Evaluating AquaCrop for simulating response of tomato to irrigation induced salinity

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Introduction

AquaCrop is considered a reliable simulation model to predict crop yield. AquaCrop is supported by the FAO and seems to provide reasonable balance between accuracy and simplicity. While AquaCrop handles crop response to conditions of salinity, there have been few studies evaluating its accuracy to this parameter. We evaluated AquaCrop for its ability to simulate crop growth, transpiration and yield under conditions of irrigation-induced salinity using an experimental database of tomato grown during different meteorological conditions and demands under highly varied conditions of irrigation water salinity and irrigation amounts.

Materials and methods

Field and lysimeter experiments were carried out in the Southern Arava Valley in Israel in fall and spring seasons. Tomato (Lycopersicon esculentum Mill. cultivar '5656') was grown. Irrigation in the field was managed with treatments of 30, 60, 100, and 130% of reference evapotranspiration (ET_0) of Class A pan with irrigation water salinity (EC_I = electrical conductivity of irrigation water) of 3 dS m^{-1}. Irrigation treatments in the lysimeters were six EC_I levels from 1 to 11 dS m^{-1} all at 130% of ET_0 and five irrigation levels of 30, 60, 100, 130 and 160 % of ET_0 all at EC_I of 3 dS m^{-1}. EC_I was regulated adding 1:1 Molar concentrations NaCl and $CaCl_2$. Irrigation was applied via drippers from soil surface covered with polyethylene mulch to reduce evaporative losses to a minimum.

AquaCrop was run to calculate yield and transpiration in fall and spring. The datasets of meteorological, crop, management, and soil data were obtained from field-measured results. Irrigation rate (Ir) was calculated with below:

$$I_r = \frac{I_{EC}}{I_{Max}} \cdot ET_o$$

where I_{EC} and I_{max} are each and maximum irrigated water of from the lysimeter experiment, respectively. I_r of the Fall and the Spring was constantly given as 15 mm d^{-1} for 5 and 8 days after sowing, respectively. Since the groundwater table (GWT) was extremely low in the experimental area, the GWT was assumed as 20.0 m so as not affect the capillary rise. Other original and modified input parameters are shown in Table 1.

Talble 1 Data set for AquaCrop

Parameters	units	Fall	Spring
cultivar		Tomato (5656)	Tomato (5656)
sowing day		22-Sep	7-Mar
Climate			
CO_2	ppm	GlobalAverage	GlobalAverage
Crop			
plant density	plants m^{-2}	13.3	13.3
CC_o	%	2	2
max canopy cover	%	80	80
canopy decline		very slow	very slow
recovered	d	7	7
max canopy	d	45	45
senescence	d	89	89
maturity	d	106	96
duration of flowering	d	42	42
flowering	d	45	45
maximum effective rooting depth	m	0.4	0.4
harvest index	%	60	60
Irrigation			
percentage of soil surface wetted	%	30	30
irrigation method		drip irrigation	drip irrigation
Field			
relative biomass	%	100	100
mulch		sawdust	sawdust
soil cover by mulch	%	100	100
weed management		perfect	perfect
Soil profile			
soil texture		sandy loam	sandy loam
soil thickness	m	2	2
PWP	%	15	15
FC	%	28	28
SAT	%	46	46
K_s	mm day^{-1}	4752	4752
gravel	mass %	0	0
root zone expansion rate	%	100	100
soil surface		46	46
Readily Evaporable Water	mm	9	9
ground water table	m	20	20
Groundwater			
characteristic of groundwater table	m	20	20

