A simulation-based approach to determine economical irrigation depth for sweet corn considering weather forecast under saline condition

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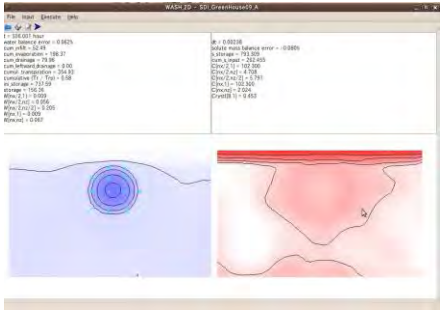
Irrigation and salinity management

- In times of scarcity, we are all responsible for using water wisely, efficiently, and productively.
- We must be more ‘water smart’ under extreme conditions (e.g., drought and salinity).
- Optimization of irrigation to improve food production and farmers’ income under saline conditions.

The goals of this study

1. To present a new scheme to determine irrigation depth such that net income is maximized considering price of water using a numerical model, WASH-2D and quantitative weather forecast.
2. To evaluate whether the optimized irrigation scheme is also applicable to saline conditions,
3. To compare the optimized irrigation scheme with other common leaching managements.



YAHOO! JAPAN

Field experiments & Treatments

Sweet corn was sown under four treatments inside the small glasshouse (May 2022- August 2022):

C: Leaching is performed when monitored salinity in the root zone reaches at critical level of crop and amount is determined according to **FAO's** guidelines. Irrigation using saline water (2 g/L NaCl solution) is automatically performed to return volumetric water content to field capacity in the root zone (**Automated drip irrigation**).

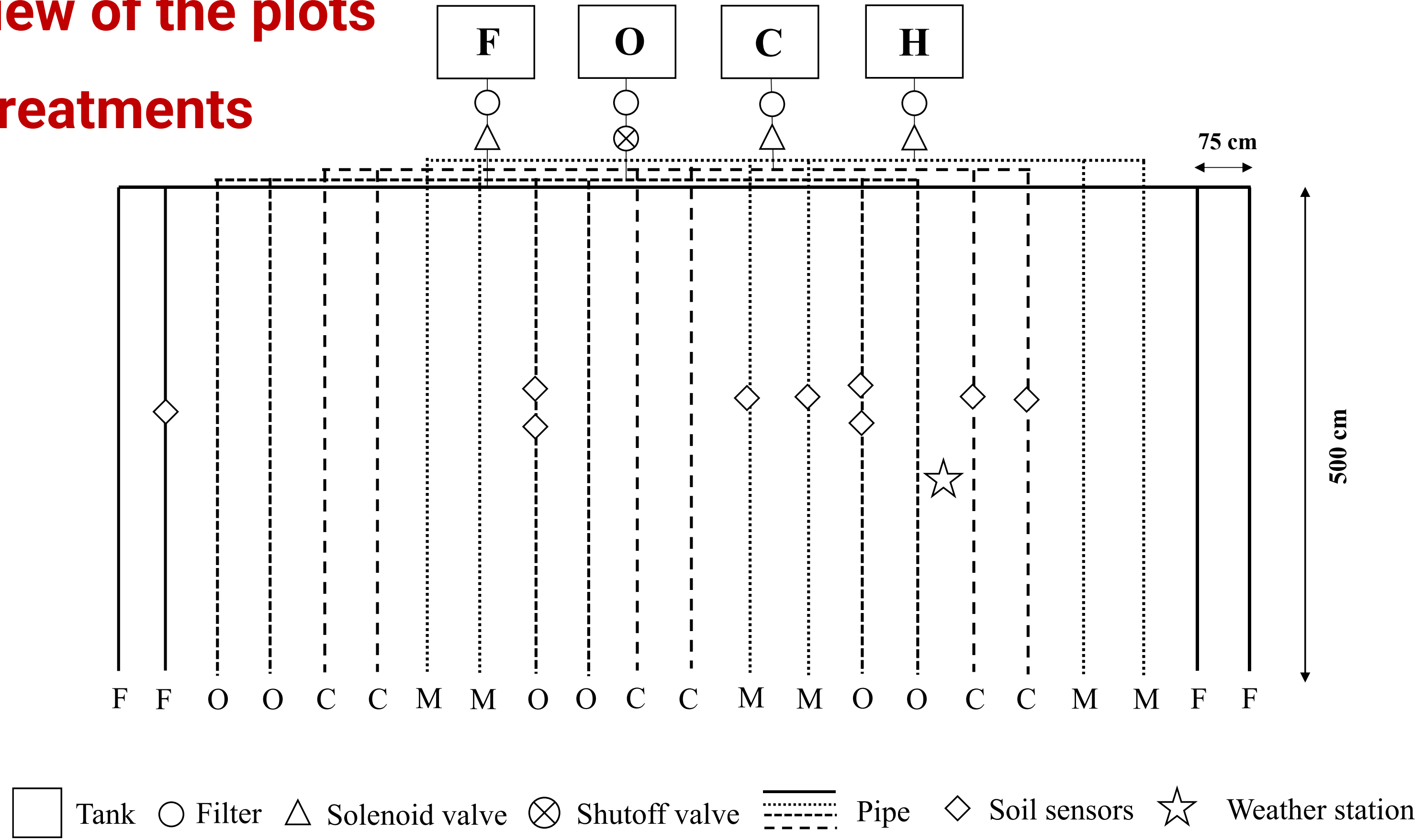
H: as above, but the root zone **soil moisture was maintained at a high** level throughout the season, without any intentional leaching.

