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WETTING PATTERN SIMULATION OF SURFACE AND SUBSURFACE DRIP IRRIGATION SYSTEMS
II- MODEL VALIDATION AND ANALYSES

Ismail, S.M.[1], Zin El-Abedin, T.K.[2], Wassif, M.A.[3], El-Nesr, M.N.[4]

ABSTRACT

The developed model 'Drip Chartist' by Ismail et al. (2006a) was verified and validated in field and by comparison to other related model "Hydrus 2D". Field validation resulted showed that the surface system without hydraulic barrier represents the real-condition by 94.99% (correlation coefficient of 0.9746) with under estimation of 0.157. While in the subsurface system with hydraulic barrier represents the real-condition by 81.96% (correlation coefficient of 0.9053) with under estimation of 0.021. Validation to Hydrus2D lead to almost coincidence in predicted values of wetting pattern. Several studies were performed using the model, like studying soil properties such as θsat, θres, Ks, and the retention and conductivity parameters of soil such as α, m, n, λps, and Υ effect on soil moisture pattern. The effect of soil texture indicated that the heavy textured soils could be simulated faster than light texture soils, while silt texture soil was simulated in longer time compared to other texture classes, solution methods, and other properties were studied as well. In addition, some construction alternatives of the system were studied like the effect of bilateral gap, dripper line burying depth, physical barrier and the emitter discharge on the wetting pattern. The model "Drip Chartist" was proved to act like intended in predicting surface and subsurface drip wetting pattern.

INTRODUCTION

Once a model has been developed, it must be evaluated to ensure its harmony for the predicted behavior, this can be realized by three

[1] Prof. of Ag. Eng.., Alex. Univ.
[2] Assoc. Prof. of Ag. Eng.,. Alex. Univ.
[3] Prof. Em. of Soil, Desert Research Center
[4] Researcher Assistant..Desert Research Center

consequent operations: *verification*, *validation*, and *output analysis*. (Law, and Kelton, 1982).

Fishman, and Kiviat, (1968) defined these operations as follow: *"Verification"* is determining whether a simulation model performs as intended, i.e., debugging the computer program to compare step by step results to manual calculations for several program runs. The second operation "*Validation*" is determining whether a simulation model, as opposed to the computer program, is an accurate representation of the real-world system under study. This can be performed: by field and laboratory experiments, by comparing its results with other trusted models, or by comparing its results with published related cases. Finally, the last operation "*Output analysis*" is the operation in which the output of the model been revised for logic, harmony, and realism. This analysis could be done by means of statistical and mathematical methods. After performing those steps, the model can be reliable and ready to use.

"Drip Chartist" verification was carried out while and after programming stage by debugging the program line by line to ensure that no errors like overflow, undeclared variables, mistyped variable names, or mistyped equations. Several runs were performed and compared to manually solved calculations. Testing of extremes was done as well. The model was validated to be free of all programmatic errors and typos after thorough tests.

Model validation was done by two methods. The first method was comparing the model results with field-measured data. The second validation method was to compare the current model's results with the results of another trustful model (Hydrus 2D). Methods of validation and comparative results are discussed below.

MODEL VALIDATION

Field measured data validation.

Field validation of the model was performed in the North Sinai research station of the Desert Research Center in "El-Shaikh Zowayed" city, 30 km from "El-Arish", and 12 km from "Rafah" on the Egyptian-Palestinians' borders. The soil texture was medium to fine sand.

Soil moisture characteristic curve was determined according to FAO (1970) and listed in table(1). Soil hydraulic conductivity was determined using van Beers (1976) method and it was 24.6m/d.

Table (1). Soil moisture characteristic curve values of the experimental site soil.

Suction (bar)	0.10	0.50	1.00	5.00	10.00	15.00
Water content (cm^3/cm^3)	0.23	0.21	0.20	0.17	0.10	0.03

In "Drip Chartist", the soil was assumed physically uniform, and the initial water content has a constant value through all the soil

profile, this situation is theoretical and is hard to be established in the real conditions. To overcome this situation, the comparison of wetting pattern was performed between the difference in soil moisture pattern after and before irrigation.

"Drip Chartist" requires some soil parameters to define the simulated soil properly. In order to find these parameters, the laboratory-measured retention values found in Table (2) were entered to the computer model RETC (van Genuchten et al., 1991), which performs a neural-networks-based prediction of soil properties. The predicted properties are listed in Table (2).

Table (2) Experimental site soil properties

Water content		van Genuchtin parameters		Hydraulic conductivity
θ_{res} %Vol	θ_S %Vol	α	n	K_s cm/min
0.0507	0.3760	3.4400	4.4248	1.7083

Soil parameters in Table (2), were entered to the current model (Drip Chartist) and a simulation was performed to two systems without physical barrier; bilateral system of 20, 40 cm buried lateral lines and single surface dripper system. The model was allowed to simulate infiltration time of 45 and 20 minuets for the first and the second systems respectively.

After harvesting, the soil moisture was measured at depths of 10, 30, 50, and 70 cm using the neutron scattering probe. For both systems measurements were taken before irrigation and every 5 minuets after irrigation. Comparative profiles were presented in Figures (1, and 2) for systems 1 and 2 respectively.

As shown in Figures (1and 2), the model appears to be very close to the measured values but with some under-estimation. The most under estimated points were the top-layer points. This could be attributed to the inaccurate measurements of the neutron probe near soil surface due to the extent of roots tailings, herbs, and other organic substances, which confuse the hydro probe readings.

