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**Paper 7**

# Functional Evaluation of Pedotransfer Functions in Irrigation Scheduling

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## Abstract

This paper investigates the effect of replacing directly measured hydraulic properties with pedotransfer functions (PTFs) on irrigation scheduling of two different crops. PTFs derived from data of the same region as the two crops, were used as input to the mathematical model SWBACROS and simulations were carried out. The results obtained, are compared to observed moisture contents and also to simulation results using directly measured soil hydraulic properties. A comparison reveals that the use of PTFs results in an overprediction of the observed moisture contents in both cases. As a consequence, determination of irrigation events and depths is significantly altered.

**Keywords:** pedotransfer functions, soil hydraulic properties, SWBACROS, irrigation scheduling, functional evaluation.

## 1 Introduction

Intensification of crop production in terms of water resources is tightly coupled to over-irrigation. Problems of fresh water shortage and groundwater contamination are thus arising on a global scale. Facing these environmental problems and finding remedies, requires the understanding of processes that take place in soil. Although the necessary equations have been established some decades ago [1], in the last two decades various mathematical models have been developed in order to simulate water and solute movement in the soil. This trend may be attributed to factors such as: the widespread use of computers, the fact that mathematical models improve the understanding of soil processes [2] and provide the ability to evaluate alternative solutions at a shorter time and less expense [3].
Obtaining reliable simulation results, requires the detailed description of parameters that characterize the field of water movement: the soil. This is usually achieved by an extensive collection of field data. As soils become spatially and temporally more

variable, satisfying the models' high data needs becomes more difficult. The determination of needed parameters requires then a substantial increase of collected soil samples, which turns out to be an arduous, time consuming and therefore expensive procedure [4, 2, 5], especially for large scale research projects [6].
The difficulty in obtaining measurements of soil parameters in the field, as well as the increased demand for input data in models, urged the scientific community to consider alternative data sources. The revival [7, 8] of the old idea [9, 10] to determine required parameters from readily available data gave a new perspective to researchers. Thus, a plethora of scientific papers (a historical review may be found in [2]) have as a target the development of functions that enable the «translation» of data we have into data we need: the so called *pedotransfer functions (PTFs)* [11]. Recently, the rapid developments of Geographical Information Systems (GIS) revealed another attractive characteristic of PTFs: they can be coupled with GIS, making easier large-scale hydrologic investigations (e.g. at watershed level). Today, nearly a century after the papers of Briggs and McLane [9] and Briggs and Shantz [10], PTFs are still a live part of soil physics: the new term "*Hydropedology*" was recently coined, [12], in order to describe the interdisciplinary field that promises to bridge the sciences of pedology and hydrology.
The determination of soil hydraulic properties, is a crucial factor in the simulation of soil water movement and storage in the unsaturated zone. Without reliable values of soil hydraulic properties, it is not possible to investigate issues concerning irrigation scheduling or agrochemicals' leaching to aquifers. Furthermore, their usefulness is extended in sciences like hydrology (e.g. calculation of runoff coefficients) and meteorology (e.g. establishing components of heat balance) [12].
Even though PTFs seem to be the answer to the shortage of required data, a reasonable question arises: given the sensitivity of mathematical models to hydraulic parameters' variation, are the indirect estimated values able to provide reliable simulation results? In an attempt to reply this question, Espino et al., [13] used the mathematical model SWATRER in order to compare observed and simulated values of soil water content and pressure head. Their results revealed that major differences can exist and the authors ended up providing six reasons why PTFs use should be done with caution and a critical eye. In the same spirit, the present paper investigates the effectiveness of PTFs' use on irrigation scheduling of a cropped soil. For this reason, the best performing PTFs for soils of the Thessaloniki plain [14] and the mathematical model SWBACROS [15] are applied in two different fields of the same region: one cultivated with sugarbeets and one cultivated with cotton. Simulation results are compared with recorded values of soil water content and changes in irrigation scheduling are discussed.

# 2 Analysis

## 2.1 The SWBACROS model

The mathematical model SWBACROS was developed in 1995 [15]. It is a FORTRAN coded software that solves the one-dimensional form of the well known Richards [1] equation:

$$C(h)\frac{\partial h}{\partial t}=\frac{\partial}{\partial z}\left[K(\theta)\left(\frac{\partial h}{\partial z}-1\right)\right]-S(h,z,t) \quad (1)$$

where θ is the volumetric soil water content [$L^3$ $L^{-3}$], h is the soil water pressure [L], C(h) is the differential moisture capacity [$L^{-1}$], z is the vertical coordinate directed positive downwards [L], K(θ) is the unsaturated hydraulic conductivity [$LT^{-1}$] and S is the sink/source term [$T^{-1}$].