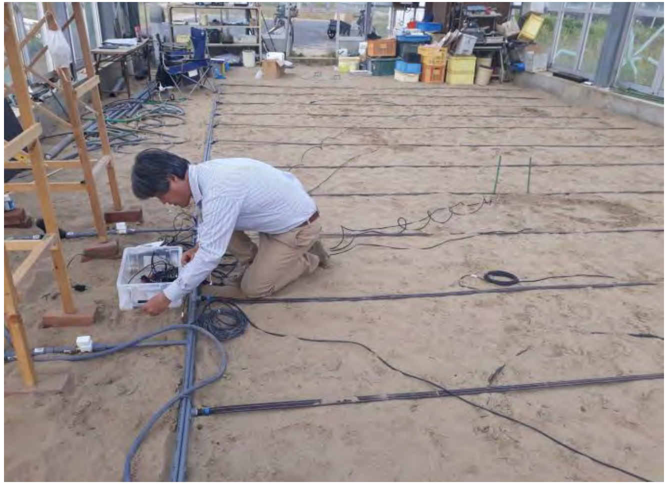
Field experiments & Treatments_ cont.

O: Leaching is unintentionally performed via the **optimized irrigation scheme** using saline water. In this scheme, irrigation depth is determined such that net income is maximized considering the price of water and weather forecasts using the WASH_2D model.

F: Automated drip irrigation with **freshwater** application.

