees in Hebei province has exceeded 5.5 million mu. The annual output exceeds 800,000 tons. Through the investigation of jujube planting cities and counties in Hebei province, it is found that the income from jujube planting is one of the important sources of local agricultural income[3].Hebei province is located in the north China plain. Average rainfall over many years is low. Agriculture USES more than 70 percent of its water. The contradiction between water use in other sectors and that in agriculture is prominent. And the aggravation of contradiction of water resource supply and demand is fatal to the development of agricultural economy[4].The precipitation pattern in Hebei province is arid in spring and hot in summer. Time characteristics of uneven distribution over the years. It can not meet the water demand of jujube tree in the whole phenological period. Therefore, the development of water-saving irrigation is the key problem to be solved in Hebei jujube cultivation management[5].Research shows that. Surface mulching preserves moisture from water Time characteristics of uneven distribution over the years. It can not meet the water demand of jujube tree in the whole phenological period. Research shows that. Surface mulching preserves moisture from water evaporate. Reducing soil erosion has a good effect. Very beneficial to the growth of crops. It has been widely used as a very effective soil management technique[6].Surface covering can effectively reduce soil evaporation. Especially after the rain. Increase soil moisture content at the root of the plant. So as to improve the water absorption and utilization efficiency of crops[7,8].As early as 1988, the orchard land cover model was introduced. Land cover changes traditional farming patterns. Reducing daily water consumption is of great significance. However, The orchard is currently under cultivation. Traditional planting patterns still predominate. The application of land cover is limited[9]. Therefore, reduce the proportion of water used for agriculture. To explore a more suitable cover pattern for jujube trees. It is of great significance to the sustainable development of jujube industry.

1.1 Effects of surface cover on soil moisture.

In China, surface cover has a long history. Studies have shown that land cover can effectively increase crop yield by improving crop water use efficiency. Practice has proved that straw mulching can reduce ineffective evaporation to retain moisture. The mechanism is as follows: first, the surface temperature is reduced by reducing the direct absorption of solar radiation to the soil surface; Second, the surface covering for water vapor, will make it re-cooling into liquid and reduce soil water loss; The third is to weaken the scour of the soil by raindrops through the surface covering, maintain the original state of the soil, reduce the production of runoff to increase the amount of rainwater infiltration[10].In recent years, the research direction has changed from single straw mulching mode to different surface mulching mode on the impact of soil moisture. The study considered not only from the perspective of water, but also from the yield and quality of fruit and other factors. By studying the characteristics of soil evaporation under different mulching materials, Jian Yao et al[11] found that compared with bare soil, soil moisture content under mulching increased significantly. JianGuo Shui and XiJing Chen[12] found that straw mulching can increase soil moisture content by 0.5%~1.7%, while film can increase soil moisture content by 1.6%~3.3%, which proves that plastic mulching is beneficial to soil moisture conservation. By studying the xilamure grassland, Xiangxin Cui etc[13] measured the soil moisture content by covering different amounts of straw, and found that straw mulching can effectively reduce soil evaporation capacity. The difference is mainly concentrated in the surface soil of 0~30cm, and gradually decreases with the deepening of depth. The principle of straw cover is that straw cover can reduce soil evaporation capacity, preserve soil moisture and improve soil moisture content. Hongchen Li[14]

et al. studied the effects of different mulching measures and combination of fish scale pits on soil w ater content in dry jujube orchards in northern Shaanxi Province through soil water location experi ments. It was found that under different treatment conditions, the soil water content of jujube seedli ngs at different phenological stages increased significantly by 0-20 cm depth and 20-100 cm soil water content of main root layers. Among them, under combination of fish scale pits an d tree branches, the soil water content was obvious increase.

