TECHNICAL UNIVERSITY OF MADRID

RESEARCH GROUP: HYDRAULICS OF IRRIGATION

SIMULATION OF SOIL WETTING PATTERNS IN DRIP AND SDI IRRIGATION. EFFECTS IN DESIGN AND IRRIGATION MANAGEMENT VARIABLES

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INTRODUCTION

Wetting bulb

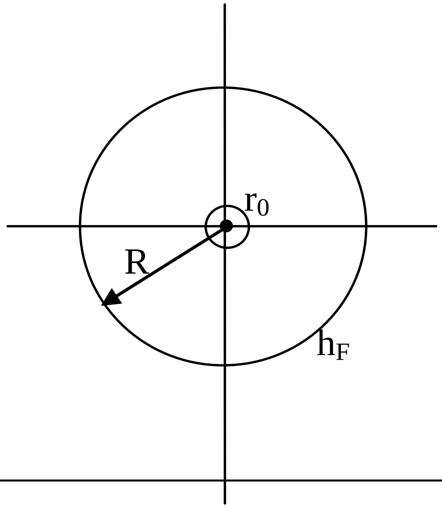
- **Direct measurements in field or containers (empirical Eqs.)** (Zur, 1996)
- **Simulated using Hydrus 2D** ⟶ **Richards' Eq.**
- **Estimated with other infiltration Eqs, (Green-Ampt) for DI** (Chu, 1994; Prevedello et al. 2009)

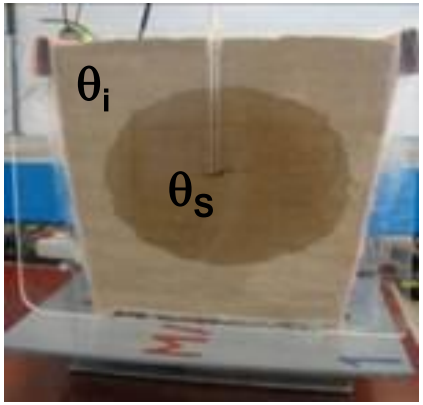
OBJETIVES

- Prediction of wetting radius in subsurface drip irrigation (SDI) assuming Green-Ampt Eq.

- Simulate and compare wetting bulbs from drip and SDI for uniform loamy soil under different scenarios. Make recomendations for proper design and management irrigation.

APLICATION OF GREEN-AMPT EQ. FOR DETERMINATION OF SDI WETTING BULB





Assumptions:

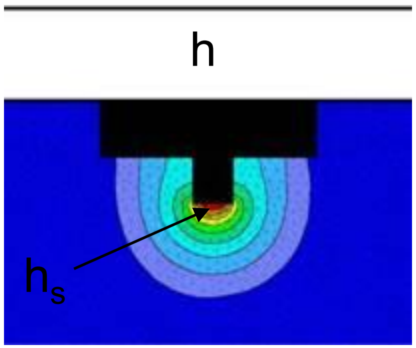
✓Gravity potential is negligible only matric potential is considered (Spherical wetted area). Radial flux.

✓Transition zone with constant θ.

✓h_F takes place in a soil layer of negligible thickness

APLICATION OF GREEN-AMPT EQ. FOR DETERMINATION OF SDI WETTING BULB

- Emitter discharge:



DI

$$q = k \cdot h^x$$

SDI

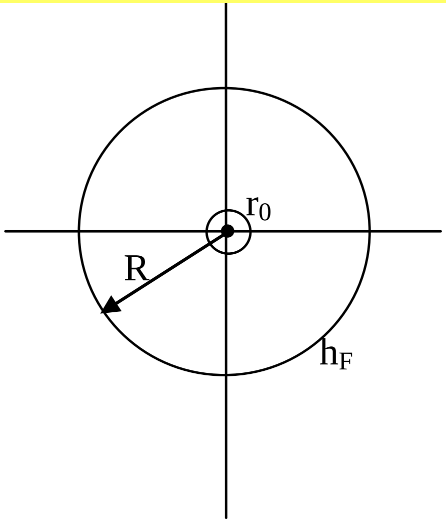
$$q = k \cdot (h - h_s)^x$$

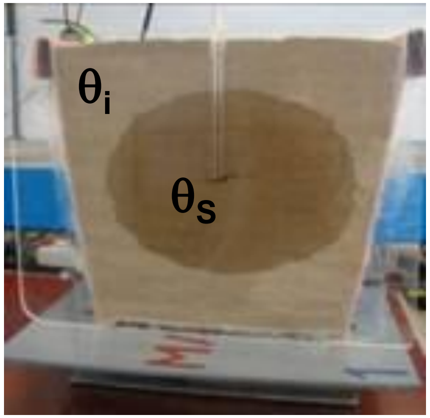
$$h_s = \left(\frac{2 - \alpha_G \cdot r_0}{8\pi \cdot K_s \cdot r_0} \right) \cdot q - \frac{1}{\alpha_G}$$

