Effect of Different Irrigation Patterns and Covering Methods on the Growth Characteristics of Onions in the Hexi Corridor

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Abstract. In order to investigate the influence of the growth characteristics of onions in the Hexi Corridor, this paper tested the growth characteristics of onions in the Oasis by using the early golden dragon onion as a test material and randomly grouped it into different irrigation modes and cover methods. There were five treatments in the experiment, and the growth characteristics of onion was measured in each reproductive period, and the results showed that: The transverse diameter and longitudinal diameter of bulb showed a decreasing trend with the increase of regulation deficit range. The transverse diameter and longitudinal diameter of bulb in T3 treatment were significantly lower than those in T1 and T2 due to the large amplitude of regulation deficit in the whole growth. There was no significant difference between T1 and T4, but it was significantly larger than T5. Moderate deficit and fine sand mulching were not conducive to the growth of bulb transverse diameter and longitudinal diameter. According to the growth characteristics of onion, the best regulation of onion growth can be achieved by covering the whole growth period with black plastic film and sufficient irrigation, which has theoretical guidance and reference significance for onion planting in Hexi irrigation area.

1. Introduction
There are many onion cultivation areas in China, among which Gansu Hexi irrigation district onion cultivation area is the area with the longest history of onion cultivation and traditional high-quality onion production in China, and is also the area with the largest onion cultivation area in China. The region has abundant sunshine, climate, high annual temperature, large temperature difference and low rainfall, which makes it suitable for the development of high-quality onion production and is the key development area for high-quality onions in China in the future. The growth process of crops is actually a process of continuous accumulation of their own dry matter, and the distribution status of dry matter accumulation determines the flow of nutrients, so the accumulation and distribution of dry matter determines the economic yield of crops[1-2]. Therefore, the study of dry matter transfer and distribution is of great significance, not only to understand the crop growth, but also to clarify the transfer of dry matter and distribution of dry matter changes in the law of the crop later to improve the yield, quality and laid the foundation. Studies have shown that drip irrigation technology changes the conventional growth environment of crops, optimizes soil moisture and nutrient supply factors, and ultimately affects the accumulation and distribution of crop biomass, which is reflected in yield improvement [3]. The response of biomass accumulation to sub-membrane drip irrigation is different
among different varieties, Liang X. et al.[4] planted four kinds of potatoes through sub-membrane drip irrigation and compared the growth characteristics index, it was found that the dry matter absorption and accumulation law of potato varieties with different uses under the conditions of sub-membrane drip irrigation did not differ significantly, potato tubers, dry matter accumulation were "S"-shaped. Curve change. Different amounts of drip irrigation have different effects on crop biomass accumulation, and Du X.J. et al.[5] found that the leaf area index and leaf daily area showed an increasing trend with the increase of drip irrigation, reaching a maximum at the drumming stage.

In summary, moderate and timely sub-membrane drip irrigation can have a positive effect on crop biomass accumulation and distribution, while blindly irrigating at low levels not only does not save water, but also causes serious crop damage. At the same time, surface cover can promote crop growth and increase biomass accumulation by optimizing soil hydrothermal environment and improving soil quality. Feng H. et al.[6] compared the growth conditions of summer corn planted with straw and mulch in a semi-humid region of northwest China, and the experimental results showed that the accumulation of biomass in the above-ground part of monoply-mulched mulch and furrow-mulched straw increased significantly, and the rapid accumulation period was earlier and lasted longer than that of single-mulched mulch or straw. Xin G.S. et al.[7] found that black mulch mulched potato has the advantages of regulating soil temperature, promoting coordination of stalk and leaf growth, improving leaf area coefficient, reasonable distribution of nutrients above and below the ground, and higher net assimilation rate. Wang H.L. et al.[8] compared corn planted with mulched corn in Dingxi, Gansu province using full-sand cover and found that full-sand cover can increase corn plant height, ear number, thousand grain weight, and also significantly improve the ears of corn traits, but the increase is smaller than mulched corn. In this experiment, three irrigation modes (full irrigation, light deficit irrigation, and moderate deficit irrigation) and three cover modes (black mulch, transparent mulch, and fine sand cover) were used for onion irrigation, and the effects of full, light, and moderate deficit irrigation and black mulch, transparent mulch, and fine sand cover on onion growth and quality were investigated. The growth characteristics response is intended to provide a reliable theoretical basis for a locally grown onion industry with high water efficiency.

