Management practice can mitigate ill effect of treated wastewater on soil and tree sap flow

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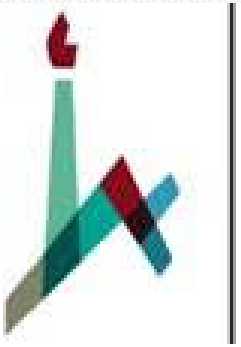
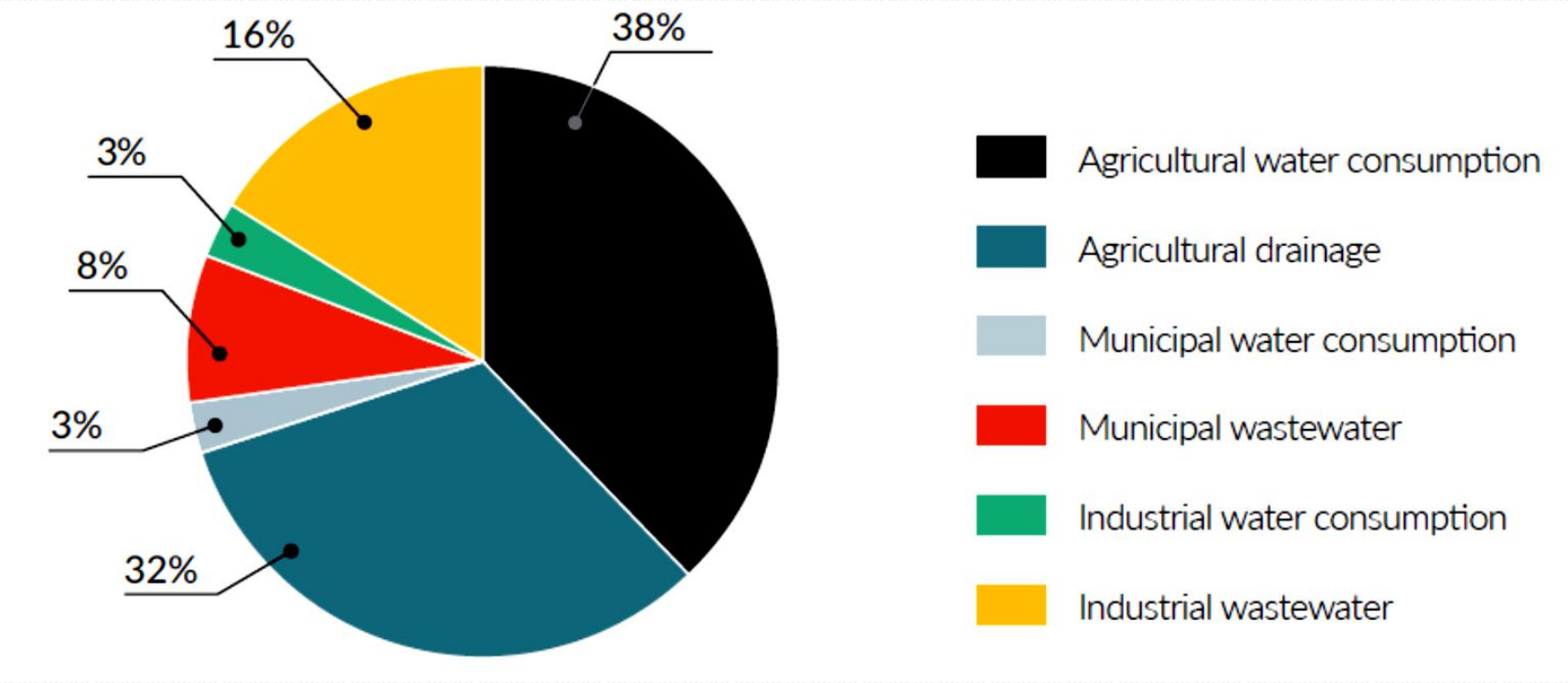


Background

- **Agriculture accounts for 70% of global fresh water consumption (Mbabazi et al., 2017)**



Source: The United Nation Water Development Report 2017

Background cont…

- It is becoming a challenge to get freshwater for irrigation
- This challenges has inspired the farming community and scientists around the world to look for alternative water sources
- Treated wastewater (TWW) is becoming popular, among different alternatives to water sources for irrigation due to its:
  - Consistent supply
  - Valuable nutrient content
    - TWW can be beneficial to crop growth and reduce the amount of fertilizers required (Bar-Tal, 2011)

Background cont…

- However, long-term irrigation with TWW causes different levels of harm to soil, environment, and plant (Levy, 2011; Nadav et al., 2013; Yadav et al., 2002)

- Long-term irrigation with TWW causes:
  - Increase in SAR (Lado et al., 2012), ESP (Schacht and Marschner, 2015), EC (Lado et al., 2012), soil sodicity (Assouline et al., 2016), DOM (Assouline and Narkis, 2011),
  - Decrease in soil aggregate stability (Schacht and Marschner, 2015), hydraulic conductivity (Assouline and Narkis, 2013; Schacht and Marschner, 2015) and Oxygen (Nadav et al., 2013)

Background cont…

- The higher salinity, ESP and DOM in TWW cause degradation of soil hydraulic properties (Assouline and Narkis, 2011; Schacht and Marschner, 2015) .

- Non-uniform wetting, insufficient water percolation, and low leaching efficiency of the soil profile.

- Destruction of the soil structure (Levy and Assouline, 2011) .

- Decreased orchard performance

Background cont…

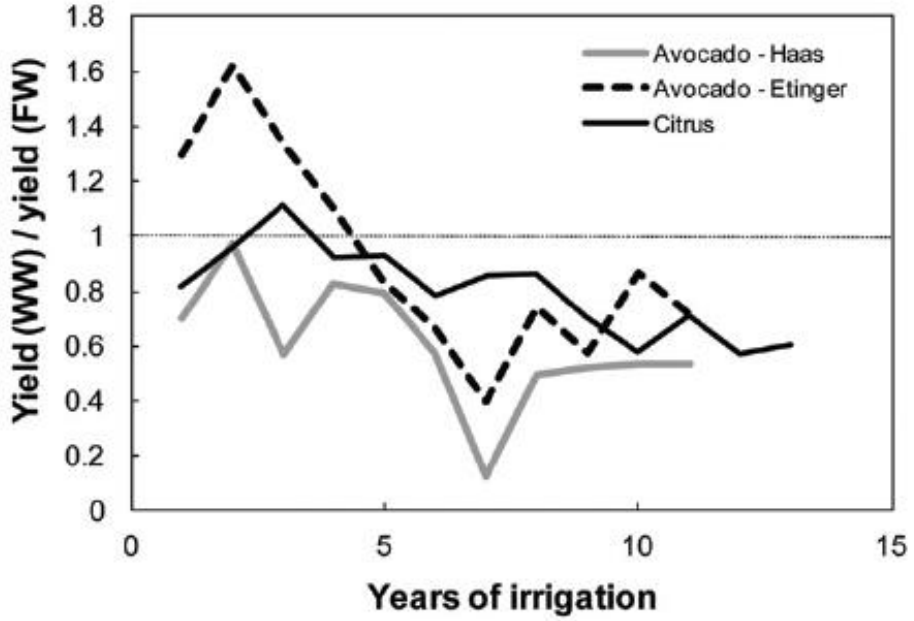


Fig. 1. The ratio between yields from wastewater (WW)-irrigated trees and yield from freshwater (FW)-irrigated trees vs. the number of consecutive irrigation years in the experiments conducted on citrus and two varieties of avocado (data for citrus were provided by Asher Aizenkot and for avocado, by Myriam Silberstein, Anat Lowengart, and Ami Keinan).

