INVESTIGATING SOIL MOISTURE DYNAMICS UNDER A NOVEL SPRAYABLE BIODEGRADABLE MULCH

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Introduction

Mulches have been used for decades to reduce soil evaporation, conserve moisture, and moderate temperature. However, conventional plastic mulches add microplastics to the soil, and post-season management of used plastic is challenging. Bio-degradable sprayable mulches are the state-of-the-art alternative to plastic mulches, offering similar benefits. These differ in physical and thermal properties from conventional films. Therefore, it is crucial to study its effects on soil moisture and evaporation.

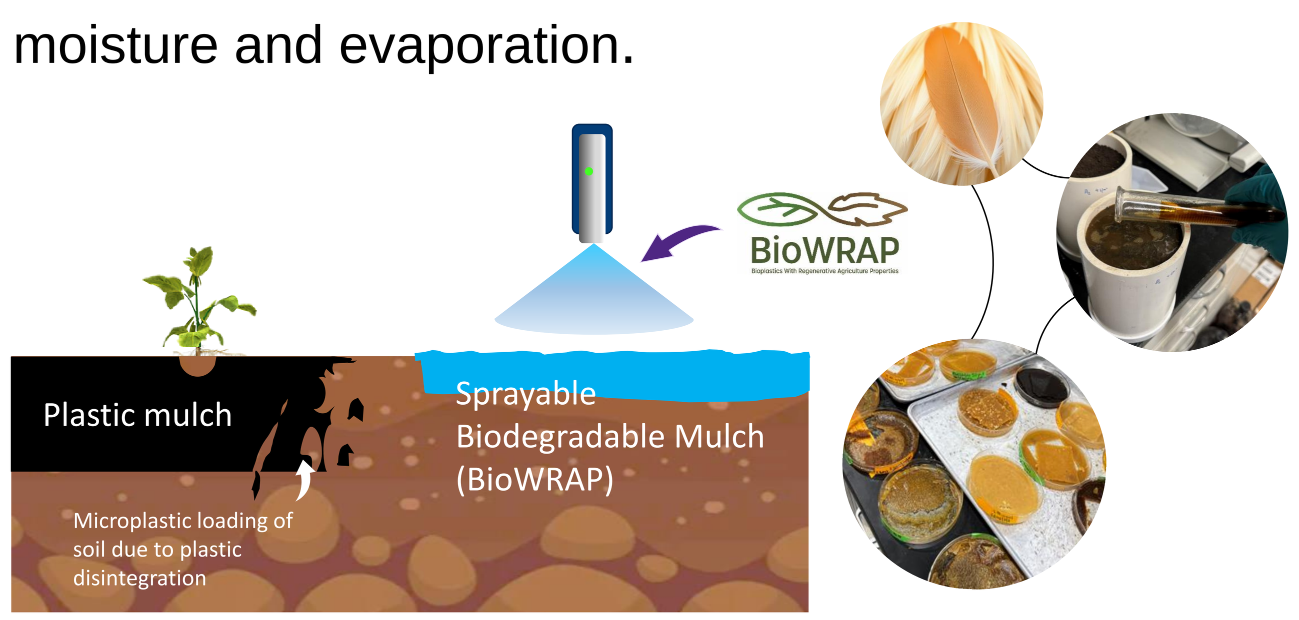

Fig.1 Schematic representation of conventional plastic mulch and sprayable biodegradable mulch

Objectives

- Investigating soil moisture and evaporation dynamics under a novel sprayable mulch - BioWRAP
- Modeling the impact of BioWRAP on soil moisture dynamics

