Using some equations to predict moisture content for different textures soil selected from Nineveh Governorate

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ABSTRACT

The study included three locations in Nineveh Governorate with calcareous soil deference in a texture clay, loam and sandy loam. The soils of this study were treated at three levels 0 , 4 and 8% of animal manure (cows, sheep and quails.(

It is clear from the application (Van Genuchten, 1980) equation that the factor θp has higher values in the university soil , the addition of manure was accompanied by an increase in the value of the factor θp, especially the cows then quail and sheep manure , Addition (8%) level was more evident .

Applying the (Fredlund and Xing, 1994) equation ,show that the values of factor (a) are higher in university soil . The addition of manure was accompanied by an increase in the value of factor (a), especially cow then quail and sheep manure, The level of addition 8% was more evident. The variation in the values of the factors (a, b and c) depending on the soil texture , plasticity index.

In general, the forms of both equations used have a measured and predicted moisture- retention curve (with high correlation) that is similar at low retention , at all the predicted retention curve is higher value than the measured . From knowing the percentage of each clay, silt and sand (Minitab-16 program) was used to predict moisture content within the tensions (0 - 33 - 300 - 500 - 1000 - 1500 kPa) , within high correlation coefficient.

Keywords: soil moisture content , predicted moisture - retention curve , soil texture , animal manure .

Introduction

According to his study organic amendments increased porosity, structure stability index, field capacity, wilting point, and available water amount and decreased bulk density and particle density of soil when compared to the control. We additionally determined that these organic amendments positively affected grain yield [8. [

[1] pointed out that the soil moisture description curve plays a fundamental role in

predicting soil mechanical properties such as permeability, shear stress, and unsaturated hydraulic conductivity, and that there are many mathematical models to predicate the moisture description curve based on the physical properties of the soil. Such as the plasticity index , soil content of fine particles, pores percentage , as well as the bulk density, organic matter, and soil texture.

[19] mentioned that the measuring of moisture description curve in the laboratory is considered one of the important measurements that requires effort and time, so many researchers suggested describing the moisture retention curve mathematically by using equations and nonlinear models with empirical standards to represent the moisture retention curve with the least significant difference and the best match between the experimental curve data and the calculated data among these equations and models

In a study conducted by [2] on the effect of improvers (polyacrylamide and sheep manure) to two soils with different textures (clay and loam)with predicting the moisture characterization curve using five mathematical models. While its results showed that the (Fredlund and Xing.,1994) model was better in predicting moisture content at high retentions in the same soils.

[14]By applying the (Van Genuchten .,1980) model showed that there is a great agreement between the measured and calculated values of the moisture content of ten studied soils, especially at tension (10 - 33 kilo Pascal), as the values of the determination coefficient ranged ($R^2 = 0.94 - 0.99$.(

In another study, the equation of (Fredlund and Xing.,1994) was used to test the moisture retention curve under different percentages of clay (5, 10, 15, 30, 60, and 100%). It was found that the equation can be used to estimate the moisture retention curve for soils with high or low clay content [9. [

It was concluded [1] by applying the model of the (Van Genuchten equation.,1980), which gave the highest agreement with the moisture characterization curve measured at six moisture tension , in the case of soils with textures (silty clay, clay loam, silty loam, and sandy loam), followed by soils with textures (silty clay loam and sandy clay loam) at five moisture tension , in the case of clay soils were compatible at four tensions. The values of the constant (a) in the equation (Fredlund and Xing.,1994) varied according to the soil texture, and its highest value was in clay soil (42.427), while its value was in sandy loam soil (20.144.(

Materials and methods:

Soil samples were collected from the surface layer to a depth of 0-30 cm from three locations; The first location represents the fields of the College of Agriculture and Forestry \ University of Mosul, the second location is one of the fields of the Nineveh horticultural Station \ Mosul, and the third location represents the soils adjacent to the Tigris River and in the village of Sherekhan, north of the city of Mosul, about ten kilometers. physical and chemical analyzes were conducted on it table (1. (

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Table 1. Some general properties of the studied soils locations

properties		Studied locations		
		University of mosul	Horticultural Station	Sherekhan
Soil separation	Clay g Kg^{-1}	650	210	80
	Silt g Kg^{-1}	320	490	310
	Sand g Kg^{-1}	30	300	610
Texture		clay	loam	Sandy loam
Bulk density	Mg m^{-3}	1.32	1.35	1.4
Porosity	%	50.18	49.05	47.16
Organic mater	g Kg^{-1}	20.2	20.1	10.0
EC	dS m^{-1}	0.8	2.1	0.8
pH		7.6	7.9	8.0
$CaCO_3$	g Kg^{-1}	350	210	195
Gypsum	g Kg^{-1}	Nile	Nile	Nile