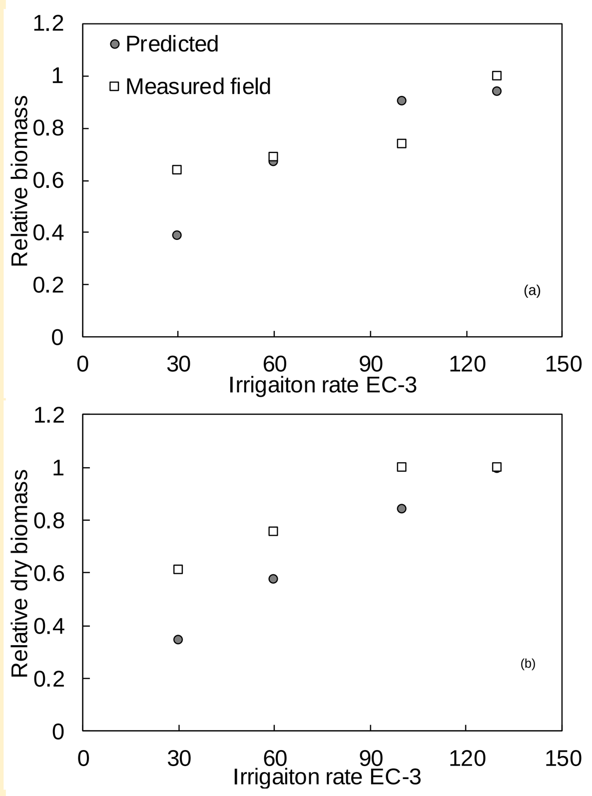

Fig. 1 Comparison of relative biomass of AquaCrop predicted and measured at the field as each irrigation level of electrical conductivity of irrigation water was 3 dS m^{-1} in the Spring (a) and the Fall (b) trial.

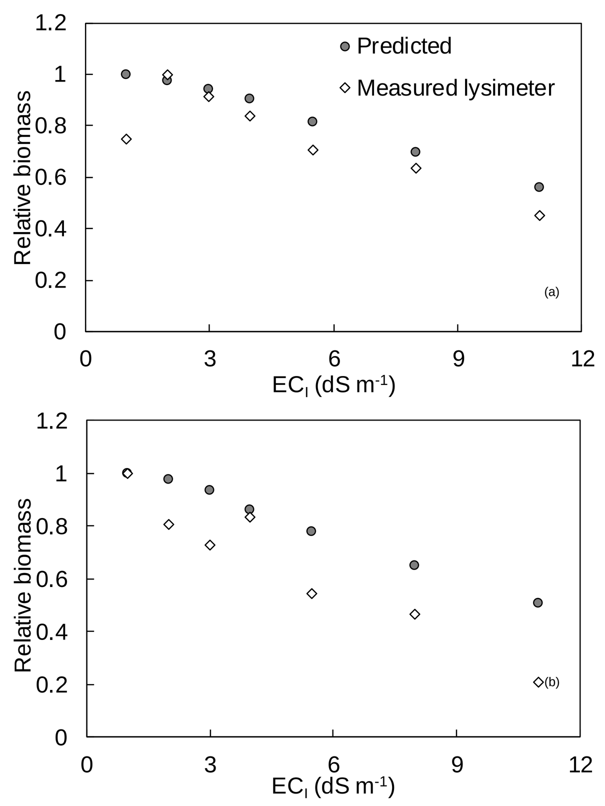

Fig. 2 Comparison of AquaCrop predicted and measured at the lysimeter relative biomass as each salinity level of irrigation level was 130 % of ET_0 in the Fall (a) and the Spring (b) trial.

Results and discussion

- Predicted biomass for each Ir in the field growing at the end of both periods agreed relatively well with measured biomass (Fig. 1).
- Predicted biomass for each EC_I in the lysimeter growing at the end of both growing periods agreed relatively well with measured biomass (Fig. 2).
- Irrigation level and salinity were found to effect biomass and transpiration alternatively, with irrigation dominant at low EC_I levels and salinity dominant when irrigation application was relatively high (Fig. 3 and 4).
- Patterns of accumulated transpiration were different in the two seasons, with gradual increase to a stable maximum in the fall and continued increase in the spring. Transpiration was simulated well, showing similar trends of the measured data in lysimeters in both fall and spring. The biomass in fall and spring was predicted relatively well (Fig. 5).

Following these results, AquaCrop appears applicable for simulation of salinity effects on yield and transpiration, at least under conditions similar to those of the current study.