The solution of Equation (1) is achieved using the Douglas-Jones predictor-corrector finite difference scheme. This implicit scheme has been proven to be one of the most satisfactory numerical schemes for the simulation of one-dimensional movement of soil water in the unsaturated zone [16, 17].

Given the appropriate initial and boundary conditions, and while accounting for the water uptake by the plant roots, SWBACROS is able to simulate the changes of soil water content with time. It is therefore easy to calculate the amount of water needed in order to satisfy the irrigation requirements of a crop, as well as the required interval between irrigation events.

The model has been validated several times in the past, against data from the literature [18, 17] and field data [15, 19, 20]. Its proven ability to simulate unsaturated flow very realistically, was the main reason for choosing SWBACROS in this study.

## 2.2 Pedotransfer functions suitable for the Thessaloniki plain

Espino et al., [13] in 1996 warned that, "*(PTFs)...may be site specific or applicable only to a particular range of soil types from where PTFs have been determined...*" and that "*Applications of pedotransfer functions to soils different from the ones used to derive PTFs, therefore, should be done with caution*". Six years later McBratney et al. [2], also stated "*...commonsensically a given pedotransfer function should not be extrapolated beyond the geomorphic region or soil type from which it was developed*". Warnings like these, were taken into account in an attempt to assess the applicability of various PTFs of the literature in the Thessaloniki plain (Northern Greece) [14].

Using data from collected soil samples, Mousouliotis et al., [14] evaluated PTFs given by [21], [22], [23], [24], [25] and [6]. In accordance with the above mentioned comments, his evaluation revealed the poor performance of most PTFs under the specific conditions of the study region. This fact, led to the creation of new PTFs using the GDMH algorithm and regression analysis.

## 2.3 Field data and simulation characteristics

Simulations of soil water content (θ $cm^3$ $cm^{-3}$) with time were carried out for two different crops: sugarbeets and cotton, using both PTFs and direct measurements of soil hydraulic parameters. Details about field data and agricultural practice, are given in paragraphs 2.3.1 and 2.3.2. Field owners irrigated both crops using their own experience. Using the concept of field capacity as the maximum soil water content limit and a crop dependent lower limit, optimal irrigation depths were calculated according to the simulation results. It was then possible to evaluate the farmer's irrigation practice and quantify the effects of replacing direct measurements of soil hydraulic parameters with PTF estimates.

### 2.3.1 Sugarbeets

Data from a 2.015 ha field cultivated in 1998 with sugarbeets were used. Soil exhibited two distinct layers (0-50cm and 50-120cm). The layers' soil water retention curves (SRCs) were determined from soil cores using ceramic plates in the laboratory. The soil water content at 15bar pressure ($\theta_{15}$) was considered as the residual ($\theta_r$) water content. A Guelph permeameter was used to measure in-situ saturated hydraulic conductivity, but obtained values were not regarded as reliable. Details about laboratory determined soil properties are given in Table 1.

| **Depth (cm)** | **Sand (%)** | **Silt (%)** | **Clay (%)** | **Organic matter (%)** | **CEC (meq gr$^{-1}$)** |
|---|---|---|---|---|---|
| 0 – 50 | 16.6 | 48.4 | 35.1 | 1.87 | 27.8 |
| 50 – 120 | 24.6 | 58.4 | 17.1 | 1.12 | 15.5 |
| **Depth (cm)** | **$\theta_s$ (cm$^3$ cm$^{-3}$)** | **$\theta_{15}$ (cm$^3$ cm$^{-3}$)** | **a (m$^{-1}$)** | **n (-)** | **$\rho_b$ (gr cm$^{-3}$)** |
| 0 – 50 | 0.475 | 0.149 | 1.46916 | 1.39695 | 1.3 |
| 50 – 120 | 0.546 | 0.067 | 0.52787 | 1.55839 | 1.4 |

Table 1: Laboratory determined soil properties of sugarbeet field.

Using the following PTFs [14]:

Field capacity:

- $FC = \exp\left[1.13475 - 0.0110226\left(S\right) - 3.21042\left(\theta_s\right) - 0.00315844\left(CEC\right)\right] \quad R^2 = 0.6578$ (2)

Soil water content at 15bar pressure:

- $\theta_{15} = 0.0674798 + 0.00428747\left(Cl\right) + 0.0167573\left(C\right) \quad R^2 = 0.5417$ (3)

VanGenuchten's parameter a:

- $a = 1.0174486\left\{\exp\left[-0.91147785 + 0.776022008\,\ell n\left(y\right)\right]\right\}^{0.81995916} \quad , \quad R^2 = 0.5328$ (4)

where

$$y = -0.0705353 - 0.77665\frac{\mathrm{FC}_{opt} + 0.894562511}{0.13325869}$$

and

VanGenuchten's parameter n:

- $$\ln(n) = -1.66026 + 0.993478(\rho_b) - 0.014917(C) - 0.000434481(Cl^2) + \\ + 0.624293\ln(Cl) - 0.00040642(\rho_b)(S) - 0.0273522(\rho_b^2)(S) - \\ - 0.0754776\left(S/_{Si}\right) + 0.0273522(\rho_b^2)(Cl^2) \qquad R^2 = 0.1902 \quad (5)$$

the following hydraulic properties were calculated (Table 2):

| **Depth (cm)** | **FC ($cm^3$ $cm^{-3}$)** | **$\theta_{15}$ ($cm^3$ $cm^{-3}$)** | **a ($m^{-1}$)** | **n (-)** |
|---|---|---|---|---|
| 0 – 50 | 0.5503 | 0.249 | 0.20213 | 1.73364 |
| 50 – 120 | 0.3644 | 0.159 | 0.53019 | 1.91452 |

Table 2: Soil properties of sugarbeet field determined from PTFs.

As can be noticed from Table 2, the FC value of the first layer exceeds the corresponding $\theta_s$ value (Table 1). This is obviously the side effect of the field capacity being calculated neglecting the SRC, but instead being calculated from a regression equation. Since FC is by definition less than $\theta_s$, it was decided that its values in Table 2 be considered simply as fitting parameters, in order to determine the van Genuchten's parameter "a" by Equation (4). The values of FC were determined from the calculated SRCs at a pressure head equal to ⅓ bar. These new FC values for both layers were found to be equal to 0.4387 $cm^3$ $cm^{-3}$ and 0.3579 $cm^3$ $cm^{-3}$ respectively.

Soil water retention curves via PTFs are constructed according to the van Genuchten equation [26] using one measured hydraulic parameter ($\theta_s$) and three calculated ($\theta_{15}$, a , n). Computed and measured SRC graphs for the two layers are presented in Figure 1.

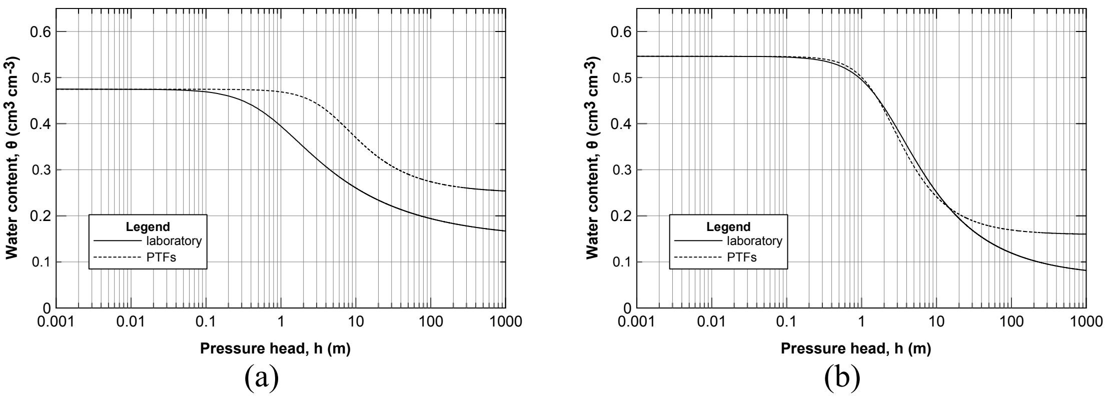



Figure 1: Soil moisture characteristics of sugarbeet field (a) 0-50cm (b) 50-120cm.

In the range of 0 to 150m pressure, the maximum difference between the two SRCs of Figure 1 is 0.123 $cm^3$ $cm^{-3}$ at 4.3m (0-50cm) and 0.057 $cm^3$ $cm^{-3}$ at 150.0m (50-120cm). The average differences for the same pressure range are 0.084 and 0.038

$cm^3$ $cm^{-3}$ respectively. For the SRCs in the 0-50cm layer, differences of 0.112 $cm^3$ $cm^{-3}$ on the average, are spread in a wide range of pressures: between 1.7m and 14.9m. It is therefore expected that for the top layer some discrepancies will occur after incorporating the SRC constructed by PTFs in a simulation model, instead of the laboratory calculated one. The magnitude of these discrepancies will be addressed in the following paragraphs.

