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Research on Underground Drip Irrigation and Soil Redistribution - Take Heshan District of Yiyang City as an Example

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Abstract: The drip flow and the buried depth of drip irrigation zone are not only important parameters of subsurface irrigation design and operation management, but also important factors affecting the migration and redistribution of soil water and fertilizer. Crop growth is closely related to soil water and nitrogen leaching, water and fertilizer transport patterns and redistribution characteristics. It is of great significance to study the migration and redistribution of soil water and fertilizer under subsurface drip irrigation for improving the utilization efficiency of water and fertilizer and improving the system of subsurface drip irrigation. In this paper, the migration mode and redistribution characteristics of water and nitrogen in subsurface drip irrigation were studied and analyzed by means of laboratory soil box experiment, considering the two factors of drip flow and the buried depth of drip irrigation belt. The main research conclusions are as follows:

I. Different drip flows had effects on soil moisture front, soil moisture content and soil water redistribution. If other conditions remain unchanged, increasing the drip flow can increase the moist body area of soil and increase the moisture content of soil. The distance between vertical and horizontal directions increased with the large drip flow, and the soil water content decreased with the increase of distance. Large drip flow can promote the redistribution of soil water after drip irrigation.

II. Different drip depth had effects on soil moisture content and soil water redistribution. When the drip depth was 0cm, the surface shape of the wet body was a "horizontal" semi-ellipse after drip irrigation. When the drip depth was 10cm and 20cm, the surface of the wet body was an "upright" semi-ellipse after drip irrigation. The larger the buried depth of the drip can make the distribution of soil moisture more uniform, and the larger the buried depth of the drip can promote the migration of water in the soil.

III. Different drip discharge had an effect on soil nitrogen redistribution, and large drip discharge promoted soil nitrogen redistribution after drip irrigation. The Nitrate Nitrogen (NO3--N) content in the moist body is lower than that near the edge of the wetting front. The content of Ammonium Nitrogen (NH4+-N) near the edge of the wetting peak is higher than that inside the wetting body.

IV. The redistribution of soil nitrogen was affected by different buried depth of drip head, and the greater buried depth of drip head could promote the redistribution of soil nitrogen. In terms of vertical and horizontal migration of ammonium nitrogen and nitrate nitrogen, on the day after drip irrigation, the cumulative effect of Nitrate Nitrogen (NO3--N) buried at a depth of 20cm was more significant near the wetting front edge at a larger vertical downward distance, and the cumulative effect of Nitrate Nitrogen (NO3--N) buried at a depth of 20cm was more significant inside the wetting body at a larger vertical downward distance. At the same time, the drip buried depth of 20cm can spread the cumulative effect inside the wet body and near the edge of the wet front to a longer horizontal distance.

Keywords：Subsurface drip irrigation, drip discharge, drip depth, soil water redistribution, soil nitrogen redistribution

I. RESEARCH OBJECTIVES AND SIGNIFICANCE

The shortage of water resources has become the first bottleneck of China's rapid economic and social development, and agricultural water consumption accounts for 60-70% of China's water consumption. Therefore, improving the efficiency of agricultural water use is beneficial to promote the economic development of our country. Drip irrigation is a water-saving irrigation method that uses water resources efficiently and has good advantages in green irrigation coupled with water and fertilizer. It can be divided into surface drip irrigation and underground drip irrigation according to the buried location of the drip head. Compared with surface irrigation and sprinkler irrigation, underground drip irrigation has the characteristics of high irrigation uniformity, small amount and multiple times, saving water and increasing production, and can effectively reduce soil evaporation and deep leakage, and improve the utilization efficiency of irrigation water. At the same time, the high degree of automation reduces labor input and operation and management costs, and has become an important irrigation technology at home and abroad, especially in water-scarce areas (Yaojiawei, 2021). Under subsurface drip irrigation, water and fertilizer transport is affected by technical parameters of drip irrigation, water and fertilizer management measures, soil physical and hydraulic characteristics, and crop root distribution, but relevant studies are not sufficient. In addition, the redistribution of water and fertilizer in soil of underground drip irrigation is different from that of surface drip irrigation and sprinkler irrigation because of its unique transport mode. Therefore, exploring the spatial diffusion law and redistribution trend of soil water and fertilizer under the condition of underground drip irrigation can enrich the theory of water-saving irrigation and promote the application of underground drip irrigation. In this paper, the characteristics of soil water and nitrogen transfer and redistribution under different drip flow and depth of drip irrigation belt were studied by soil box experiment, which provided reference for underground drip irrigation system.

