Effects of different Irrigation Water limits and mulching methods on growth Indexes of Jujube seedlings

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Abstract

From the perspective of water-saving irrigation, this experiment studied the effects of different irrigation limits and coverage methods on the growth indicators of jujube seedlings. The growth indicators include jujube height, plant diameter, jujube stem and leaf area. Compared with other treatments, each growth index showed the best performance under the condition of film covering level (M2). M2 mode is most suitable for jujube seedling growth. Among them, the growth rate of jujube head increases first and then decreases during flowering and fruiting, and reaches a peak during fruit expansion period, and finally reaches a stable value; plant diameter increases first and then decreases after flowering and fruit setting. The fruit expansion period begins to increase gradually. At this time, the fruit has the highest growth rate until the peak value; the jujube stem is thicker in the early stage of flowering and fruit setting, and the growth rate is relatively slow, and then gradually increases to the peak of the fruit expansion period, reaching a stable value. The leaf area grew fastest at the flowering and fruiting stage, with the highest growth rate, and then gradually decreased. Although the fruit expansion period increased, the growth was slow.

Keywords

Jujube seedling; lower limit of irrigation; mulching method; growth indicator.

1. Introduction

Water is the source of life and the cradle of civilization. With the development of economy and society, the contradiction between human and natural resources is more and more prominent. In the United Nations 2006 evaluation of 192 countries and regions, China's total water resources ranked 127. However, the per capita water resources in China is about 2200 m³, which is only 1/4 of the world average[1]. In addition, the water pollution problem is becoming more and more serious, which leads to the water shortage increasing the contradiction between human and natural resources[2]. According to the Water Resources Bulletin of the Ministry of Water Resources, the average annual water resources in Hebei Province is 20.5 billion m³ and the available water volume is 17 billion m³. Per capita water resources are 307 m³, which is only 1 / 7 of the national average[3].

With the development of economy, people ignore environmental problems while developing economy, and then cause a series of poverty problems. In order to solve these two problems at the same time, the government has actively led the people to take a series of measures in fruit tree planting in an attempt to exchange the least investment for the maximum return, one of which is the upper and lower limits of irrigation. Zhu Jinxia et al[4].studied the effects of different irrigation upper and lower limits on the yield of Lycium barbarum. It was found that the yield and quality of Lycium barbarum reached the maximum when the upper and lower limit of irrigation was 675m³/ 667 ㎡ from the point

of view of sustainable utilization of soil water. Wu Guohong and so on[5] studied the yield of seedless white grape with different upper and lower limits of irrigation, and showed that when the cultivation method of the combination of hose and root area restriction was implemented in turpan, when the upper and lower limits of irrigation were controlled at 1025 m³/667㎡, the grape yield reached 1508.5 kg/667 ㎡. . Zhao Yunge and others[6] set up three different irrigation treatments, namely, 50% / 80% (W1), 60% / 90% (W2) and 70% / 100% (W3) of farmland holding capacity.

When studying the yield of apple, it is found that the demand of water for apple yield is not the more irrigation, the higher the yield, but the trend of W2 > DM > W1 > W3. With the development of economy, people also put forward higher requirements for the living standard. In recent years, researchers have paid more attention to the influence of crop water use efficiency on fruit yield to the quality of fruit tree. Wang Ying and others[7] studied the quality of pear jujube by setting different irrigation upper and lower limits. It was found that increasing the upper and lower limit of irrigation had a great effect on most nutrients of pear jujube fruit, but it could not increase the content of citric acid in pear jujube, but on the contrary, it could not increase the content of citric acid in pear jujube. If the lower limit of irrigation is too low, the content of citric acid in the fruit will be reduced. According to the study of the effect of different irrigation modes on the quality of walnuts, Zhao, et al.[8] showed that the highest quality, the largest volume, the highest kernel rate and the highest total yield were compared with other irrigation, C2 (drip irrigation, lower limit of irrigation, 45 mm).You Lei et al [9] found that the effect of different irrigation treatment methods on the quality of Xinjiang ash jujube: from the dripper flow rate and the lower limit of irrigation water, when the lower limit of irrigation water is 22.5 mm, the flow rate of the dripper is 3.75 L, the fruit quality is the best . Hu Jiashuai et al.[10]The effect of different irrigation on the yield and quality of red dates in the south of Xinjiang was found. The irrigation quota was 1050 mm in all the drip irrigation treatments, the number of irrigation times was 10 times, and the yield and quality of the 18 treatments were better.

Different irrigation upper and lower limits and mulching methods will form different soil wetting bodies, which will have an important effect on the growth of jujube seedlings. The height of jujube head, the diameter of stems, the diameter of plants and the leaf area of jujube seedlings, and so on, are important to the growth of jujube seedlings. Is the most visible indicator of the difference. Jujube seedlings grow irreversibly by adding a series of indexes such as plant height, leaf area and stem diameter. In essence, the growth index of jujube seedling is the external performance of physiological index in the growth process of jujube seedling. The jujube seedling coordinates with the ending environment through the change of internal physiological index to achieve the best growth. These changes have a direct impact on crop production Quantity and quality We first study the responses of external growth indicators to different irrigation upper and lower limits and cover patterns, and try to explain these differences, which is also an important means of research[11][12].

For jujube trees, there are problems of fruit development and yield, but the significance of vegetative growth of young jujube seedlings is greater than reproductive growth. Only when the branches are fully grown in childhood can they lay a foundation for the harvest of fruits in adulthood [13]. Thus

provides the theory support for the water - saving irrigation of jujube.2 Experimental program and research method

2. Overview of the study area and experimental design

2.1 Overview of the test area

The test site is located in the Chinese Date Research Center of Hebei Agricultural University, Baoding City, Hebei Province, which belongs to the northern part of the North China Plain. It has a north latitude of 38°51′, a longitude of 115°28′, an altitude of 17.20 m, a multi-year average temperature of 12 ℃ and an average annual precipitation of 550 mm. It belongs to the temperate monsoon climate. The precipitation is mainly concentrated in the summer, the four seasons are distinct, the summer is hot and rainy, the winter is cold and dry, and the average annual water surface evaporation is 1910.4 mm. The test soil is plough layer soil and matrix mixed soil, and the soil fertility is uniform. The soil bulk density was 1.34 g/cm3, and the field water holding capacity was 29.8 cm3/cm3. The soil nutrient index of the test was: pH 7.51, organic matter 2.62%, available potassium 100.23 mg/kg, available phosphorus 20.18 mg/kg, and available nitrogen 90.37 mg/kg.