2. Materials and Methods

2.1. Overview of the test site

The experiment was conducted from March to September 2018 at the experimental farm of the Agricultural Extension Center of Minqin County, Gansu Province, and harvested on September 10, 2018. The area is located in the northeastern part of the Hexi Corridor and the downstream part of the Shiyang River Basin in Gansu Province, at latitude 38°3′ north and longitude 101°49′ east. The test area is a temperate continental arid climate zone with an extreme maximum temperature of 39.5°C, an extreme minimum temperature of -27.3°C, an average annual temperature of 8.3°C, an elevation of 1472m, an annual precipitation of 127.7mm, a reproductive period of 102.7 mm, an evaporation of 2623mm, 3073.5 hours of sunshine, and a frost-free period of 162 days. According to the rainfall data of the last 50 years, the average annual precipitation in this area is generally about 116.5 mm. The main soil type was silt-filled soil from 0 to 60 cm, and the soil below 60 cm was sandy loam, with an average weight capacity of 1.54 g·cm⁻³. the nutrient content of the soil was 4.89 g·kg⁻¹ of organic matter, 0.48 g·kg⁻¹ of total nitrogen, 1.33 g·kg⁻¹ of total phosphorus, 18.92 g·kg⁻¹ of total potassium, and the pH value of the test plot was 4.998 g·kg⁻¹, 0.9 g·kg⁻¹ of total nitrogen, 1.9 g·kg⁻¹ of total phosphorus, and 1.9 g·kg⁻¹ of total potassium. 8.02, total salt 1.685 g·kg⁻¹, irrigation water mineralization 0.86 g·L⁻¹.

2.2. Test Design and Method

The test onion variety is "Early Golden Dragon", provided by Jiuquan Great Dunhuang Agricultural Products Co. The seedlings were sown in the daylight greenhouse on March 9, 2018, and transplanted
to the field on May 10, 2018. The seedlings were transplanted in rows 15 cm apart and plants 10 cm apart, with 8 rows of one film, one plant per hole, and transplanting depths of 2 to 3 cm, with a test plot area of 30 m² (2m×15 m). In spring, 50 kg of calcium superphosphate, 22 kg of diammonium phosphate, 25 kg of potassium sulfate and 20 kg of urea were applied as base fertilizer. 8 kg of urea was irrigated with head water on May 26, 17 kg of urea was irrigated with secondary water on June 9 and 25 kg of nitrogen-phosphorus compound fertilizer was irrigated with tertiary water on July 7 after the onion slowing period. Under black mulch, the test can be divided into full irrigation (T1, local irrigation amount), light deficit irrigation (T2, about 75% of full irrigation), moderate deficit irrigation (T3, about 65% of full irrigation), and medium deficit irrigation (T3, about 65% of full irrigation). Mulch (T4), fine sand cover (T5). The test treatments are shown in Table 1 and the irrigation amount and irrigation times are shown in Table 2.

Table 1 Experimental design

| Treatments             | Black film mulching | White film mulching | Fine sand mulching |
|------------------------|---------------------|---------------------|--------------------|
| Copious irrigation     | T1                  | T4                  | T5                 |
| Mild DRI               | T2                  | -                   | -                  |
| Moderate DRI           | T3                  | -                   | -                  |

Table 2 The parameters under drip irrigation for onion

| Treatments | May 12th | May 27th | June 11th | June 26th | July 11th | July 26th | August 10th | August 25th | Irrigation quota (m³·hm⁻²) |
|------------|----------|----------|-----------|-----------|-----------|-----------|--------------|--------------|---------------------------|
| T1         | 900      | 600      | 550       | 650       | 650       | 650       | 650          | 650          | 5300                      |
| T2         | 900      | 425      | 425       | 450       | 450       | 450       | 450          | 450          | 4000                      |
| T3         | 900      | 350      | 350       | 380       | 380       | 380       | 380          | 380          | 3500                      |
| T4         | 900      | 600      | 550       | 650       | 650       | 650       | 650          | 650          | 5300                      |
| T5         | 900      | 600      | 550       | 650       | 650       | 650       | 650          | 650          | 5300                      |

2.3. Growth Indicator measurement method

2.3.1. Plant height. Plant height (maximum height from the ground surface to the green leaf elongation of the plant) was measured by selecting 5 plants in the middle of each plot every 15 d and measuring with a steel tape measure.

