Effect of irrigation with Aquaculture Drainage Water on hydraulic properties of Arava soils along three growing cycles of basil.

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INTRODUCTION

Global intensification of aquaculture production to keep pace with an ever-increasing food and nutrition demands from the growing population is characterized by discharge of huge drainage water volumes containing concentrated dissolved organic and inorganic compounds. Parallelly, the increasing water scarcity in the age of climate change a challenge to agricultural production and sustainable global food security. Since aquaculture drainage water (*ADW*) is rich in essential nutrients, its use in agricultural irrigation would reduce environmental pollution and water withdrawal from underground aquifers.

We hypothesized that irrigation with *ADW* will alter the natural hydraulic properties of irrigated soil. Also, *ADW* can be an alternative fertilization source without any need to add nitrogen and phosphorous fertilizers to the irrigation water.

Objectives

The overarching objective was to investigate the temporal dynamics in soil hydraulic properties under simulated field conditions of regular *ADW* irrigation and tap water (*TW*).

MATERIALS AND METHODS

A system comprised of drainage lysimeters (Fig.2) was constructed in a climate controlled greenhouse to measure the Evapotranspiration (Equation 1) and drainage rate of Arava loamy sand and sandy soils. The soil water balance equation was modified to:

Eq 1. $$ET \approx Irr - Dr$$

Where *ET* is evapotranspiration, *Irr* and *Dr* are irrigation and drainage quantities, respectively, assuming steady state conditions under which no changes in the soil water storage.

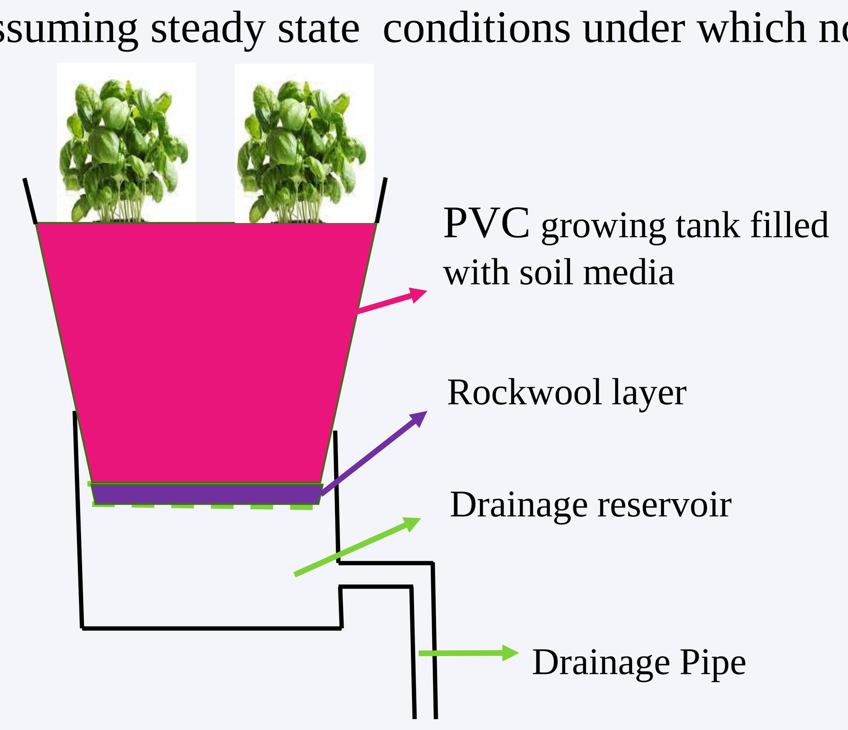

Figure 1: A schematic illustration of a single lysimeter unit.

Figure 2: Drainage lysimeter system.

Three growing cycles for basil were simulated by regular gravity-drip irrigation with aquaculture drainage water (*ADW*) and tap water mixed with commercial fertilizer (*TW*). A minimum leaching fraction of 50% was maintained. To each lysimeter, 7 basil seedlings were planted to mimic field conditions.

The temporal dynamics of infiltration rate and near-saturated hydraulic conductivity under a tension of –6 cm of water (*K-6*) was measured with a Mini disk tension infiltrometer device.

The long-term effect of irrigation with *ADW* and *TW* on the soil's retention curve was measured on sandy soil by using the hanging water column method. The measured data was fitted to Van Genuchten model (Equation 2) in RETC software (van Genuchten et al.,1991).