The three locations are located on latitude and longitude as shown in the(table 2(

Table 2. longitude , latitude and Elevation of the study locations

Location	longitude	latitude	Elevation\m
University of mosul	43° 14' 65"	36° 38' 2"	223
Horticultural Station	43° 13' 5"	36° 36' 3"	218
Sherekhan	43° 11' 0"	36° 40' 91"	225

The experiment includes three factors: soil texture variation factor (clay, Loam, sandy loam), animal manure source factor (cows, sheep, and quail) and finally the level of addition factor (control treatment, level 4% and level 8%) with three replications.

The size distribution of soil particles was estimated by using the hydrometer method for all soil samples described by [11] . Undisturbed soil samples were brought to the laboratory using a metal cylinder with a diameter 4.6 cm and a height 5 cm [16 . [

$\rho b=Ms/Vt$---------1

The value of the porosity of the study soils was calculated from knowing the bulk density values and adopting a value of (2.65 Mg m-3) for the particle density as stated in [16. [

$f=(1-\rho b/\rho s)100$-----2

To estimate the saturated hydraulic conductivity in the laboratory, the constant head method was used for an excited soil sample using a metal cylinder with a diameter of 6.5 cm and a height of 10 cm, according to [16] equation:

$K_s= V/At \quad L/\Delta H$-------3

The main weight diameter was estimated by using the dry sieving and wet sieving methods as stated in [15] equation.

MWD= (∑_(i=1)^n⁡〖(xi)¯ wi〗)/(∑_(i=1)^n⁡Wi)- ----4

Estimate the (Potential Structural Deformation Index) in soil structure [6] according to the equation:

5---------

The upper and lower plastic limit for soil samples was estimated [17. [

The plasticity Index was calculated as stated in [7-: [

PI = LL –PL-------6

Moisture characterization curves were obtained in the laboratory and described by [16] for all soil samples at (33,300 ,500 ,1000,1500) kPa by means of a pressure cooker with a ceramic disc.

The degree of soil pH and electrical conductivity were estimated in a soil extract at a ratio of (1:1) using the pH - meter and EC-meter, respectively, according to the method mentioned in [7] .The total calcium carbonate was estimated by the titration method , as stated in [18] . The organic matter was estimated by estimation of organic carbon by oxidation using concentrated sulfuric acid and potassium dichromate titrated with ammonium ferrous sulfate, as stated in [13] .The proportion of gypsum was estimated according to the [18. [

Table 2. Some physical properties of the soils of the studied locations

properties	Unit	Studied locations		
		University of mosul	Horticultural Station	Sherekhan
initial moisture content	$g\ g^{-1}$ %	4.99	2.08	1.4
field capacity	%	25.4	22.0	15.0
permanent wilting point	%	14.8	12.5	8.2
Available water	%	10.6	9.5	6.8
Saturated water conductivity	$cm\ hr^{-1}$	2	2.6	3.8
conductivity degree		Medium	High	High
Dry mean weight diameter	mm	6.0	5.91	4.1
Wet mean weight diameter rate	mm	1.0	0.64	0.54
Potential Structural Deformation Index	%	83.33	86.92	85.82
Dry aggregate stability	%	90	72	61.2
Wet aggregate stability	%	21.72	11.2	10.1

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Results and discussion

The results in(Table 3) showed a difference in the values of θp and Sp included in the calculation of the constants (m, n , α) used in the(Van Genuchten.,1980) equation, as the values of θp were more pronounced in university soils and ranged between (0.347-0.405) while they were lower in the soil of the horticulture station, which ranged between (0.319 - 384), followed by Sherekhan soil, ranged between (0.282 – 0.321.(