2.3.2. Bulb longitudinal and transverse diameters. 5 plants were selected in the middle of each plot every 15 days to determine the bulb longitudinal and transverse diameters, which were measured with a vernier caliper.

2.4. Statistical Analysis of Data
The measured data were calculated using EXCEL 2010, and ANOVA and significance tests were performed using the SPSS 16.0 data processing system.

3. Results and Analysis

3.1 Plant height
Plant height is one of the important indicators of crop growth and development, and Figure 1 shows the growth dynamics of onion plant height at different reproductive stages. As shown in Figure 1, the
plant height increased with the time of reproductive period in each treatment and decreased after the bulb expansion period. From July 25 to August 10, the onion entered the bulb expansion period, and on August 10, the onion plant height increased by 10.54%, 14.16% and 13.32%, respectively, compared with the treatment T2, T3 and T5, with significant difference, but decreased by 0.18% compared with the treatment T4, with no significant difference. On August 26, the onion entered the maturity stage, the height of the plant decreased gradually, and the height of T1 increased by 19.31% and 16.01% compared with treatments T2, T3, and T5 respectively. The plant height was 19.65%, and 5.36% and 3.78% higher than that of T2 and T4 treatments, with no significant difference. It can be seen that different irrigation and cover methods had various impacts on plant height, and the full irrigation was significantly larger than the light and moderate deficit irrigation among the irrigation treatments. Among the irrigation treatments, full irrigation was significantly more effective than light and medium deficit irrigation. The most significant effect of transparent mulch on plant height was observed at the seedling and leaf development stages, while black mulch at the bulb expansion and maturity stages. There was no significant difference between the two cover methods, but the effect was significantly larger than that of fine sand cover.

![Figure 1](image_url)

**Figure 1.** The effect of different irrigation patterns and covering methods on plant height of onion

### 3.2 Horizontal diameter of onion

The dynamic changes of onion bulb transverse diameter with reproductive time are shown in Table 3. For the three irrigation treatments, with the increase of the deficit adjustment, the bulb diameter is smaller, that is, the average bulb diameter during the whole reproductive period is T1 > T2 > T3, medium deficit adjustment treatment T3 due to the larger deficit adjustment throughout the reproductive period, the bulb diameter is significantly lower than T1 and T2, the decrease of 19.85% and 9.67% respectively. At maturity, T1 bulb diameter was 12.32% and 21.34% higher than that of T2 and T3, respectively. At the maturity stage, T1 and T4 bulb mean diameter was 16.01% and 12.62% higher than that of T5, while at the maturity stage, T1 and T4 bulb mean diameter was 16.01% and 12.62% higher than that of T2 and T3, respectively. T5 was 15.63% and 11.64% higher than T1 > T4 > T2 > T5 > T3, respectively. T5 was 15.63% and 11.64% higher than T1 > T4 > T2 > T5 > T3, and it could be seen that moderate loss and fine sand cover were not favorable to the growth of bulb transverse diameter.
### Table 3. The effect of different irrigation patterns and covering methods on horizontal diameter of onion (cm)

| Treatments | Date of determination |  |  |  |  |  |
|------------|-----------------------|---|---|---|---|---|
|            | Jun. 25th             | Jul. 10th | Jul. 25th | Aug. 10th | Aug. 25th | Sept. 10th |
| T1         | 3.62a                 | 5.91a     | 7.83a     | 8.75a      | 9.08a      | 10.21a      |
| T2         | 3.39bc                | 5.40bc    | 7.14b     | 8.02b      | 8.50b      | 9.09b       |
| T3         | 3.14c                 | 4.63c     | 6.32cd    | 7.23c      | 8.15bc     | 8.41c       |
| T4         | 3.42b                 | 5.56b     | 7.47ab    | 8.72ab     | 9.05ab     | 9.86ab      |
| T5         | 3.12cd                | 4.60cd    | 6.62c     | 7.67bc     | 8.28bc     | 8.83bc      |