Eq 2. $$\theta = \theta_r + \frac{(\theta_s - \theta_r)}{[1 + (\alpha\,\psi)^n]^m}$$

To quantify the post –season evaporation rate, Time Domain Reflectometry (*TDR*) sensors were installed at depth of 10 cm, to measure water content depletion over time.

REFERENCES

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RESULTS

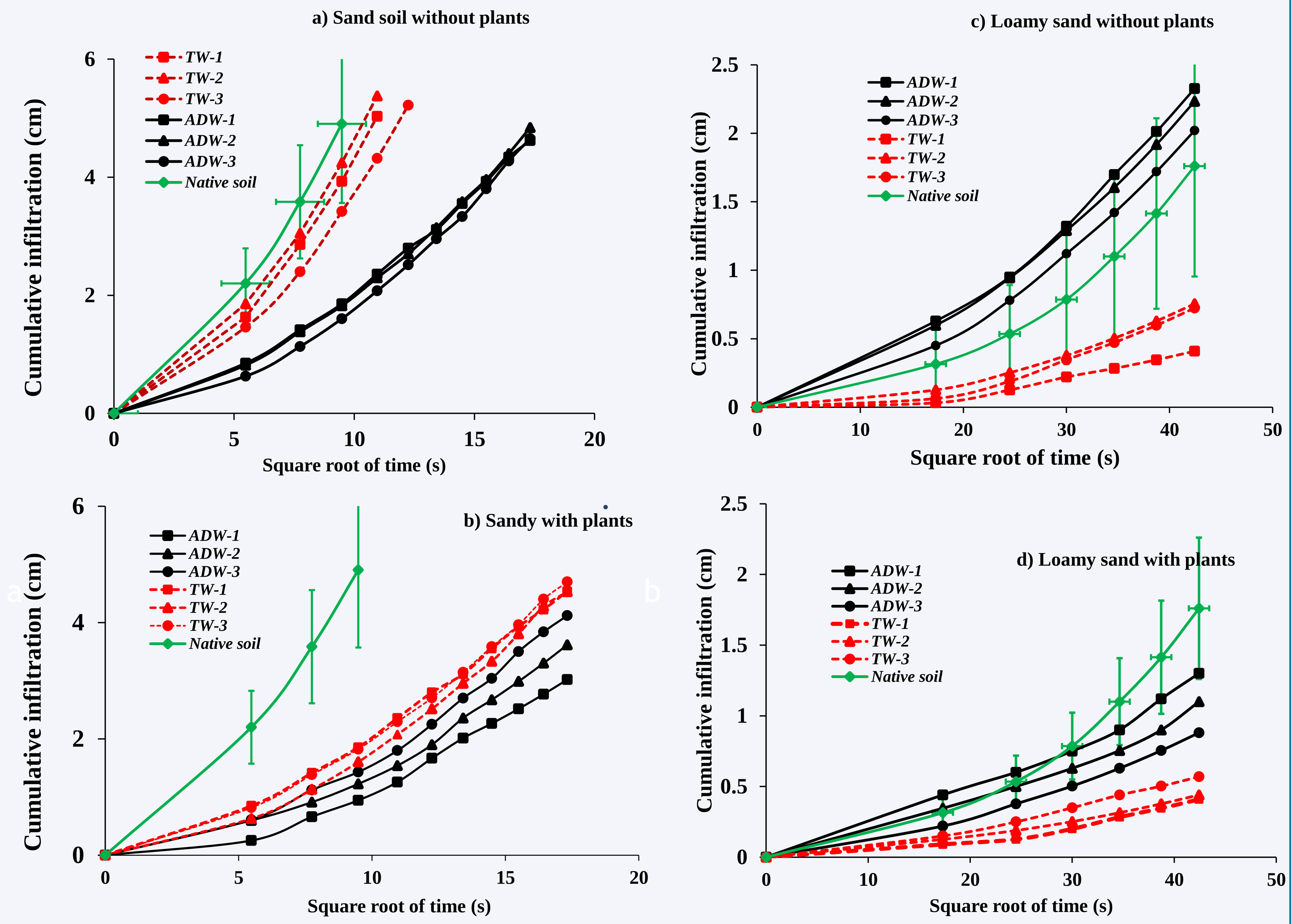

Figure 3. Mean values of cumulative infiltration versus square root of time within the first 300 and 1800 seconds in sandy soil and loamy sand soil under irrigation with *ADW* (black symbols) and *TW* (red symbols), n = 4. Symbols *ADW-1*, *ADW-2* and *ADW-3* and *TW-1*, *TW-2* and *TW-3*, indicate for soil irrigated with aquaculture drainage water and tap water for the 1st, 2nd and 3rd growing cycle, respectively.

