Effect of Different Irrigation Patterns and Covering Methods on Physiological characteristics of Onions Under Membrane Drip Irrigation

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Abstract. In order to investigate the influence of the physiological characteristics of onions in the Hexi Corridor, this paper tested the physiological 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 physiological characteristics of onion was measured in each reproductive period, and the results showed that: The net photosynthetic rate, stomatal conductance, and intercellular CO₂ concentration all decreased with increasing amplitude of the transfer loss. Although the net photosynthetic rate, stomatal conductance, and intercellular CO₂ concentration of black mulch T1 were higher than those of transparent mulch T4, there was no significant difference between the two treatments, and the net photosynthetic rate, stomatal conductance, and intercellular CO₂ concentration of T1 and T4 were significantly higher than those of sand mulch T5. The physiological characteristics of the onion can be best controlled by irrigation while covering the onion with black mulch throughout the growing season, which is of great significance for onion cultivation in the Hexi Corridor.

1. Introduction
Onion (Allium cepa L.) is a common vegetable in the genus onion, which is not only tasty and delicious, but also has high nutritional value. Also, the high yield of onion not only can be eaten as a vegetable, but also has high medicinal value. Onion contains prostaglandin A, which can reduce peripheral vascular resistance, lower blood viscosity, can be used to lower blood pressure, refreshing, relieve stress, and prevent colds. In addition, onions can also remove oxygen free radicals in the body, enhance metabolism, anti-aging, prevention of osteoporosis, which is suitable for the elderly health food. With the development of modern agriculture, the economic benefits of onions are becoming more and more significant, and their cultivation area and promotion rate are increasing. In a sense, therefore, the development of the plantation industry has a certain role in promoting the development of Minqin's agricultural economy, and is becoming increasingly important. The leaf is the main site of crop photosynthesis, and photosynthetic products play a pivotal role in the crop's own production and dry matter formation. The sub-membrane drip irrigation regulation deficit changes the crop growth and development status, the formation of the number of crop leaves, and indirectly changes the rate of

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photosynthesis. Therefore, the relationship between photosynthesis and water regulation has become one of the hotspots of research by many scholars. Zhao C.M. et al[1] investigated the effects of deficit irrigation on transpiration and photosynthesis of perennial pear and jujube trees. The results showed that water stress decreased photosynthetic and transpiration rates of pear and jujube trees, but water rehydration increased photosynthetic and transpiration rates of crops after water stress, but the two rates increased by different magnitudes (photosynthetic rate > transpiration rate). Meng Z.J. et al[2] concluded that timely and moderate water regulation had a significant effect on the transpiration rate of summer corn, but not on the photosynthetic rate, but the photosynthetic rate after crop rehydration had an overcompensation effect, which inhibited nutrient growth, facilitated the operation and distribution of photosynthetic products to the seeds, and promoted reproductive growth. Huang H.X. et al[3] studied the changes of leaf gas exchange and chlorophyll fluorescence parameters during the fruiting season of pepper by setting up four irrigation treatments (mild, moderate, severe deficit irrigation and normal irrigation), and showed that water deficit significantly reduced the photosynthetic rate, transpiration rate, and stomatal conductance of crop leaves. This experiment divides the reproductive stages of onions into seedling, leaf development, bulb expansion and maturation stages, and carries out water control and comprehensive analysis of onion physiological characteristics in order to find the optimal cover material and water control solution for the local development of water-saving and efficient onion production.

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℃, an extreme minimum temperature of -27.3℃, an average annual temperature of 8.3℃, 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 Jiuan 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 (2 m×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 |
|------------|----------|----------|-----------|-----------|-----------|-----------|-------------|-------------|
| T1         | 900      | 600      | 550       | 650       | 650       | 650       | 650         | 5300        |
| T2         | 900      | 425      | 425       | 450       | 450       | 450       | 450         | 4000        |
| T3         | 900      | 350      | 350       | 380       | 380       | 380       | 380         | 3500        |
| T4         | 900      | 600      | 550       | 650       | 650       | 650       | 650         | 5300        |
| T5         | 900      | 600      | 550       | 650       | 650       | 650       | 650         | 5300        |

2.3. Physiological index measurement method
The daily changes of photosynthetic rate (Pn), stomatal conductance (Gs), intercellular CO₂ concentration (Ci) and other physiological parameters of onion leaves were measured at 7:00, 10:00, 13:00, 16:00, 19:00 and 21:00 on sunny days in five onion plants with uniform growth potential. Three stable readings were taken for 3 d and averaged.