(Shani and Or, 1995)

hs → sensitive to r_0 , Ks, q

APLICATION OF GREEN-AMPT EQ. FOR DETERMINATION OF SDI WETTING BULB





Continuity Eq:

$$q \cdot dt = \Delta\theta \cdot 4\pi \cdot R^2 \cdot dR$$

$$V(t) = \int_0^t q \cdot dt = \Delta\theta \cdot \frac{4}{3}\pi \cdot \left(R^3 - r_0^3\right)$$

APLICATION OF GREEN-AMPT EQ. FOR DETERMINATION OF SDI WETTING BULB

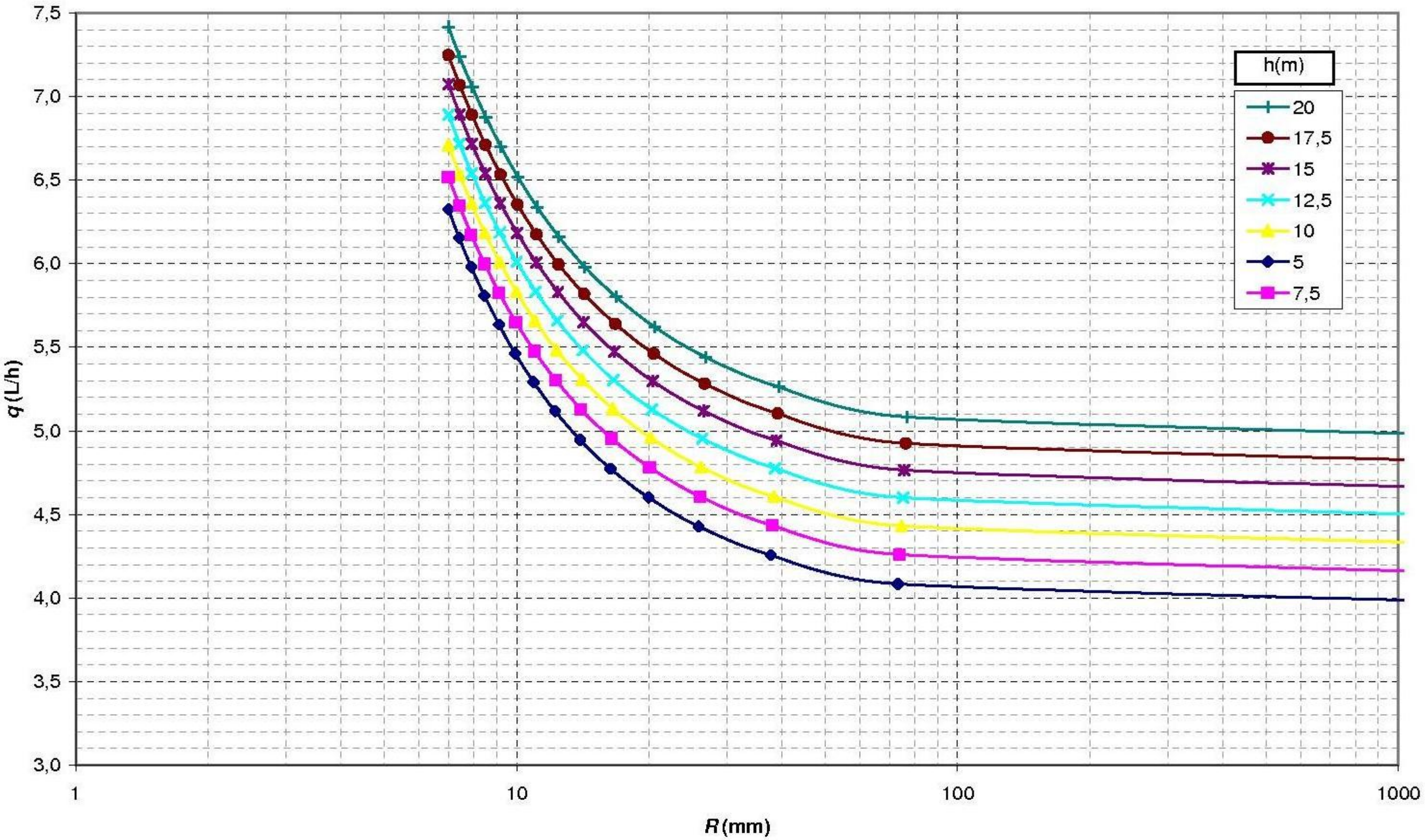
Darcy Eq: $u \cdot dr = -K \cdot dh \qquad u = \dfrac{q}{4 \cdot \pi \cdot r2}$