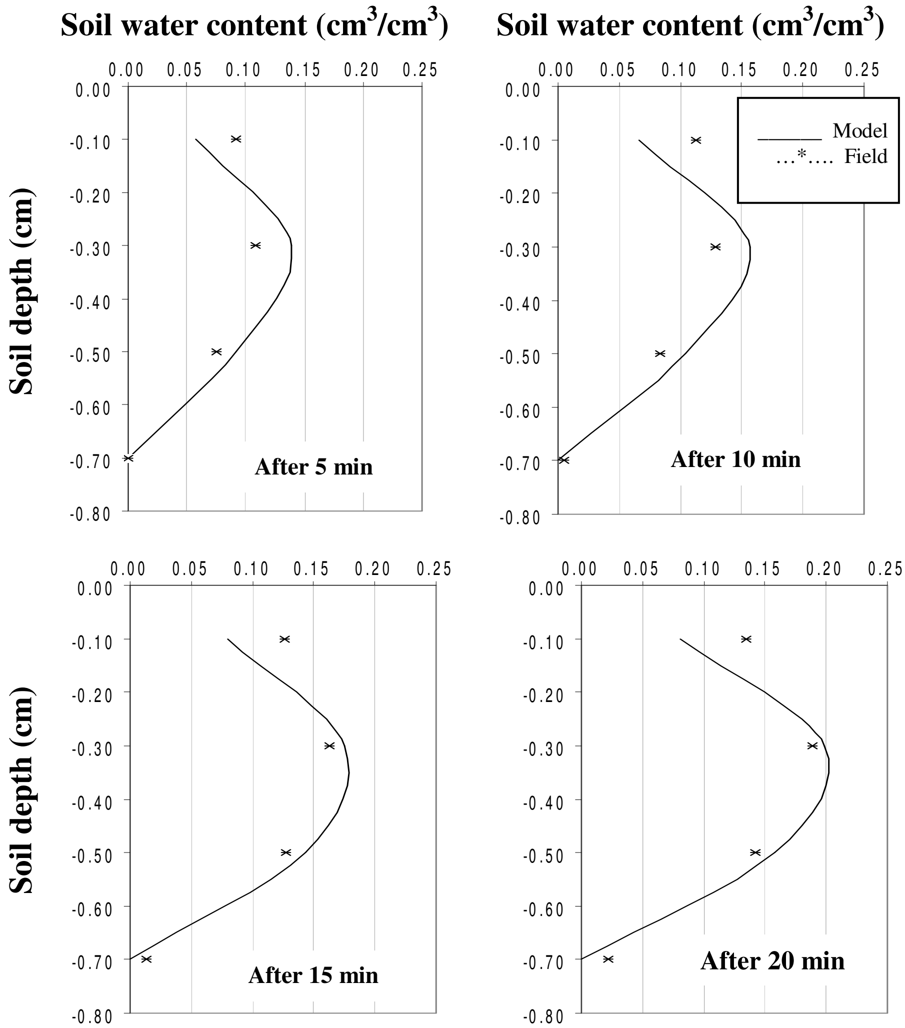
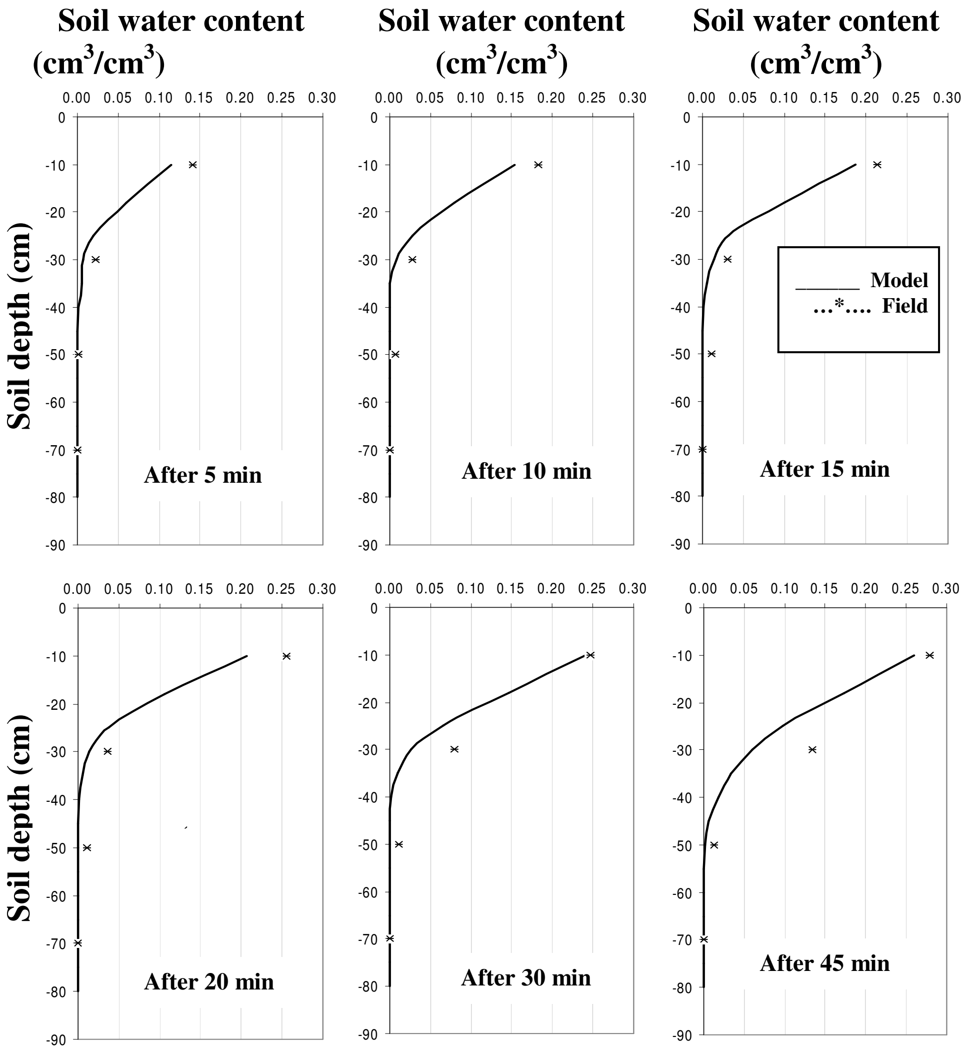


Figure (1):Field measured moisture content increment values compared to model predicted values for bilateral 20, 40 cm treatment measured at times 5, 10, 15, and 20 minuets after infiltration start.

To evaluate the overall amount of under-estimation, a 45^{o} line was drawn to compare measured values vs. estimated values as presented in Figure (3). In the surface system without hydraulic barrier (Fig 3-a), the model represents the real-condition by 94.99% (correlation coefficient of 0.9746)



Figure(2).Field measured moisture content increment values compared to model predicted values for surface drip treatment measured at times 5, 10, 15, 20, 30, and 45 minuets after infiltration start.

with under estimation of 0.157. While in the subsurface system with hydraulic barrier (Fig 3-b), the model represents the real-condition by 81.96% (correlation coefficient of 0.9053) with under estimation of 0.021. However, these values gave high confidence in the simulated results for both surface and subsurface with some under estimation to be considered.

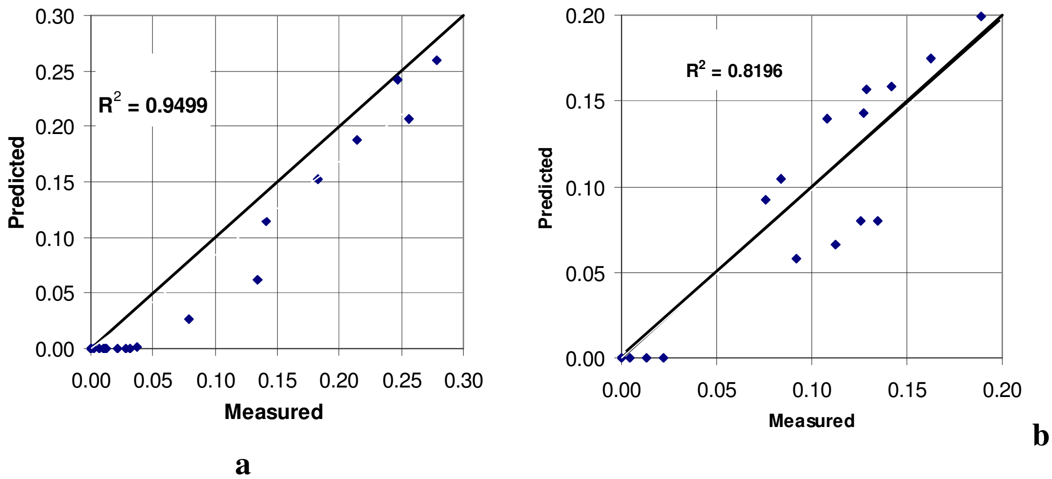


Figure (3) Field-measured versus model-predicted values of soil moisture increase after infiltration for: (a) single dripper line, (b) bilateral system.

Comparative validation to "Hydrus 2D" model.