II. EXPERIMENTAL DESIGN

Two test factors were set for drip irrigation in indoor soil tank, namely, drip head flow rate and buried depth of drip irrigation belt. Among them, drip head flow rate was set at 2L/h and 5.5L/h, buried depth of drip irrigation belt was set at 3 levels: 0cm, 10cm and 20cm, and redistribution time was set at 0d, 2d and 5d, totaling 18 treatments. For specific treatments, see Table 2-1. During the experiment, the controlled irrigation amount was 7.2L and the concentration of $(NH_4)_2SO_4$ solution was 500mg/L as a fixed variable. The experiment was completed in the Water Conservancy Laboratory of College of Civil Engineering, Hunan City University from March 2, 2023 to April 28, 2023. The experimental soil samples were taken from a field with a depth of 10-30cm at 28°31'29" north latitude and 112°23'0" east longitude, Heshan District, Yiyang City, Hunan Province. The average soil bulk density was 1.2g/cm3, the average field water retention and saturated water content were 0.32 and 0.5, respectively, and the soil particle size gradingwas14.9% sand, 23.1% silt and 62% clay, which belonged to the silt loam

Table 2-1 Test level factors

	Dripper discharge 2L/h			Dripper discharge 5.5L/h		
Time after drip irrigation	0d	2d	5d	0d	2d	5d
Drip depth 0cm	B1	B2	B3	B10	B11	B12
Drip depth 10cm	B4	B5	B6	B13	B14	B15
Drip depth 20cm	B7	B8	B9	B16	B17	B18

III. INDOOR SOIL BOX DRIP IRRIGATION TEST

The soil box used in the indoor soil box drip irrigation test is a 30 ° fan-shaped glass box, with 8 rows and 8 columns of 5cm drawn on both sides of the box × 5cm square grid. Before drip irrigation, fill the soil in the soil box, and take 2512g soil samples with a sieve diameter of 2mm from each layer. After filling each layer of soil, compact the soil evenly and roughen it. A total of 8 layers of soil samples need to be filled, and the drip head position at the corresponding depth of underground drip irrigation should be reserved in a timely manner. After filling the soil box, it should be left to stand for one day. When drip irrigation, a 500mg/L ammonium sulfate solution needs to be prepared, and the speed of the peristaltic pump needs to be set according to the flow rate of the drip head (the flow rate of the drip head is 2L/h, corresponding to the peristaltic pump speed of 1.9r/min, and the flow rate of the drip head is 5.5L/h, corresponding to the peristaltic pump speed of 2.2r/min).Transparent plastic sheets should be pasted on both sides of the soil box in advance, with a water filling amount of 7.2L. The drip irrigation time should correspond to the drip flow rate (the drip irrigation time is 216min for a drip flow rate of 2L/h, and 78r/min for a drip flow rate of 5.5L/h). During the drip irrigation process, the wetting front of the soil should be drawn at intervals of 1min, 5min, 10min, 15min, 30min, 60min, etc. After the drip irrigation is completed, if it is necessary to measure the test data on the day of drip irrigation, the box should be opened for further measurement of the test indicators. The sampling location and process are shown in Figures 2-1 and 2-2. If it is necessary to measure the redistribution data after 2 and 5 days of drip irrigation, the change process of the wetting front should be depicted every other day.

