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PREDCTION OF SOIL MOISTURE CHARACTRIC CURVE BY USING VAN GENUCHTEN MODEL (1980) AND SOILPAR2 FOR SOME SOIL AT NINEVEH GOVERNORATE

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ABSTRACT

Five locations were chosen, two of them at the university of Mosul (L1, L2), and the other at Al-Shalalat (L3), Baybokh (L4) and Khorsobad (L5), all of them were chosen different in vegetation cover at Nineveh governorate, to study the moisture content distribution, and the predicated moisture by using Van Genuchten (1980) and Soilpar2 program at four depths. Physical and chemical properties were determined, after soil samples were collected and air dry, then sieved through 2 mm sieve. Results revealed that high best fit between the measured moisture and predicted by Van Genuchten (1980) for all locations and depths at suction more than 50 Kpa, especially at 800, 1100 and 1500 Kpa respectively, with a correlation coefficient (r) ranged between (0.93-0.99). Also, result showed that the measured and predicated values were not variable with depths for all locations. The reason for that related to homogenous of soil texture. On the other hand, the measured values were variable with the predicted by using Soilpar2 between locations and depths. High best fit between the measured and predicted values at 10 and 20 Kpa for all locations, with a correlation coefficient ranged between (0.85-0.98).

INTRODUCTION

The moisture description curve (Soil Water Characteristic Curve, SWCC) is expressed by the relationship between the tensile potential (Matric potential) and the volumetric moisture content of the soil (John *et al*., 2021, Liu and Lennartz, 2019). Studying the behavior of the moisture curve is necessary to know the water Availability of the plant (Kuang *et al*., 2021), which is determined between the field capacity and the permanent wilting point, infiltration rate, diffusivity, sorptivity, water potential and Movement of soil solution within the porous medium. Soil hydrological information is required in simulation model applications for agricultural systems, groundwater dynamics, water erosion, soil conservation and other processes. There has long been a marked interest in low-cost and rapid methods for estimating soil aqueous properties from commonly available soil data (Schaap *et al*., 2001, Vereecken *et al*., 2010). Each soil has its own moisture description curve, the moisture content of soil is affected by the proportions of soil separates) Hashem and Houston, 2016). When the proportion of clay and silt increases, the amount of moisture content is greater than that of sandy soil, at the same moisture tension due to the increase in the specific surface area and the increase in the distribution of the pore size gradient and because the small and medium sized pores are more numerous and have a high ability to trap water and retain it for a longer period (Al-bayati, 2008, Hassan and Al-kahwaji, 2008, Al-Khatib and Al-Rawi, 2015, Barakat, 2017). Bulk density affects the amount of water held by soil at different moisture tensions because it changes the Size distribution of Soil pores (Wallor *et al*., 2018). Bulk density values are affected by organic matter and this is reflected in porosity values through the relationship between them (Vereecken *et al*., 2010, Morris *et al*., 2015). Arshad and others (1996) stated that when organic matter increases in the soil, it causes an increase in the soil's capacity to hold on to water because it affects the stability of the aggregates, which increases the porosity value and decreases the bulk density value (Yüksel, 2012, Souad Abdel Kazem 2021).

Organic matter has an impact on the physical properties of the soil (Liu *et al*., 2020), which in turn affects the amount of moisture content and the ability of the soil to retain moisture in larger quantities. Organic matter works to increase the bulk density and decrease the total porosity, as well as increasing soil aggregates and improving soil construction (Kechavarzi *et al*., 2010). Organic matter has the ability to retain water in larger quantities due to the increase in capillary pores and its high surface area, which leads to an increase in the soil's ability to retain water (Hassan, 1990). (Menberu *et al.* 2021) explained that increasing organic matter in most agricultural soils leads to increased soil aggregates, which increases the availability of water for plants, and the Increasing organic matter improves the structure of the soil and increases its porosity, which increases the soil's ability to retain water at the limits of field capacity, and the effect of organic matter is less at the limits of the wilting point (Rezanezhad *et al*. ،2016).

Sray Al-din (2018) noticed a clear difference between the laboratory-measured moisture tension curves and those predicted using the Van Genuchten 1980 equation for the studied samples. The reason for this difference results from the difference in the properties of the studied soils. The results showed an increase in soil water retention with increasing soil clay content. One of the studied soils with the highest clay content (49.54%) had the ability to retain high amounts of water, while the soil with low clay content (22.24%) had a low capacity to retain water. The constants of the Van Genuchten 1980 model (α, n and m) are related to the tensile curve and the slope of the curve depends on the distribution of soil pore sizes as stated in (Al-dulaimi and Mahdi, 2019, Wang *et al*., 2021). Al-khalifa (2021) found that there are differences in the values of the equation constants from one site to another, and the reason for this is the difference in the values of both the moisture content at saturation and the remaining moisture content, which is affected by the percentage of clay and the organic carbon content in the soil and their role in the formation of soil aggregates, their stability and bulk density. The aims of this research are to compare the measured moisture with the predicted by using Van Genuchten (1980) and Soilpar2 for soil under and different in vegetation cover and depths.