2.2 Experiment material

The test materials in this study were 1 year old Hunan egg date jujube seedlings（Ziziphus jujuba Mill. 'Hunanjidanzao'）. The selected seedlings were uniform in shape and grew well. The tree height was about 0.6 m.

The pot used in the experiment was an ordinary round plastic flowerpot with a size of 33 cm × 35 cm (diameter × pot height) and a volume of 115L. The flow rate of drip irrigation device was 0.8 L /h. The test soil is composed of medium loam and nutrient soil according to the weight ratio of 3:1. Each pot is placed at a distance of 20 cm. It is evenly placed outside the air-permeable and protected from the rain. It is sheltered by the canopy during rainfall and placed in the open air at other times. During the experiment, temperature, humidity, rainfall and evaporation were observed and recorded.

2.3 Test design

The trial began on April 15, 2016 and ended on September 19, 2016. The test can be divided into four phenological periods as shown in Table 2.1.

Table 2.1 timetables for the four phenological periods

time	phenological period
4.15-5.16	Budding stage (stage I)
5.17-6.29	Flowering and fruiting stage (II)
6.30-8.11	Fruit expansion stage (stage III)
8.12-9.19	Fruit ripening stage (IV)

There are two influencing factors in the experimental design, namely, different upper and lower limits of irrigation 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 was made from wheat straw, which was cut into pieces about 8 cm in length and evenly spread in the flowerpot. The thickness of the straw mulching was 2 cm in natural state. According to the water demand of jujube 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%~65%, 65%~75% and 75%~85% of the field moisture retention, respectively. Unified irrigation was conducted with a flow rate of 0.8 L/h. There were 9 treatments and 3 replicates in the experiment. Each pot was planted with one jujube seedling, a total of 27 POTS. All treatments were randomly assigned, and horticultural measures, pest control and other management were unified. The experimental design scheme is shown in table 2.2.

Tab. 2.2 Experimental design

Coverage method	Irrigation upper and lower limits	Numbering
Bare soil	55%~65%	L1
	65%~75%	L2
	75%~85%	L3
tectorial membrane	55%~65%	M1
	65%~75%	M2
	75%~85%	M3
Straw	55%~65%	J1
	65%~75%	J2
	75%~85%	J3

When the water content of the soil is reduced to the expected percentage of the field water holding rate, that is, 55%, 65% and 75% of the field water holding rate, the water content of the field is calculated by the formula (2-1), and the water content of the soil is respectively increased to 65%, 75% and 85% of the field water holding rate, respectively.

The lower limit of irrigation water is calculated according to formula (2- 1):

$$m = 1.34 \times V \times (\theta_{max} - \theta_{min}) \quad (2\text{-}1)$$

In the formula above： m —Lower irrigation water limit, kg/ basin；1.34—Dry bulk density of soil in basin， g/cm3； V —The volume of the soil in the basin, with a value of 0.02564 m3； θ_{max} —Upper limit of soil moisture content； θ_{min} —Lower limit of soil moisture content。

The times of irrigation by phenological period are shown in Table 2.3.

Tab. 2.3 The irrigation frequency of jujube under different cover modes with different irrigation conditions in the whole phenological period

mulching method	Bud and leaf spreading stage			Flowering and fruiting stage			Fruit expanding stage			fructescence		
	High water	Middle water	Low water	High water	Middle water	Low water	High water	Middle water	Low water	High water	Middle water	Low water
Exposed soil	7	6	5	13	11	10	17	15	14	12	11	10
Straw	6	5	4	10	9	8	14	12	11	11	10	9
Mulching	6	5	4	9	8	7	13	11	10	10	9	8

2.4 Determination index and determination method

(1) determination of water holdup in the field-method of single—ring[14].

(2) Measurement of growth index

The growth indexes were as follows: jujube head height, diameter of jujube head, stem diameter and leaf growth (Table 2.4).

Tab. 2.4 Observation items and methods for growth indicators

Observation item	Observation period	Observation method

Jujube head height	7d/turn	The height of each jujube head was determined, and the average value was taken as the height of the jujube head of the test tree.
Jujube head diameter	7d/turn	The basal diameter of each jujube head was measured and the average value was taken as the diameter of the stem of the jujube head of the test tree.
Leaf growth	7d/turn	Measure the length and width of the leaves to calculate the area of the leaves
Plant stem diameter	20d/turn	At the distance of each test tree from the soil surface 5cm, measure it in east-south and north-south directions, and then take the average value as the diameter of the plant.

2.5 Data processing methods

The test data was collated and plotted using Excel, and statistical analysis was performed in SPSS 18.0 software. One-way ANOVA was performed on the relevant indicators, and multiple comparisons were performed using the Duncan method ($P<0.05$, significant level).

3. Results and analysis

3.1 Analysis of growth trend of Jujube Seedling and Jujube head height

By table 3.1 it can be seen that the lower limit on coverage under the condition of different irrigation treatment, jujube jujube seedlings height increased, there are significant differences, and with the continuous growth of jujube head height, significance of difference is more and more big, the integrated throughout the growing season, processing the M2 (mulch, water processing) are in different periods of time than other treatment showed significant difference, jujube looks like the head height is better than other processing.

Tab.3.1 Accumulated growth of the jujube head during the whole phonation period

Date	process mode								
	J1	J2	J3	M1	M2	M3	L1	L2	L3
6-4	23.15a	21.03a	20.50a	23.13a	22.67a	20.77a	22.13a	20.40a	20.93a
6-11	24.10b	22.50b	23.47b	26.93b	44.63a	24.46b	24.00b	23.40b	24.83b
6-18	31.65bc	23.57c	26.57bc	32.83b	53.70a	31.13bc	28.37bc	26.17bc	26.07bc
6-25	38.10bc	25.33e	27.46de	41.53b	58.00a	36.10bcd	39.96bc	35.03bcde	30.63cde
7-2	44.70bc	28.70e	29.60de	48.00b	64.50a	40.13bcd	46.93b	42.76bc	34.43cde
7-9	55.40bc	34.00de	32.26e	62.90ab	73.13a	48.33bcd	60.9ab	55.47bc	40.87cde
7-16	57.65bc	42.43de	34.17e	67.37ab	78.63a	56.80bc	67.80ab	66.87ab	47.8de
7-23	59.65bc	48.10cd	34.80d	75.93ab	90.26a	58.17bc	76.43ab	81.80a	54.77cd
7-30	76.15c	50.70de	35.73e	94.30abc	108.97a	77.47bc	95.30abc	100.90ab	70.80cd
8-6	94.40bc	50.63d	51.33d	109.86ab	124.73a	92.03bc	111.83ab	111.00ab	86.27c
8-13	112.10bcd	55.9e	65.10e	126.67b	147.17a	102.60cd	120.97bc	121.33bc	98.57d
8-20	118.20bcd	59.37e	78.57e	135.43b	159.17a	104.90cd	124.80bc	126.73b	102.93d
8-27	119.25bcd	59.87f	80.2e	135.57b	159.67a	108.17cd	125.20bc	126.80bc	103.23d
9-3	118.25bcd	59.40g	81.30f	135.70b	160.50a	108.70cd	126.00bc	130.03bc	103.70e

Note: the small and medium letters in the table indicate that there is a significant difference in each treatment when p=0. 05.