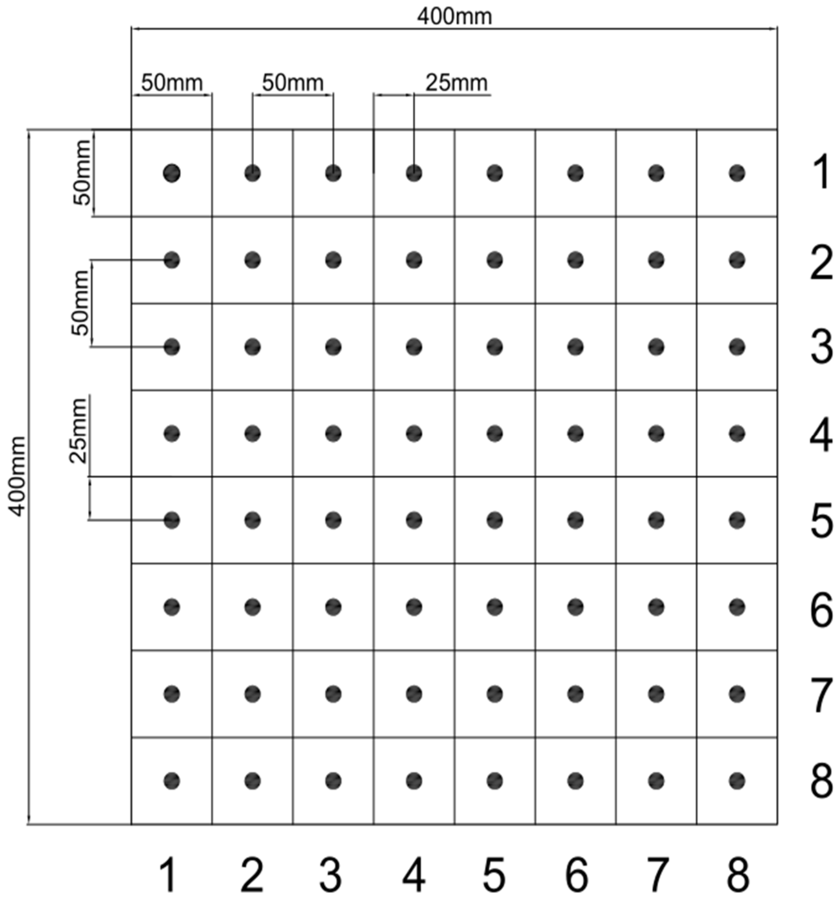

Fig2-1 Distribution diagram of sampling sites

Fig2-2 Actual flow chart of sampling

IV. OBSERVATION INDEX AND TEST METHOD

A. Soil Nitrate Nitrogen (NO3--N)

1) Take a conical bottle numbered in Arabic numerals, add 5g soil and 50ml deionized water to the soil solution to be tested according to the ratio of soil to water of 1:10, and place it in an oscillator for 15min. After the oscillation, pour the supernatant in the conical bottle into a small plastic bottle with funnel and filter paper corresponding to the conical number, and filter it twice with a water filter membrane after filtering.
2) The pipette gun will absorb 1mL of the filtrate to be tested and add it into the reagent tube equipped with 10mL nitrate nitrous acid reagent, shake evenly and cool to room temperature.
3) 1mL nitrate nitrogen color developing reagent was dropped into the reagent tube after room temperature.
4) The concentration of nitrate nitrogen (NO3+-N) was detected with the lightning magnetic water quality analyzer DGB480.

B. Soil Ammonium Nitrogen (NH4+-N)

1) Take the mixed soil sample for measuring nitrate nitrogen, mix the liquid according to the ratio of soil to water 1:10, and filter it twice.
2) Use a pipette gun to absorb 10mL of the filtrate to be tested and put it into the reagent tube, then drop 0.5mL sodium tartrate and 0.5mL Nessler's reagent, and shake evenly after dropping different reagents.
3) The concentration of ammonium nitrogen (NH4+-N) was detected by the lightning magnetic water quality analyzer DGB480.

C. Soil pH and EC

1) Take a glass conical bottle and number it with Arabic numerals from small to large. Take 5g soil and 25mL deionized water and mix it into the soil solution to be tested according to the soil-water ratio of 1:5.
2) Oscillate with an oscillator for 15min, pour the supernatant into a funnel with filter paper, and filter it into a small plastic bottle with the corresponding number of the glass cone bottle.
3) Determine the pH and EC values in small plastic bottles with a pH detector and conductance meter, record the data, and enter the data into the computer. After measuring, clean the probe of pH and EC meter with pure water before making the next measurement.

D. Soil REDOX Potential (ORP/Eh)

1) The instrument uses the thunder magnetic TR-901 soil ORP meter. First, the electrode is cleaned with pure water.
2) Calibrate the working electrode and the reference electrode.
3) Measuring point, the reference electrode and the working electrode are inserted into the grid sampling point at a certain depth, the two electrodes can not contact each other, and the results are recorded directly after the reading is stable.
4) After the measurement, the electrode surface adhesion soil clean.

E. Analysis methods

The test data were analyzed by Microsoft Excel and the charts were drawn by Microsoft Excel and Surfer software.

F. Numerical simulation analysis method

Water and fertilizer transport using water solute transport simulation software Hydrus.

V. THIS CHAPTER SUMMARIZES

the experiment data and phenomena of indoor bin drip irrigation test, such as moisture content and wetting front shape. Different emitter discharge (2L / h, 5.5L / h) and different buried depth (0cm, 10cm, Effects of 20cm) on soil wetting front and soil moisture content.The effects of drip irrigation on soil water redistribution were discussed from three time dimensions: drip irrigation end day, 2 days and 5 days. The results were summarized as follows: 1 Different emitter discharge had effects on soil wetting front, soil water content and soil water redistribution. Under other conditions, increasing emitter discharge can increase soil wetted area and soil water content. Large emitter discharge increases the distance of soil moisture between vertical and horizontal directions. The soil moisture content decreases with the increase of distance in vertical and horizontal directions. Large emitter discharge can promote the redistribution of soil moisture after drip irrigation. Different drip irrigation depth has influence on soil moisture content and soil water redistribution. When the emitter depth is 0cm, the surface shape of the wetted body is " horizontal " semi-ellipse after drip irrigation, and when the emitter depth is 10cm and 20cm. After drip irrigation, the surface of wetted body is " vertical " semi-ellipse. The depth of drip irrigation belt can make the distribution of soil water content more uniform, and the depth of drip irrigation belt can promote the movement of soil water.

VI. ACKNOWLEDGEMENTS

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