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DETECTING SOIL MOISTURE RETENTION CURVE FROM IN SITU MEASUREMENTS

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ABSTRACT

This work aims to detect soil moisture retention curve of sandy soil up to 15 bars using in situ measurements of tensiometers and neutron probe. An experiment had been conducted in Inshas at the Farm of Soil and Water Researches Department, Nuclear Researches Center, Atomic Energy Authority. Tensiometers and neutron moisture meter were used to determine soil matric potentials and soil moisture contents (θ), simultaneously. Some values of soil matric potential in tensiometric range and the versus moisture contents were used to calculate van Genuchten parameters (m, n, and α). This method called tensiometric method. This method and van Genuchten method are differed through the calculation of these parameters, where van Genuchten's depends on all data of θ and h until 15 bars while in tensiometric method depends on θ and h in tensiometric range only. The outputs of these methods had been tested statistically and compared with different methods to evaluate its outputs.

The obtained data showed no significant differences between the outputs of tensiometric, Brooks- Corey, and modified Brooks - Corey methods in the range of the experimental data, whenever van Genuchten, Campbell and its modified method were non- significant differences for the two depths. Brooks - Corey and Campbell's methods gave abnormal data at saturation point.

Calculations of tensiometric method are easier than van Genuchten's one and it considered field one because it depends on the in situ measurements.

Keywords: Tensiometer, Neutron probe, Soil moisture retention curve, Air entry suction.

INTRODUCTION

Combination work between tensiometers and neutron scattering meter had been played an important task in situ measurements to obtain the actual hydrophysical soil properties.

Neutron moisture meter is an indirect tool to determine the soil moisture content in situ using fast neutron scattering. The advantage of this method is the determine of soil moisture contents in the deeper soil depths without soil destruction. Adding to this point, the obtained results are high accurate. As well as neutron moisture meter could used to determine many of soil hydraulic properties which related to soil moisture content e.g. Soil water storage, soil moisture characteristic curve, irrigation scheduling and unsaturated hydraulic conductivity. (El-Gendy, 1989).

Soil moisture retention curve (SMRC) is the relationship between the values of soil moisture content (θ) and soil matric suction (h). It is a main soil hydro-physical property and can be used for determining soil hydraulic properties and their applications (i.e. Unsaturated hydraulic conductivity, Hydraulic diffusivity, Diameters of soil pores, Soil field capacity, Wilting point, Available water, Soil water stress and Irrigation scheduling).

IAEA (1976) used in situ measurements of neutron moisture meter for soil moisture contents and tensiometers for soil matric suction to obtain the soil moisture retention curve in tensiometric range.

Talha *et al.* (1979) showed that the amount of water retained in the soil at relatively low values of matric suction (ranging between 0-1 atm of suction) is depend primarily upon the capillary effect and pore size distribution and hence, it is strongly affected by soil structure. The inflexion point lies mostly at log tension higher than 3 hence the moisture content at this point can not express the soil moisture content at the field capacity.

El- Gendy (1989), and El-Gendy et al (2000) used a method of IAEA (1976) for determining soil moisture retention curve of soils of Nubarria and Wadi Sudr soils in tensiometric range.

Many authors had been used the outputs of the laboratory methods and the numerical models to express the soil moisture retention curve e.g., Brooks and Corey (1964); Campbell (1974) and van Genuchten (1980)

In the last few years' numerical models for simulating fluid flow in unsaturated zone has used increasingly popular. Forty years ago till now, many authors express SMRC in mathematical models (King, 1965; Brutsaert, 1967; Taylor and Luthin, 1969; Farrell and Larson, 1972).

Several investigators express the soil moisture retention curves in numerical models (Brooks and Corey, 1964; Campbell, 1974 and van Genuchten, 1980).

Vereecken (1988) subdivided empirical soil moisture models into four categories based on there functional: (1) exponential (2) power (3) Cosine hyperbolic and (4) Error functions. Many authors used a power function relationship to characterize soil moisture retention curve (Brooks – Corey 1964; Visser, 1966 Campbell 1974 and van Genuchten, 1980).

Brakenscik (1977) used the matric suction up to 100 cm water to determine the bubbling pressure or air entry suction (h_b) and pore size index (λ). The later parameter (λ) is close related with both n and m parameters of the van Genuchten model.

SMRC which depends on five parameters (i.e. residual soil moisture content θr); total soil porosity (ϕ); bubbling pressure (h_b) and (n, m) which are constants depend on curve shape.

Hamish *et al.* (1996) used two large sets (A, B horizons) of soil water content data from soils of Australia to evaluate five widely used equations (Brook – Corey, Campbell, Hutson – Cass, King and van Genuchten). They found that the sigmoidal equation of (Hutson – Cass, King and van Genuchten) described the measured soil water contents with high accuracy. As for the simpler power – Law functions also gave a very good description and most of the occurred at water content near saturation from physically unrealistic equation discontinuity around the air entry potential.