Results

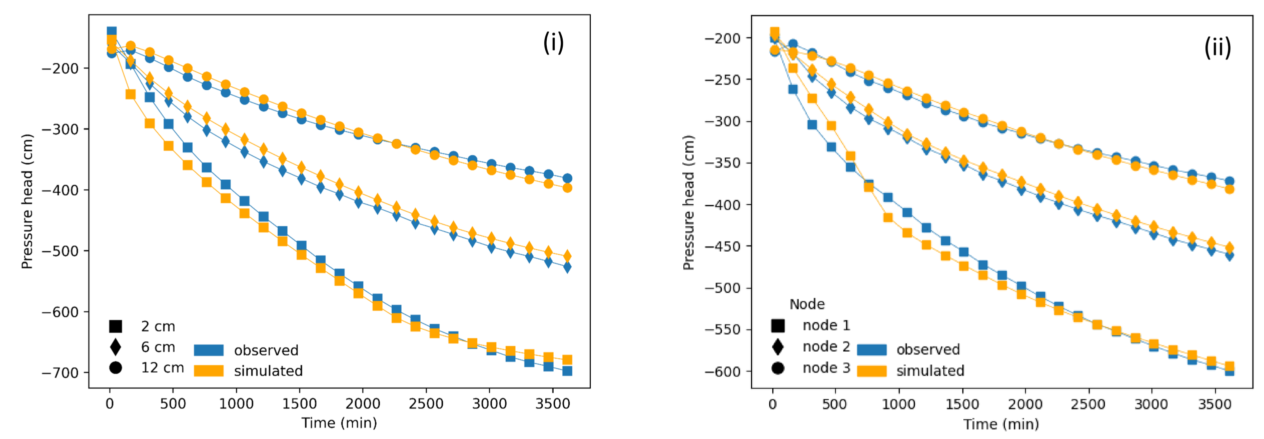

Fig.4 Observed vs simulated pressure head following calibration in column a (i) and b (ii) without BioWRAP

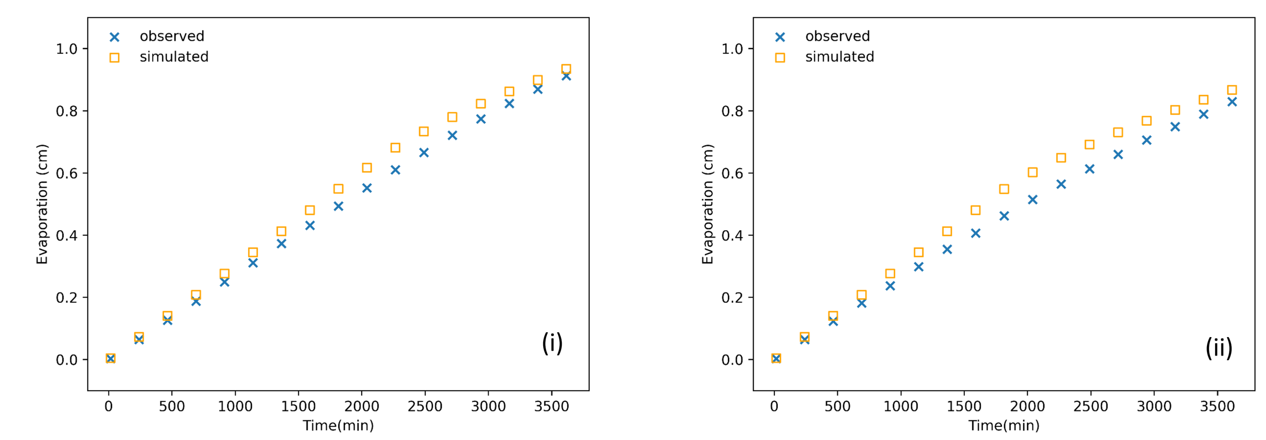

Fig.5 Observed vs simulated cumulative evaporation after in column a (i) and b (ii) without BioWRAP

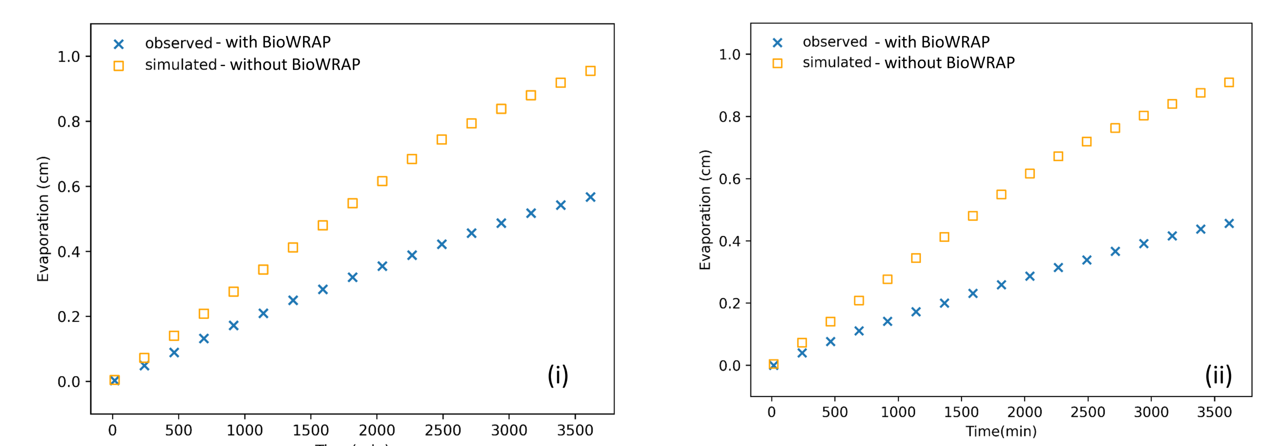

Fig.6 Cumulative soil evaporation with (observed) and without BioWRAP (simulated) in column a (i) and b (ii).