- After 4 to 5 years of TWW irrigation, 20-40% yield reduction was reported

Source: Assouline and Narkis, 2013

Background cont…

- **The possible contributing factors to the decline in the performance of TWW irrigated orchards are:**
  - **Salinity damage;**
  - **Specific ion toxicity (Cl, Na, B);**
  - **Damage to soil structure; and**
  - **Aeration problems**
- **Therefore, a wide variety of management strategies are required to cope with the present challenges arising from long-term irrigation of agricultural land with poor quality water specifically TWW.**

Background cont…

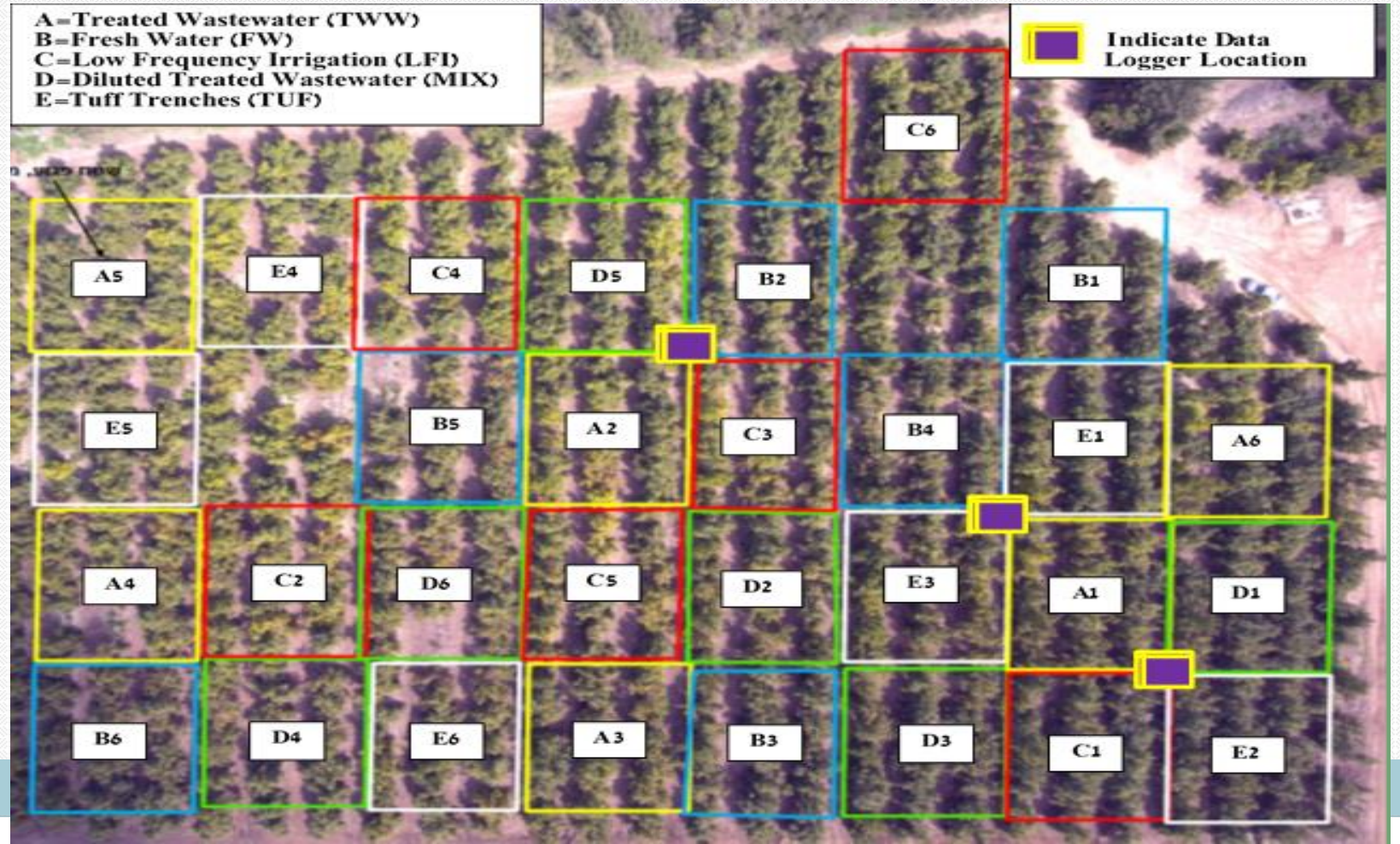
- **The proposed management options in this study are:**
  - **Irrigation with fresh water (FW)**
  - **Low frequency irrigation (LFI)**
  - **Mixing TWW with FW (1-part TWW:1-part FW)**
  - **Installing tuff trenches (TUF)**

Objectives the study

- To Identify and characterize change in soil chemical properties following prolonged irrigation with TWW, compared to the treatments designed
- To quantify tree physiological response to the proposed remediation alternatives.
- To Identify the most effective remediation alternatives (technologies) for improved soil quality, and tree physiology

The study area and design

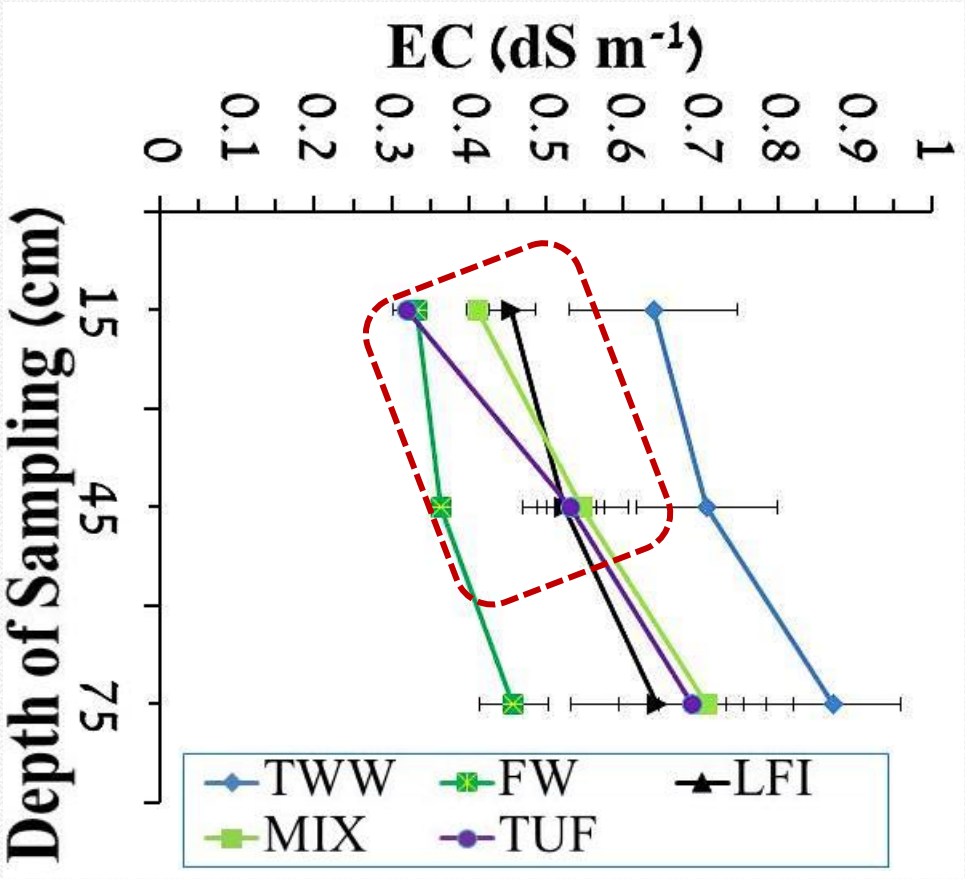
- The experiment was conducted in a mature commercial fruit bearing avocado orchard at Kibbutz Yasur, Israel.