By analyzing the diurnal variation of jujube head height (see figure 3-1, figure 3-2, and figure 3-3, respectively), the relationship between the growth rate and time of the head height of jujube seedlings under different irrigation upper and lower limits and mulching methods can be seen. It can be seen from the figure that the growth rate of the height of the jujube head during the whole growth period of the height of the jujube head under different treatments was different with the difference in the upper and lower limits of irrigation, but the change trend was the same among all treatments. By comparing the growth rate of the height of the jujube head under the three mulching methods, it can

be seen that the growth trend of the height of the jujube head under the three mulching methods was the same, which showed that the growth rate of the height of the jujube head was first increased and then decreased in the flowering and fruit-setting period, and reached a peak in the fruit swelling period, and finally reached a stable value. See table 3.2 for the mean and peak fluctuations of the growth rate of jujube head height.

In the treatment of the lower limit of three different irrigation waters, among them, the treatment of L2, M2, J2 in the respective coverage mode, the height growth rate of jujube head is faster than the lower limit of the other two irrigation waters, which means that with the lower limit of irrigation water Different, the growth rate will also be different, and there will not be too much difference due to different coverage methods. In this test, with the increase or decrease of the lower limit of irrigation, the other two lower irrigation limits under each coverage mode The growth rate will be slightly smaller than L2, M2, and J2. Moreover, suitable water can promote the growth of jujube head to a certain extent. At the initial stage, the growth of jujube head is the fastest. At this stage, most of the nutrients are transferred to the jujube, and the jujube grows rapidly. After the fruit setting period, the jujube head grows to a certain height, and with the beginning of vegetative growth, the growth of the jujube head begins to slow down. Relatively speaking, the L2, M2, and J2 treatments in different coverage modes have relatively higher growth rates of M2 than L2 and J2 (see Figure 3-4).

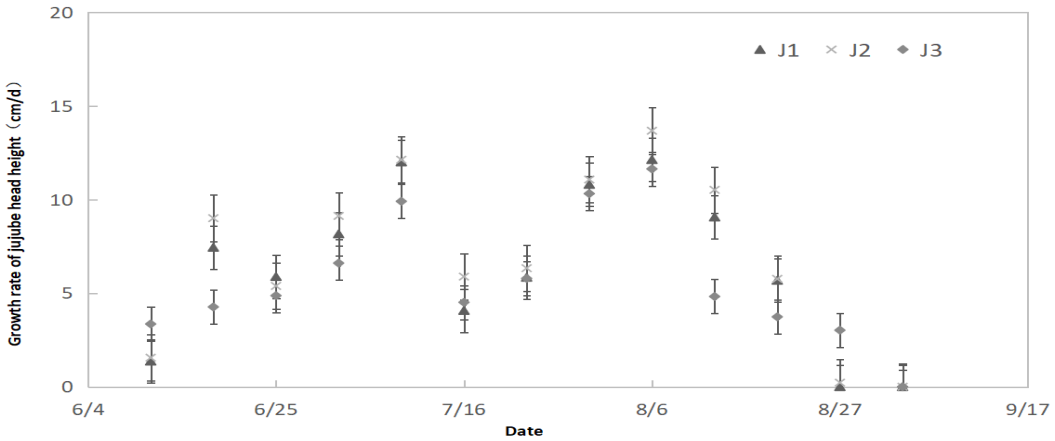

Fig.3-1 The variations in height of the top of jujube under different irrigation quotas under straw mulching

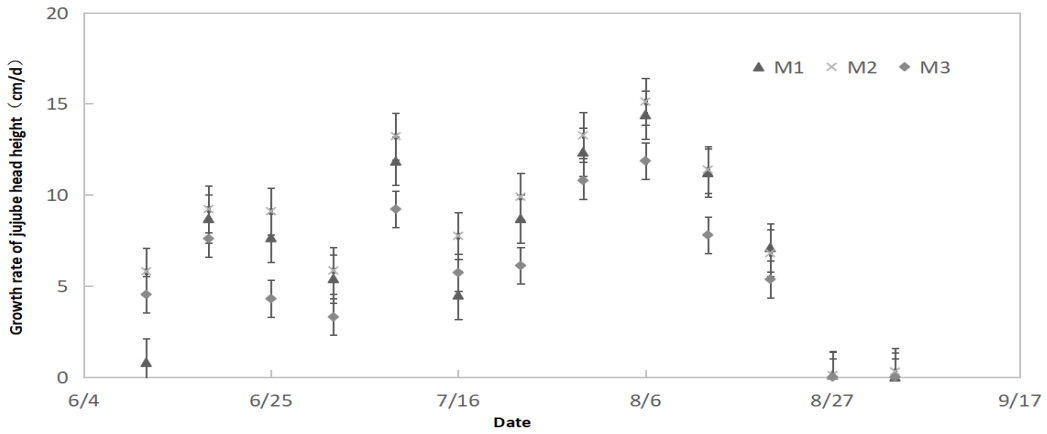

Fig.3-2 The variations in height of the top of jujube under different irrigation quotas under different filming