The infiltration rate was consistently higher in the *TW* irrigated sandy soil as compared to *ADW* irrigated soil (Fig 3a,b). Interestingly, on loamy sand soil, irrigation with *ADW* resulted into higher infiltration rate than in *TW* (Fig 3c,d). Also, *K-6* of sandy soil was decreased by up to 64 % upon irrigation for 3 growing cycles with *ADW* from the native soil and *TW*. Whereas on loamy sand soil, *ADW* irrigation caused a 13 % increase in *K-6* compared to *TW* which caused up to 78% decrease from the native soil.

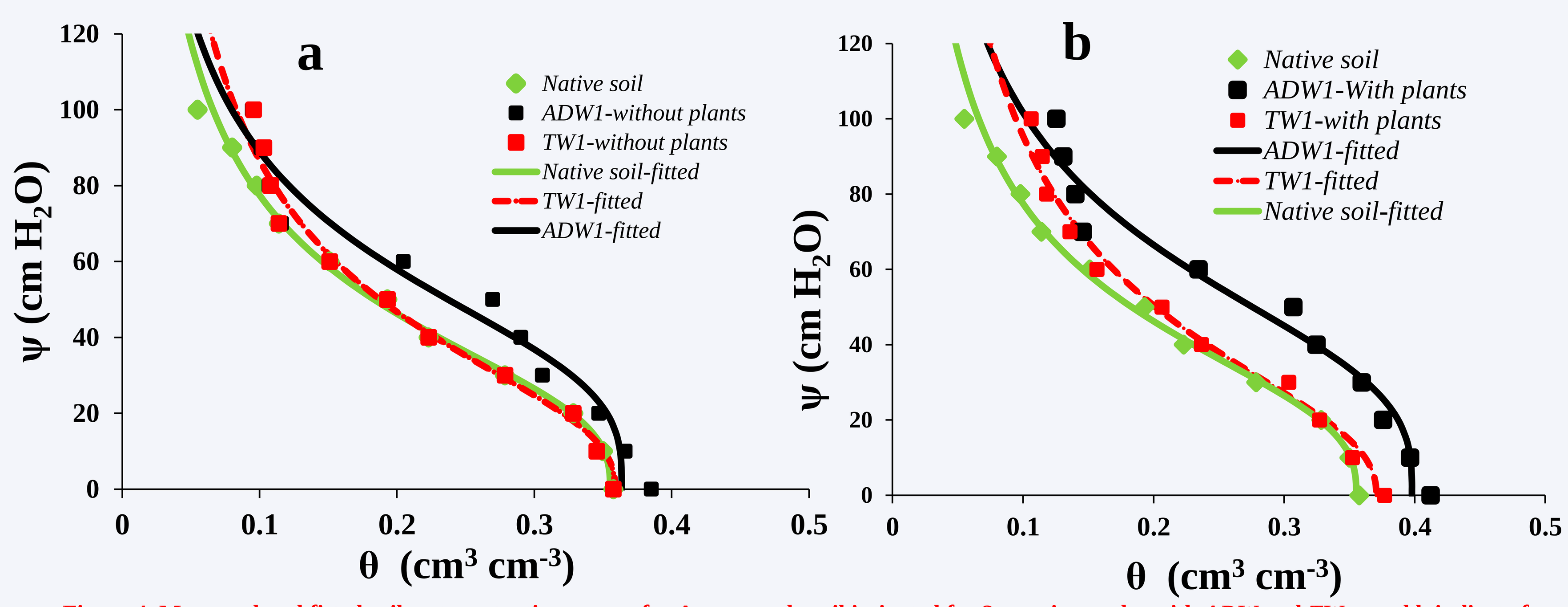

Figure 4. Measured and fitted soil water retention curves for Arava sandy soil irrigated for 3 growing cycles with *ADW* and *TW*. a and b indicate for soil sampled from the 1st growing cycle lysimeters without plants and with plants, respectively.

The *ADW* on sandy soil increased the water holding capacity. Water contents at saturation and field capacity were higher in *ADW* irrigation compared to *TW* and native soil (Fig 4). While evaporation rate in *ADW* irrigated soil was 50% higher than the measured rates in *TW* (Fig 5).