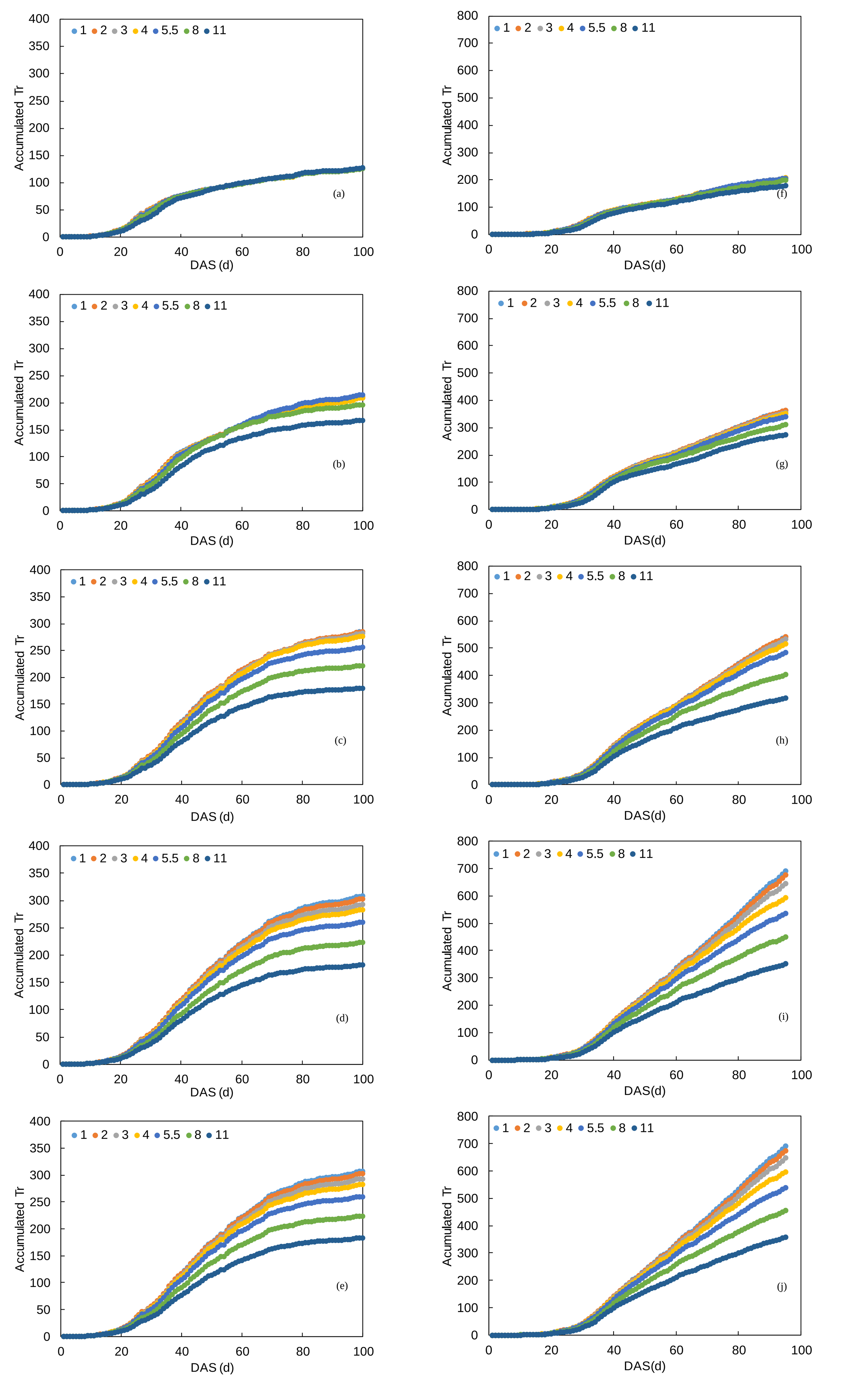

Fig. 3 AquaCrop predicted T_r of each irrigation level of 30 (a and f), 60 (b and g), 100 (c and h), 130 (d and i), 160 (e and j) % of ET_0 and each salinity level through growing period in the Fall (a, b, c, d, and e) and the Spring (f, g, h, i, and j) trial. Numbers in legends indicate salinity level with dS m^{-1}.