MATERIALS AND METHODS

Five locations (L) were chosen with deferent vegetation caver in Nineveh governorate. Disturb and undisturbed Soil samples were collected at for depths (d) (0 – 10), (10 – 20), (20 – 30) and (30 – 40) cm from all locations. Soil samples were taken to the laboratory for air drying, then pass through 2 mm sieve. Physical and chemical properties were determined. Column with 5 cm with diameter 5 cm and 5 cm high to the determent the bulk density. Physical properties were including soil texture, bulk density, hydraulic conductivity, plastic consistency and sticky limit. According to (Gee and Bauder, 1986 and Blake and Hartge, 1986. and Hassan, 1990).

$$PI = w_L - w_I$$

Where: PI Plasticity index (%), W_L Liquid limit (%), W_I Plastic limit (%).

$$f = \left[1 - \left(\frac{\rho_b}{\rho_s}\right)\right] * 100$$

Where: f Porosity (%), ρb bulk density, ρs particle density.

Chemical properties were including pH, EC and organic matter according to (page and others, 1982) shows Table (2).

Table (1): Soil texture for the study area.

Location & Vegetation Cover types	depth	Particle size distribution (gm Kgm^{-1})			Sand particle class					Texture class
		sand	silt	clay	Very find sand	Find sand	Medium sand	Coarse sand	Very coarse sand	
L1 Bore	d 1	516	323	160	57	203	115	108	33	L
	d 2	451	388	160	54	172	84	110	31	L
	d 3	357	462	180	39	148	70	77	23	L
	d 4	293	466	240	68	142	35	34	14	L
L2 Grass & weeds	d 1	539	160	300	18	162	111	186	62	SCL
	d 2	537	142	320	36	173	111	169	48	SCL
	d 3	530	139	330	30	160	115	177	48	SCL
	d 4	475	194	330	27	120	103	171	54	SCL
L3 Forest tree	d 1	454	255	290	35	154	107	131	27	CL
	d 2	406	293	300	30	147	93	114	22	CL
	d 3	315	364	320	37	145	66	57	10	CL
	d 4	294	346	360	15	80	70	101	28	CL
L4 Wheat grain	d 1	575	224	200	34	176	135	197	33	SL
	d 2	517	322	160	36	156	127	167	31	L
	d 3	516	323	160	33	103	147	199	34	L
	d 4	501	398	100	38	143	129	167	24	L
L5 Potato	d 1	214	377	408	18	82	55	48	11	C
	d 2	224	356	420	20	56	40	76	32	C
	d 3	190	409	400	23	46	37	56	28	C
	d 4	195	404	400	22	77	27	42	27	C

Estimation of the moisture characteristics curve of the soil

Laboratory method

The moisture content was measured at laboratory by using pressure cooker at the suctions (10, 20, 30, 50, 100 and 300) Kpa. The pressure membrane was used for the suctions (500, 800, 1100 and 1500) Kpa based on (Klute, 1986).

Table (2): physical and chemical properties for the study area.