Soil chemical characteristics

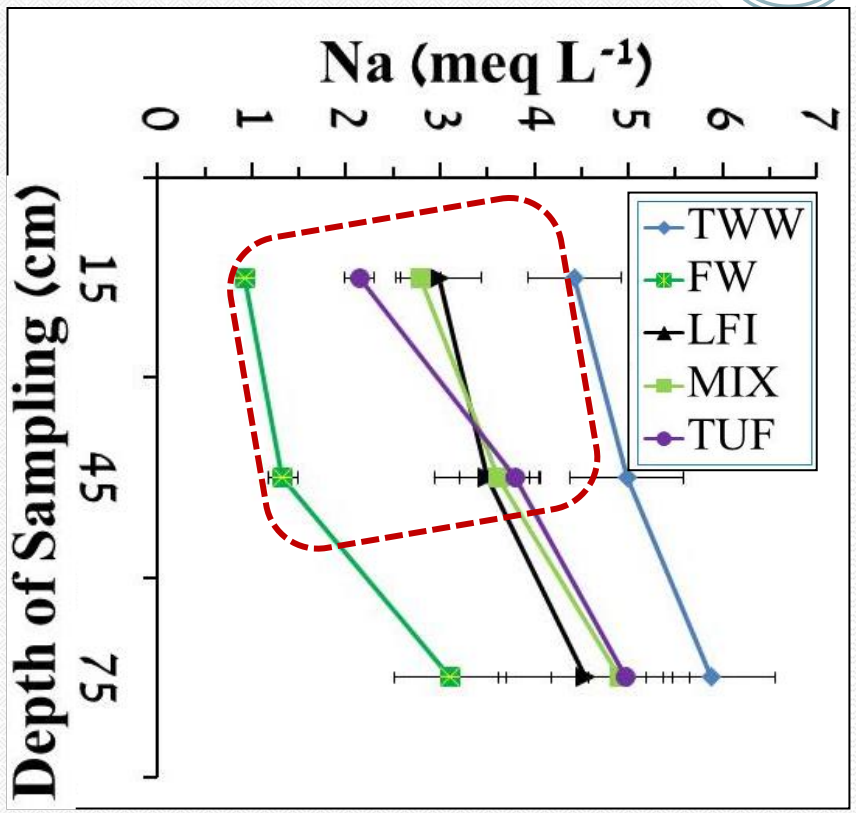
- Soil samples were collected to a depth of 90 cm (at 30 cm intervals) annually at the end of the irrigation season in all plots under drippers to analysis:
  - **Electrical conductivity (EC)**
  - **Concentrations of Cl**
  - **Water soluble cations (Na, Ca and Mg)**
  - **SAR every year at the end of irrigation season in (1:2 one part soil & two part water) water extract**

Effect of treatments applied on soil salinity (EC)



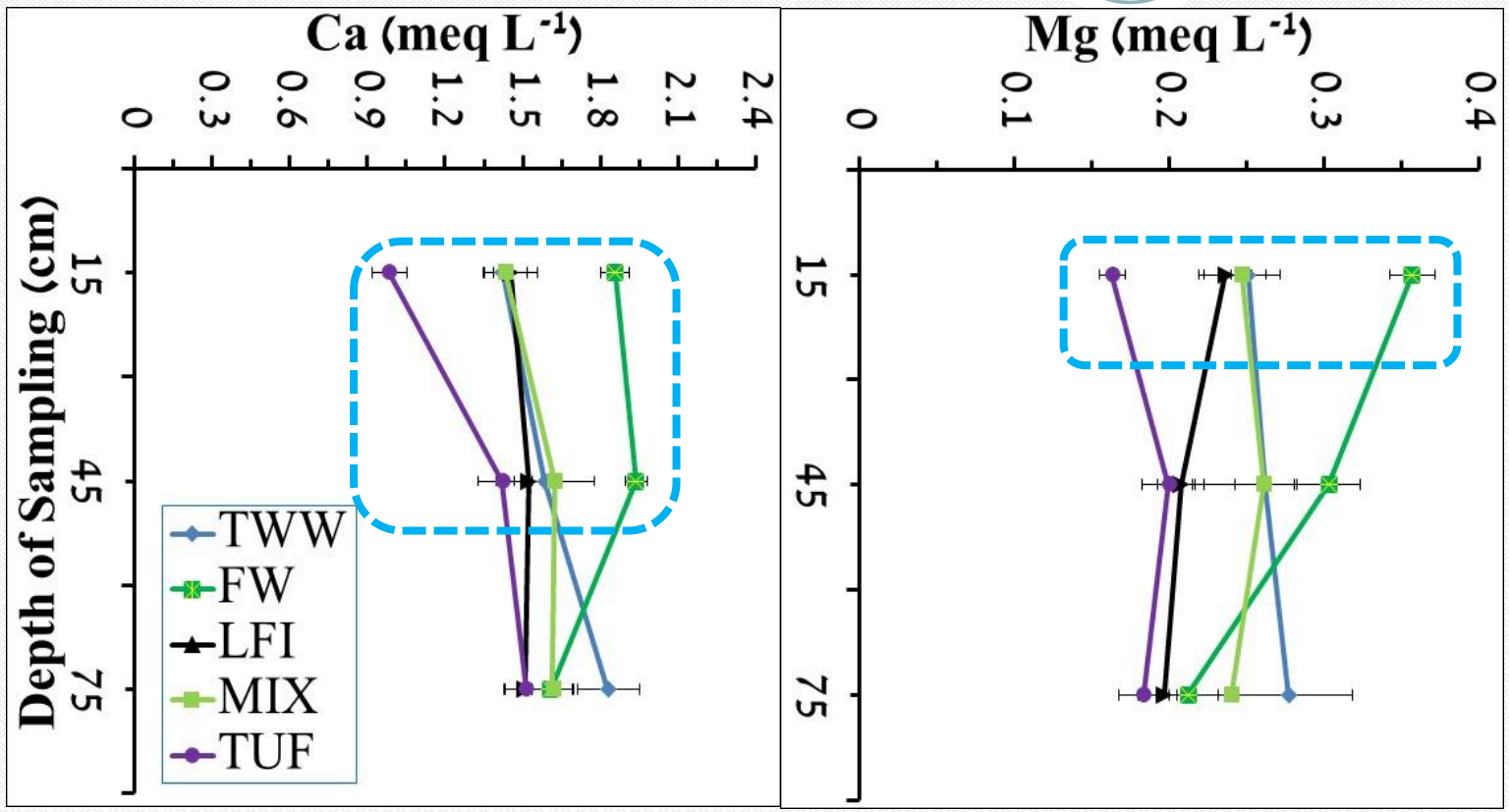
- EC is significantly reduced in all treatments at depth of 0-60 cm compared to TWW control