"Drip Chartist" and "Hydrus 2D" uses the same soil formulas and input parameters. The main problem in comparing results was that Hydrus2D deals only with flux from a point source, not with discharge rate like "Drip Chartist". However, the discharge was converted to flux by dividing the former by the infiltration area. But in drip irrigation this area is not fixed as it varies with time. For solving this problem several adjustments were performed:

- Variable boundary conditions were adjusted for decreasing flux with time.
- Volume balance was checked to ensure that same volume of water was applied in both models.

Fig (4) shows an isoline comparison between the current model and Hydrus2D output diagram of simulating water movement in a sandy soil through a 3L/h emitter for 60 minuets. The results of both models matches very well, and almost coincide in boundaries. Although Hydrus2D is more accurate, and performs smoother iso-lines, but the current model is quicker and simpler in interface.

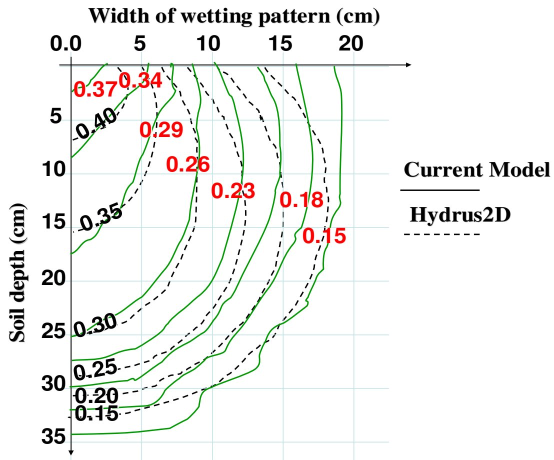


Figure (4): Water content isolines between the current model and Hydrus 2D by 3L/h emitter for 60 minuets.

MODEL ANALYSIS

The effect of some inputs parameter on the modle output was studied. Studying each parameter has special inputs and constrains while all the studies have the some output measures. The output-measures are the dimensions of the wetting pattern in some arbitrary isolines, and the simulation time consumed on the PC.

Soil physical properties effect on soil-water pattern.

Wetting pattern is expected to be affected by soil physical parameters. These parameters are: saturated water content (θ_{sat}), residual water

content (θ_{res}), beginning water content (θ_b), retention parameter (n), bubbling pressure inverse (α [cm^{-1}]), hydraulic conductivity (K_s [cm/min]), and pore-connectivity parameter (Υ). The study was applied to a sandy soil, within a profile of 50 cm depth, 35 cm width (radius), grid spacing of 2.5 cm, and cumulative water volume of 8 liters.
Each variable will be studied separately within an acceptable range while the other variables remain constant to the default values. The studied values are presented in Table (4) (default values are bolded).

Table (4) studied values for each soil parameter, where default values of each parameter is bolded.

Case	$\boldsymbol{\theta_{sat}}$	$\boldsymbol{\theta_{res}}$	$\boldsymbol{\theta_{begin}}$	**n**	α (cm^{-1})	K_s (cm/min)	Υ
1	0.3450	0.0526	0.065	2.70	0.03530	0.047	0.05
2	0.3550	0.0626	0.075	2.80	0.04500	0.095	0.20
3	0.3650	**0.0726**	**0.085**	**2.93**	0.06000	0.145	0.30
4	**0.3759**	0.0826	0.095	3.00	0.07500	0.215	0.40
5	0.3850	0.0926	0.105	3.10	**0.09015**	0.285	**0.50**
6	0.3950	0.1026	0.115	3.18	0.10500	0.295	0.60
7	0.4050	0.1126	0.125		0.12000	0.345	0.70
8	0.4150	0.1226	0.135		0.14500	0.395	0.95
9	0.4250	0.1326	0.145			0.445	
10			0.155			**0.495**	

The results of the seven studied properties were plotted in Fig. (5). A discussion to each property will be shown in the following:

1- $\boldsymbol{\theta_{sat}}$ appears to affect wetting pattern shape only near the saturation zone as shown in fig (5a). In the same way, the width of the wetting pattern is affected as shown in fig (5b). In Fig (5c) the simulation time and steps appear to increase in the extremes of the θ_{sat} values, while minimum time achieved in the middle of the tested zone.

2- $\boldsymbol{\theta_{res}}$ affects wetting pattern shape near saturation zone as shown in Fig (5 a, b and c). The widths of the isolines show an increasing trend with a strange jump in the 0.0926 isoline. However, this jump may be due to some cumulative over shooting in the van Genuchten formulae. Simulation time of these cases is directly proportional to the θ_{res} value.

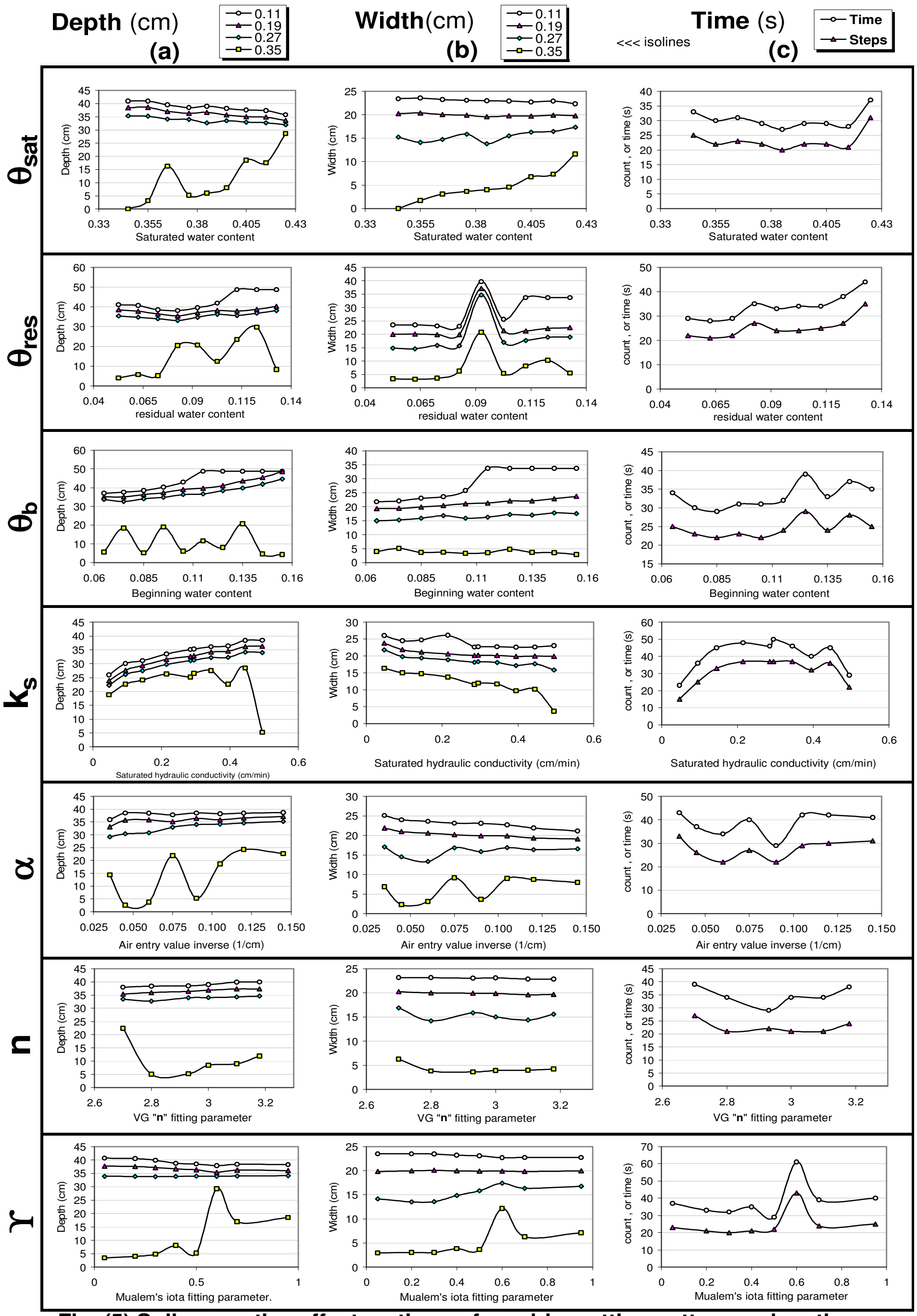


Fig. (5) Soil properties effect on the surface drip wetting pattern and on the simulation time