HongbingLi[15] studied the different plant mulching of jujube seedlings in Yulin area of northern S haanxi Province, he found that harvesting and covering plants regularly could change the harmful p henomenon of soil water consumption in less rainfall season.ShuiliDong[16] studied the temporal a nd spatial variation of soil moisture under two different mulching modes in mountain jujube orchard s, and found that straw mulching could effectively increase the soil moisture content in 0-40 cm soil layer of surface layer for grass mulching, while both modes had little effect on the soil m oisture content in 60-80 cm soil layer of deep layer.YuyanZhou[17] et al. studied the effects of black film mulching, whi te film mulching, inter-row grass growing and clear tillage on soil moisture in apple orchards. Compared with clear tillage, the other four mulching modes all had certain effects on soil moisture storage. Among them, after 2 months, black film mulching was the largest, followed by white film mulching, and clear tillage was the second Minimum illumination. QingjiangWang[18]et al. studied the changes of soil moisture, soil bulk density and soil structure under different patterns of Mulching in Huangguan pear orchard, and found that straw mulching could better maintain soil moisture with the extension of irrigation duration.Unger and Vigil [19] studies show that the fruit-grass complex system can not play a very good role in increasing soil water content and water storage when the annual rainfall is between 300 and 400 mm.

It can be seen that the effect of surface mulching on soil moisture is very obvious. Current studies mostly focus on straw, plastic film and plant mulching.These coverage modes should have their own advantages in different planting areas. Local areas should take measures according to local conditions and choose suitable local coverage modes from the perspective of saving agricultural water, so as to provide theoretical and technical support for the development of local planting industry and increase the per capita income of local farmers.

1.2 Effects of different irrigation limits on physiological indexes of crops.

For crops, the change of water content in the external living environment will directly cause physiological changes inside the crops. In recent years, many scholars have turned their attention to the relationship between physiological indexes and crop moisture. It can be divided into the effects of photosynthesis, chlorophyll content and leaf water potential. The key of crop photosynthesis is the content of chlorophyll.

Its content was significantly higher than that of leaf photosynthesis and plant senescence index. PengPeng Chen etc[20] found that the chlorophyll content of jujube was closely related water content through the effects of different mulch on chlorophyll content. The less water, the higher the content.JuanWang and others studied the effects of different deficit irrigation on chlorophyll and leaf water potential in Southern Xinjiang. They found that under different deficit irrigation, chlorophyll increased first and then decreased, but there was no significant difference in chlorophyll content during the same phenological period.The change of leaf water potential in a day shows a trend of first increasing and then decreasing, which reached the maximum at about 10 a.m, then slowly decreasing and reached the minimum at 14:00-16:00 p.m. When Yuzhong Ren etc[21] studied the effects of different irrigation methods on chlorophyll in jujube, he found that the chlorophyll content in jujube was on the rise in the whole phenological period. In terms of the same growth period, drip irrigation was the highest among different irrigation methods. When Shouwen Sun[22] studied the change rules of chlorophyll SPAD value (relative chlorophyll content) of new leaves and functional chlorophyll in apples in arid area, he found that: In the fruit trees studied, the chlorophyll SPAD of the newborn leaves was higher in July, while the chlorophyll SPAD value of the functional leaves was higher than that of the new leaves, and was the highest in August. Compared with the two fruit orchards, the chlorophyll SPAD values of the orchards in different areas were different, but for the new leaves, the changes were not significant. Yesim Erdem etc[23] carried out a drip irrigation experiment on watermelon and found that water deficit can make the fruit have a higher concentration of soluble solids and increase the sugar content.

Through the study of the physiological characteristics of Walnut in Xinjiang, we found that[24] : with the passage of time, the change of chlorophyll content in leaves is obvious, generally, the chlorophyll content will increase first and then decrease; the difference of chlorophyll content index in different treatments at the same time is not obvious, but for the same treatment, the difference of phenophase and chlorophyll content is large. At the same time, they also concluded that with the change of phenological period, the change trend of leaf water potential in the morning, midnight and evening probably showed a "V" parabolic form. Kaizer etc[25] concluded that crops respond to water stress during drought by reducing the rate of photosynthesis to improve their ability to survive. By studying the response relationship between the photosynthetic rate of four different trees and soil moisture content in Inner Mongolia, Liansheng Guo et al[26] concluded that there was an inseparable relationship between the photosynthetic rate of crops and soil moisture content. Generally speaking, the increase of soil moisture content was conducive to improving the photosynthetic rate. It can be seen from the studies on the effects of different scholars on the physiological characteristics of different crops that the effects of different water contents on the physiological characteristics of different crops have their own characteristics.