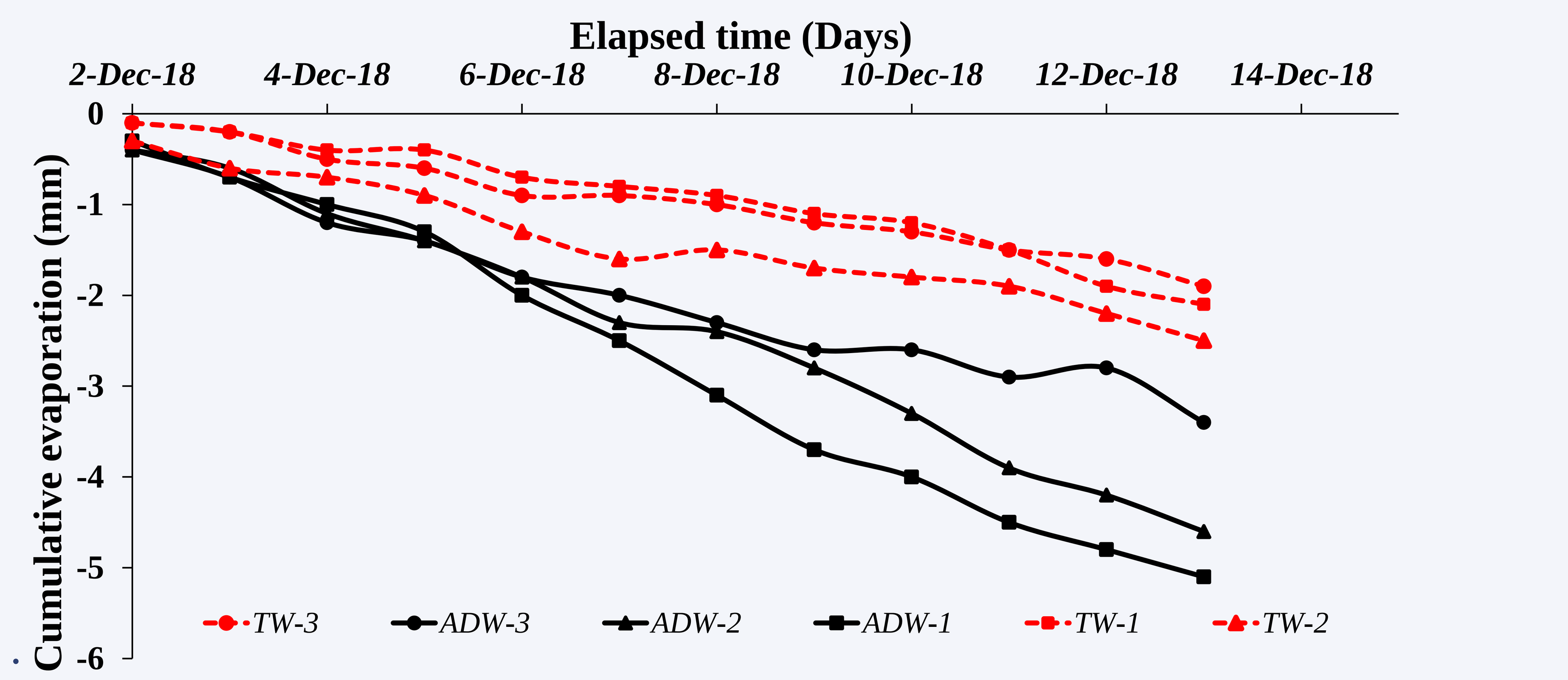

Figure 5. Temporal changes in post-season cumulative evaporation from wet bare sandy soils over a 14 days measured with TDR probes following irrigation cessation both with *ADW* and *TW*. Symbols *ADW-1*, *ADW-2* and *ADW-3* and *TW-1*, *TW-2* and *TW-3*, indicate for soil irrigated with aquaculture drainage water and tap water, respectively, for the 1st, 2nd and 3rd growing cycle, respectively.

CONCLUSIONS

- Based on the results, irrigation with an organic nutrient rich aquaculture drainage water can improve the hydraulic behaviour of Arava soils.
- Irrigation with wastewater from aquaculture has the potential to increase water use efficiency and nutrient use efficiency in arid and semi arid regions.
- The ability of *ADW* inducing changes to the natural hydraulic properties of soils might be a result of the accumulation of suspended solids on the soil.
- Basil yield and leaf N, P and K content from *ADW* irrigation was consistently at a comparable rate as that from *TW* suggesting no need for addition of nitrogen an phosphorous fertilizers to the irrigation water. As such aquaculture effluent can be utilized to improve crop productivity and quality of crop produce