Effect of treatments applied on soil Na concentration



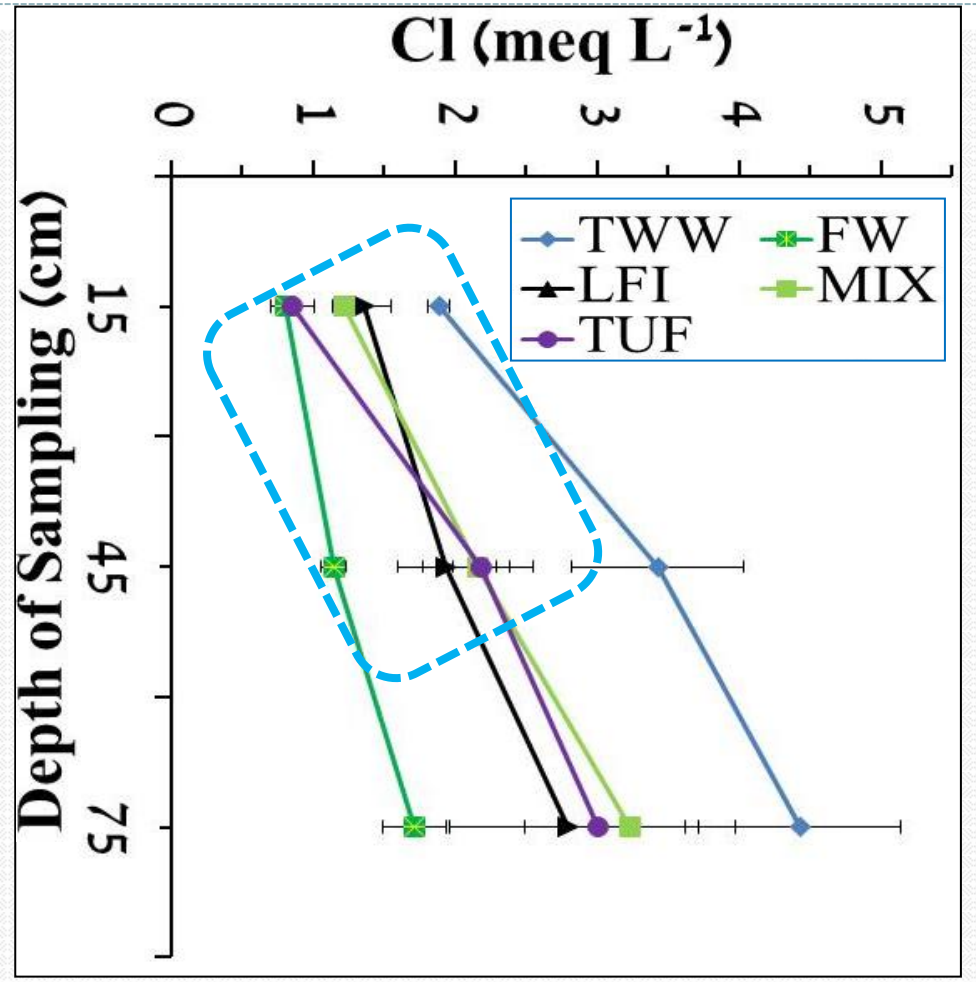
☞ **Na concentration is significantly reduced in all treatments compared to TWW control at depth of 0-60 cm**

Effect of treatments applied on soil Ca & Mg concentration



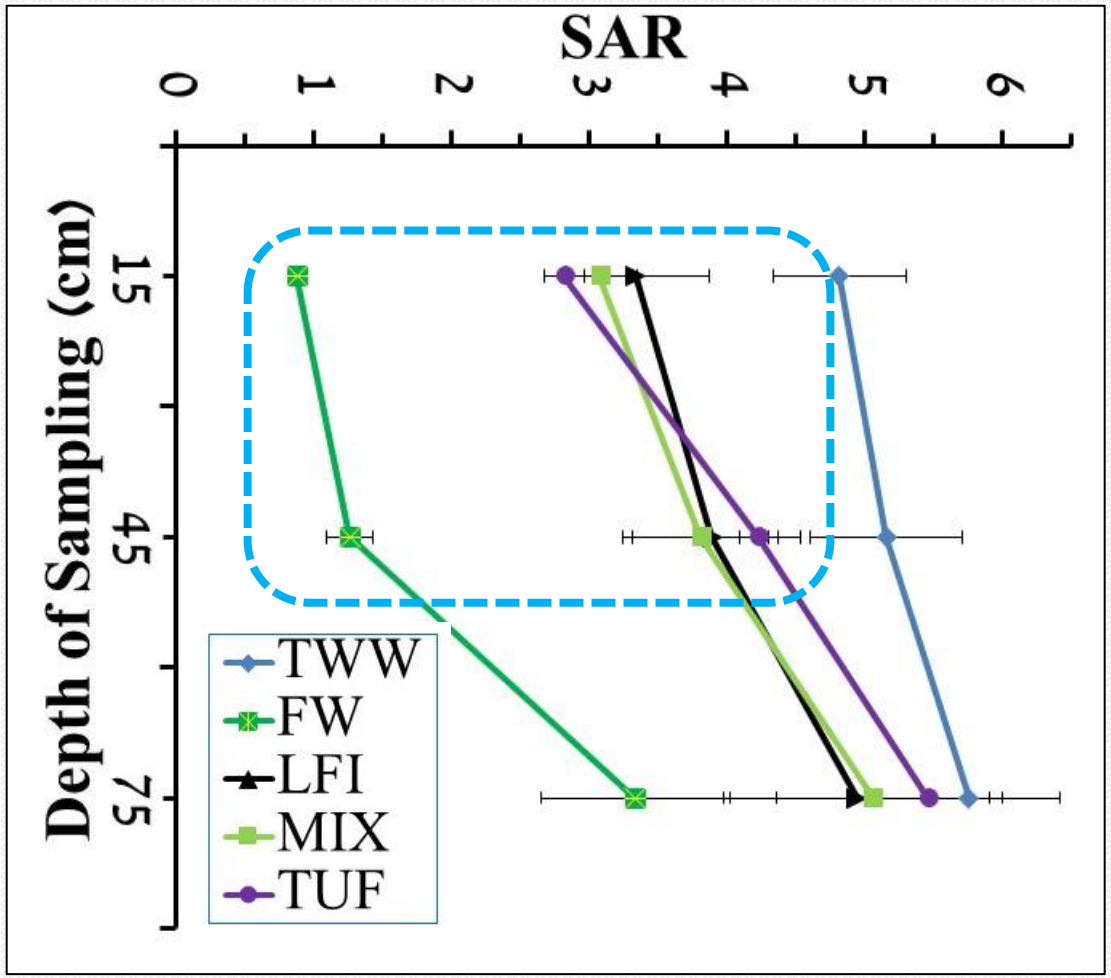
☞ Ca & Mg concentrations are significantly increased in FW and decreased in TUF compared to control at 0-30 cm depth

Effect of treatments applied on soil Cl concentration



☞ **Cl concentrations is significantly reduced in all treatments compared to control at 0-60 cm depth**

