GesCoN

A Decision Support System for managing fertirrigation in vegetable crops

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GesCoN

What is *GesCoN*?

- Is a DSS intended as a tool to help vegetable growers in managing fertigation (irrigation and N nutrition) <u>in drip-irrigated vegetable crops under open field conditions</u>
- Easy to use
  (no need for numerous or complex daily inputs)
- Particularly suitable for operating in NVZ
  (no drainage water and leaching)

GesCon
- Main sections

Plant growth section

- DW accumulation
- Root growth (geometry and volume)
- Plant height
- % of soil covered

Water balance section

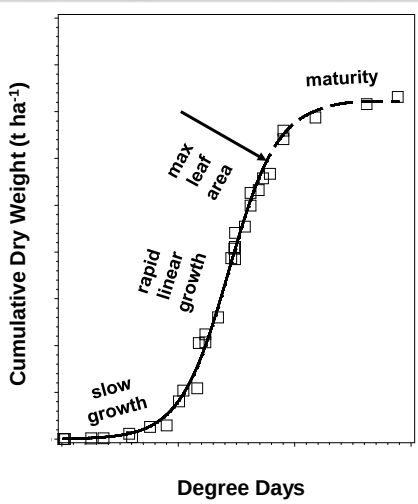
- ET_0 (FAO-PM, PT, Hargreaves)
- Kc (single, dual approach)
- Total Available Water (root vol. in wet soil)
- Water stress

N balance section

- N plant uptake
- N mineralization from SOM
- N mineral in soil

GesCon
• Plant growth section - Predicting aerial plant growth

Dry weight accumulation



Logistic model:

$$DW = \frac{\beta_1}{(1 + e^{(\beta_2 + \beta_3 t)})}$$

where:
B_1, β_2, β_3= function parameters

t =thermal sum (degree days) calculated as:

$$\sum_{i-1}^{n} (T_{mean} - T_{base})$$

$$If\ T_{growthmax} < T_{max}$$

T_{base} and $T_{growthmax}$ are required

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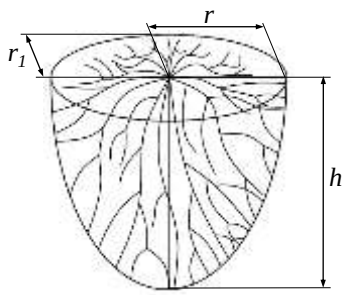
• Plant growth section - Predicting root growth



Geometry: half-truncated ellipsoid

Volume:

$$V_{Root} = \pi r \times r_1 \left(\frac{2h}{3}\right)$$

r and *h* are linearly incremented until the day of maximum root growth

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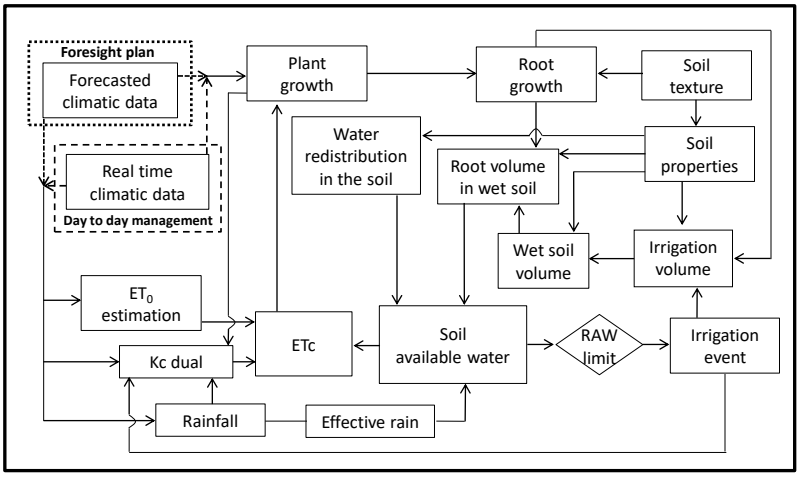
• Water balance section – General balance scheme

Water balance scheme



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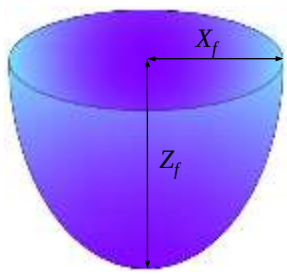
Water balance section – Volume and geometry of wet bulbs



From:Schwartzman and Zur (1986)

Geometry: half-truncated ellipsoid

Volume: $V_{wb} = \pi X_f^{\,2}\left(\frac{2(Z_f)}{3}\right)$

Xf and *Zf* are respectively the radius and the depth of wetted soil volume beneath each emitter (m),

$Z_f = f(Vm, Ks, q)$ $\quad Z_f = 2.54(V_m)^{0.63}\left(\frac{K_s}{q}\right)^{0.45}$

$X_f = f(Vm, Ks, q)$ $\quad X_f = 0.91(V_m)^{0.22}\left(\frac{K_s}{q}\right)^{-0.17}$

Vm = volume of applied water (m^3),
Ks = saturated hydraulic conductivity ($m\ s^{-1}$),
q = emitter flow rate ($m^3\ s^{-1}$).