location	depth	Bulk density ($Mgm.m^{-3}$)	Porosity (%)	Liquid limit (%)	Plastic limit (%)	Plasticity index	pH	EC ($dS.m^{-1}$)	Organic carbon(%)
L1	d 1	1.20	54.43	29.5950	28.9281	0.6669	8.5	0.59	1.0374
	d 2	1.27	51.99	31.7068	28.1988	3.5080	8.4	0.45	1.0773
	d 3	1.23	53.36	33.3540	29.3053	4.0487	7.9	0.42	0.8778
	d 4	1.23	53.28	31.9599	27.7220	4.2379	7.9	0.31	1.596
L2	d 1	1.27	51.71	34.6144	30.2419	4.3725	7.7	0.36	0.798
	d 2	1.28	51.62	34.112	30.0476	4.0644	7.7	0.51	0.9975
	d 3	1.29	51.29	35.2795	30.6397	4.6398	7.8	0.39	0.798
	d 4	1.36	48.36	36.4266	27.9913	8.4353	7.9	0.31	0.798
L3	d 1	1.36	48.47	36.9991	31.0589	5.9402	7.7	0.51	2.1147
	d 2	1.32	49.86	39.1203	28.7195	10.4008	7.6	0.37	1.3965
	d 3	1.27	52.02	39.9578	30.0285	9.9293	7.7	0.32	1.1571
	d 4	1.25	52.74	41.3757	31.3777	9.9979	7.8	0.28	1.4364
L4	d 1	1.37	47.96	36.4203	29.0812	7.3391	7.8	0.38	1.596
	d 2	1.37	48.25	35.8856	30.7390	5.1466	7.7	0.34	1.197
	d 3	1.23	53.37	39.7256	31.1256	8.6000	7.7	0.38	1.8354
	d 4	1.05	60.24	39.2778	32.5357	6.7421	7.6	0.52	1.7556
L5	d 1	1.24	53.17	43.3962	29.8757	13.5205	7.4	2.79	1.7157
	d 2	1.15	56.26	47.0973	31.4596	15.6377	7.7	1.79	1.5162
	d 3	1.16	55.93	49.0237	30.1139	18.9098	7.6	1.56	1.7955
	d 4	1.26	52.11	44.7641	29.1298	15.6343	7.6	2.06	1.3566

Mathematical equations

Recently, the process of measuring moisture suction using devices has been replaced by the application of some mathematical equations, which is faster than the process of measuring soil moisture suction in laboratory. These equations are:

Van Genuchten (1980)

$$\theta_v = \theta_r + \frac{\theta_s - \theta_r}{[1 + (\alpha h)^n]^m}$$

Where θv volumetric moisture content ($cm^3\ cm^{-3}$), θr residual moisture content, θs saturated moisture content, α, n and m are constant, h head cm.

Soilpar2

The program provides 15 procedures for estimating soil coefficients, including moisture content at different potentials, showing program components and allowing users to easily process inputs, upload selected data, view charts and maps, and export outputs to CropSyst and MS Excel formats. It allows the entry and storage of physical, chemical and hydrological information of the soil and allows the storage of site-specific information (soil description, latitude, longitude, height, slope, user feedback). The program also allows importing data from CropSyst and MS Excel files. (Acutis & Donatelli, 2003).

RESULTS AND DISCUSSION

The values of the measured volumetric moisture content (θv) at 10, 20, 33, 50, 100, 300, 500, 800, 1100 and 1500 Kpa. for the studied area at a depth d1, d2, d3 and d4. indicate that moisture at field capacity was (0.7685) at L6d2 and was lower at L1d1 (0.2954). Whereas the values of permanent wilting point were (0.2288) at L8d3 and (0.1125) at L1d4. The higher values were in soil which content high percent of clay, this result agreed with Al-wazan (2000). The effect of vegetation cover and organic matter on soil structure which reflect on the capability of soil moisture content (Hassan and Al-kahwaji, 2008 and Al-Khalifa, 2021).

Figure (1) indicate the moisture characteristic of the measured values and the predicted values by Van Genuchten 1980 and Soilpar2 model. For L1, the measured values of the moisture content were close and fit with the predicted values of both Van Genuchten and Soilpar2 at high suction, and little far at low suction.