Table: Calibrated soil hydraulic parameters

Parameter	Column (a)	Column (b)
θ_r [cm³/cm³]	0.109	0.109
θ_s [cm³/cm³]	0.542	0.42
α [m⁻¹]	0.00114	0.00155
n	2.207	3.18
K_s [cm/min]	0.00016	0.00014
R^2	0.99	0.99
RMSE [cm]	~14	~11

Table: Calibrated "composite layer" hydraulic parameters

Parameter	value
θ_r [cm³/cm³]	0.06
θ_s [cm³/cm³]	0.7
α [m⁻¹]	0.000163
n	1.032
K_s [cm/min]	1.19E-05

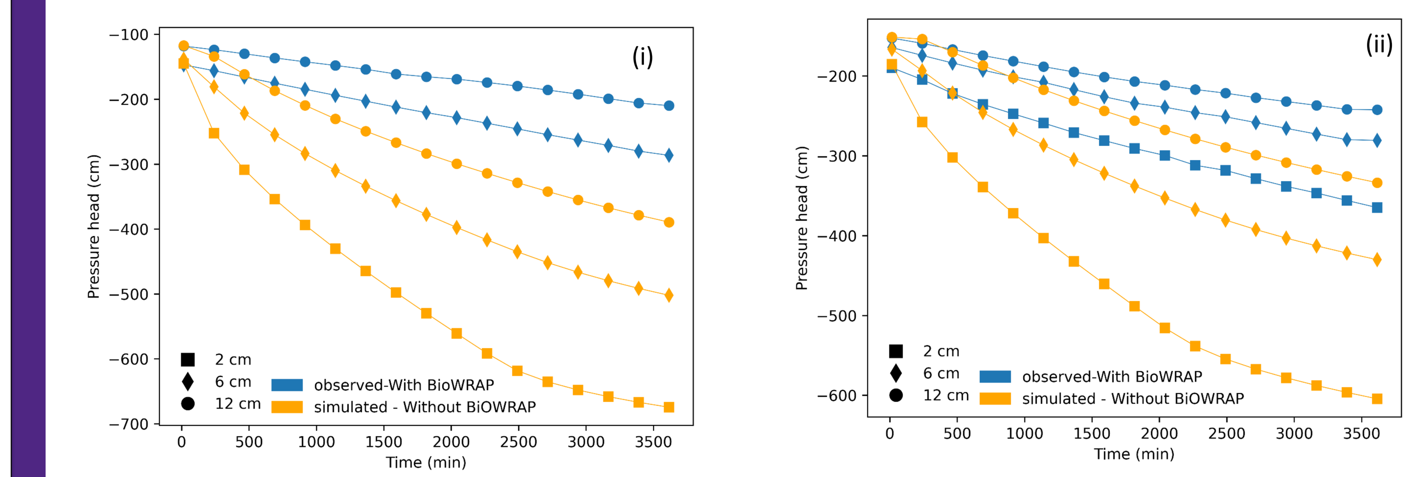

Fig.7 Soil pressure head with (observed) and without BioWRAP (simulated) in column a (i) and b (ii).