### 2.3.2 Cotton

Cotton was cultivated in 2006 in a field consisting of two layers (0-35cm, 35-80cm). According to USDA classification, the soil of the first layer belongs to clay loam textural class while the second to the silty loam class. SRCs were determined in the laboratory using ceramic plates. Undisturbed soil samples were subjected to ten different pressures on the range from 0.1 to 15 bars.
Saturated hydraulic conductivity $K_s$ was derived from two 785.40 $cm^3$ undisturbed soil cores for each layer. Measurements were taken using the constant head permeameter method but inconsistent values were obtained for each layer. Specific details about the laboratory determined soil properties of cotton field, are given in Table 3.

| Depth (cm) | Sand (%) | Silt (%) | Clay (%) | Organic matter (%) | CEC (meq $gr^{-1}$) |
|---|---|---|---|---|---|
| 0 – 35 | 24.0 | 46.0 | 30.0 | 1.87 | 26.00 |
| 35 – 80 | 26.0 | 60.0 | 14.0 | 1.12 | 19.63 |
| **Depth (cm)** | **$\theta_s$ ($cm^3$ $cm^{-3}$)** | **$\theta_{15}$ ($cm^3$ $cm^{-3}$)** | **a ($m^{-1}$)** | **n (-)** | **$\rho_b$ (gr $cm^{-3}$)** |
| 0 – 35 | 0.455 | 0.185 | 0.7836 | 1.2921 | 1.47 |
| 35 – 80 | 0.476 | 0.129 | 0.4212 | 1.8148 | 1.35 |

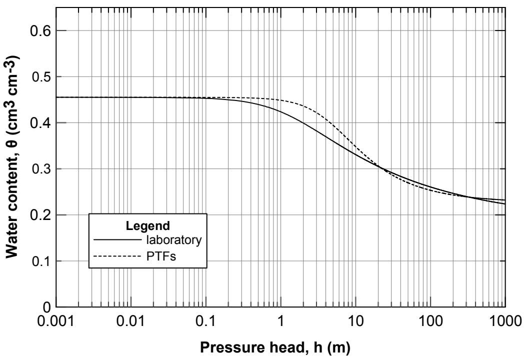
Table 3: Laboratory determined soil properties of the cotton field.

As in paragraph 2.3.1, using the PTFs proposed in [14], yielded FC values that exceed the values of saturation water content. Following the same approach as in the previous case, these FC values were simply used for contributing to the determination of van Genuchten's "a". The final values of FC were calculated via the SRCs (at pressure head equal to ⅓ bar), using the measured values of $\theta_s$ and the calculated by the PTFs values of $\theta_{15}$, a and n. These final values are presented in Table 4:

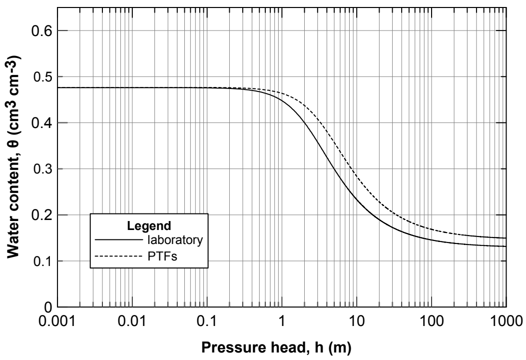
| Depth (cm) | FC ($cm^3$ $cm^{-3}$) | $\theta_{15}$ ($cm^3$ $cm^{-3}$) | a ($m^{-1}$) | n (-) |
|---|---|---|---|---|
| 0 – 35 | 0.417 | 0.227 | 0.21259 | 1.70642 |
| 35 – 80 | 0.394 | 0.146 | 0.26905 | 1.89497 |

Table 4: Final soil properties of the cotton field determined from PTFs.

Soil moisture retention curves of the two layers are presented in Figure 2:



(a)



(b)

Figure 2: Soil moisture characteristics of the cotton field (a) 0-35cm (b) 35-80cm.

A numerical inspection on the differences between the two SRCs of each layer, in the range of 0 to 150m pressure, reveals that moderate differences for the top layer (Figure 2a) are observed between 1 and 6m pressure approximately (0.036 $cm^3$ $cm^{-3}$ on the average). For the bottom layer a similar average difference of 0.034 $cm^3$ $cm^{-3}$ is observed, which is uniformly distributed on a wider pressure range: between 1.7 and 30m. Maximum differences are found to be 0.040 $cm^3$ $cm^{-3}$ at 3m (0-35cm) and 0.051 $cm^3$ $cm^{-3}$ at 4.4m (35-80cm).
Taking into consideration the above mentioned values, it is expected that replacement of directly estimated SRCs with the indirectly estimated ones will produce similar simulation results, with minor to moderate inconsistencies between observed and simulated soil water content values.

