Characteristics test of single point source wetting body of surge and spring root irrigation

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Abstract. In order to further explore the change rule of soil wetting characteristics in surge and spring root irrigation, the single-point source flooding test of jujube micro-irrigation demonstration base in northern mountainous area was studied. Under different flow conditions, soil wetting front migration distance and water distribution of the law, the results show that: wetting wet front movement quickly, with the passage of time and gradually slow down. The wetting radius of the horizontal flow increases with the increase of the drip flow. In the process of water redistribution, the wetting peak velocity of the small droplet shows a "failure" phenomenon, and the wet front migration rate larger drip flow significantly slows down. The general trend of soil moisture content of the single-point source moistening source is: the farther away from the straight line of the drip, the lower the water content of the soil; at the end of the irrigation, the soil water content decreases along the depth direction. As time goes on, the areas with high water content gradually migrate down from the surface layer, and finally the soil moisture distribution characteristics of low surface layer, high middle layer and low bottom layer are formed.

1. Introduction

Yongquan root irrigation is a new type of micro-irrigation technology suitable for fruit trees proposed in China in recent years. It supplies irrigation water directly to the roots of fruit trees, reducing ineffective evaporation on the ground and blockage of irrigation devices. Wu Pute et al. [1] studied the output benefits of Yongquan root irrigation, and the results showed that Yongquan root irrigation increased net income by 2480 $/hm² and 6218.3 $/hm², respectively, compared with drip irrigation and tube irrigation. Fei Liangjun [2] studied the change law of the wet body of the jujube and spring in the mountainous area of northern Shaanxi. It is assumed that the calculation formula of the horizontal diffusion radius when the vertical wet depth reaches the designed depth of the planned wet layer. Che Yinwei [3] adopted different irrigation methods (yongquan root irrigation, drip irrigation, ground irrigation) and different irrigation quotas for pear jujube trees in northern Shaanxi. They effect on physiological indexes, yield and water use efficiency of the pear tree. The research showed that the root irrigation and drip irrigation in Yongquan significantly increased the yield of jujube trees compared with...
ground irrigation. The yield increased with the irrigation quota first and then decreased. Water use efficiency decreases with increasing irrigation quota. Wang Youke [4] studied the soil water movement law of Yongquan root after irrigation, and analyzed the characteristics of pore size, hole depth, and soil wetting body changes at 24 and 48 hours after irrigation stop. The recommended hole depth and hole diameter of Yongquan root irrigation are 30-40 cm and 6 cm respectively. Zhang Lujun [5] studied the root irrigation arrangement method of pear-jujube tree springs, and the results showed that the soil moisture and the main absorption root zone of jujube trees were best matched after two irrigation devices were arranged for each plant. Install with two sprinklers per plant. Li Penghong et al. [6] researched the wet point of the intersection of multi-point sources in Yongquan root irrigation, and showed that the dual-point source of Yongquan root irrigation is better than the single-point source and the four-point source. In summary, the current research on point source infiltration is mainly focused on drip irrigation and film hole irrigation, and research on Yongquan root irrigation is currently rare. In this experiment, Yongquan root infiltration test was carried out in the field of jujube trees in northern Shaanxi Province using in situ soil. The wetting front migration law of the root irrigation in Yongquan with different dripper flow was studied. Based on the principle of water balance, the calculation formula of the average soil moisture content in the humid body is deduced. It reveals the characteristics of the characteristics of the wet soil in Yongquan root irrigation soil.

2. Materials and methods

2.1. Overview of the test site
The test area is located in the terraced jujube garden on the sloping field of Mengcha Village, Mizhi County, southern Yulin. The test tree is a ten-year pear tree. Good performance and relatively barren. The climate belongs to a typical warm temperate and semi-arid climate, with dry climate, abundant sunshine, and large temperature difference between day and night, suitable for crop growth. The multi-year average precipitation is 392.9 mm, the multi-year average temperature is 8.8 ℃, the absolute maximum and minimum temperatures are 38 ℃ and -25 ℃, the frost-free period is 160 days, and the annual average sunshine is 2372.7 hours.