Integral form: $\displaystyle\int_{r_0}^{R} \frac{q}{4 \cdot \pi \cdot r2}\, dr = -\int_{hs}^{h_F} K \cdot dh$

$$\frac{q}{4 \cdot \pi \cdot r_0}\left(1 - \frac{r_0}{R}\right) = K\left(h_S - h_F\right)$$

$$q = k \cdot (h - h_s)^x$$

RESULTS AND DISCUSSION



R = r_0 ⟶ $q_{max} = k \cdot (h - h_F)^x$

R ⟶ ∞ $q_{min} = k \cdot \left(h - h_F - \frac{q_{min}}{4 \cdot \pi \cdot r_0 \cdot K} \right)^x$

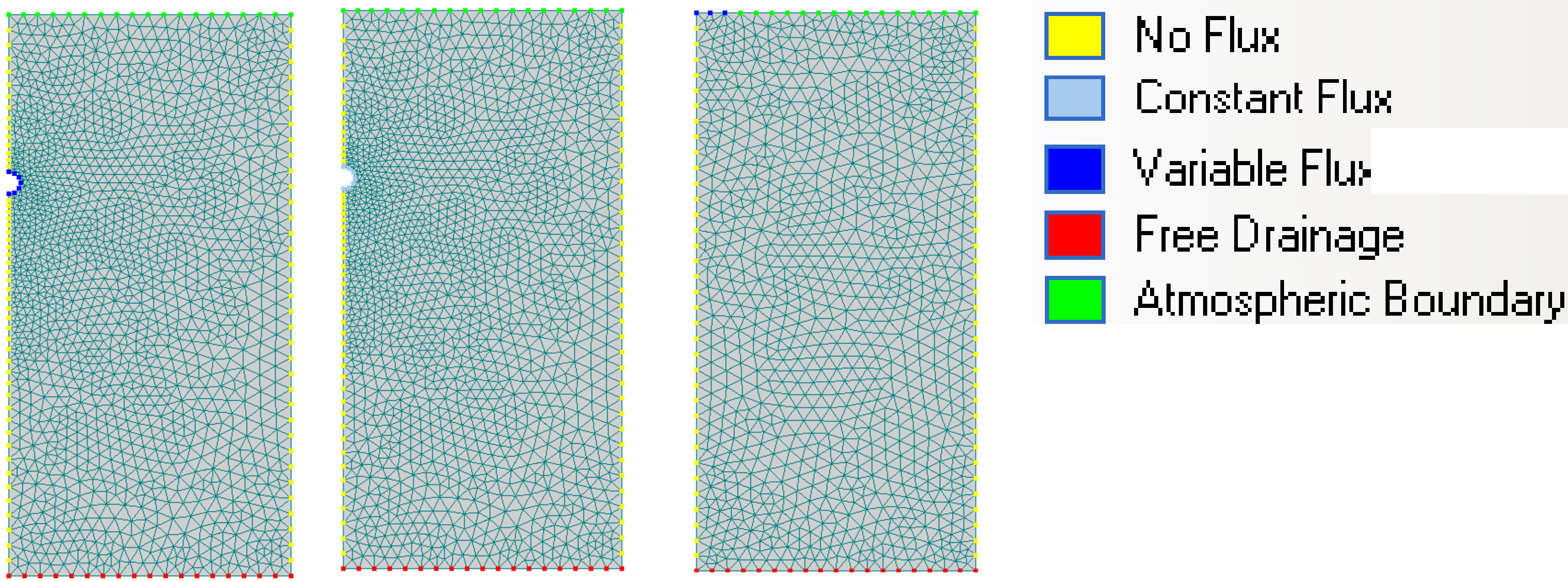
APLICATION OF RICHARD'S EQ. FOR DETERMINATION OF SDI WETTING BULB