Schematic view of the plots of the treatments



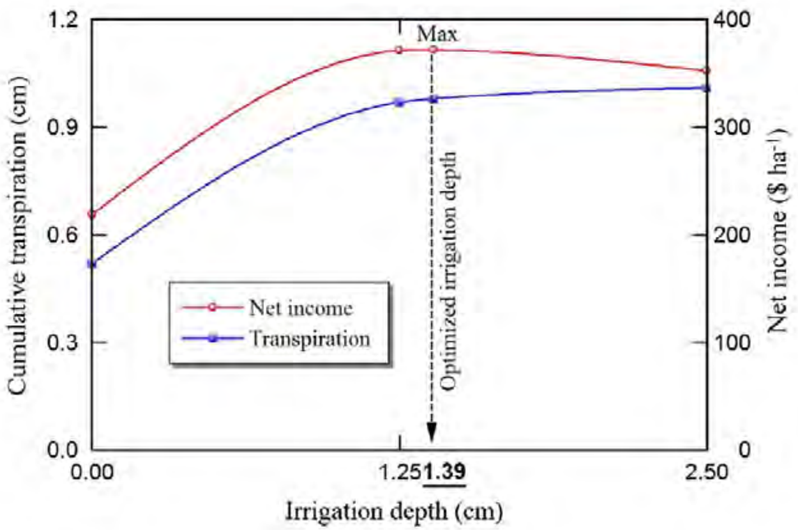


WD5-WET-SDI

Virtual Net Income

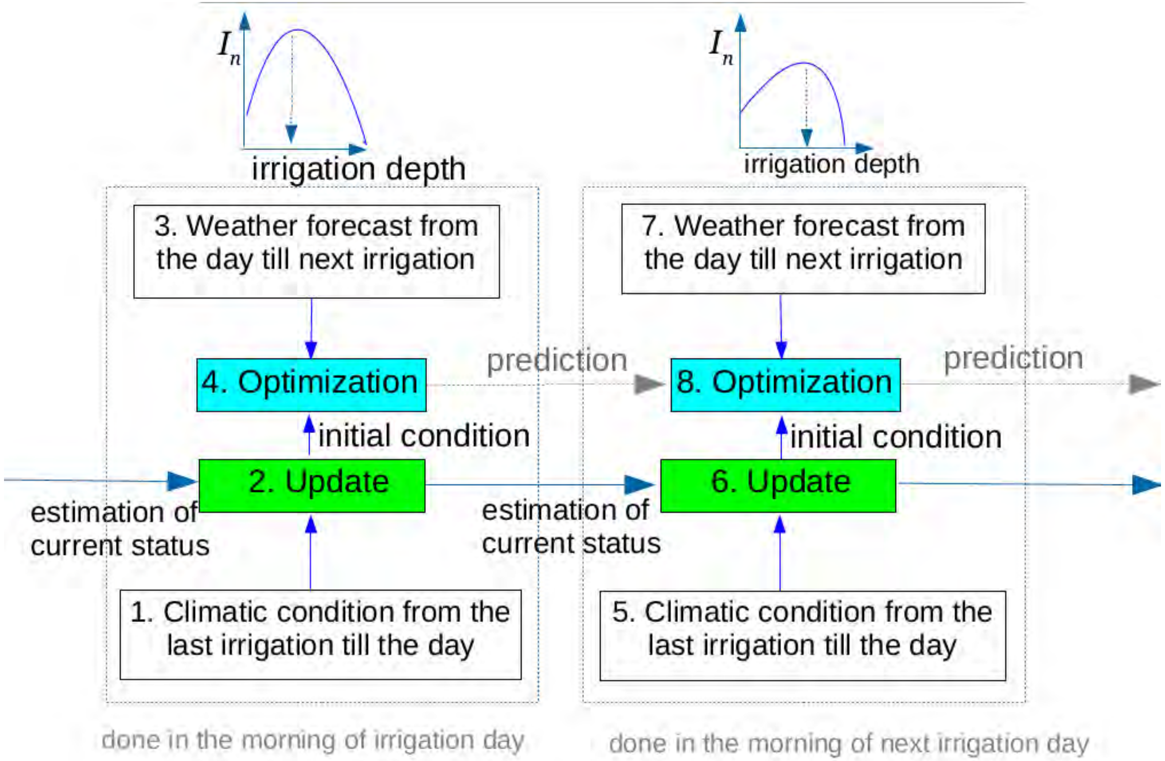
I_n (\$ ha^{-1}) is calculated on the assumption that yield of sold part of crops is proportional to cumulative transpiration at each irrigation interval:

$$I_n = P_c \varepsilon \tau_i k_i - P_w W - C_{ot}$$



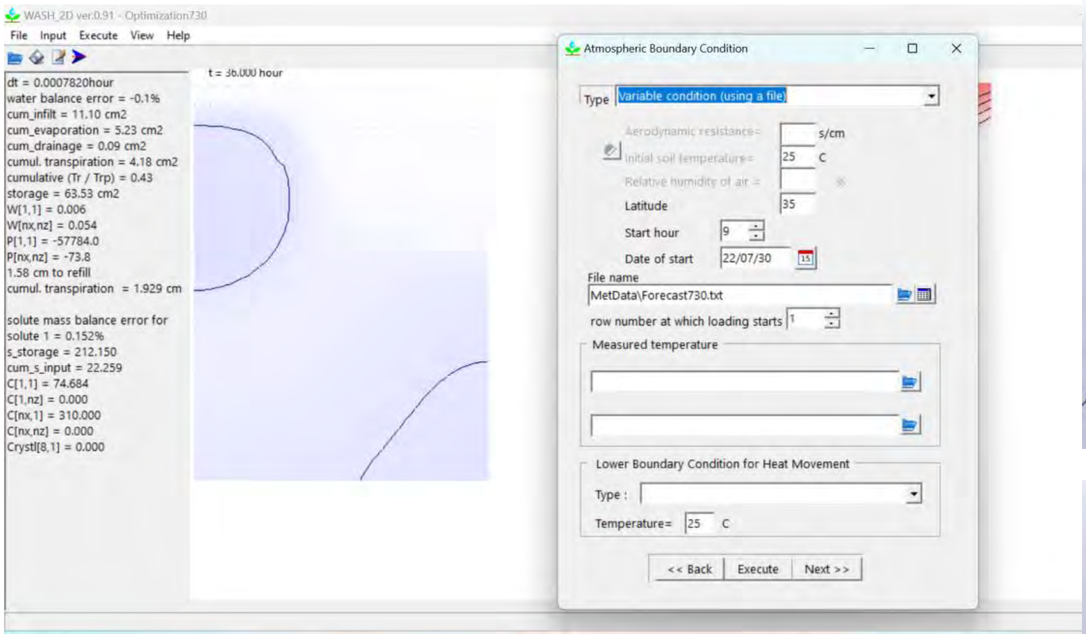
P_c is the producer's price of crop (\$ kg^{-1} DM),
ε is transpiration productivity of the crop (produced dry matter (kg ha^{-1}) divided by cumulative transpiration,
τ_i is cumulative transpiration between two irrigation events,
k_i is the income correction factor, used to avoid underestimation of I_n due to smaller transpiration rate in the initial growth stage,
P_w is the price of water (\$ kg^{-1}),
W is the irrigation depth (1 mm = 10,000 kg ha^{-1}),
C_{ot} is other costs (e.g., fertilizers, pesticides, etc.) (\$ ha^{-1}).

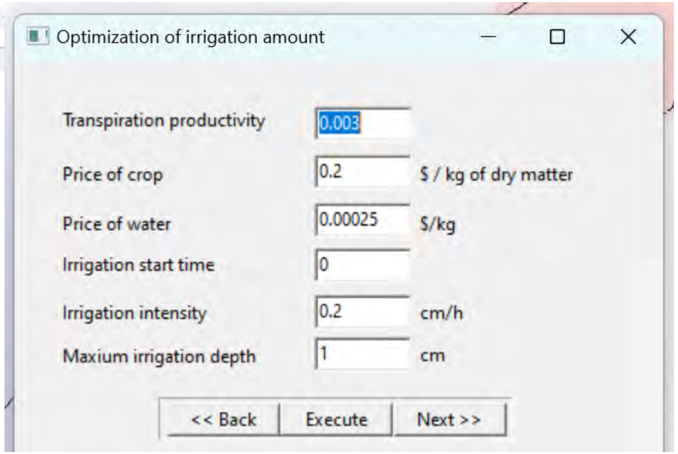
Routine procedure for optimizing irrigation (Fujimaki et al., 2020)

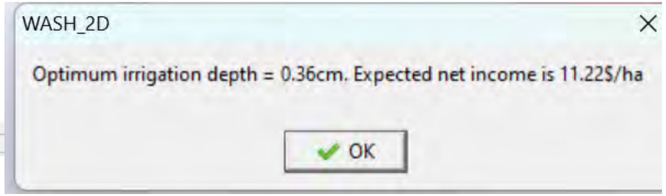


Irrigation interval: 2 days

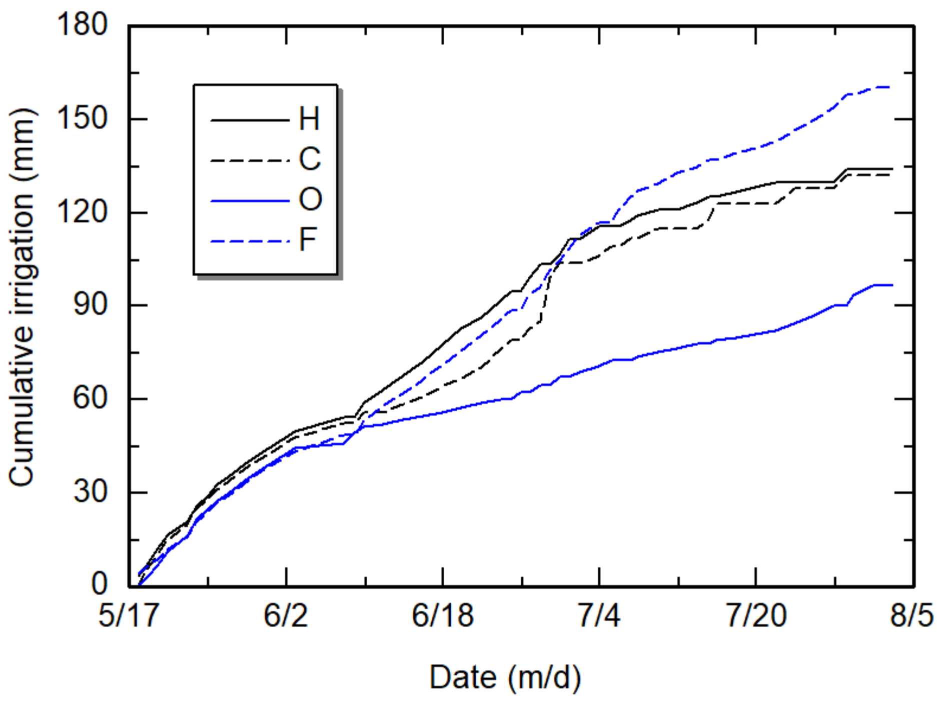
Screenshots of the user interface of WASH_2D