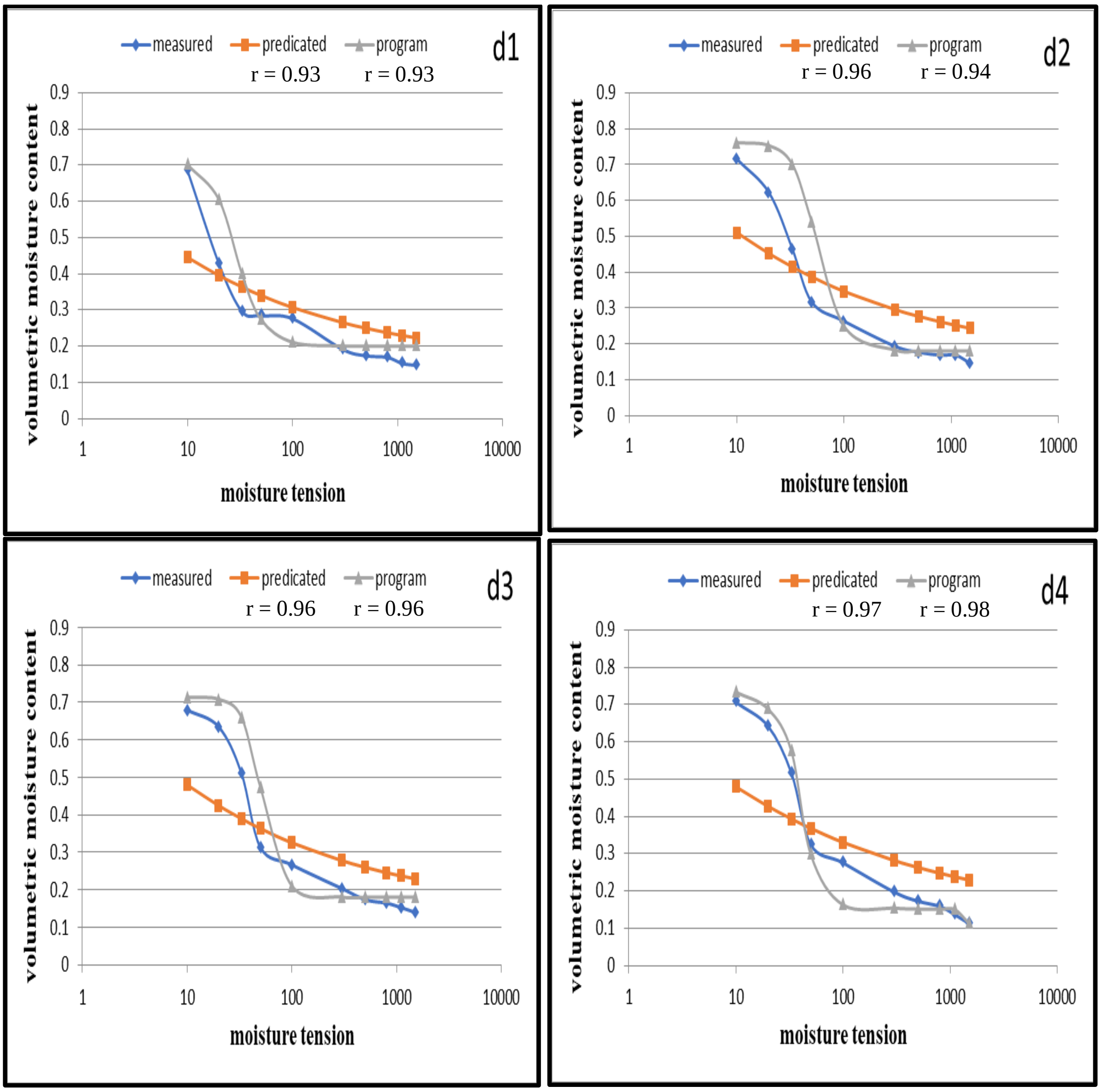

Figure (1): the measured moisture content and predicated value by using Van Genuchten (1980) and Soilpar2 program for L1 location with depths.

Figure (2) are presented the curves of the location L2 with the depths d1, d2, d3 and d4. respectively, it is shown that there is best fit between the measured and predicted values using the equation of Van Genuchten at (50 and 100 Kpa) for d1, d2 and d3. While at d4 was best fit at (30 to 1500 Kpa). The difference between the values related to the clay particles in d4 depth compared with the other depths. On the other hand, soilpar2 gave best fit at d2 and were not best fit at d1, d3 and d4. This result agreed with the result of (Al-jawade, 2015 and Al-Khalifa, 2021).