BOUNDARY CONDITIONS

Line source simulations; emitter spacing = 0.3 m

SDI (r_0= 0.02 m) **DI**

Rectangle: 0.5 X 1 m^2



non-regulated emitter **regulated emitter** **regulated emitters**

MATERIALS AND METHODS

Soil hydraulic properties

Loamy soil

Mat	Qr	Qs	Alpha	n	Ks	l
1	0,0609	0,3991	1,11	1,4737	8,36E-005	0,5

θ_i= 0.14 gravimetric (0.1 volumetric);D_b= 1,4 g/cm^3.

Irrigation laterals

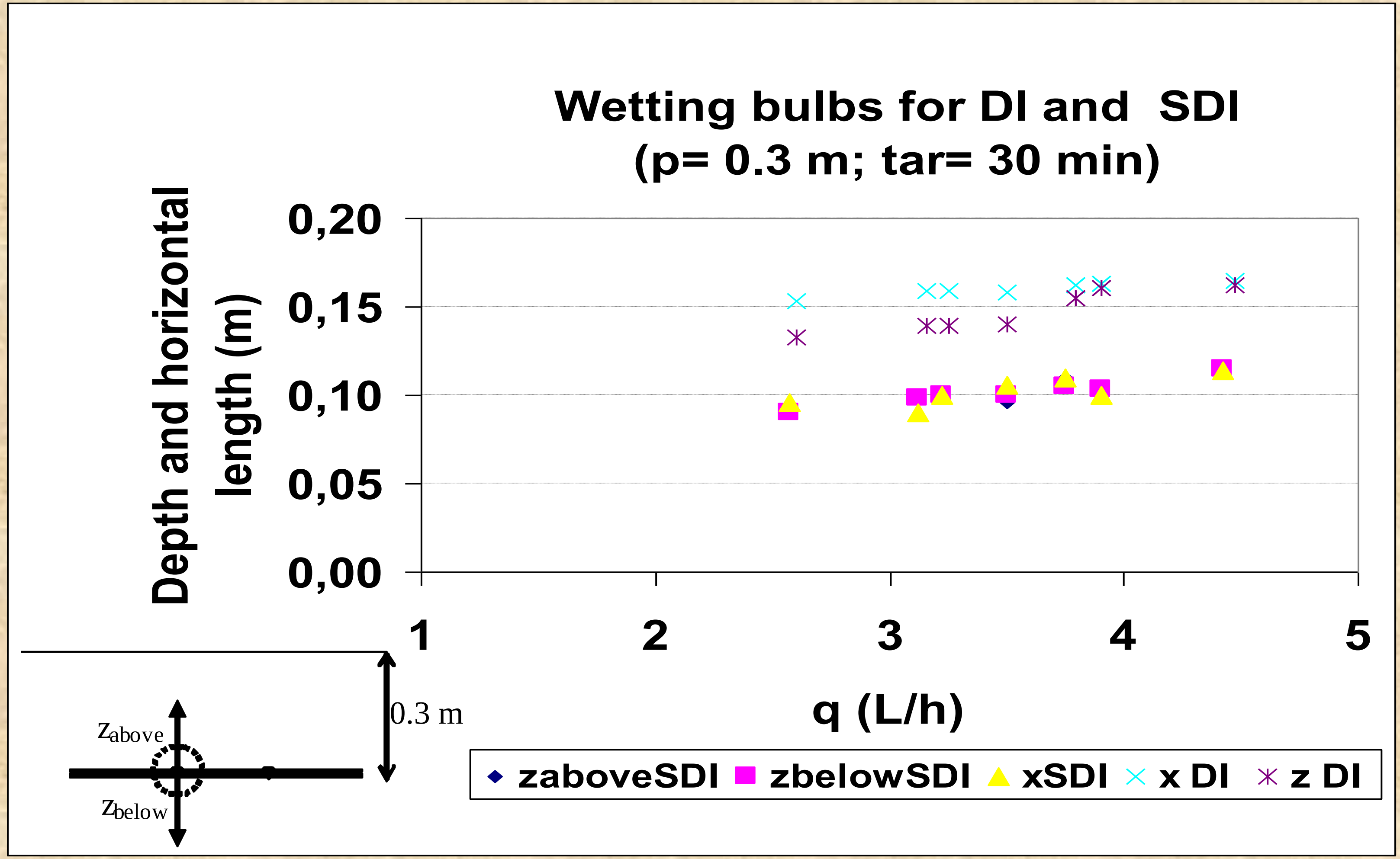
SDI and DI laterals 50 m long. Depth of buried emitters= 0.3 m