El- Gendy *et al.* (2000) used the neutron calibration equation to express soil moisture content in van Genuchten's model to obtain the soil matric potential in situ directly. The obtained model could be used to carry out the irrigation scheduling on basis of detecting the soil matric suction.

The objective of this work is to detect soil moisture retention curve up to15 bars using in situ measurements of both tensiometers and neutron moisture meter.

MATERIALS AND METHODS

This work was conducted in the Farm of Soil and Water Department, Nuclear Research Center, Atomic Energy Authority, Inshas. Some physical, hydrophysical and chemical properties of Inshas sandy soil were determined according to the standard methods of Klute (1986). Residual moisture content (θr) was determined using air dry until reaching constant soil moisture content and saturation point (θs) equals total porosity (ϕ) approximately. Tables (1 and 2).

Neuron calibration curves at different soil depths were determined using neutron moisture meter CPN, 50mCi. (503 Dr hydro-probe) Americium-241 Beryllium source according to IAEA (1976). Table (3) shows the regression equations of neutron calibration curves at 30 and 45 cm soil depths under study.

Volumetric soil moisture contents were determined at 100, 300, 1000, 3000, 5000, 8000, 10000 and 15000 mbar using pressure plate apparatus according to Klute (1986) to obtain the soil moisture retention curve data.

The experimental area was a plot of 100-m^2 (10m × 10m). An access tube of neutron moisture meter was installed in the center of the plot to detect the changes of soil moisture content at the two depths (45 and 60 cm) after different times from flooding. Water content of the surface soil layer was determined using gravimetric method. Three sets of tensiometers were replicated at the studied soil depths. Each set was installed at 50- cm far from the neutron access tube to avoid the interaction between the fast neutrons and the water in tensiometers. These tensiometers were used to determine the values of soil matric potential.

Different models had been used to represent the (θ and h) relationship. These models are:

van Genuchten's model (1980) Eq. 1:

$$\theta_h = \theta_r + (\phi - \theta_r)[1 + (\alpha h)^n]^{-m} \quad \text{------} \quad (1)$$

Where:

θ_h, is the volumetric soil moisture content at h ,mbar

θ_r, is the volumetric residual soil moisture content,

ϕ, is the total porosity [taken equals to saturation point on volume fraction],

α, is the inverse of the air entry suction, and

n &m , are constants of the fitting soil moisture retention curve.

Brooks and Corey's model (1964) depends on λ parameter (pore size index) and h_b (air entry suction. mbar). Eq. 2

$$(\theta - \theta_r) / (\phi - \theta_r) = (h_b / h)^{\lambda} \quad \text{----------------} \quad (2)$$

θ_r, is the volumetric residual soil moisture content,

ϕ, is the total porosity,

h_b,is the air entry suction,
h, is the matric suction.

Modified Brooks and Corey, model (according to van Genuchten and Nielsen, 1985), Eq. 3:

$$\theta = \phi \quad \text{----------------------------} \quad h \leq h_b \ (3a)$$

$$\theta = \theta_r + (\phi - \theta_r)(\alpha h)^{-\lambda} \quad \text{-----------} \quad h > h_b \ (3b)$$

Campbell's model (1974) as in Eq. 4:

$$\theta = \phi (\alpha h)^{-\lambda} \qquad (4)$$

Modified Campbell's model (1985) as in Eq. 5:

$$\theta = \phi \quad \text{----------------------------} \quad h \leq h_b \ (5a)$$

$$\theta = \phi (\alpha h)^{-\lambda} \quad \text{--------------------} \quad h > h_b \ (5b)$$

Tensiometric method (under study)

The method of van Genuchten (1980) depends on a single point to calculate m, n and α while the tensiometric method depends on the number of (θ & h) relationship points to be more suitable for calculating m, n and α parameters. The experimental data in tensiometric range (0-850 mbar) were determined using tensiometers and neutron moisture meter. Soil matric suction can be used to calculate the pore size index (λ) (Brooks and Corey 1964) according to Brakensiek (1977). This method can be calculate (λ) from the Log of the effective soil moisture content $\left(se = \dfrac{\theta - \theta_r}{\theta_s - \theta_r} \right)$ and Log matric suction (mbar).

Brakensiek (1977) calculated h_b at S_e=1 in the linear regression equation as in Eq. 6:.

$$\text{Log Se} = A - B \text{ Log h} \quad \text{-------------------} \quad (6)$$

Substitution with S_e=1 in Eq. 7 to obtain the air entry suction (h_b) as in Eq. 7:

$0 = A - B \text{ Log } h_b$, then. $\text{Log } h_b = \dfrac{A}{B}$

$$h_b = 10^{A/B} \quad \text{--------------------------------} \quad (7)$$

From h_b, it can calculate α using the relationship between α and h_b ($\alpha = 1/h_b$).