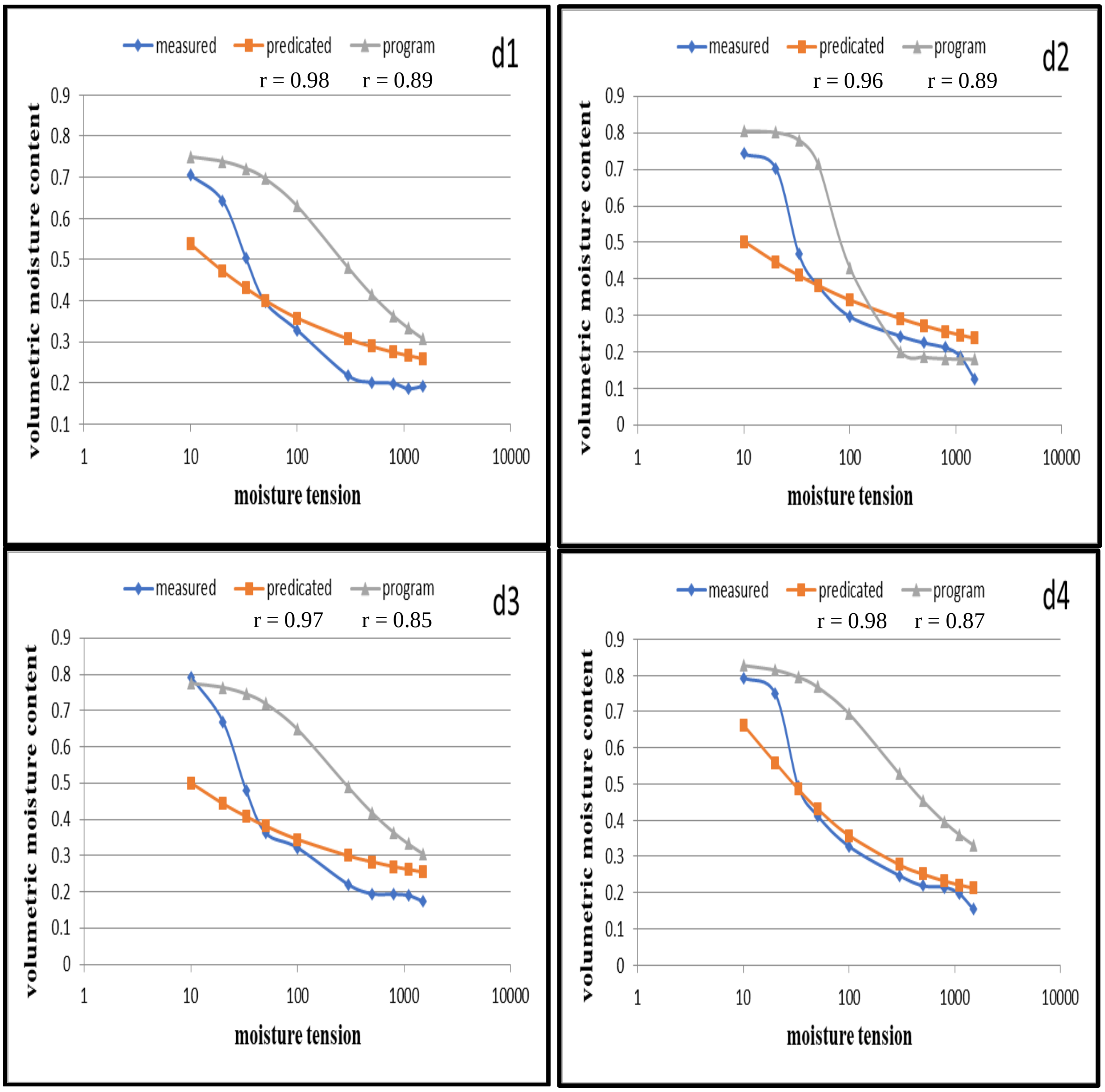

Figure (2): the measured moisture content and predicated value by using Van Genuchten (1980) and Soilpar2 program for L2 location with depths.

While Figure (3) represents the location of the L3 with four depths. The values of the measured moisture content were best fit with the predicted values with Van Genuchten at (50 to 1500 Kpa). On the other hand, by using Soilpar2 gave best fit at both d1 and d4 and not fit at d2 and d3. These variations may be related to the variation of soil texture and organic matter. This result agreed with the result of (Al-Khalifa, 2021).