Table 3a .Constants for applying the (Van Genuchten .,1980) equation on university soils

treatment	θs	Θr	Θs-θr	θp	Log(hp)	hp	d θ/d Log h	Sp	m	n	α
control	0.5	0.195	0.305	0.347	1.14	13.88	0.08	0.262	0.167	1.201	0.091
Cow 4%	0.55	0.21	0.34	0.38	1.207	16.12	0.081	0.239	0.174	1.211	0.077
Cow 8%	0.6	0.25	0.35	0.425	1.221	16.666	0.11	0.314	0.185	1.228	0.079
Sheet 4%	0.481	0.213	0.268	0.347	1.148	14.08	0.07	0.262	0.189	1.233	0.09
Sheet 8%	0.55	0.237	0.305	0.393	1.154	14.28	0.09	0.313	0.221	1.285	0.092
Quail 4%	0.5	0.2	0.3	0.35	1.187	15.384	0.076	0.256	0.185	1.227	0.082
Quail 8%	0.56	0.25	0.31	0.405	1.2	15.87	0.084	0.273	0.196	1.224	0.081

In general, an increase in the values of the factor θp is observed by adding animal manure , depending on the source of manure and the percentage of addition, the highest value was It has an addition rate of 8% when treated with cow manure (0.425, 0.384 - 0.321), followed by the addition of quail manure (0.405, 0.36, 0.31) and finally sheep manure (0.393, 0.351, 0.298) to the soil of the university and the horticulture station of Nineveh and Sherekhan, respectively

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Table 3b .Constants for applying the (Van Genuchten .,1980) equation on horticultural station soils

treatment	θs	Θr	Θs-θr	θp	Log(hp)	hp	d θ/d Log (h)	Sp	m	n	α
control	0.47	0.168	0.302	0.319	1.39	25	0.087	0.288	0.206	1.259	0.108
Cow 4%	0.52	0.216	0.304	0.368	1.5	35.7	0.07	0.23	0.168	1.202	0.057
Cow 8%	0.54	0.229	0.311	0.384	1.6	40	0.071	0.23	0.168	1.202	0.047
Sheet 4%	0.49	0.187	0.303	0.338	1.45	31.25	0.064	0.212	0.156	1.185	0.08
Sheet 8%	0.5	0.202	0.298	0.351	1.52	33.33	0.07	0.234	0.171	1.206	0.071
Quail 4%	0.5	0.189	0.311	0.344	1.52	33.33	0.072	0233	0.170	1.205	0.076
Quail 8%	0.51	0.21	0.3	0.36	1.5	32.25	0.067	0.225	0.165	1.197	0.063

The study was parallel to [4] achieved , that adding poultry manure (C/N ratio = 3.75- 4 %) to the soil is accompanied by an increase in moisture content within the tension of 10-1500 kilopascals.

It is also noted from Table (3) that the value of the constant α decreases (0.157, 0.108, 0.091) with an increase in the percentage of clay in the control soil samples (80 , 210 , 650) gm kg -1 for Sherekhan, horticulture Station and University, respectively, and this came in parallel according to the results obtained by [5] , where he indicated that the values of the constant(α) decrease (0.145 , 0.036 and 0.008) with the increase of the clay content in the soil (Sandy loam , Loam and Clay) respectively.

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Table 3c. Constants of application the (Van Genuchten .,1980) equation on Sherekhan soil

treatment	θs	Θr	Θs-θr	θp	Log(hp)	hp	d θ/d Log (h)	Sp	m	n	α
control	0.45	0.114	0.336	0.282	0.93	8	0.082	0.246	0.178	1.217	0.157
Cow 4%	0.48	0.126	0.354	0.303	1.04	11.11	0.087	0.246	0.178	1.217	0.126
Cow 8%	0.5	0.142	0.358	0.321	1.07	11.764	0.087	0.243	0.176	1.214	0.101
Sheet 4%	0.46	0.12	0.34	0.29	1.95	90.90	0.080	0.237	0.172	1.208	0.137
Sheet 8%	0.47	0.126	0.344	0.298	1	10	0.081	0.236	0.172	1.207	0.125
Quail 4%	0.47	0.126	0.344	0.298	1	10	0.081	0.236	0.172	1.207	0.125
Quail 8%	0.48	0.14	0.34	0.31	1.04	10.98	0.082	0.242	0.176	1.213	0.117

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Figure1) represents the relationship between moisture retention and volumetric moisture content values (cm3 cm-3) for control soils . In general, the moisture retention of the university soil (clay texture) is higher than that of the horticulture station soil (loam texture), followed by Sherikhan soil (sandy loam texture), Apparently the measured and predicted moisture content by applying the (Van Genuchten equation.,1980) under low retention (less than 200 kilopascals) with Similar results .