## 2.4 Simulation results

### 2.4.1 Sugarbeets

Sowing took place on March 30$^{th}$, 1998. Simulation period was considered to start on June 9$^{th}$ and to end on October 7$^{th}$. During that time, groundwater table was observed at a depth of 140cm. Throughout the simulation period, the farmer applied a total of 159mm distributed in three irrigation events. Irrigation water was applied using a travelling gun (Christiansen's uniformity coefficient was 91.8%). Recorded precipitation at the same period was 71.7mm. Observed root depth was 55cm on July 2$^{nd}$, 1998.
On June 4$^{th}$, the vertical soil water content distribution was determined after carefully extracting undisturbed soil samples from various depths. By solving the van Genuchten equation with respect to pressure head h, the observed soil water contents were transformed into pressure head values, the latter forming the initial condition of the simulation. Due to the lack of reliable $K_s$ values, it was decided to let SWBACROS' optimisation routine to estimate the $K_s$ values that provided the closest approximation of observed soil water content in both layers.
Simulation results are graphically presented in Figure 3 and Figure 4, for two of the soil layers where observed data existed: 0-20cm and 40-60cm.

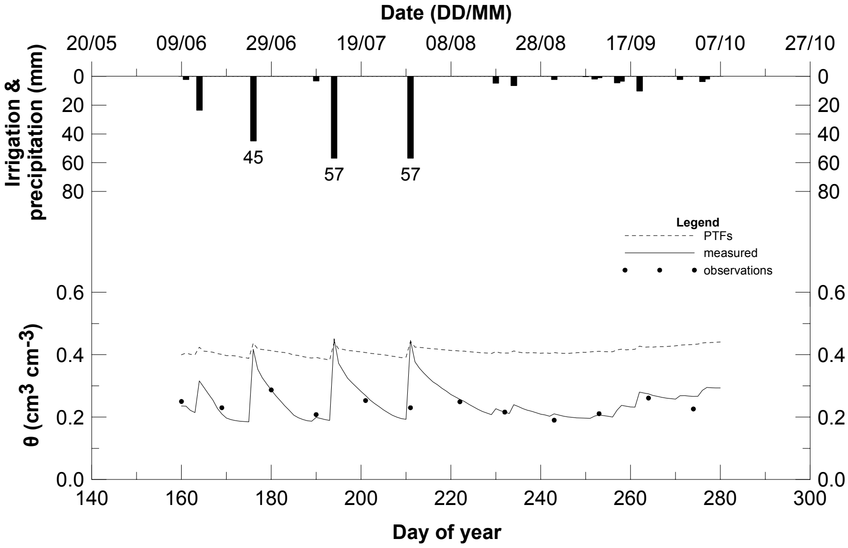



Figure 3: Observed versus simulated soil water content for the 0-20cm layer of the sugarbeet field. Numbered vertical bars indicate applied irrigation depths.

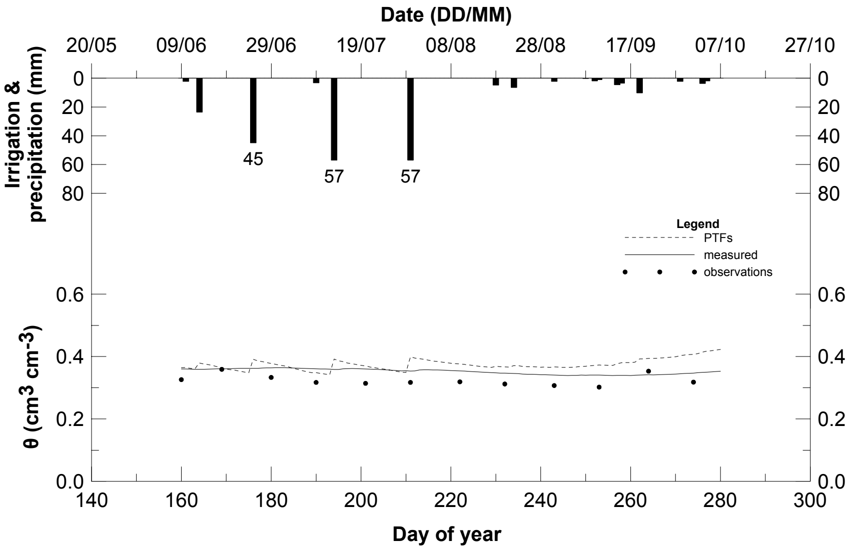



Figure 4: Observed versus simulated soil water content for the 40-60cm layer of the sugarbeet field. Numbered vertical bars indicate applied irrigation depths.

Upon visual inspection of Figure 3 an Figure 4, it is obvious that the measured hydraulic properties simulate observed soil water content (θ) values in a very accurate and realistic way. The root mean square (RMS) values are found to be 0.064 $cm^3\ cm^{-3}$ and 0.034 $cm^3\ cm^{-3}$ respectively. Calculated hydraulic properties from PTFs on the other hand, perform worse: corresponding RMS values for these two layers are almost three times higher (0.180 $cm^3\ cm^{-3}$) for the 0-20cm layer and almost two times higher (0.057 $cm^3\ cm^{-3}$) for the 40-60cm layer.