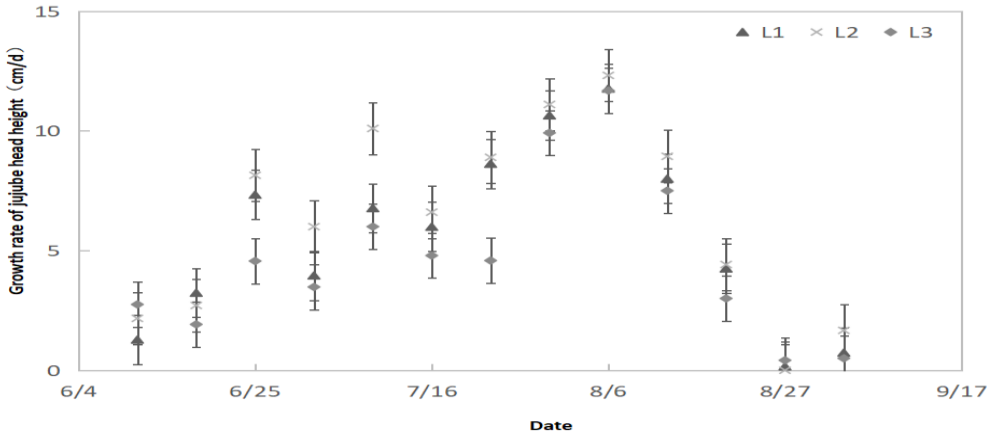

Fig.3-3 The variations in height of the top of jujube under bare soil

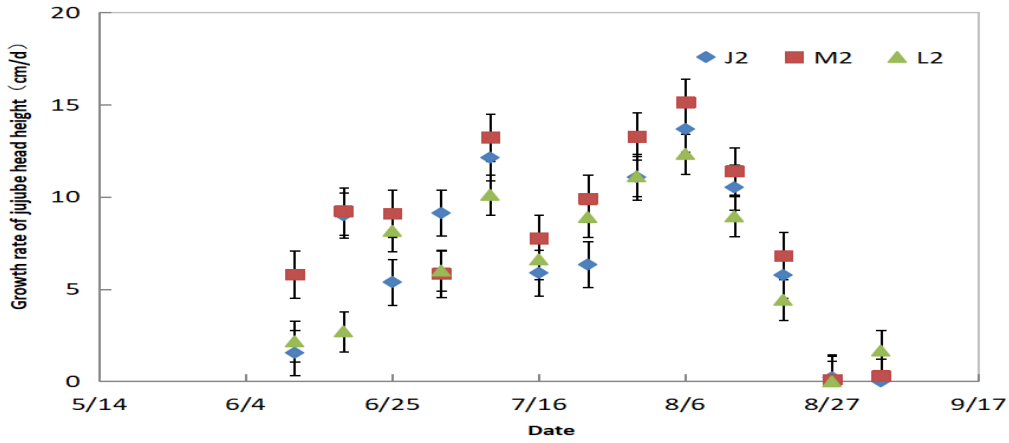

Fig.3-4 The variations in height of the top of jujube under three kinds of covering conditions

Tab.3.2 The fluctuation and peak value of high growth rate of jujube head

process mode	Fluctuation mean of flowering and fruiting period	Fruit swelling peak	Fruit ripening peak
L1	3.094	6.771	11.767
L2	3.123	10.100	12.317
L3	1.802	6.000	11.683
M1	4.875	11.850	14.400
M2	5.370	13.220	15.120
M3	5.110	9.220	11.870
J1	3.840	12.000	12.125
J2	5.180	12.120	13.668
J3	5.036	9.900	11.632

3.2 Analysis on the trend of stem diameter growth of jujube

As can be seen from Table 3.3, during the whole phenological period of the jujube seedlings, with the increasing diameter of the base of the jujube head, there is a trend of steady growth among the treatments, with little significant difference, after entering the flowering and fruiting stage. Significant difference began to appear, M2 showed a certain difference compared with other treatments, but not very significant, relatively speaking, M2 jujube head base diameter than other treatments to grow faster than other treatments.

Tab. 3.3 Cumulative growth of head stalks in the whole phonation period

Date	process mode								
	J1	J2	J3	M1	M2	M3	L1	L2	L3
6-4	4.22a	4.28a	4.20a	4.37a	4.34a	4.43a	4.33a	4.50a	4.41a
6-11	4.53a	4.53a	4.51a	4.40a	4.39a	5.00a	4.58a	4.85a	4.62a
6-18	4.91ab	4.92ab	4.63b	4.79ba	4.77ab	5.48a	4.92ab	5.08ab	4.78ab
6-25	5.22ab	5.00ab	4.69b	4.99ba	5.06ab	5.64a	5.27ab	5.69a	4.94ab
7-2	5.40a	5.27a	4.94a	5.10a	5.65a	5.68a	5.83a	5.82a	5.59a
7-9	5.91a	5.70a	5.34a	5.43a	6.46a	5.73a	6.66a	6.18a	6.59a
7-16	8.42a	5.95b	6.13ab	7.52ab	7.11ab	7.61ab	7.22ba	7.36ab	6.88ab
7-23	9.50a	6.33b	6.83ab	8.70ab	7.53ab	8.17ab	7.90ab	7.85ab	7.32ab
7-30	9.82a	7.32a	7.28a	9.26a	8.43a	9.64a	8.68a	9.15a	8.36a
8-6	9.24ab	7.75b	7.93b	9.85ab	11.61a	10.09ab	9.71b	10.14ab	8.94ab
8-13	9.88ab	8.62b	8.88b	10.30ab	12.45a	11.01ab	10.64ab	11.03ab	9.80ab
8-20	10.95ab	9.00ab	9.56ab	10.92ab	12.79a	11.57ab	11.39ab	11.98ab	10.57ab
8-27	10.92ab	9.61b	9.63b	11.22ab	13.45a	11.72ab	11.43ba	12.23ab	11.02ab
9-3	11.39ab	10.57b	10.26b	11.46ab	14.05a	12.06ab	12.11ab	12.32ab	12.71ab

Note: the small and medium letters in the table indicate that there is a significant difference in each treatment when p=0. 05.

Analysis of the rough daily variation of jujube stems (see Figure 3-5, Figure 3-6, Figure 3-7, respectively), we can see the growth rate of jujube and jujube stems under different irrigation methods. The relationship between time, as can be seen from the figure, although the stems of the jujube vary with the lower limit of the irrigation water, the total change trend is the same in each treatment, which is presented as: In the early stage of flowering and fruit setting, the growth rate is relatively slow, and then gradually increases to the peak of the fruit expansion period. For the vegetative growth, the growth rate of the jujube stem is also reduced, reaching a stable value, and finally until the growth stops. The decline rate and peak value of jujube stem growth rate are shown in Table 3.4.

Under the three different coverage modes, the growth trend of jujube stems was also the same under each coverage, but the growth time of jujube trees in different coverage methods was different. It can be seen from the figure that the jujube stems are thick in flowering and fruiting period. The peak of growth rate peaked at different times. Under bare soil conditions, the three treatments reached their peak on July 9, while in the mulch and straw mulching modes, the peak time of both appeared on July 16, compared with bare soil. Delayed for one week under conditions. Among the irrigation quotas under the three coverage modes, the growth rate of L2, M2, and J2 is relatively fast. Compared with the L2, M2 and J2 treatments under different coverage modes, the growth rate of the jujube diameter of M2 is faster than that of L2 and J2 (see Figure 3-8 for details).