3- **θ_b** before irrigation, affects wetting pattern as shown in Fig (5 a, b, and c). Excluding the near saturation isoline, all the isolines location moves towards the increment direction of depth and width, i.e. the wetting pattern area increases with the increment of θ_{begin}. The simulation time trend tends to increase on the increment of θ_{begin}.

4- In Fig (5 a, b, and c) (K_s) affects the wetting area profile widely, however, the more the K_s value, the more depth of the specified isolines. In contrast, K_s is inversely proportional to the width of isolines. Explicitly, the increment of the K_s causes narrower width and longer depth of wetting area. Therefore, in drip irrigation systems of higher conductivity soils the emitters must be closer to each other, and irrigation should be managed so that to give smaller amounts of water on shorter frequencies to avoid deep percolation. Inversely to the θ_{sat} effect on simulation time, K_s extreme values of the tested range leads to the least simulation time, while the peak simulation time was achieved in the middle value of 0.295 cm/min which took twice the time of the 0.047 cm/min as they was simulated in 46 and 23 seconds respectively.

5- Air entry inverse (α) effect is nearly like the θ_{sat} effect on wetting pattern, as it increases the wetting depth and decreases the wetting width, the least simulation time was obtained at the middle range values of α while peak time is obtained at the edges. The similarity of α plots to the θ_{sat} plots may be attributed to the direct physical relationship between them through the soil-water retention curve.

6- The retention fitting parameter n has no effect on wetting pattern within the tested range values Fig(5 a, d and c),

7- Mualem's fitting parameter (Υ), was found to be ineffective to the wetting pattern and to the simulation time as well, but an exception in the Υ=0.6 value, as it spread the saturation zone in depth and width, and doubles the simulation time. This could be ascribed to equation instability due to this value. The insignificant effect of on the wetting pattern supports the approximation made by van Genuchten et al. (1991) to take an average value of 0.5 to all soils.

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Effect of Soil texture on soil wetting pattern.

The wetting pattern it is deep and narrow in sandy soils, and shallow and wide in clayey soils. A study was done on the twelve main textures to find out the location of the previously considered isolines' values (0.11, 0.19, 0.27, and 0.35).

The study was applied to a soil profile of 50 cm depth, 35 cm width (radius), grid spacing of 2.5 cm, and cumulative water volume of 12 liters. However, soil physical properties default values varied according to each texture. The suggested default values are shown in Table (5).

Table (5) Soil properties of some soil texture classes in the model case-study.

Texture Class	Symbol	θ_{sat}	θ_{res}	θ_{begin}	n	α (cm^{-1})	K_s (cm/min)	Υ
Sand	S	0.376	0.073	0.085	2.930	0.090	0.4950000	0.5
Loamy Sand	L Sa	0.387	0.081	0.109	2.013	0.079	0.2431940	0.5
Sandy Loam	Sa L	0.413	0.090	0.132	1.669	0.051	0.0736800	0.5
Loam	L	0.443	0.122	0.156	1.517	0.024	0.0470000	0.5
Silt	Si	0.429	0.116	0.095	1.523	0.011	0.0578333	0.5
Silty Loam	Si L	0.453	0.137	0.197	1.536	0.013	0.0606667	0.5
Sandy Clay Loam	Sa C L	0.450	0.125	0.175	1.405	0.040	0.0091597	0.5
Clay Loam	C L	0.479	0.154	0.200	1.362	0.017	0.0056806	0.5
Silty Clay Loam	Si C L	0.503	0.178	0.218	1.375	0.009	0.0077153	0.5
Sandy Clay	Sa C	0.465	0.169	0.294	1.218	0.030	0.0078819	0.5
Silty Clay	Si C	0.500	0.176	0.326	1.205	0.011	0.0066736	0.5
Clay	C	0.503	0.181	0.359	1.171	0.012	0.0102431	0.5

The results of the case-studies were plotted in Fig (6). As shown in chart (1a) the heavy textured soils was simulated faster than light texture soils. Silt texture soil was simulated in longer time compared to other texture classes.

Charts (1b) and (1c) show the wetting pattern depth and width. No trend could be expected to all texture classes, some trends found within the fine textured group and within the coarse to medium group.

In the coarse to medium textures' group, the minimum depth of 0.35 isoline trend appears to be increasing in the coarse to fine

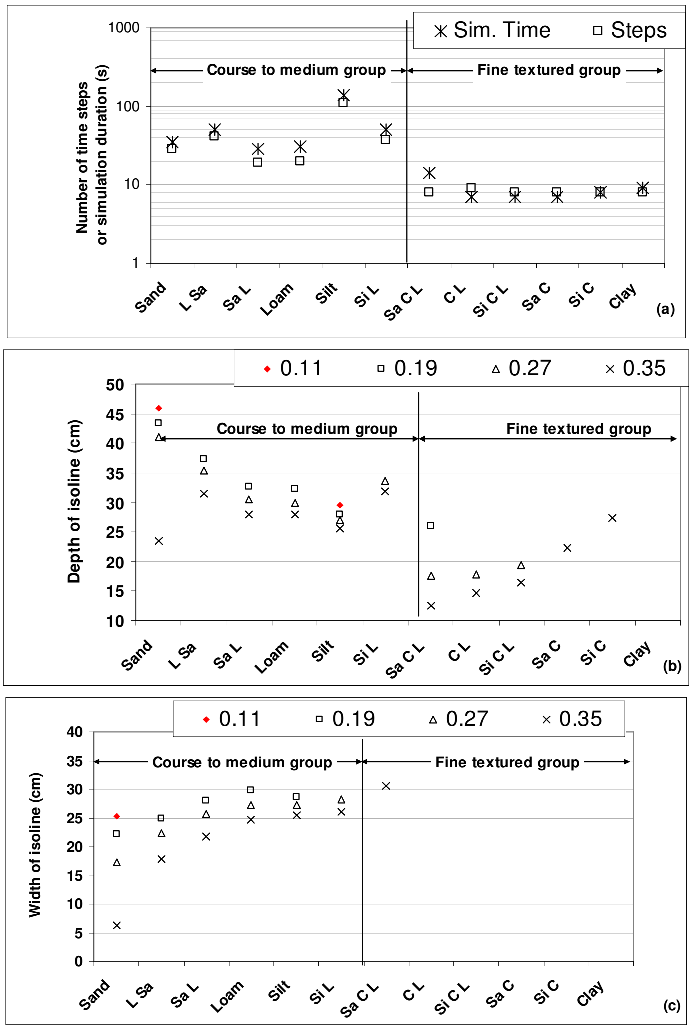


Figure (6) Texture class study using the "Drip Chartist" model.

direction. In the heavy textures group, the 0.35 isoline is moving deeper as the texture going finer. This could be ascribed to θ_{res} and θ_{begin} always increase when the texture goes finer.

