Study on The Effect of Humic Acid on The Migration Distance of Wetting Front During Water Infiltration

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Abstract. Humic acid is widely used at this stage, and studying the influence of humic acid on the transportation distance of wet front in the process of soil water infiltration is helpful to agricultural production. Orthogonal test table L16 (4^3) was used to design the test plan. Three test factors, humic acid, soil bulk density, and initial soil moisture content, were selected, and four levels were selected for each factor for experimental research. The test results show that all three factors have an impact on the distance of the wet front migration, but humic acid has the largest and most obvious impact.

Keywords: Humic acids, water infiltration, wetting front, migration distance.

1. Introduction
Humic acid is a ubiquitous, plant-derived, brown-black polymeric acid [1], which has properties such as weak acidity, hydrophilicity, ion exchange, complexation, redox and physiological activity. Humic acid, metals and organic matter form complexes through complex reactions to affect the agricultural environment [1]. At this stage, humic acid can be extracted from corn plants of different maturity [2] to study the structure and composition of humic acid [3-4] to better understand the role of humic acid. Humic acid is now widely used in agricultural production and soil remediation and other fields, deeply involved in soil improvement, water saving and drought resistance, fertilizer efficiency [1], promoting plant growth etc. However, there are few reports on the influence mechanism of humic acid on water infiltration, and the research focuses on the influence on crop water use efficiency. Cover the soil surface with a humic acid solution to conduct a water infiltration test to study the influence of humic acid on the transport distance of water infiltration and wetting front in order to better serve agricultural production.

2. Materials and methods
2.1. Test materials and devices
The test soil sample is taken from the soil at a depth of 20-40cm underground (near the Yangling Soil and Water Conservation Research Institute), which is air-dried, ground, and passed through a 2mm
sieve. At the same time, using Mastersize 3000 (laser particle size analyzer) to determine the mechanical composition of the test soil sample, its particle size volume content is: <0.001mm is 2.58%, <0.002mm is 6.50%, <0.01mm is 31.40%, <0.05mm is 81.06%, <0.1mm is 93.85%, <0.25mm is 98.95, <0.5mm is 99.97%, and <2mm is 99.99%. After analysis, the soil texture is clay loam.

Humic acid is composed of 3.74% fulvic acid, 3.23% water-insoluble matter, 11% flocculation, 13.47% K2O, 64.37% organic matter, and 15.19% moisture. It is weakly alkaline weathered coal humic acid.

See literature for test device [5].

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2.2. Experiment design

The test selects the concentration of humic acid (12.5%, 16.7%, 25.0%, 50.0%), soil bulk density (1.32g/cm3, 1.35g/cm3, 1.37g/cm3, 1.39g/cm3) and soil initial moisture content (2 %, 5%, 8%, 11%) 3 factors were used as the test influencing factors to carry out the water infiltration test. In order to ensure the accuracy and scientificity of the experiment under the premise of reducing the workload of the experiment, the orthogonal experiment design L16 (4\(^5\)) is used to arrange the experiment plan. Two sets of blank control tests are added (Blank 1: Clear water infiltration, bulk density 1.32g/cm3, initial moisture content 11%; Blank 2: Clear water infiltration, bulk density 1.35 g/cm3, initial moisture content 5%) to verify the test result. Each set of test programs was repeated 3 times. During the test, the observation time of wet front migration was recorded according to the principle of dense first and sparse.

3. Result and analysis

3.1. Experiment design

The dynamic process of the movement distance of the wet front under the action of humic acid and the infiltration time is shown in Figure 1.

It can be seen from Figure 1 that at the end of the experiment, the wet front migration distance of some test groups has stabilized, but the wet front migration distance of some test groups has not reached a stable state, showing an increasing trend.

![Figure 1. Dynamics of wetting front migration.](image-url)
3.2. Experiment design
Using EXCLE 2013 to visually analyze the test results (Table 1) and the analysis of variance (Table 2), it can be seen from Table 1: that the humic acid concentration range is the largest, indicating that the change in humic acid concentration affects the infiltration and wetting front migration. The influence of distance is the greatest; the range of initial soil moisture content is the smallest, indicating that among the three influencing factors considered in this experiment, its influence on the distance of wet front migration is less than that of humic acid concentration and soil bulk density; The extreme value is between the extreme value of the humic acid concentration and the initial soil moisture content, indicating that the influence of the change in soil bulk density on the distance of the wet front is at an intermediate level.

| Test | HAC/% | γ/g·cm⁻³ | θ/% | Results/cm |
|------|-------|-----------|-----|------------|
| 1    | (12.5)| (1.32)    | (2) | 5.7        |
| 2    | 1     | 2(1.35)   | 2(5) | 4.1        |
| 3    | 1     | 3(1.37)   | 3(8) | 21.6       |
| 4    | 1     | 4(1.39)   | 4(11)| 7.3        |
| 5    | 2(16.7)| 1        | 2   | 8.4        |
| 6    | 2     | 2        | 1   | 10.8       |
| 7    | 2     | 3        | 4   | 6.8        |
| 8    | 2     | 4        | 3   | 7.0        |
| 9    | 3(25.0)| 1        | 3   | 9.4        |
| 10   | 3     | 2        | 4   | 10.4       |
| 11   | 3     | 3        | 1   | 10.9       |
| 12   | 3     | 4        | 2   | 15.0       |
| 13   | 4(50.0)| 1        | 4   | 14.9       |
| 14   | 4     | 2        | 3   | 13.9       |
| 15   | 4     | 3        | 2   | 12.0       |
| 16   | 4     | 4        | 1   | 21.2       |
| Ij   | 9.7   | 9.6      |     | 12.2       |
| Ilj  | 8.3   | 9.8      |     | 9.9        |
| IIIj | 11.4  | 12.8     |     | 13.0       |
| IVj  | 15.5  | 12.6     |     | 9.9        |
| Range| 7.3   | 3.2      |     | 3.1        |

Table 1. Intuitive analysis.

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| Factors                | SS   | f | F   | P    |
|------------------------|------|---|-----|------|
| HAC                    | 118.27| 3 | 1.16|      |
| Soil bulk density      | 36.76| 3 | 0.36|      |
| Initial moisture content| 30.52| 3 | 0.30|      |
| Error                  | 203.50| 6 |     |      |

Table 2. Intuitive analysis.
4. Conclusions
Humic acid has the most significant influence on the transportation distance of the wet front of soil moisture infiltration, which is greater than the influence of soil bulk density and soil initial moisture content on the transportation distance of the wet front. Provide a scientific research foundation for follow-up research.

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