Tensiometric method is the modified method to calculate m, n and α of van Genuchten's model (1980). This method uses van Genuchten's model (1980) to calculate θ of soil moisture retention curve.

3:4: Statistical procedures.

Statistical analysis and equation fitting were done using " EXCELL" program on a personal computer.

Table (1): physical and hydrophysical properties of Inshas sandy soil.

Soil depth cm	Particle size distribution			Texture class	Bulk density g/cm^3	Total porosity cm^3 cm^{-3}	θr*	Ks cm/h
	Sand	Silt	clay					
45	96.1	1.3	2.6	Sandy	1.78	32	0.020	71.2
60	96.1	1.1	2.8	Sandy	1.73	34	0.018	71.3

*θr is the residual soil water content

Table (2): chemical properties of Inshas sandy soil.

Soil depth Cm	Soluble cations (meq/L)				Soluble anions (meq/L)				SAR	EC, dS/m	PH
	K^+	Mg^{++}	Ca++	Na^+	CO_3^-	$H CO_3^-$	Cl^-	SO_4^-			
45	0.19	1.10	4.40	2.65	---	3.10	5.00	0.24	1.598	0.6	7.6
60	0.18	1.60	3.90	3.63	---	3.50	5.10	0.71	2.245	0.7	7.6

EC and Soluble cations and anions in soil paste
PH in soil suspension of 1: 2.5 soil: water

Table (3): Regression equations of neutron moisture meter at different soil depths of soil under study

Depths	Regression equation	Coefficient of determination R^2
45	θ = 0.1171 C.R – 0.0149	0.9642
60	θ = 0.0952 C.R - 0.0069	0.9443

θ, is the volumetric soil moisture content
C.R, is the neutron count ratio (count in soil / count in shield).

RESULTS AND DISCUSSIONS

Data in Table (4) show the soil moisture content on volume basis (θ) as a function of soil matric suction (h) at 45 and 60 -cm depths of Inshas sandy soil. The relationship between the two variables (θ & h) represents soil moisture retention curve (SMRC). This relationship had been detected with an integrated work between in situ measurements with neutron scattering method and gravimetric method in the laboratory for determining soil moisture content. As for the soil matric suction that had been detected by the integration between tensiometers and pressure plate- apparatus. Soil matric suction in tensiometric range was detected for calculating (α, n and m) of van Genuchten's model using Tensiometric method. These parameters beside the residual soil moisture content and saturation point according to van Genuchten's model were used to predict soil moisture contents from saturation to wilting points. As for van Genuchten's method all h values of the experimental data of (θ and h) had been used to calculate the model parameters (α, n and m) in van Genuchten's model as in equation (1).

Data in Table (4) reveal that soil moisture content in Inshas sandy soil at 60-cm depth is always higher than at 45-cm depth, at the same values of soil matric suction. This finding can be interpreted using the pore size distribution according to the classification of De Leenheer and De Boodt (1965).

According to the relationship between soil moisture content and the diameter of soil pores (El - Gendy and Bedawy, 2002) the size of drained pores can be determined using equations 8 and 9 for both soil depths under study:

Fig (1) show the pore size distribution of Inshas sandy soil at 45 and 60-cm depths

$$P_{45cm} = 0.018 + (0.3103)\left[\left(\frac{d\mu}{3000\alpha}\right)^{-1.6641} + 1\right]^{-0.3918} \quad ------8$$

$$P_{60cm} = 0.02 + (0.3008)\left[\left(\frac{d\mu}{3000\,\alpha}\right)^{-1.6039} + 1\right]^{-0.3765} \quad -------9$$

According to the classification of De Leenheer and De Boodt (1965).Volume drained pores (VDP) in Inshas sandy soil are high (88.8 and 86.3 % from the total porosity) at 45 and 60- cm depths. This is a logic characterization of sandy soil because it has loose structure and high percent of coarse sand. So, the quickly drainable pores (QDP) are dominant (81.8 and 78.4% at the same depths, respectively). It can notice that QDP at 45-cm depth and higher than at 60-cm depth, so, the depleted water from 45-cm to 60-cm depth is more than from 60-cm depth to the deeper depths. The effect of slowly drainable pores (SDP) and the coarse capillary pores (CCP) are smaller. Whenever, Water holding pores (WHP) at 45-cm was less than that at 60-cm depth (5.3 and 6.7 %, respectively), that is making the soil moisture contents at 60-cm depth higher than that at 45-cm depth.