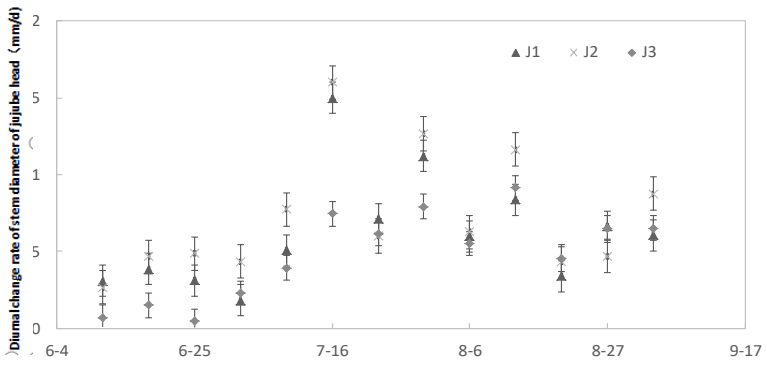

Fig.3-5 The variations of diameter of top of jujube under different irrigation quotas under straw mulching

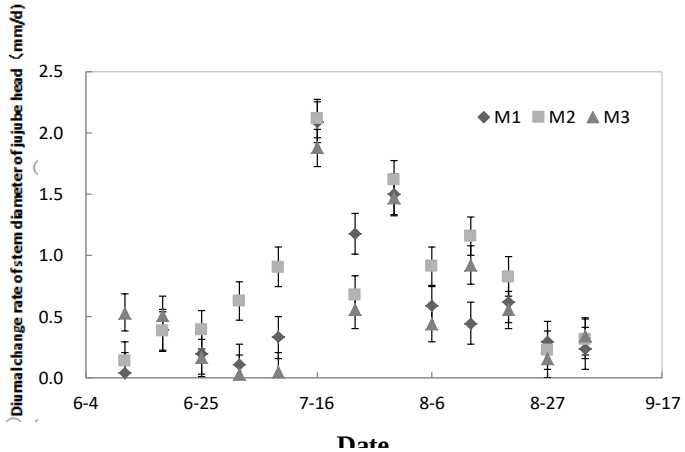

Fig.3-6 The variations in diameter of the top of jujube under different irrigation

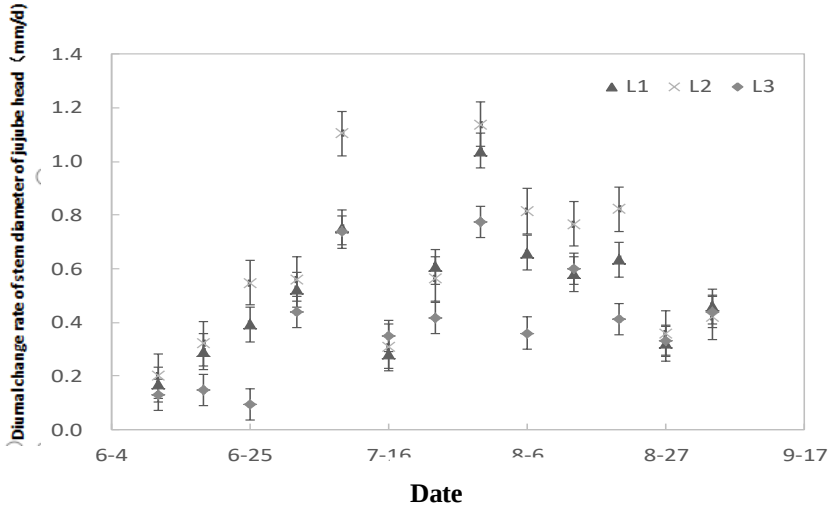

Fig.3-7 The variations in diameter of the top of jujube under different irrigation quotas under bare soil conditions

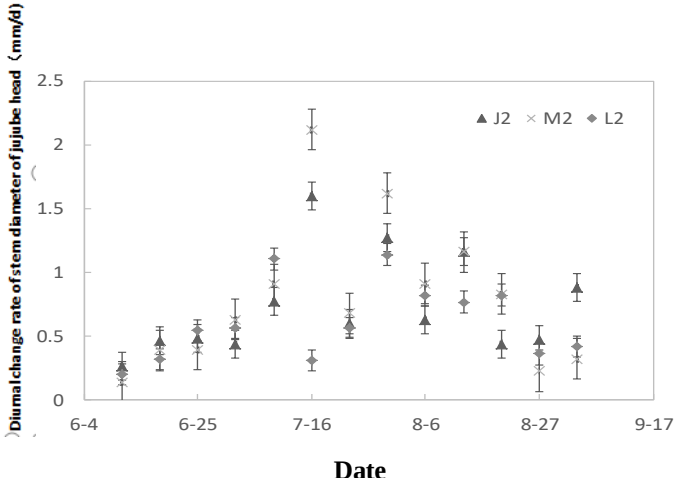

Fig.3-8 The variations in diameter of the top of jujube under different irrigation quotas under three kinds of coverage conditions

Tab.3.4 The chart in decrease rate and peak value of the diameter of growth rate of jujube head

process mode	Falling range of flowering and fruiting stage	Fruit swelling peak	Fruit ripening peak
L1	0.471	0.753	1.040
L2	0.795	1.105	1.138
L3	0.388	0.737	0.773
M1	0.917	2.093	1.500
M2	1.443	2.120	1.620
M3	1.320	1.880	1.477
J1	0.790	1.500	1.120
J2	1.000	1.600	1.268
J3	0.128	0.745	0.793

3.3 Analysis on the growth trend of the diameter of Jujube Seedling

It can be seen from Table 3.5 that there is no significant difference in plant diameter among all treatments during the whole growth period of jujube seedlings. Therefore, it can be seen that different mulching methods and lower and upper limits of irrigation do not cause the difference between different treatments.

Tab.3.5 The cumulative growth value of jujube tree diameter during the Total phenology period

Date	process								
	J1	J2	J3	M1	M2	M3	L1	L2	L3
6-4	12.02a	11.81a	11.68a	12.18a	11.85a	11.97a	11.69a	11.52a	11.76a
6-24	12.85a	12.23a	13.41a	12.94a	12.56a	13.03a	13.22a	13.11a	13.59a
7-14	13.64a	12.96a	13.69a	14.12a	14.05a	13.58a	13.87a	13.76a	14.53a
8-3	14.45a	14.90a	16.61a	15.42a	15.06a	15.33a	14.57a	15.74a	14.87a
8-23	16.13a	15.59a	17.23a	15.82a	17.35a	17.51a	15.22a	16.30a	15.39a
9-8	16.83abc	16.31bc	17.82ab	16.12bc	18.73a	18.21ab	15.64c	17.04abc	16.86abc

Note: the small and medium letters in the table indicate that there is a significant difference in each treatment when p=0. 05.