An overprediction of observed θ values between 0.13 and 0.22 $cm^3\ cm^{-3}$ is observed in the 0-20cm layer, throughout the simulation period. Differences still exist but seem less pronounced in deeper layers (eg. ranging from 0.00 to 0.09 $cm^3\ cm^{-3}$ for the 40-60cm layer) as can be seen in Figure 4. Similar results were also reported by Espino et al., [13].

An additional comment derived from Figures 3 and 4 is that PTFs provide θ values which are always close to saturation. This is attributed to the combination of initially high soil water content and the high $K_s$ value assigned by the SWBACROS' optimisation routine at depths between 50 and 120cm. Under these conditions, the bottom of the drier 0-50cm layer is affected by its contact to the wetter and more permeable 50-120cm layer. The pressure head of the 0-50cm layer is therefore reduced to values around 3-7m that correspond to θ values close to 0.4 $cm^3\ cm^{-3}$ (Figure 1a).

The aforementioned discrepancies caused by using PTFs, are of such magnitude that should greatly affect irrigation scheduling. Taking into account that using PTFs tends to overpredict soil water content (Figures 3 and 4), it is expected that simulated soil water content will reach the lowest allowable depletion limit fewer times compared to using measured soil hydraulic properties. As a consequence, using PTFs instead of measured hydraulic properties will lead to larger irrigation less total irrigation depth over the simulation period.

Considering the average (a) soil water content, (b) field capacity and (c) permanent wilting point values over each day's root depth, the rescheduling of irrigation events was simulated. For these simulations, the lowest allowable depletion limit of available soil water was set to 50% [27]. The results presented in Figure 5 show that the use of PTFs resulted in two irrigation events with a total depth of 117.5mm. Compared to the actual irrigation applied to the field (159mm in three events), this depth corresponds to a 26.1% reduction in irrigation depth.

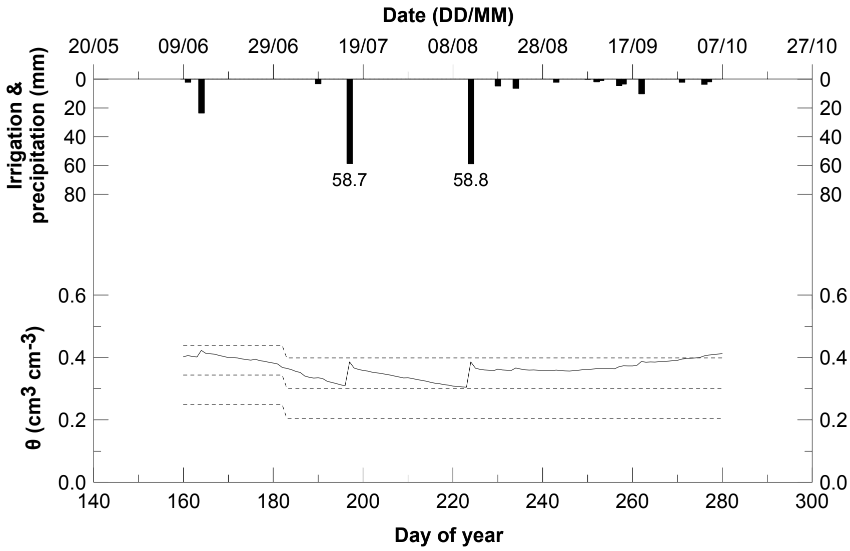



Figure 5: Irrigation scheduling of the sugarbeet field according to PTFs. Numbered vertical bars indicate applied irrigation depths.

### 2.4.2 Cotton

Simulation period was considered from June 24th to October 6th, 2006. Sowing was done on May 5th, while light soil tillage took place on the 15th and 20th of May. Observed soil moisture contents were recorded every 10cm, using the Diviner 2000 portable device. The minimum depth of groundwater table was 1.02m, but the vast majority of times it was observed at depths greater than 1.30m.

During the simulation period, three irrigation events applied 80.0mm of water, using a rolling irrigation sprinkler (Christiansen's uniformity coefficient was 73.0%). In the same period, the cotton field received 149.2mm of precipitation. Roots reached a maximum depth of 50cm, which was considered as the wetting depth for the transformation of volumetric soil water content to millimeters of irrigation depth.

To deal with the inconsistent laboratory measured $K_s$ values, it was decided to let SWBACROS' optimisation routine to determine those values that minimise the difference between observed and simulated water contents. In this routine, the average values of the laboratory determined $K_s$ for each layer served as initial estimates.

Simulation results for 0-35cm layer are presented in Figure 6, while for the 35-80cm layer in Figure 7. It is noted that in these Figures, simulated and observed values refer to the average values of each layer.