Table (4): Soil moisture contents and soil suctions at 45 and 60 cm depths of Inshas sandy soil

45 cm depth		60 cm depth	
h. bar	Exp. θ	h. bar	Exp. θ
20	0.1300	20	0.1640
35	0.1100	25	0.1340
40	0.1070	30	0.1250
46	0.0940	35	0.1112
48	0.0900	38	0.1090
51	0.0910	45	0.1010
70	0.0780	50	0.0960
75	0.0680	80	0.0810
80	0.0620	95	0.0690
88	0.0600	110	0.0680
96	0.0570	120	0.0630
100	0.0550	160	0.0610
110	0.0540	330	0.0440
120	0.0600	1000	0.0320
186	0.0550	2000	0.0270
330	0.0380	3000	0.0250
1000	0.0250	5000	0.0220
2000	0.0270	8000	0.0200
3000	0.0250	10000	0.0200
5000	0.0220	15000	0.0200
8000	0.0200		
10000	0.0188		
15000	0.0180		

(In situ) shaded area , (lab) the others

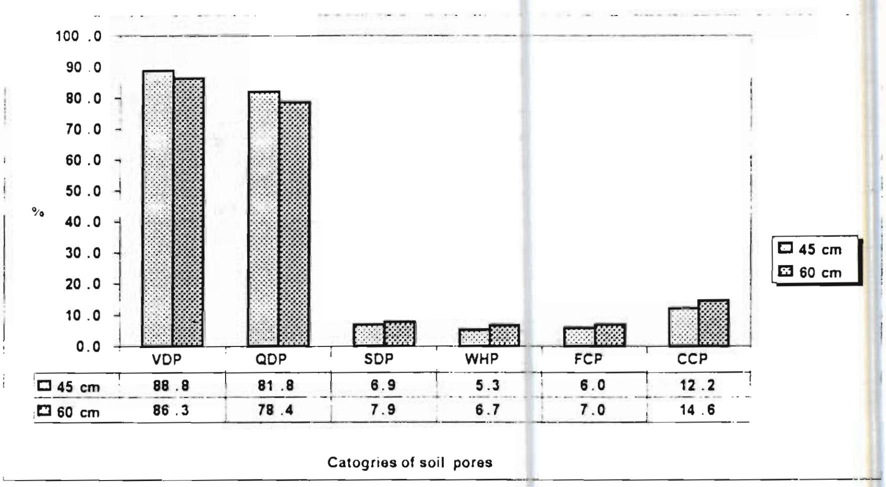


Fig (1): Pore size distribution at both 45 and 60-cm depths of Inshas sandy soil

Van Genuchten's calculations require the total experimental data (from 20 to 15000 mbars) to calculate (α, n and m) for 45 and 60 -cm , which are obtained in Table (5). van Genuchten's model for 45 and 60 - cm depth are shown in equations (10 and 11) :

At 45 cm depth

$$\theta_h = 0.018 + (0.3103)\,[1+(0.1231\,h)^{2.0311}]^{-0.5077} \quad \text{-------- (10)}$$

At 60 cm depth

$$\theta_h = 0.0200 + (0.3008)\,[1+(0.1021\,h)^{1.9661}]^{-0.4914} \quad \text{----- (11)}$$

Tensiometric method, which don't need the all experimental data as in van Genuchten method but needs a set of data in tensiometric range beside the residual soil moisture content and saturation point. So, the matric suctions of (20 to 186 mbar and from 20 to 160 mbar) were used to calculate (α, n and m) for 45 and 60 cm depths. These calculations are shown in Tables (6 and 7). While van Genuchten's model at 45 and 60 - cm depths using (α, n and m) via calculations of tensiometric method had been represented SMRC at the two soil depths under study, equations (12 and 13):

At 45 cm depth

$$\theta_h = 0.018 + (0.3103)\,[\,1 + (0.2098h)^{1.6441}\,]^{-0.3918} \quad (12)$$

At 60 cm depth

$$\theta_h = 0.0200 + (0.3008)\,[\,1 + (0.1919h)^{1.6039}\,]^{-0.3765} \quad (13)$$

Table (5): Values of soil moisture retention curve parameters at 45 and 60-cm depth, which calculated according to both van Genuchten and tensiometric methods

Parameter	van Genuchten's method		Tensiometric method	
	45cm	60cm	45cm	60cm
M	0.5077	0.4914	0.3918	0.3765
N	2.0311	1.9661	1.6441	1.6039
α	0.1231	0.1021	0.2098	0.1919
h_b	8.1256	9.7924	4.7660	5.2120
λ	-	-	0.6441	0.6039

Tables (6 and 7) and Figs. (2 and 3) show and illustrate the calculation of SMRC's parameters using tensiometric method in sandy soil at 45 and 60 cm depths.