Although there is no significant difference in the diameter of jujube seedlings during the whole phenological period, it can be seen from the daily variation of plant diameter (see Figure 3-9, Figure 3-10, Figure 3-11). Next, the relationship between plant diameter and time at different irrigation limits. It can be seen from the figure that under the different coverage modes, the lower limit of different irrigation water has the same effect on the diameter of the plant, which results in the same trend of the plant diameter. The change trend is that the diameter of the plant increases first and then decreases after flowering and fruit setting. After entering the fruit expansion period, it began to gradually increase. In each coverage mode, the peak growth rate of each planting water limit is shown in Figure 3-13. Relatively speaking, the L2, M2, and J2 treatments in different coverage modes, in contrast, the plant growth rate of M2 is faster than L2 and J2 (see Figure 3-12 for details).

From the above we can see that in bloom fruit-bearing stage, jujube head height, jujube, stem diameter, stalk diameter growth rate will show some fluctuations, and causes of the fluctuation is: the same plant growth rate is different from different parts of the different organs, and during the growth of jujube seedlings in this a few parts, other organs are also growing, resulting in the nutrient distribution, therefore, because the influence of other organs in the process of growth, head height, resulting in jujube jujube head diameter, stalk diameter growth rate to fluctuate, and cause the override mode jujube seedling growth cycle arrival time is consistent with the fluctuation causes different reasons.

In this process, the fluctuations of L2, M2 and J2 in the treatment were the largest, because their growth indexes were the best, so they were also greatly affected by other organs under this treatment. After entering the flowering and fruit-setting stage, the growth rate gradually rose to the maximum,

and after reaching the fruit expansion stage, the growth rate gradually decreased. The reason for the decrease was that most of the main nutrients were used in the fruit growth during this period, which caused the growth rate of the height of the jujube head, the diameter of the jujube head and the plant diameter to gradually decrease.

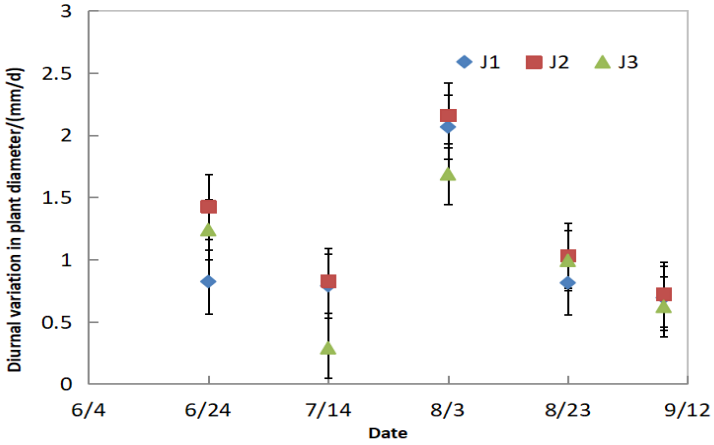

Fig3-9 The variations in plant diameter under different irrigation quotas under straw mulching condition

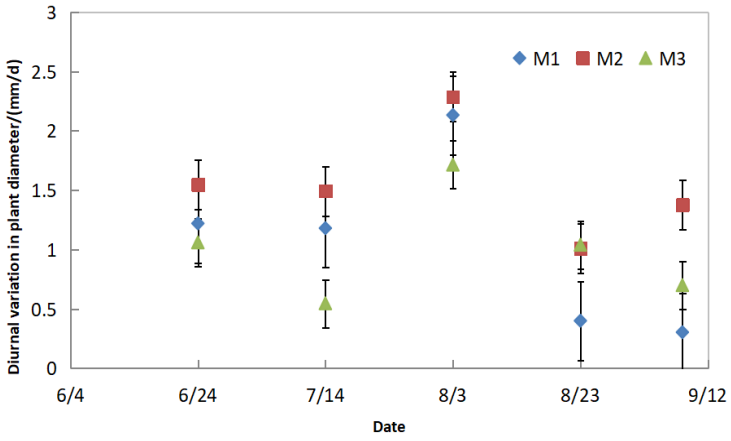

Fig.3-10The variations of plant diameter under different irrigation quotas under filming condition

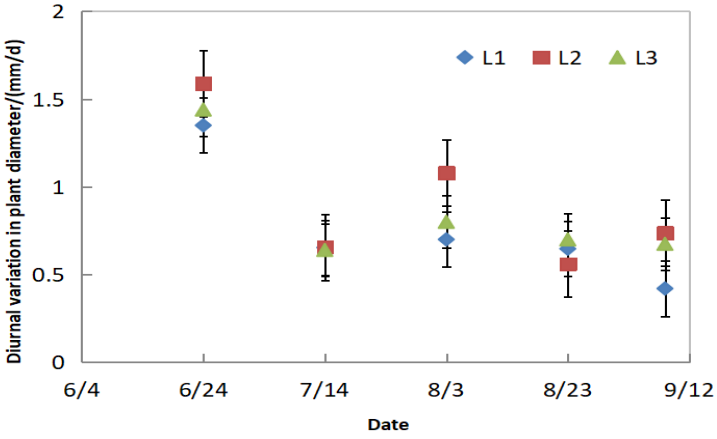

Fig.3-11 The variations in plant diameter under different irrigation quotas under bare soil condition

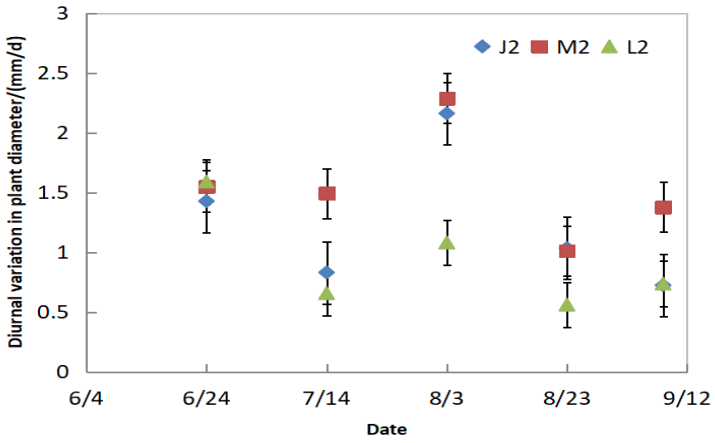

Fig.3-12 The variations in plant diameter under different irrigation quotas under three covering conditions