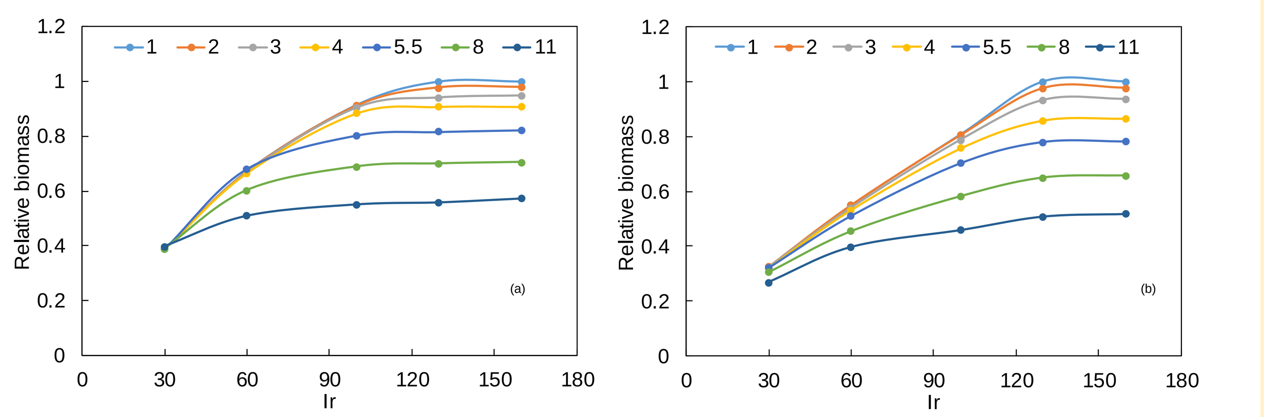

Fig. 4 AquaCrop predicted relative biomass of each irrigation level of each salinity level in the Fall (a) and the Spring (b) trial. Numbers in legend indicate salinity level with dS m^{-1}.

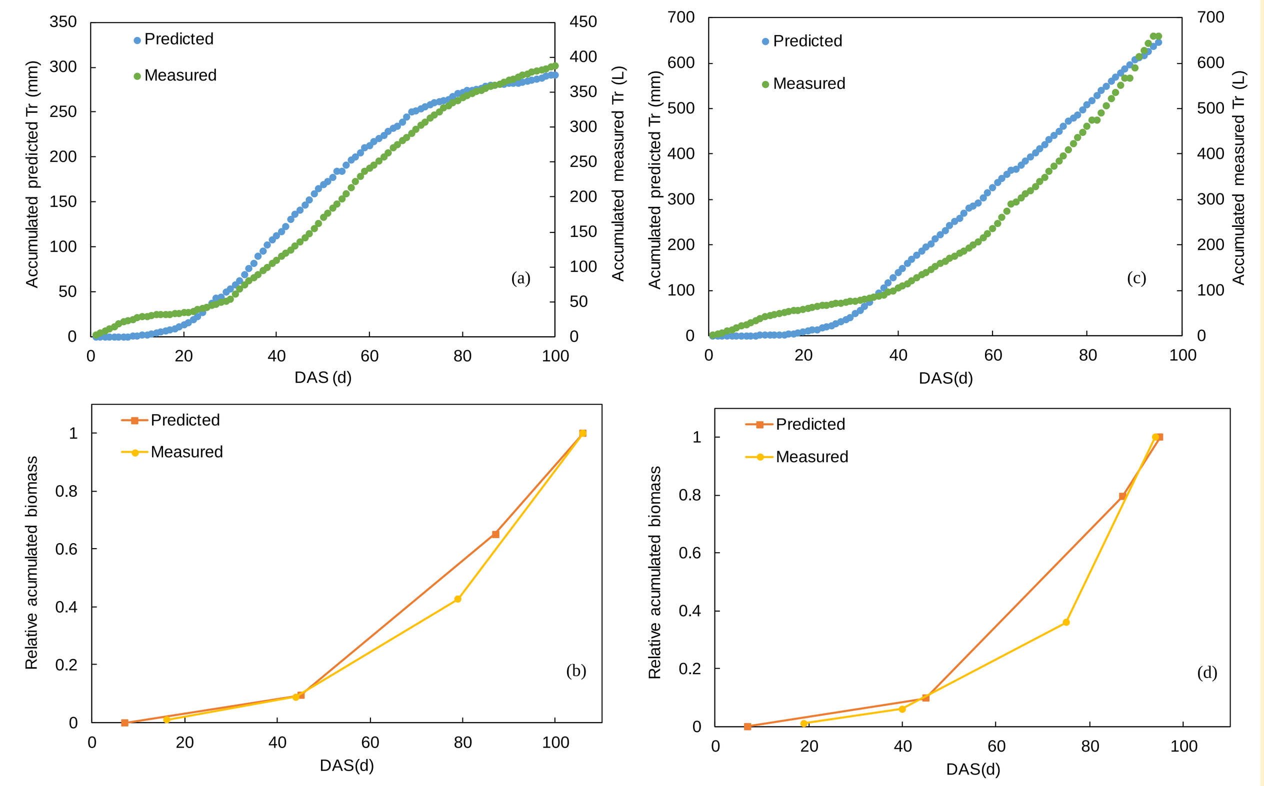

Fig. 5 Comparison of AquaCrop predicted and measured accumulated transpiration and relative biomass as I_r of 130 % of ET_0 and EC_I of 3 dS m^{-1} in the Fall (a and b) and the Spring (c and d) trial.

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