Table (6): Values of van Genuchten's constants which obtained using the tensiometric method at 45 cm depth

h. mbar	Exp.θ	log h	log Se
20	0.1300	1.3010	0.4398-
35	0.1100	1.5441	0.5252-
40	0.1070	1.6021	0.5396-
46	0.0940	1.6628	0.6082-
48	0.0900	1.6812	0.6316-
51	0.0910	1.7076	0.6257-
70	0.0780	1.8451	0.7108-
75	0.0680	1.8751	0.7900-
80	0.0620	1.9031	0.8455-
88	0.0600	1.9445	0.8657-
96	0.0570	1.9823	0.8979-
100	0.0550	2.0000	0.9208-
110	0.0540	2.0414	0.9327-
120	0.0600	2.0792	0.8657-
186	0.0550	2.2695	0.9208-

A = 0.4368
B = 0.6441
Log h_b = 0.6782
h_b = 4.7660
α = 0.2098
λ = 0.6441
n = 1.6441
m = 0.3918

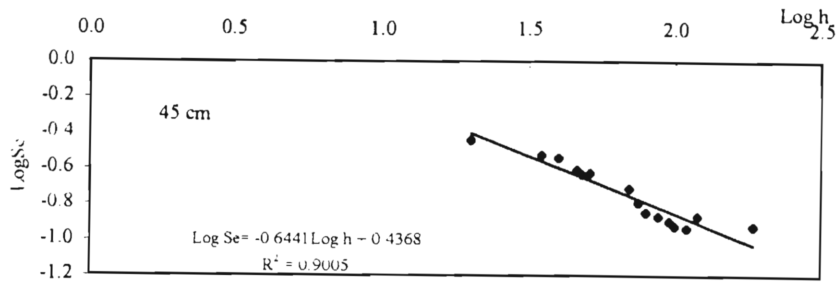
Table (7): Values of van Genuchten's constants which obtained using the tensiometric method at 60- cm soil depth

h. mbar	Exp θ	log h	Log Se	
20	01640	130103	0319915.	A = 0.433 B = 0.6039 Log h_b = 0.7170 h_b = 5.2120 cm α = 0.1919 λ = 0.6039 n = 1.6039 m = 0.3765
25	01340	139794	0421373.	
30	01250	1477121	0457089.	
35	01112	1544068	0518283.	
38	01090	1579784	0528888.	
45	01010	1653213	0569793.	
50	00960	169897	0597464.	
80	00810	190309	0692948.	
95	00690	1977724	0788082.	
110	00680	2041393	0797037.	
120	00630	2079181	0844809.	
160	00610	220412	0865494.	

Tables (8 and 9) show calculations of SMRC's parameters using van Genuchten's method in sandy soil at 45 and 60 -cm depths.

Data in Table (5) show that h_b values at 45 and 60 cm depths (using v.G. method) are higher than in the tensiometric method, that makes the values of αParameter in van Genuchten method less than in Tensiometric one because αParameter is the inverse of the air entry suction (bubbling pressure. As for m and n, which affect the slope of the curve, they are affected by the curve fitting (affected by the input of the experimental data and the method of calculation). The important thing is no significant difference between the experimental and the predicted data.

Pore size index (λ)of Brooks and Corey (1964), which is the fundamental parameter for calculating m and n, Rawls and Brakensiek (1985) mentioned that. αparameter could be calculated according to Brakensiek (1977) in the Tensiometric method, as the slope of the relationship between Log Se and Log h. It worthy to mention that, Se parameter is called effective saturation by Mualem (1976) which equals $[(\theta_h - \theta_r)/ (\theta_s - \theta_r)]$. Se values at 20 mbar at 45 and 60-cm depths were 0.3633 and 0.4787, respectively. This indicates that the soil ability to water store at the 60-cm depth is more than that at 45-cm depth. What makes sure that higher values of air entry suction at 60-cm depth (9.7924 and 5.2120 mbar) than at 45 cm depth (8.1256 and 4.7660 mbar, respectively) of calculations' v. G and tensiometric method, respectively). Increasing of h_b means that the ability of soil to retain moisture at saturation point along (h_b) stage. Rawls and Brakensiek (1985) found that (h_b) values ange rom .24 o 1.74 bar or andy oil s as ound n his work. They found that (λ)parameter was ranged from 0.6039 to 0.6491 in sandy texture soil as was found in this work.



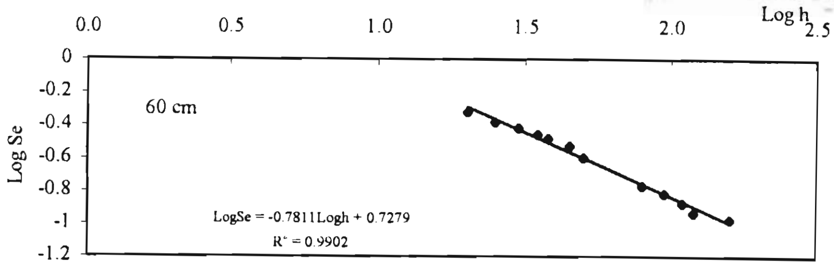


Fig. (2): The relationship between effective saturation (Se) and pressure head (h) at both 45 and 60- cm depths of Inshas sandy soil.

