Assessment of Water and Solute Movement in Dune -sand Under Drip Irrigation

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1. Introduction

Salts in the soil water limit plant growth by making less availability uptake by plant roots. Salt movement and concentration is intimately tied to water movement, hence salinity management is largely a function of water management in any irrigation system. This is a difficult research problem because solute concentrations in soil water are not easy to meas ure. Herein, drip irrigation is a unique irrigation system. In this approach the emitters are placed directly on the soil surface. As a result, one has a case of three-dimensional flow beneath the emitter, which differs from the usual one-dimensional flow problem of surface irrigation. Salt movement, and hence salt distribution in soils is directly related to water movement (Nakayama and Bucks, 1986). Recently, using time domain reflectometry (TDR) as a method for automated in measurement of bulk soil electrical conductivity (EC_b) offers the promise of improved temporal resolution in tacking solution movement. By using TDR method it is now available to monitoring the water and solute transport/distribution beneath the emitter in drip irrigation in various time interval to discernment of critical period. Estimation of concentration of conservation solutes from EC_b requires either determination of a direct relationship between EC_b and soil solution electrical conductivity (EC_w). The objectives of these study were to; (1) relationship of EC_b with EC_w and soil water content (q_w) in dune-sand soil (2) water and solute movement under the drip irrigation in dune-sand soil.

2. Material and methods

Theory- Estimation of q_w by TDR method; The travel time for a pulsed electromagnetic signal along a soil-TDR probe is dependent on the velocity of the signal and the length of the waveguide. The velocity is dependent on the dielectric constant (K_a) of the material surrounding the waveguide. The K_a of water relative to other soil constitutes is high. Consequently, changes in q_w can be directly related to the change in the K_a of bulk soil.

Relationship of EC_b with EC_w and q_w; In a two-pathway model (Rhoades et al., 1976), electrical conduction is assumed to take place along two parallel conducting paths. The predominant path is through the soil solution (EC_w), also know as pore water electrical conductivity. According to this model for a given q_w, the relation between EC_b and EC_w given in a linear form, $EC_b = EC_s + Tq_w EC_w$, in which EC_s is apparent electrical conductivity of the solid phase of the soil, and T is a transmission coefficient.

Experimental layout-The experiment was conducted at the Arid Land Research Center (location 35°32´N, 134°13´E), Tottori University, Japan. The TDR method was used to obtaining measurement results remotely. The 36 soil-TDR probes were used as a waveguide, which connected to the TDR/multiplexes (Campbell Co. TDR100/SDMX50 multiplexes). The calibration processes were examined on soil columns, with 8 different levels of q_w and 8 different levels of salt concentration as a salts solution, totally 64 soil column samples (dune-sand soil). To identify/assess the salt and solute movement under the drip irrigation with crop condition in dune-sand soil an experiment with drip irrigation system was set up under no rainfall condition. A water-tank was used to preparing saline water. The main pipe line that was connected to the pump carry out water from water-tank to the 3 laterals by passing through the main valve, filter, and pressure gauge. Each lateral occupied with 7 emitters which where spaced at 0.3m apart. The emitters were online model of 2.0 lph in 0.1MPa working pressure. The EC_w and SAR of the saline water was 3.0 dS/m and 5 respectively, which did available by mixing the sodium chloride and calcium chloride in to the water. The system was operated at a regime of daily base on the estimation of actual evapotranspiration (*ETc*). Three laterals (I, II, III) were operated according to the three irrigation level; 1.00*ETc*, 1.15*ETc* and 1.30*ETc* respectively. To moisture and salinity monitoring in the soil tests were carried out in the field and in the laboratory. EC_w and q_w were measured at one hourly interval by making use of a data logger (Campbell Co. CR23X) and 12 soil-TDR probes for each irrigation treatment were installed in a vertical grid across the row in one side of the central emitter in four depths of 10, 25, 45, 70 cm and 10, 20, 30 cm radially from emitter (sensors I-1 to III-12). Laboratory tests were performed to measuring salinity concentration and pH of soil in end of the irrigation season by soil sampling.