2. Experimental methods and research methods.

2.1 Study area overview and experimental design.

2.1.1 Overview of the experimental area.

Experiment site is located in Baoding city, Hebei province Hebei agricultural university, Chinese jujube research center, belong to the north of the north China plain, north latitude 38 ° 51 ', longitude 115 ° 28 ', elevation 17.20 meters, for many years, the average temperature 12 ℃, annual precipitation 550 mm, belong to the temperate zone monsoon climate, rainfall mainly concentrated in the summer, four seasons, winter cold and dry, hot summer and rainy, average annual evaporation from water surface is 1910.4 mm. The soil used in the experiment was mixed topsoil and matrix soil, and the soil fertility was uniform. The soil bulk density was 1.34g/ cm3, and the field water holding capacity was 29.8 cm3 / cm3. Soil nutrient index was PH7.51, organic matter 2.62%, available potassium 100.23 mg/kg, available phosphorus 20.18 mg/kg, available nitrogen 90.37 mg/kg.

The change of average daily temperature during the experimental period is shown in figure 2-1.

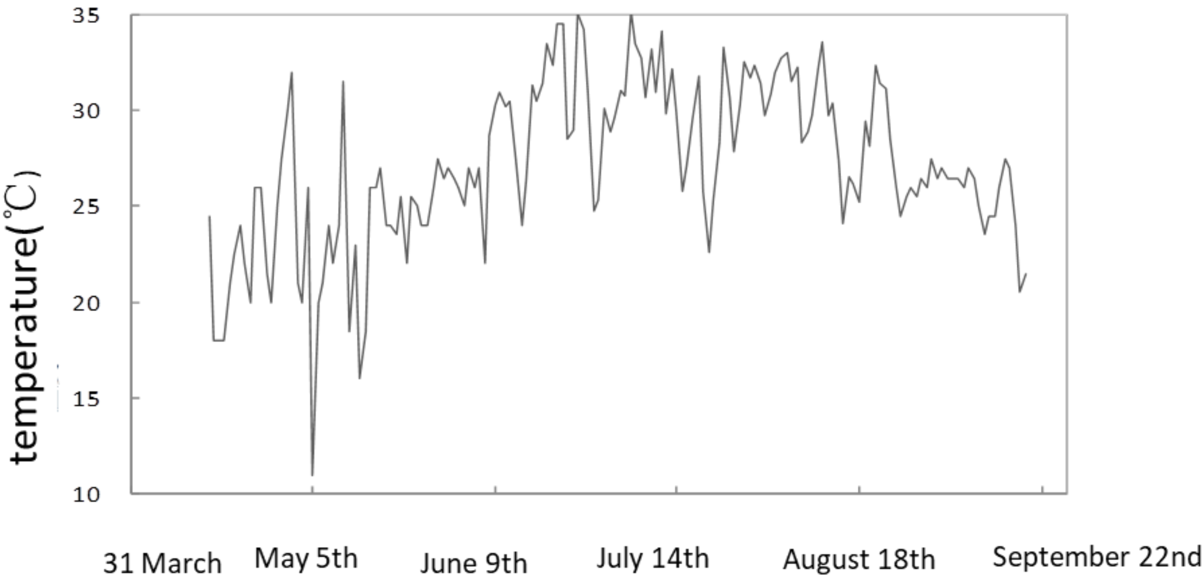

Fig.2-1 Daily temperature changes during the experimental period

2.1.2 Experimental materials.

The experimental materials used in this study were one-year Ziziphus jujuba Mill. 'Hunanjidanzao'. The selected seedlings had a uniform tree shape, good growth, and the tree height was about 0.6 meters.