Tables (8 and 9) show the calculations of van Genuchten's method parameters to obtain soil moisture content and matric suction (θ_p) the midway between θ_p and θ_r where $\theta_p = (\theta_s + \theta_r)/2$, at which all parameters (α, n and m) of van Genuchten' s model, λ (Pore size index) and h_b (air entry suction) are calculated for Inshas soil at the different soil depths.

Table (8): Values of van Genuchten's constants for 45 -Cm depth of Inshas sandy soil using van Genuchten's method

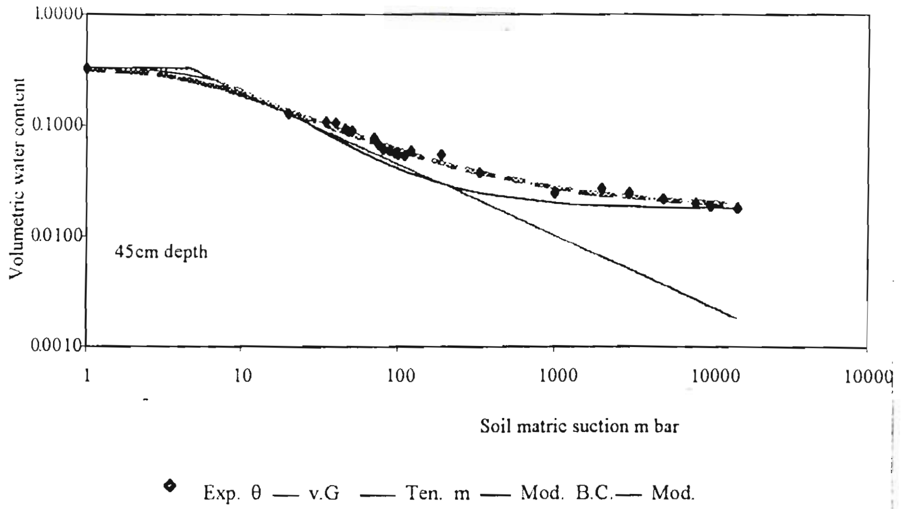
h. mbar	log h	Exp.. θ	
20	1.3010	0.1300	θ_p = 0.1732 (d.θ/d log h) = 0.2748 hp =13.7652 Sp =0.8857 m = 0.5077 n = 2.0311 α 0.1231 h_b = 8.1257
35	1.5441	0.1100	
40	1.6021	0.1070	
46	1.6628	0.0940	
48	1.6812	0.0900	
51	1.7076	0.0910	
70	1.8451	0.0780	
75	1.8751	0.0680	
80	1.9031	0.0620	
88	1.9445	0.0600	
96	1.9823	0.0570	
100	2.0000	0.0550	
110	2.0414	0.0540	
120	2.0792	0.0600	
186	2.2695	0.0550	
330	2.5185	0.0380	
1000	3.0000	0.0250	
2000	3.3010	0.0270	
3000	3.4771	0.0250	
5000	3.6990	0.0220	
8000	3.9031	0.0200	
10000	4.0000	0.0188	
15000	4.1761	0.0180	

Table (9): Values of van Genuchten's constants for 60 –cm depth of Inshas sandy soil using van Genuchten's method.

h. mbar	log h	Exp.θ	
20	1.3010	0.1640	θ_p = 0.1704
25	1.3979	0.1340	(d.θ/d log h)=0.2542
30	1.4771	0.1250	h_p =17.4064
35	1.5441	0.1112	Sp=0.8450
38	1.5798	0.1090	m = 0.4914
45	1.6532	0.1010	n =1.9661
50	1.6990	0.0960	α= 0.1021
80	1.9031	0.0810	h_b= 9.7924
95	1.9777	0.0690	
110	2.0414	0.0680	
120	2.0792	0.0630	
160	2.2041	0.0610	
330	2.5185	0.0440	
1000	3.0000	0.0320	
2000	3.3010	0.0270	
3000	3.4771	0.0250	
5000	3.6990	0.0220	
8000	3.9031	0.0200	
10000	4.0000	0.0200	
15000	4.1761	0.0200	

Data presented in Tables (10 and 11) and illustrated in Figs (3 and 4) include the input h and output θ of van Genuchten and tensiometric methods at 45 and 60 cm depths of Inshas sandy soil, as well as, the experimental data of (.θ&h), Brooks and Corey (1964), Campbell (1974). The output of tensiometric method Brooks and Corey (1964) and modified Brooks and Corey reveal no significant difference among 45 and 60 cm depths (see Tables 10 and 11).