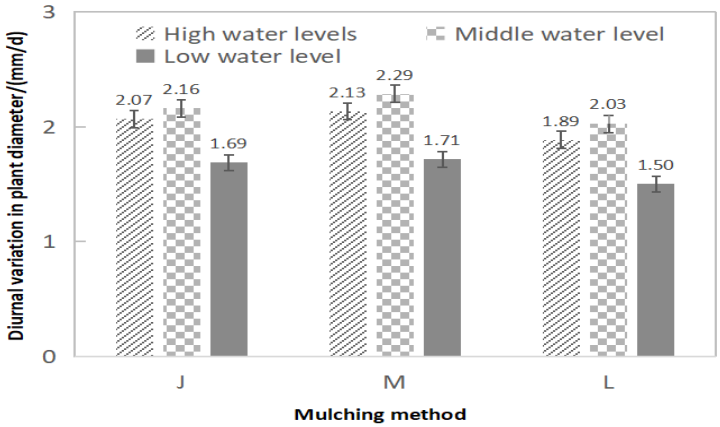

Fig.3-13 The peak of growth rate of plant diameter under the irrigation quota under various types of coverage

3.4 Analysis on the growth trend of the leaves of Jujube Seedling

The relationship between the growth rate of jujube seedling leaves and time under different irrigation upper and lower limits under different mulching methods (see figure 3-14, figure 3-15, figure 3-16). The diagram shows that the growth rate of the water processing blades tend to after the first increase gradually become smaller, the processing of leaf growth trend, and leaf growth rate between the cover means with the same change trend, were presented as follows: in the flowering period of fastest growth, fruit while growth peak, the cause of this result for jujube seedlings to late vegetative growth, and increase the photosynthesis, leaf increased rapidly, so that the photosynthetic capacity increased, to a certain degree of leaf, leaf growth rate began to decline gradually, after entering fruit enlargement period, although rose, but then began to decline, the decline reason is: The nutrient transport was frequent in the period of fruit expansion, which provided nutrients for the later fruit growth, and thus led to a small increase in the growth rate of leaves. At the ripening stage of fruit, the growth rate of leaves was slow, and the growth rate of leaves continued to decrease. FIG. 3-18 shows the peak growth rate of leaves at the upper and lower limits of irrigation under different mulching modes.

Compared with the three treatments of L2, M2 and J2 under different mulching methods, the growth rate of M2 was faster than that of L2 and J2 (see figure 3-17 for details).

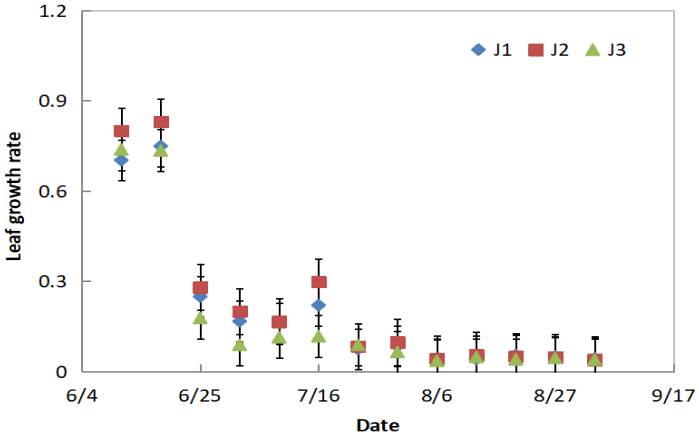

Fig.3-14The growth rates of leaf under different irrigation quotas under straw mulching condition

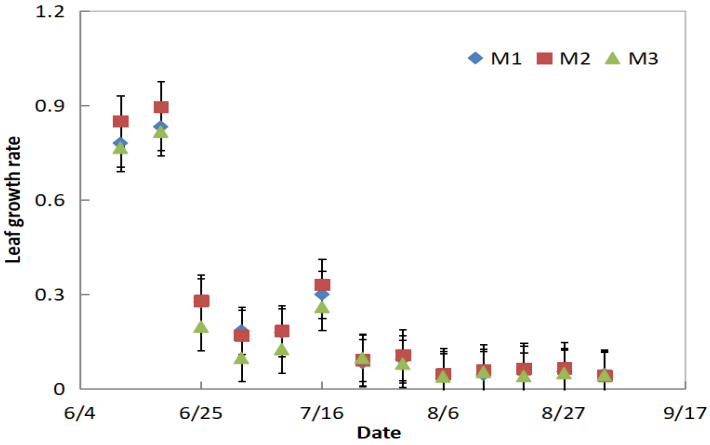

Fig.3-15 The growth rate of leaves under different irrigation quotas under filming condition

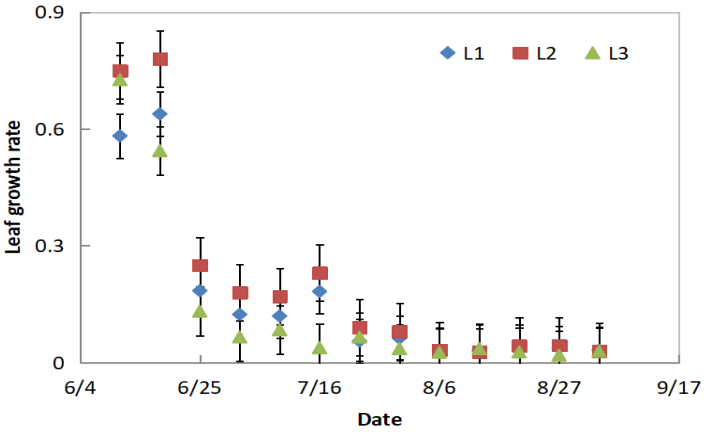

Fig.3-16 The growth rate of leaves under different irrigation quotas under bare soil condition

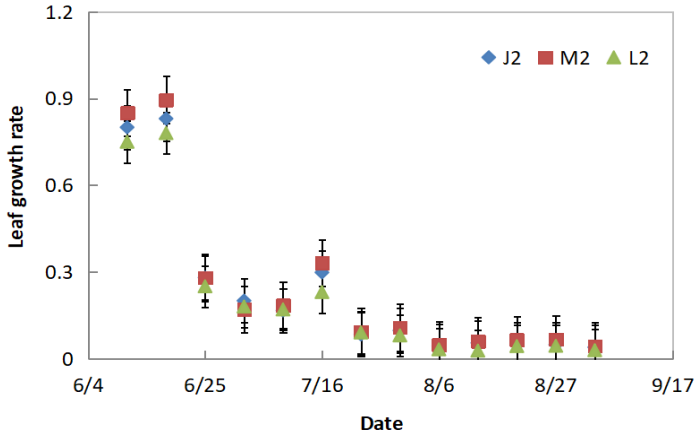

Fig.3-17 The growth rate of leaves under different irrigation quotas under three coverage conditions