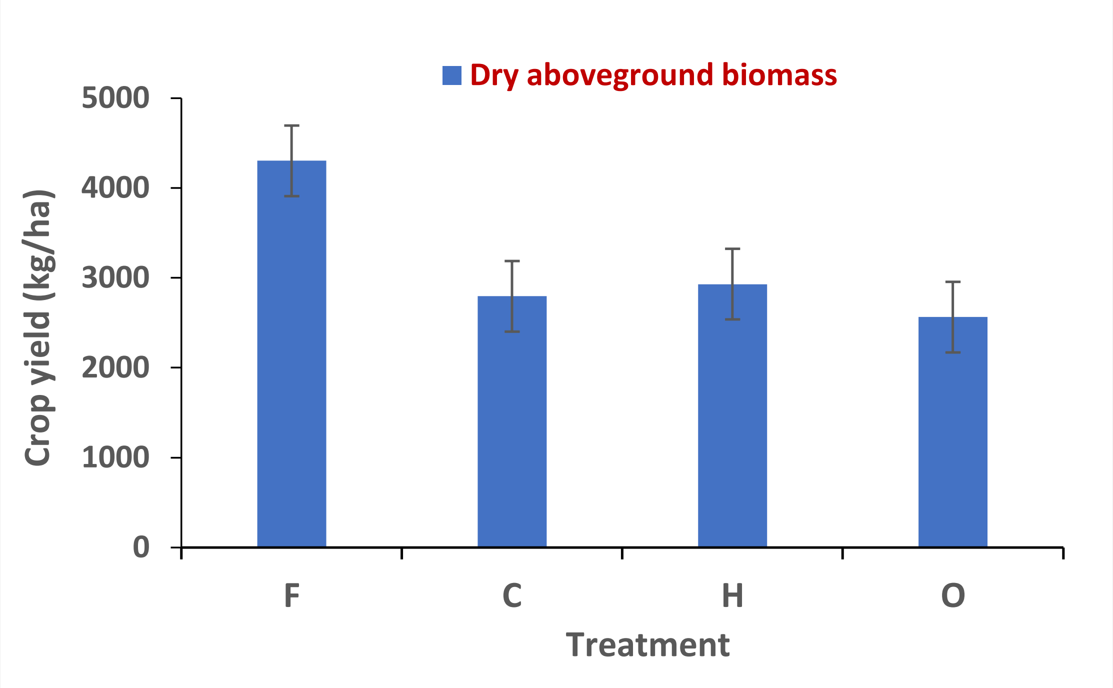


Time evolution of cumulative irrigation depth for all treatments



- The O treatment reduced 26.7% and 27.8% of water use compared to the C and M treatments, respectively.
- The difference between the control treatment and the salinity treatments in terms of cumulative irrigation depth increased over time