For the same reason, however, the width of isolines increase in the coarse-to-fine direction as shown in chart (c), However, the output charts of the "Drip Chartist" induce the reality that fine textured soils let the water spread horizontally than vertically, while the contrary is right for the coarser texture classes.

Soil properties calculation method effect on wetting pattern.

The major formulas affect soil-water infiltration relationships are the retention models (van Genuchten's (VG) and Brookes and Corey's (BC) relationships), and the conductivity models like of Mualem's and Burdine's. Moisture pattern affected by either formula, Another calculation method affect moisture pattern is the matric flux potential (MFP) integration method.

The study was applied to sandy soil, with a profile of 18.75 cm depth, 13.75 cm width (radius), grid spacing of 1.25 cm, and cumulative water volume of 0.75 liters.

Three retention models were tested; VG, BC, and mixed model of them. Two conductivity models were tested as well; Mualem's, and Burdine's. Also, two integration formulas were examined; Trapezoidal, and Simpson's. The retention and conductivity models case study were plotted in Fig (7).

As shown in fig. (7a), the fastest simulation has been established through the combination BC retention model, with Burdine's conductivity model. It was done in 12 seconds, while the slowest simulation was that of VG-Mualems' combination as it spans 64.5 s.. However, for the retention models, the speed sequence was BC, Mixed, then VG models from faster to slower, for the conductivity models, Mualems' model appear to take more time than Burdines' in all benchmarks, nonetheless, no difference was found between Simpson's and trapezoidal integration methods in time.

According to the effect on wetting pattern, charts 2b and 2c in Fig (7) the changing in calculation method changes the shape of wetting pattern, especially in the saturated area (0.35 isoline) depth which fluctuate severely with the models, and the saturated area width but not as depth fluctuation. The outer boundary of the pattern had not changed as much with models (0.11 isoline), it fluctuated four cm in depth and two cm in width, this result that the model used affects the moisture content distribution within a semi fixed boundaries.

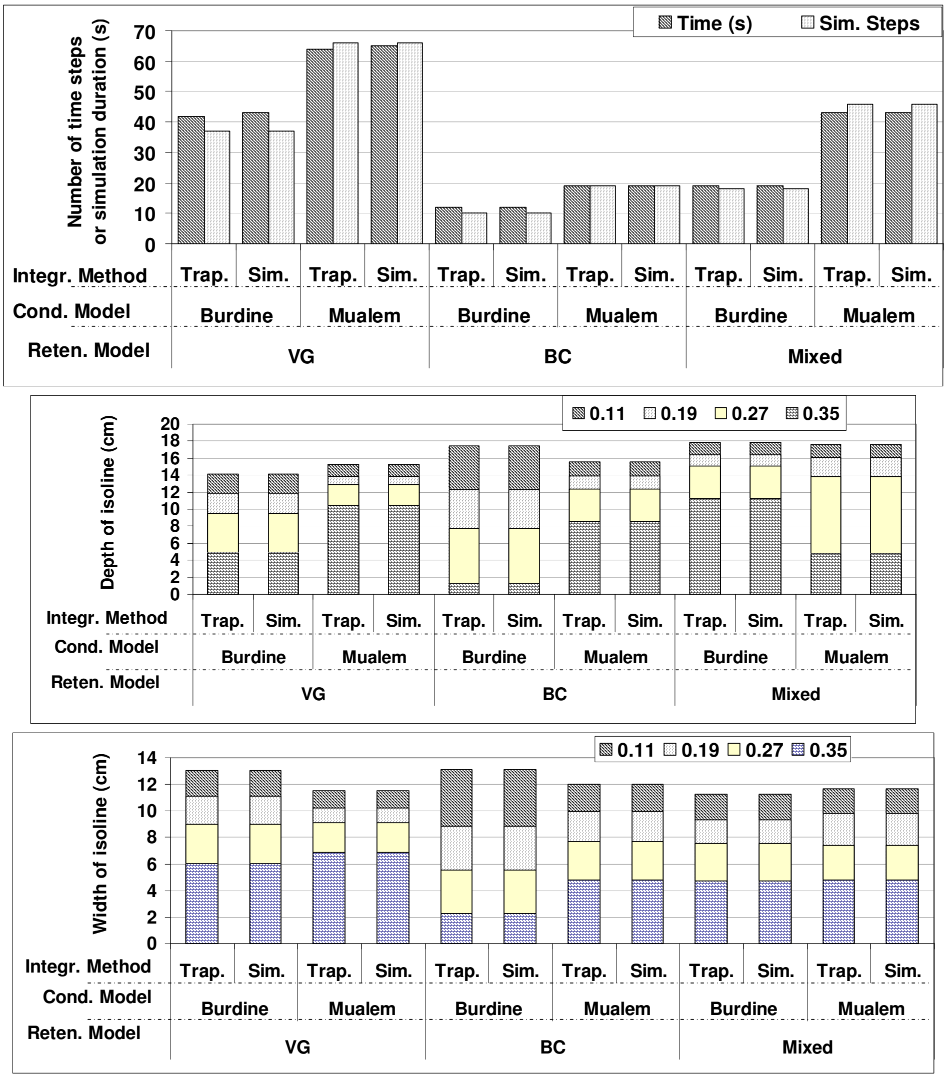


Figure (7): Study moisture model, conductivity model, and numerical integration, Studying the effect of A: simulation time, B: isolines depth, and C: isolines width.

From the above results, it can be concluded that Mualem's conductivity model lead to wider and deeper profile than Burdine's in both VG and BC retention models. This result is changed when using the mixed retention model. It is useful to validate the model results in lab or field.

<u>Bilateral gap effect on soil-water pattern.</u>

Ismail et al. 2006b studied the hydraulic barricading of water in drip system through a secondary buried dripper line. The relative location between the two lines is called "Bilateral Gap".

Bilateral gap has been varied from 4cm to 32cm with 4cm increment, each level was evaluated just after emission stopped (before redistribution), and after 6 hours of redistribution (the experiment time starts from the infiltration beginning not end.)

All studied cases applied to a sandy soil, with a profile of 50 cm depth, and 35 cm width (radius), with grid spacing of 2.5 cm. Each case had two recorded snapshoot. One after cumulative volume of 2 liters, and the other after emission stopped and redistribution takes action for 6 hours. Redistribution was modeled the same way as infiltration; but with the emission source discharge set to zero as reported by Campbell (1985). The upper dripper line was laid on soil surface, while the secondary line was buried on different depths.

Fig (8) shows sample of "Drip Chartist" output of five bilateral-gap spaces (8,16,24,28 and 32cm), in addition to a control treatment of single lateral case. The results indicated that as the bilateral gap increases; the wetting patterns of the "application" stage (the upper patterns) spread more in the vertical direction with a throttle appearance as the gap exceeds 12 cm till it reaches 24cm, where the wetting pattern of either emitter has been totally separated (no overlapping). This shows that the barricading effect of the second dripperline vanishes after 20cm gap space.