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. The effect of different irrigation patterns and covering methods on the net photosynthetic rate of onions
The dynamics of the net photosynthetic rate of onion under different irrigation and cover patterns are shown in Figure 1. For the three different irrigation treatments, the NAR decreased with the increase of the loss-adjusted irrigation rate. At 8:00 a.m., the net photosynthetic rate of fully irrigated treatment T1 was slightly higher than that of lightly irrigated treatment T2, with an increase of 0.84 μmol·m⁻²·s⁻¹, while the net photosynthetic rate of moderate water-deficit irrigated treatment T3 was 24.29% lower than that of T1; At 10:00 a.m., the net photosynthetic rate gradually increased to a maximum with sufficient light. T3 was significantly lower than T1 by 17.90%; Then the net photosynthetic rate showed a decreasing trend and reached its lowest value at 12:00 noon, which may be due to the high temperature during this period, which closed the stomata of the crop, resulting in the lowest net photosynthetic rate. Compared with T2 and T3, the net photosynthetic rate of T1 increased by 0.26 and 1.16 μmol·m⁻²·s⁻¹, respectively. For the three different mulching treatments, the net photosynthetic rate of T1 and T4 was significantly higher than that of T4, but the net photosynthetic rate of T1 and T4 was significantly higher than that of T5. At 8:00 a.m., the net photosynthetic rate of black mulch T1 was slightly higher than that of transparent mulch T4, with an increase of 0.33 μmol·m⁻²·s⁻¹, while the
sand-covered treatment T3 significantly reduced the photosynthetic rate by 22.51% compared to T1; at 10:00 a.m., with sufficient light, the NPS increased gradually to a maximum value, while the T1 treatment increased the NPS by 1.06% compared to T4, while T3 significantly reduced the NPS by 12.04% compared to T1; then the NPS showed a decreasing trend and reached a maximum value at 12:00 noon. The average daily net photosynthetic rate of all the treatments was T1>T4>T2>T5>T3, and the average daily net photosynthetic rate of the T1 treatment was 0.51 and 1.33 μmol·m⁻²·s⁻¹ higher than that of T4 and T5, respectively. The net photosynthetic rate of onion was 11.78%, 31.14%, 6.19%, and 29.34% higher than that of T2, T3, T4 and T5, respectively.

![Figure 1](image1.png)

Figure 1. Effect of different irrigation and cover patterns on the net photosynthetic rate of onions.

3.2 The effect of different irrigation patterns and covering methods on the stomatal conductance of onions

The dynamics of onion stomatal conductance under different irrigation and cover patterns are shown in Figure 2. For the three different irrigation treatments, stomatal conductance decreases with increasing deficit adjustment. At 8:00 a.m., stomatal conductance of fully irrigated treatment T1 was slightly higher than that of lightly deficit irrigated treatment T2 by 79.04 mmol·m⁻²·s⁻¹, while that of moderate water deficit irrigated treatment T3 was significantly lower than T1 by 35.07%; at 10:00 a.m., stomatal conductance gradually decreased to the minimum value. The stomatal conductance of T1 treatment was 10.58% higher than that of T2, while that of T3 was 30.77% lower than that of T1. Then, the stomatal conductance of T1 increased by 36.15 and 119.74 mmol·m⁻²·s⁻¹ at 18:00 p.m. For the three different cover treatments, the black mulch treatment T1 had a higher porous conductivity than the transparent treatment T2 and T3. At 8:00 a.m., the pore conductance of black mulch T1 was slightly higher than that of transparent mulch T4, with an increase of 31.14 mmol·m⁻²·s⁻¹, while the pore conductance of fine sand T3 was 28.50% lower than that of T1. The average daily stomatal permeability of all the treatments was as follows: T1>T4>T2>T5>T3, which increased by 13.48%, 41.83%, 4.94%, and 34.17% compared with T2, T3, T4, and T5, respectively.
3.3 The effect of different irrigation patterns and covering methods on the intercellular carbon dioxide concentration of onions