The POTS used in the experiment were all ordinary round plastic flowerpots, with a size of 33cm*35cm (diameter * basin height) and a volume of 115 liters. The flow rate of drip irrigation is 0.8 l/h. The experimental soil is made up of medium loam and nutrient soil by weight ratio of 3 to 1. Each potted plant is placed 20cm away from the pot, evenly placed in a naturally ventilated outdoor environment with a rain shelter. Large canopy is used for shelter when raining, and placed in the open air at other times. During the experiment, temperature, humidity, rainfall and evaporation were observed and recorded.

2.1.3 Experimental design

The experiment started on April 15, 2016 and ended on September 19, 2016. The experiment can be divided into four phenological periods, as shown in table 2.1.

Table 2.1 Four phenology period schedules

time	Phenological phase
4.15-5.16	Germination and leaf development（Phase I）
5.17-6.29	Flowering and fruiting（Phase II）
6.30-8.11	Fruit swelling（Phase III）
8.12-9.19	Fruit ripening stage（Phase IV）

Two influencing factors were designed, namely, different irrigation upper and lower limits and different covering methods. Three treatments were set for the mulching method, namely bare soil, mulching and straw mulching. The film thickness was 0.015mm and the material was black polyethylene plastic film. Straw mulching is made of wheat straw, which is cut into 8cm fragments and evenly spread in the flowerpot. Under natural conditions, the covering thickness is 2cm. According to the water demand of early seedlings and with reference to sl13-2004 "irrigation test specifications", three irrigation levels, namely low water, medium water and high water, were set. Soil moisture content was controlled to account for 55% to 65%, 65% to 75% and 75% to 85% of the field moisture retention, respectively. Unified irrigation was carried out by irrigators with a flow rate of 0.8 l/h. Nine treatments and three replicates were set in the experiment. One seedling was planted in each pot, a total of 27 POTS. All treatments are randomly assigned, horticultural measures, pest control, etc. Are managed uniformly. The experimental design scheme is shown in table 2.2.

Tab. 2.2 Experimental design

Cover means	Irrigation upper and lower limits	Serial number
Bare soil	55%~65%	L1
	65%~75%	L2
	75%~85%	L3
Film mulching	55%~65%	M1
	65%~75%	M2
	75%~85%	M3
straw	55%~65%	J1
	65%~75%	J2
	75%~85%	J3

When the soil moisture content decreases to the expected field moisture holding percentage, namely 55%, 65% and 75% of the field moisture holding rate, irrigation is carried out. The upper and lower limits of irrigation are calculated by formula (2-1), and the soil moisture content is finally increased to 65%, 75% and 85% of the field moisture holding rate respectively.

The upper and lower limits of irrigation are derived from equation (2-1)

$$m = 1.34 \times V \times (\theta_{max} - \theta_{min})$$

Where :m- upper and lower limits of irrigation, kg/ basin; 1.34- dry bulk density of soil in the basin, g/ cm3; V- soil volume in the basin, 0.02564 cubic meters; θ_{max} - soil moisture content on-line. ; θ_{min} - lower limit of soil moisture content.

2.2 Determination index and determination method.

(1) chlorophyll -- -- absorption spectrometry

(2) vitamin C-- -- titration method

(3) determination of plant cell membrane permeability -- conductance meter method

(4) determination of water holdup in the field -- -- indoor ring knife method

The growth indexes measured in the experiment were the height of jujube head, the diameter of jujube head, the diameter of plant and the growth of leaves, as shown in table 2.4.

Tab. 2.3 Observation items and methods for growth indicators

Observation project	Observation period	Observation method
Jujube head height	7d/time	The height of each jujube head was measured and the average value was taken as the height of the jujube head in the experimental tree
Jujube head diameter	7d/time	The diameter of the base of each jujube head was determined, and the mean value was taken as the diameter of the jujube head of the test tree.
Leaf growth	7d/time	Measure the length and width of the leaves and calculate the area of the leaves.
Leaf growth	20d/time	At the distance of 5cm from the soil surface of each test tree, measurements were made in east, west and north and south directions, and then the average value was taken as the plant diameter.