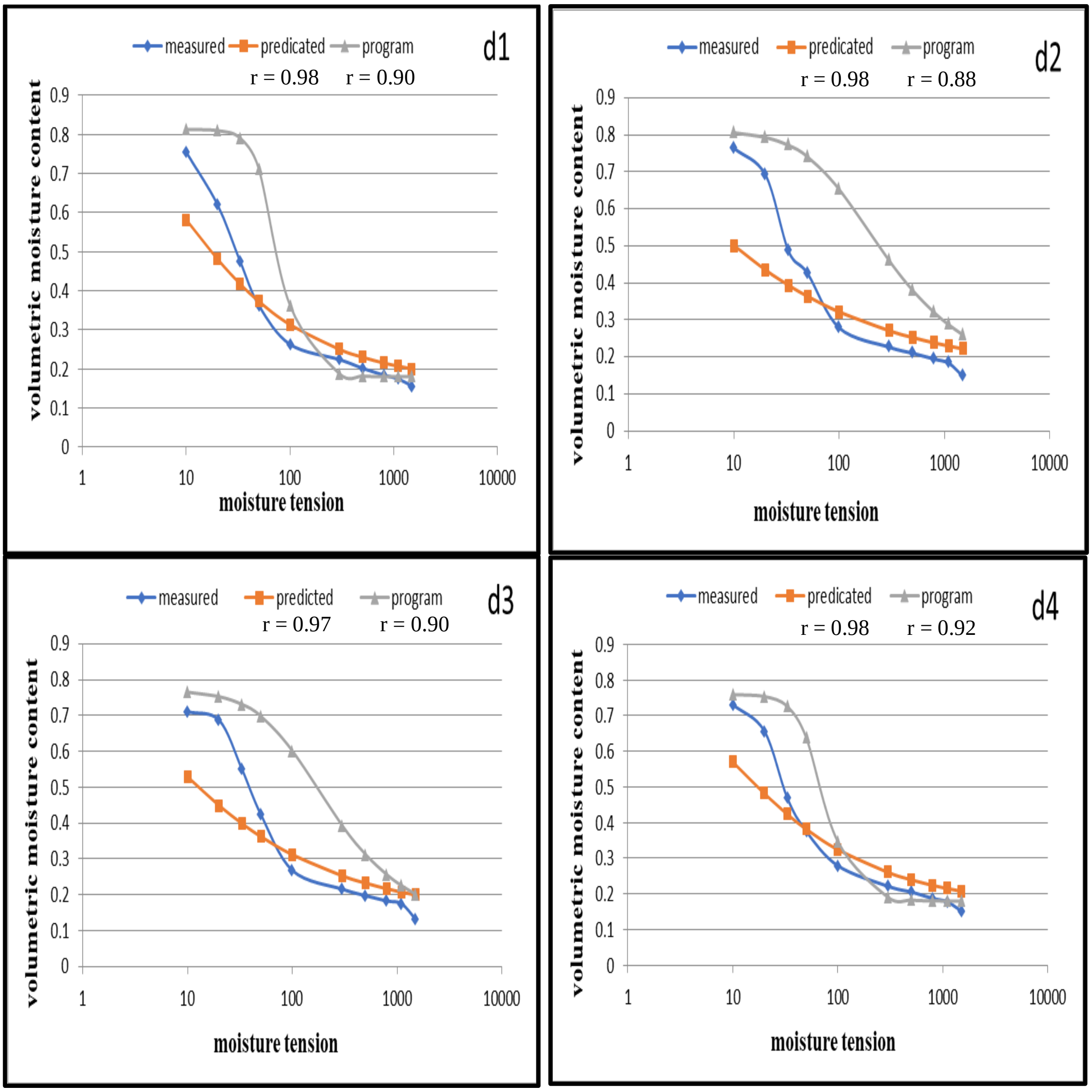

Figure (3): the measured moisture content and predicated value by using Van Genuchten (1980) and Soilpar2 program for L3 location with depths.

The result between the measured and predicated moisture content were similar to location L3. Figure (5) for L5, result indicated that both the measured and predicated measured content were best fit at d1, d2, d3 and d4 by using Van Genuchten and Soilpar2 except d4 was not best fit by using Soilpar2.