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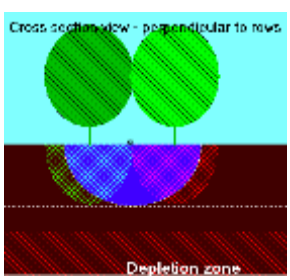
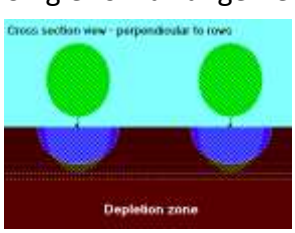
Water section - Available water: root volume inside wet bulbs

Twin rows arrangement



Single row arrangement



Total available water is calculated on the basis of roots volumes inside the wet bulbs

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N balance section – general scheme

Nitrogen balance scheme

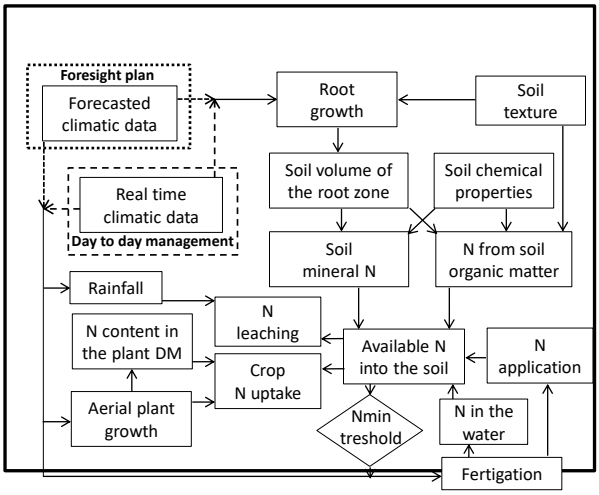

Figure 4 – Scheme of the main relationships considered in the water balance by GesCoN software.

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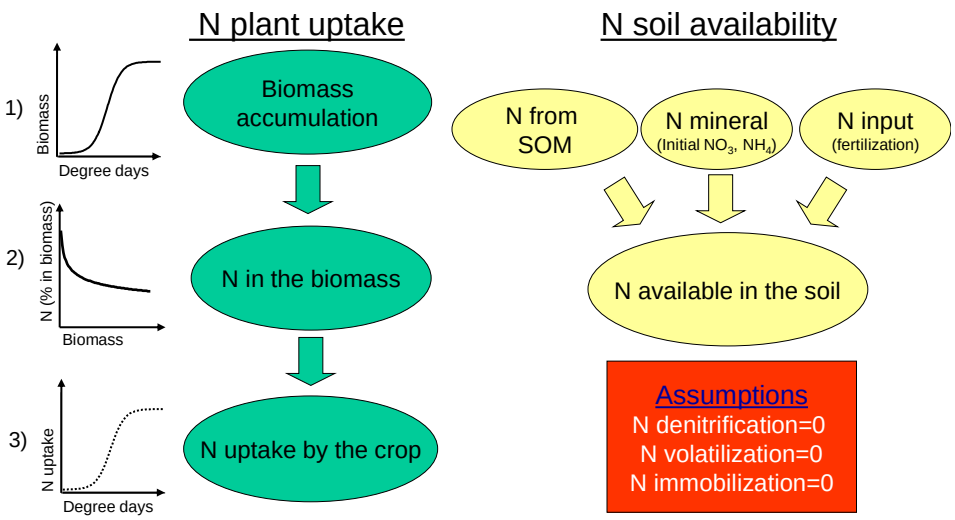
N balance section – computing the daily balance

N-*fertilization*$_d$ = N-plant *uptake*$_d$ - N-soil *availability*$_d$



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N balance section – computing N mineralization from SOM

Nitrogen from SOM mineralization

SOM mineralization computed according to the model of Hénin and Dupuis (1945), modified and validated (Boiffin et al., 1986; Mary and Guérif, 1994).

$$dailyN_{SOM} = Soil_{wt} \frac{N_{org}}{1000} k_2 P \frac{1}{365}$$

Daily N mineralization

$Soil_{wt}$ = weight of the soil interested by the roots
N_{org} = soil organic N content (g kg^{-1})

$$k_2 = \frac{1200}{(clay + 200)(0.3\,CaCO_3 + 200)} \left(\frac{T}{2} - 5\right)$$

Mineralization coefficient

Clay = clay content (g/100g of soil)
$CaCO_3$ = calcium carbonate (limestone) content (g/kg of soil)
T = mean daily temperature

$$P = f_r\, I\, Ts$$

Modifier of the mineralization coefficient

f_r = crop management coefficient
Ts = tillage factor
I = mineralization weight coefficient

GesCoN – Software functioning

How it works?