The water distribution pattern of six hours after opening the irrigation valve showed that:

1. Although the same amount of water was used, the bilateral system has highly effect on water redistribution compared with the single lateral.

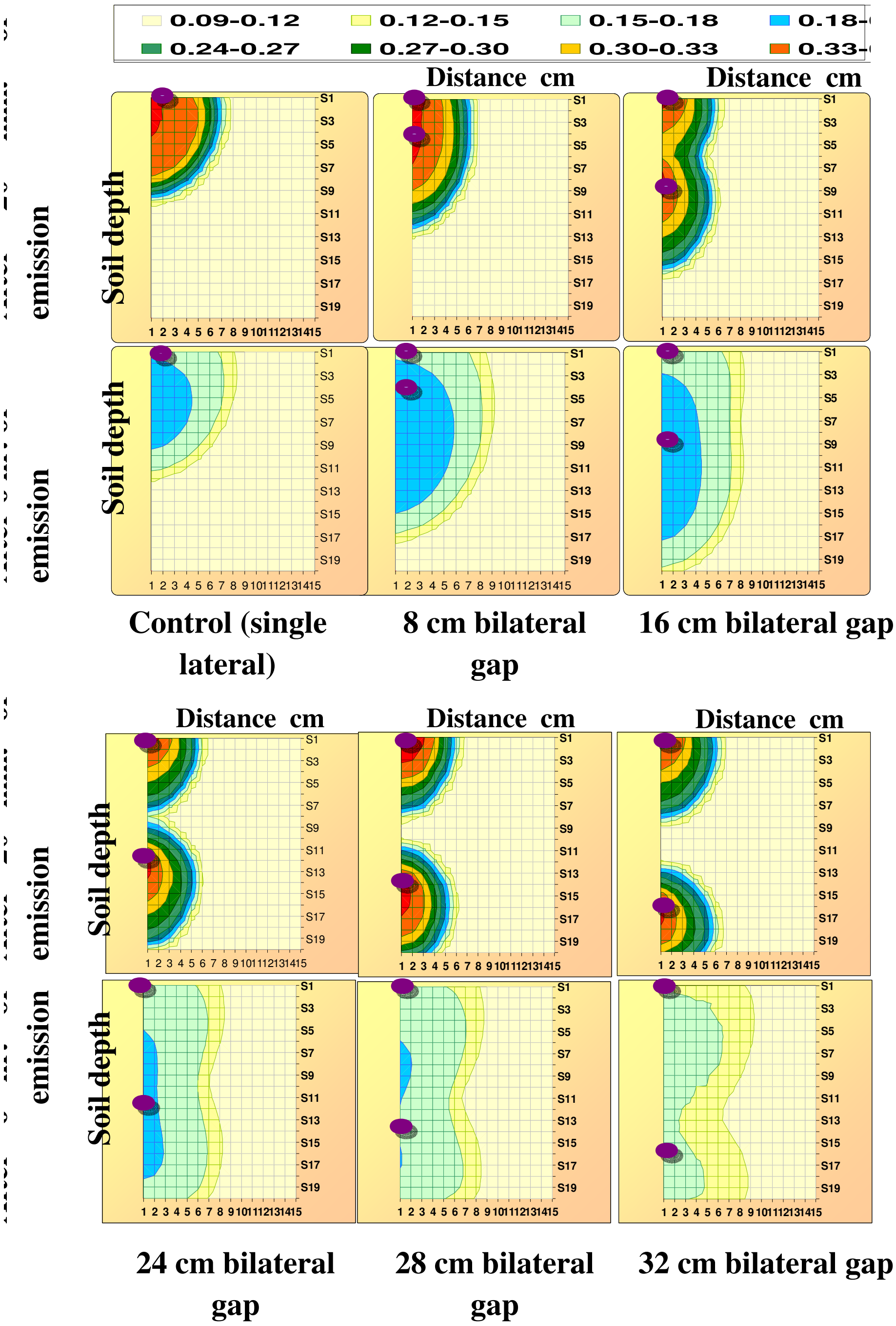


Figure (8). Drip Chartist output of bilateral gap case-study

2. As the bilateral gap space increases, the wetting pattern in redistribution spread more in horizontal direction but with low moisture content values (0.12 to 0.18)
3. Field capacity wetting range (0.18-0.21) appears in the shallow root zone only below 20 cm gap space.
4. The highest isoline occurs in the 4cm gap space (although it is not practical), but the 8 to 16 cm gap space seems to have very good wetting patterns in the root zone.

Upper lateral location effect on soil-water pattern.

Bilateral method of subsurface drip irrigation has two main variables, the location of dripper line, or the location of the upper one and the gap spacing between them. In the previous case-study the gap spacing was studied; so in this case-study, the upper dripper line location effect will be studied.

Upper lateral location was varied as 0, 6, 10, 14, and 20cm depth from soil surface. Bilateral gap level values were 6, 10, and 14cm, each case was evaluated just after emission stopped (before redistribution), and after 6 hours of redistribution. Results indicated that, in the "application" stage; the wetting pattern moves downward with the increment of upper lateral depth as shown in fig (9). On the other hand, the redistribution patterns had not been affected widely except in the smaller gap spaces, this could be ascribed to the no-flow boundary conditions, which prevents flow through lower boundary as well as side boundaries, therefore, the water is forced to be redistributed on the soil profile.

Physical barrier effect on soil-water pattern.

Physical barrier has four design parameters; depth, width, thickness, and forming shape. The effects of first two parameters on the wetting pattern were evaluated by the "Dripchartest" for 2.5 l/h water application. The wetting pattern was investigated for barrier with 30cm at three depths as 0, 25 and 30cm as shown in fig (10).