Visual inspection of the simulations for the two soil layers, indicates that in contrast to the calculated properties from PTFs, measured hydraulic properties provide simulated θ values that are in closer agreement to the observed values. This is further supported, after taking into account the corresponding RMS values: 0.0258 $cm^3\ cm^{-3}$ for the 0-35cm layer in contrast to 0.0625 $cm^3\ cm^{-3}$ and 0.0232 $cm^3\ cm^{-3}$ for the 35-80cm layer in contrast to 0.0254 $cm^3\ cm^{-3}$.

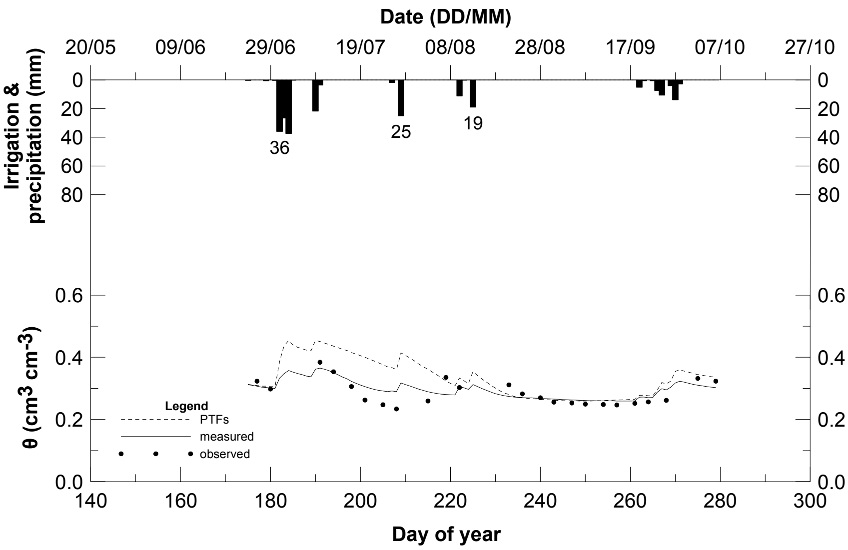



Figure 6: Observed versus simulated soil water content for the 0-35cm layer of the cotton field. Numbered vertical bars indicate applied irrigation depths.

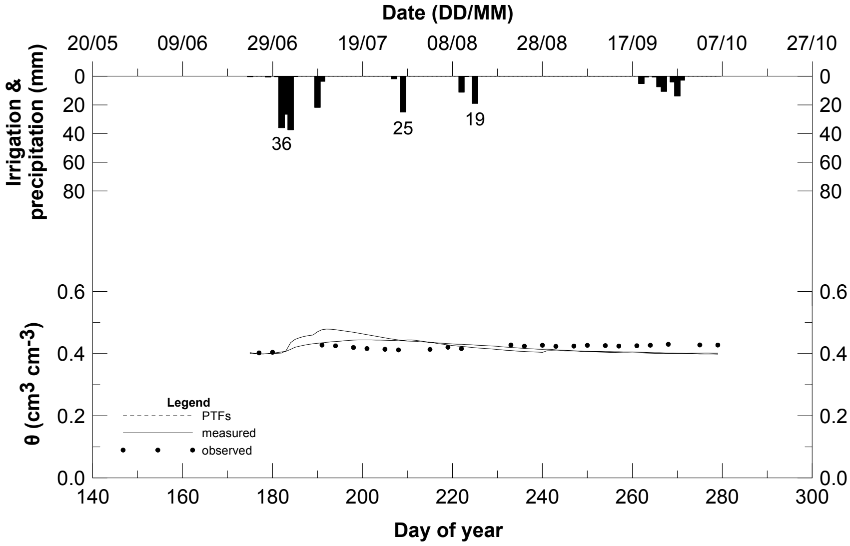



Figure 7: Observed versus simulated soil water content for the 35-80cm layer of the cotton field. Numbered vertical bars indicate applied irrigation depths.

It is clear that, performing simulations using PTFs generally leads to overestimation of observed soil water contents. This is especially true for the top layer, where high discrepancies between 0.3 and 0.5 $cm^3$ $cm^{-3}$ can be partly attributed to (i) the differences of SRCs in the 0.1-10m pressure range (Figure 2a) and partly to (ii) the disturbance of the soil surface by tillage. It is possible that the hydraulic behaviour of the disturbed soil is not accurately represented by the pedotransfer functions selected in this study. Soil tillage did not affect the 35-80cm layer though, thus differences is soil water simulation are less obvious (Figure 7). These findings are in accordance to the findings presented by Espino et al., [13] who they also observed fewer discrepancies in deeper layers than in the top layer.

Discrepancies discussed above, are expected to have an impact on irrigation scheduling. For the simulation of irrigation scheduling, the determination of a lower allowable soil water content limit was a requisite. According to FAO [27], for crop evapotranspiration between 5 and 6 mm $d^{-1}$ root water uptake starts to be reduced after the 65% of available soil water content is depleted. The same limit was used in order to determine the time and amount of applied irrigation.