Fig. (3) illustrates the behavior of all methods of determination at 45 and 60 cm depth for Inshas sandy soil, which are taken in consideration effect of bubbling pressure (Air entry suction). The output of Brooks and Corey and Campbell's methods had been separated in Fig (4) because they have high values of soil moisture content. They have abnormal values of saturation points (i.e. 0.8351 and 0.8853 for Brooks and Corey and Campbell methods at 45 cm depth, respectively) and (i.e. 0.8541 and 0.8693 for Brooks and Corey and Campbell methods at 60 cm depth, respectively). These values affect the shape volumes of SMRC of the other methods, which are became compacted in small range without non-characterization. So the modification for Brooks and Corey and Campbell via making the soil moisture content in h_b stage constant (equals to saturation point) as was done in El Gendy method (2001). Generally, the output of Campbell and modified Campbell do not agree with the experimental data and non- significant effects. As for the output of Brooks and Corey (1964) and the modified one (1985) they agree with the experimental data after h_b stage but there are no significant in h_b stage as shown in Fig. (3) and Fig. (4).



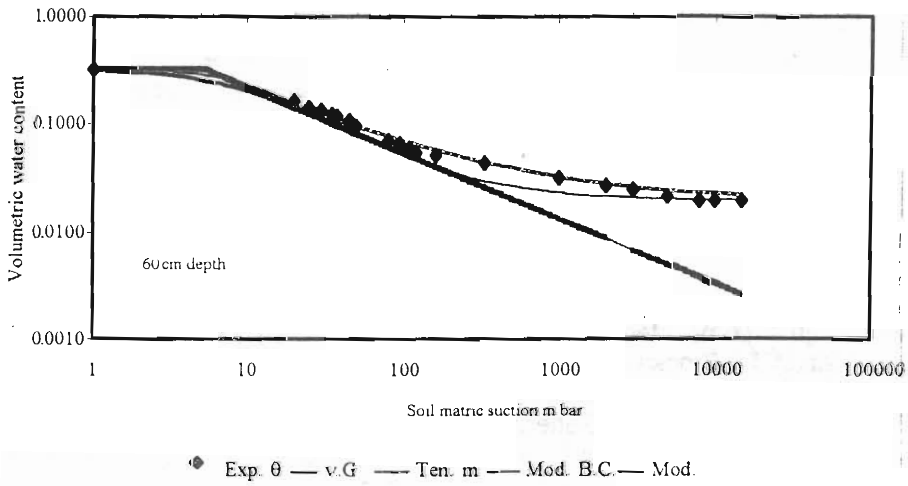


Fig (3): Values of experimental and predicted SMRC using van Genuchten, tensiometric, modified B.C. and modified Campbell for Inshas sandy soil at 45 & 60 cm depth.

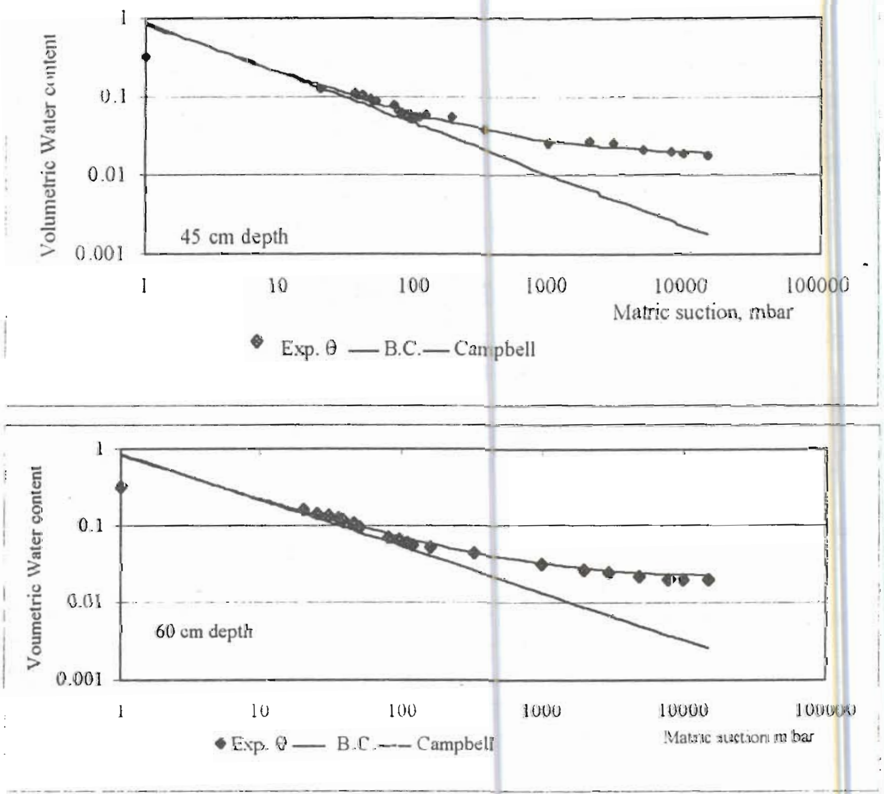


Fig (4): Values of experimental and predicted SMRC using both using Brooks.Corey (1964). and Campbell for Inshas sandy soil.