Regulated and non-regulated emitters spaced 0.3 m

Irrigation tests

Inlet flow and head pressures at both lateral extremes were measured over the time.
Irrigation was applied for 30 and 60 min at three different inlet pressures

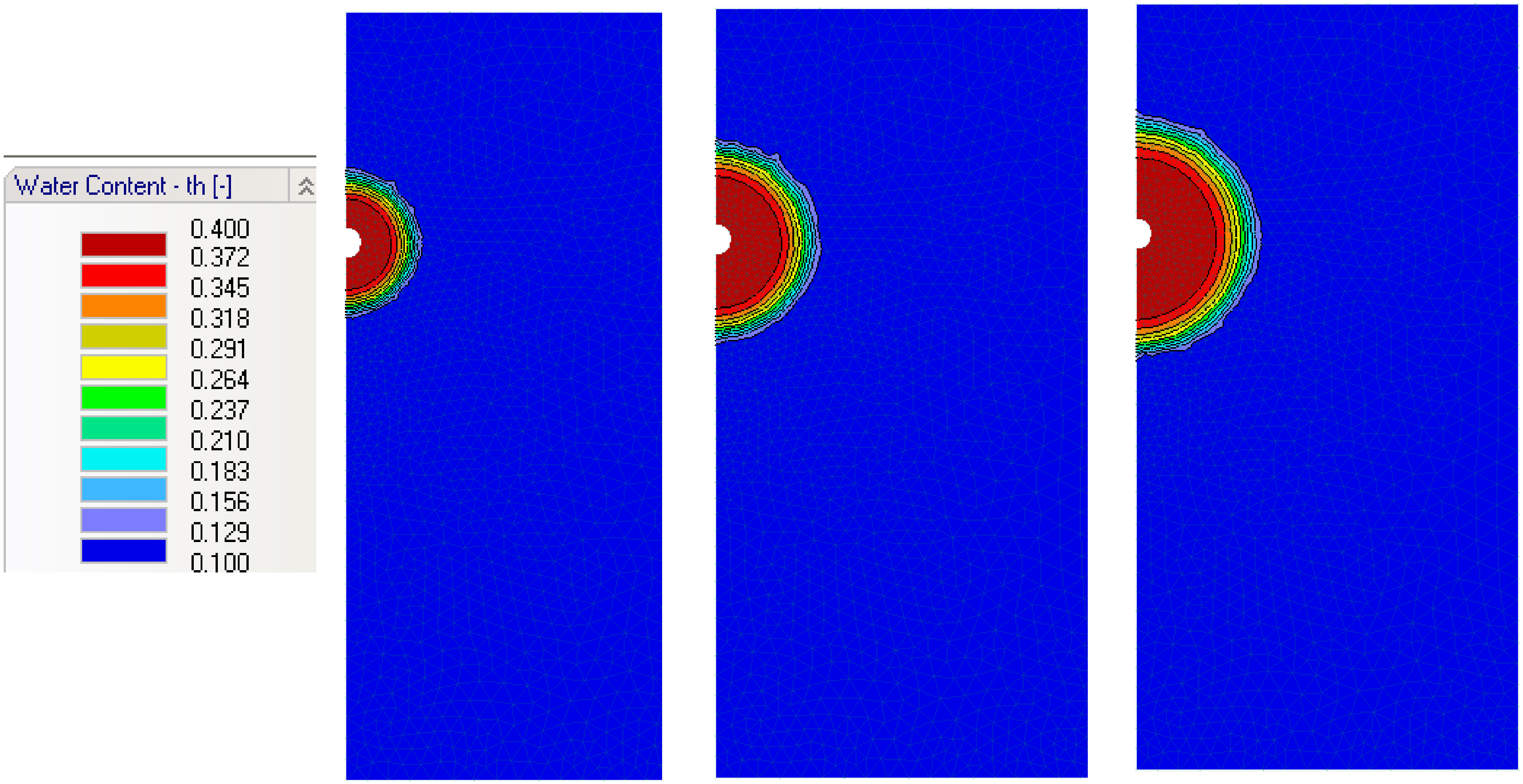
RESULTS AND DISCUSSION



Uniformity of water distribution in laterals: $CVq_{SDI} \le 0.080$; $CVq_{DI} \le 0.085$