In generally the predicted values are higher than is measured . As the values of the equation constants (θS , θr and θP) which related to the characteristics of the study soil so it is possible to give higher moisture content values. The values of the correlation coefficient between the measured and predicted moisture content were high and ranged between (0.98-0.99) , this later result was parallel to [3] obtained in his study of three location in Nineveh Governorate, with a correlation coefficient ranging between (0.96-0.98 .(

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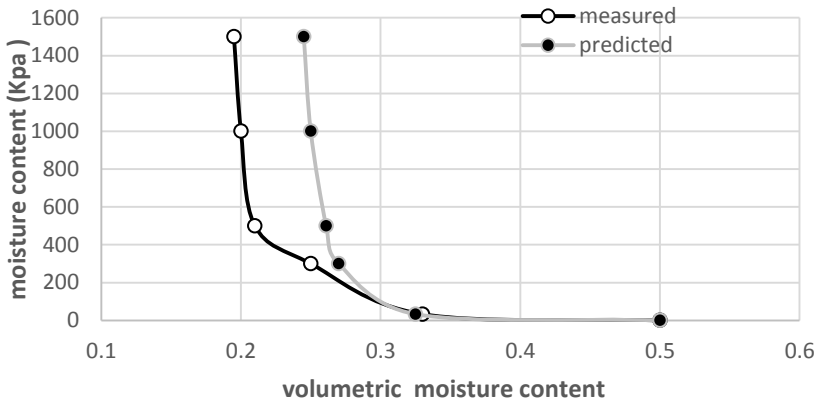

Figer (1a) the measured and predicted moisture retension curve of university soil (control treatment)

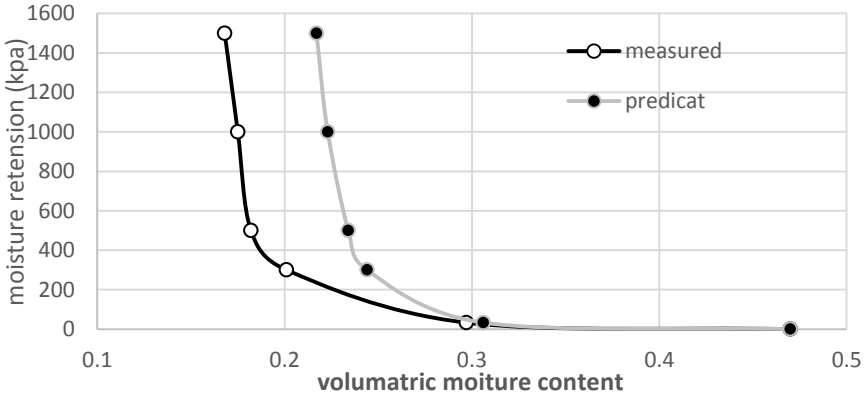

Figure (1b) the measured and predicted moisture retension curve of horticulture station soil (control treatment)

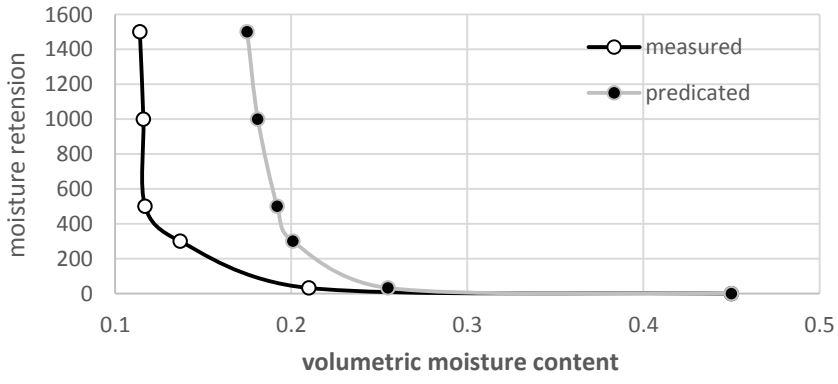

Figure (1c) the measured and predicted moisture retension curve of sherekhan soil (control treatment)