2.2. Test plan design
With reference to the flow range of Yongquan root irrigation and irrigator 4 L/h ~ 10 L/h, the test settings are 4 L/h, 6 L/h, 8 L/h. The irrigation amount of each jujube tree is based on the appropriate drip irrigation volume of 80 L/tree. Three schemes of 60 L, 80 L, and 100 L are set, because the wetted body uses the method of digging the vertical section to observe the movement of the wetted front. It is assumed that the shape of the wetted body is an axisymmetric shape with the drip line as the axis of gravity, which is equivalent to the experimental wetted body. Only half of the actual wet volume, so the irrigation volume of the test was set to 30 L, 40 L, 50 L; each group of tests was carried out at the same location, each group of tests was repeated 2 times, the specific test design is shown in Table 1.

| Treatment | Dripper Flow (L/h) | Irrigation amount (L) | Time (min) |
|-----------|--------------------|-----------------------|------------|
| 1         | 4                  | 40                    | 600        |
| 2         | 6                  | 40                    | 400        |
| 3         | 8                  | 40                    | 300        |
| 4         | 8                  | 50                    | 375        |
| 5         | 8                  | 30                    | 225        |

2.3. Test device
Yongquan root irrigation supplies irrigation water directly to the roots of fruit trees, reducing ineffective evaporation on the ground and blockage of the irrigator, as shown in Figure 1. This test system is mainly composed of a Markov flask and a simulated dripper. As shown in Figure 2, the irrigation device is
located 5 cm from the edge of the vertical section, and the irrigation device is 20 cm high (15 cm vertically inserted into the soil, and 5 cm exposed). The horizontal section uses the dripper as the origin, and the vertical section is parallel to the X direction; a vertical line is drawn from the irrigator to the vertical section, and the vertical section origin is 15 cm in the vertical direction along the insertion direction of the irrigator (the bottom of the dripper end), with the direction of gravity as the Y axis. The dripper’s flow is calibrated with a measuring cylinder and a stopwatch; the movement distance of the wet front is measured with a steel ruler; at the end of the irrigation and at intervals of 24 to 48 hours, the soil is drilled with soil and the soil moisture content is measured by the drying method.

3. Results and analysis

3.1. Influence of dripper flow on the wet front migration in horizontal section

Figure 1, Figure 2 and Figure 3 show the migration process of the wet front of the wet section of the wet spring horizontal section of the Yongquan root irrigation, with an infiltration volume of 40 L and a dripper flow of 4 L/h, 6 L/h, and 8 L/h, respectively. The movement shape of the horizontal front of the wet front is basically circular, and the distance in the X direction is slightly larger than the distance in the Y direction. This may be due to the influence of the vertical section of the wet body. The test was designed to monitor the horizontal front infiltration and vertical infiltration. The test site was cut into horizontal and vertical planes that were perpendicular to each other. The original structure voids of the soil were destroyed at the vertical plane. The horizontal wetting front along the vertical plane moved faster and formed a gradient, which caused the diffusion distance in the X direction of the horizontal plane to be slightly larger. Y distance. The wet front migrated faster at first, and the infiltration rate gradually slowed down over time. After infiltration of 40 L of water, the wet fronts of the 4 and 4 L/h, 6 L/h, and 8 L/h wetted bodies moved to 39.1 cm, 42 cm, 44.8 cm, and 37.00 cm, 38.3 cm, and 40.5 cm, respectively. After 24 hours of re-distribution, the wet fronts of the 4 L/h, 6 L/h, and 8 L/h wetted bodies in the X and Y directions moved to 52.4, 54.5, 59.2 and 50.1, 54.3, and 57.2 cm, respectively; after 48 hours, The wet fronts in the X and Y directions moved to 56.5 cm, 58.3 cm, 64.6 cm, and 54.8 cm, 58 cm, and 63.1 cm, respectively. It can be seen that during the irrigation process, the X direction moves faster than the Y direction, but after redistribution, the wet shape is approximately circular.
3.2. Influence of dripper flow on wet front migration in vertical section