Irrigation scheduling using PTFs is presented in Figure 8. Following the same approach as in the previous case of sugarbeets, the simulation refers to the average soil water content over each day's rootdepth. The field capacity and permanent wilting point values are also averaged over the same depth. Change of these values observed on day 200, denotes the root penetration into the second layer.

As can be easily noticed by comparing the applied and suggested irrigation practices, while the farmer applied a total of 80mm in 3 irrigation events, using PTFs resulted in only one light irrigation (19.5mm) at the beginning of simulation period. It is obvious that, this irrigation policy may pose a major threat to the crop physiology and production.

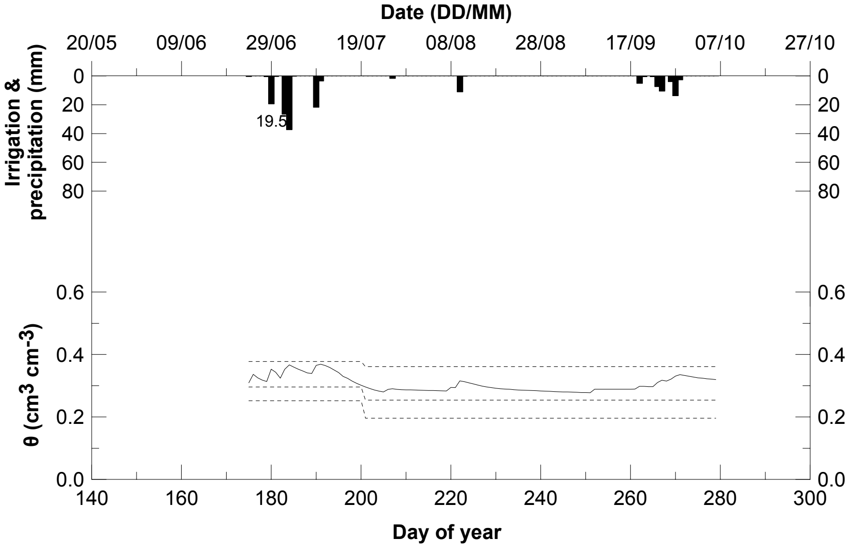



Figure 8: Irrigation scheduling according to PTFs' calculated hydraulic parameters. Numbered vertical bars indicate applied irrigation depths.

# 3 Results and discussion

Knowing how much and when to irrigate are of paramount importance in agriculture. In this paper, published PTFs proposed for use in the Thessaloniki plain (Northern Greece), are incorporated into the SWBACROS model in order to evaluate their performance in irrigation scheduling.

Using the proposed PTFs for the determination of field capacity (FC), resulted in values higher than soil water content at saturation, $\theta_s$. Soil water retention curves (SRCs) of the van Genuchten type were constructed using (i) the measured value of $\theta_s$ and (ii) PTFs for the determination of the parameters $\theta_{15}$, a and n. Comparison between SRCs constructed by PTFs and laboratory determined SRCs, in the range of 0 to 150m, revealed major differences in only one case (0.123 $cm^3$ $cm^{-3}$ at 4.3m pressure – Figure 1a). At pressures less than 0.3m, the choice to fix $\theta_s$ at its measured value, made the SRCs to coincide and the discrepancies to be less pronounced.

Attempting to use SRCs constructed by PTFs in soil water content simulation, resulted in higher differences between observed and predicted values at the surface soil layers. In these layers, the soil undergoes continuous drying and wetting cycles and soil pressure head is varying in a wide range of values. Thus, the discrepancies between laboratory determined SRCs and SRCs constructed by PTFs' (in whatever range of pressures) are transformed into differences in soil water content predictions. In deeper layers, where soil water content is higher and discrepancies between SRCs are smaller, differences in soil water content predictions are reduced. Disturbance of soil surface by tillage before the beginning of simulations may be partly responsible for the improper description of the soil hydraulic behaviour by PTFs.

A common finding of the simulations in the two selected fields of this study, is that PTFs produced less accurate estimates of observed soil water content, although they were derived from soil samples of the same region. As PTFs are derived from a limited number of samples it is expected that they cannot completely capture the spatial variability of soil hydraulic parameters.

Functional evaluation of PTFs in terms of irrigation scheduling revealed that, by predicting higher soil water contents, they prolong the time interval between irrigation events. In turn, this results in reduced total irrigation depths. PTFs may even lead to light irrigation practices, which may jeopardize the production capability of crops cultivated in regions with hot summer.

Being such an attractive alternative to field data collection, further research should be deicated to PTFs, in order to diminish the uncertainty of the water balance models' results when they are used as input.

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