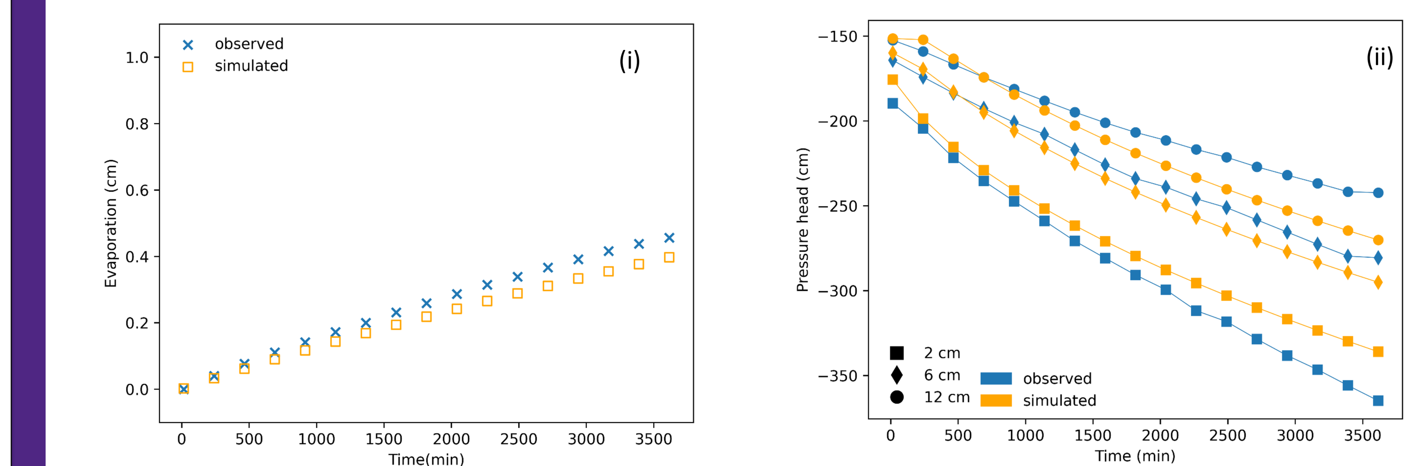

Fig.8 Observed vs simulated (HYDRUS-1D) cumulative evaporation (i) and pressure head (ii) under BioWRAP application. R^2~0.84 and RMSE ~13.3 cm.

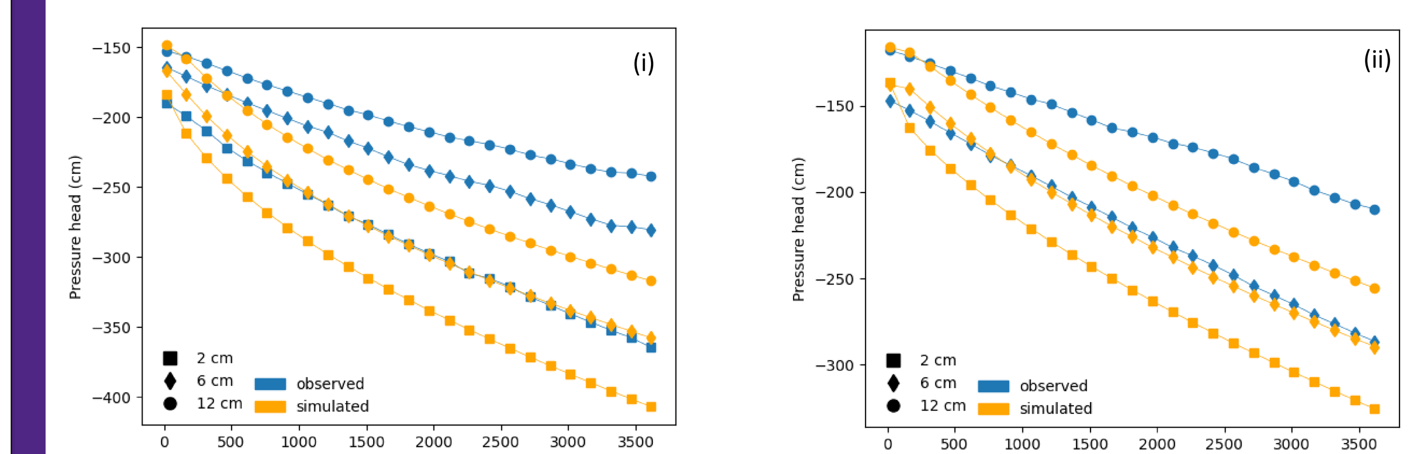

Fig.9 Observed vs simulated pressure head under BioWRAP application simulated by numerical solution using desiccant method-derived WVP.

Methods

❑ Growth chamber experiment

✓ 20 x 20 cm columns were packed with soil.

✓ Tensiometers installed at three depths (2,6,12 cm).

✓ Soil evaporation monitored using a weighing balance.