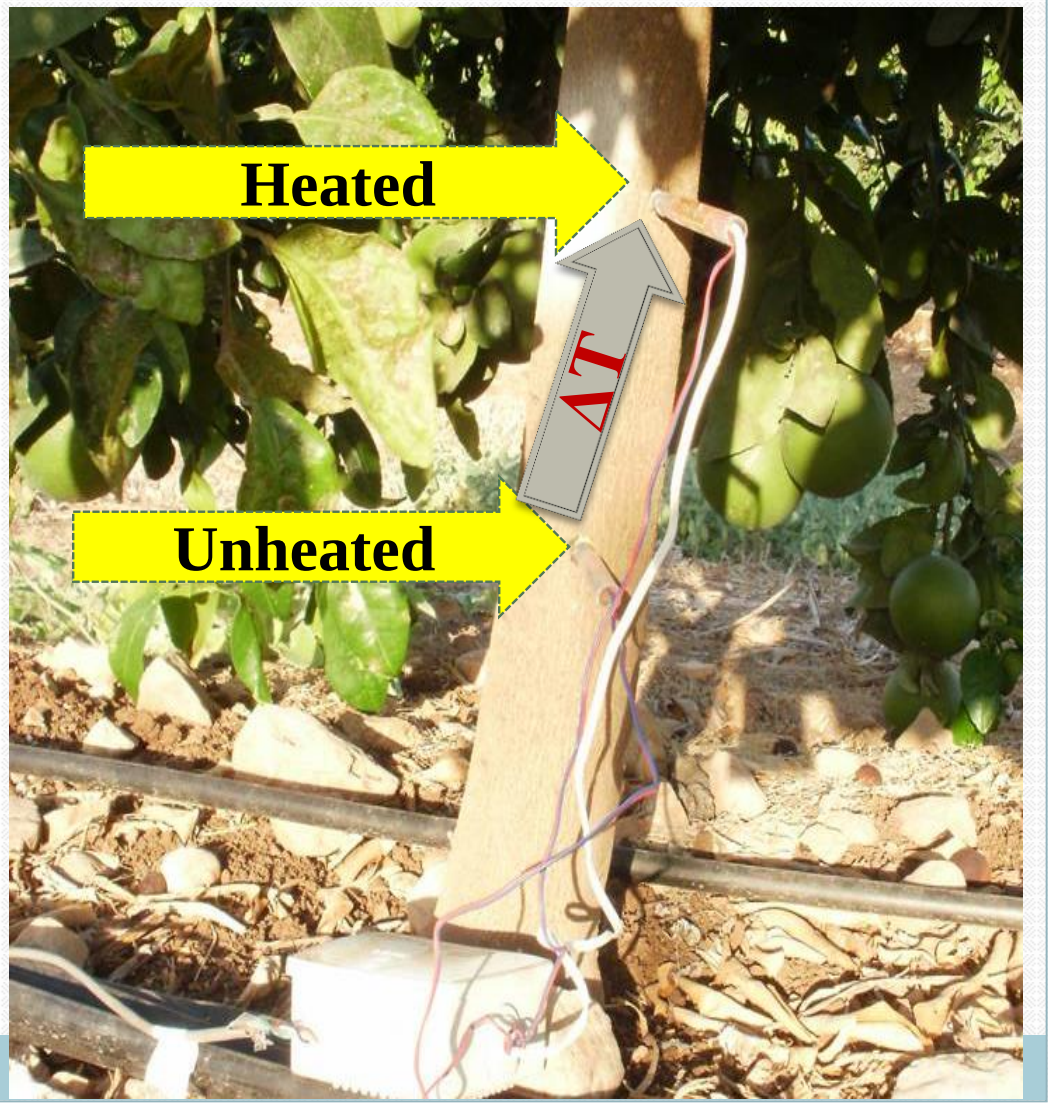
Effect of treatments applied on soil SAR



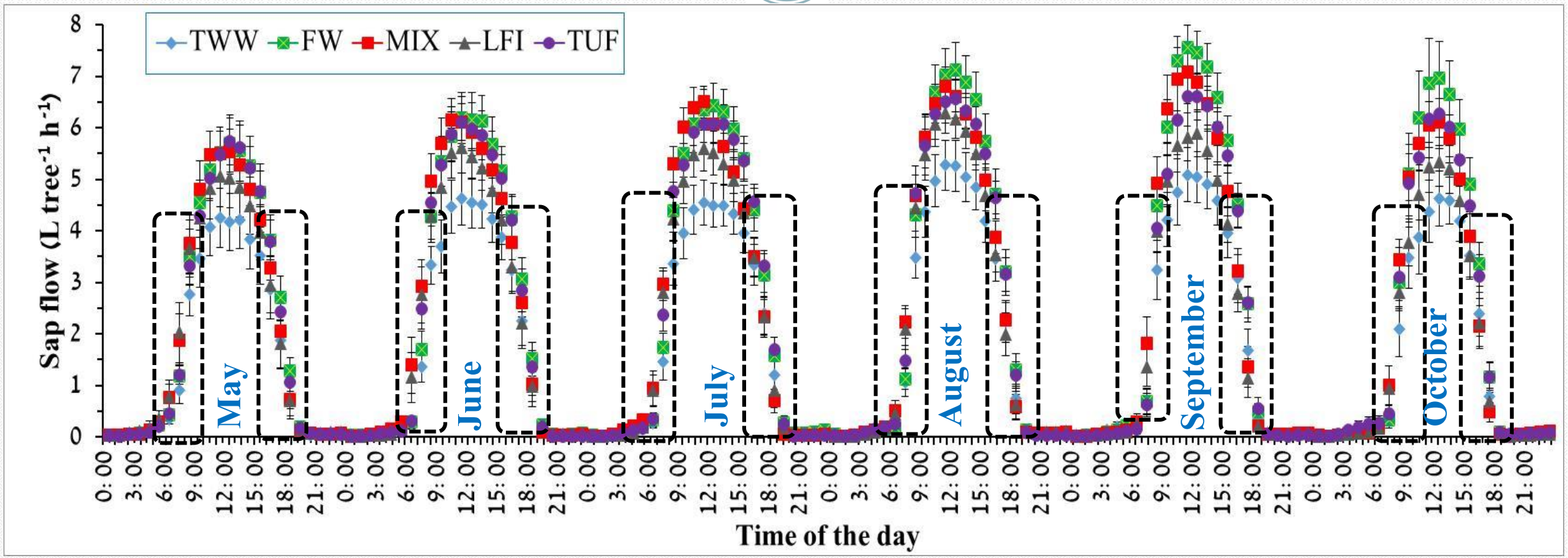
- **Sodium adsorption ratio (SAR) is significantly reduced in all treatments compared to control at 0-60 cm depth.**