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Table 4. Volumetric moisture content %(saturation moisture content, upper plastic and lower plastic limit) for the study soils

treatment	Saturation moisture content			Upper plastic limit			Lower plastic limit			average
	university	Horticulture station	shere khan	university	Horticulture station	shere khan	university	Horticulture station	sherekhan	
control	41.2	37.5	27.47	37.76	38.61	25.47	30.71	29.71	19.11	31.65
Cow 4%	47.3	42.04	30.35	46.1	42.1	28.73	29.39	32.27	22.5	36.87
Cow 8%	58.9	55.13	40.0	51.24	50.52	35	46.27	41.04	27.72	45.09
Sheep 4%	44.01	43	30.86	42	41.94	27.41	36.85	33.94	23.84	35.99
Sheep 8%	48.3	46.31	29.3	48.03	47.56	35.5	39.23	35.6	27.83	39.74
Quail 4%	48.6	44.74	28.43	41.42	42.15	28.22	36.23	29.28	23.2	35.80
Quail 8%	53.6	48.1	36.74	52	47	32.86	40.8	34.3	27.23	41.4
Average	48.85	45.26	31.87	45.5	44.32	30.45	38.48	33.73	24.49	

)

Table 5) that the constants of the equation (Fredlund and xing, 1994) especially the factor (a) has high values in the university soil compared with the soil of the Nineveh Horticulture station, then followed by the soil of Sherekhan, and the values of factor(a) increase by adding animal manure , especially at the second level of addition 8%, then the level of 4% against the control sample. The value of factor

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Table 5. Constants of application the (Fredlund and xing ., 1994) equation.

treatment	University of mosul			Horticulture station Nineveh			sherekhan		
	a	b	c	a	b	c	a	b	c
control	22.91	1.216	0.522	14.04	1.421	0.512	21.160	1.234	0.521
Cow4%	40.31	1.05	0.533	28.94	1.138	0.527	20.996	1.237	0.521
Cow 8%	49.14	1.01	0.537	41.464	1.04	0.534	22.811	1.209	0.522
Sheep 4%	25.49	1.17	0.525	22.314	1.216	0.522	16.772	1.325	0.516
Sheep 8%	27.37	1.15	0.526	36.27	1.08	0.531	18.550	1.283	0.518
Quail4%	27.37	1.15	0.526	33.24	1.101	0.530	19.037	1.272	0.519
Quail 8%	42.09	1.04	0.534	34.0	1.09	0.530	24.988	1.180	0.524

)

a) was (49.14, 40.31, 22.91) at the level of (8%, 4% cow manure compared with soil of university sample) respectively, and this factor appears to be more evident when treating cows, then quails, and finally sheep versus the control treatment. This result in parallel with [12] concluded that the value of factor (a) gradual with increasing the level of addition of organic improvers compared to the control soil.

The reason for the difference in the values of these constants in different study locations is due to the variation in the values of the upper and lower limits of plasticity as well as the values of the plasticity index according to the different soil texture in these locations, which plays a key role and included in the calculations of these constants. Also, the different sources, characteristics and components of the organic manure used have a major role in influencing the values of these constants. In addition to the effect of organic manure on raising the saturation moisture content values θS, which is considered one of the constants in this equation.

)Figure 2) represents the relationship between moisture retention and volumetric moisture content values (cm 3 cm - 3) measured and predicted by applying the equation (Fredlund and xing .,1994) for control soil samples. In general, the moisture content of the university soil (clay texture) is higher than in the soil of the horticulture station (loam), followed by Sherekhan soil (sandy loam). It is also shown that the measured moisture content and predicted under low retention (less than 200 kilopascals) with similar values, and this result came parallel to what was reached by [1] in some of his study location . In general, the predicted moisture content values are higher than those measured, the correlation coefficient values between them are high (0.94 .(

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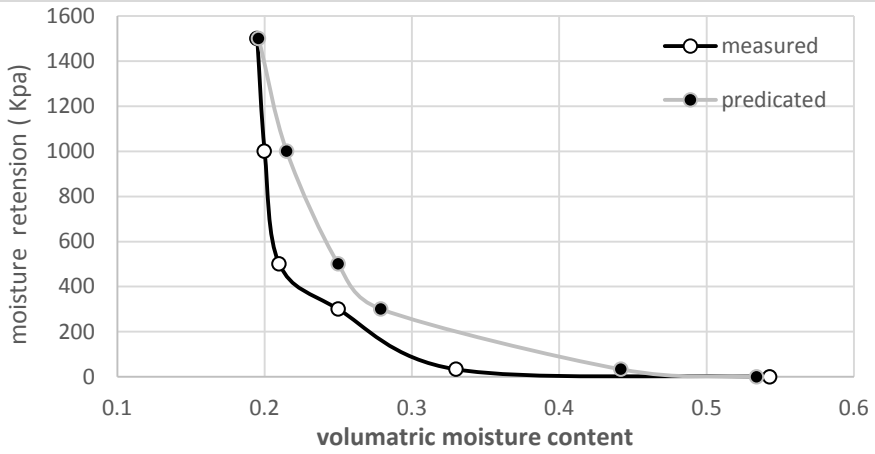