RESULTS AND DISCUSSION

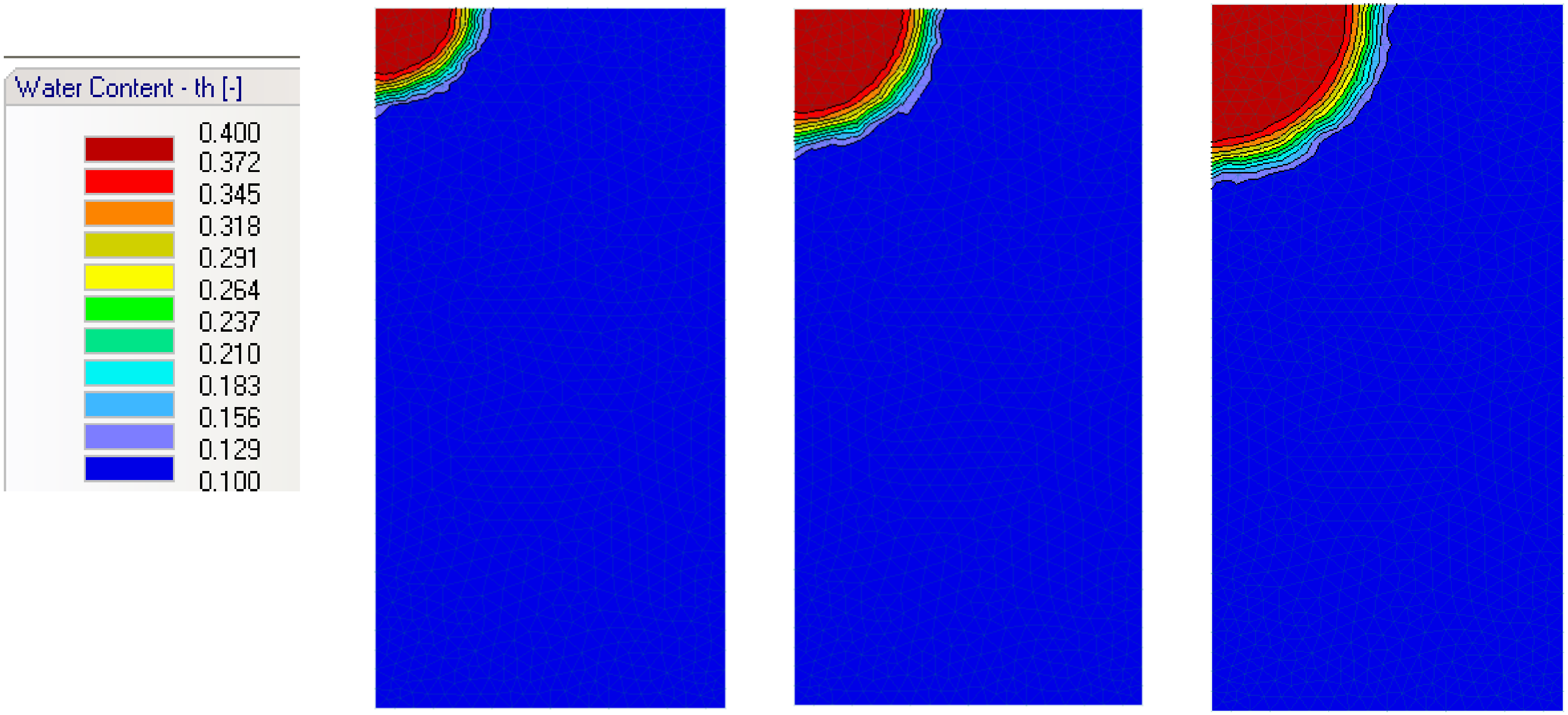
SDI non regulated emitter. p= 0.3 m. Inlet pressure: 11mca