Figure 4, Figure 5 and Figure 6 show the change of the migration distance of the wet front in the vertical section of the wet body with different dripper flow in Yongquan root irrigation. It can be seen that the wet front of the vertical section moves in the Y direction faster than in the X direction. At the end of the infiltration of 40L of water, the moving distances of the wet body in the 4 L/h, 6 L/h, and 8 L/h dripper flow directions are X and Y, respectively They are: 40.9cm, 39.8 cm, 43.1 cm and 53.0 cm, 47.3 cm, 45.7 cm. In the X direction, the wetting front of the wetting body with the 8 L/h dripper flow moves fastest, but in the Y direction, the 8 L/h moving is the slowest and the 4 L/h moving distance is the largest. The water accumulation height in the irrigation device is different. The water accumulation height in the 4 L/h, 6 L/h, and 8 L/h irrigation devices reaches approximately 2 cm, 5 cm, and 8 cm, respectively. At 6cm, small holes are infiltrated into the side wall to prevent the overflow of the dripper directly from the top when the flow of the dripper is too large. The depth of water accumulation in the 8 L/h humidifier is the largest. Both the infiltration channel and the water pressure have advantages, so the infiltration distance in the X direction is also the largest; although there is a gradient of the dripper flow in the Y direction, the amount of infiltration of each wetted body is constant, and the infiltration time is different. The influence of the infiltration capacity, the phenomenon that the small droplet flow rate Y moved to the wet front has the largest phenomenon.

![Fig. 3 Wetting front transportation distance of 8 L/h wetting body in horizontal profile](image1)

![Fig. 4 Wetting front transportation distance of 4 L/h wetting body in vertical profile](image2)

![Fig. 5 Wetting front transportation distance of 6 L/h wetting body in vertical profile](image3)
3.3. Redistribution of dripper wetted body with different dripper flow

Figures 7 and 8 show the redistribution of the dripper’s wetted body at different dripper flow rates. It can be seen that after the irrigation infiltration, the wetting front in the Y direction moves faster than the X direction. In the Y direction, the change of the wet front between the wet bodies during the period from the end of the infiltration to 24 hours is the most dramatic. The 8 L/h wet body wet front has the largest migration rate. The smallest of the distances becomes the largest, and between 24 hours and 36 hours of redistribution, the wet front of each wetted body tends to stabilize and changes at approximately the same migration rate. After redistribution for 36 hours, 4 L/h, 6 L/h, 8 L/h. The flow rate of the wetted body in the Y direction moves to 68 cm, 73 cm, and 76 cm, respectively. At the end of the infiltration, the migration distance of the wetting front in the Y direction is greater than that of the large dripper, but during the redistribution period, it shows a clear failure phenomenon; in the X direction, the treatment is humidified from the end of the infiltration to 24 hours. The migration rate was basically the same, but between 24 hours and 48 hours of redistribution, the wet front of 6 L/h and 8 L/h wetted bodies had a significantly higher migration rate than 4 L/h. After redistribution for 38 hours, 4 L/h and 6 L/h. The horizontal wetting fronts of the wetting bodies with h and 8 L/h dripper flow were moved to 59.0 cm, 64.0 cm, and 66.2 cm, respectively.

4. Conclusion

The wet front migration of the wet body is faster at first, and gradually slows down with the passage of time. A logarithmic function can be used to establish a relationship model between the wet front migration distance and time, and the fitting effect is better. In the case of the same irrigation volume, at the end of irrigation, the wetting radius of the horizontal section increases with the increase of the dripper’s flow rate; on the vertical section, the small wetting body’s flow rate of the wetted body's vertical wetting front moves at a larger distance Large, but the horizontal wet front migration distance is larger and the dripper flow is small; during the redistribution of water, the wet peak migration of the small drip
flow shows a clear "failure" phenomenon, and the wet front migration rate is larger than the drip flow significantly slowed down. When the dripper flow rate is the same, the moving distance of the wet front increases with the increase of irrigation volume.

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