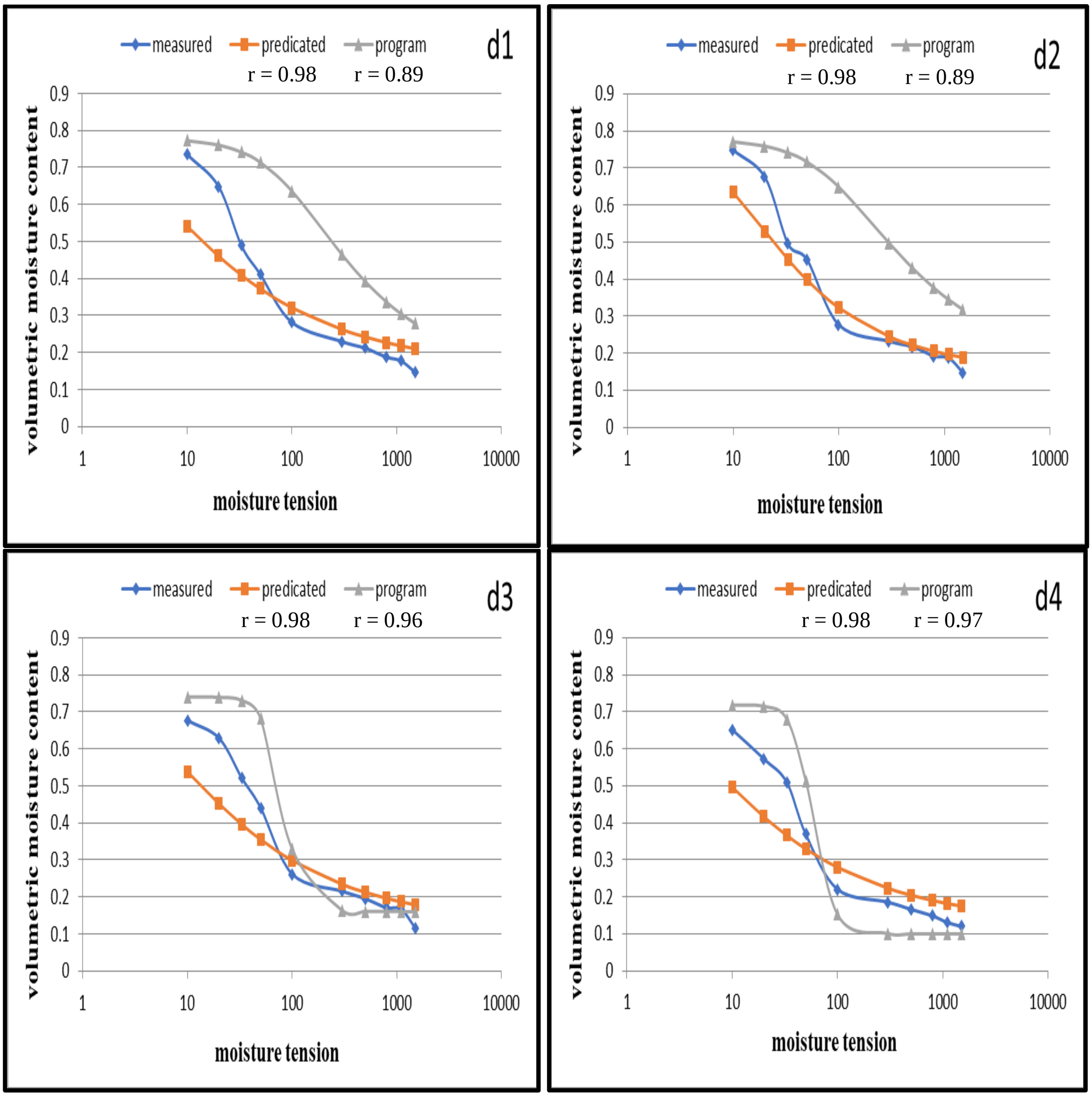

Figure (4): the measured moisture content and predicated value by using Van Genuchten (1980) and Soilpar2 program for L4 location with depths.

From the above result Van Genuchten 1980 equation gave best fit at the suction more than 50 Kpa especially at (800, 1100 and 1500 Kpa). There is no difference between the depth for the measured and predicated at the same location. While using Soilpar2 gave difference values between measured and predicated moisture content between the location and sometime the depth at the same location.