2.3 Data processing methods

The experimental data were statistically plotted using Excel2010, single factor anova was performed using Spsse8.0 statistical analysis software, and multiple comparisons were performed using dun can method ($P<0.05$,significant level).

3. Results and analysis

3.1 Analysis of chlorophyll content in jujube seedlings

The chlorophyll content measured in the mature stage of fruits under different mulching methods and the significant differences among different treatments are shown in table 6.1. As can be seen from the table, in the ripening stage of fruit, the chlorophyll content of each treatment under different irrigation conditions was significantly different under different irrigation conditions. By analyzing the experimental data of three times, the results show that M2 has a certain significant difference compared with other treatments. Moreover, during this period, chlorophyll content in leaves decreased with time. In the three coverage modes, the mean variation ranges of each treatment are shown in figure 6-1. It can be seen from the figure that the variation of L2, L2 and J2 in each coverage mode during this period has the largest decline. And about the reason for decline in chlorophyll content is: with the maturity of the fruit, the required nutrients also gradually began to decrease, photosynthesis is then began to decline, and as the change of climate, photosynthetic capacity also began to reduce, thus affecting the formation of chlorophyll, resulting in a decrease of chlorophyll content, and covered in 3 different processing, processing L2M2J2 were dropping serious, The reason is that compared with the treatment under the upper and lower limits of the other two irrigation systems, it is relatively denser and has more leaves. Therefore, it is also greatly affected by the climate and thus has the largest decline.

The data analysis shows that although there is no obvious difference, the chlorophyll content of L2, M2 and J2 is more in the three irrigation water treatments.

In comparison, the chlorophyll content of l2, m2 and j23 under different mulching methods was more than that of the other two mulching methods in the same period. (see table 6.1, table 6.2 and table 6.3 for details)

Table 3.1 Content of chlorophyll in each treatment condition unit：mg/g

Date	Processing method								
	J1	J2	J3	M1	M2	M3	L1	L2	L3
8-25	3.48ab	3.06ab	3.42ab	2.88b	3.63a	3.16ab	2.87b	3.10ab	2.95b
9-1	2.63a	2.85a	3.20a	2.83a	3.29a	3.045a	2.69a	3.00a	2.92a
9-8	2.63ab	2.82ab	3.14ab	2.50ab	3.27a	1.97b	2.64ab	2.61ab	2.91ab

Note: small letters in the table indicate the significance of differences among treatments when p=0.0 5