Table (11): Significance test of the variations between the experimental data and output of determination methods of SMRC at 45-cm depth

V.G (θ)	B.C (θ)	Camp.(θ)	Tensi.(θ)	Mod. B.C (θ)	Mod. Camp.(θ)
7.063	1.082	8.042	1.489	1.082	8.042

Table (12): Significance test of the variations between the experimental data and output of determination methods of SMRC at 60-cm depth

V.G (.θ)	B.C (.θ)	Camp.(. θ)	Tensi.(. θ)	Mod. B.C (.θ)	Mod. Camp.(. θ)
6.429	<u>0.005</u>	14.898	<u>0.4833</u>	<u>0.005</u>	14.898

Underline values are non-significant, where the tabulated t was 2.08 and 2.09 for 45 and 60-cm depth, respectively.

Generally Tensiometric method the accurse method to detect the soil moisture retention curve in situ until wilting point (15 bar) by using values of soil matric suction in Tensiometric range. Moreover, it can be used its model to detect the soil matric potential, which is used in irrigation scheduling, where there is no direct method in accurately to measure matric suction up to 15 bar in situ. For this propose the model will able to do this as in the following phase:

$$h = (1/\alpha)\,[\,S_e^{-1/m} - 1]^{1/n}$$

$$h = (1/\alpha)\,[\,(\,(\theta-\theta_r)/(\theta_s-\theta_r))^{-1/m} - 1]^{1/n}$$

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استبيان منحنى الشد الرطوبى الأرضي من القياسات الحقلية

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يهدف هذا البحث إلى إمكانية تتبع وتقدير منحنى الشد الرطوبى الأرضي حقليا من خلال استخدام جهاز الرطوبة النيوتروني وأجهزة الشد الرطوبى الأرضي (التنشيومترات).

في هذا البحث تم اقتراح طريقة حقلية لتقدير منحنى الشد الرطوبى الأرضي وهذه تسمى الطريقة التنشيومترية التي تعتمد على تقدير قيم الشد الرطوبى الأرضي في المدى التنشيومترى وتقدير المحتوى الرطوبى الأرضي باستخدام جهاز الرطوبة النيوتروني بالإضافة إلي معرفة الرطوبة المتبقية ونقطة التشبع، ومن خلال هذه القيم أمكن حساب ثوابت نموذج فان جنختن (١٩٨٠) لمنحنى الشد الرطوبى لأرضى، وهذه الثوابت هي n ,m. α وهى طريقة سهلة الحساب عن طريقة حساب فان جنختن. كما تستخدم الطريقة المقترحة نموذج فان جنختن للتعبير عن منحنى الشد الرطوبى الأرضي بعد تقدير هذه الثوابت. ومن مميزات هذه الطريقة إنها تعتمد على مدى من قيم الشد الرطوبى في المدى التنشيومترى فقط وكذلك القيم المناظرة للمحتوى الرطوبى الأرضي لتقدير هذه لثوابت ، في حين تعتمد حسابات فان جنختن على جميع النقط المتحصل عليها من أجهزة الشد الرطوبى المعملية ويحدد نقطة واحدة على المنحنى لتقدير هذه الثوابت. وطريقة فان جنختن معقدة الحسابات عن الطريقة المقترحة. وقد قورنت النتائج المتحصل عليها بطريقة فان جنختن وبركس كوري (١٩٦٤) والطريقة المعدلة لبركس كوري وكذلك طريقة كامبل (١٩٧٤) والطريقة المعدلة له أيضا. وقد اختبر الفرق بين النتائج المتحصل عليها مع القيم التجريبية.

١. ويمكن تلخيص أهم النتائج المتحصل عليها في النقاط الآتية: نواتج الطريقة التنشيومترية وبركس كوري (١٩٦٤) والطريقة المعدلة لبركس كوري لم تظهر أي فروق معنوية مع النتائج المعملية لمنحنى الشد الرطوبى الأرضي عند العمقين تحت الدراسة (٤٥ ، ٦٠ سم).
٢. الطريقة التنشيومترية التي تعتمد على تقدير ثوابت فان جنختن في المدى التنشيومترى كانت اكثر دقة من طريقة فان جنختن (١٩٨٠) التي تعتمد على تقدير هذه الثوابت عند نقطة واحدة على منحنى الشد الرطوبى الأرضي.
٣. طريقة فان جنختن (١٩٨٠) و كامبل (١٩٧٤) و كامبل المعدلة كان بينها وبين النتائج المعملية فروق معنوية.
٤. طريقة كامبل أعطت نتائج غير طبيعية وغير مقبولة لقيم نقطة التشبع وعند قيم الشد الرطوبى الأرضي العالية عن المقدرة معمليا.
٥. الطريقة التنشيومترية لا تحتاج لنتائج الشد الرطوبى الأرضي المعملية (وعاء وغشاء الضغط) حيث إنها تعتمد فقط على بعض القياسات الحقلية للرطوبة والشد الرطوبى في المدى التنشيومترى.