3.3 **longitudinal diameter of onion**

The dynamic changes of onion bulb longitudinal diameter with reproductive time are shown in Table 4. For the three irrigation treatments, the bulb longitudinal diameter decreased with the increase of the deficit adjustment amplitude, i.e., the average transverse diameter of bulb longitudinal diameter during the whole reproductive period was T1 > T2 > T3, and the bulb longitudinal diameter of the medium deficit adjustment treatment T3 was significantly lower than T1 and T2 due to the larger deficit adjustment amplitude during the whole reproductive period, with the decrease of 16.49% and 8.93% respectively. At the mature stage, the bulb diameter of T1 was 10.33% and 18.96% higher than that of T2 and T3, respectively. The mean longitudinal diameter of T1 bulb was 3.42% higher than that of T4 and 14.17% higher than that of T5, which was not significantly different. In the mature stage, T1 and T4 were 12.64% and 8.84% higher than T5, respectively, and the bulb longitudinal diameters of all treatments were T1 > T4 > T2 > T5 > T3. In the mature stage, the bulb diameter of all treatments was T1 > T4 > T2 > T5 > T3 in the order of T1 > T4 > T2 > T5 > T3, and it could be seen that moderate loss and fine sand cover were not favorable to the growth of bulb diameter.

### Table 4. The effect of different irrigation patterns and covering methods on longitudinal diameter of onion (cm)

| Treatments | Date of determination |  |  |  |  |  |
|------------|-----------------------|---|---|---|---|---|
|            | Jun. 25th             | Jul. 10th | Jul. 25th | Aug. 10th | Aug. 25th | Sept. 10th |
| T1         | 3.62a                 | 5.91a     | 7.83a     | 8.75a      | 9.08a      | 10.21a      |
| T2         | 3.39bc                | 5.40bc    | 7.14b     | 8.02b      | 8.50b      | 9.09b       |
| T3         | 3.14c                 | 4.63c     | 6.32cd    | 7.23c      | 8.15bc     | 8.41c       |
| T4         | 3.42b                 | 5.56b     | 7.47ab    | 8.72ab     | 9.05ab     | 9.86ab      |
| T5         | 3.12cd                | 4.60cd    | 6.62c     | 7.67bc     | 8.28bc     | 8.83bc      |

### 4. Discussion

The plant height tended to increase in each treatment as the reproductive period progressed, but decreased after the bulb expansion period. Different irrigation and mulching patterns had different effects on plant height, with full irrigation being significantly larger than light and moderate deficit irrigation among the irrigation treatments. The increase of plant height by transparent mulch at the seedling and leaf development stages and by black mulch at the bulb expansion and maturity stages was small, but significantly larger than that of fine sand mulch. The bulb transverse diameter tended to decrease with the increase of the deficit adjustment, and in the moderate deficit adjustment treatment T3, the bulb transverse diameter was significantly lower than that in T1 and T2, with a decrease of
19.85% and 9.67%, respectively. The same trend was also observed in the bulb diameter, i.e., the bulb diameter of T3 was significantly lower than that of T1 and T2 due to the larger loss in the whole fertility cycle, with a decrease of 16.49% and 9.67%, respectively. The black mulch treatment T1 was not significantly different from the transparent mulch treatment T4. In the black mulch treatment T1 and transparent mulch treatment T4, there was no significant difference in bulb longitudinal diameter, while the sandy mulch treatment T5 had significantly lower bulb longitudinal diameter than T1 and T4, and the bulb transverse and longitudinal diameters of all treatments at maturity were T1 > T4 > T2 > T5 > T3, which showed that both moderate loss and sandy mulch were unfavorable to the growth of bulb transverse and longitudinal diameters.

5. Conclusion
The transverse diameter and longitudinal diameter of bulb showed a decreasing trend with the increase of regulation deficit range. The transverse diameter and longitudinal diameter of bulb in T3 treatment were significantly lower than those in T1 and T2 due to the large amplitude of regulation deficit in the whole growth. There was no significant difference between T1 and T4, but it was significantly larger than T5. Moderate deficit and fine sand mulching were not conducive to the growth of bulb transverse diameter and longitudinal diameter. According to the growth characteristics of onion, the best regulation of onion growth can be achieved by covering the whole growth period with black plastic film and sufficient irrigation, which has theoretical guidance and reference significance for onion planting in Hexi Corridor.

Acknowledgments
The authors would like to thank the President fund for scientific research innovation and application of Hexi University in 2019 (No. XZ2019012) and the Doctoral research start-up gold project of Hexi University in 2020 (No. KYQD2020012) for the funding and lab facilities.

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