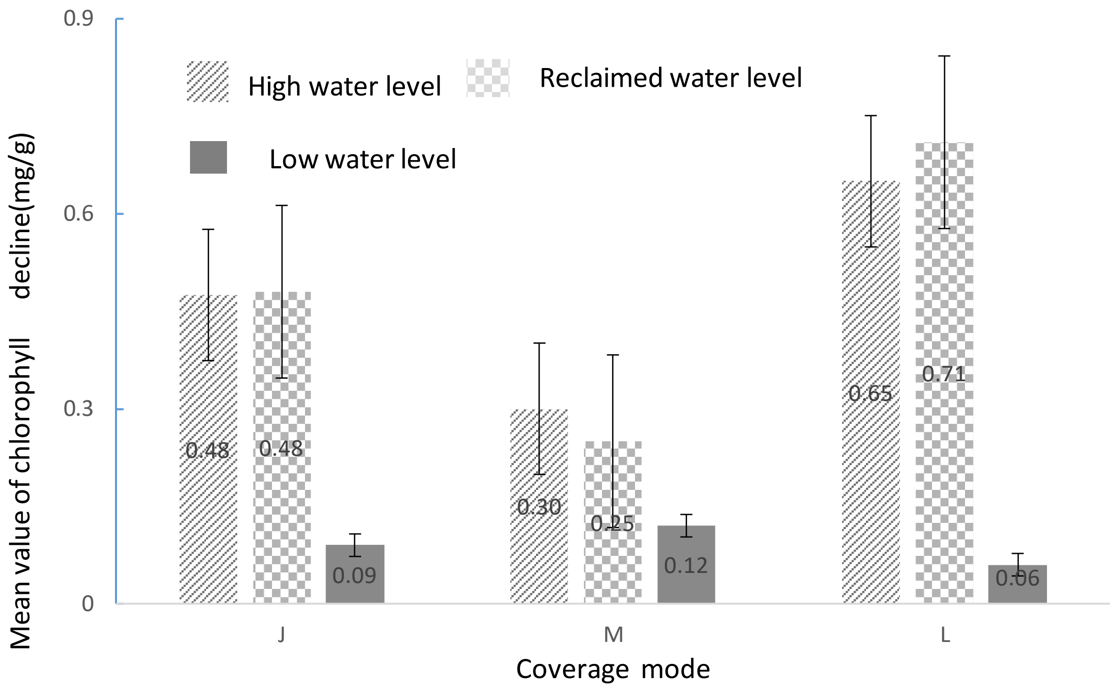

Fig. 3-1 The mean value of different treatment chlorophyll under different coverage modes

3.2 Analysis of VC content in jujube seedling leaves

Under different mulching methods, the VC content in the leaves measured at the ripening stage of the fruits and the significant differences among the treatments were shown in table 6.2. It can be seen from the table that, in this period, although the difference of VC content between different irrigation upper and lower limits under different coverage methods was not obvious, it can be seen that M2 compared with other treatments had certain significant differences. Moreover, the VC content of the leaves in each treatment showed an upward trend, and the variation trend was the same among different mulches, and there was no significant difference due to different mulching methods. The increase of VC in each treatment under three different coverages is shown in figure 6-2. There are two reasons for the increase of VC content. First, in the mature stage of fruit, the metabolism of jujube seedlings produces VC, and VC accumulates more and more. Second, it is because the VC has the effect of antioxidant, it can protect the blade, reduce the rate of leaf senescence, the reason may be as time goes on, photosynthesis are also falling, thus lead to the VC content will increase gradually accumulated, and the increase of VC can reduce the side effects of photosynthesis of plants, which can improve the ability to cope with climate change. In the upper and lower limits of irrigation under the three mulch methods, the VC content of L2, M2 and J2 was more and the amount of increase was more.

Compared with the three treatments of L2M2J2 under different coverage modes, the VC content of M2 was more than that of the other two types of coverage in the same period. (see table 6.2 for details).

Tab. 3.2 Content of Vitamin C under Various Treatment Conditions unit：mg/100g FW

date	handle								
	J1	J2	J3	M1	M2	M3	L1	L2	L3
8-25	263.77a	216.87a	287.48a	298.12a	259.51a	268.68a	232.70a	234.77a	219.78a
9-1	288.68b	322.33ab	341.47ab	280.21b	388.00a	327.98ab	272.93b	277.92b	300.59b
9-8	343.46b	353.53ab	391.35ab	375.06ab	436.31a	357.20ab	402.60ab	349.85ab	399.17ab

Note: small letters in the table indicate the significance of differences among treatments when p=0.05