Irrigation time: 30 min 60min 90min

RESULTS AND DISCUSSION

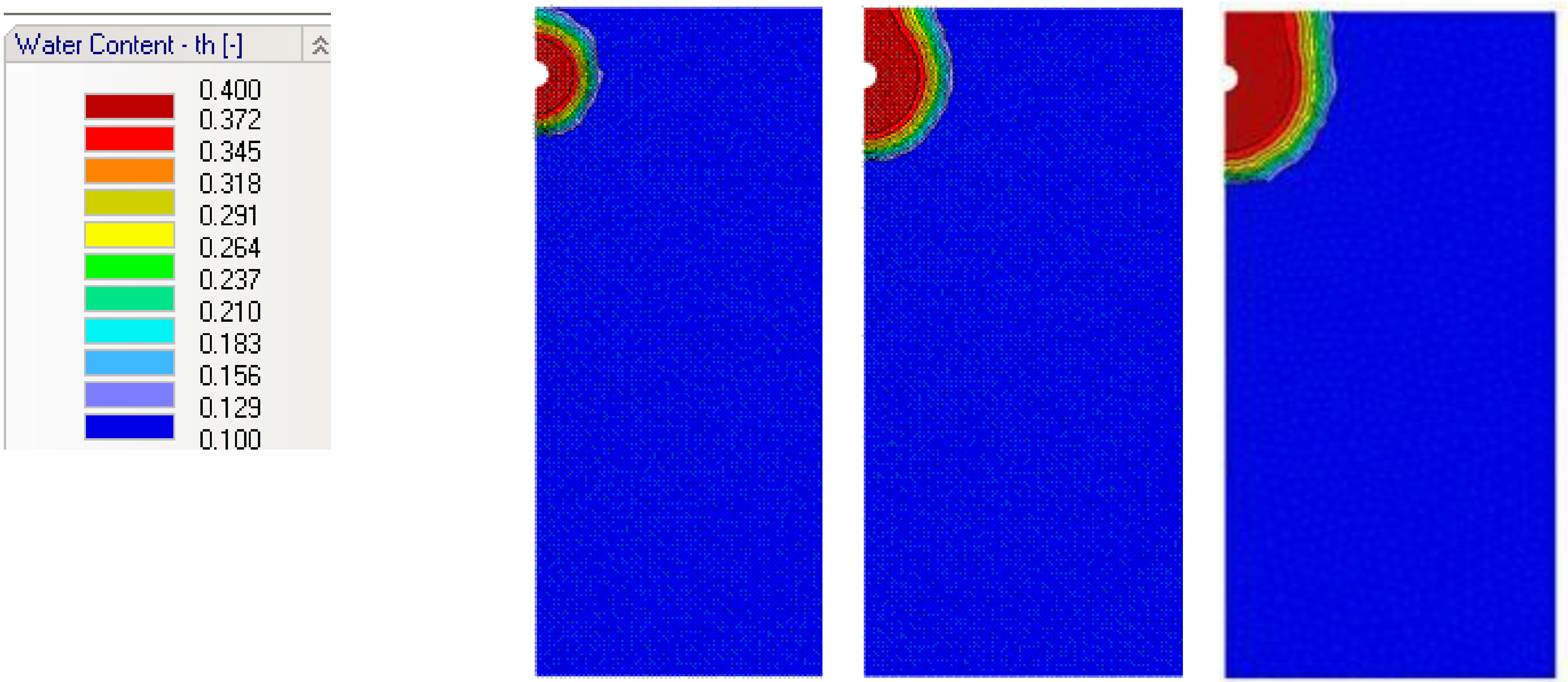
DI non regulated emitter. Inlet pressure: 11mca



Irrigation time: 30 min 60min 90min

RESULTS AND DISCUSSION

SDI non regulated emitter. p= 0.1 m. Inlet pressure: 11mca



Irrigation time: 30 min 60min 90min

CONCLUSIONS

- **Wetting bulbs in SDI could be aproximated by the equation developed under the assumption of Green-Ampt Eq. SDI emitter discharge could also be correlated with the wetted radius .**

- **Simulation of wetting bulbs by numerical simulation, using Richard’s eq., is a valuable tool for making suggestions on proper design variables (emitter spacing; emitter depth) and/or operation variables (inlet head, irrigation time) in DI and SDI under different scenarios.**

RECOMENDATIONS

- In the loamy soil studied, uniformity of water aplication was very good for both irrigation methods DI and SDI. However, wetting bulb size for DI was smaller than SDI. Thus, it will require higher irrigation times to wet the same root zone.

- Other scenarios simulated for the loamy soil show that emitter depth higher than 10 cm is advisable to prevent soil surface wetting for most of irrigation times. No significant differences were observed for 0.2 and 0.3 m depths.

THANK YOU FOR YOUR ATTENTION