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3. Results and Discussion

The relation of the K_a on q_w was found by making the polynomial carve between K_a and q_w recorded for all soil column samples (**Fig.1**). Further, the q_w was computed by Topp et al. (1980) model, to evaluation for dune sand (**Fig.1**). The results show that the Topp et al. model has significant results for dune-sand. Theoretically, the interception of curves between EC_b against q_w give EC_s but practically we observed different intercepts for this soil. Arbitrarily selecting water content values and evaluating EC_b corresponding with different EC_w at the same q_w can make better estimation of both T and EC_s. This is represented in **Fig.2**, where each slope represents Tq_w and the intercepts represent EC_s. The linear fit (R^2) improves as q_w increases, confirming the problem in accurately estimating the relationship between EC_b and EC_w at very low q_w. The values of EC_s (**Fig.2**) at different water contents appear to be the same, but are actually different. A linear relationship of the form $\alpha q_w+\beta$ was used to relate EC_s to q_w. The data was represented well for α=0.29 and β=0.0804 (R^2=0.9877). The resulting EC_b, EC_w and q_w relationship thus obtained as an equation.

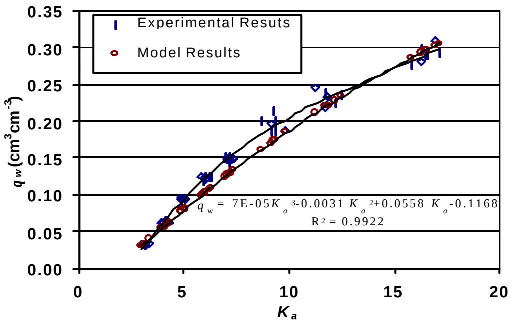

Fig. 1 Relation of K_a and q_w.

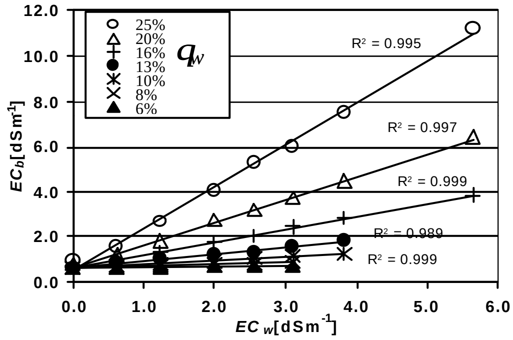

Fig. 2 Relation between EC_b and EC_w and q_w.

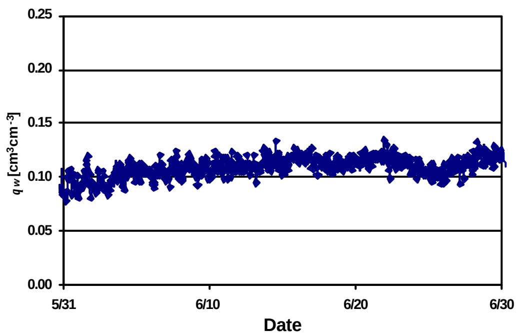

Fig. 3 Variation of q_w around sensor III5.

Moisture and salt distribution in the soil- The amount of water applied as irrigation varied 1.7-4.3 mm/day during the June to 1.2-7.7 mm/day during the July according to the season. The hourly q_w monitored by TDR in spatial condition show that q_w varies from 0.04 cm^3cm^{-3} before irrigation and 0.08-0.10 cm^3cm^{-3} after irrigation (depend on the irrigation time) for sensor I1 during the season, which is 0.08 and 0.09 cm^3cm^{-3} before irrigation and 0.10 and 0.12 cm^3cm^{-3} for sensor II1 and III1 respectively. The variation of q_w in all treatment around sensors II1 and II1 was between the field capacity (FC) and wilting point (WP) in the soil, but for the sensor I1 before the irrigation that was near to WP. Simultaneously, the EC_w variation around sensors 1 show that the EC_w increases a few days after irrigation started. EC_w was about 12, 15, and 20dSm^{-1} for senores I1, II1 and III1 respectively, in first month of irrigation season and continues to increase in the second month. Apparently in dune-sand the water front movement for a unit of time in radial direction is less than to the depth, though the radial movement is more affective on root distribution and establishment of plant. So it seems the q_w variation around sensors 2 and 5 have more relation to for this situation in the dune-sand soil (Fig.3). The value of EC_w was 20~25 dSm^{-1} for sensors 2, but that was 25~30 dSm^{-1} for sensors 5.

4. Conclusion

The number of 36 soil TDR-probes was calibrated and used to assessment of water and solute movement under drip irrigation system in dune-sand. The variation of water content in the dune-sand even in nearest place to emitter (10cm in depth and radial) was less than 0.15 cm^3cm^{-3}, which decreasing by distance from emitter location. The results indicated the EC_w increased in the soil a few days after irrigation started. The value of EC_w was 25~30 dSm^{-1} towards fringes of the wetted soil volume and 10~15 dSm^{-1} under the emitters location.

References

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