The dynamic changes of onion intercellular CO$_2$ concentration under different irrigation and cover patterns are shown in Figure 3. For the three different irrigation treatments, the intercellular CO$_2$ concentration decreased with the increase of deficit irrigation. At 8:00 a.m., intercellular CO$_2$ concentration was slightly higher in fully irrigated treatment T1 than in lightly irrigated treatment T2, with an increase of 58.71 μmol·mol$^{-1}$, while moderate water deficit T3 was significantly lower than T1 by 29.18% (P < 0.05); at 10:00 a.m., intercellular CO$_2$ concentration gradually decreased to a minimum. The intercellular CO$_2$ concentration increased by 46.28 and 68.63 μmol·mol$^{-1}$ in T1 compared with T2 and T3, respectively. At 8:00 a.m., the intercellular CO$_2$ concentration of black mulch T1 was slightly higher than that of transparent mulch T4, with an increase of 8.38 μmol·mol$^{-1}$, while that of sand mulch T3 was significantly lower than that of T1. The intercellular CO$_2$ concentration increased by 3.27% in T1 compared to T4, and decreased significantly by 31.67% in T3 compared to T1; Subsequently, the intercellular CO$_2$ concentration showed a decreasing trend and reached a maximum value at 18:00 in the afternoon. Compared with T4 and T5, the intercellular CO$_2$ concentration of T1 treatment increased by 8.10 and 82.98 μmol·mol$^{-1}$, respectively. The daily mean intercellular CO$_2$ concentration of all treatments was T1 > T4 > T2 > T3 > T5, and the daily mean intercellular CO$_2$ concentration of T1 increased by 16.11%, 37.88%, 2.25%, and 39.34% compared with T2, T3, T4, and T5, respectively.
4. Discussion
The net photosynthetic rate, stomatal conductance, and intercellular CO₂ concentration decreased with increasing amplitude of the regulation loss. At 10:00 a.m., when there was sufficient light, the net photosynthetic rate gradually increased and reached its maximum value, while the T1 treatment increased the net photosynthetic rate, stomatal conductance and intercellular CO₂ concentration by 7.75%, 10.58% and 9.38%, respectively, while the T3 treatment significantly decreased the net photosynthetic rate by 17.90%, 30.77% and 34.82%, respectively, compared with the T1 treatment; the net photosynthetic rate then showed a decreasing trend and reached its maximum value at 12:00 noon. The lowest values were probably due to the high temperature during this period, which closed the stomata of the crop, resulting in the lowest net photosynthetic rate, which increased by 0.26 and 1.16 μmol·m⁻²·s⁻¹ for the T1 treatment compared to T2 and T3, respectively; while the stomatal conductance and intercellular CO₂ concentration showed an increasing trend, reaching a maximum value at 18:00 p.m. The stomatal conductance and intercellular CO₂ concentration of the T1 treatment during this period increased by 0.26 and 1.16 μmol·m⁻²·s⁻¹ for the T1 treatment compared to T2 and T3, respectively. CO₂ concentration increased by 36.15, 119.74 mmol·m⁻²·s⁻¹, and 46.28 and 68.63 μmol·m⁻²·s⁻¹ compared with T2 and T3, respectively. net photosynthetic rate, stomatal conductance, and intercellular CO₂ concentration were higher in the black mulch treatment T1 than in the transparent mulch treatment T4, with no significant difference between the two treatments, but the physiology of onions in T1 and T4 was not significantly different. Wang Y.C. et al[4] studied the effects of different ranges of water deficit on the photosynthetic characteristics of crops and showed that water deficit can significantly reduce the net photosynthetic rate, transpiration rate, and stomatal conductance of crop leaves, and the magnitude of the decrease is greater with the higher degree of water deficit, which is consistent with the results of this study. The experimental findings are consistent with those of this experiment. Yun X.R. et al[5] found that the net photosynthetic rate and transpiration rate of white mulch were higher than those of black mulch, which was different from the conclusions of this experiment, which might be related to the experimental conditions and crop type. Huang D.Z. et al[6] compared the effects of transparent mulch, black mulch and fine sand cover on the net photosynthetic rate, transpiration rate and intercellular CO₂ concentration of onions, and showed that the net photosynthetic rate, transpiration rate and intercellular CO₂ concentration of onions under black mulch were greater than those under white mulch.

5. Conclusion
The net photosynthetic rate, stomatal conductance, and intercellular CO₂ concentration all decreased with increasing amplitude of the transfer loss. Although the net photosynthetic rate, stomatal conductance, and intercellular CO₂ concentration of black mulch T1 were higher than those of transparent mulch T4, there was no significant difference between the two treatments, and the net photosynthetic rate, stomatal conductance, and intercellular CO₂ concentration of T1 and T4 were significantly higher than those of sand mulch T5. The physiological characteristics of the onion can be best controlled by irrigation while covering the onion with black mulch throughout the growing season, which is of great significance for onion cultivation in the 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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