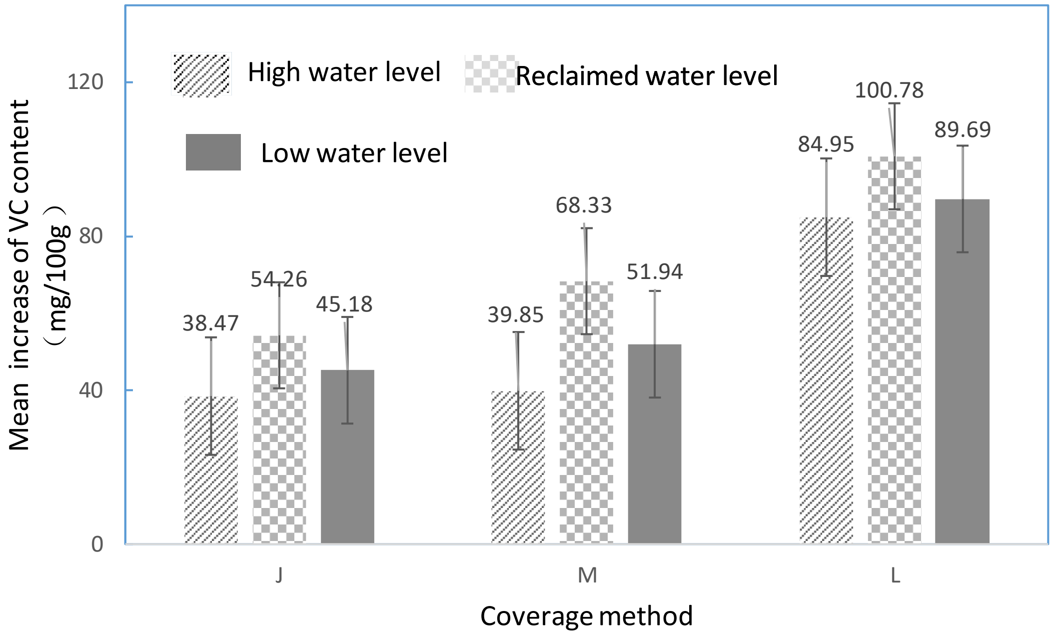

Fig. 3-2 The mean value of different treatment Vitamin C under different coverage modes

3.3 Electrical conductivity analysis of jujube seedling leaves

Under different mulching methods, the leaf conductivity measured at the ripening stage of fruits and the differences between them are shown in table 6.3. It can be seen from the table that, after treatment with different irrigation upper and lower limits, on the whole, the conductivity of each treatment under the three coverage modes presents certain significant differences. As can be seen from the results, the conductivity of M2 is the smallest. The electrical conductivity of the blades in each treatment showed an upward trend, which was also true in the three coverage modes. The average increase of conductivity in each treatment under three different coverages is shown in figure 6-3. There are two reasons for the increase of electrical conductivity: 1. During the ripening period of fruit, the climate changes constantly, causing damage to leaf cells; 2. With the change of climate, the photosynthetic capacity of the leaves is gradually reduced, so that the leaves are affected by the harmful side effects of photosynthesis and the ions in the cells flow out, resulting in an increase in electrical conductivity. Among them, the conductivity of L2 treatment increased the most, because the growth of L2 treatment was relatively luxuriant, the leaves were relatively more, the impact of climate and photosynthesis was relatively large, so the decline was the largest. In comparison, the conductivity of L2 was the lowest in lowest in the three irrigation treatments, so the damage rate of leaves was the lowest.

Compared with the three treatments of L2, M2 and J2 under different coverage modes, the conductivity and content of M2 were less than the other two types of coverage in the same period. (see table 6-3 for details)

Tab. 3.3 Conductivity under Various Treatment Conditions unit：ds/m

date	handle								
	J1	J2	J3	M1	M2	M3	L1	L2	L3
8-25	0.18bc	0.29ab	0.21abc	0.21abc	0.19bc	0.23ab	0.21abc	0.19bc	0.23a
9-1	0.33ab	0.34ab	0.37a	0.36a	0.24b	0.33ab	0.30ba	0.29ab	0.30ab
9-8	0.32bcd	0.32bcd	0.36bc	0.43a	0.26e	0.37b	0.29de	0.32bcd	0.31de

Note: small letters in the table indicate the significance of differences among treatments when p=0.0 5