Sector setup module

- 12 input forms classified by topic
- Soil classification sub-routine
- Hargreaves Preistley Taylor calibration sub-routine

Fertigation manager module

- Initial simulation
- Real-time management
- Output: Fertigation plan (numerical and graphical)
- Output: Crop performance (yield, DW), water and thermal stresses, seasonal climate behaviour, dual Kc variation
- Fertirrigations views

GesCoN – Sector Setup module

• *Setting crop, soil, irrigation, N, geographical parameters and meteo files*

Sector setup

Sector Info	Sector ID; Geographical position; NVZ area; Meto hystorical data file
Soil chemical profile	SOM; Organic N; NO_3; NH_4; $CaCO_3$
Soil texture	Clay; Silt; Sand; Soil classification
Soil properties	Bulk density; Field capacity; Wilting point; Saturated hydralic conductivity
Crop profile	Species; cv.; Plants arrangements; Planting date; Expected yield; HI
Plant growth	Shoot growth param.; Root growth param.
Nitrogen assets	Critical curve parameters; preplanting N; N in irrigation water
ET_0 assessment	ET_0 from station; Penman-Monteith; PT, Hargreaves; Hargreaves calibration
Kc options	Single; Dual (% soil covered; h plant)
Irrigation setup	Lines spacing; Emitters spacing; Emitters flow rate; Irr. efficiency
SOM mineralization	Mineralization coeff; Tillage factor; Plought dt.; Crop residues managment
Pedotransfer func.	Bulk density; Field capacity; Wilting point; Saturated hydralic conductivity

GesCoN – Fertigation manager module

• *Fertigation manager options*

1 – Foresight (simulation)
prediction of
- growth
- water consumption
- N-uptake

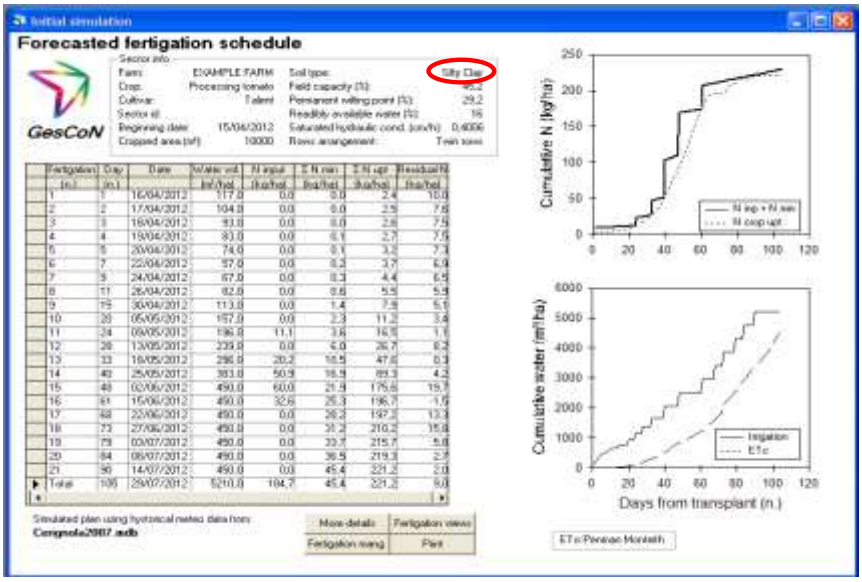
using multiannual averaged daily climate data

2 – Real-time (actual crop)
prediction of:
- growth,
- water needs
- N needs

using actual (and +1 day forecast) meteo data

GesCoN Fertigation manager module

• *Simulation output - example on a processing tomato crop*



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Conclusions

- *GesCoN* provides usefull advices (both in simulation or in real-time application) for managing fertigation in vegetable crops under open field conditions;
- the use of the software is simple. Irrigation (if Hargreaves model is calibrated and used) and fertigation can be controlled even with a minimum input of daily data (T_{min} and T_{max});
- no leaching is assured by the precise control of wetting depth (never below the rooting zone), so it is particularly suitable in NVZ areas;
- calibration and validation of the software is needed for different crops and under different environments.

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Elia, A. and G. Conversa (2015). "A decision support system (GesCoN) for managing fertigation in open field vegetable crops. Part I-methodological approach and description of the software." Frontiers in Plant Science 6.

Conversa, G., A. Bonasia, F. Di Gioia and A. Elia (2015). "A decision support system (GesCoN) for managing fertigation in vegetable crops. Part II-model calibration and validation under different environmental growing conditions on field grown tomato." Frontiers in Plant Science 6.

http://journal.frontiersin.org/article/10.3389/fpls.2015.00319/full

http://journal.frontiersin.org/article/10.3389/fpls.2015.00495/full

Two papers have been recently published. The first describe the methodologial approach and the second is the calibration on processing tomato

Thank you for your attention

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