Effect of treatments applied on tree sap flow

- ✓ **Sap flow was measured by thermal dissipation probes (Granier, 1987)**



Effect of treatments applied on daily course of sap flow



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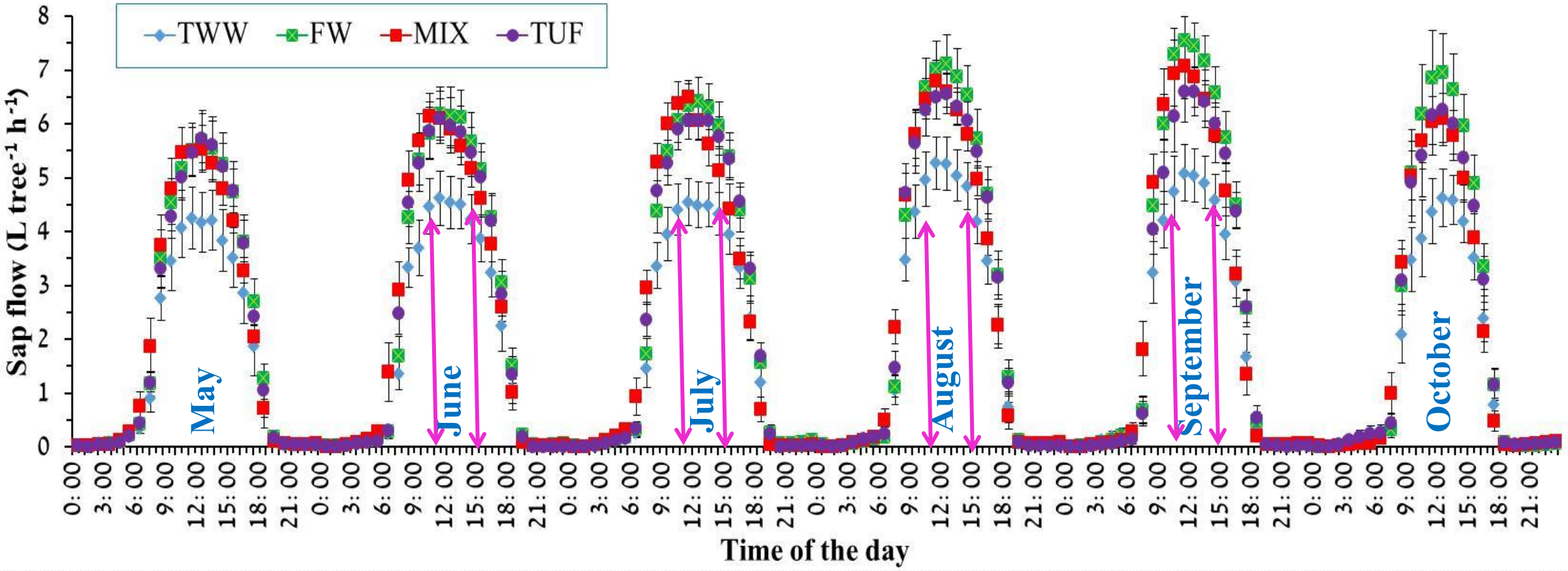
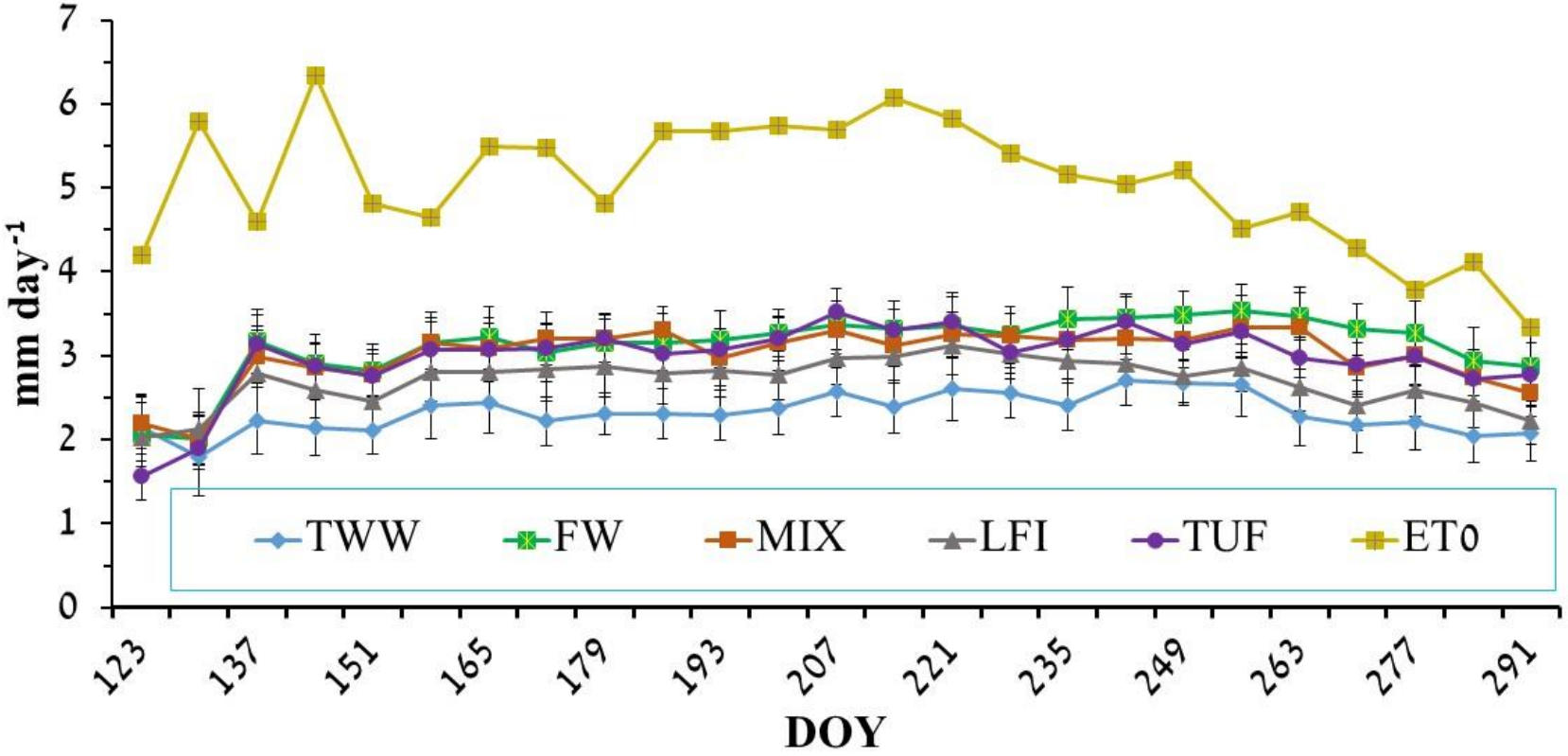
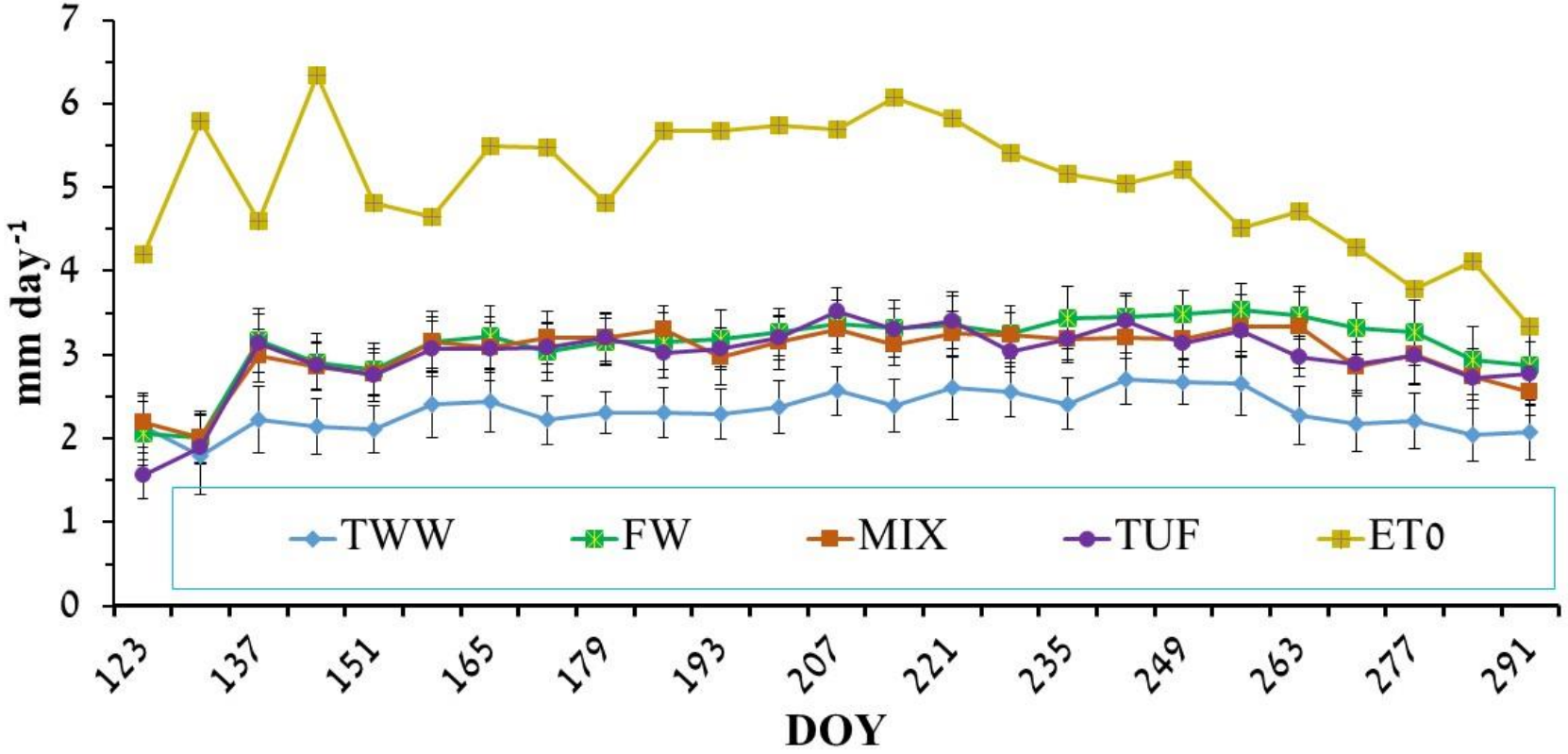