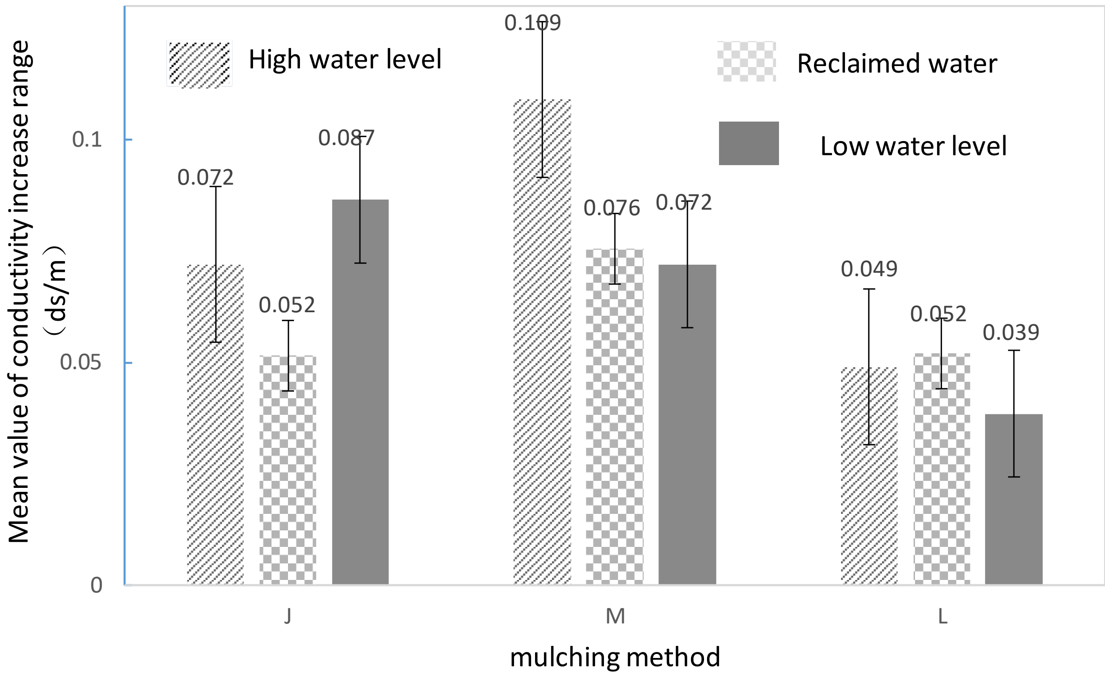

Fig.3-3 The mean value of different treatment electrical conductivity under different coverage modes

Under the treatment of different irrigation upper and lower limits under the three mulching methods, the physiological indexes of the M2 treatment were all better than those under the other two mulching methods, the chlorophyll content and vitamin c content were both higher than those under the other two mulching methods, the conductivity was lower, and the leaf injury rate was lower.

4. Discussion and Conclusion

The chlorophyll, VC and conductivity of M2 were significantly different from those of other treatments under different irrigation limits and mulching methods. In summary, the chlorophyll and VC contents in M2 treatment were higher each time than those in the base treatment, and the conductivity was lower and the injury rate was the lowest. In this chapter, the following conclusions were obtained by studying the growth indexes of jujube seedlings under different treatments:

(1) The chlorophyll content of the leaves measured at the mature stage of the fruits under different mulching methods was significantly different among the treatments. Among them, M2 is more significantly different from other treatments. Moreover, the chlorophyll content of leaves decreased with time. During this period, the L2, M2 and J2 changes in the treatment under each coverage mode decreased the most.

(2) Under the mulching mode, there was a significant difference in the content of VC in the leaves measured at the ripening stage between treatments, and M2 showed a certain significant difference compared with other treatments. Moreover, the VC content of the leaves in each treatment showed an increasing trend, and the variation trend was the same among the mulches, and there was no significant difference due to different mulching methods.

(3) Under different mulching methods, there were significant differences in leaf conductivities measured at the ripening stage between treatments. After treatment with different irrigation limits, the conductivity of M2 was the smallest. The electrical conductivity of the blades in each treatment showed an upward trend, which was also true in the three coverage modes. Among them, compared with L2, M2 and J2 under different coverage modes, the conductivity and content of M2 were less than those of the other two types of coverage in the same period.

Therefore, considering the experimental conditions, the jujube seedlings grew best when the soil mo isture content was 65% to 75% of the field water holding capacity and the mulching conditions wer e film mulching, and the physiological indicators were better than other treatments.

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