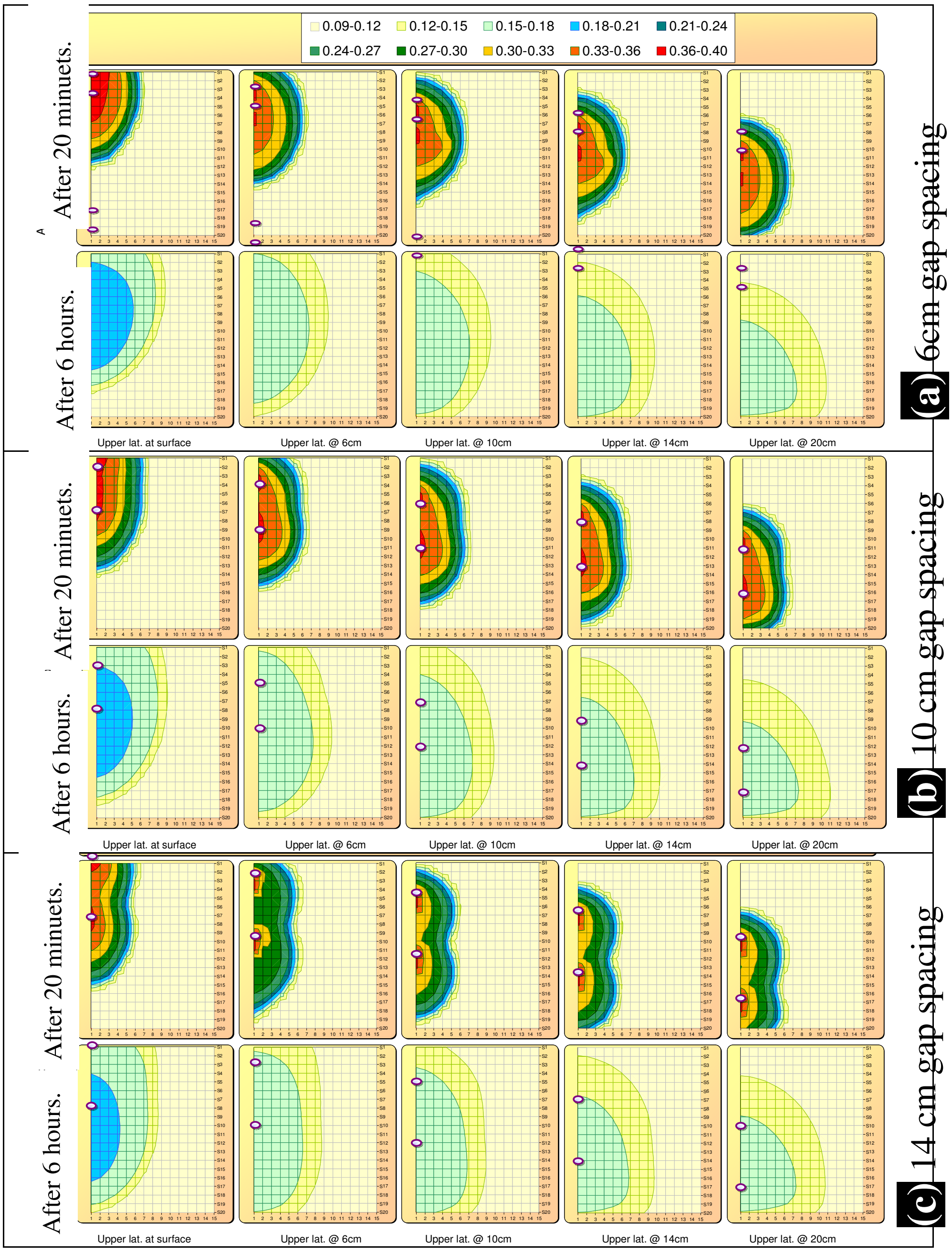
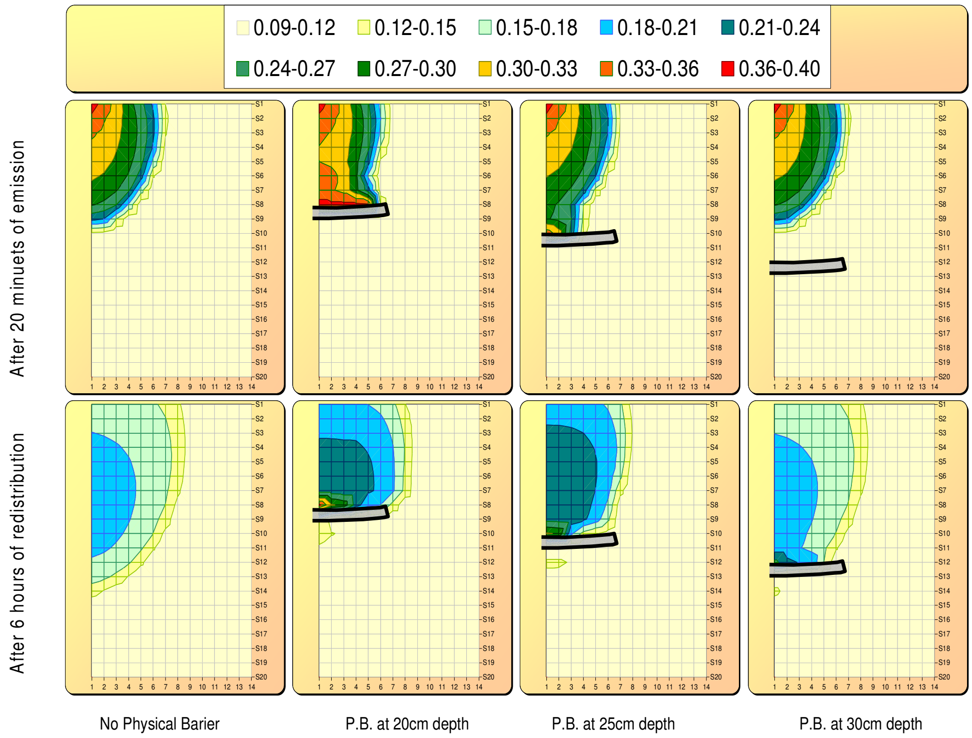


Fig.(9), Drip Chartist output of upper lateral location case-study



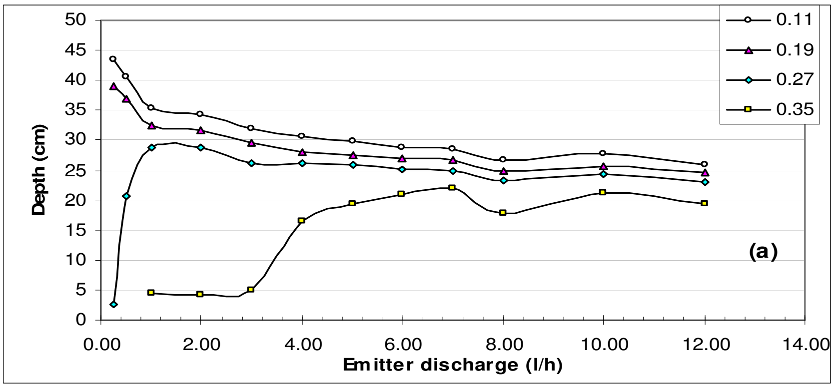
Figure(10) "Drip Chartist" output wetting pattern of physical barrier with 30cm at 20,25,30cm depth.

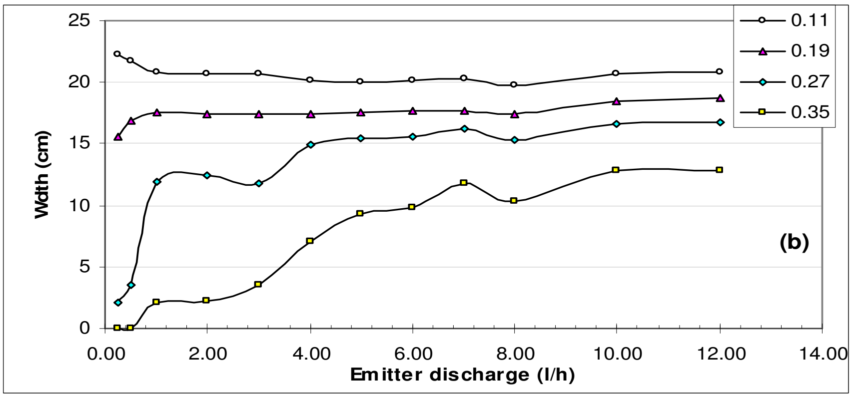
The effect of the physical barrier is noticeable at both application (after 20min.of emission and redistribution phases (after 5 hr of emission),

Based on the above, it is recommended to apply lower emitter discharge rate in sandy soil, which leads to gradual distribution of moisture content and more wetting pattern area. No effect could be noticed in the deepest barrier (30cm depth) during application phase, while noticeable during redistribution till the water reaches the barrier. The 20 cm barrier depth wider pattern than other cases, but the 25 cm barrier depth shows moisture distribution in the root zone.
According to the results, it is recommended to use a 30cm width physical barrier at 25cm depth.