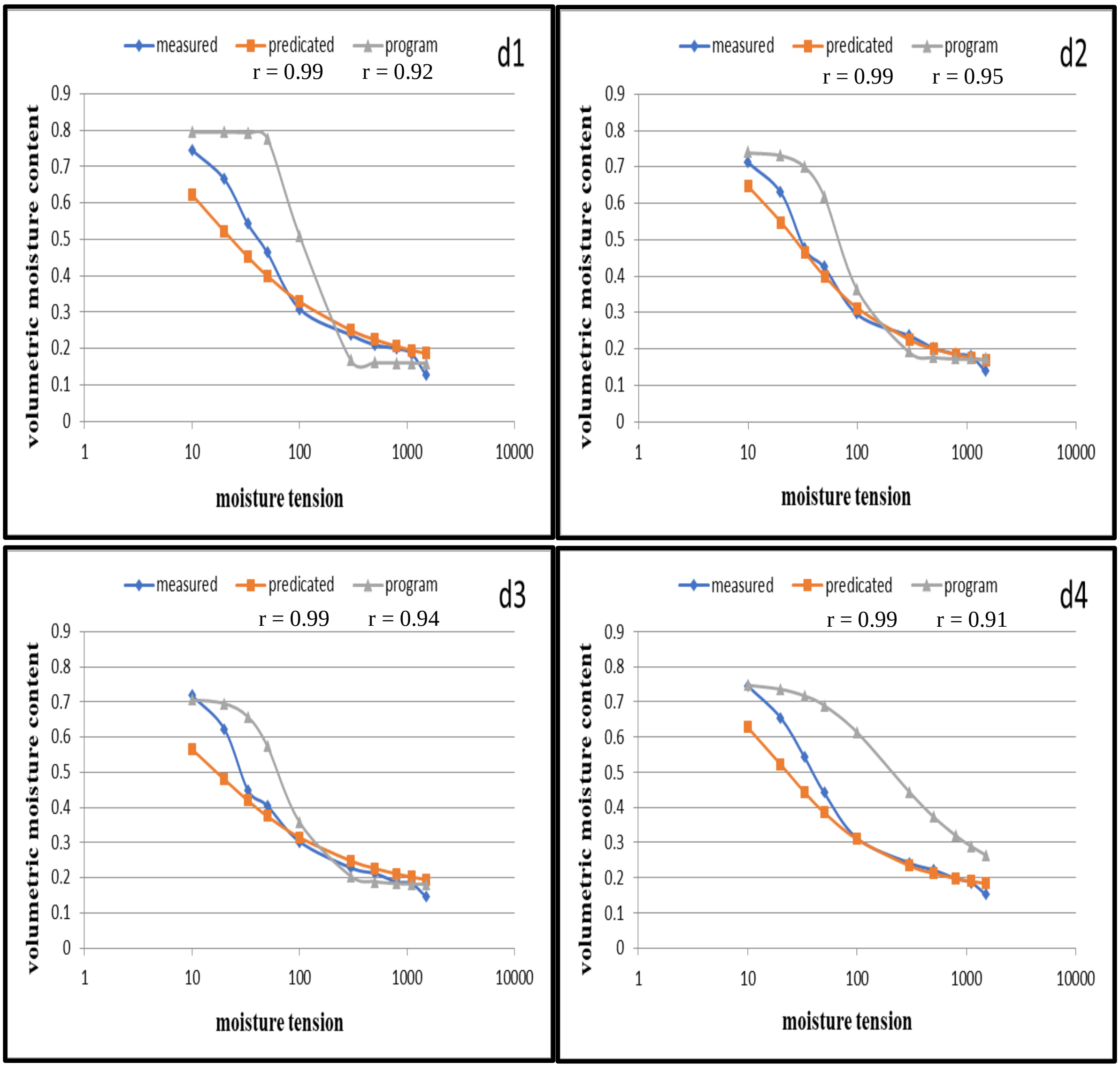

Figure (5): the measured moisture content and predicated value by using Van Genuchten (1980) and Soilpar2 program for L5 location with depths.

CONCLUSIONS

The conclusion of this study showed that the predicted values of moisture content by Van Genuchten (1980) were best fit with the measured value at all locations and depths at high suction. Also, the predicted values of moisture content by Soilpar2 were best fit with the measured value. at the locations L1 and L5 for all depths.

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CONFLICT OF INTEREST

The authors state that there are no conflicts of interest with the publication of this work.

التنبؤ بمنحنى الوصف الرطوبي باستخدام نموذج Van Genuchten (1980) وبرنامج Soilpar2 لبعض الترب في محافظة نينوى

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الخلاصة

اختيرت خمس مواقع اثنان منهم ضمن جامعة الموصل (L1، L2)، الشلالات L3، بايبوخ L4، خورسباط L5، مختلفة الغطاء النباتي ضمن محافظة نينوى لدراسة توزيع المحتوى الرطوبي المقاس مختبريا والمتنبأ به باستخدام معادلة (1980) Van Genuchten وبرنامج Soilpar2 ولأربعة أعماق. اجريت التحاليل الفيزيائية والكيميائية لنماذج التربة، بعد تجفيف التربة هوائيا، ونخلت بمنخل قطر فتحاته 2 ملم. اظهرت النتائج وجود توافق كبير جدا بين قيم المحتوى الرطوبي المقاسة والمتنبأ بها في اغلب المواقع والاعماق عند الشدود الأكثر من (50 كيلوباسكال) وبالأخص عند الشدود العالية (800، 1100، 1500 كيلوباسكال). كانت قيم معامل الارتباط (r) بين (0.93 – 0.99). يمكن تطبيق معادلة (1980) Van Genuchten للشدود العالية حيث تعطي قيم محتوى رطوبي قريبة من قيم المحتوى الرطوبي المقاسة في المختبر، كما أظهرت الدراسة أنه لم يكن لعمق التربة تأثير على قيم المحتوى الرطوبي بحيث كانت الفروق قليلة بين عمق واخر لنفس الموقع والسبب في ذلك يعود الى تماثل نسجة التربة. أظهرت الدراسة اختلاف بين قيم المحتوى الرطوبي المقاسة والمتنبأ بها باستخدام برنامج Soilpar2 بين موقع واخر. اختلفت القيم للأعماق لنفس الموقع. كان اعلى توافق بين القيم المقاسة والمتنبأ بها عند الشدود المنخفضة (10, 20 كيلوباسكال) لجميع المواقع. معامل الارتباط كانت قيمه بين (0.85 – 0.98).

الكلمات المفتاحية: اعماق، برنامج Soilpar2، الغطاء النباتي، نسجة التربة.

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