Figure (2A) the measured and predicated moisture retension curve of university soil (control treatment)

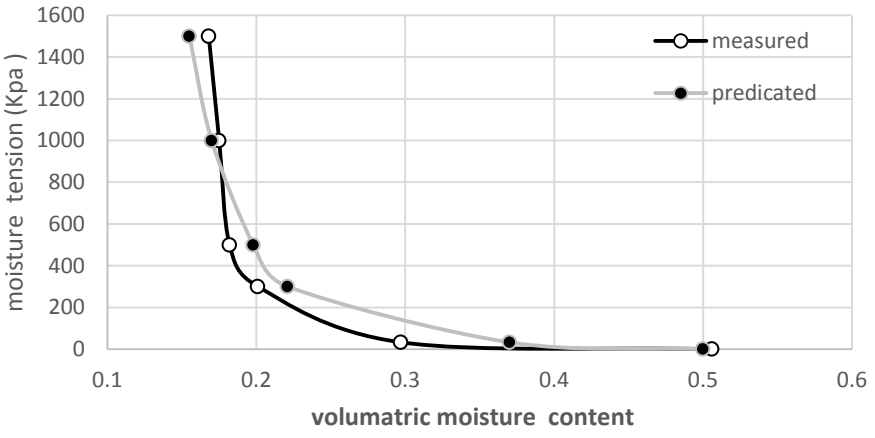
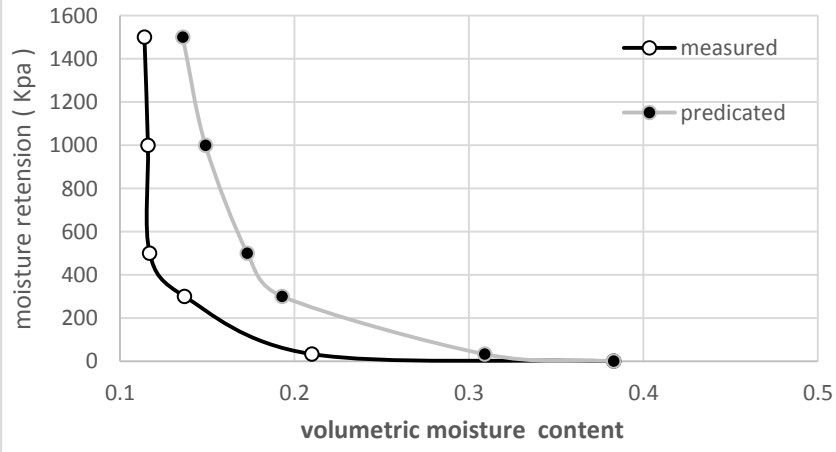


Figure (2B) the measured and predicated moisture retension curve of horticulture station soil (control treatment)



Figur (2C) the measured and predicated moisture retension curve of sherekhan soil (control treatment)

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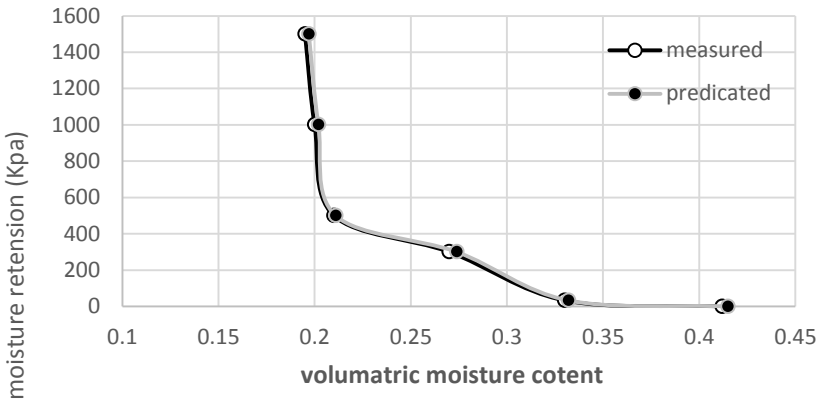
The Minitab-16 program was used to predict the volumetric moisture content within the retention of (0, 33 , 300 , 500, 1000, 1500) kPa by knowing and entering each of clay, silt and sand percentage as in the following equation:

Θv0= 0.14+0.242 Clay + 0.369 Silt
Θv33= 0.0915+0.212 Clay + 0.323 Silt
Θv300= 0.0597+0.241 Clay + 0.183 Silt
Θv500= 0.0284+0.164 Clay + 0.24 Silt
Θv1000= 0.0387+0.148 Clay + 0.21 Silt
Θv1500= 0.0409+0.144 Clay + 0.196 Silt

)Figure 3) shows the relationship between the volumetric moisture content values (cm 3 cm -3) measured and predicted using the Minitab-16 program against the moisture retention, with a correlation coefficient (r = 0.99.(



Figer (3a) the measured and predicated moisture retension curve of university soil (control treatrment)

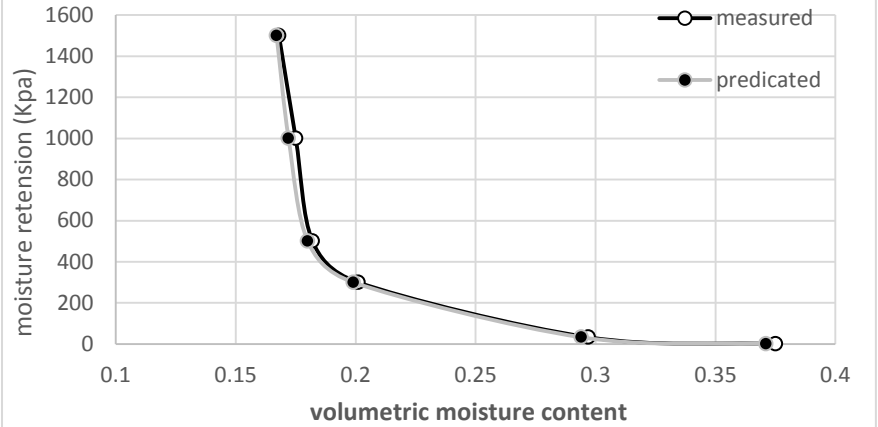


Figure (3b) the measured and predicted moisture retension curve of horticultural station (control treatment)

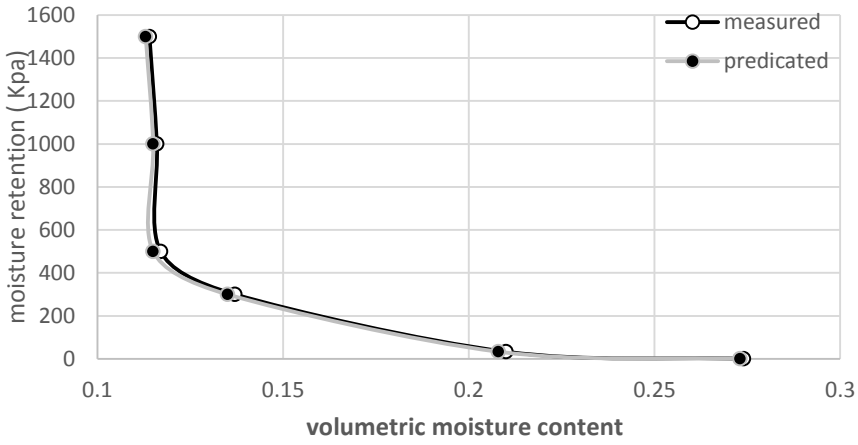


Figure (3c) the measured and predicted moisture retension curve of sherekhan soil (control treatment)

Conclusion:

Adding animal manure (cows, sheep, and quail) to soils with different textures at a rate of 4% and 8% led to an increase in the soil's ability to conserve moisture, especially at the level of 8% for cow, quail, and sheep manure compared to the control soil. In general application (Van Genuchten) and (Fredlund and Xing) equations have a measured and predicted moisture- retention curve (with high correlation) that is similar at low retention , at all the predicted retention curve is higher value than the measured.

It is possible to apply a(Minitab-16 program) to predict moisture content within different tension value , based on each clay, silt and sand percentage , with a high correlation coefficient.

Conflict of interest

Regarding the publication of this manuscript, the authors declare that there are no conflicts of interest .

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