Emitter discharge effect on soil-wetting pattern.

In this study the emitter discharge rate varies from 0.25 *l*/h to 12 *l*/h; however, twelve application rates were applied the study based on sandy soil, with a profile of 50 cm depth, 35 cm width (radius), and grid spacing of 2.5 cm, and cumulative volume of 5 liters.





Figure(11) Wetting pattern and simulation characteristics as affected by emitter discharge: (a), and (b) Depth and width of some moisture contents' isolines ,respectively.

The results were plotted in Fig (11). It can be noticed from chart (a), that using a larger discharge emitter lowers the location of the 0.11 isoline, while raises the near saturation front (the 0.35 isoline). In chart (b) it clear that using a larger discharge emitter does not affect the 0.11 isoline while it spread the 35 isoline to a distant location.

This means that the whole pattern is being condensed in a smaller area when using a larger discharge emitter and using low flow rate emitter let the water pattern covers more area but with gradual decrease of moisture content. The using higher flow rate emitter lets the water pattern covers less area but with almost saturated zone. This could be attributed to the limitation of infiltration rate of the soil. The higher flow rate emitter pushes a large amount of water in small time that the soil cannot redistribute to the around areas, therefore, water accumulates and saturated condition occurs in this small spreading area. On the other hand, lower flow rates allow lateral distribution of water as well as vertical distribution and hence it result in more area with no saturation occurrence.

It is advised to use higher emitter discharge rates to achieve less operation time and thus less pumping costs. On the other hand, lower emitter discharge rates lead to gradual distribution of moisture and more wetting pattern area. Doing so requires more is required but with lower pressure.

CONCLUSION

The "Drip Chartist" model verification indicated the reliability the simulation model of surface and subsurface drip irrigation especially in light textured soils. It was also proved to be able to simulate two sources of water working simultaneously one above the other.

Several model-based studies were performed to benchmark the model and concluded that:

- All of the soil properties, mostly the saturated water content, the residual water content, the beginning wetness, and the saturation hydraulic conductivity affect wetting pattern.

- Soil texture class affects wetting pattern shape significantly, on the coarse-to-fine direction, width of an isoline increase, while depth of the isoline decreases actually and increases relatively.

- The usage of either combination of retention-conductivity models results in a different wetting pattern, however, more lab experiments needed to verify which model's combination is the best match to reality in a specific texture class.

- According to the model studies, it is obviously that the best wetting pattern distribution could be achieved using gap space between the two-dripper lines of 8cm to 16cm.

- Using bilateral system in a sandy soil; shallower upper dripper line (from 0 to 10cm) with gap size of about 10 cm enhances the wetting pattern distribution in root zone.

- It was clear that using the physical barrier in sandy soil with 30cm width at 25cm depth is very satisfactory. No need of more depth or width if the infiltration time is 20 minute.

- The studies showed that using higher emitter discharge rates leads to achieve more saturated area around the root zone, and to lower operation time, and pumping energy

The results recommended of the optimum values of the model parameters, formulas, and settings to ensure accurate, reliable, and fast modeling of surface and subsurface drip irrigation system.

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نمذجة توزيع الرطوبة لنظم الري بالتنقيط السطحي وتحت السطحي

ب- تحقيق وتحليل النموذج

سمير محمد إسماعيل[1]، طارق زين العابدين[2]، محمد عبده وصيف[3]، محمد بهجت النسر[4].

تم تحقيق النموذج الرياضي "Drip Chartist" الذى قدمه Ismail et al. (2006a) بإجراء التجارب الحقلية وذلك للتأكد من دقة التنبؤ فكان معامل الارتباط بين القيم المقاسة وبين القيم المتنبأ بها تتراوح فى حالة الرى السطحى وبدون حاجز هيدروليكى ٠,٩٧ مع حيود سلبي under estimation بمقدار ٠,١٥٧ بيما فى حالة وجود الحاجز الهيدروليكى كان معامل الارتباط ٠,٩٠ و بحيود سلبى ٠,٠٢١. كما قورنت مخرجات النموذج بمخرجات نموذج آخر Hydrus2D وأظهرت النتائج توافقا يقارب التطابق بين النموذجين.

أجريت العديد من الدراسات باستخدام النموذج الرياضي، مثل دراسة تأثير عدد من خواص التربة مثل (θsat, θres, Ks,) على شكل مخطط البلل. كما درس تأثير كل من قوام التربة و النماذج الرياضية لعلاقات الشد الرطوبي وطرق الحل الرياضية على مخطط البلل أيضا. بالإضافة إلى ذلك أجريت بعض الدراسات على البدائل التركيبية للنظام حيث درس تأثير عمق دفن خط التنقيط وتأثير المسافة البينية بين الخطين فى النظام مزدوج الخط كما درس تأثير عمق وعرض الطبقة البلاستيكية التي توضع تحت النقاط فى الأراضى الرملية. كما درس تأثير تصرف النقاط أيضا على شكل مخطط البلل.

أثبت النموذج الرياضى المستنبط كفاءة كبيرة وحقق كل أهداف إنشائه للتنبؤ بشكل مخطط البلل تحت نظم الري بالتنقيط السطحي وتحت السطحي كما يلي:.

- يتأثر شكل الابتلال بكل خواص التربة الطبيعية ويزداد التأثر بخواص المحتوى الرطوبى عند التشبع و المحتوى الرطوبي المتبقي (الذي تنعدم عنده التوصيلية الهيدروليكية) والابتلال المبدئي للتربة وبخاصية التوصيلية الهيدروليكية عند التشبع.
- فئة قوام التربة تؤثر على شكل الابتلال بشدة، حيث يزيد عرض البلل ويقل عمقه كلما اتجهنا للفئات الأكثر نعومة والعكس صحيح.
- بناء على نتائج المحاكي، في نظام خطي التنقيط يجب أن تتراوح المسافة البينية بين خطي التنقيط ما بين ٨ إلى ١٦سم فى التربة الرملية. حيث يؤدي ذلك لتحسين شكل الابتلال. كما ينصح بوضع الخط الأعلى على عمق من صفر وحتى ١٠ سم لنفس القوام.
- أظهرت النتائج أن العرض الأمثل للحاجز المادي فى الأراضى الرملية يبلغ ٣٠ سم بينما عمقه الأمثل يبلغ ٢٥ سم.
- من نتائج الدراسات على المحاكي أنه ينصح باستخدام المنقط الأقل تصرفا للحصول على توزيع متجانس للرطوبة فى منطقة البلل ولتفادي مشاكل التشبع الزائد فى منطقة الجذور. على الجانب الآخر، استعمال المنقط الأقل تصرفا يحتاج زمنا أكبر للري قد لا يكون متاحا لدى بعض المزارع، ولذا يجب الموازنة بين الأمرين للحصول على أفضل النتائج.

[1] أستاذ نظم الري، رئيس قسم الهندسة الزراعية، كلية الزراعة، جامعة الإسكندرية
[2] أستاذ مساعد نظم الري، قسم الهندسة الزراعية ، كلية الزراعة، جامعة الإسكندرية
[3] أستاذ الأراضى المتفرغ، مركز بحوث الصحراء
[4] باحث مساعد وحدة الري والصرف، قسم صيانة الأراضي، مركز بحوث الصحراء