Comparison of crop yield among all treatments

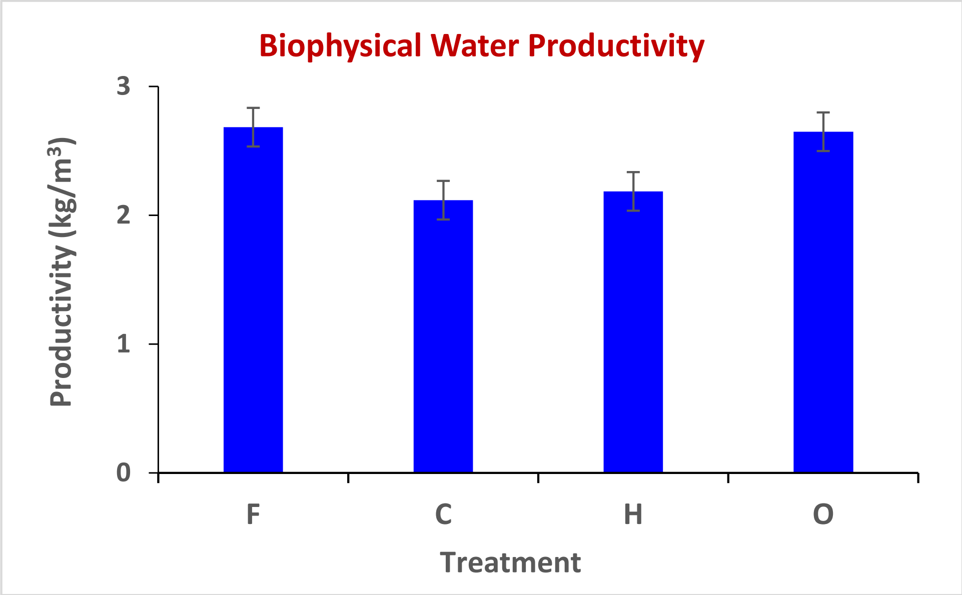


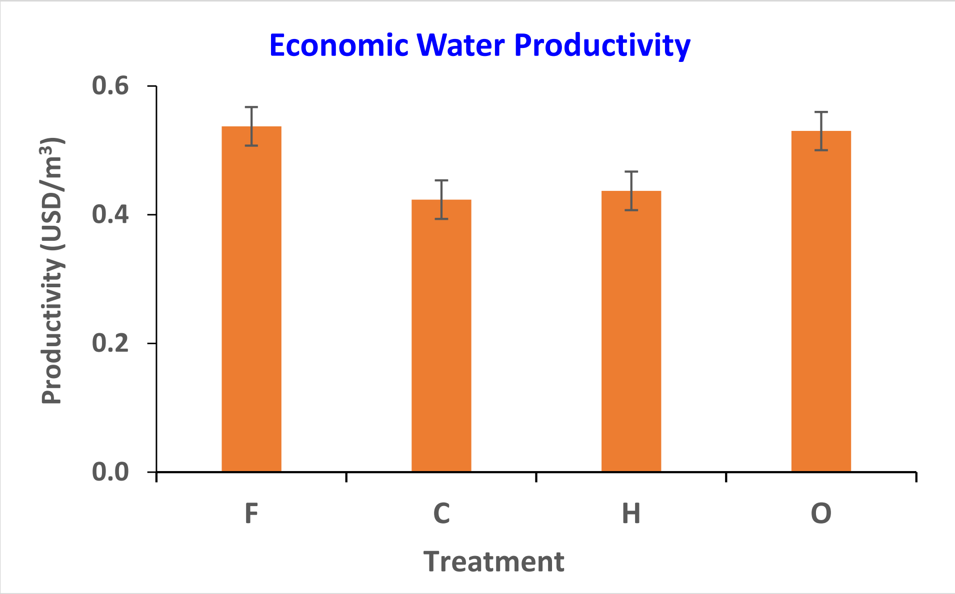
- The control treatment had a significant difference with the salinity treatments in terms of crop yield.
- No significant difference was observed between the salinity treatments.

Comparison of water productivity among all treatments

$$BWP = \frac{Y}{V}$$

$$EWP = \frac{I}{V}$$





- The O treatment showed a significant difference compared to other salinity treatments in WP and EWP.
- This treatment did not show a significant difference compared to the control treatment in WP and EWP.

Key findings and recommendations

- ✓ There is no significant difference in crop yield between the salinity treatments, but water use was significantly reduced through the optimized irrigation.
- ✓ The optimized irrigation scheme could substantially increase water productivity.
- ✓ The optimized irrigation could increase farmers' net income compared to other salinity treatments.
- ✓ Under automated drip irrigation, applying two leaching cycles (C) and maintaining high soil water content (H) during the growing season achieved similar performance.
- ✓ It is suggested to investigate the proposed irrigation scheme for medium and heavy soil textures, various levels of water salinity, different crops, and climates.