✓ Water Vapor transmission rate (WVTR) estimation through BioWRAP: ASTM-E96 dessicant method

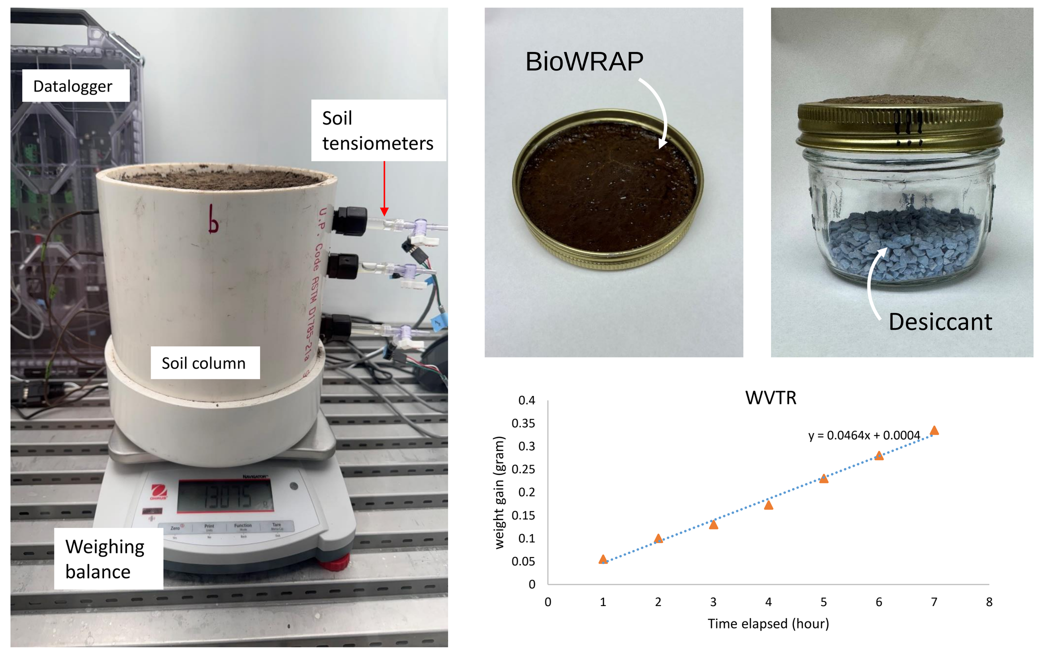

Fig.2 Soil Column setup in Growth Chamber and water vapor transmission rate experiment setup (Temperature 25°C, RH 60%).

❑ Simulation framework

➢ HYDRUS-1D Model simulation

- Top layer is replaced by a composite layer composed of Soil + BioWRAP mulch

➢ Numerical solution of Richard's equation for soil moisture movement in variable saturated soil with tailored surface boundary conditions incorporating water vapor permeance (WVP).

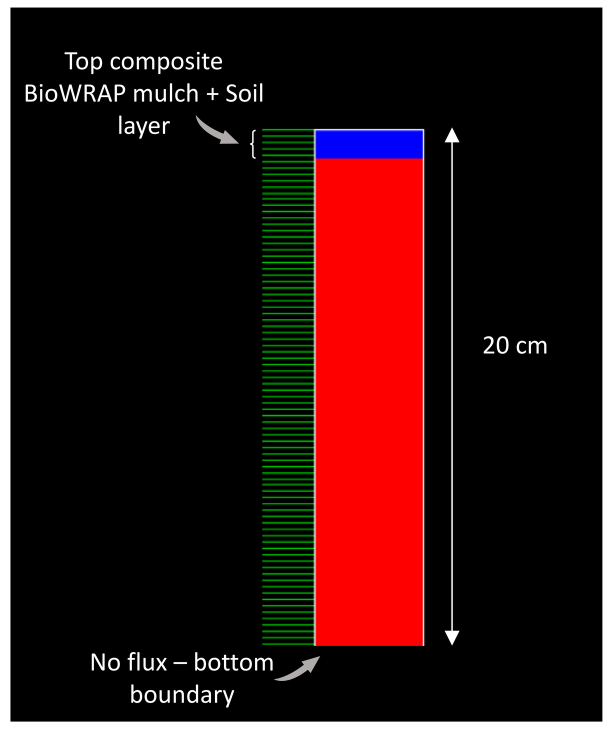

Fig.3 HYDRUS-1D setup for simulating sprayable mulch

Discussion

- Soil Evaporation under BioWRAP was lower than the bare soil evaporation rate and retained more moisture (less negative soil pressure head).
- Introducing the composite layer helps in the simulation of evaporation from BioWRAP-covered soil using HYDRUS; however, it overestimates the soil pressure head values.
- The desiccant method provided a low WVP, resulting in lower evaporation losses. Water Vapor permeance may result in a better prediction; however, it needs to be redetermined using the water method, ASTM E96.
- A proper determination of the WVP can be helpful in the determination of the resistance term offered by the sprayable mulch in methods like Penman-Monteith for Evapotranspiration estimations.