Effects of Drip Irrigated Saline Water on the Growth of Sorghum in a Dune Sand field

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1. Introduction

The water available for irrigation is limited, and should be used efficiently and conserved to ensure continued supply. Water use efficiency is the beneficial utilization of irrigation water applied (Khan et el. 2003). Drip irrigation system (DIS) requires less water, since only a portion of the soil surface is wetted, which means that evaporation losses are reduced and water use efficiency is improved. On the other hand, DIS has the ability to minimize the salt concentration of the soil water near the plant roots. Sorghum is a high temperature tolerant crop that grows in widely different climate under both irrigated and non-irrigated conditions, especially in semi-arid and arid regions. Sorghum also has a moderate tolerance of salt. Salinity affects crop growth by decreasing water availability to roots due to osmotic effect of external salt and by toxic effects with in the plant. The objective of the study is (i) to assess the effect of irrigation regimes and irrigation interval on sorghum water use efficiency under drip irrigated with saline water, and (ii) to evaluate soil stability for next irrigation season after use of saline water and salt accumulation under DIS.

2. Materials and methods

The experiments were conducted in a green house at the Arid Land Research Center, Tottori University (35^o 32'N and 134^o 13' E), in a sand dune. The soil was siliceous sand with 95% sand, 1.3% silt, and 3.7% clay. The treatments included four irrigation regimes water amount and two irrigation intervals (1-day and 2-days) using saline water (EC = 4 dS m^{-1}). Irrigation treatments were as an index of pan evaporation (Ep); i.e. Ep×0.5, Ep×0.75, Ep×1.0, and Ep×1.25. A randomized complete block design with three replicates was adopted. Date of sowing was about second half of March 2004 with a density of 8 seeds m^{-2}. The dimensions of each plot were 1.2 m × 1.2 m. Each plot included 144 plants in 3 rows, 0.4 m wide (Fig.1). Pan evapotranspiration was measured using 3 small pans (as replication) daily (9:00am). Fertilizer was applied uniformly to each treatment when the soil was plowed. Soil evaporation was estimated using a total of 6 micro-lysimeter (0.6 m in height and 0.13 m in diameter); 3 for 1-day and 3 for 2-day irrigation intervals. Meteorological factors were recorded to estimate potential evapotranspiration using recommended models.

Soil water content (θ_w) and soil solution electrical conductivity (EC_w) distribution were assessed by soil sampling from different depths and radius from emitter laterals line (0-5, 5-15, 15-30, 30-45 cm depths in 0.0, 10.0, and 25.0 cm radius). The variation of θw and EC_w for two depths of 10 and 20 cm (zone of high root density) were recorded during the experiments for each irrigation treatment using TDR method. The soil-TDR probes were calibrated for dune sand soil with 11 levels of soil water content, θ_w (0.02, 0.04, 0.06, 0.08, 0.1, 0.12, 0.14, 0.16, 0.18, 0.2, and 0.25 cm^3 cm^{-3}) and 8 levels of salinity (EC_w) using NaCl (0.0, 0.8, 1.7, 2.0, 2.4, 4.9, 6.1, and 7.1 dS m^{-1}).

3. Results and discussion

Because of the importance of soil-TDR probes accuracy in dune sand where the range of water holding capacity is 0.03-0.08 cm^3 cm^{-3}, the final results of soil-TDR probes calibration are presented. The relationship between TDR dielectric constant (ε), output of TDR for θw, and the θw obtained by gravimetric method for all soil column samples was found by making a polynomial plot

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between ε and θw (Fig. 2). Estimation of EC_w from out put of TDR (EC_b) requires the determination of a direct relationship between those two. Under constant θ_w and temperature, the concentration of soil solution can be directly determined from TDR measured by assuming a linear relation between EC_b and EC_w. However, for the field conditions, we need to obtain independent calibration for individual soils. The Roads et al. (1976) model was used to obtain EC_w from EC_b. This model require preliminary measurements of EC_b, EC_w, and θ_w to obtain the empirical constants for the following equation; $EC_b = ECs + T\theta_w EC_w$, where T is a transmission coefficient and ECs is contribution of the solid fraction of soil. According to this model, EC_b at constant θ_w is linearly related to EC_w. A linear relationship of the form $a\ \theta_w + b$ was used to relate ECs to θ_w. The data was represented well for $a = 69.153$ and $b = -9.861$ ($R^2 = 0.959$). The ratio of (EC_b – ECs)/ EC_w is equal $T\theta_w$ which is plotted vs. θ_w in Fig. 3.

The results indicated that the variation of Ep under the green house was 3.11±1.7 mm during the early crop growing stage. The average temperature and humidity during the early crop growing stages was 14.0±11.0^{o}C and 68.0±27.0%, respectively.

4. Conclusion

Management DIS for saline water use on sorghum (based on the pan evaporation with different irrigation regimes and interval) was evaluated. TDR method was used for recording θ_w and EC_w variation in the root zone. TDR was calibrated for dune sand. The results of this research can be useful for improving saline water management under DIS and crop water use efficiency.

Fig.1 Experiment layout in greenhouse

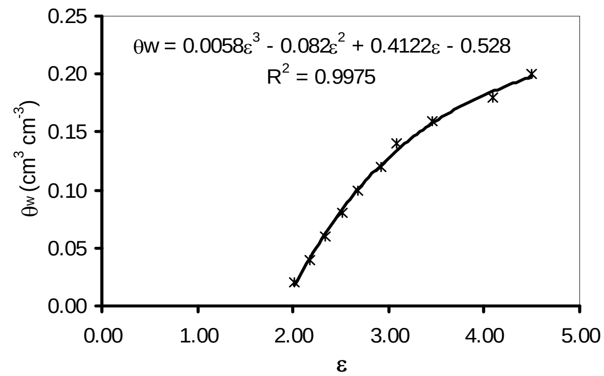

Fig.2 The ε-θw relation in dune soil

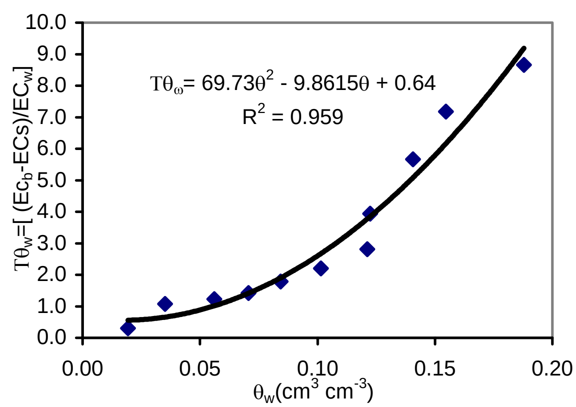

Fig. 3.Relation between (EC_b-ECs) / (ECw) vs. θw in dune soil.

References

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