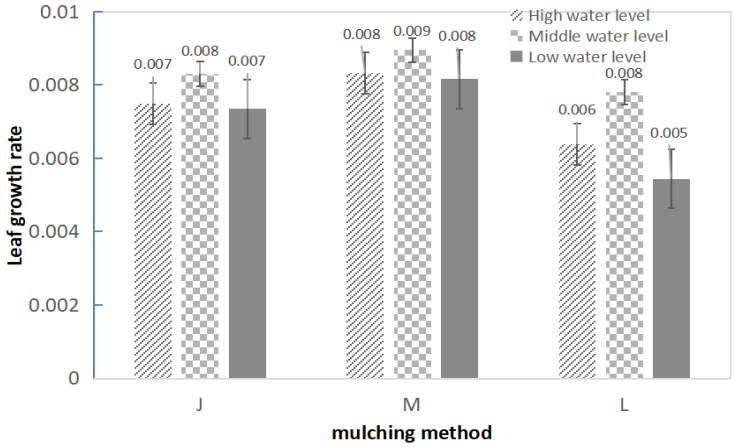

Fig.3-18 The peaks of growth rate of leaves under the various irrigation quota under various types of coverage

The results showed that the height of jujube head, stem diameter and plant diameter of M2 treatment were significantly higher than those of other treatments, including leaf growth rate, and the overall growth rate was better than that of other treatments.

4. Discussion and Conclusion

In this experiment, the effects of the lower limit of irrigation on the main stem diameter, jujube height, jujube stem diameter and leaf growth of jujube seedlings were studied by pot experiment. The results showed that the height of jujube head, the weight of jujube stem, the diameter of plant head and the growth rate of leaves under M2 treatment were better than those of other treatments under different coverage and different irrigation limits.

By measuring the new shoots of jujube seedlings and jujube hanging under different treatments, the following conclusions were drawn:

The results were as follows:

the growth rate of jujube head increased first and then decreased during the flowering and fruiting period, reached a peak during the fruit expansion period, and finally reached a stable value until the end of the growth period. With the different irrigation amount, the growth rate will also be different. The suitable water can promote the growth of jujube head to a certain extent. The growth rate of jujube head is the fastest in the fruit expansion period. Most of the nutrients in this stage are jujube.

The head passes, the jujube grows rapidly, and the fruit expands to the fruit ripening stage. As the jujube grows to a certain height, and with the beginning of vegetative growth, the growth of the jujube begins to become slow until it reaches a stable value.

as far as the stem diameter of jujube head was concerned, the basal diameter of M2 jujube head grew faster than other treatments after the flowering and fruit-setting period. In the early stage of flowering and fruit setting, the growth rate of stem diameter of jujube head was relatively slow, and then gradually increased to the peak value of the new growth period. This fluctuation was also the largest change in the whole growth period, after entering the fruit expanding stage. The growth rate began to increase gradually again until the peak value. During this process the stem diameter increased rapidly and then the growth gradually stopped until it reached a stable value. The difference of mulching pattern also affected the time of the peak growth rate of the diameter of jujube head in the new growing period. Generally speaking, bare soil was more important than it. He covers both ways faster than a week.

(3) as far as the effect of different irrigation upper and lower limits on the plant diameter of jujube seedlings was concerned, the effect of different irrigation lower water limits on the plant diameter of jujube seedlings was also different under different mulching modes, which resulted in the different trend of plant diameter. The change trend of plant diameter was as follows: the plant diameter first increased and then decreased at the flowering and fruit setting stage, and then gradually increased at the fruit expanding stage. At this time, the growth rate was the largest and reached the peak value.

(4) Under the different irrigation methods, the effects of different irrigation limits on the leaf growth of jujube seedlings were different under different coverage methods. Among them, the leaf growth was the fastest under M2 condition, and the leaf area of jujube seedlings was in flowering and fruiting stage. The growth rate is the fastest, the growth rate is the largest, and then gradually declines. Although there is an increase in the fruit expansion period, the growth is relatively slow.

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References

[1] Chen Jiaqi. Nature, water, man [J]. Journal of Natural Resources, 2004, (06): 689 / 693.
[2] Chen Pengpeng. Effects of different mulching and water deficit on pear jujube trees [D]. Yang Ling: northwest University of Agriculture and Forestry Science and Technology, 2015.
[3] Cheng Bin. Current situation and Countermeasures of Water-saving Agriculture Development in Hebei Province [J]. Hebei Agriculture, 2016, (06): 45—48.
[4] Zhu Jinxia, Zhang Yuanpei, Zheng Guobao, et al. Effects of different irrigation quantity on photosynthetic characteristics and yield of Lycium barbarum L. [J]. Water-saving irrigation, 2012, (01): 28-30+33.
[5] Wu Guohong, Luo Qiangwei, Suleiman Aziz, et al. Effect of different irrigation quantity on growth and yield of seedless white grape [J]. Xinjiang Agricultural Science, 2013,50 (05): 889 / 893.
[6] Zhao Yunge. Study on root distribution and soil moisture dynamics of apple trees under different irrigation conditions [D]. Taiyuan: Taiyuan University of Technology, 2017.
[7] Wang Ying. Effects of different irrigation quantity on physiological characteristics, yield and quality of pear jujube [D]. Yang Ling: northwest Agricultural and Forestry University of Science and Technology, 201.1.
[8] Zhao Yunge. Study on root distribution and soil moisture dynamics of apple trees under different irrigation conditions [D]. Taiyuan: Taiyuan University of Technology, 2017.
[9] You Lei, Ma Ying-Jie, Hong Ming, et al. Effects of different irrigation treatments on colouring quality of jujube fruit [J]. Water-saving irrigation, 2015, (08): 33-37.

[10] Hu Jia Shuai, Wang Zhenhua, Zheng Xurong. Effect of irrigation on yield, quality and water use of drip irrigation jujube [J]. Journal of Irrigation and drainage Machinery Engineering, 2016, 34(12): 1086-1092.
[11] Fernández J.E., Díaz-Espejo A., Infante J.A., et al. Water relations and gas exchange in olive trees under regulated deficit irrigation and partial rootzone drying[J]. Plant and Soil, 2006, Vol.284,(1-2):273-291.
[12] Bai Lin. Effects of mulching and water deficit irrigation on water consumption and growth of pear jujube trees [D]. Yang Ling: northwest University of Agriculture and Forestry Science and Technology, 2012.
[13] Zhao Chunming. Study on the effect of water deficit treatment on physiological growth indexes of pear trees [D]. Yang Ling: northwest University of Agriculture and Forestry, 2010.
[14] Zhang Ming stick. Soil science and agronomy [M]. Beijing: water and electricity, 1994.