☛ **The hourly mean daily course of sap flow is significantly higher in FW MIX and TUF compared to TWW between 10:00 am and 2:00 pm.**

Effect of treatments applied on seasonal course of sap flow

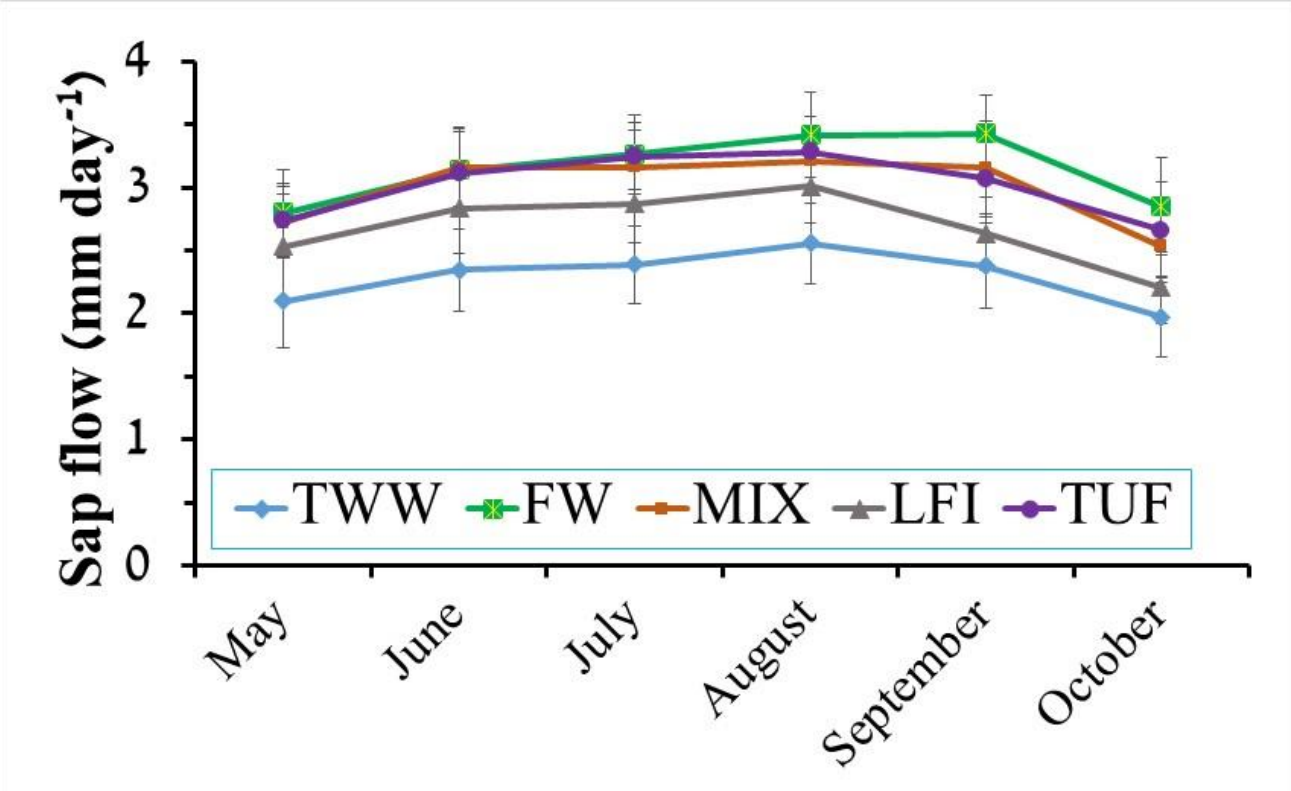


Effect of treatments applied on seasonal course of sap flow

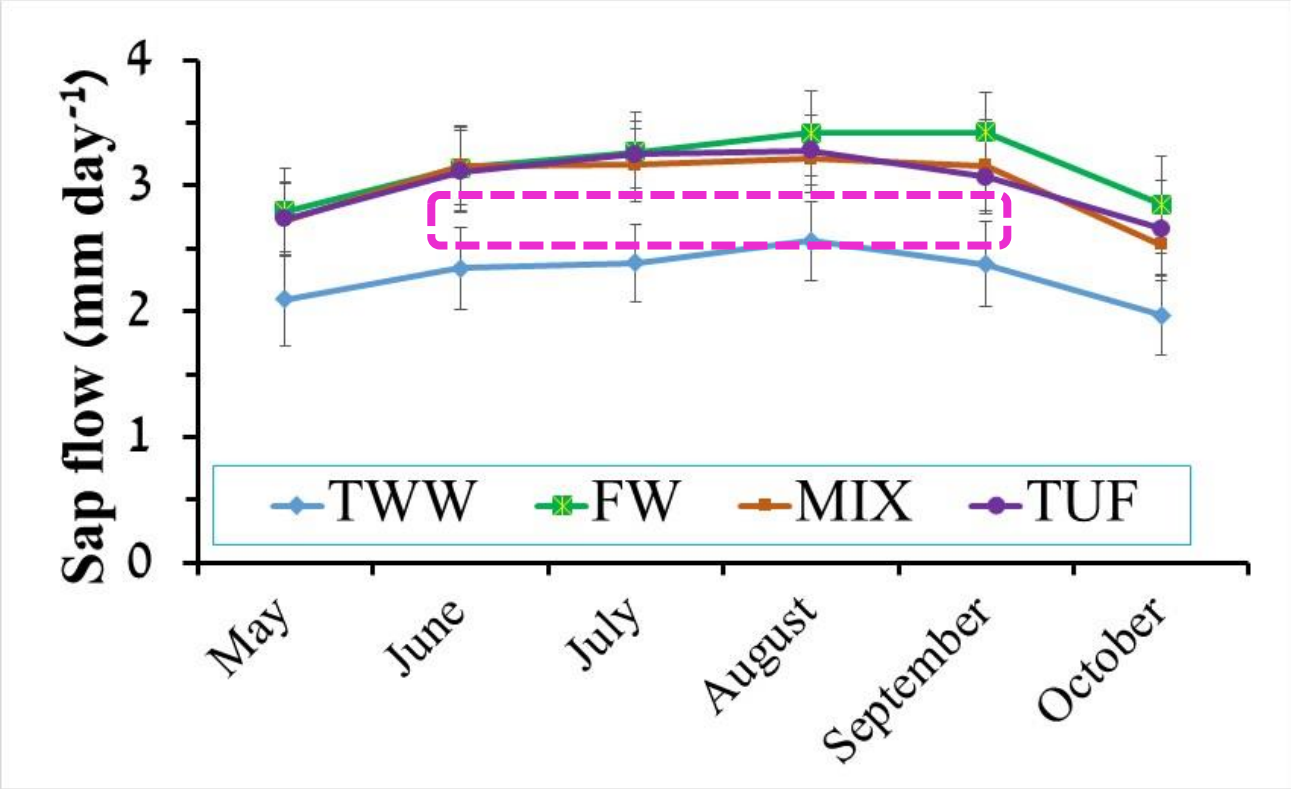


☛ **The weekly average sap flow per day is significantly higher in FW, MIX and TUF compared to TWW during most measurement periods.**

Effect of treatments applied on mmonthly average sap flow/day

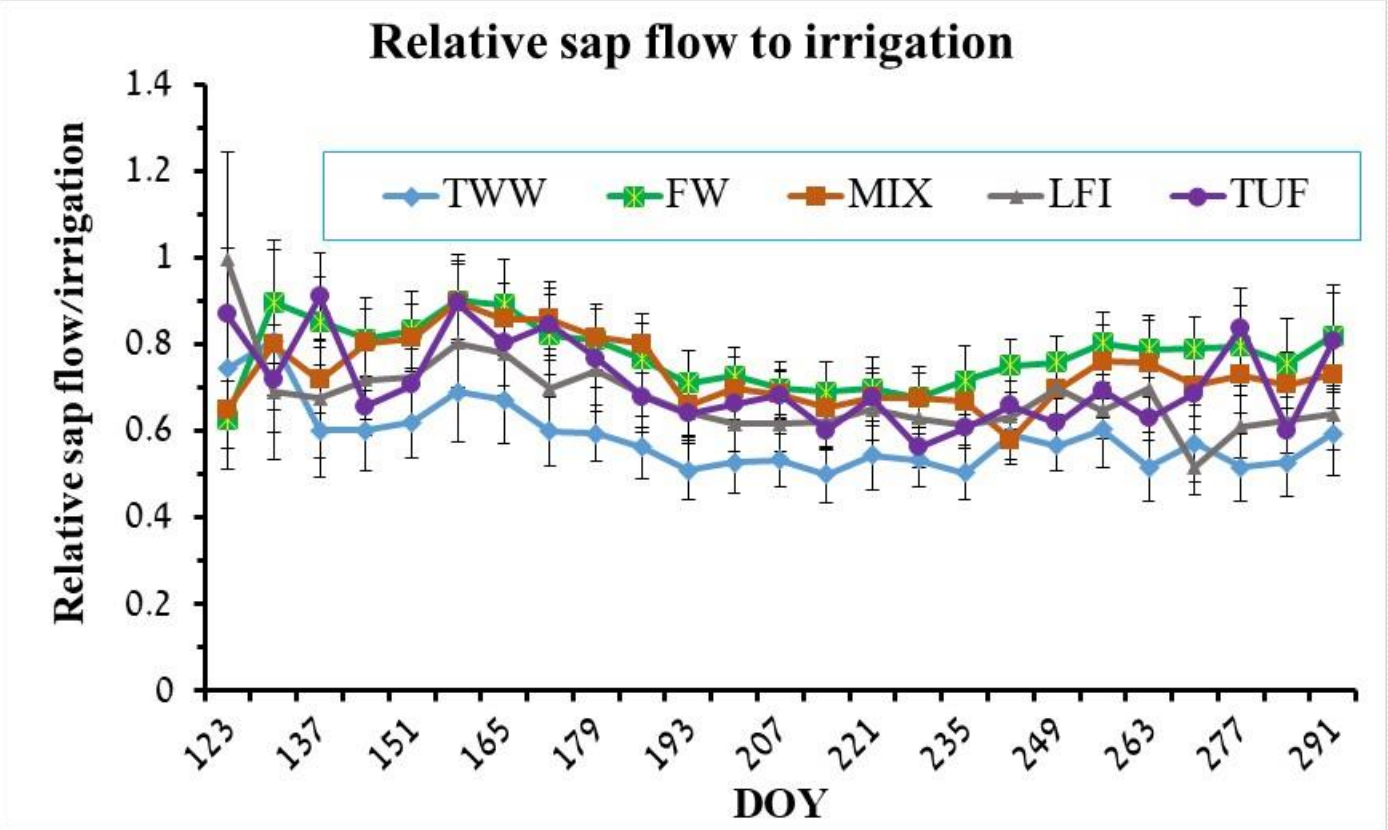


Effect of treatments applied on mmonthly average sap flow/day



☞ **The monthly average sap flow/day in FW, MIX, and TUF is significantly higher than TWW June –September**

Effect of treatments applied relative sap flow to irrigation



☞ **The average daily relative sap flow to irrigation amount applied in FW, MIX, TUF and LFI are ~24 %, 21%, 18%and 13% higher than TWW, respectively.**

Conclusions

- ☞The treatment effect on improving soil chemical properties varied with depth
- ☞FW, MIX and TUF enhanced the leaching of sodium at different magnitudes leading to reduced SAR and salinity that probably prevented and mitigated damage to soil structure.
- ☞The leaching of soluble salts from the top soil may have contributed to better availability of water for the avocado trees as revealed by the sap flow.
- ☞The treatment effect on tree sap flow is tangible at midday (10:00 am -2:00 pm) indicating that tree water demand is regulated by VPD and climatic variables.
- ☞Even though further analysis of soil physico-chemical changes and plant responses are ongoing, there is tangible evidence that FW, MIX and TUF are reliable candidate treatments for prevention and mitigation of TWW adverse effects on soil physico-chemical properties and trees response.

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